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ТЕМАТИЧЕСКИЙ РЕФЕРАТИВНЫЙ СБОРНИК № 49-1

“HEMT”

(«Транзисторы с высокой подвижностью электронов»)

Журнальные публикации

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Журнальные публикации

"Enhancement-Mode N-Polar GaN MISFETs With Self-Aligned Source/Drain Regrowth"

We report gate-first enhancement-mode (E-mode) N-polar GaN MISFET devices with self-aligned source/drain regions by molecular beam epitaxy regrowth and with a SiNxgate dielectric. E-mode operation at Vds= 4.0 V is demonstrated for devices with gate lengths >; 0.18 μm with a 20-nm GaN channel and a high-temperature SiNxgate dielectric. A high drain current of 0.74 A/mm was measured for an Lg= 0.62-μm device with a peak transconductance of 225 mS/mm and a positive threshold voltage of 1 V. The on resistance of the device was 2 Ω·mm. Devices show short-channel effect with decreasing gate lengths. [J1]

"Design and Analysis of a DC-43.5-GHz Fully Integrated Distributed Amplifier Using GaAs HEMT-HBT Cascode Gain Stage"

Design and analysis of a dc-43.5-GHz fully integrated distributed amplifier (DA) using a GaAs high electron-mobility transistor (HEMT) heterojunction bipolar transistor (HBT) cascode gain stage is presented in this paper. The proposed DA is fabricated in a stacked 2-μm InGaP/GaAs HBT, 0.5-μm AlGaAs/GaAs enhancement- and depletion-mode HEMT monolithic microwave integrated circuit technology. A modified m-derived network and an HEMT-HBT cascode amplifier with inductive peaking technique are investigated to enhance the bandwidth of the DA. The bias networks of the DA are fully integrated in a single chip without off-chip bias-T or bias components. The measured average small-signal gain is 8.5 dB. The measured minimum noise figure is 4.2 dB. The measured maximum output 1-dB compression point (P1 dB) and the maximum output third-order intercept point are 8 and 18 dBm, respectively. Moreover, the DA is successfully evaluated with an eye diagram measurement, and demonstrates good transmission quality. [J2]

"RF Performance of Deep-Recessed N-Polar GaN MIS-HEMTs Using a Selective Etch Technology Without Ex Situ Surface Passivation"

We present a deep-recessed nitrogen-polar AlGaN/GaN MIS-HEMT employing a V-gate structure recessed through a thick GaN cap to prevent dc-to-RF dispersion. A process for selectively dry etching N-polar GaN over AlGaN has been established to achieve repeatable etch depth for the gate recess. Devices with a drawn gate length of 0.7- μm showed a current-gain cutoff frequency (fT) of 15 GHz and a power-gain cutoff frequency (fmax) of 42 GHz. A continuous-wave output power density of 5.5 W/mm was measured at 4 GHz, with a record associated power-added efficiency of 74% and a large-signal gain of 14.5 dB at a drain bias of 24 V. [J3]

"Two-Stage GaN HEMT Amplifier With Gate-Source Voltage Shaping for Efficiency Versus Bandwidth Enhancements"

In this paper a two-stage 2-GHz GaN HEMT amplifier with 15-W output power, 28-dB power gain, and 70% power-added efficiency (PAE) is presented. [J4]

"Sub-1-dB Noise Figure Performance of High-Power Field-Plated GaN HEMTs"

In this letter, we report the state-of-the-art micro wave noise performance of discrete 0.15-μm-gate-length field plated (FP) GaN HEMTs. The FP GaN HEMTs yielded a peak fт/fmaxof 60 GHz/150 GHz at Vds = 10 V. An fmaxof 230 GHz was obtained at Vds = 20 V. At 2.5 V, the source-drain bias and dc power dissipation of 200 mW/mm, a minimum noise figure (NFmin) of 0.89 dB, and an associated gain (AG) of 11 dB were measured at 10 GHz. At 20 GHz the NFminand AG were 1.9 and 6.2 dB, respectively. The sub-1-dB microwave noise performance at 10 GHz is the best ever reported for FP high-power GaN HEMTs, which can be attributed to their lateral scaling and deep-submicrometer gate lengths. [J5]

"Enhancement-Mode InAlN/AlN/GaN HEMTs With Leakage Current and on/off Current Ratio"

Postprocessing annealing in forming gas at 400 °C was performed on enhancement-mode lattice-matched

InAlN/AlN/GaN high-electron-mobility transistors fabricated by selective etch of InAlN under a Pt gate. After postprocessing annealing, the device reverse gate leakage current decreased from 10-7to 10-12A/mm at Vgs= -1 V and Vds= 6 V, showing an ON/OFF current ratio of 1012that is the highest reported value for all GaN-based transistors. The gate diode breakdown voltage was observed to increase from ~9 to ~29 V; the transistor threshold voltage was also found to shift from 0.6 to 1.2 V. All these observations indicate that an electrically thinner and more insulating interlayer is most likely formed between the Pt gate and underlying channel after postprocessing annealing, which is ascribed to multiple possible mechanisms including increase in barrier height, reduction in interface states introduced during the gate recess process, formation of a thin oxide layer. etc. [J6]

"Normally Off AlGaN/GaN Metal-2DEG Tunnel-Junction Field-Effect Transistors"

We present the first AlGaN/GaN tunnel-junction FETs (TJ-FETs) featuring a metal-2-D-electron-gas (2DEG) Schottky tunnel junction at the source. The control of the source-to-drain current flow is realized through a gate-controlled tunnel junction instead of a gate-controlled 2DEG channel. The TJ-FETs exhibit normally off operation (Vth= +1.35 V) in an otherwise normally on as-grown sample. The unique high-density 2DEG in AlGaN/GaN heterostructures enables the formation of a Schottky tunnel barrier with nanometer-scale barrier thickness even with a large Schottky barrier height (e.g., ~0.8 eV). In the OFF state, the source Schottky junction provides natural reverse-blocking capability, resulting in significant leakage reduction and low OFF-state current. A drive current of 326 mA/mm, a high ION/IOFFratio (1010), and a low subthreshold swing (89 mV/dec) are obtained. [J7]

"Improved Modeling of GaN HEMTs on Si Substrate for Design of RF Power Amplifiers"

An improved large-signal modeling approach of GaN on Si devices for RF high-power applications is presented. This approach accounts for the parasitic buffer loading effect under microwave RF operation in addition to the self-heating and trapping effects associated with high-power operation conditions. A hybrid optimization (genetic and Simplex) technique based procedure is used to determine the optimal values of the model extrinsic elements. These elements are de-embedded from multibias S-parameter measurements to find the intrinsic part of the device, which is then used to construct a nonlinear current-charge (represented by nonlinear charge and current sources) based model for the gate current of the device. Pulsed and static dc IV characteristics are used for modeling of the drain current. The validity of the developed modeling approach is verified by comparing simulated large-signal single- and two-tone simulation with measured data of a 2-mm $({hbox {10}}times {hbox {200}} mu{hbox {m}})$GaN HEMT on Si substrate. The model has been employed for designing a class-AB power amplifier. Very good agreement between the amplifier simulation and measurement shows the validity of the model. [J8]

"Electric-Field-Driven Degradation in off-State Step-Stressed AlGaN/GaN High-Electron Mobility Transistors"

The critical degradation voltage of AlGaN/GaN high-electron mobility transistors during off-state electrical stress was determined as a function of Ni/Au gate dimensions (0.1-0.17 $muhbox{m}$), drain bias voltage, and source/drain-gate contact distance. Devices with different gate lengths and gate-drain distances were found to exhibit the onset of degradation at different source-drain biases but similar electric field strengths, showing that the degradation mechanism is primarily field driven. The degradation field was calculated to be sim1.8 MV/cm by Automatically Tuned Linear Algebra Software simulations. Transmission electron microscopy imaging showed creation of defects under the gate after dc stress. [J9]

"Single-Chip 220-GHz Active Heterodyne Receiver and Transmitter MMICs With On-Chip Integrated Antenna"

This paper presents the design and characterization of single-chip 220-GHz heterodyne receiver (RX) and transmitter (TX) monolithic microwave integrated circuits (MMICs) with integrated antennas fabricated in 0.1- μm GaAs metamorphic high electron-mobility transistor technology. The MMIC receiver consists of a modified square-slot antenna, a three-stage low-noise amplifier, and a sub-harmonically pumped resistive mixer with on-chip local oscillator frequency multiplication chain. The transmitter chip is the dual of the receiver chip by inverting the direction of the RF amplifier. The chips are mounted on 5-mm silicon lenses in order to interface the antenna to the free space and are packaged into two separate modules. [J10]

"GaN Single-Polarity Power Supply Bootstrapped Comparator for High-Temperature Electronics"

A high-performance bootstrapped comparator operating with a single-polarity power supply is demonstrated for GaN high-temperature electronics applications. The comparator features monolithically integrated enhancement-

mode (E-mode) and depletion-mode (D-mode) AlGaN/GaN HEMTs. The tail current source uses an E-mode HEMT, enabling single-polarity power supply. The E-mode input stage could cover a wide voltage comparison range (from 1 to 6 V) while the bootstrapped loads are implemented with D-mode HEMTs. At room temperature, the comparator delivers a voltage gain as high as 79 V/V and a unity-gain bandwidth of 206 MHz. At 250, a maximum voltage gain of 40 V/V and a unity-gain bandwidth of 84 MHz are obtained. [J11]

"Efficiency Enhancement of Doherty Amplifier Through Mitigation of the Knee Voltage Effect"

This paper presents an approach to maximize the efficiency of a Doherty power amplifier (PA) with the knee voltage effect. Since the carrier PA with, which is the usual matching impedance for a carrier PA at a low power region, does not reach to the saturated operation at the 6-dB back-off power level, the maximum efficiency could not be achieved. However, the carrier amplifier can be driven into the saturation using the load impedance larger than and can deliver the maximum efficiency even under the knee voltage effect. The optimized design for the maximum efficiency at the back-off level is derived. The optimized amplifier is analyzed and simulated in terms of its load modulation behavior, efficiency, and output power, then compared with the conventional Doherty PA. The enhanced performance is demonstrated by the Doherty PA built using CREE's GaN HEMT CGH40045 devices at 2.655 GHz. For worldwide interoperability for microwave access applications with a 7.8-dB peak-to-average power ratio, the proposed PA delivers an efficiency of 49.3% at an output power of 42 dBm with an acceptable linearity of 23.1 dBc. The linearity is improved to 43 dBc by employing a digital feedback predistortion technique, satisfying the system linearity specification. [J12]

"A Current-Transient Methodology for Trap Analysis for GaN High Electron Mobility Transistors"

Trapping is one of the most deleterious effects that limit performance and reliability in GaN HEMTs. In this paper, we present a methodology to study trapping characteristics in GaN HEMTs that is based on current-transient measurements. Its uniqueness is that it is amenable to integration with electrical stress experiments in long-term reliability studies. We present the details of the measurement and analysis procedures. With this method, we have investigated the trapping and detrapping dynamics of GaN HEMTs. In particular, we examined layer location, energy level, and trapping/detrapping time constants of dominant traps. We have identified several traps inside the AlGaN barrier layer or at the surface close to the gate edge and in the GaN buffer. [J13]

"Self-Aligned Technology for N-Polar GaN/Al(Ga)N MIS-HEMTs"

In this letter, we introduce a scalable self-aligned technology for N-polar GaN MIS-HEMTs which can be used to achieve significant improvement in device performance by minimizing the source and drain access resistances. The methodology consists of a refractory-metal gate-first process followed by the regrowth of polarization-doped graded InGaN and InN layers by plasma-assisted molecular-beam epitaxy. The regrowth has been optimized to achieve ohmic contact resistance as low as 23 Ω-μm to the N-face 2-D electron gas. Excellent maximum current of 1.4 A/mm and a very low on resistance of 590 Ω-μm was achieved at (VG- VT) = 6 V for LG= 500 nm. Peak transconductance of 343 mS/mm is also state of the art for the given gate length and aspect ratio. Excellent fT.LGproduct of 15.9 GHz-μm with minimal drain delay was also achieved for LG= 600 nm. [J14]

"Improvement of the Off-State Breakdown Voltage With Fluorine Ion Implantation in AlGaN/GaN HEMTs"

Improvement of the AlGaN/GaN high-electron mobility transistor's (HEMT's) off -state breakdown voltage is achieved by implanting 19F+ions at an energy of 50 keV and dose of 1 Ч 1012cm-2under the gate region using BF3as the source. The charge state of the implanted fluorine ions changes from positive to negative in the AlGaN/GaN structure because of fluorine's strong electronegativity. The negative-charged fluorine ions at the back side of the two-dimensional electron gas can raise the energy barrier of the GaN buffer layer under the channel, effectively blocking the current injected from the source to the high-field region of the GaN channel when the HEMT is biased at off-state. The source-injected electrons, if not blocked, could flow to the high-field region and initiate a premature three-terminal off-state breakdown in a conventional AlGaN/GaN HEMT. A 38% improvement of the three-terminal off-state breakdown voltage and 40% improvement of the power figure-of-merit VBD-off2/Ronare achieved in the enhanced back barrier HEMT. [J15]

"-Gate MOS-HEMTs by Methods of Ozone Water Oxidation and Shifted Exposure"

This letter reports, for the first time, a Γ-gate metal-oxide-semiconductor high-electron-mobility transistor (MOS-HEMT), which can achieve gate-length reduction, improved gate insulation, and formations of a field plate and a full surface passivation within the drain-source region at the same time by using the ozone water oxidation and shifted exposure techniques. The present Γ-gate MOS-HEMT has demonstrated significant improvements of 523% in the two-terminal gate-drain breakdown, 137% in the on -state drain-source breakdown, and

28%/39.3% in the unity-gain cutoff frequency/maximum oscillation frequency (fT/fmax), as compared to a conventional Schottky-gate device fabricated upon the same epitaxial structure by using an identical optical mask. [J16]

"Comprehensive Study on the Bias-Dependent Equivalent-Circuit Elements Affected by PECVD SiN Passivation in AlGaN/GaN HEMTs"

In this paper, a comprehensive study on the effect of plasma-enhanced chemical-vapor-deposited SiN surface passivation on the bias-dependent small-signal equivalent-circuit elements is carried out for AlGaN/GaN high-electron mobility transistors on a high-resistivity silicon substrate. The direct-current and small-signal performance of the device was found to be improved by surface passivation. The small-signal equivalent-circuit parameters at various gate and drain biases were extracted, and the physical mechanisms of their bias-dependent behaviors before and after passivation are discussed in detail. [J17]

"Electrothermal Access Resistance Model for GaN-Based HEMTs"

The high-power density in GaN-based high-electron-mobility transistors (HEMTs) increases demands on the accurate extraction and modeling of electrothermal effects such as self-heating. This paper presents a new electrothermal model of the access resistances in GaN HEMTs, taking into account both self heating and bias dependence. A coplanar ungated transfer length method (TLM) structure has been used to extract the resistance versus temperature, bias, and RF power. The temperature dependence is extracted from dc measurements at ambient temperatures between 293 and 443 K. Small-signal measurements are used to extract the time constants in the thermal impedance. The bias dependence of the current is characterized by isothermal large-signal RF measurements between 1 and 6 GHz. A new method for extracting the thermal resistance from the large-signal measurements together with temperature-dependent dc measurements is also presented. [J18]

"Novel Tunable Millimeter-Wave Grating-Gated Plasmonic Detectors"

We present the development of tunable, narrow-band plasmonic millimeter wave detectors. The current generation of this class of detector monolithically integrates a 2-D plasmonic absorber and a bolometric sensor in a GaAs/AlGaAs HEMT located at the vertex of a broad-band antenna. Response and transport measurements demonstrate absorption by high-order plasmon modes sensed by the integrated bolometer and with a two order of magnitude improvement in sensitivity and noise equivalent power over prior generations of 2-D plasmonic detectors. We compare these recent results with the state of the art in millimeter and submillimeter wave-detection technology. [J19]

"X-band power performance of N-face GaN MIS-HEMTs"

A report is presented on the X-band power performance of N-face GaN-based metal-insulator-semiconductor high-electron-mobility transistors (MIS-HEMTs). The use of an AlN-based back-barrier enabled low sheet resistance, eliminated alloy disorder scattering to the 2-D electron gas (2DEG), and provided carrier confinement under high electric fields for device scaling. At 10 GHz, a peak power-added efficiency of 56 with a continuous-wave output power density (Pout) of 5.7 W/mm were measured in devices with 0.7 m gate length and 28 V drain bias. A maximum drain efficiency of 70 and saturated output power density of 6 W/mm were achieved. These results are the first demonstration of dispersion-free large-signal operation in N-face devices beyond the C-band. [J20]

"Concurrent Hex-Band GaN Power Amplifier for Wireless Communication Systems"

In this letter, we propose a novel multi-section transmission line matching technique applied to the design of a concurrent hex-band HEMT GaN power amplifier (PA). The PA has been designed for a concurrent operation at 0.9, 1.8, 2.5, 3.5, 5.2, and 5.8 GHz. Experimental results have shown minimum and maximum saturated output power levels of 33 dBm and 36.7 dBm respectively over the different frequency bands, with the power added efficiency (PAE) ranging from a minimum of 20% to a maximum of 49%. A detailed comparison between simulation and experimental results data has also been reported. [J21]

"RF performance of InAlN/AlN/GaN HEMTs on sapphire substrate"

DC and RF performances of an In0.15Al0.85N/AlN/GaN high electron mobility transistor (HEMT) on sapphire substrate with 8.3 nm barrier layer thickness are reported. The device provides a maximum DC current density of 1 A/mm and a peak extrinsic transconductance of 325 mS/mm. A current gain cutoff frequency (FT) of 80 GHz and a power gain cutoff frequency (FMAX) of 130 GHz are obtained for a 110 nm gate length transistor corresponding to the highest reported values from InAlN/AlN/GaN HEMTs grown on sapphire substrate. [J22]

"Proposal of High-Electron Mobility Transistors With Strained InN Channel"

By using a Schrojdinger-Poisson equation solver, we calculate band diagrams of potentially record fast III-N high electron mobility transistors (HEMTs), which are based on strained InN channels. Assuming cation polarity, pseudomorphic HEMT devices are proposed with a relaxed InAlN buffer layer having Al mole fraction in the range of 0.10-0.15 and with an InAlN barrier layer. Calculations indicate highly confined electrons in the channel with a density of 1.4-2 Ч 1013cm-2if the 5-10-nm-thick InN channel is separated from the barrier by ≤ 0.8-nm-thick GaN spacer. Alternatively, for a nonpolar structure with an Al mole fraction of 0.3 in the InAlN buffer and for a doping 5 Ч 1019cm-3in the InAlN barrier, we calculate the InN channel carrier density of approximately 1.4 Ч 1013cm-2. We propose to use high-k dielectrics to insulate the gate from the barrier for both of the transistor structures. [J23]

"Effect of source-drain spacing on DC and RF characteristics of 45 nm-gate AlGaN/GaN MIS-HEMTs"

A report is presented of the fabrication of 45 nm-gate AlGaN/GaN MIS-HEMTs with a source-drain spacing Lsd range from 0.5 to 2.0 m on sapphire substrate. Their DC and RF characteristics have been measured. The maximum transconductance gm increased with decreasing Lsd. On the other hand, the cutoff frequency fT and maximum oscillation frequency fmax had maximum values at Lsd = 1.0 μm. The maximum values of fT and fmax were 188 GHz and 173 GHz, respectively. The reduction of fT and fmax at Lsd = 0.5 μm results from the greatly increased parasitic gate capacitance. [J24]

"InGaAs HEMT with InAs-rich InAlAs barrier spacer for reduced source resistance"

An InAlAs/InGaAs HEMT with an InAs-rich barrier spacer (In0.52Al0.48As) to reduce the parasitic resistance is reported. Devices were obtained with a source resistance of 170 Ω-μm. A 40 nm gate length In0.7Ga0.3As HEMT with Lside= 100 nm and tins= 10 nm shows excellent transconductance and subthreshold characteristics including gm = 1.6 mS/μm, DIBL = 122 mV/V and S = 80 mV/ dec at VDS= 0.5 V. In addition, this device exhibits an fT= 530 GHz and fmax= 445 GHz at VDS= 0.7 V. These excellent characteristics mainly arise from a reduction in the source resistance through the use of the InAs-rich InAlAs spacer. [J25]

"Reduced surface leakage current and trapping effects in AlGaN/GaN high electron mobility transistors on silicon with SiN /Al 2 O 3 passivation"

The surface leakage currents and the surface trapping effects of the AlGaN/GaN high electron mobility transistors (HEMTs) on silicon with different passivation schemes, namely, a 120 nm plasma enhanced chemical vapor deposited SiN, a 10 nm atomic layer deposited (ALD) Al2O3and a bilayer of SiN/Al2O3(120/10 nm) have been investigated. After SiN passivation, the surface leakage current of the GaN HEMT was found to increase by about six orders; while it only increased by three orders after the insertion of Al2O3between SiN and AlGaN/GaN. The surface conduction mechanism is believed to be the two-dimensional variable range hopping for all the samples. The leakage current in the etched GaN buffer layer with SiN/Al2O3bilayer passivation was also much smaller than that with only SiN passivation. The pulse measurement shows that the bilayer of SiN/Al2O3passivation scheme can effectively reduce the surface states and suppress the trapping effects. [J26]

"Development of a Versatile Physics-Based Finite-Element Model of an AlGaN/GaN HEMT Capable of Accommodating Process and Epitaxy Variations and Calibrated Using Multiple DC Parameters"

We present a physics-based finite-element model of operation of an AlGaN/GaN HEMT with device geometry inputs taken from transmission electron microscope cross sections and calibrated by comparison with measured electrical data comprising standard field-effect transistor metrics and less well-known model parameters. A variety of electrical outputs from the model are compared to experiment, and the level of agreement is reported. [J27]

"Dual-Gate GaN MMICs for MM-Wave Operation"

This letter describes the millimeter-wave operation of III-N dual-gate MMICs based on a complete mm-wave MMIC technology suitable for operation up to 110 GHz. The GaN HEMTs have a gate length of 100 nm, yield high maximum transconductance, and very low parasitic capacitances. The cutoff frequency fTis above 80 GHz at an operation bias of 15 V in a fully passivated device. Dual-gate devices were developed for high gain at high gate widths and for substantial improvements in gain per stage on MMIC level. Complete III-N MMICs in grounded coplanar passive technology were designed. A single-stage dual-gate MMIC at 60 GHz yields 150 mW

(840 mW/mm) of output power. A second MMIC shows a linear gain of greater than 10 dB at 94 GHz. It further yields an output power of 22.8 dBm (190 mW or 520 mW/mm) in CW-operation to a 50 Ω load with a maximum PAE of 7% at 94 GHz. The letter demonstrates the advantage of GaN dual-gate devices in power gain over common-source devices while maintaining essential improvements in power density. [J28]

"Kink Effect in AlGaN/GaN HEMTs Induced by Drain and Gate Pumping"

Kink effects are studied in conventional AlGaN/GaN high-electron-mobility transistors by measuring their current-voltage characteristics with various bias sweeping conditions at drain and gate terminals. It is found that the kink effect is induced by drain and gate pumping. The magnitude of kink is directly related to the maximum drain voltage and current levels during on-state operation. The hot electrons in the 2-D electron gas channel generated under high drain bias could be injected into the adjacent epitaxial buffer layer where they can be captured by donor-like traps. Hot electron trapping and the subsequent field-assisted de-trapping is suggested to be the dominant mechanism of kink generation in the studied device. The extracted activation energy of the traps accounting for the kink effect is 589 pm67 meV from temperature-dependent transient measurement, and is close to the energy of the E_{2}trap widely reported in GaN layers. [J29]

"High-Efficiency Power Amplifier"

In this article, the design of a high-efficiency harmonically tuned GaN HEMT PA has been presented. The PA presents state-of-the-art measured efficiency and gain performance at 3.5 GHz, demonstrating the success of the dedicated transistor modeling, the bare-die mounting and implementation technique, and the circuit design methodology. [J30]

"Simulation of Short-Channel Effects in N- and Ga-Polar AlGaN/GaN HEMTs"

We have carried out 2-D simulation of N-polar and Ga-polar AlGaN/GaN HEMTs to investigate short-channel effects in highly scaled devices. N-polar HEMTs were found to have better drain-induced barrier lowering (DIBL) suppression than Ga-polar HEMTs. The short-channel effects were found to originate from the 2-D potential distribution in the channel and space-charge-limited current through the buffer. The inverted structure of the N-polar HEMT was found to provide better suppression of short-channel effects under idealized theoretical assumptions that were used in the model presented. [J31]

"A Novel Transparent AZO-Gated pHEMT and Photosensing Characteristics Thereof"

A novel transparent Al-doped ZnO (AZO)-gated Al0.2Ga0.8As/In0.2Ga0.8As pseudomorphic high-electron mobility transistor (pHEMT) has been comprehensively investigated. The proposed AZO-gated pHEMT has demonstrated superior temperature-dependent performance, including two-terminal gate-drain breakdown/turn-on voltages of-63/3.4 (-56.4/3.4) V, an intrinsic voltage gain AVof 257 (176), and a gate voltage swing of 1.18 (1.13) V at 300 (450) K. An excellent thermal threshold coefficient ∂Vth/ΘT of -1.8 mV/K was also obtained. A conventional Au-gated device with the same gate dimensions of 1 Ч 100 μm2was also fabricated in comparison. In addition, high optical transmittance values of 82%-98% for incident energy values of 1.24-3.54 eV are achieved in the AZO film. The present AZO-gated HEMT has demonstrated three-terminal tunable optical responsivity due to a photovoltaic effect. Photosensing characteristics under different radiation wavelengths of white light, red light (632 nm), and near infrared (980 nm) are also studied. [J32]

"Correlation Between AlGaN/GaN MISHFET Performance and Insulation Layer Quality"

HfO2films of 15 nm were deposited using atomic layer deposition at temperatures varying from 110°C to 200°C and then to 300°C on AlGaN/GaN HEMT structures. Devices with 300°C HfO2show dramatically better ON and OFF-state characteristics under dc biases than those with HfO2deposited at lower temperatures. High-resolution X-ray diffraction, together with X-ray reflectivity measurements, confirms the superior film quality of the 300°C HfO2in comparison to the lower temperature grown films. [J33]

"Note: Ultra-high frequency ultra-low dc power consumption HEMT amplifier for quantum measurements in millikelvin temperature range"

We have presented theory and experimentally demonstrated an efficient method for drastically reducing the power consumption of the rf/microwave amplifiers based on HEMT in unsaturated dc regime. Conceptual one-stage 10 dB-gain amplifier showed submicrowatt level of the power consumption (0.95 mu W at frequency of 0.5 GHz) when cooled down to 300 mK. Proposed technique has a great potential to design the readout amplifiers for ultra-deep-cooled cryoelectronic quantum devices. [J34]

"Analytical approach to optimise the efficiency of switching mode power amplifiers loaded with distributed matching networks"

This study describes the design methodology of optimising the power-added efficiency (PAE) of switching mode power amplifiers (SMPAs). To maximise efficiency, design optimisation of the harmonic loading networks using an analytical analysis approach is proposed. Indeed, by carefully designing a distributed harmonic control network at the output of the SMPA, the insertion loss through the load network can be minimised. To validate the PAE optimisation approach, two 10 W inverse class F power amplifiers (PAs) were designed, manufactured and tested at a frequency of 2.45 GHz using a GaN HEMT transistor. The first PA prototype was matched with a standard distributed harmonic loading network and the second with the proposed distributed harmonic loading network. The measured PAE and gain for the second prototype were improved by 3 and 0.17 dB to reach 73 and 14 dB, respectively. [J35]

"A 60-GHz Frequency Tripler With Gain and Dynamic-Range Enhancement"

In this paper, a single-stage 60-GHz frequency tripler is presented with $-{hbox{1.1}}$-dB conversion gain in a 0.15-$mu{hbox {m}}$pseudomorphic HEMT process. When the input power backs off, unlike most of its counterparts, the conversion gain of the proposed tripler degrades very little. This feature is achieved by adjusting load impedances independently for the first and third harmonic. Besides the enhancement of the third harmonic power, substantial fundamental power is also generated without additional power consumption and is further used to drive an auxiliary diode tripler. The third harmonic power from the original field-effect transistor (FET) and the auxiliary diode tripler are combined with the conversion gain further enhanced, and the power dynamic range is also extended due to the power contributed from the auxiliary tripler. Quantitative analysis for the harmonic loading effect of the FET tripler and the bias selection for the diode tripler are conducted by using the equivalent-circuit models. The theories are verified by computer-aided design simulations and experimental results. [J36]

"Temperature-Dependent Microwave Noise Characteristics in ALD /AlGaN/GaN MISHEMTs on Silicon Substrate"

Temperature-dependent microwave noise characteristics are presented in an atomic-layer-deposited /AlGaN/GaN metal-insulator-semiconductor high-electron mobility transistor (HEMT) (MISHEMT) on a Si substrate over a wide temperature range from -40 to 200 C. Typical noise parameters, including minimum noise figure, noise equivalent resistance, and associate gain, are measured over the whole temperature range. The conventional Schottky-gate HEMT with the same epistructure is also compared. The temperature dependences of and for the MISHEMT are found to be similar to those for the conventional HEMT, respectively, whereas less temperature dependence of is found in the GaN MISHEMT. The degradation rate of the noise performance of MISHEMT is found to be comparable to that of the other reported GaN HEMTs on SiC and sapphire substrates and also comparable to that of GaAs HEMTs. [J37]

"AlGaN/GaN high electron mobility transistors on 100 mm silicon substrates by plasma molecular beam epitaxy"

GaN high electron mobility transistor (HEMT) structures have been grown by plasma molecular beam epitaxy on 100 mm diameter silicon substrates. Crack-free films with thicknesses of up to 1.7mcmwere deposited without the use of strain-relaxing buffer layers. X-ray measurements indicate high structural uniformity and the Pendellosung oscillations are observed due to the abruptness of the AlGaN/GaN interface. Capacitance-voltage measurements display a sharp pinch-off with a depleted GaN buffer layer and no measurable charge accumulation at the substrate-epi interface. Transmission line measurements on the GaN HEMT buffer and substrate indicate a loss of less than 0.2 dB/mm up to 20 GHz. An average sheet resistance of 443Omega /sqwith a standard deviation of 0.8% and a mobility of 1600cm2/V swere obtained for an Al0.25Ga0.75N/GaNHEMT. Transistors were fabricated with a current density of 1.2 A/mm and a transconductance of 290 mS/mm which is quite comparable to GaN HEMTs on SiC. [J38]

"Integrated Optical and Electrical Analysis: Identifying Location and Properties of Traps in AlGaN/GaN HEMTs During Electrical Stress"

A new methodology is developed to determine spatial location and properties of traps generated by electrical stressing of AlGaN/GaN high-electron mobility transistors, based on integrated optical and electrical analysis. Mild off-state stress increases irreversibly the number of traps located in the near-surface AlGaN region at the gate edge. A deep level with 0.45-eV activation energy in fresh devices changes its nature to interacting defect after the off-state stress, accompanied by an activation energy change. These results are consistent with trap

generation in the near-surface AlGaN region at the gate edge related to high electric field and gate leakage current, as stressing does not result in the generation of cracks in the AlGaN layer. [J39]

"Analytical Modeling of High-Frequency Noise Including Temperature Effects in GaN HEMTs on High-Resistivity Si Substrates"

In this paper, analytical modeling of high-frequency noise was carried out including temperature effects in AlGaN/GaN high electron mobility transistors (HEMTs) on high-resistivity Si substrates over a wide temperature range from -50°C to 200°C. The device's microwave S-parameters and overall noise parameters, including minimum noise figure (NFmin), equivalent noise resistance (Rn), and optimum source reflection coefficient (| opt| and opt) were measured over the whole temperature range. Its small signal equivalent circuit parameters (ECPs) and internal noise source coefficients (P, R, and C) were extracted at each measurement temperature and their temperature variances were fitted using a quadratic relationship. An analytical model of the overall noise parameters is proposed based on Pucel's PRC theory. It is compared with two other commonly used analytical models and verified with the measured data, including temperature dependence. The feedback capacitance Cgdwas found to be important to accurately simulate all the measured noise parameters over temperature. [J40]

"Field-Plate Structure Dependence of Current Collapse Phenomena in High-Voltage GaN-HEMTs"

Four types of the field-plate (FP) structure were fabricated to discuss the relation between the current collapse phenomena and the electric-field peak in high-voltage GaN-HEMTs. The on -resistance increase caused by current collapse phenomena is dramatically reduced by the single-gate-FP and dual-FP structures compared with the source-FP structure, because the gate-edge electric field was reduced by the gate-FP electrode. The dual-FP structure was slightly more effective to suppress the collapse phenomena than the single-gate-FP structure, because the two-step FP structure relaxes the electric-field concentration at the FP edge. These results show that the gate-edge peak strongly affects the on -resistance modulation. Although the FP edge peak also causes the collapse phenomena, its influence is weak. [J41]

"AlGaN/GaN HEMTs on (001) Silicon Substrate With Power Density Performance of 2.9 W/mm at 10 GHz"

AlGaN/GaN High Electron Mobility Transistors (HEMT) on a (001)-oriented silicon (Si) substrate are fabricated. The device with a gate length of 300 nm and a total gate periphery of 300 µm exhibits a maximum dc drain current density of 600 mA/mm at VGS= 0 V with an extrinsic transconductance (gm) of about 200 mS/mm. An extrinsic current gain cutoff frequency (ft) of 37 GHz and a maximum oscillation frequency (fmax) of 55 GHz are deduced from S-parameter measurements. At 10 GHz, an output power density of 2.9 W/mm associated to a power-added efficiency (PAE) of 20% and a linear gain of 7 dB are obtained at VDS= 30 V and VGS= -2 V. To our knowledge, these power results represent the highest output power density ever reported at this frequency on GaN HEMT grown on (001) Si substrate. [J42]

"Extraction of AlGaN/GaN HEMT Gauge Factor in the Presence of Traps"

Repeatable gauge factors (GFs) of an AlGaN/GaN high-electron mobility transistor (HEMT) device were obtained after eliminating parasitic charge-trapping effects. Many GFs for AlGaN/GaN HEMTs are reported in the literature, and charge traps could be responsible for the four orders of magnitude variation in reported GFs. By employing continuous subbandgap optical excitation, the effect of nonrepeatable charge-trapping transients was effectively minimized, allowing the GF to be accurately measured. The measured GF (-2.8 0.4) is reasonably close to the simulated GF (-7.9 5.2) calculated from stress-induced changes in the 2-DEG sheet carrier density and mobility. [J43]

"Off-State Breakdown Characterization in AlGaN/GaN HEMT Using Drain Injection Technique"

AlGaN/GaN high-electron mobility transistor's (HEMT's) off-state breakdown is investigated using drain-current injection techniques with different injection current levels. Competitions between the source leakage and gate leakage, pure leakage and impact ionization, and source- and gate-injection-induced impact ionization during the drain-injection measurement are discussed in detail. It was found that the breakdown originates from the source/gate leakage at low drain injection levels but is dominated by source/gate-induced impact ionization process at high drain injection currents. The source-induced impact ionization usually precedes the gate-induced impact ionization in low-gate leakage devices, resulting in a premature three-terminal off-state breakdown. We also found that the gate-bias value affects the breakdown voltage in the conventional three-terminal off-state breakdown I-V measurement and should be carefully considered. [J44]

"GaN Power Transistors on Si Substrates for Switching Applications"

In this paper, GaN power transistors on Si substrates for power switching application are reported. GaN heterojunction field-effect transistor (HFET) structure on Si is an important configuration in order to realize a low loss and high power devices as well as one of the cost-effective solutions. Current collapse phenomena are discussed for GaN-HFETs on Si substrate, resulting in suppression of the current collapse due to using the conducting Si substrate. Furthermore, attempts for normally off GaN-FETs were examined. A hybrid metal-oxide-semiconductor HFET structure is a promising candidate for obtaining devices with a lower on-resistance (Ron) and a high breakdown voltage (Vb). [J45]

"Demonstration of a 0.48 THz Amplifier Module Using InP HEMT Transistors"

In this letter, we present an amplifier module operating at a frequency of 0.48 THz. This represents almost a 50% increase in solid-state amplifier operating frequency compared to prior state of the art, and is the highest reported amplifier to date. The amplifier demonstrates a peak gain of 11.7 dB measured in a waveguide split-block housing. Sub 50-nm InP HEMT transistors with an estimated fMAX> 1 THz are used to achieve this level of performance. The five stage amplifier is realized in coplanar waveguide, and uses monolithically integrated dipole probes to couple the chip from the WR 2.2 waveguide. [J46]

"Wide-Dynamic-Range Zero-Bias Microwave Detector Using AlGaN/GaN Heterojunction Field-Effect Diode"

An AlGaN/GaN HEMT-compatible lateral field-effect diode has been used for zero-bias microwave detector application. Using the versatile fluorine plasma ion treatment technique, we have been able to realize a diode that exhibits strong nonlinearity near zero bias, thus, eliminating DC supplies in microwave detector circuits. The AlGaN/GaN microwave detectors deliver high sensitivity, wide dynamic range and high temperature operating capability. The maximum zero-bias curvature coefficient (??) measured are 11.6 V-1and 3.2 V-1at 50??C and 250??C, respectively, yielding a directly-measured sensitivity (??v) of 1027 mV/mW at 50??C and 466 mV/mW at 250??C. The peak conjugately-matched sensitivity (??v,opt) is projected to be 9030 mV/mW at 2 GHz at 50??C. At room temperature, the wide dynamic range of 53 and 54 dB at 2 and 5 GHz are observed, respectively, both of which are the highest values reported so far. [J47]

"Broadband Time-Domain Measurement System for the Characterization of Nonlinear Microwave Devices With Memory"

This paper describes a novel fully calibrated four channel broadband time-domain measurement system for the characterization of nonlinear microwave devices with memory. The hardware architecture of the proposed time-domain measurement system is based on a wideband sub-sampling principle. The sampling heads work at a high strobe signal repetition frequency that can be tuned between 357-536 MHz. We achieve a 40-GHz RF frequency bandwidth and a 160-MHz IF bandwidth. This instrument enables the measurement of carrier and envelope waveforms at both ports of nonlinear microwave devices driven by broadband modulated multicarriers. The test-bench is applied to the cross modulation characterization of a 15-W GaN HEMT CREE S-band power amplifier with memory due to different biasing circuit configurations. The amplifier under test is driven by the sum of a large-signal modulated carrier (double-sideband amplitude modulation at 3.6 GHz) and a small single-tone signal at a 110-MHz offset frequency. Our significant contribution comes from the capability of the measurement system to record the time-domain waveforms of several nonadjacent modulated signals on a similar time equivalent scale for different cases of memory effects of the power amplifier under test. [J48]

"Pulsed-IV Pulsed-RF Cold-FET Parasitic Extraction of Biased AlGaN/GaN HEMTs Using Large Signal Network Analyzer"

A new pulsed-IVpulsed-RF cold field-effect transistor (cold-FET) technique is presented to extract the parasitics of AlGaN/GaN HEMTs under various quiescent dc-biasing points. The measurement system implemented with a large signal network analyzer applies the technique of multiple recording to acquire pulsed-RF small-signal S-parameters with no loss of dynamic range as the pulse duty cycle decreases. These cold-FET measurements are performed on unpassivated and silicon nitride (SiN) passivated devices by turning the device off for 1 ?s with a 1% duty cycle to analyze the impact of slow thermal and trapping effects on the device parasitics. The parasitic fringe capacitances extracted are found to be bias independent, except for the gate to drain capacitance in devices without SiN passivation. In unpassivated devices, the drain parasitic resistance is found to rapidly increase with increasing drain bias at negative gate to source voltages. On the contrary, in devices with SiN passivation, the dependence of the resistance with the drain bias voltage is much less significant. A simple physical model is used to fit the functional dependence of the 2-D electron gas (2DEG) concentration upon the

gate-to-source and gate-to-drain voltages, which is then proposed for fitting the measured data. The analysis indicates that the variation of the resistance with bias voltage in the device studied with SiN passivation and also for the unpassivated device at VGS=0 V is well accounted for by the reduction of the mobility with increased temperature due to self-heating, whereas for the device studied without SiN passivation, the increase of the drain resistance with drain voltages at negative gate bias principally arises from the decrease of the 2DEG population in a narrow region near the gate contact. An equivalent circuit is also introduced to explain the decrease of the source and drain parasitic inductances with increasing drain voltages at large n--egative gate bias, which is observed in unpassivated devices. [J49]

"Experimental study on effect of second-harmonic injection at input of classes F and F-1 GaN power amplifiers"

This presented study focuses on the impact of gate-source voltage waveforms on power added efficiency performances of GaN HEMTs for the design of class F and class F-1amplifiers. It is shown that second-harmonic signal injection at the gate port of transistors can lead to efficiency improvements in the case of class F operation and efficiency deteriorations in the case of class F-1operation. This work is applied to a 15 W GaN HEMT die from Cree at a fundamental frequency Fo equal to 2 GHz. Calibrated on-wafer time domain measurements are reported. [J50]

"Strained AlInN/GaN HEMTs on SiC With 2.1-A/mm Output Current and 104-GHz Cutoff Frequency"

We report on a dc/RF performance of lattice-strained AlInN/GaN high-electron mobility transistors (HEMTs) on SiC substrate. HEMT devices were fabricated with gate periphery of 2 Ч 150 μm with an 80-nm T-gate and ~2.5-μm source-drain spacing. Fabricated devices simultaneously demonstrated up to 2.11 A/mm with ft-ext= 104 GHz and ft-int= 113 GHz. The high performance is attributed to the combination of low Rsh~ 230 Ω/sq (μ ~ 1079 cm2/V · s, ns~ 2.39 Ч 1013cm-2) and thin ~110- total barrier thickness with a short gate length. Other device parameters include Rc= 0.29 Ω · mm, Ig,leak= 27.9 μA/mm, gm,peak= 432 mS/mm, and Vth= -5.8 V. To our knowledge, this is among the highest current densities reported for any HEMT operating with a unity current gain frequency exceeding 100 GHz. [J51]

"AlGaN/GaN/AlGaN DH-HEMTs Breakdown Voltage Enhancement Using Multiple Grating Field Plates (MGFPs)"

GaN-based high-electron mobility transistors with planar multiple grating field plates (MGFPs) for high-voltage operation are described. A synergy effect with additional electron channel confinement by using a heterojunction AlGaN back barrier (BB) is demonstrated. Suppression of the OFF-state subthreshold gate and drain leakage currents enables breakdown voltage enhancement over 700 V and a low ON-state resistance of 0.68 mΩ Ч cm2. Such devices have a minor tradeoff in ON-state resistance, lag factor, maximum oscillation frequency, and cutoff frequency. A systematic study of the MGFP design and the effect of Al composition in the BB is described. Physics-based device simulation results give insight into electric field distribution and charge carrier concentration, depending on the field plate design. [J52]

"Optoelectronic Mixer Based on Composite Transparent Gate InAlAs-InGaAs Metamorphic HEMTs"

In this study, sputtered indium-tin-oxide (ITO) formed ITO/Au/ITO was used to form composite transparent gate InAlAs-InGaAs metamorphic HEMTs (CTG-MHEMT), with an optoelectronic mixer significantly markedly improved front-side optical coupling efficiency. The proposed CTG-MHEMT exhibits a high responsivity (λ = 1310 nm) of 1.71 A/W under optimal bias conditions. A -3 dB electrical bandwidth of 400 MHz is produced by the photovoltaic effect and dominated by the long lifetime of the excess holes. The -3 dB electrical bandwidth associated with the photoconductive effect is 2.3 GHz, and is determined mainly by the short electron life time. A power gain cut-off frequency (fmax) of CTG-MHEMT of 18.2 GHz was achieved. This value, is much larger than that of TG-MHEMT (14.6 GHz) because Au nano particles improved the gate resistance. The optoelectronic mixing efficiency was enhanced by tuning the gate bias conditions. The CTG-MHEMT optoelectronic mixer is a cost-effective device, and based on the optical and electrical characteristics, is a promising candidate for simplifying the system architecture in fiber-optic microwave transmission applications. [J53]

"Thermal Storage of AlGaN/GaN High-Electron-Mobility Transistors"

The thermal stability and electrical characteristics of GaN high-electron-mobility transistors (HEMTs) were investigated. Storage tests were carried out at 400°C for 48 h to study the ohmic-contact stability by means of

the transmission line model. It was found that Ti/Al/Ni/Au ohmic contacts were stable and had superior thermal performance, but the Schottky contact may be more sensitive to the temperature. After thermal storage for 48 h at 400°C, the Schottky barrier height was increased, and the ideality factor decreased. Two types of isolation structures were also investigated under the same condition. DC tests were implemented to study the phenomenon and provide feedback for potential process improvements. [J54]

"Sb-HEMT: Toward 100-mV Cryogenic Electronics"

In this paper, we present a first full set of characteristics (dc, fT, fmax, and noise) of InAs/AlSb high-electron mobility transistors (HEMTs) operating under cryogenic temperature and low-power conditions. Those results are systematically compared and deeply analyzed at room temperature and 77 K. The characteristics improvement achieved at 77 K open up the possibility to develop ultralow-power cryogenic electronics (low-noise amplifier), featuring excellent high-frequency/noise performances below 100-mV dc biasing. [J55]

"Balance of power"

Researchers at TriQuint Semiconductor in the US have developed a GaN high electron mobility transistor (HEMT) on Si substrate that can deliver an X-band power performance comparable to that of a standard GaN on SiC device. It has the highest power added efficiency (PAE) ever achieved for these devices: 65 at 10 GHz, and this result makes GaN on Si technology an attractive, cost-effective solution for several military and commercial applications, such as radar and wireless communications in the S- to X-band range (2-12 GHz). [J56]

"N-Polar InAlN/AlN/GaN MIS-HEMTs"

N-polar metal-insulator-semiconductor high-electron-mobility transistors (MIS-HEMTs) were fabricated from a GaN/AlN/InAlN/GaN heterostructure grown by metalorganic chemical vapor deposition on a vicinal sapphire substrate, using Si3N4as the gate insulator. Hall measurements in van der Pauw geometry on the heterostructure showed a sheet charge density and a mobility of 2.15 Ч 1013cm-2and 1135 cm2·V-1·s-1, respectively. Resistance measurements revealed anisotropic conductivity with respect to the surface steps induced by the substrate misorientation, and the sheet resistance of the 2-D electron gas was as low as 226 Ω/□ in the parallel direction. MIS-HEMTs with a gate length of 0.7 μm and a source-drain spacing of 2.2 μm had a peak drain current of 1.47 A/mm and an on-resistance of 1.45 Ω·mm. At a drain bias of 8 V, the current- and power-gain cutoff frequencies were 14 and 25 GHz, respectively. [J57]

"Thermal resistance of AlGaN/GaN HEMTs on SopSiC composite substrate"

In this reported work, the thermal resistance of AlGaN/GaN HEMTs processed on SopSiC composite substrate is determined by electrical I-Vpulsed measurement. SopSiC substrate is based on an innovative structure with a thin Si single crystal layer transferred on top of a thick polycrystalline SiC wafer. For the first time, it is demonstrated that the thermal resistivity of such devices reaches 18.9 K mm/W when 7.5 W/mm power is dissipated, while 23.5 K mm/W are measured on silicon in the same conditions. This result shows the capabilities of composite substrates to compete with silicon for microwave power applications. [J58]

"GaN on Si HEMT with 65% power added efficiency at 10 GHz"

A 65% power added efficiency (PAE) at 10 GHz for a AlGaN/GaN high electron mobility transistor on silicon substrate is presented. This PAE is achieved with an associated output power of 6.1 W/mm and an associated gain of 13.1 dB for a 400 μm gate-width transistor biased at 40 V drain voltage. Epitaxial AlGaN/GaN layers are grown on 4-inch silicon substrate. Nitride defined 0.25 μm T-gate process, which allows formation of an integrated field plate, is used for these devices. A source-connected second field plate is also implemented to improve device performance at high operation voltage. [J59]

"GaN-Based Submicrometer HEMTs With Lattice-Matched InAlGaN Barrier Grown by MBE"

GaN-based high electron mobility transistors (HEMTs) with a nearly strain-free high-Al-content quaternary barrier and electron mobilities up to 1590 cm2/Vs have been grown on 4H-SiC using molecular beam epitaxy (MBE). The processed devices with 150-nm gate length exhibit a high dc performance with a maximum current density of 2.3 A/mm and an extrinsic transconductance up to 675 mS/mm that is among the highest values reported until now for any III-N transistor. We further present, to our knowledge, the first power measurements at 10 GHz of MBE-grown GaN HEMTs with nearly lattice-matched InAlGaN barrier achieving 47% power-added efficiency at 10 V and an output power density of 5.6 W/mm at 30-V bias. [J60]

"Design of a Highly Efficient 2-4-GHz Octave Bandwidth GaN-HEMT Power Amplifier"

In this paper, the design, implementation, and experimental results of a high-efficiency wideband GaN-HEMT power amplifier are presented. A method based on source-pull/load-pull simulation has been used to find optimum source and load impedances across the bandwidth and then used with a systematic approach to design wideband matching networks. Large-signal measurement results show that, across 1.9-4.3 GHz, 9-11-dB power gain and 57%-72% drain efficiency are obtained while the corresponding power-added efficiency (PAE) is 50%-62%. Moreover, an output power higher than 10 W is maintained over the band. Linearized modulated measurements using a 20-MHz long-term evolution signal with 11.2-dB peak-to-average ratio show an average PAE of 27% and 25%, an adjacent channel leakage ratio of -44 and -42 dBc at 2.5 and 3.5 GHz, respectively. [J61]

"Schottky-Ohmic Drain AlGaN/GaN Normally Off HEMT With Reverse Drain Blocking Capability"

In this letter, we propose an AlGaN/GaN normally off high-electron mobility transistor (HEMT) with reverse drain blocking capability. The device features a Schottky-ohmic drain electrode in which a Schottky-controlled normally off channel is inserted between the gate and the conventional ohmic drain contact. Under negative reverse drain bias, the normally off channel provides an energy barrier that effectively blocks the reverse current conduction while contributing only 0.55 V onset voltage in the forward-biased on state. In a device with a gate-drain distance of 9 m, a reverse blocking voltage of -321 V was obtained at VGS= 0 V, comparable with the forward blocking voltage of 351 V; at VGS= 3 V, the reverse blocking voltage was -276 V. The new HEMT also exhibits no degradation in drain saturation current and does not need extra photomask or process steps to fabricate. When forward biased at VGS= 3 V, the proposed device achieved a specific on resistance of 1.97 mΩ · m2. [J62]

"Scalability of Sub-100 nm InAs HEMTs on InP Substrate for Future Logic Applications"

We have experimentally studied the scaling behavior of sub-100-nm InAs high-electron mobility transistors (HEMTs) on InP substrate from the logic operation point of view. These devices have been designed for scalability and combine a thin InAlAs barrier and a thin channel containing a pure InAs subchannel. InAs HEMTs with gate length down to 40 nm exhibit excellent logic figures of merit, such as ION/IOFF= 9 Ч 104, drain-induced-barrier lowering = 80 mV/V, S = 70 mV/dec, and an estimated logic gate delay of 0.6 ps at VDS= 0.5 V. In addition, we have obtained excellent high-frequency operation with Lg= 40 nm, such as fT= 491 GHz and fmax= 402 GHz at VDS= 0.5 V. In spite of the narrow bandgap of InAs subchannel, under the studied conditions, our devices are shown not to suffer from excessive band-to-band tunneling. When benchmarked against state-of-the-art Si devices, 40-nm InAs HEMTs exhibit ION= 0.6 A/μm at ILeak= 200 nA/μm. This is about two times higher IONthan state-of-the-art high-performance 65-nm nMOSFET with comparable physical gate length and ILeak. [J63]

"An Ultra-Wideband Balun Using Multi-Metal GaAs MMIC Technology"

In this paper, we demonstrate an ultra-wideband MMIC Marchand balun that utilizes a two-layer benzocyclobutene (BCB) GaAs MMIC process with a total of 4 metal layers. This multi-metal technology is built upon a standard GaAs HEMT technology with full compatibility. The fabricated balun achieved an approximately 11:1 bandwidth from 2 to 22 GHz, with less than 3-degree maximum phase imbalance, and less than 1 dB maximum amplitude imbalance. To our knowledge, this is the largest bandwidth ratio ever reported for an MMIC Marchand balun. [J64]

"68-110-GHz-Band Low-Noise Amplifier Using Current Reuse Topology"

This paper proposes a new topology for a broadband low-noise-amplifier (LNA). A common-gate (CG) amplifier with a matching inductor composes a unit cell, and the unit cells are cascaded to increase gain. As both the input and output impedances of the unit cell are matched to 50 Ω for a wide frequency range, it is possible to increase the gain while maintaining wide bandwidth. Thus, high-gain and broadband performance can be obtained using this topology. The other features of the amplifier are its small size, low power consumption, and current reuse topology. This paper presents the design methodology of a multistage CG amplifier with a matching inductor. Fabricated in an 80-nm InP HEMT process, we developed an ultra-broadband LNA. The LNA with a three-stage CG amplifier exhibited a gain of 18 dB and a noise figure of 3.5 dB from 68 to over 110 GHz. The power consumption was 12 mW under a power supply voltage of 3 V. The chip size is 0.55 Ч 0.75 mm2. Furthermore, we developed a receiver for passive millimeter-wave imagers by integrating a six-stage LNA with a power detector. The chip size of the receiver is 1.1 Ч 0.75 mm2. The sensitivity of the pre-amplified detector was more than 2 000 V/mW from 75 to 100 GHz. These results show that the topology is one of the best candidates for high-gain and broadband LNA with small size and low power consumption. [J65]

"A 10-mW Submillimeter-Wave Solid-State Power-Amplifier Module"

In this paper, we demonstrate a packaged sub-millimeter wave solid-state power amplifier (SSPA). The SSPA is implemented in coplanar waveguide (CPW) and uses an advanced high fMAXInP HEMT transistor with a sub 50-nm gate. A monolithically integrated CPW dipole-to-waveguide transition eliminates the need for wirebonding and additional substrates. On-chip compact tandem couplers are used for power combining. The amplifier demonstrates 15-dB small-signal gain at 340 GHz. Peak saturated output power of 10 mW at 338 GHz is obtained at the waveguide flange out-put for the SSPA module. [J66]

"High Microwave-Noise Performance of AlGaN/GaN MISHEMTs on Silicon With Gate Insulator Grown by ALD"

High microwave-noise performance is realized in AlGaN/GaN metal-insulator semiconductor high-electron mobility transistors (MISHEMTs) on high-resistivity silicon substrate using atomic-layer-deposited (ALD) Al2O3as gate insulator. The ALD Al2O3/AlGaN/GaN MISHEMT with a 0.25- ??m gate length shows excellent microwave small signal and noise performance. A high current-gain cutoff frequency fTof 40 GHz and maximum oscillation frequency fmaxof 76 GHz were achieved. At 10 GHz, the device exhibits low minimum-noise figure (NFmin) of 1.0 dB together with high associate gain (Ga) of 10.5 dB and low equivalent noise resistance (Rn) of 29.2 ??. This is believed to be the first report of a 0.25-??m gate-length GaN MISHEMT on silicon with such microwave-noise performance. These results indicate that the AlGaN/GaN MISHEMT with ALD Al2O3gate insulator on high-resistivity Si substrate is suitable for microwave low-noise applications. [J67]

"Full-Wafer Characterization of AlGaN/GaN HEMTs on Free-Standing CVD Diamond Substrates"

We report on electrical characterization and uniformity measurements of the first conventionally processed AlGaN/GaN high electron mobility transistors (HEMTs) on free-standing chemical-vapor-deposited (CVD) diamond substrate wafers. DC and RF device performance is reported on HEMTs fabricated on ~ 130-??m-thick and 30-mm round CVD diamond substrates without mechanical carrying wafers. A measured fT??LGproduct of 12.5 GHz ????m is the best reported data for all GaN-on-diamond technology. X-band power performance of AlGaN/GaN HEMTs on diamond is reported to be 2.08 W/mm and 44.1% power added efficiency. This letter demonstrates the potential for GaN HEMTs to be fabricated on CVD diamond substrates utilizing contact lithography process techniques. Further optimization of the epitaxy and diamond substrate attachment process could provide for improvements in thermal spreading while preserving the electrical properties. [J68]

"AlGaN/GaN HEMTs With Low Leakage Current and High On/Off Current Ratio"

In this letter, we propose using an oxide-filled isolation structure followed by N2/H2postgate annealing to reduce the leakage current in AlGaN/GaN HEMTs. An off-state drain leakage current that is smaller than 10-9A/mm (minimum 5.1 ?? 10-10A/mm) can be achieved, and a gate leakage current in the range of 7.8 ??10-10to 9.2 ? ? 10-11A/mm (VGSfrom -10 to 0 V and VDS= 10 V) is obtained. The substantially reduced leakage current results in an excellent on/off current ratio that is up to 1.5 ?? 108. An improved flicker noise characteristic is also observed in the oxide-filled devices compared with that in the traditional mesa-isolated GaN HEMTs. [J69]

"30-GHz Low-Noise Performance of 100-nm-Gate-Recessed n-GaN/AlGaN/GaN HEMTs"

We demonstrate a 100-nm-gate-recessed n-GaN/AlGaN/GaN high-electron mobility transistor (HEMT) with low-noise properties at 30 GHz. The recessed GaN HEMT exhibits a low ohmic-contact resistance of 0.28 ????mm and a low gate leakage current of 0.9 ??A/mm when biased at VGS= -3 V and VDS= 10 V. At the same bias point, a minimum noise figure of 1.6 dB at 30 GHz and an associated gain of 5 dB were achieved. To the best of our knowledge, this is the best noise performance reported at 30 GHz for gate-recessed AlGaN/GaN HEMTs. [J70]

"Passivation of Al N /Ga N high electron mobility transistor using ozone treatment"

Ozone treatment of AlN on AlN/GaNheterostructures produces effective surface passivation and chemical resistance to the AZ positive photoresist developer used for subsequent device fabrication. The ozone-passivated AlN/GaNhigh electron mobility transistors (HEMTs) exhibited low gate leakage currents, high gate modulation voltage, and minimal drain current degradation during gate pulse measurements. With an additional oxygen plasma treatment on the gate area prior to the gate metal deposition, enhancement-mode AlN/GaNhigh electron mobility transistors were realized. The gate characteristics of the HEMTs treated with the ozone and oxygen plasma behaved in a manner similar to a metal oxide semiconductor diodelike gate current-voltage characteristic instead of a Schottky diode. Drain breakdown voltages of 23 and 43Vfor d- and e-mode HEMTs

were obtained, respectively. For d-mode HEMTs, there was no reduction in the drain current during the gate pulse measurements at frequencies of 1, 10, and 100kHz. For the e-mode HEMT, the drain current was reduced 5% at 100kHz. [J71]

"Detection of an endocrine disrupter biomarker, vitellogenin, in largemouth bass serum using AlGaN/GaN high electron mobility transistors"

Endocrine disrupters are known to have negative effects on the environment and human health. Real time detection of vitellogenin, an endocrine disrupter biomarker, was demonstrated using AlGaN/GaN high electron mobility transistors (HEMTs). Anti-vitellogenin antibodies were chemically anchored to the gold-coated gate area of the HEMT and immobilized with thioglycolic acid. The potential difference that occurs from the vitellogenin antigen-antibody interaction-induced caused a drain current change in the HEMT. The HEMT sensor was tested for vitellogenin detection both in phosphate buffer saline and largemouth bass serum. [J72]

"Design of -Band and -Band Colpitts Oscillators Using a Parasitic Cancellation Technique"

An X-band and two Ka-band monolithic microwave integrated circuit (MMIC) common drain Colpitts oscillators using a parasitic cancellation technique are designed and fabricated in a 0.2-μm GaAs pHEMT technology with a fTof 60 GHz. The parasitic cancellation technique significantly improves the negative resistance and increases the maximum operating frequency, which is suitable for microwave and millimeter-wave applications. An in-depth theoretical analysis of the Miller effect and insights in the behavior of the input impedance with the parasitic cancellation are provided. The effect of the Q-factor of the inductor used in the cancellation, and the impact of the parasitic cancellation technique on phase noise and frequency tuning range are analyzed and discussed in detail. The X-band design has a measured phase noise of -117.5 dBc/Hz at 1 MHz offset with an output power of -9.3 dBm . The first Ka-band design has a measured phase noise of -94 dBc/Hz at 1 MHz offset with an output power of +0.2 dBm. The second Ka-band design providing more flexibility has a measured phase noise of -98.5 dBc/Hz at 1 MHz offset with an output power of + 0.3 dBm. The two Ka-band designs achieve very high fOSC/fTratios and also demonstrate performance comparable to the best previously published oscillators in a similar frequency range. [J73]

"An X-Band AlGaN/GaN MMIC Receiver Front-End"

This letter presents an integrated AlGaN/GaN X-band receiver front-end. This is to the authors knowledge the first published results of an integrated AlGaN/GaN MMIC receiver front-end. The receiver uses an integrated SPDT switch to reduce size, weight and cost compared to circulator based transceiver front-ends. The integrated front-end has more than 13 dB of gain and a noise figure of 3.5 dB at 11 GHz. [J74]

"A Self-Aligned InGaAs HEMT Architecture for Logic Applications"

In this paper, we present a novel self-aligned process for future III-V logic FETs. Using this process, we have demonstrated enhancement-mode 90-nm-gate-length InGaAs HEMTs with excellent logic figures of merit. We have carried out a detailed analysis of this device architecture to determine its future scaling capabilities. We find that, as the insulator is scaled to achieve enhancement mode, the performance of the device is limited by degradation of the ION/IOFFratio due to gate leakage current. By use of TLM test structures, we have determined that the barrier resistance dominates the source resistance. We use a trilayer TLM model to predict the expected evolution of the contact resistance as it is scaled to realistic VLSI dimensions and find that the current technology results in resistance values that are two orders of magnitude higher than the desired target for sub-22-nm nodes. Using the model, we explore different options for device redesign. Both ION/IOFFand source-resistance limitations imply that the use of a high-kgate dielectric will be required for future device implementations. [J75]

"AlInN/AlN/GaN HEMT Technology on SiC With 10-W/mm and 50% PAE at 10 GHz"

High-frequency high-electron-mobility transistors (HEMTs) were fabricated on AlInN/AlN/GaN heterostructures grown by low-pressure metal-organic chemical vapor deposition on a SiC substrate. The results presented in this letter confirm the high performance that is reachable by AlInN-based technology with an output power of 10.3 W/mm and a power-added efficiency of 51% at 10 GHz with a gate length of 0.25 ??m. A good extrinsic transconductance value that is greater than 450 mS/mm and exceeding AlGaN/GaN HEMT results was also measured on these transistors. To our knowledge, these results are the best power results published on AlInN/GaN HEMTs. These good results were attributed to optimized heterostructure properties associated with low-resistance ohmic contacts and an effective passivation layer minimizing drain current slump in high-frequency operations. [J76]

"Effects of Threading Dislocations on AlGaN/GaN High-Electron Mobility Transistors"

This brief aims to show the effects of threading edge dislocations on the DC and RF performance of GaN high-electron mobility transistor (HEMT) devices. A state-of-the-art high-frequency and high-power HEMT was investigated with our full-band cellular Monte Carlo (CMC) simulator, which includes the full details of the band structure and the phonon spectra. A complete characterization of the device has been performed using experimental data to calibrate the few adjustable parameters of the simulator. Thermal simulations were also carried out with commercial software in order to operate the corrections needed to model thermal effects. The approach of Weimann based on the results of Read, Bonch-Bruevich and Glasko, and РоГ‚ВїдоГ‚Вїr was then used to model with our CMC code the dislocation effects on the transport properties of HEMT devices. Our simulations indicate that GaN HEMT performance exhibits a fairly large dependence on the density of thread dislocation defects. Furthermore, we show that a threshold concentration exists, above which a complete degradation of the device operation occurs. [J77]

"Wireless Detection System for Glucose and pH Sensing in Exhaled Breath Condensate Using AlGaN/GaN High Electron Mobility Transistors"

Peltier element cooling of ungated AlGaN/GaN high electron mobility transistors (HEMTs) is shown to be an effective method for condensing exhaled breath, enabling the measurement of the pH and glucose of the exhaled breath condensate (EBC). By comparison with standard solutions, the current change measured in the HEMTs with EBC shows that the sensitivity of the glucose detection is lower than the glucose concentration in the EBC of healthy human subjects and the pH of the condensate from the exhaled breath is within the range of 7-8, typical of that for human blood. The HEMT sensors can be integrated into a wireless data transmission system that allows for remote monitoring. Details of the transmitter and receiver design for the transmission system are given. Our work demonstrates the possibility of using AlGaN/GaN HEMTs for extended investigations of airway pathology without the need for clinical visits. [J78]

"High-Voltage High-Efficiency Ultrawideband Pulse Synthesizer"

A novel ultrawideband pulse synthesizer based on distributed amplifier topology is presented. The basic concept is to combine different delayed Gaussian pulses with both positive and negative polarities to form an UWB pulse. Compared to other ultrawideband pulse-formation methods, this method can have both high-efficiency and high-voltage output. The prototype circuit based on 0.25-??m pHEMT transistors is fabricated, and the fabricated pulse synthesizer consumes only 1-mA current under 5-V power supply with high energy efficiency of 10.1% at 10-MHz pulse repetition frequency (PRF). Measurement results show that with 1.5 -V amplitude and 240-ps Gaussian input pulse, the output pulse of the designed UWB pulse synthesizer is centered at 4 GHz with 4.5-V peak to peak amplitude (into 50-ohms load) and 1.0-ns duration at 50% of the peak pulse envelope. [J79]

"High-Power Ka-Band Performance of AlInN/GaN HEMT With 9.8-nm-Thin Barrier"

We report the first CW Ka-band radio-frequency (RF) power measurements at 35 GHz from a passivated Al0.82In0.18N/GaN high-electron mobility transistor on SiC with 9.8-nm-thin barrier. This device delivered a maximum of 5.8 W/mm with a power-added efficiency of 43.6% biased at VDS= 20 V and 10% IDSSwhen matched for power at CW. The device was grown by metal-organic chemical vapor deposition with 2.8-??m source-drain spacing and a gate length of 160 nm. An excellent ohmic contact was obtained with an Rcof 0.62 ? ???mm. The maximum extrinsic transconductance was 354 mS/mm with an IDSSof 1197 mA/mm at a VGSof 0 V, an ft of 79 GHz, and an fmaxof 113.8 GHz. [J80]

"Electrothermal Monte Carlo Simulation of GaN HEMTs Including Electron-Electron Interactions"

A Monte Carlo device simulator was developed to investigate the electronic transport properties in AlGaN/GaN high-electron mobility transistors (HEMTs). Electron-electron interactions were included using a particle-particle-particle-mesh coupling scheme. Quantum corrections were applied to the heterointerface using the effective potential approach due to Ferry. Thermal effects were also included by coupling the particle-based device simulator self-consistently with an energy balance solver for the acoustic and optical phonons. The electrothermal device simulator was used to observe the temperature profiles across the device. Hot spots or regions of higher temperatures were found along the channel in the gate-drain spacing. Results from electrothermal simulations show self-heating degradation of performance at high source-drain bias. More importantly, the observed nonequilibrium phonon effects may play an important role in determining the thermal distribution in these HEMTs, resulting in reliability issues such as current collapse. [J81]

"100-nm-Gate (Al,In)N/GaN HEMTs Grown on SiC With"

One-hundred-nanometer-gate (Al,In)N/GaN high-electron-mobility transistors (HEMTs) grown on semi-insulating SiC achieve a maximum current density of 1.84 A/mm at VGS= 0 V, an extrinsic transconductance of 480 mS/mm, and a peak current gain cutoff frequency as high as fT= 144 GHz, which is the highest so far reported for any (Al,In)N/GaN-based HEMT. This fTmatches the best published values that we could find for 100-nm-gate (Al,Ga)N/GaN HEMTs, thus closing the cutoff frequency gap between (Al,In)N/GaN and (Al,Ga)N/GaN HEMTs. Additionally, similar devices grown on (111) high-resistivity silicon show a peak fTof 113 GHz, also setting a new performance benchmark for (Al,In)N/GaN HEMTs on silicon. Our findings indicate significant performance advantages for (Al,In)N/GaN HEMTs fabricated on SiC substrates. The improved performance for devices grown on SiC is derived from the superior transport properties of (Al,In)N/GaN 2DEGs grown on that substrate. [J82]

"Surface passivation of aln/gan mos-hemts using ultra-thin al2 o3 formed by thermal oxidation of evaporated aluminium"

A simple method is reported for fabrication of AlN/GaN MOS-HEMTs. Ultra-thin Al2O3, which is formed using thermal oxidation of evaporated Al, was used for surface passivation and as a gate dielectric. Prior to formation of Al2O3, the Al protects the very sensitive AlN epilayer from exposure to processing liquid chemicals. Fabricated two-finger AlN/GaN MOS-HEMTs with 3 m gate length and 200 m gate width showed good gate control of drain currents up to a gate bias of 3 V and achieved a maximum drain current, IDSmax, of ~900~mA/mm. The peak extrinsic transconductance, Gmax, of the device is ~100~mS/mm at VDS= 8=V. Capacitance-voltage (C-V) characteristics of Al2O3/AlN/GaN circular test MOS structures were observed and measured. They exhibited no hysteresis, indicating the good quality of the thermally grown Al2O3for realising AlN/GaN MOS-HEMTs for high power and high frequency applications. [J83]

"AlGaN/GaN HEMT on (111) single crystalline diamond"

AlGaN/GaN HEMTs have been fabricated directly on (111) oriented single crystal diamond with 1.3 Гґ—1013cm-2channel sheet charge density and 731 cm2/Vs mobility. 0.2 Г‚їm gate length devices showed 0.73 A/mm maximum drain current density and fTand fmaxcutoff frequencies of 21 and 42 GHz. [J84]

"107-GHz (Al,Ga)N/GaN HEMTs on Silicon With Improved Maximum Oscillation Frequencies"

We report high-speed fully passivated deep submicrometer (Al,Ga)N/GaN high-electron mobility transistors (HEMTs) grown on (111) high-resistivity silicon with current gain cutoff frequencies of as high as fT= 107 GHz and maximum oscillation frequencies reaching fMAX= 150 GHz. Together, these are the highest fTand fMAXvalues achieved for GaN-based HEMTs implemented on silicon substrates to date. The performance reported here is competitive with recently published results for similar geometry high-performance passivated HEMTs on semi-insulating silicon-carbide substrates. [J85]

"On the Recovery Time of Highly Robust Low-Noise Amplifiers"

Recently, GaN-based low-noise amplifiers (LNAs) were shown to provide high ruggedness together with low noise figure. Since no limiter is required to protect the input, these LNAs allow for simplified receiver architectures. This paper presents an in-depth analysis of the recovery time of a highly rugged LNA. Recovery time is measured in the time domain, and an analytical approximation is developed that allows to estimate and optimize recovery. A new measurement setup is established in order to determine the impact of the overdrive pulse on LNA gain. An X-band LNA is shown as an example. It survives input overdrive powers of up to 46 dBm under pulsed and 40 dBm under continuous wave conditions, with a noise figure of 2.8 dB. Extremely short recovery times below were simulated and measured. [J86]

"Integrated Voltage Reference Generator for GaN Smart Power Chip Technology"

GaN smart power chip technology has been realized using a GaN-on-Si HEMT platform, featuring monolithically integrated high-voltage power devices and low-voltage peripheral devices for mixed-signal functional blocks. In particular, this brief presents the imperative analog functional block-voltage reference generator for smart power applications with wide-temperature-range stability. The circuit is capable of proper functions within a wide temperature range from room temperature up to 250Г‚В°C, illustrating the unique advantage of the wide-bandgap GaN in high-temperature operation. The voltage reference generator was designed with an AlGaN/GaN HEMT and Schottky diodes, and the devices were operated in the subthreshold regime to obtain low power consumption. The voltage reference generator achieved an average drift of less than 0.5 mV/Г‚В°C and can be used as a reference voltage in various biasing and sensing circuits. [J87]

"Schottky-Drain Technology for AlGaN/GaN High-Electron Mobility Transistors"

In this letter, we demonstrate 27% improvement in the buffer breakdown voltage of AlGaN/GaN high-electron mobility transistors (HEMTs) grown on Si substrate by using a new Schottky-drain contact technology. Schottky-drain AlGaN/GaN HEMTs with a total 2-??m-thick GaN buffer showed a three-terminal breakdown voltage of more than 700 V, while conventional AlGaN/GaN HEMTs of the same geometry showed a maximum breakdown voltage below 600 V. The improvement of the breakdown voltage has been associated with the planar contact morphology and lack of metal spikes in the Schottky-drain metallization. [J88]

"Low-Noise Amplifier at 2.45 GHz [JTC Contests]"

An LNA with 15 K noise at 2.45 GHz working at ambient temperature has been developed using the GaAs metamorphic HEMT iT8002D manufactured by GigOptix. Unfortunately, this transistor has been discontinued. We replaced iT8002D by the FHX45X, general purpose GaAs SuperHEMT manufactured by Eudyna in the same circuit. FHX45X has the same gate width of 280 um. The measured S parameters were quite similar to the original LNA. The noise was increased to about 18 K at 2.45 GHz. We feel that FHX45X can be used as a replacement for the iT8002D. Based on the results of this LNA, we are developing a wideband (0.54 GHz) LNA that will work at ambient temperatures as well as cryogenic temperatures for radio astronomy applications. [J89]

"On-State and Off-State Breakdown Voltages in GaAs PHEMTs With Various Field-Plate and Gate-Recess Extension Structures"

GaAs pseudomorphic high-electron mobility transistors (PHEMTs) with various field-plate (FP) and gate-recess (GR) extensions were fabricated. Their on-state resistance (Ron), breakdown voltage, flicker noise, and microwave characteristics were investigated. The FP length and GR width extensions can be controlled to improve significantly the breakdown voltage of PHEMTs. The design-of-experiment approach was employed with 16 transistors. The FP length extension was found to improve efficiently the off-state breakdown voltage (BVoff) because of its suppression of the thermionic-field emission of gate electrons. However, an FP-induced depletion region cannot easily suppress channel impact ionization, which dominates the on-state breakdown voltage (BVon). Additionally, the FP length extension reduces the flicker noise of a device that is caused by surface states. The GR width extension has an opposite effect, because the exposed area of the uncap Schottky layer exposure increases with the GR width. [J90]

"Chloride ion detection by InN gated Al Ga N /Ga N high electron mobility transistors"

Real time chloride ion detection using InN gated AlGaN/GaNhigh electron mobility transistors (HEMTs) was demonstrated. The InN thin film on the gate area of the HEMT provided fixed surface sites for reversible anion coordination. The drain current of the HEMT sensor exhibited increased a function of chloride ion concentration. The positive ions (Na+, Mg+2, and H+) in the chloride ion solutions showed no effect on the chloride ion concentration detection. The sensor was tested over a range of chloride ion concentrations from 100nMto100mcm. The chloride ion HEMT sensors can be integrated with AlGaN/GaNHEMT based pHand glucose sensors for exhaled breath condensate glucose monitoring technology. The HEMT based sensor can also be integrated into a wireless data transmission system for remote sensing applications. [J91]

"AlGaN/GaN HEMT With 300-GHz"

We report on a gate-recessed AlGaN/GaN high-electron mobility transistor (HEMT) on a SiC substrate with a record power-gain cutoff frequency (fmax). To achieve this high fmax, we combined a low-damage gate-recess technology, scaled device geometry, and recessed source/drain ohmic contacts to simultaneously enable minimum short-channel effects (i.e., high output resistance Rds) and very low parasitic resistances. A 60-nm-gate-length HEMT with recessed AlGaN barrier exhibited excellent Rdsof 95.7 ????mm, Ronof 1.1 ~ 1.2 ?? ?? mm, and fmaxof 300 GHz, with a breakdown voltage of ~ 20 V. To the authors' knowledge, the obtained fmaxis the highest reported to date for any nitride transistor. The accuracy of the fmaxvalue is verified by small signal modeling based on carefully extracted S-parameters. [J92]

"Enhancement-Mode GaN MIS-HEMTs With n-GaN/i-AlN/n-GaN Triple Cap Layer and High- Gate Dielectrics"

This letter presents details of high-performance enhancement-mode GaN MIS high-electron-mobility transistor (MIS-HEMT) devices. Devices with an n-GaN/i-AlN/n-GaN triple cap layer, a recessed-gate structure, and high-kgate dielectrics show high drain current and complete enhancement-mode operation. The maximum drain current and threshold voltage (Vth) are 800 mA/mm and +3 V, respectively. These results indicate that a recessed AlGaN/GaN MIS-HEMT with the triple cap could be a promising new technology for future device applications. [J93]

"HFinFET: A Scalable, High Performance, Low Leakage Hybrid n-Channel FET"

In this letter, we propose the design and simulation study of a novel transistor, called HFinFET, which is a hybrid of an HEMT and a FinFET, to obtain excellent performance and good off-state control. Followed by the description of the design, 3-D device simulation has been performed to predict the characteristics of the device. The device has been benchmarked against published state of the art HEMT as well as planar and nonplanar Si n-MOSFET data of comparable gate length using standard benchmarking techniques. [J94]

"Temperature dependence of plasmonic terahertz absorption in grating-gate gallium-nitride transistor structures"

Strong plasmon resonances have been observed in the terahertz transmission spectra (1-5 THz) of large-area slit-grating-gate AlGaN/GaN-based high-electron-mobility transistor (HEMT) structures at temperatures from 10 to 170 K. The resonance frequencies correspond to the excitation of plasmons with wave vectors equal to the reciprocal lattice vectors of the metal grating, which serves both as a gate electrode for the HEMT and a coupler between plasmons and incident terahertz radiation. Wide tunability of the resonances by the applied gate voltage demonstrates potential of these devices for terahertz applications. [J95]

"Process and Contamination Effects on the Single-Event Response of AlSb/InAs HEMTs"

We investigate the dependence of the single-event response of AlSb/InAs HEMTs on details of the doping, layer thicknesses, and contamination levels. The transconductance depends on the Δ-doping and layer thickness, which are shown to have the maximum impact on charge collection when the device is biased near the pinch-off voltage. In the on condition (near zero gate bias), the effect is minimal. The possible role of carbon contamination near the substrate-buffer heterointerface in reducing some of the longer transients is discussed. [J96]

"An Ultra-Low-Power MMIC Amplifier Using 50-nm -Doped Metamorphic HEMT"

An ultra-low-power monolithic amplifier using 50-nm gate-length GaAs metamorphic high-electron-mobility transistor (MHEMT) has been designed and fabricated by a coplanar waveguide monolithic microwave integrated circuit process. A double (5-doped In0.52Al0.48As/In0.53Ga0.47As MHEMT technology with optimal doping profiles was used to achieve both ultra-low dc power consumption and good dynamic-range performance. The single-stage amplifier operates in the 24-GHz band and shows typical gain of 7.2 dB, ±0.5 dB bandwidth of 1.2 GHz, return losses better than 9 dB, and input IP3(IIP3) of +3 dBm while consuming only 0.9 mW of dc power. These experimental results demonstrate the outstanding potential of MHEMT technology for ultra-low-power applications such as wireless sensor networks. [J97]

"Effects of Short-Term DC-Bias-Induced Stress on n-GaN/AlGaN/GaN MOSHEMTs With Liquid-Phase-Deposited as a Gate Dielectric"

This paper presents a comparative study of the degradation of dc characteristics and drain current collapse under dc-bias stress in passivated metal-oxide-semiconductor high-electron mobility transistor (MOSHEMT), unpassivated HEMT, and passivated HEMT devices. The Al2O3oxide thin film that is used as a gate dielectric and a passivation layer in MOSHEMTs is prepared by a simple, low-cost, and low-temperature liquid-phase deposition (LPD) technique. All devices are subjected to short-term dc-bias stress to investigate the reliability of the oxide and its passivation effect. In the case of MOSHEMTs and passivated HEMTs, the gradual reduction in drain current is found within 20-h drain-bias stress, which is apparently caused by the hot-electron injection and trapping in the buffer, and a barrier layer that is operated at a high drain voltage. However, faster degradation is found in unpassivated HEMTs, and some devices are permanently damaged due to the degradation of unpassivated surface states. Nonetheless, the current is partially recovered for all devices after gate stress, and no damage to the MOSHEMTs is observed. Therefore, it is believed that the Al2O3thin film that is prepared through the LPD technique is effective as a gate dielectric and as a surface passivation layer in reducing device degradation during dc-bias stress and in diminishing the current collapse effect in MOSHEMTs. [J98]

"Gate-Recessed Enhancement-Mode InAlN/AlN/GaN HEMTs With 1.9-A/mm Drain Current Density and 800-mS/mm Transconductance"

Having a drain current density of 1.9 A/mm, a peak extrinsic transconductance of 800 mS/mm (the highest reported in III-nitride transistors), ft/fmaxof 70/105 GHz, and Vbrof 29 V, 150-nm-gate enhancement-mode InAlN/AlN/GaN high-electron-mobility transistors are demonstrated on SiC substrates using plasma-based gate-recess etch. The possible plasma-induced damage in the gate region was investigated using interface-trap

states extracted from temperature-dependent subthreshold slopes. [J99]

"AlGaN/GaN Microwave Switch With Hybrid Slow and Fast Gate Design"

We present a novel approach to reduce the off-state capacitance of microwave transistor switches. The new design includes a "slow gate" layer, which allows for complete depletion of the channel in the source-drain region, thus reducing the gate-channel capacitance. Due to very high impedance at high frequencies, the "slow gate" shunting effect and its own capacitance contributions are negligibly small. This novel approach is validated by demonstrating an AlGaN/GaN single-pole double-throw switch with the "slow gate" layer formed by InGaN film. The new gate design decreases the insertion loss of the fabricated switch by approximately 0.5 dB and increases the isolation by approximately 5 dB. [J100]

"Design of Highly Efficient Load Modulation Transmitter for Wideband Cellular Applications"

In this paper, the high potential of varactor-based dynamic load modulation (DLM) techniques for wideband cellular applications is demonstrated. A systematic design procedure is proposed to ensure high-efficiency wideband performance. It incorporates harmonically tuned power amplifier (PA) concepts and tunable matching techniques in an integrated design. A DLM transmitter at 2.65 GHz with a peak output power of 6 W is designed using the proposed procedure. In order to investigate the wideband performance of the implemented demonstrator, WCDMA signals with scaled bandwidths are employed. The signal peak-to-average ratio is 7 dB and the same for all the experiments. For the 38.4-MHz signal, which has a corresponding channel bandwidth of > 40 MHz, an average power added-efficiency (PAE) of 44%, normalized mean square error (NMSE) of -35 dB, and adjacent channel leakage ratio (ACLR) of -43 dBc are measured. [J101]

"Comparison of N- and Ga-Face GaN HEMTs Through Cellular Monte Carlo Simulations"

We compare the performance of GaN HEMT devices based on the established Ga-face technology and the emerging N-face technology. Starting from a state-of-the-art N-face device, we obtain the analogous Ga-face layout imposing the constraint of the same channel charge in both structures, and then, we simulate both the configurations with our full-band cellular Monte Carlo simulator, which includes the full details of the band structure and the phonon spectra. Moreover, we define a modeling approach based on gate-to-2-D electron gas distance and capacitance discussions, which allows a fair comparison between the N- and Ga-face technologies. Full direct current and RF simulations were performed and compared with available experimental data for the N-face device in order to calibrate the few adjustable simulator parameters. Our simulations indicate that N-face GaN HEMTs exhibit improved RF performance with respect to Ga-face devices. Furthermore, the use of an AlN layer in N-face devices results in a reduced alloy scattering and offers a strong back-barrier electron confinement to mitigate short-channel effects, thus improving the cutoff frequency for highly scaled devices. [J102]

"Self-consistent analysis of AlSb/InAs high electron mobility transistor structures"

The influences of channel layer width, spacer layer width, and delta -doping density on the electron density and its distribution in the AlSb/InAs high electron mobility transistors (HEMTs) have been studied based on the self-consistent calculation of the Schrodinger and Poisson equations with both the strain and nonparabolicity effects being taken into account. The results show that, having little influence on the total two dimensional electron gas (2DEG) concentration in the channel, the HEMT's channel layer width has some influence on the electron mobility, with a channel as narrow as 100-130 E being more beneficial. For the AlSb/InAs HEMT with a Tedelta -doped layer, the 2DEG concentration as high as 9.1Ч1012cm-2can be achieved in the channel by enhancing the delta -doping concentration without the occurrence of the parallel conduction. When utilizing a Sidelta -doped InAs layer as the electron-supplying layer of the AlSb/InAs HEMT, the effect of the InAs donor layer thickness is studied on the 2DEG concentration. To obtain a higher 2DEG concentration in the channel, it is necessary to use an InAs donor layer as thin as 4 monolayer. To test the validity of our calculation, we have compared our theoretical results (2DEG concentration and its distribution in different sub-bands of the channel) with the experimental ones done by other groups and show that our theoretical calculation is consistent with the experimental results. [J103]

"The role of ultrathin AlN barrier in the reduction in the hot electron and self-heating effects for GaN-based double-heterojunction high electron mobility transistors"

We propose an AlN/GaN/InGaN/GaN double-heterojunction high electron mobility transistor (DH-HEMT) structure with a 4 nm thin AlN barrier layer. The performance of the DH-HEMT device is investigated by using two-dimensional numerical simulation. The conduction band profile is obtained by using the Poisson's equation and Fermi-Dirac statistics in combination with the polarization charges. Due to large conduction-band offset of

the AlN/GaN interface and strong polarization of AlN, the minor channel at GaN/InGaN interface can be eliminated. Further, the hot electron and self-heating effects on the transport properties of this DH-HEMT are investigated by using hydrodynamic model. In comparison with the AlGaN barrier DH-HEMT and conventional HEMT, this kind of DH-HEMT can effectively reduce the hot electron effect under high voltage. The reason is that the maximum field strength is far below the critical value for the existence of the hot electron effect in the AlGaN barrier DH-HEMTs and conventional HEMTs with the same voltage 6 V. The simulation results also show that the ultrathin AlN barrier layer can significantly reduce thermal impedance, and then lower the self-heating effect. Furthermore, the passivation layer has significant role in the self-heating effect of the ultrathin barrier DH-HEMTs. [J104]

"Extensive analysis of the luminescence properties of AlGaN/GaN high electron mobility transistors"

This paper reports on an extensive analysis of the electroluminescence spectra of GaN-based high-electron mobility transistors (HEMT) submitted to different bias regimes. The results described within this paper indicate that: (i) under ON-state bias conditions, HEMT can emit a weak luminescence signal, localized at the edge of the gate toward the drain side; (ii) for low drain voltage levels, the electroluminescence spectrum has a Maxwellian shape, which is typical for hot carrier luminescence; (iii) for high drain voltage levels, parasitic emission bands are generated, possibly due to the recombination of hot electrons through defect-related sites. Electroluminescence data are compared with results of cathodoluminescence measurements, to provide an interpretation for the experimental results. [J105]

"Proton irradiation effects on AlN/GaN high electron mobility transistors"

AlN/GaN high electron mobility transistors (HEMTs) were irradiated with 5 MeV protons at fluences from 2Ч1011to 2Ч1015protons/cm2. Changes from 10% to 35% of the saturation drain current and the source-drain resistances were observed for the HEMTs exposed to the proton irradiations due to radiation-induced carrier scattering and carrier removal. Both forward and reverse bias gate currents were increased after proton irradiation and affected the drain current modulation in the positive gate bias voltage range. There was almost no gate-lag observed for the HEMT exposed to 2Ч1011protons/cm2irradiation and minimal changes for the higher doses, which implied that few surface traps were created by the high energy proton irradiation. [J106]

"AlGaN/GaN MOS-HEMTs With Gate ZnO Dielectric Layer"

The vapor cooling condensation system is used to grow ZnO insulator films of low carrier concentration and high resistivity as the gate dielectrics for AlGaN/GaN metal-oxide-semiconductor high-electron-mobility transistors (MOS-HEMTs). The saturation drain-source current and the maximum extrinsic transconductance are measured as 0.61 A/mm and 153 mS/mm, respectively. The gate leakage currents, determined with the forward gate bias of VGS= 3.5 V and the reverse gate bias of VGS= -12 V, applied are 1.21 Ч 10-4A/mm and 7.16 Ч 10-6A/mm, respectively. The unit gain cutoff frequency and maximum frequency of the oscillation are also measured as 7.2 and 11.5 GHz, respectively. The low-frequency noise obtained is well fitted with a 1/f function in the linear region. Hooge's coefficient α is extracted as 9.74 Ч 10-5when the MOS-HEMTs operate at 100 Hz and VGS= -4 V . The current recoveries of the gate and drain lags are determined to be 61% and 47% for the MOS-HEMTs, respectively. [J107]

"Aspect Ratio Impact on RF and DC Performance of State-of-the-Art Short-Channel GaN and InGaAs HEMTs"

We report a comparison between state-of-the-art GaN and InGaAs HEMTs in terms of the minimum aspect ratio required to limit short-channel effects. DC and RF simulations were carried out through our full-band cellular Monte Carlo simulator, which includes the full details of the band structure and the phonon spectra. Our results indicate that the minimum aspect ratio for GaN devices is 15 for negligible short-channel effects and 10 for reduced short-channel effects. On the other hand, InGaAs devices perform well for lower aspect ratio values such as 7.5 and 4-5 for negligible and reduced effects, respectively. The origin of this difference between GaN and InGaAs HEMTs is believed to be related to the different dielectric constants of the two materials and the corresponding difference in the electric field distributions related to short-channel effects. [J108]

"MMIC LNAs for Radioastronomy Applications Using Advanced Industrial 70 nm Metamorphic Technology"

Radioastronomy applications, as well as others, require ultra-low-noise front ends for high-sensitivity receivers. In this way, the image produced from a radio-telescope using such advanced components has a higher

resolution and therefore allows scientists to obtain a clearer representation of the environment. The low-noise amplifier is the key component of a high sensitivity receiver (demonstrating a very low noise figure, even in the millimeter-wave frequency region). Such electrical performance is obtained from the combined use of an advanced technology (fTand fmax> 250 GHz, LG<; 0, 1 μm) and appropriate design methodologies that take into account electrical specifications and system constraints in the context of the targeted application. In this contribution, we will present both the performance of the employed technology (OMMIC 70 nm GaAs mHEMT) and the related low-noise design methodologies that have led to the realization of four different LNAs operating from 5 GHz up to 100 GHz and beyond. [J109]

"Novel Energy-Dependent Effects Revealed in GeV Heavy-Ion-Induced Transient Measurements of Antimony-Based III-V HEMTs"

High-bandwidth (16 GHz) time-resolved charge-collection measurements for heavy-ion irradiation of up to 70 GeV/amu are performed on low-power 6.1 lattice spacing InAlSb/InAs HEMT devices. Event cross sections are measured to be significantly larger than the active areas of the devices. Novel energy-dependent effects are observed. [J110]

"Linearity enhanced 2.4 GHz WLAN HBT power amplifier using digitally-controlled tunable output matching network with pHEMT switch in GaAs BiFET technology"

Presented is the linearity improvement technique of a power amplifier (PA) using a digitally-controlled tunable output matching network implemented in GaAs BiFET technology. The load impedance of the heterojunction bipolar transistor (HBT) power device in the last stage of the PA is adjustable in terms of output power levels by a metal-insulator-metal (MIM) capacitor array with pHEMT switches in the output matching network. A 2.4 GHz two-stage PA for IEEE 802.11g, Wireless Local Area Network (WLAN) application, is implemented to demonstrate the technique. Not only is the maximum linear output power of the PA increased by 2.5 dB, but the linearity is also improved by 4 dB at the output power of 15 dBm for the error vector magnitude specification of 28 dB. [J111]

"GaN HEMT PA with over 84% power added efficiency"

Described are the design procedure and measured performance of a PA targeted for the W-CDMA downlink band exhibiting over 84% PAE at 2.14%GHz. The PA is designed with an uncharacterised GaN HEMT. A measurement-based design approach is used to optimise the source and load impedance at the fundamental frequency with class-F-1harmonic terminations enforced. S-parameters extracted from a full-wave EM model characterising the impedance transformation from the virtual drain of the GaN HEMT to an output matching circuit are used to design class-F-1second- and third-harmonic terminations. The highest efficiency for the final PA occurred 10 MHz off the design frequency, exhibiting 84.9 PAE, 8.2 W output power and 18.4 dB of gain at 2.15 GHz. [J112]

"High-current-density high-voltage normally-off AlGaN/GaN hybrid-gate HEMT with low on-resistance"

A high-voltage normally-off AlGaN/GaN hybrid-gate HEMT (HG-HEMT) with high current-density and low on-resistance on Si substrate is fabricated. The proposed device features a hybrid-gate consisting of a short E-mode gate and a long D-mode gate. In the off-state, the short E-mode gate confirms the normally-off operation, while the D-mode gate can clamp the channel potential at a low drain voltage, which delivers high blocking capability. In the on-state, the short E-mode channel and the D-mode channel providing lower channel resistance facilitate high on-current or low on-resistance. Therefore, the HG-HEMT achieves a high breakdown voltage and low on-resistance simultaneously. Compared with the conventional device, the HG-HEMT is shown to deliver comparable breakdown voltage while featuring 62% lower on-resistance. [J113]

"Computation of the phase and amplitude noise in microwave oscillators and a simplified calculation method for far enough from the carrier offsets"

New results regarding phase and amplitude noise analysis in microwave oscillators for moderate offset frequencies from the carrier are presented. Although the phase noise process in an oscillator is a large signal non-stationary process, it is proved that for the purpose of phase noise calculations for moderate offset frequencies, the phase noise process can be considered as a small signal stationary process and by this assumption, a valid approximation of the phase noise spectrum at these offset frequencies is obtained. By this consideration, a simplified approach for the purpose of the phase and amplitude noise spectrum calculations, at far enough from the carrier offset frequencies, by avoiding the numerical ill-conditioning of the harmonic balance

equations, is presented. Owing to the presence of the common phase process in the circuit variables, for the practical resolution of the noise relations, it is necessary to introduce an extra constraint on the phase or the amplitude process. Here, it is theoretically proved that this constraint will not change the total noise spectrum of the oscillator. Another form of conversion matrix analysis is presented and the cause of error in the computation of the phase noise at offset frequencies near to the carrier is investigated. The theoretically verified characteristics of phase and amplitude noise analysis methods have been observed in a P-HEMT oscillator at 10.23 GHz. [J114]

"Growth and characterization of iron-doped semi-insulating InP buffer layers for Al-free GaInP/GaInAs high electron mobility transistors"

We characterize the resistivity of InP buffer layers deposited by metal-organic vapor-phase epitaxy for the fabrication of Al-free GaInP/GaInAs high electron mobility transistors (HEMTs). Achieving highly-resistive InP buffer layers on semi-insulating (SI) InP:Fe substrates has long been recognized to be challenging. This is particularly true in HEMT applications because such devices are especially sensitive to the deleterious effects of buffer leakage currents. Our experiments show that impurities arising from the SI InP substrate as well as from reactor parts produce an overall n-type doping concentration of n=1-10Ч1016cm-3near the buffer/substrate interface, which decays exponentially to a level of 4Ч1014cm-3after approximately 1mcmof InP growth. This nonintentional impurity incorporation leads to a parasitic channel in the buffer and a current leakage path for the HEMT structures, regardless of the growth conditions used. Highly-insulating buffer layers could however be obtained with InP doped by Fe at a concentration of 6Ч1016cm-3in a thin region near the InP:Fe substrate. The sheet resistance consequently increased from RS=3 000Omega / for the not intentionally doped InP layers to RS=9.4Ч107Omega / when Fe-doping is used in the buffer layers, a value suitable for the realization of high-speed HEMTs. As a demonstration vehicle, Al-free pseudomorphic T-gate GaInP/GaInAs HEMTs with a 100 nm footprint were fabricated and achieved a cutoff frequency of fT=fMAX"--3c;250GHzbased on a still nonoptimized channel structure featuring a mobility and sheet carrier concentration of 10 000cm2/V sand 1012cm-2, respectively. The present work differentiates itself from previous Fe doping studies of InP by clarifying and quantifying the physical processes leading to parasitic conduction in not intentionally doped InP buffer layers grown on InP:Fe substrates. [J115]

"X-band high-power HEMT SPDT switch with selectively anodised aluminium substrate"

A high-power HEMT single-pole double-throw (SPDT) switch is introduced, based on a multichip module structure with a selectively anodised aluminium substrate. The proposed high-power SPDT switch uses thick anodised aluminium (Al2O3) layers and bare high-power HEMTs directly mounted on an aluminium substrate for an effective heatsink and high electrical isolation. A 4.4 Ч 3.1 mm compact highpower SPDT switch for X-band phased array applications is demonstrated. The fabricated X-band SPDT switch has a measured insertion loss of less than 1.3 dB and an isolation of 20.3 dB. In particular, the X-band switch exhibits an on-state power-handling capability that exceeds 35.5 dBm at a compression point of 1 dB. The experimental results suggest that the developed hybrid IC technology, which is based on selectively anodised aluminium, can be applied to high-power X-band SPDT switch applications. [J116]

"Investigation of a Class-J Power Amplifier With a Nonlinear for Optimized Operation"

This paper presents the operation principle of Class-J power amplifiers (PAs) with linear and nonlinear output capacitors (Couts). The efficiency of a Class-J amplifier is enhanced by the nonlinear capacitance because of the harmonic generation from the nonlinear Cout, especially the second-harmonic voltage component. This harmonic voltage allows the reduction of the phase difference between the fundamental voltage and current components from 45° to less than 45° while maintaining a half-sinusoidal shape. Therefore, a Class-J amplifier with the nonlinear Coutcan deliver larger output power and higher efficiency than with a linear Cout. As a further optimized structure of the Class-J amplifier, the saturated PA, a recently-reported amplifier in our group, is presented. The phase difference of the proposed PA is zero. Like the Class-J amplifier, the PA uses a nonlinear Coutto shape the voltage waveform with a purely resistive fundamental load impedance at the current source, which enhances the output power and efficiency. The PA is favorably compared to the Class-J amplifier in terms of the waveform, load impedance, output power, and efficiency. These operations are described using both the ideal and real models of the transistor in Agilent Advanced Design System. A highly efficient amplifier based on the saturated PA is designed by using a Cree GaN HEMT CGH40010 device at 2.14 GHz. It provides a power-added efficiency of 77.3% at a saturated power of 40.6 dBm (11.5 W). [J117]

"Parasitic Compensation Design Technique for a C-Band GaN HEMT Class-F Amplifier"

A class-F/inverse class-F load circuit design method that includes parasitic elements such as drain-source

capacitance and bonding wire inductance has been developed. For the class-F load circuit design, a reactance function which has zeros at even harmonic frequencies and poles at odd harmonic frequencies is expanded to an -ladder circuit including parasitic elements through the use of the second Cauer canonical form. For the inverse class-F load circuit design, the zero points and the poles are exchanged. One stage of the -ladder circuit can be approximately replaced to a distributed circuit element for higher frequency operation. The proposed method allows parasitic compensation up to an arbitrary harmonic order by adding zeros and poles. Additionally, if distributed circuit elements are used, the method also compensates frequency dispersive characteristics of microstrip lines. According to the proposed method, a class-F amplifier using an AlGaN-GaN HEMT has been fabricated at 5.8 GHz. The fabricated class-F amplifier delivered high efficiency characteristics, with a maximum drain efficiency of 79.9%, a maximum power-added efficiency (PAE) of 71.4%, and an output power of up to 33.4 dBm at 5.86 GHz. [J118]

"Analysis of terahertz plasma resonances in structures with two-dimensional electron systems periodically modulated by interdigitated gate"

Simple analytical model is developed to evaluate spatial distribution of sheet electron density in the channel of the high-electron mobility transistor (HEMT)-like structure periodically modulated by the bias voltages applied to interdigitated gate. Resonant frequencies of plasma oscillations excited in the two-dimensional electron gas (2DEG) channel of such structures are evaluated in the ideal and realistic situations. The realistic model accounts for the ungated regions which due to nonideality of gate contact-2DEG channel system can be also affected by the gate bias voltages. It is shown that plasma resonances in realistic structures with fringed ungated regions deviate from those predicted by the ideal model. The model developed can be used to interpret the terahertz plasmon spectra measured experimentally. [J119]

"Benchmarking of Thermal Boundary Resistance in AlGaN/GaN HEMTs on SiC Substrates: Implications of the Nucleation Layer Microstructure"

A thermal boundary resistance (TBR) is associated with the presence of an AlN nucleation layer (NL) in AlGaN/GaN high-electron-mobility transistors (HEMTs) grown on SiC substrates, raising device temperature beyond what is expected from the simple thermal conductivities of the main device layers. TBR was found to differ by up to a factor of four between different device suppliers, all using standard metal-organic chemical vapor deposition (MOCVD) growth techniques, related to the detailed NL microstructure. Optimizing the NL crystalline structure in MOCVD could therefore significantly improve heat extraction from AlGaN/GaN HEMTs into the SiC substrate, potentially reducing peak channel temperature rise by up to 40%, significantly benefiting device reliability. [J120]

"10-Gbit/s Quadrature Phase-Shift-Keying Modulator and Demodulator for 120-GHz-Band Wireless Links"

This paper presents a 120-GHz-band 10-Gbit/s quadrature phase-shift-keying (QPSK) modulator and demodulator. To reduce system complexity, the modulator employs direct modulation, and the demodulator uses differentially coherent detection. We fabricated the modulator monolithic microwave integrated circuit (MMIC) and demodulator MMIC with 0.1-μm-gate InP HEMTs. The test element of the modulator had a static error-vector magnitude of 10%. We mounted the modulator and demodulator MMICs in separate modules. The size of the modules was 20 mm Ч 8 mm Ч 25 mm. The main lobe in the spectrum of 10-Gbit/s QPSK signals ranged from 123 to 133 GHz. The bit error rate for 10-Gbit/s 27- 1 pseudorandom binary sequence data was smaller than 10-10at a received power of -38.5 dBm. [J121]

"Process Dependence of Proton-Induced Degradation in GaN HEMTs"

The 1.8-MeV proton radiation responses are compared for AlGaN/GaN HEMTs grown under Ga-rich, N-rich, and NH3-rich conditions. The NH3-rich devices are more susceptible to proton irradiation than the Ga-rich and N-rich devices. The 1/ fnoise of the devices increases with increasing fluence. Density functional theory calculations show that N vacancies and Ga-N divacancies lead to enhanced noise in these devices. [J122]

"N-Polar GaN/AlN MIS-HEMT for Ka-Band Power Applications"

In this letter, we demonstrate the millimeter-wave power performance from N-polar GaN-based metal-insulator-semiconductor high-electron-mobility transistors. The device consists of a GaN spacer structure with an AlN barrier to reduce the alloy scattering. High Si doping in GaN without excessive surface roughening has been achieved using a digital doping scheme with a low ohmic contact resistance of 0.16 Ω·mm. An fTand an fMAXof 56 and 130 GHz, respectively, were obtained for a 150-nm gate length. A peak output power of 1.9 W/mm with

a power-added efficiency (PAE) of 14% was achieved for VDS= 20 V, and a peak output power of 2.2 W/mm with a 12% efficiency and a linear transducer power gain of 5.7 dB was achieved for VDS= 30 V at 30 GHz. The cause of the low PAEwas determined to be due to the current collapse from the RF-IVmeasurements, and remedies have been suggested to minimize the dc-RF dispersion. [J123]

"Testing the Temperature Limits of GaN-Based HEMT Devices"

The high temperature stability of AlGaN/GaN and lattice-matched InAlN/GaN heterostructure FETs has been evaluated by a stepped temperature test routine under large-signal operation. While AlGaN/GaN high-electron mobility transistors (HEMTs) have failed in an operating temperature range of 500°C, InAlN/GaN HEMTs have been operated up to 900°C for 50 h (in vacuum). Failure is thought to be still contact metallization stability related, indicating an extremely robust InAlN/GaN heterostructure configuration. [J124]

"Study on the Temperature Dependence of the Microwave-Noise Characteristics in AlGaN/GaN HEMTs"

In this brief, we present a detailed study on the temperature dependence of the microwave noise characteristics in AlGaN/GaN high-electron mobility transistors on high-resistivity silicon substrate. The temperature-dependent microwave noise parameters of AlGaN/GaN HEMT on Si were measured over a wide temperature range of -50°C-200°C. The physical mechanisms of the temperature behavior for the overall noise figure (NFmin) and internal noise sources coefficients (P, R, and C) were analyzed and discussed in detail. [J125]

"Importance of impurity diffusion for early stage degradation in AlGaN/GaN high electron mobility transistors upon electrical stress"

Early stage degradation of AlGaN/GaN high electron mobility transistors (HEMTs) submitted to off- and on-state voltage bias stress was studied using UV light-assisted drain current trapping characteristics. Besides electronic traps generated underneath the gate during off-state stress, both stress conditions lead to trap generation in the transistor access region close to the drain side of the gate edge. UV light-assisted trapping analysis strongly indicates these traps to be located in the AlGaN subsurface layer of the AlGaN/GaN HEMT. Trap evolution during off-state stress performed at base plate temperatures from room temperature to 150 °Cwas found to exhibit an activation energy of 0.26 eV, consistent with impurity diffusion along dislocations. [J126]

"High Breakdown ( ) AlGaN/GaN HEMTs by Substrate-Transfer Technology"

In this letter, we present a new technology to increase the breakdown voltage of AlGaN/GaN high-electron-mobility transistors (HEMTs) grown on Si substrates. This new technology is based on the removal of the original Si substrate and subsequent transfer of the AlGaN/GaN HEMT structure to an insulating carrier wafer (e.g., glass or polycrystalline AlN). By applying this new technology to standard AlGaN/GaN HEMTs grown on Si substrate, an AlGaN/GaN HEMT with breakdown voltage above 1500 V and specific on resistance of 5.3 mΩ·cm2has been achieved. [J127]

"Low-Noise Microwave Performance of 0.1 m Gate AlInN/GaN HEMTs on SiC"

We report the first microwave noise characterization of AlInN/GaN HEMTs. Transistors with a 0.1 μ m gate implemented on a semi-insulating SiC substrate achieve a maximum current density of 1.92 A/mm at VGS= 0 V, a measured transconductance gM= 480 mS/mm, and a peak current gain cutoff frequency fT= 121 GHz with a simultaneous maximum oscillation frequency fMAX= 142 GHz. At 10 (20) GHz, our HEMTs exhibit a minimum noise figure Fminof 0.62 (1.5) dB together with a high associated gain GAof 15.4 (13.3) dB. The Fminvalues are among the lowest reported in nitride HEMTs, and the GAvalues are the best so far found in the literature, demonstrating the excellent potential of AlInN/GaN HEMTs for low-noise microwave applications. [J128]

"High-Performance Integrated Dual-Gate AlGaN/GaN Enhancement-Mode Transistor"

In this letter, we present a new AlGaN/GaN enhancement-mode (E-mode) transistor based on a dual-gate structure. The dual gate allows the transistor to combine an E-mode behavior with low on-resistance and very high breakdown voltage. The device utilizes an integrated gate structure with a short gate controlling the threshold voltage and a long gate supporting the high-voltage drop from the drain. Using this new dual-gate technology, AlGaN/GaN E-mode transistors grown on a Si substrate have demonstrated a high threshold voltage of 2.9 V with a maximum drain current of 434 mA/mm and a specific on-resistance of 4.3 m Ω·cm2at a breakdown voltage of 643 V. [J129]

"205-GHz (Al,In)N/GaN HEMTs"

We report 55-nm gate AlInN/GaN high-electron-mobility transistors (HEMTs) featuring a short-circuit current gain cutoff frequency of fT = 205 GHz at room temperature, a new record for GaN-based HEMTs. The devices source a maximum current density of 2.3 A/mm at VGS= 0 V and show a measured transconductance of 575 mS/mm, which is the highest value reported to date for nonrecessed gate nitride HEMTs. Comparison to state-of-the-art thin-barrier AlGaN/GaN HEMTs suggests that AlInN/GaN devices benefit from an advantageous channel velocity under high-field transport conditions. [J130]

"Oxygen gas sensing at low temperature using indium zinc oxide-gated AlGaN/GaN high electron mobility transistors"

Indium zinc oxide (IZO)-gated AlGaN/GaN high electron mobility transistors (HEMTs) were used to detect oxygen gas. Amorphous IZO films with high carrier concentration of 1021cm-3were deposited on the gate region of the HEMTs by cosputtering from ZnO and In2O3targets. The changes in IZO gated-AlGaN/GaN HEMT drain current were used to monitor the presence of oxygen. The IZO gated AlGaN/GaN HEMT sensors were tested with O2at room temperature, 50 °C, and 120 °C. There was no response to O2at room temperature. At 50 °C, the sensors could sense O2but gradually saturated. The sensor showed a strong response to the oxygen gas at 120 °C, which is a much lower temperature than with conventional oxide-based oxygen sensors that typically operate in the range of 400-700 °C. This enhanced oxygen sensing sensitivity was due to the amplification effect of the AlGaN/GaN HEMT. A preannealing step at 350 °Cwas also found to improve the sensitivity and response time of O2sensing at 120 °C. [J131]

"30-nm InAs PHEMTs With and"

We present 30-nm InAs pseudomorphic HEMTs (PHEMTs) on an InP substrate with record fTcharacteristics and well-balanced fTand fmaxvalues. This result was obtained by improving short-channel effects through widening of the side-recess spacing (Lside) to 150 nm, as well as reducing parasitic source and drain resistances. To compensate for an increase in Rsand Rddue to Lsidewidening, we optimized the ohmic contact process so as to decrease the specific ohmic contact resistance (Rc) to the InGaAs cap to 0.01 Ω·mm. A 30-nm InAs PHEMT with tins= 4 nm exhibits excellent gm,max of 1.9 S/mm, fTof 644 GHz, and fmaxof 681 GHz at VDS= 0.5 V simultaneously. To the knowledge of the authors, the obtained fTin this work is the highest ever reported in any FET on any material system. This is also the first demonstration of simultaneous fTand fmaxhigher than 640 GHz in any transistor technology. [J132]

"Thermal instability of copper gate AlGaN/GaN HEMT on Si substrate"

Thermal reliability of nickel (Ni) and copper (Cu) gate AlGaN/GaN high electron mobility transistors (HEMTs) is investigated. Though the current-voltage characteristics of as-deposited Cu gate AlGaN/GaN HEMTs is superior to those of Ni gate AlGaN/GaN HEMTs, severe degradation was observed after aging at 220°C. This instability problem should be carefully taken into account in practical applications of Cu gate AlGaN/GaN HEMTs. [J133]

"Characterization and Analysis of the Temperature-Dependent on -Resistance in AlGaN/GaN Lateral Field-Effect Rectifiers"

The on-resistance and its temperature dependence of the high electron mobility transistor (HEMT)-compatible lateral field-effect rectifier (L-FER) are investigated. Three types of transfer length method (TLM) patterns are utilized to extract the temperature-dependent electrical parameters of the resistance model. The technique presented in this paper delivers a direct and simple methodology for the investigation of the temperature dependence of the on-resistance in the L-FER. The simulated output characteristics of the L-FER are in good agreement with the experimental results. [J134]

"Threshold Voltage Control in HEMTs by Work-Function Engineering"

The first demonstration of high-Al-composition (> 70%) AlGaN high electron mobility transistors (HEMTs) is reported. High electron mobility (~1300 cm2/Vs at room temperature) was achieved in novel high-Al-composition AlGaN 2-D electron gas structures. The threshold voltages (Vth) of Al0.72Ga0.28N/AlN/GaN HEMTs were shifted from -1.0 to -0.13 V by employing different gate metal stacks, Al/Au and Ni/Au, respectively. With a 4-nm Al2O3gate dielectric on top of the nitride heterostructures, the ~0.9-eV work-function difference between Al and Ni induced ~0.9-V Vthshift in the pairs of the Al/Au and Ni/Au gate HEMTs, which indicates that the Fermi level is unpinned at the ALD Al2O3/AlGaN interface. The results were reproducible for HEMTs of various gate lengths. The results suggest that it is possible to obtain enhancement- and depletion-mode AlGaN HEMTs using work-function engineering which can enable integrated monolithic digital circuits without postgrowth recess

etching or ion implantation. [J135]

"Proposal and Performance Analysis of Normally Off GaN/InAlN/AlN/GaN HEMTs With 1-nm-Thick InAlN Barrier"

Design considerations and performance of n++GaN/InAlN/AlN/GaN normally off high-electron mobility transistors (HEMTs) are analyzed. Selective and damage-free dry etching of the gate recess through the GaN cap down to a 1-nm-thick InAlN barrier secures positive threshold voltage, while the thickness and the doping of the GaN cap influence the HEMT direct current and microwave performance. The cap doping density was suggested to be 2 Ч 1020cm-3. To screen the channel from the surface traps, the needed cap thickness was estimated to be only 6 nm. Design is proved by an experiment showing a constant value of the HEMT dynamical access resistance, while a single-pulse experiment indicated almost collapse-free performance. On the other hand, it is found that the n++GaN cap does not contribute to the HEMT drain current conduction, nor does it provide a path for the off-state breakdown. HEMTs with a gate length of 0.25 μm and a 4-μm source-to-drain distance show a drain-to-source current of 0.8 A/mm, a transconductance of 440 mS/mm, a threshold voltage of ~0.4 V, and a cutoff frequency of 50 GHz. A thin and highly doped GaN cap is also found to be suitable for the processing of normally on HEMTs by adopting the nonrecessed gate separated from the cap by insulation. [J136]

"Improved Linearity for Low-Noise Applications in 0.25- GaN MISHEMTs Using ALD as Gate Dielectric"

Improved device linearity for low-noise applications has been demonstrated in 0.25-μm AlGaN/GaN metal-insulator-semiconductor high-electron-mobility transistors (MISHEMTs) using atomic-layer-deposited (ALD) Al2O3as gate dielectric. The measured dc transconductance, microwave small signal, and noise performance feature less dependence on drain current as compared to conventional Schottky-gate AlGaN/GaN HEMTs. Two-tone intermodulation measurement shows that the MISHEMT has a higher value of third-order intercept (IP3). The improved device linearity suggests that the ALD Al2O3/AlGaN/GaN MISHEMT on high-resistivity silicon substrate is promising for high-linearity low-noise amplifier applications. [J137]

"Integrated Circuit Implementation for a GaN HFET Driver Circuit"

This paper presents the design and implementation of a new integrated circuit (IC) that is suitable for driving the new generation of high-frequency GaN HFETs. The circuit, based upon a resonant switching transition technique, is first briefly described and then discussed in detail, focusing on the design process practical considerations. A new level-shifter topology, used to generate the zero and negative gate-source voltages required to switch the GaN HFET, is introduced and analyzed. The experimental measurements included in this paper report the results of tests carried out on an IC designed and fabricated as part of the multiproject die in high-voltage process H35B4 of Austriamicrosystems. They fully demonstrate the performance of the proposed driver that opens the possibility of fully exploiting the wide capabilities and advantages of GaN devices for use in power electronics applications. [J138]

"Novel Metamorphic HEMTs With Highly Doped InGaAs Source/Drain Regions for High Frequency Applications"

In this paper, we report the first result of a strained In0.52Ga0.48As channel high-electron mobility transistor (HEMT) featuring highly doped In0.4Ga0.6As source/drain (S/D) regions. A lattice mismatch of 0.9% between In0.52Ga0.48As and In0.52Ga0.48As S/D has resulted in a lateral strain in the In0.52Ga0.48As channel region, where the series resistance is reduced with highly doped S/D regions. An experimentally validated device simulation is advanced for the proposed HEMT, and the results of this paper have shown that there are 60% drive-current and 100% transconductance improvements, compared with the conventional structure. A remarkable 150-GHz increase in the cutoff frequency has been seen for the proposed structure over the conventional one as well for the shown devices. [J139]

"Microwave Noise and FET Devices"

In this article, a short presentation of available FET technologies (GaAs MESFET, ПI-V HEMT, and silicon CMOS) has been presented. Why minimum NF is suitable to benchmark different low-noise technologies has been discussed. Following this, basic concepts related to thermal noise in FETs and the reason why such technologies feature outstanding low-noise performance was illustrated/ and a short survey of minimum NF evolution has been presented. InP HEMT technology undoubtedly constitutes the best low-noise technology (especially to address applications in W or G Band). The noise performance of silicon MOSFET technology/ which is widely used in many applications because of its low cost, does not outperform that of GaAs pHEMT

technology/ unless channel engineering is performed. [J140]

"Optimized Design of a Highly Efficient Three-Stage Doherty PA Using Gate Adaptation"

We demonstrate an optimized design of a highly efficient three-stage Doherty power amplifier (PA) for the 802.16e mobile world interoperability for microwave access (WiMAX) application at 2.655 GHz. The "three-stage" Doherty PA is the most efficient architecture among the various Doherty PAs for achieving a high peak to average power ratio (PAPR) signal. However, it has a problem in that the carrier PA has to maintain a saturated state with constant output power when the other peaking PAs are turned on. We solved the problem using a gate envelope tracking (ET) technique. For the proper load modulation, the gate biases of the peaking PAs were adaptively controlled, and the peak power and maximum efficiency characteristics along the backed-off output power region were successfully achieved. Using Agilent's Advanced Design System and Matlab simulations, the overall behavior of the three-stage Doherty PA with the ET technique employed was fully analyzed, and the optimum design procedure is suggested. For the WiMAX signal with a 7.8-dB PAPR, the measured drain efficiency of the proposed three-stage Doherty PA is 55.4% at an average output power of 42.54 dBm, which is an 8-dB backed-off output power. Digital predistortion was used to linearize the proposed PA. After linearization, a -33.15 dB relative constellation error performance was achieved, satisfying the system specifications. This is the best performance of any 2.655-GHz WiMAX application ever reported, and it clearly shows that the proposed three-stage Doherty PA is suitable as a highly efficient and linear transmitter. [J141]

"A 120-145 GHz Heterodyne Receiver Chipset Utilizing the 140 GHz Atmospheric Window for Passive Millimeter-Wave Imaging Applications"

For passive mm-wave imaging applications, broadband mm-wave receivers functioning within atmospheric windows are highly desired. Within this paper, a heterodyne receiver chipset utilizing the 140 GHz atmospheric window is presented. The heterodyne chipset is based on two different millimeter-wave monolithic integrated circuits (MIMICs). One is the receiver MIMIC including a low-noise amplifier, a down-conversion mixer, a frequency multiplier and a local oscillator buffer amplifier together with a local oscillator distribution network. The other is a voltage-controlled oscillator (VCO) working in the 35 GHz frequency range to generate the local oscillator signal for the receiver (down-converter) chip. The process technology chosen to realize the chipset is a 100 nm gatelength metamorphic InAlAs/InGaAs high electron mobility transistor (HEMT) technology on 50 µm thick and 4 inch diameter GaAs substrates. The chips are utilizing a grounded coplanar waveguide (GCPW) technology. For an operation frequency band from 120 to 145 GHz, the receiver demonstrates a flat conversion gain between -1 and +2 dB with a power consumption of 120 mW. The VCO is tuneable from 31 to 37 GHz with associated output power levels from -2 to +1 dBm. Detailed descriptions of the individual building blocks are given and measured results are presented for the building blocks as well as for the receiver. [J142]

"High Efficiency WCDMA Power Amplifier With Pulsed Load Modulation (PLM)"

Complex non-constant-envelope modulations are often used in wireless communications. A power amplifier (PA) is developed based on the concept of pulsed load modulation (PLM) that can enhance the power efficiency of the PA when the output power is back off from the peak due to modulations. The PLM technique utilizes the time-varying behavior of switched resonators to form an optimal, power dependent load impedance. The switched resonator consists of a balanced pair of switching mode PAs that drive a high-Q bandpass filter. In addition to its efficiency enhancement through PLM, the PA is able to preserve the linearity of complex modulations through the architecture of envelope delta-sigma modulation (EDSM). In this paper, a 1.87 GHz PLM power amplifier is fabricated with a pair of 0.35 µm GaAs pHEMT devices. The duty cycle tests show its significant improvement on power efficiency at different back-off levels over traditional Class-B amplifiers. The PA module is also tested with a single-channel WCDMA signal with peak to average ratio (PAR) of 10.8 dB. It has achieved 39 dBc adjacent channel leakage ratio (ACLR) at 5 MHz offsets without needing additional linearization techniques. The power added efficiency in this case is 43% including the loss of the output filter and 52.6% if the loss of the filter is de-embedded. [J143]

"Normally-off operation AlGaN/GaN MOS-HEMT with high threshold voltage"

Normally-off operation AlGaN/GaN high electron mobility transistors have been developed utilising a fluorine-based treatment technique combined with a metal-oxide-semiconductor gate architecture. Threshold voltage as high as 5.1 V was achieved by using an 16 nm-thick Al2O3gate oxide film. Additionally, the device performed a drain current density of 500 mA/mm and a peak transconductance of 100 mS/mm, which are comparable to the conventional normally-on devices. [J144]

"Modeling GaN: Powerful but Challenging"

As GaN technology has developed, first in research laboratories and more recently in multiple commercial device manufacturers, the demand for improved nonlinear models has grown alongside the device process improvements. The need for improved models for GaN is twofold: first, GaN devices have unique nuances in behavior to be addressed; second, there is a desire for improved accuracy to take full advantage of the performance wins to be gained by GaN HEMT performance in the areas of high efficiency and high-power operation. [J145]

"MMIC-Based Components for MM-Wave Instrumentation"

In this letter, we present results of fully integrated 90-130 GHz receiver based on 100 nm mHEMT technology. The receiver contains a low noise amplifier (LNA), mixer and LO multiplier chain integrated into a single monolithic microwave integrated circuit (MMIC). The circuit is packaged into a waveguide block, characterized and compared to on-wafer measurements. Waveguide to microstrip transitions are used to interface the MMIC to the waveguide. A breakout LNA circuit is also packaged, and its performance is compared to the receiver. The LNA noise was characterized on a wafer and after packaging. The packaged module is measured at both room and cryogenic temperatures, NF of 3.7 dB is measured at 300 K and 0.9 dB at 20 K. [J146]

"Gate Bias Dependence of Single Event Charge Collection in AlSb/InAs HEMTs"

Single event charge collection in AlSb/InAs HEMTs is shown to depend on the gate bias. Spatial correlation between excess channel carriers and the horizontal field is shown to be the key factor. Hole accumulation in the AlSb buffer layer increases the electron concentration in the two-dimensional electron gas, increasing the collected charge. Potential drop across access regions reduces charge collection towards zero gate bias. A secondary but perceptible dependence on high field electron mobility is demonstrated. [J147]

"Monte Carlo Study of the Dynamic Performance of a 100-nm-Gate InAlAs/InGaAs Velocity Modulation Transistor"

We report a Monte Carlo study of the dynamic behavior of an InAlAs/InGaAs velocity modulation transistor (VMT) based on the topology of a double-gate high electron mobility transistor (DG HEMT), which is a HEMT with two opposite gates controlling the carrier flow through the conducting channel. In the VMT, the source and drain electrodes are connected by two channels with different mobilities, and electrons are transferred between both by changing the gate voltages in differential mode (DM). As a result, the drain current is modulated while keeping the total carrier density constant, thus, in principle, avoiding capacitance charging/discharging delays. However, the low values taken by the transconductance, as well as the high capacitance between the two gates in DM operation, lead to a deficient dynamic performance. [J148]

"Characterization of GaN HEMT Low-Frequency Dispersion Through a Multiharmonic Measurement System"

In this paper, the experimental characterization of low-frequency dispersion (i.e., long-term memory effects) affecting microwave GaN HEMTs is carried out by adopting a new nonlinear measurement system, which is based on low-frequency multiharmonic signal sources. The proposed setup, which has been fully automated by a control software procedure, enables given source/load device terminations at fundamental and harmonic frequencies to be synthesized. Different experimental results are provided to characterize well-known effects related to low-frequency dispersion (e.g., knee walkout and drain current collapse) and to demonstrate the validity of assumptions commonly adopted for electron device modeling. [J149]

"Emerging N-Face GaN HEMT Technology: A Cellular Monte Carlo Study"

This paper aims to investigate the potential of the emerging N-face technology with respect to both the direct current and radio frequency performance of GaN high electron mobility transistor (HEMT) devices. High-frequency high-power state-of-the-art HEMTs were investigated with our full-band cellular Monte Carlo simulator, which includes the full details of the band structure and the phonon spectra. A complete characterization of these devices was performed using experimental data to calibrate the few adjustable parameters of the simulator. The effect of scaling the device dimensions, such as the gate length and the access region lengths, on the device performance was analyzed. In addition, the enhancement-mode configuration of the N-face structure was investigated. Our simulations showed that N-face devices represent an important step in engineering HEMT devices for delivering high power density and efficiency at microwave and millimeter-wave frequencies. [J150]

"A 1-25 GHz GaN HEMT MMIC Low-Noise Amplifier"

This letter presents an ultra-wideband low noise amplifier (LNA) using gallium-nitride (GaN) high-electron mobility transistors (HEMT) technology. A -3 dB bandwidth of 1-25 GHz with 13 dB peak power gain is achieved using a modified resistive-feedback topology. To obtain such a wide bandwidth, several bandwidth enhancement techniques are utilized. An inductor connected to the source of the input transistor ensures good input matching (|S11| <; -9 dB) across the entire bandwidth. The shunt feedback loop and the inductive source degeneration minimize all the required inductor values. This GaN HEMT LNA is believed to have the widest bandwidth among all GaN HEMT monolithic microwave integrated circuit (MMIC) LNAs reported to date. With 3.3 dB minimum noise figure (F), 33.5 dBm maximum output-referred third-order intercept point (OIP3), 20 dBm maximum output-referred 1 dB compression point (Output P1 dB), this MMIC amplifier is comparable in performance to distributed amplifiers (DAs) but with significantly lower power consumption and smaller area. [J151]

"Enhancement-Mode AlN/GaN/AlGaN DHFET With 700-mS/mm and 112-GHz"

An enhancement-mode (E-mode) AlN/GaN/AlGaN double-heterojunction field-effect transistor (DHFET) with record high-frequency performance is reported. E-mode operation was achieved through vertical scaling of the AlN barrier layer. Parasitic resistances were reduced through ohmic contact recess etching followed by regrowth of n+ GaN by molecular-beam epitaxy and SiN deposition to increase the sheet charge density in the access regions of the device, resulting in an extremely low on-resistance of 1.06 Ω · mm. A DHFET with an 80-nm gate length had a threshold voltage of 0.21 V, an extrinsic transconductance (gm) of 0.70 S/mm, a current-gain cutoff frequency (fT) of 112 GHz, and a maximum oscillation frequency (fmax) of 215 GHz. To our knowledge, these are the highest gm, fT, and fmaxvalues reported to date for an E-mode GaN HFET. [J152]

"Breakdown Enhancement of AlGaN/GaN HEMTs on 4-in Silicon by Improving the GaN Quality on Thick Buffer Layers"

We have achieved a 9 ??m-thick AlGaN/GaN high-electron mobility transistor (HEMT) epilayer on silicon using thick buffer layers with reduced dislocation density (DD). The crack-free 9 ??m-thick epilayer included 2 ??m i-GaN and 7 ??m buffer. The HEMTs fabricated on these devices showed a maximum drain-current density of 625 mA/mm, transconductance of 190 mS/mm, and a high three-terminal OFF breakdown of 403 V for device dimensions of LgWgLgd=1.5/15/3 ??m . Without using a gate field plate, this is the highest BV reported on an AlGaN/GaN HEMT on silicon for a short Lgdof 3 ??m. A very high BV of 1813 V across 10 ??m ohmic gap was achieved for i-GaN grown on thick buffers. As the thickness of buffer layers increased, the decreased DDof GaN and increased resistance between surface electrode and substrate yielded a high breakdown. [J153]

"10-Gbit/s Wireless Link Using InP HEMT MMICs for Generating 120-GHz-Band Millimeter-Wave Signal"

We have developed a 120-GHz-band wireless link whose maximum transmission data rate is 11.1 Gbit/s. The wireless link uses millimeter-wave monolithic integrated circuits (MMICs) for the generation of a 120-GHz-band millimeter-wave wireless signal. The MMICs were fabricated using 0.1-mum-gate InP-HEMTs and coplanar waveguides. The wireless link can handle four kinds of data rate for OC-192 and 10-Gbit Ethernet standards with and without forward error correction (FEC). We succeeded in the error-free transmission of a 10-Gbit/s signal over a distance of 800 m. The introduction of FEC into the 120-GHz-band wireless link decreased the minimum received power for error-free transmission, and improved the reliability of the link. [J154]

"and of 47 and 81 GHz, Respectively, on N-Polar GaN/AlN MIS-HEMT"

In this letter, we demonstrate the record small-signal performance from N-polar GaN-based metal-insulator-semiconductor high-electron-mobility transistors (MIS-HEMTs) by using a GaN spacer structure with an AlN barrier to reduce alloy scattering. High Si doping in GaN without excessive surface roughening has been achieved using a digital doping scheme. A low ohmic contact resistance of 0.16 ?? ?? mm was measured. Submicrometer gates were fabricated by electron-beam lithography using a triple-layer resist process. fTand fMAXof 47 and 81 GHz, respectively, were obtained for the 150-nm-gate-length device. Further analysis has been done to understand the effect of access resistance on the high-frequency performance, defining a pathway for getting a higher gain and thus achieving a better high-frequency performance from N-polar GaN-based HEMTs. [J155]

"AlGaN/GaN HEMT High Power Densities on /poly-SiC Substrates"

In this letter, successful operation at 10 GHz of T-gate HEMTs on epitaxial structures grown by metal-organic chemical vapor deposition (MOCVD) or MBE on composite substrates is demonstrated. The used device fabrication process is very similar to the process used on monocrystalline SiC substrate. High power density was

measured on both epimaterials at 10 GHz. The best value is an output power density of 5.06 W/mm associated to a power-added efficiency (PAE) of 34.7% and a linear gain of 11.8 dB at VDS= 30 V for the components based on MOCVD-grown material. The output power density is 3.58 W/mm with a maximum PAE of 25% and a linear gain around 15 dB at VDS= 40 V for the MBE-grown material. [J156]

"Effects of Multigate-Feeding Structure on the Gate Resistance and RF Characteristics of 0.1- Metamorphic High Electron-Mobility Transistors"

We investigate the effects of a multigate-feeding structure on the gate resistance (Rg) and RF characteristics of the high electron-mobility transistors (HEMTs). In this structure, the increase of Rgwith the gatewidth (W) is minimized; therefore, high maximum frequency of oscillation (fmax) is achieved. Various numbers of gate feedings (Ngf) using the air-bridge interconnections are adopted for fabricating the 0.1-mum depletion-mode metamorphic HEMTs. From these structures, we observe great reduction in Rgwith the increase of Ngf, and their relationship is given by Rgprop 1/[2middot(Ngf-1)]2, where Ngf=2,3,4,...; on the other hand, the effects of Ngfon other small-signal parameters are negligible. Calculated cutoff frequency (fT) and fmaxfrom the extracted small-signal parameters all show good agreement with the measurement results. fTis slightly decreased with the increase of Ngfdue to the increase of gate-to-source capacitance. fmaxis, however, greatly increased with Ngf, and this effect becomes greater at longer total gatewidth (W times number of gate fingers) . This is due to the smaller Rgat greater Ngfin the multigate-feeding structure. We propose that this gate-feeding structure provides a very effective way to suppress Rgand maximize fmaxfor the applications of the HEMTs with long W. [J157]

"Minipressure sensor using AlGaN/GaN high electron mobility transistors"

AlGaN/GaN high electron mobility transistors (HEMTs) with a polarized polyvinylidene difluoride (PVDF) film coated on the gate area exhibited significant changes in channel conductance upon exposure to different ambient pressures. The PVDF thin film was deposited on the gate region with an ink-jet plotter. Next, the PDVF film was polarized with an electrode located 2 mm above the PVDF film at a bias voltage of 10 kV and 70 °C. Variations in ambient pressure induced changes in the charge in the polarized PVDF, leading to a change in surface charges on the gate region of the HEMT. Changes in the gate charge were amplified through the modulation of the drain current in the HEMT. By reversing the polarity of the polarized PVDF film, the drain current dependence on the pressure could be reversed. Our results indicate that HEMTs have potential for use as pressure sensors. [J158]

"-Band pHEMT Gilbert Mixers With Polyphase and Coupled-Line Quadrature Generators"

In this paper, three kinds of Kalpha/Ku-band Gilbert mixers are demonstrated using 0.15- mum AlGaAs/InGaAs pseudomorphic high electron mobility transistor technology. Thanks to the semiinsulating GaAs substrate, microwave passive components have a low-loss feature, and polyphase filters work up to higher frequencies. Highly accurate tantalum-nitride thin-film resistors utilized in polyphase filters result in perfect quadrature operation. Therefore, our proposed single-sideband up-converter operates at 15 GHz with a 63-dB sideband rejection ratio, and another 34-GHz in-phase/quadrature (I/Q) subharmonic down-converter reaches <0.4-dB magnitude and < 1deg phase errors. More than 50-dB local oscillator (LO) leakage suppression is achieved in the I/Q subharmonic mixer. On the other hand, a 40-GHz stacked-LO subharmonic mixer with a novel compensation technique is also proposed and demonstrated to improve LO speed and reduce the amount of transistors, as compared to previous work. [J159]

"Localized Damage in AlGaN/GaN HEMTs Induced by Reverse-Bias Testing"

Reverse-bias testing in AlGaN/GaN HEMTs at high (negative) gate voltage is found to induce a catastrophic increase in gate leakage current IG, with only a slight degradation of drain current ID. Electroluminescence (EL) microscopy demonstrates that leakage current injection is localized within ldquohot spotsrdquo at the gate edges, possibly corresponding to defects in the semiconductor material or at the metal-semiconductor interface. The density of ldquohot spotsrdquo increases during tests and is correlated with the increase of IGand electroluminescence intensity and with an enhancement of trapping effects such as current collapse. [J160]

"Evaluation of GaN HEMT degradation by means of pulsed I-V, leakage and DLTS measurements"

The effects of short-term step-stress on the performance of GaN HEMTs have been evaluated for the first time by means of current deep-level-transient-spectroscopy (DLTS) measurements. When subjected to high reverse gate bias the devices experienced an increase in the drain current dispersion as well as in the gate current. Current DLTS measurements carried out during the stress experiment show that the device degradation can be associated to the formation of a defect that is thermally activated with an energy of 0.5 eV. [J161]

"RF Performance of N-Polar AlGaN/GaN MIS-HEMTs Grown by MOCVD on Sapphire Substrate"

We present a high-performance nitrogen-polar AlGaN/GaN metal-insulator-semiconductor high-electron-mobility transistor grown on sapphire substrate using metal-organic chemical vapor deposition. Source-terminated field plates were used to mitigate the electric field in the drain-extension region and reduce DC-to-RF dispersion. Devices with 0.7-mum gate length showed a current-gain cutoff frequency (fT) of 14 GHz and a power-gain cutoff frequency (fmax) of 36 GHz. A continuous-wave output power density of 4.7 W/mm was measured at 4 GHz, with an associated power-added efficiency of 64% and a large-signal gain of 14.4 dB at a drain bias of 30 V. [J162]

"A Novel Self-Pinching Gate Biasing Scheme for Safe Operation and Characterization of GaN HEMTs"

This letter presents a novel gate bias configuration for GaN HEMTs that ensures a safe operation of this kind of device by protecting the gate from forward turn-on. The bias circuit includes a simple series diode in the DC path that blocks any positive current from the gate, in other words it restricts the gate diode of the device to operate in forward bias. The new bias circuit ensures a safe operating condition of FET/HEMT transistors during forward turn-on while not hampering or degrading performance under normal operating condition. [J163]

"A 200 GHz Monolithic Integrated Power Amplifier in Metamorphic HEMT Technology"

A millimeter-wave monolithic integrated circuit power amplifier operating in the frequency range between 186 and 212 GHz is presented. The amplifier, dedicated to high-resolution imaging radar and communication systems, is realized in a 100 nm gate length metamorphic high electron mobility transistor technology. The three-stage design with four parallel transistors in the output stage achieves a linear gain of more than 12 dB and provides a saturated output power of more than 9 dBm and 7 dBm at 192 and 200 GHz, respectively. [J164]

"Fast detection of a protozoan pathogen, Perkinsus marinus, using AlGaN/GaN high electron mobility transistors"

Antibody-functionalized, Au-gated AlGaN/GaN high electron mobility transistors (HEMTs) were used to detect Perkinsus marinus. The antibody was anchored to the gate area through immobilized thioglycolic acid. The AlGaN/GaN HEMT drain-source current showed a rapid response of less than 5 s when the infected solution was added to the antibody-immobilized surface. The sensor can be recycled with a phosphate buffered saline wash. These results clearly demonstrate the promise of field-deployable electronic biological sensors based on AlGaN/GaN HEMTs for Perkinsus marinus detection. [J165]

"High power N-face GaN high electron mobility transistors grown by molecular beam epitaxy with optimization of AlN nucleation"

We investigated the effect of AlN nucleation layers (NLs) on the structural and electrical properties of N-face GaN grown on C-face 6H-SiCsubstrates by plasma-assisted molecular beam epitaxy. The GaN films were characterized by secondary ion mass spectroscopy, x-ray diffraction, and transistor electrical measurements. It was found that an AlN NL grown in the N-rich regime was essential for realizing highly resistive GaN buffers. The mosaic structure of the GaN epilayers was systematically correlated with the AlN nucleation conditions. N-face high electron mobility transistors fabricated on these low-leakage buffers demonstrated the highest output power density at 4 GHz to date of 8.1 W/mm with an associated power-added efficiency of 54%. [J166]

"In Al N /Ga N metal-oxide-semiconductor high electron mobility transistor with Al 2 O 3 insulating films grown by metal organic chemical vapor deposition using Ar and N H 3 carrier gases"

Al2O3thin films were deposited by a metal organic chemical vapour deposition on InAlN/GaNheterostructures using Ar or NH3as a carrier gas. Effects of NH3and Ar carrier gases on the electrical and structural properties of Al2O3/InAlN/GaNHEMT devices were investigated by current voltage, current collapse, and Auger electron spectroscopy measurements. Al2O3deposited using Ar as a carrier gas leads to a substantial gate leakage current reduction with no increase of the current collapse compare to Schottky gate based HEMT. On the other hand, HEMT electrical performance shows degradation if NH3carrier gas is used. Similarly, Auger electron spectroscopy revealed presence of carbon on InAlN surface when NH3carrier gas was applied. It is suggested that the formation of carbon-related traps on the InAlN surface takes place in the early stages of the Al2O3deposition with NH3carrier gas that strongly influences the HEMT performance. [J167]

"Imaging capability of pseudomorphic high electron mobility transistors, Al Ga N /Ga N, and Si

micro-Hall probes for scanning Hall probe microscopy between 25 and 125 °C"

The authors present a comparative study on imaging capabilities of three different micro-Hall probe sensors fabricated from narrow and wide band gap semiconductors for scanning hall probe microscopy at variable temperatures. A novel method of quartz tuning fork atomic force microscopy feedback has been used which provides extremely simple operation in atmospheric pressures, high-vacuum, and variable-temperature environments and enables very high magnetic and reasonable topographic resolution to be achieved simultaneously. Micro-Hall probes were produced using optical lithography and reactive ion etching process. The active area of all different types of Hall probes were 1Ч1 mcm2. Electrical and magnetic characteristics show Hall coefficient, carrier concentration, and series resistance of the hall sensors to be 10 mOmega /G, 6.3Ч1012 cm-2, and 12 kOmega at 25 °Cand 7 mOmega /G, 8.9Ч1012 cm-2and 24 kOmega at 125 °Cfor AlGaN/GaNtwo-dimensional electron gas (2DEG), 0.281 mOmega /G, 2.2Ч1014 cm-2, and 139 kOmega at 25 °Cand 0.418 mOmega /G, 1.5Ч1014 cm-2and 155 kOmega at 100 °Cfor Si and 5-10 mOmega /G, 6.25Ч1012 cm-2, and 12 kOmega at 25 °Cfor pseudomorphic high electron mobility transistors (PHEMT) 2DEG Hall probe. Scan of magnetic field and topography of hard disc sample at variable temperatures using all three kinds of probes are presented. The best low noise image was achieved at temperatures of 25, 100, and 125 °Cfor PHEMT, Si, and AlGaN/GaNHall probes, respectively. This upper limit on the working temperature can be associated with their band gaps and noise associated with thermal activation of carriers at high temperatures. [J168]

"Al Ga As /Ga As high-electron mobility transistor with In 0.1 Ga 0.9 As /In 0.22 Ga 0.78 As /In 0.1 Ga 0.9 As channel grown by metal-organic chemical vapor deposition"

A composite-channel high-electron mobility transistor (HEMT) on GaAs substrate is designed and fabricated, using the following methodology to improve device performance: (1) an AlGaAs buffer layer, (2) an AlGaAs/GaAssuperlattice layer, and (3) an In0.1Ga0.9As/In0.22Ga0.78As/In0.1Ga0.9Ascomposite channel. For comparison, a control HEMT without the composite channel is fabricated in parallel (whose channel comprises only a 125-E-thick In0.22Ga0.78Aslayer). These two devices are grown by metal-organic chemical vapor deposition. The peak extrinsic transconductance (gm,ext)of the control HEMT with a gate length of 1mcmis 160mS/mm, while the peak gm,extof the composite-channel HEMT of the identical gate length is measured to be 186mS/mm. The on-state breakdown voltage of the composite-channel HEMT is as great as 9.7V, which represents an improvement of 1.4Vover the control HEMT. The control HEMT exhibits a current gain cutoff frequency (fT)of 12.5GHzand a maximum frequency of oscillation (fmax)of 31.5GHz, while the composite-channel HEMT-exhibits an fTof 16.9GHzand an fmaxof 37.4GHz. Experimental data reveal that the composite-channel structure provides improved gate-to-source voltage swing, improved saturation current density, enhanced fT, enhanced fmax, and enhanced breakdown voltage without compromising electron mobility. The composite-channel HEMT is thus far superior to the control HEMT and is highly promising for use in high-frequency applications. [J169]

"Performance Analysis of 60-nm Gate-Length III-V InGaAs HEMTs: Simulations Versus Experiments"

An analysis of recent experimental data for high-performance In0.7Ga0.3As high electron mobility transistors (HEMTs) for logic applications is presented. By using a fully quantum mechanical ballistic model, we simulate In0.7Ga0.3As HEMTs with gate lengths of LG= 60, 85, and 135 nm and compare the result to the measured IV characteristics, including drain-induced barrier lowering, subthreshold swing, and threshold voltage variation with gate insulator (wide-bandgap barrier layer) thickness, as well as on-current performance. To first order, devices with three different oxide thicknesses and channel lengths can all be described by a ballistic model for the channel with appropriate values of parasitic series resistance. For high gate and drain voltages (VGS-VT=0.5 V and VDS=0.5 V), however, the ballistic simulations consistently overestimate the measured on-current (a sign of higher transconductance), and they do not show the experimentally observed decrease in on-current with increasing gate length. With no parasitic series resistance at all, the simulated on-current of the LG= 60 nm device is about twice the measured current. According to the simulation, the estimated ballistic carrier injection velocity for this device is about 2.7 times 107cm/s. Because of the importance of the semiconductor capacitance, the simulated gate capacitance is about 2.5 times less than the insulator/barrier capacitance. Possible causes of the transconductance degradation observed experimentally under high gate voltages in these devices are also explored. In addition to a possible gate-voltage-dependent scattering mechanism, the limited ability of the source to supply carriers to the channel and the effect of nonparabolicity are likely to play a role. The drop in the on-current at higher gate biases with increasing gate length, is an indication that the devices operate below th- e ballistic limit. [J170]

"Current collapse reduction in InAlM/GaN MOS hemtHEMTs by in situ surface pre-treatment and atomic layer deposition of ZrO2 high-k gate dielectrics"

Atomic layer deposition (ALD) is supplied to grow ZrO2high-k gate dielectrics and fabricate InAlN/GaN metal oxide semiconductor (MOS) high electron mobility transistors (HEMTs). Ex situ chemical surface cleaning and optimised in situ InAlN surface pre-treatment by ALD lead to a substantial suppression of drain-source current collapse owing to a high-quality InAlN/oxide interface. In addition, the gate leakage current was suppressed by about three orders of magnitude. [J171]

"Improved Microwave Noise Performance by SiN Passivation in AlGaN/GaN HEMTs on Si"

Effects of silicon nitride (SiN) surface passivation by plasma enhanced chemical vapor deposition (PECVD) on microwave noise characteristics of AlGaN/GaN HEMTs on high-resistivity silicon (HR-Si) substrate have been investigated. About 25% improvement in the minimum noise figure (NFmin) (0.52 dB, from 2.03 dB to 1.51 dB) and 10% in the associate gain (Ga) (1.0 dB, from 10.3 dB to 11.3 dB) were observed after passivation. The equivalent circuit parameters and noise source parameters (including channel noise coefficient (P), gate noise coefficient (R), and their correlation coefficient (C)) were extracted. P, Rand Call increased after passivation and the increase of C contributes to the decrease of the noise figure. It was found that the improved microwave small signal and noise performance is mainly due to the increase of the intrinsic transconductance (gm0) and the decrease of the extrinsic source resistance (Rs). [J172]

"DC to 50 GHz single-pole four-throw InP-HEMT switch IC with highly uniform performance"

A single-pole four-throw (SP4T) switch IC with a 3 dB bandwidth of over 50 GHz, which is believed to be the highest among cold-FET SP4T switches, is presented. A miniature and ideal divergence structure with an advanced four-level interconnect provides highly uniform performance in different paths. [J173]

"Effect of Buffer Layer Structure on Drain Leakage Current and Current Collapse Phenomena in High-Voltage GaN-HEMTs"

High-voltage (> 400 V) GaN high-electron mobility transistors were fabricated using two types of heterostructures with different buffer layer structures. The buffer layer structure affected the crystal defect density in grown AlGaN/GaN heterostructure. The static on-resistance under low applied voltage was independent of the buffer layer structure because it has no influence on the 2-D electron-gas density. On the other hand, the drain leakage current through the grown layers and the dynamic on-resistance increase caused by the current collapse phenomena depended on the buffer layer structure. The leakage current was reduced by the AlN/n-GaN/AlN layers because of the potential barrier at the AlN/n-GaN interface and no-depletion of the n-GaN layer. In addition, the experimental results showed that the dynamic on-resistance was increased with the edge dislocation density and was not influenced by the screw dislocation density. From these results, it can be expected that edge dislocation is related to the electron trapping center, which must be reduced to suppress the current collapse phenomena. [J174]

"Development of ultra wideband, high efficiency, distributed power amplifiers using discrete GaN HEMTs"

This study describes the design and performance of a discrete ultra wideband GaN HEMT distributed power amplifier (DPA) with over 5 W (37 dBm) output power and a PAE exceeding 27 in the 0.02-3 GHz frequency range. The implemented DPA design is comprised of three discrete GaN HEMT devices. Its performance was enhanced using tapered drain lines and non-uniform gate capacitive coupling. The design methodology is based on both small and large signal analysis using harmonic balance technique, and their associated predicted and experimental results are discussed here in detail. [J175]

"Comparison of characteristics of AlGaN channel HEMTs formed on SiC and sapphire substrates"

The fundamental device characteristics of AlGaN channel high electron mobility transistors formed on 4H-SiC and sapphire substrates are compared, and it is found that the drivability is apparently better for the SiC substrate. Judging from the simultaneous enhancement in mobility and the carrier concentration of the two-dimensional electron gases for the SiC substrate, the advantages of the SiC substrate originate from the excellent crystal quality of the AlGaN channel layer including the interface with the AlGaN barrier layer, which should be due to less lattice mismatch with the substrate. [J176]

"The Kink Effect at Cryogenic Temperatures in Deep Submicron AlGaN/GaN HEMTs"

The kink effect has been studied in deep submicron AlGaN/GaN high-electron mobility transistors by measuring their DC, RF and pulsed performance at cryogenic temperatures. In these devices, the kink effect is mainly due

to traps: it appears at T< 260 K and can be removed either by applying UV light or biasing the gate with short pulses. Its appearance is related to the fluorine-based treatment (CF4/O2plasma) used for etching the passivant, treatment which creates traps below and around the gate. This link between the kink and the etching treatment has also been confirmed in optically defined gate devices with different fluorine plasma exposure times. [J177]

"Increase of Breakdown Voltage on AlGaN/GaN HEMTs by Employing Proton Implantation"

The breakdown voltage of new AlGaN/GaN high electron mobility transistors (HEMTs) was increased considerably without sacrificing any other electrical characteristics by proton implantation. The breakdown voltage of proton-implanted AlGaN/GaN HEMTs with 150 KeV 1 times 1014-cm-2fluence after thermal annealing at 400 degC for 5 min under N2ambient was 719 V, while that of conventional device was 416 V. The increase of the breakdown voltage is attributed to the expansion of the depletion region under the 2-D electron gas (2-DEG) channel. The depletion region expanded downward into the GaN buffer layer because implanted protons acted as positive ions and attracted electrons in the 2-DEG channel. [J178]

"Changes of Electrical Characteristics for AlGaN/GaN HEMTs Under Uniaxial Tensile Strain"

This letter investigates the characteristics of unpassivated AlGaN/GaN high-electron mobility transistors (HEMTs) under uniaxial tensile strain. Mechanical stress can produce additional charges that change the HEMT channel current. This phenomenon is dependent upon gate orientation and may be the result of the piezoelectric effect and changes in electron mobility due to the applied uniaxial stress. In addition, results show that tensile strain reduces the transient current, which is likely due to the additional donorlike surface states created through the piezoelectric effect. [J179]

"Simulation and Optimization of Gate Temperatures in GaN-on-SiC Monolithic Microwave Integrated Circuits"

This paper presents 3-D thermal simulation studies of GaN-on-SiC monolithic microwave integrated circuits (MMICs) containing multifinger micrometer-scale high electron mobility transistors (HEMTs). The heat spreading effect of HEMT source, gate, and drain metallizations on peak structure temperatures is examined. The impacts of a realistic die attach material and rear-of-die heat transfer coefficient on structure temperatures, and in particular on temperature nonuniformity, are examined. Variable gate finger spacing, in which the gate spatial positions are described by polynomials as a function of gate number, is investigated as a means for optimizing the temperature uniformity from gate-to-gate. A thermal simulation code with a parametric MMIC geometry-based mesh generator and a deformable mesh consistent with sequential movement of gate finger positions during optimization is employed for all of the studies. The code is multiscale with a sufficient resolution range to handle a multifinger HEMT structure while also including the MMIC die, die attach metallization, and a realistic heat transfer coefficient associated with microchannel coolers. A variable gate pitch geometry based on an optimized cubic polynomial demonstrates considerable advantage in temperature uniformity. [J180]

"Improving the Linearity of GaN HEMTs by Optimizing Epitaxial Structure"

This paper presents an effective method of improving the linearity of GaN/AlGaN high-electron mobility transistors (HEMTs) by optimizing barrier (AlGaN Layer) thickness or implementing doped GaN cap or a combination of both. HEMT devices with different epitaxial structures were simulated, fabricated, and measured to demonstrate this. Third-order intermodulation distortion and adjacent channel power ratio measurements were performed in order to compare linearity experimentally. A significant improvement of linearity is observed for an optimized architecture. [J181]

"Superconductor-to-Semiconductor Interface Circuit for High Data Rates"

We present a new kind of rapid-single-flux-quantum (RSFQ) output driver together with a pseudomorphic high electron mobility transistor (p-HEMT) amplifier both operating at liquid helium temperature. The passive interconnect including the interchip connection between the RSFQ output driver and the first transistor stage of the semiconductor amplifier is the key element for signal matching and was optimized for minimizing the reflections to the RSFQ circuit. The RSFQ output driver is based on a single-flux-quantum to dc converter and a voltage doubler. The circuit is realized in the Niobium based 1 kA/cm2process of FLUXONICS Foundry and provides up to 438-muV output voltage. We demonstrate high-speed experiments of the output driver in combination with two different semiconductor amplifier circuits at liquid helium temperature. The output voltage of a 2-Gb/s data stream was measured to be about 3.5 mV. [J182]

"Thermal Study of the High-Frequency Noise in GaN HEMTs"

The high-frequency noise performance of the GaN HEMT is studied for temperatures between 297-398 K. The access resistances RSand RDhave a limiting effect on the noise performance, and in this paper, their temperature dependence is studied in detail for a 2 times 100 mum GaN HEMT. RSand RDshow an increase of 0.71 and 0.86 %/K, respectively. The self-heating effect due to dissipated power is also studied to allow accurate intrinsic small-signal and noise parameter extraction. The thermal resistance is measured by infrared microscopy. Based on these results, a temperature dependent noise model including self-heating and temperature-dependent access resistances is derived and verified with measurements. [J183]

"Epitaxial Optimization of 130-nm Gate-Length InGaAs/InAlAs/InP HEMTs for Low-Noise Applications"

The epitaxial structure of 130- nm gate-length InGaAs/InAlAs/InP high electron mobility transistors (HEMTs) has been studied in order to optimize the device performance when biased under low-noise conditions. Three essential epitaxial parameters have been varied: the In channel content ([In]: 53%, 70%, and 80%), the delta-doping concentration (delta: 3, 5, and 7 times 1012cm-2), and the Schottky layer thickness (dSL: 9,11, and 13 nm). All HEMTs exhibited low gate-leakage current IGbelow 1 muA/mm at a low-noise bias, except dSL= 9 nm due to a too thin Schottky layer thickness. It was verified that the lowest noise figure NF was achieved when the square root of the drain-to-source current IDSover transconductance gmexhibited a minimum. A clear optimum for both dSland delta was observed with respect to minimum noise figure NFmin. Increasing [In] only provided a slight reduction in N-Fmin. In contrast, the RF performance was much more affected by increasing [In]. The lowest NFminwas achieved with a delta doping of 5 times 1012cm2and a dSLof 11 nm. [J184]

"High-Performance 0.1- Gate AlGaN/GaN HEMTs on Silicon With Low-Noise Figure at 20 GHz"

The realization of high-performance 0.1-mum gate AlGaN/GaN high-electron mobility transistors (HEMTs) grown on high-resistivity silicon substrates is reported. Our devices feature cutoff frequencies as high as fT= 75 GHz and fMAX= 125 GHz, the highest values reported so far for AlGaN/GaN HEMTs on silicon. The microwave noise performance is competitive with results achieved on other substrate types, such as sapphire and silicon carbide, with a noise figure F = 1.2-1.3 dB and an associated gain Gass= 8.0-9.5 dB at 20 GHz. This performance demonstrates that GaN-on-silicon technology is a viable alternative for low-cost millimeter-wave applications. [J185]

"Anomalous Kink Effect in GaN High Electron Mobility Transistors"

An anomalous kink effect has been observed in the room-temperature drain current IDversus drain voltage VDScharacteristics of GaN high electron mobility transistors. The kink is originated by a buildup (at low VDS) and subsequent release (at high VDS) of negative charge, resulting in a shift of pinch-off voltage VPtoward more negative voltages and in a sudden increase in ID. The kink is characterized by extremely long negative charge buildup times and by a nonmonotonic behavior as a function of photon energy under illumination. The presence of traps in the GaN buffer may explain both spectrally resolved photostimulation data and the slow negative charge buildup. [J186]

"N-Face GaN/AlGaN HEMTs Fabricated Through Layer Transfer Technology"

We present a new method to fabricate N-face GaN/AlGaN high electron mobility transistors (HEMTs). These devices are extremely promising for ultrahigh frequency applications where low contact resistances and excellent carrier confinement are needed. In this letter, the N-face of a Ga-face AlGaN/GaN epilayer grown on Si (111) is exposed by removing the Si substrate. To provide mechanical support, prior to the substrate removal, the Ga-face of the wafer is bonded to a Si (100) carrier wafer. The resultant N-face GaN/AlGaN heterostructures exhibited record transport properties (mue= 1670 cm2/Vmiddots, ns= 1.6 times 1013/ cm2, and Rsh= 240 Omega/sq). These excellent transport properties rendered N-face HEMTs with 30% higher maximum drain current than Ga-face HEMTs and good RF characteristics (fT= 10.7 GHz middotmum and fmax= 21.5 GHzmiddotmum), comparable to state-of-the-art Ga-face devices. [J187]

"A High-Linearity Single-Pole-Double-Throw Pseudomorphic HEMT Switch Based on Tunable Field-Plate Voltage Technology"

A high-isolation high-linearity GaAs pseudomorphic high-electron mobility transistor single-pole-double-throw microwave switch was developed using a tunable field-plate (FP) bias voltage technology. In this paper, a piece of FP metal was deposited between 0.15-mum-long gate and drain terminals. An extra FP-induced depletion region was generated to suppress the harmonics of switching associated with OFF-state operation. When switching into the ON-state, the FP switch is associated with an insertion loss similar to that of the standard

switch below 6 GHz. However, the isolation performance can be enhanced by 10 dB using an FP technology, which reduces the OFF-state capacitance that is produced by the extra FP-induced depletion region. The FP provides an additional mechanism to suppress the power of the second- and third-order harmonics in the OFF-state with slight ON-state insertion-loss degradation. [J188]

"Single-Chip Boost Converter Using Monolithically Integrated AlGaN/GaN Lateral Field-Effect Rectifier and Normally Off HEMT"

We demonstrate a single-chip switch-mode boost converter that features a monolithically integrated lateral field-effect rectifier (L-FER) and a normally off transistor switch. The circuit was fabricated on a standard AlGaN/GaN HEMT epitaxial wafer grown with GaN-on-Si technology. The fabricated rectifier with a drift length of 15 mum exhibits a breakdown voltage of 470 V, a turn-on voltage of 0.58 V, and a specific on-resistance of 2.04 mOmegaldrcm2. The L-FER exhibits no reverse recovery current associated with the turn-off transient because of its unipolar nature. A prototype of GaN-based boost converter that includes monolithically integrated rectifiers and transistors is demonstrated using conventional GaN-on-Si wafers for the first time to prove the feasibility of the GaN-based power IC technology. [J189]

"100 nm gate AlGaN/GaN HEMTs on silicon with fT = 90 GHz"

The realisation of 0.1 mum gate AlGaN/GaN high electron mobility transistors grown on high-resistivity silicon substrates is reported. A maximum current density of 750 mA/mm and an extrinsic transconductance of 225 mS/mm are achieved. The devices feature a record current gain cutoff frequency as high as fT=90 GHz, the highest value ever reported from a GaN-based device grown on a silicon substrate. The results demonstrate the great potential of GaN-on-silicon technology for low-cost millimetre-wave applications. [J190]

"Influence of Field Plate on the Transient Operation of the AlGaN/GaN HEMT"

In this letter, a link between the AlGaN/GaN high-electron-mobility-transistor (HEMT) field plate (FP) and the rate of reoccupation of surface traps is presented. Surface traps are considered to be among the primary factors behind HEMT performance deterioration at high frequencies. Results from simulations using the commercial software package DESSIS are presented, in which the FP is found to reduce trap reoccupation by limiting the tunneling injection of electrons into surface traps in the gate-drain region and thus considerably improve the transient operation of the device. [J191]

"AlN/GaN insulated gate HEMTs with HfO2 gate dielectric"

AlN/GaN single heterojunction MOS-HEMTs grown by molecular beam epitaxy have been fabricated utilising HfO2high-Kdielectrics deposited by atomic layer deposition. Typical DC transfer characteristics of 1.3 m gate length devices show a maximum drain current of 950 mA/mm and a transconductance of 210 mS/mm with gate currents of 5 A/mm in pinch-off. Unity gain cutoff frequencies, ftand fmax, were measured to be 9 and 32 GHz, respectively. [J192]

"AlGaN/GaN HEMT With a Transparent Gate Electrode"

AlGaN/GaN high-electron-mobility transistors (HEMTs) with indium tin oxide (ITO) transparent gate electrodes have been fabricated. The transparent gate electrodes enable the investigation of photon, electron, and phonon behaviors in active regions in HEMTs using optical characterizations such as electroluminescence, photoluminescence, and Raman spectroscopy technologies. Leakage current, on/off ratio, and transparency have been compared for transistors using Ni/Au/Ni, ITO, and Ni/ITO stacks as gate electrodes. Compared to the Ni/Au/Ni gate transistor, the ITO gate device shows a comparable current gain cutoff frequency (fT) but a much lower power gain cutoff frequency (fmax) due to the low conductivity of ITO. [J193]

"Effect of Parasitic Resistance and Capacitance on Performance of InGaAs HEMT Digital Logic Circuits"

In this brief, the impact of parasitic resistance and capacitance on InGaAs HEMT digital logic circuits is investigated via device simulations and circuit analysis. We present the correlation between device geometry and circuit delay for various structural scenarios. When the gate-to-S/D contact distance Lsgis scaled down to logic device standards, high integration density and additional circuit performance can be expected as compared with experimental devices that are demonstrated to date. This brief highlights the importance of engineering the device structure outside the channel region to achieve high device performance and device density. Scaled InGaAs HEMTs show superior performance over experimental devices and 27% less power consumption for the same circuit-speed constraint. [J194]

"Pulsed Active Load-Pull Measurements for the Design of High-Efficiency Class-B RF Power Amplifiers With GaN HEMTs"

A novel pulsed class-B load-pull measurement system is developed to characterize GaN HEMTs targeting the design of high-efficiency class-B or class-C power amplifiers operating under a pulsed-bias and pulsed-RF (pulsed-IV/RF) condition. Based on a large-signal network analyzer, the test system uses an active load-pull method to provide stable open-loop pulsed-RF loads into the drain at omega0and 2omega0while bypassing slow-memory effects. The load-pull measurement data obtained from AlGaN/GaN HEMTs under the class-B operation reveal that there exist optimal loads for pulsed-IV/RF condition, which differ from the ones found for a dc-IVand continuous wave condition. This is due to the avoidance of slow-memory effects in the pulsed-IV/RF load-pull measurements, which are known to degrade the device RF performance: a 2-dB increase in output power is obtained for a GaN HEMT on sapphire. The optimized pulsed-RF active load for a GaN HEMT on SiC demonstrates a power-added efficiency of 82% with 17.8-dBm output power under quasi class-B pulsed operation at 2 GHz. [J195]

"Effect of Dielectric Thickness on Power Performance of AlGaN/GaN HEMTs"

The effect of SiNxpassivation thickness on the power performance of AlGaN/GaN high-electron-mobility transistors (HEMTs) has been studied. A model is proposed to explain the surface-state dispersion and passivation of AlGaN/GaN HEMTs. Based on this model, a multidielectric passivation method has been proposed and demonstrated to both provide lower dielectric capacitance and help remove dc-RF dispersion. [J196]

"A MMIC Doubler Based on Novel Open/Short Stub Hybrids"

A new configuration of a balanced frequency PHEMT monolithic microwave integrated circuit doubler using open/short stub hybrids is proposed. With multi-coupled lines technology, the phase shifter is produced and applied to a Ka-band doubler successfully. As compared to the conventional lumped-element doubler, this phase shifter can make the doubler more compact in size and flexible in design. The doubler achieves an operation band width of 23 to 26 GHz with the best conversion loss of 7.4 dB at 25 GHz. In addition, the fundamental frequency suppression is better than 24.1 dB, and the chip dimension is as small as 0.85 times 1.1 mm2. [J197]

"Importance of the Gate-Dependent Polarization Charge on the Operation of GaN HEMTs"

We investigate the influence of the gate-voltage dependence of the polarization charge on the electron sheet charge density in the channel and how it reflects on the device transfer and output characteristics in GaN HEMTs. We find that a 10% increase in the polarization charge is needed to match the experimental data when the gate-voltage dependence of the polarization charge is included in the theoretical model. This information is important for calibration in commercial device simulators and for better understanding of the quality of the GaN/AlGaN interface. [J198]

"An Active IF Balun for a Doubly Balanced Resistive Mixer"

In this letter, we present a wideband active intermediate frequency (IF) balun for a doubly balanced resistive mixer implemented using a 0.5 mum GaAs pHEMT process. The 0.3 times 0.5 mm2IF balun was realized through a DC-coupled differential amplifier in order to extend IF frequency of the mixer to DC. The measured amplitude and phase imbalances were less than 1 dB and 5deg, respectively, from DC to 7 GHz. The output third order intercept (OIP3) and P1 dB of the IF balun were 18 dBm and 6 dBm, respectively at 1 GHz. The mixer with the IF balun is 1.7 times 1.8 mm2in size, has a conversion loss of 2 to 8 dB from 8 to 20 GHz RF frequency at a fixed IF of 1 kHz, which proves the mixer operates successfully at an IF frequency close to DC. The measured OIP3 were +10 to +15 dBm over the operating frequency with a DC power consumption of 370 mW. [J199]

"Tunable two-dimensional plasmon resonances in an InGaAs/InP high electron mobility transistor"

Voltage-tunable plasmon resonances in the two-dimensional electron gas (2DEG) of a high electron mobility transistor (HEMT) fabricated from the InGaAs/InP materials system are reported. The device was fabricated from a commercial HEMT wafer by depositing source and drain contacts using standard photolithography and a semitransparent gate contact that consisted of a 0.5mcmperiod transmission grating formed by electron-beam lithography. Narrow-band resonant absorption of terahertz radiation was observed in transmission in the frequency range of 10-50cm-1. The resonance frequency depends on the gate-tuned sheet charge density of the 2DEG. The observed separation of resonance fundamental from its harmonics and their shift with gate bias are compared with theory. [J200]

"Hybrid Large-Signal/Lumped-Element Electro-Thermal Modeling of GaN-HEMTs"

This paper shows a practical approach to GaN-based HEMT self-consistent electro-thermal simulation for circuit modeling and reliability estimation. A physical-level lumped element dynamic thermal network able to describe the 2-D device geometry is self-consistently coupled with a novel electro-thermal compact large-signal model. The results obtained with the lumped-element thermal network are compared with finite-element simulations and shown to provide valuable estimates of the thermal behavior of very large 2-D structures. Measured results taken at ambient temperatures between 200 and 400 K are shown to be well described by the model. [J201]

"-band Transmitter and Receiver for 10-Gb/s Impulse Radio With an Optical-Fiber Interface"

A W-band millimeter-wave transmitter and receiver that are based on impulse radio (IR) architecture were developed. The IR-based apparatuses have an optical-fiber input/output interface board that supports multi protocol signals (OC-192 and 10 GbE) and that implements a forward error correction (FEC), enabling 10-Gb/s data transmission both in space and fiber seamlessly. Analyzing an IR-based receiver model with simple on/off demodulation architecture, required signal-to-noise ratios were calculated for IR-based systems affected by various inter-symbol interference (ISI) levels. A millimeter-wave module used in the transmitter, consisting of a 6.5-ps pulse modulator with InP-based HEMTs and a band-pass filter formed on an alumina substrate, emitted wavelets, or RF pulses, with an average power of -26 dBm, occupying frequencies between 78-93 GHz. A front-end module used in the receiver, consisting of two cascaded low-noise amplifiers, an envelope detector, and a limiting amplifier, had a sensitivity of -36 dBm. In a back-to-back test where the transmitter and receiver were connected by a waveguide, disabling the FEC, error-free operation was achieved with a test pattern of PRBS 231-1 at the OC-192 compliant data rate of 9.95328 Gb/s. Furthermore, using a horn antenna and enabling the FEC, radio transmission and reception in a distance of 20 cm were confirmed with a bit error rate of less than 10-12. These results confirmed the basic technologies for simple and compact IR-based systems, which could be used as an alternative to fiber optic cables. [J202]

"Square-Gate AlGaN/GaN HEMTs With Improved Trap-Related Characteristics"

In this brief, the trap-related characteristics of high-breakdown AlGaN/GaN high-electron-mobility transistors (HEMTs) were investigated. Compared with a conventional multifinger layout, the square-gate design presented reduced the current collapse from 19% to 6% and almost eliminated the gate lag. The flicker noise density and the gate leakage decreased from 1.16 times10-10to 1.17 times10-111/Hz (f= 100 Hz) and from 7.36 times10-5to 1.80 times10-6A/mm (VGS= -4 V and VDS= 100 V), respectively. The breakdown voltage was also improved from 350 to 650 V. With the channel area away from the defects generated by the mesa etching process, the square-gate AlGaN/GaN HEMTs demonstrated excellent performance with much less trapping effects. [J203]

"Measurement of Channel Temperature in GaN High-Electron Mobility Transistors"

In this paper, a simple and reliable method to estimate the channel temperature of GaN high-electron mobility transistors (HEMTs) is proposed. The technique is based on electrical measurements of performance-related figures of merit (IDmaxand RON) with a synchronized pulsed I-Vsetup. As our technique involves only electrical measurement, no special design in device geometry is required, and packaged devices can be measured. We apply this technique to different device structures and validate its sensitivity and robustness. [J204]

"Ballistic Transport in InP-Based HEMTs"

Ballistic transport has been of interest in semiconductor devices for quite some time, and its effect has been used to predict quite-different device performance. Here, we investigate the role of ballistic transport in a short-channel InGaAs/InAlAs HEMT through full-band cellular Monte Carlo simulations. We can examine the contrast in behavior between when scattering mechanisms are present and when they are turned off. When the scattering processes are completely removed, the output characteristics show a distinct change in behavior over all drain voltages. This result is in qualitative agreement with prior arguments, suggesting that triodelike behavior should be expected due to enhanced drain-induced barrier lowering. However, we find that explicit band-structure effects are observable in the output characteristics of the ballistic transistor. We also find that this distinctive behavior gradually disappears as scattering is turned on, particularly in the drain end of the device. We also develop a method of determining the probability that electrons pass through the gate region in a ballistic manner in the presence of realistic scattering. Even when the gate is only 10 nm long, we find that this probability is only on the order of 50% in these devices. We also examine the ballistic ratio in our device as a function of gate length. [J205]

"Physics-Based Compact Model for AlGaN/GaN MODFETs With Close-Formed-and-Characteristics"

A set of explicit analytical solutions to the charge concentration, current, and capacitance characteristics of AlGaN/GaN MODFETs in different working regions is developed. First, a unified charge control expression applicable to both subthreshold regions and strong inversion regions is determined, while the parasitic channel effect in AlGaN layer is also taken into account. The onset voltage for this parasitic channel is estimated for the first time. Based on the improved charge control model, the current (Ids), the transconductance (gm), and the output conductance (gd) are given explicitly and are applicable in a wide bias range. Moreover, the gate-to-source capacitance (Cgs) and gate-to-drain capacitance (Cgd) have been obtained analytically under various applied biases, and, consequently, the cutoff frequency can be predicted. The present model shows good agreement with the experimental data and is useful for microwave circuit design and analysis. [J206]

"Mechanism of Increased High-Frequency Channel Noise With PECVD SiN Passivation in AlGaN/GaN HEMTs"

The effect of SiN surface passivation on high-frequency channel noise in AlGaN/GaN high-electron-mobility transistors on a high-resistivity Si substrate is investigated. It was observed that the channel noise increased after SiN surface passivation by plasma-enhanced chemical vapor deposition. The mean square of the channel noise voltage increased about three times at a bias of Vd= 12V and Id= 120 A/mm. Based on the analysis on the noise source components in the channel region, it is believed that the channel noise increase is mainly due to the modification of the lateral electrical field profile by surface passivation. The modification of the lateral electrical field profile after passivation is verified by the 2-D numerical simulation and the observation that the gate leakage increases and the breakdown voltage decreases. The measured correlation coefficient between the channel noise and the gate noise agrees with the proposed mechanism of the electrical field profile modification by surface passivation. [J207]

"Low-Voltage and High-Speed Operations of 30-nm-Gate Pseudomorphic HEMTs Under Cryogenic Conditions"

In this letter, we fabricated 30-nm-gate pseudomorphic In0.52Al0.48As/In0.7Ga0.3As HEMTs with multilayer cap structures to reduce source and drain parasitic resistances; we measured their dc and radio-frequency characteristics at 300, 77, and 16 K under various bias conditions. The maximum cutoff frequency fT was 498 GHz at 300 K and 577 GHz at 77 K. The maximum fT exceeded 600 GHz at 16 K. Even at a drain-source voltage Vdsof 0.4 V, we obtained an fTof 500 GHz at 16 K. This indicates that cryogenic HEMTs are favorable for low-voltage and high-speed operations. Furthermore, the present 30-nm-gate HEMTs at 300 K show almost the same fT values at the same dc-power dissipation as compared to 85-nm-gate InSb-channel HEMTs. The improvement of the maximum-oscillation-frequency fmaxvalues was also observed at 77 and 16 K. [J208]

"Evaluation and Numerical Simulations of GaN HEMTs Electrical Degradation"

In this letter, the effects of dc stress on GaN high-electron-mobility transistors' performance are investigated by means of experimental measurements and numerical simulation. A degradation of both dynamic (pulsed I-V) and static characteristics (dc) has been observed on stressed devices, and it has been experimentally related to the formation of an electron trap in the AlGaN barrier layer. Numerical simulations carried out on the tested structure by introducing a trapping region at the gate edge of the device barrier confirm the experimentally observed device degradation. The worsening of the dynamic performance is induced by both an increase in trap concentration and/or depth of the trapping region while the degradation of the dc characteristics can be explained by an increase in the trapping-region depth. [J209]

"Tuning in to RF MEMS"

RF MEMS technology was initially developed as a replacement for GaAs HEMT switches and p-i-n diodes for low-loss switching networks and X-band to mm-wave phase shifters. However, we have found that its very low loss properties (high device Q), its simple microwave circuit model and zero power consumption, its high power (voltage/current) handling capabilities, and its very low distortion properties, all make it the ideal tuning device for reconfigurable filters, antennas and impedance matching networks. In fact, reconfigurable networks are currently being funded at the same level-if not higher-than RF MEMS phase shifters, and in our opinion, are much more challenging for high-Q designs. [J210]

"Dedicated Large-Signal GaN HEMT Model for Switching-Mode Circuit Analysis and Design"

A novel large-signal gallium nitride (GaN) high electron mobility transistor (HEMT) model that focuses on and

improves analysis and design of switching-mode power amplifiers (PAs) is presented in this letter. The proposed model can be constructed using standard DC and AC characterization measurements and easily implemented in any computer-aided design (CAD) software to simulate and design switching-mode amplifiers. The model can predict the behavior of a switching-mode PA accurately at saturation and, due to the proposed approach, also well in the weak compression region. Using the developed model, an inverse class-F PA is designed and fabricated for validation purposes. The prototype developed using the proposed model achieved power-added efficiency (PAE) of 67% for an output power of 36.7 dBm at 2.35 GHz. Comparison between simulation and measured results of the manufactured PA proves the validity and accuracy of the proposed model. [J211]

"A Wideband Power Amplifier MMIC Utilizing GaN on SiC HEMT Technology"

The design and performance of a wideband power amplifier MMIC suitable for electronic warfare (EW) systems and other wide bandwidth applications is presented. The amplifier utilizes dual field plate 0.25- mum GaN on SiC device technology integrated into the three metal interconnect (3 MI) process flow. Experimental results for the MMIC at 30 V power supply operation demonstrate greater than 10 dB of small signal gain, 9 W to 15 W saturated output power and 20% to 38% peak power-added efficiency over a 1.5 GHz to 17 GHz bandwidth. [J212]

"A Cool, Sub-0.2 dB Noise Figure GaN HEMT Power Amplifier With 2-Watt Output Power"

This paper reports on a S-, C-band low-noise power amplifier (LNPA) which achieves a sub-0.2 dB noise figure (NF) over a multi-octave band and a saturated output power (Psat) of 2 W at a cool temperature of -30degC . The GaN MMIC is based on a 0.2 mum AlGaN/GaN-SiC HEMT technology with an fT~ 75 GHz. At a cool temperature of -30degC and a power bias of 15 V-400 mA, the MMIC achieves 0.25-0.45 dB average NF over a 2-8 GHz band and a linear P1dBof 32.8 dBm (~ 2 W) with 25% power-added efficiency (PAE). At a medium bias of 12 V-200 mA, the amplifier achieves 0.1-0.2 dB average NF across the same band and a P1dBof 32.2 dBm (1.66 W) with 35% PAE. The corresponding saturated output power is greater than 2 W. At a low noise bias of 5 V-200 mA, a remarkable 0.05-0.15 dB average NF is achieved with a P1dB> 24 dBm and PAE ~ 33%. These results are believed to be the lowest NF ever reported for a multi-octave fully matched MMIC amplifier capable of > 2 W of output power. [J213]

"An AlN/Ultrathin AlGaN/GaN HEMT Structure for Enhancement-Mode Operation Using Selective Etching"

A novel device structure incorporating an ultrathin AlGaN barrier layer capped by an AlN layer in the source-drain access regions has been implemented to reliably control threshold voltage in AlGaN/GaN high-electron-mobility transistors. A recessed-gate structure has been used to decrease 2-D electron gas (2DEG) density under the gate, thus controlling threshold voltage while maintaining low on-resistance and high current density. The structure presented in this letter implements an ultrathin AlGaN structure grown by metal-organic chemical vapor deposition capped with AlN to maintain a high 2DEG density in the access regions. A selective wet etch using heated photoresist developer is used to selectively etch the AlN layer in the gate region to the AlGaN barrier. We have demonstrated a repeatable threshold voltage of +0.21 V with 4-nm AlGaN barrier layer thickness. [J214]

"AlGaN channel HEMTs on AlN buffer layer with sufficiently low off-state drain leakage current"

The buffer layer in AlGaN channel HEMTs to suppress the off-state drain leakage current is investigated. By employing an AlN for the buffer layer in Al0.39Ga0.61N/Al0.16Ga0.84N HEMTs, the off-state drain leakage current was sufficiently suppressed and the breakdown voltage was enhanced. It was considered that employing the AlN for the buffer layer is important for extracting the superior material properties of the AlGaN in the channel layer. [J215]

"Impact of Proton Irradiation-Induced Bulk Defects on Gate-Lag in GaN HEMTs"

The relationship between proton-induced defects and gate-lag in GaN high-electron mobility transistors (HEMTs) is examined using simulations and experiments. Surface traps are primarily responsible for the pre-irradiation gate-lag. Experimental data and detailed two-dimensional device simulations demonstrate that bulk traps increase the amount of observed gate-lag after irradiation to high-proton fluences. [J216]

"A Wideband Multiharmonic Empirical Large-Signal Model for High-Power GaN HEMTs With Self-Heating and Charge-Trapping Effects"

A complete empirical large-signal model for high-power AlGaN/GaN HEMTs (GaN HEMT) utilizing an improved

drain current (Ids) formulation with self-heating and charge- trapping modifications is presented. The new drain current equation accurately models the asymmetric bell-shaped transconductance (gm) for high Idsover a large range of biases. A method of systematically employing dynamic IV behavior using pulsed-gate IV and pulsed-gate-pulsed-drain IV datasets over a wide variety of thermal and charge-trapping conditions is presented. The composite nonlinear model accurately predicts the dynamic IV behavior, S-parameters up to 10 GHz, and large-signal wideband harmonic behavior for a multitude of quiescent gate-source and drain-source biases as well as third-order intermodulation distortion (IM3). [J217]

"Analysis of degradation mechanisms in lattice-matched InAlN/GaN high-electron-mobility transistors"

We address degradation aspects of lattice-matched unpassivated InAlN/GaN high-electron-mobility transistors (HEMTs). Stress conditions include an off-state stress, a semi-on stress (with a partially opened channel), and a negative gate bias stress (with source and drain contacts grounded). Degradation is analyzed by measuring the drain current, a threshold voltage, a Schottky contact barrier height, a gate leakage and an ideality factor, an access, and an intrinsic channel resistance, respectively. For the drain-gate bias 38Vparameters are only reversibly degraded due to charging of the pre-existing surface states. This is in a clear contrast to reported AlGaN/GaN HEMTs where an irreversible damage and a lattice relaxation have been found for similar conditions. For drain-gate biases over 38 V InAlN/GaN HEMTs show again only temporal changes for the negative gate bias stresses; however, irreversible damage was found for the off-state and for the semi-on stresses. Most severe changes, an increase in the intrinsic channel resistance by one order of magnitude and a decrease in the drain current by 70%, are found after the off-state 50Vdrain-gate bias stresses. We conclude that in the off-state condition hot electrons may create defects or ionize deep states in the GaN buffer or at the InAlN/GaN interface. If an InAlN/GaN HEMT channel is opened during the stress, lack of the strain in the barrier layer is beneficial for enhancing the device stability. [J218]

"Impact of uniaxial strain on n-channel In 0.15 Ga 0.85 As high electron mobility transistors"

This letter reports on a study of the impact of uniaxial strain on the characteristics of InGaAs high electron mobility transistors (HEMT) by bending GaAs chips up to a strain level of 0.4%. Systematic changes in the threshold voltage and intrinsic transconductance were observed. These changes can be well predicted by Schrodinger-Poisson simulations of the one-dimensional electrostatics of the device that include the piezoelectric effect, Schottky barrier height change, and sub-band quantization change due to strain. The effect of strain on the device electrostatics emerges as a dominant effect over that of transport in the studied InGaAs HEMTs. [J219]

"Stable AlGaN/GaN high electron mobility transistors with tungsten nitride gate metallisation"

An AlGaN/GaN high electron mobility transistor (HEMT) with tungsten nitride (WNx) Schottky gate fabricated on a sapphire substrate is presented. Gate forward current stress was chosen to evaluate the stability of the Schottky gate. After stress, this WNxHEMT remains stable, while the conventional Ni/Au HEMT shows performance degradation and failure. The maximum output power density from this device is 5 W/mm at 2 GHz. A combination of these findings indicates the robust performance of this WNxmaterial and its potential as a Schottky gate for AlGaN/GaN HEMTs. [J220]

"Dependence of GaN HEMT Millimeter-Wave Performance on Temperature"

This paper presents extensive thermal characterization of recently fabricated high-performance millimeter-wave GaN/SiC devices from four sources across temperature (-25??C to + 125??C). The changes with temperature for: output power at millimeter-wave frequencies (Pout), pinchoff voltage (Vp), knee-voltage (Vk), onresistance (Ron), power-added efficiency (PAE), saturated drain current (Idss), power gain (G), and transconductance (gm) are measured, statistics studied, and correlations investigated. Temperature-coefficients are established for Pout, Vp, Vk, Ron, PAE, Idss, G, and gmin GaN technology. The main findings are: 1) Pout's temperature dependence can be negative or positive, opposite of G's and Idss's strong negative temperature dependence, and 2) the pinchoff voltage's dependence on temperature is very weak. The results obtained provide monolithic microwave integrated circuit designers with key information required for meeting performance over a wide temperature range. [J221]

"Source access impedance model for AlGaN/ GaN HEMTs"

Thermal noise caused by source parasitic impedance (Rs) is one of the most important noise mechanisms in AlGaN/GaN HEMTs. A physical based frequency dependent Rsmodel is proposed. This model has been implemented in the PUCEL model for validation purpose, and the results show that the minimum noise figure

(Fmin) of an AlGaN/GaN HEMT is not linear but nonlinear against frequency. [J222]

"A 18 GHz Broadband Stacked FET Power Amplifier Using 130 nm Metamorphic HEMTs"

A broadband power amplifier (PA) with a 3 dB power bandwidth of 72% is presented using metamorphic high electron mobility transistors (mHEMTs). A stacked FET structure, where transistors are series connected to combine voltage swings, is employed to overcome relatively low breakdown voltages of mHEMTs. Series-connected PA's show much higher load impedance compared to the parallel combined transistors, which allows output matching to be realized in the low quality (Q)-factor region, providing the broadband performance. The fabricated PA using quadruple-stacked 130 nm mHEMTs has a gain of 21.2 dB and saturated output power of 26.4 dBm with power added efficiency (PAE) of 33% at the design frequency of 18 GHz. The 3 dB output power bandwidth is from 10 to 23 GHz. [J223]

"Gate-First AlGaN/GaN HEMT Technology for High-Frequency Applications"

This letter describes a gate-first AlGaN/GaN high-electron mobility transistor (HEMT) with a W/high-kdielectric gate stack. In this new fabrication technology, the gate stack is deposited before the ohmic contacts, and it is optimized to stand the 870degC ohmic contact annealing. The deposition of the W/high-kdielectric protects the intrinsic transistor early in the fabrication process. Three different gate stacks were studied: W/ HfO2, W/Al2O3, and W/HfO2/Ga2O3. DC characterization showed transconductances of up to 215 mS/mm, maximum drain current densities of up to 960 mA/mm, and more than five orders of magnitude lower gate leakage current than in the conventional gate-last Ni/Au/Ni gate HEMTs. Capacitance-voltage measurements and pulsed-IVcharacterization show no hysteresis for the W/HfO2/ Ga2O3capacitors and low interface traps. These W/high-kdielectric gates are an enabling technology for self-aligned AlGaN/GaN HEMTs, where the gate contact acts as a hard mask to the ohmic deposition. [J224]

"Simultaneous measurement of temperature and thermal stress in AlGaN/GaN high electron mobility transistors using Raman scattering spectroscopy"

Raman spectroscopy, utilizing both the GaN E2and A1(LO)phonon modes, has been used to simultaneously probe temperature and thermal stress in operating AlGaN/GaN high electron mobility transistors (HEMTs). Temperature and thermal stress profiles across the active region of an AlGaN/GaN HEMT were determined. The results were found to be in good agreement with thermal and thermomechanical simulations. The maximum temperature rise and thermal stress measured in the GaN layer are located close to the drain edge of the gate contact, reaching 240 °Cand -0.37 GPa, respectively, for a power dissipation of 25 W/mm (40 V). [J225]

"Electrothermal Large-Signal Model of III-V FETs Including Frequency Dispersion and Charge Conservation"

An empirical large-signal III-V field-effect transistor (FET) model has been developed. Three improved drain-source current (I-V) modeling equations capable of representing arbitrarily shaped transconductance (Gm) curves are proposed from level-1 to level-3. These models are characterized by the static dc and the multibias pulsed I-Vmeasurements along with their dependences on temperature, so as to account for the frequency dispersion and the self-heating effects. By partitioning the Gmplots into five regions, specific parameters of the various model levels can be directly associated with the regions. Besides, the fitting parameters have inherent consistent definitions among different model levels, where some of the key model parameters can be extracted directly from measurements. For the gate-charge formulation (Q-V), a novel charge-conservative gate charge model is presented to accurately trace the nonlinear gate-source (Cgs) and gate-drain (Cgd) capacitance values. The comprehensive large-signal model is then validated by comparing the predicted I-V, C-V, S-parameters as well as power characteristics with the measured results of III-V FETs. [J226]

"Design and Analysis of Ultra Wideband GaN Dual-Gate HEMT Low-Noise Amplifiers"

In this paper, we present three ultra wide bandwidth low-noise amplifiers (LNAs) using dual-gate AlGaN/GaN HEMT devices. The single-stage, resistive feedback amplifiers target two different frequency bands: two LNAs operate in 0.3-4 GHz and one LNA is in 1.2-18 GHz. All three LNAs are capable of better than 13:1 bandwidth. The first low frequency amplifier uses a microstrip design and achieves 17.7 dB flat gain between 300 MHz-3 GHz, and 1.2 dB minimum noise figure around 1.3 GHz. The second 0.3-4 GHz LNA uses coplanar waveguide transmission lines and demonstrates 18 dB flat gain and 1.5 dB noise figure between 2 and 5 GHz. The high frequency microstrip-type LNA shows an average of 13 dB gain and between 2-3 dB noise figure across the band. The robust LNAs can be operated under various bias voltages while similar gain and noise figure performance are maintained. [J227]

"Gate-Recessed InAlN/GaN HEMTs on SiC Substrate With Passivation"

We studied submicrometer (LG= 0.15-0.25 ??m) gate-recessed InAlN/AlN/GaN high-electron mobility transistors (HEMTs) on SiC substrates with 25-nm Al2O3passivation. The combination of a low-damage gate-recess technology and the low sheet resistance of the InAlN/AlN/GaN structure resulted in HEMTs with a maximum dc output current density of IDS,max= 1.5 A/mm and a record peak extrinsic transconductance of gm,ext= 675 mS/mm. The thin Al2O3passivation improved the sheet resistance and the transconductance of these devices by 15% and 25%, respectively, at the same time that it effectively suppressed current collapse. [J228]

"MOCVD-Grown AlGaN Buffer GaN HEMTs With V-Gates for Microwave Power Applications"

We report the performance of AlGaN buffer GaN high-electron mobility transistors (HEMTs) grown by metal-organic chemical vapor deposition. GaN HEMTs on high-quality AlGaN buffer were grown on SiC substrates. The incorporation of an AlGaN buffer into the GaN HEMT significantly improves channel confinement and suppresses the short-channel effect. Advanced deep-recess V-gate structures were employed to optimize the device for better microwave power performance. With a 10- nm GaN channel layer sandwiched between the AlGaN barrier and buffer, excellent power performance was achieved. The output power density is 13.1 W/mm, and the associated power-added efficiency is 72% at 4-GHz frequency and 48- V drain bias. This power performance is comparable to the state-of-the-art GaN HEMTs grown on GaN buffers, indicating that the AlGaN buffer in our optimized device structure does not introduce any noticeable trapping. [J229]

"Influence of Dynamic Access Resistances on the Linearity of Large GaN HEMT Powerbars"

This paper presents a study of the dynamic access resistance related nonlinearity of GaN HEMT devices with very large periphery. The bias-dependent access resistance is deembeded to the chip reference plane. Our measurement results show that the bias dependence for such a large device is insignificant, at least within the investigated 2 GHz frequency band. Instead, the main source of nonlinearity is the current source. Quantitatively, linearity measurements reveal a good linear behavior of these devices. [J230]

"Adsorption-Controlled Growth of BiFeO3 by MBE and Integration with Wide Band Gap Semiconductors"

BiFeO3thin films have been deposited on (001) SrTiO3, (101) DyScO3, (011) DyScO3, (0001) AlGaN/GaN, and (0001) 6H-SiC single crystal substrates by reactive molecular beam epitaxy in an adsorption-controlled growth regime. This is achieved by supplying a bismuth over-pressure and utilizing the differential vapor pressures between bismuth oxides and BiFeO3to control stoichiometry in accordance with thermodynamic calculations. Four-circle x-ray diffraction and transmission electron microscopy reveal phase-pure, epitaxial films with rocking curve full width at half maximum values as narrow as 7.2 arc seconds (0.002deg). Epitaxial growth of (0001)-oriented BiFeO3thin films on (0001) GaN, including AlGaN HEMT structures, and (0001) SiC has been realized using intervening epitaxial (111) SrTiO3/ (100) TiO2buffer layers. The epitaxial BiFeO3thin films have 2 in-plane orientations: [1120] BiFeO3|| [112macr0] GaN (SiC) plus a twin variant related by a 180deg in-plane rotation. This epitaxial integration of the ferroelectric with the highest known polarization, BiFeO3, with high bandgap semiconductors is an important step toward novel field-effect devices. [J231]

"Gate-Recess Technology for InAs/AlSb HEMTs"

The gate-recess technology for Si delta-doped InAs/AlSb high-electron-mobility transistors (HEMTs) has been investigated by combining atomic force microscopy (AFM) inspection of the gate-recess versus time with electrical device characterization. Deposition of the gate metal on the In0.5Al0.5As protection layer or on the underlying AlSb Schottky layer resulted in devices suffering from high gate-leakage current. Superior dc and high frequency device performance were obtained for HEMTs with an insulating layer between the gate and the Schottky layer resulting in a reduction of the gate leakage current IGby more than two orders of magnitude at a drain-to-source voltage VDS of 0.1 V. The existence of this intermediate insulating layer was evident from the electrical measurements. AFM measurements suggested that the insulating layer was due to a native oxidation of the AlSb Schottky layer. The insulated-gate HEMT with a gate length of 225 nm exhibited a maximum drain current IDhigher than 500 mA/mm with good pinchoff characteristics, a dc transconductance gmof 1300 mS/mm, and extrinsic values for cutoff frequency fTand maximum frequency of oscillation fmaxof 160 and 120 GHz, respectively. [J232]

"A 1-20-GHz Broadband MMIC Demodulator for Low IF Receivers in Multistandard Applications"

This paper presents the design and performance of a 1-20-GHz broadband demodulator for low IF receivers dedicated to multistandard applications. Unlike the conventional in-phase/quadrature (I/Q) demodulator, this

circuit uses three paths 120deg phase shifted from one another instead of only two 90deg phase shifted I and Q paths. This feature makes the proposed demodulator less sensitive to phase mismatch and permits to achieve very broadband operation. Demodulated quadrature phase-shift keying constellation diagrams are presented to illustrate our purpose, although in practice our demodulator is not restricted to a particular modulation type. The circuit achieves a measured conversion gain better than -8 dB and its sensitivity reaches -65 dBm at 5.8 GHz. The 2 mm times 3 mm chip was fabricated using the ED02AH process (0.25-mum GaAs enhancement/depletion mode pseudomorphic HEMT) provided by the OMMIC foundry. To the best of our knowledge, this is the first demodulator operating in such a broad frequency range reported to date. [J233]

"AlGaN/GaN HEMT With Integrated Recessed Schottky-Drain Protection Diode"

We present an AlGaN/GaN high-electron mobility transistor (HEMT) with an integrated recessed protection diode on the drain side of the transistor channel. Results from our Schottky-drain HEMT demonstrate an excellent reverse blocking with minor tradeoff in the on-state resistance for the complete device. The excellent quality of the forward diode characteristics indicates high robustness of the recess process. The reverse blocking capability of the diode is better than-110 V. Physical-based device simulations give an insight in the respective electronic mechanisms. This is the first time that a recessed Schottky-drain diode integrated in a HEMT device is presented. [J234]

"A High-Efficiency GaN-Based Power Amplifier Employing Inverse Class-E Topology"

A high efficiency, GaN based power amplifier (PA) employing the inverse class-E topology is reported. The parasitic inductance and large output capacitance of the packaged active device are used as the series inductance and compensated by a shunt inductor, respectively. The composite right/left-handed transmission line is used as a harmonic control network. For the experimental validation, an inverse class-E PA is designed using a GaN HEMT and tested with a continuous wave at 1 GHz. From the measured results, the drain efficiency and power-added efficiency (PAE) of 79.7% and 78.8% with a gain of 19.03 dB is achieved at an output power of 41.03 dBm. Also, the inverse class-E PA can deliver the output power and PAE of over 40.8 dBm and 65% through the bandwidth of 100 MHz. [J235]

"Development of enhancement mode AlN/GaN high electron mobility transistors"

Enhancement mode AlN/GaN high electron mobility transistors (HEMTs) were fabricated from originally depletion-mode structures using oxygen plasma treatment on the gate area prior to the gate metallization. Starting with a depletion mode AlN/GaN HEMT, the threshold voltage of the HEMT could be shifted from -3.2 to 1 V depending on the oxygen plasma treatment time to partially convert the AlN barrier layer into Al oxide. The gate current was reduced and the current-voltage curves show metal-oxide semiconductor diodelike characteristics after oxygen plasma treatment. [J236]

"Frequency performance enhancement of AlGaN/GaN HEMTs on diamond"

The performance of an AlGaN/GaN high electron mobility transistor (HEMT) on diamond substrate is reported. Presented is a device with a gate footprint LG=40 nm and a periphery WG= 100 mum that exhibits fT= 85 GHz and fmax= 95 GHz. It is believed that this represents the best frequency performance of a GaN-on-diamond HEMT. [J237]

"HEMT-Based Readout Technique for Dark- and Photon-Count Studies in NbN Superconducting Single-Photon Detectors"

Dark counts in superconducting single-photon detectors (SSPDs) manifest themselves as spontaneous, transient voltage pulses, typically indistinguishable from photon counts. We present here a new readout technique based on integrating the SSPD with a low-noise, cryogenic high-electron-mobility transistor (HEMT) with high-input impedance. This arrangement allowed us to achieve amplitude resolution of the recorded output transients. In two-dimensional superconducting nanostripes, the physics of photon counting is based on the hotspot formation mechanism, while the dark counts correspond to voltage transients triggered by the vortex-antivortex motion and/or phase-slip centers. Thus, their respective transients can be distinguished by comparing the output pulse amplitude distributions. Our scheme also allowed us to perform photon-energy-resolution studies by comparing the SSPD output pulse amplitude distributions (the mean pulse amplitude and the distribution width) collected for incident single photons with different energies. [J238]

"Cryogenic Semiconductor Amplifier for RSFQ-Circuits With High Data Rates at 4.2 K"

The connection of RSFQ circuits with commercial room temperature electronics and amplifying SFQ pulses with

high data rates require cryogenic interface amplifiers. Such amplifiers should provide extremely high bandwidth, low noise and low power consumption at the same time. Various hybrid amplifiers based on commercial p-HEMT transistors in an embedded microwave design were designed and characterized. Towards the p-HEMT transistor characterization at cryogenic temperature the biasing settings according to an optimum between voltage gain and low power consumption were determined. Thus a total power consumption of 2 mW and a voltage gain of 12 dB per single stage were achieved. For a preamplifier and an amplifier concept a multiple number of these stages were implemented in a microstrip and a coplanar transmission line design with a special matched interconnect taper towards the RSFQ components. Measurements of the amplifiers, the combination of an amplifier with a RSFQ circuit at 4.2 K showed their good performances without any disturbance of the RSFQ circuit. Due to the losses between the stages a total gain of 25 dB with a four stage amplifier was achieved; pulse rates went up to 3 Gb/s. The total power consumption was in the range of 8 mW. Further increase of data rates will be achieved by improving the matching between RSFQ output stage and amplifier. [J239]

"High-Performance N-Face GaN Microwave MIS-HEMTs With >70% Power-Added Efficiency"

A high-performance N-face GaN metal-insulator-semiconductor high-electron-mobility transistor was fabricated. A dual-AlN back-barrier scheme was developed using polarization engineering to provide a large total dipole moment, which allowed enhanced modulation doping for a higher 2-D electron gas density without parallel conduction. Devices with 0.6-mum gate length showed an fTand fmaxof 17 and 58 GHz, respectively. A highest power-added efficiency (PAE) of 71% at 4 GHz was measured in these devices with 20-V drain bias. At 28 V, an output power density of 6.4 W/mm with 67% PAE was achieved. [J240]

"Ku-band high-power amplifier MMIC with on-chip gate biasing circuit"

A new active bias scheme for GaAs HEMT high-power amplifier (HPA) MMICs is proposed that compensates variation of gate threshold voltage and temperature. The quiescent currents of the amplifier were estimated within Г,В±0.7Г,В± when the threshold voltage varied from Г,В±0.3 to 0.3Г,В±V. Also, the measured quiescent currents were increased with temperature, providing compensation of temperature variations. A Ku-band HPA, using 0.5Г,В±Г,В±m GaAs pHEMT processes, was fabricated to demonstrate the suggested bias topology. [J241]

"102-GHz AlInN/GaN HEMTs on Silicon With 2.5-W/mm Output Power at 10 GHz"

Grown on a (111) high-resistivity silicon substrate, 0.1-mum gate AlInN/GaN high-electron mobility transistors (HEMTs) achieve a maximum current density of 1.3 A/mm, an extrinsic transconductance of 330 mS/mm, and a peak current gain cutoff frequency as high as fT= 102 GHz, which is the highest value reported so far for nitride-based devices on silicon substrates, as well as for any AlInN/GaN-based HEMT regardless of substrate type. Continuous-wave power measurements in class-A operation at 10 GHz with VDS= 15 V revealed a 19-dB linear gain, a maximum output power density of 2.5 W/mm with an ~23% power-added efficiency (PAE), and a 9-dB large-signal gain. At VDS= 8 V, the output power is 1 W/mm, and the peak PAE reaches 50%. Results demonstrate the interest of AlInN/GaN on silicon HEMT technology for low-cost millimeter-wave and high-power applications. [J242]

"High-Temperature Microwave Performance of Submicron AlGaN/GaN HEMTs on SiC"

The effect of temperature on the small-signal radio-frequency (RF) performance of submicron AlGaN/GaN high-electron-mobility transistors on SiC has been studied from room temperature (RT) up to 600 K. A relation between ambient and channel temperatures has been established by means of finite-element simulations. The thermal behavior of the intrinsic parameters Cgs, Cgd, gm, int, and gdshas been extracted accurately from RF measurements by means of the small-signal equivalent circuit. Main dc parameters (ID, gm, ext) show reductions close to 50% between RT and 600 K, mainly due to the decrease in the electron mobility and drift velocity. In the same range, fTand fmaxsuffer a 60% decrease due to the reduction in gm, ext and a slight increase of Cgsand Cgd. An anomalous thermal evolution of Cgdat low IDhas been identified, which is indicative of the presence of traps. [J243]

"Seamless On-Wafer Integration of Si(100) MOSFETs and GaN HEMTs"

The first on-wafer integration of Si(100) MOSFETs and AlGaN/GaN high electron mobility transistors (HEMTs) is demonstrated. To enable a fully Si-compatible process, we fabricated a novel Si(100)-GaN-Si(100) virtual substrate through a wafer bonding and etch-back technique. The high thermal stability of nitride semiconductors allowed the fabrication of Si MOSFETs on this substrate without degrading the performance of the GaN epilayers. After the Si devices were fabricated, the nitride epilayer is exposed, and the nitride transistors are processed. By using this technology, GaN and Si devices separated by less than 5 mum from each other have been fabricated, which is suitable for building future heterogeneous integrated circuits. [J244]

"Demonstration of Low-Leakage-Current Low-On-Resistance 600-V 5.5-A GaN/AlGaN HEMT"

This letter demonstrates a high-voltage, high-current, and low-leakage-current GaN/AlGaN power HEMT with HfO2as the gate dielectric and passivation layer. The device is measured up to 600 V, and the maximum on-state drain current is higher than 5.5 A. Performance of small devices with HfO2and Si3N4dielectrics is compared. The electric strength of gate dielectrics is measured for both HfO2and Si3N4. Devices with HfO2show better uniformity and lower leakage current than Si3N4passivated devices. The 5.5-A HfO2devices demonstrate very low gate (41 nA/mm) and drain (430 nA/mm) leakage-current density and low on-resistance (6.2 Omegamiddotmm or 2.5 mOmegamiddotcm2). [J245]

"SiN-passivated Gamma -gate Al 0.27 Ga 0.73 N /GaN high electron mobility transistors by using a shifted exposure method"

Effective gate-length reduction, surface passivation, and a field-plate structure upon the gate-drain region of a Gamma -gate Al0.27Ga0.73N/GaNhigh electron mobility transistor (HEMT) have been achieved at the same time. The present SiN-passivated device with a 0.6mcmgate length and a 0.6mcmlong field plate has demonstrated superior dc and rf characteristics as compared to a conventional-gated structure. Physical insights of device performance with respect to different SiN layer thicknesses are also investigated. [J246]

"Ultrathin InAlN/AlN Barrier HEMT With High Performance in Normally Off Operation"

We present GaN-based high electron mobility transistors (HEMTs) with a 2-nm-thin InAlN/AlN barrier capped with highly doped n++GaN. Selective etching of the cap layer results in a well-controllable ultrathin barrier enhancement-mode device with a threshold voltage of +0.7 V. The n++GaN layer provides a 290-Omega/square sheet resistance in the HEMT access region and eliminates current dispersion measured by pulsed IVwithout requiring additional surface passivation. Devices with a gate length of 0.5-mum exhibit maximum drain current of 800 mA/mm, maximum transconductance of 400 mS/mm, and current cutoff frequency fTof 33.7 GHz. In addition, we demonstrate depletion-mode devices on the same wafer, opening up perspectives for reproducible high-performance InAlN-based digital integrated circuits. [J247]

"An Optically Clocked Transistor Array for High-Speed Asynchronous Label Swapping: 40 Gb/s and Beyond"

We describe the development of an optically clocked transistor array (OCTA) interface device for label swapping high-speed asynchronous burst optical packets. The OCTA integrates the three critical functions of serial-to-parallel (SP) conversion, parallel-to-serial (PS) conversion, and clock-pulse generation into a simple optoelectronic integrated circuit (OEIC) to create a single-chip interface between the input/output baseband optical labels and a CMOS label processor. The result is a high-performance label swapping solution which is compact and low power. In this paper, a detailed investigation of the design and optimization of the circuit is first performed, followed by testing of device stability under subsystem operating conditions. Finally, demonstrations of single-channel switching speeds allowing greater than 100-Gb/s operation, 40-Gb/s SP and PS conversion with an eight-channel OCTA, and error-free label swapping of 10-Gb/s asynchronous optical packets with a prototype label swapper module are described. [J248]

"Barrier-Layer Scaling of InAlN/GaN HEMTs"

We discuss the characteristics of high-electron mobility transistors with barrier thicknesses between 33 and 3 nm, which are grown on sapphire substrates by metal-organic chemical vapor deposition. The maximum drain current (at VG= 2.0 V) decreased with decreasing barrier thickness due to the gate forward drive limitation and residual surface-depletion effect. Full pinchoff and low leakage are observed. Even with 3-nm ultrathin barrier, the heterostructure and contacts are thermally highly stable (up to 1000degC). [J249]

"Plasma Waves Subterahertz Optical Beating Detection and Enhancement in Long-Channel High-Electron-Mobility Transistors: Experiments and Modeling"

A photomixed laser beam of two 1.55 mum continuous-wave lasers is used for interband photoexcitation in submicron gate length InAlAs/InGaAs transistors. Results show the clear excitation of plasma oscillation modes in the transistor channel. A strong amplification of the optical beating detection in the 0-600 GHz range is observed as a function of drain-source voltage. Numerical results, using hydrodynamic model coupled to a pseudo-2D Poisson equation, are in good agreement with experiments concerning the plasma frequency dependence with gate voltage. Moreover, this model confirms both optical beating detection at subterahertz frequencies and the enhancement observed when drain-source voltage increases. [J250]

"Phase-Noise Improvement of GaAs pHEMT K-Band Voltage-Controlled Oscillator Using Tunable Field-Plate Voltage Technology"

This letter presents a voltage-controlled oscillator (VCO) with low phase-noise performance by applying tunable field-plate (FP) voltage on 0.15-mum-gate-length GaAs pseudomorphic high-electron-mobility transistors (pHEMTs). In this letter, the FP metal between gate and drain terminals was connected to a single pad and was controlled by an extra voltage supplier (VFP). Owing to the depth modulation of FP-induced depletion region at various FP voltages, the device flicker noise was also improved by applying negative VFP. This technique is convenient to be applied in standard pHEMT fabrication and particularly attractive for reducing the phase noise of VCO design without extra power consumption. A tunable phase-noise inductor-capacitor feedback 21-GHz VCO was demonstrated. The measured phase noise of this novel design is -95 dBc/Hz at an offset frequency of 1 MHz, and this value can be improved to -99.6 dBc/Hz at VFPof -5.5 V. The core dc-power consumption of this circuit is 30.8 mW. [J251]

"Reliability of GaN High-Electron-Mobility Transistors: State of the Art and Perspectives"

Failure modes and mechanisms of AlGaN/GaN high-electron-mobility transistors are reviewed. Data from three de-accelerated tests are presented, which demonstrate a close correlation between failure modes and bias point. Maximum degradation was found in "semi-on" conditions, close to the maximum of hot-electron generation which was detected with the aid of electroluminescence (EL) measurements. This suggests a contribution of hot-electron effects to device degradation, at least at moderate drain bias (VDS<30 V). A procedure for the characterization of hot carrier phenomena based on EL microscopy and spectroscopy is described. At high drain bias (VDS>30-50 V), new failure mechanisms are triggered, which induce an increase of gate leakage current. The latter is possibly related with the inverse piezoelectric effect leading to defect generation due to strain relaxation, and/or to localized permanent breakdown of the AlGaN barrier layer. Results are compared with literature data throughout the text. [J252]

"X- and Ka-band power performance of AlGaN/GaN HEMTs grown by ammonia-MBE"

A report is presented on the power performance of deep submicron AlGaN/GaN high electron mobility transistors grown by ammonia molecular beam epitaxy. At 10 GHz, 70% power-added-efficiency (PAE) and 3 W/mm power density were demonstrated at a drain bias of 20 V. At 30 GHz, 31% PAE and 6.5 W/mm power density were achieved at a drain bias of 40 V. [J253]

"Enhancement-Mode Metamorphic HEMT on GaAs Substrate With 2 S/mm and 490 GHz"

This letter presents the results of an enhancement mode metamorphic high-electron-mobility transistor device on a GaAs substrate with a 70% indium composition channel. A 35-nm gate length device exhibits a 490-GHz current gain cutoff frequency (fT), a transconductance (gm) of 2 S/mm, a threshold voltage (Vth) of 0.11 V (enhancement mode) and a low on- resistance of 0.37 Omega mm. These attributes make the device well-suited for millimeter-wave circuit applications. [J254]

"Novel Miniature and Broadband Millimeter-Wave Monolithic Star Mixers"

In this paper, three monolithic star mixers using a new miniature dual balun are proposed. The first one is a double spiral transformer mixer, and the second one is a trifilar transformer mixer. Both of these are fabricated using a commercial GaAs pseudomorphic HEMT process. The third is a 3-D transformer mixer, which is fabricated using a commercial CMOS process. These mixers exhibit bandwidths over 25-45 GHz (57%) with local oscillator isolations better than 20 dB. These star mixers are smaller than (lambda/6timeslambda/6) for the mixer core area. Compared with traditional star mixers, these mixers demonstrate 80% size reduction, and achieve good performance with the smallest chip size among all star mixers using monolithic microwave integrated circuit processes. [J255]

"Critical Voltage for Electrical Degradation of GaN High-Electron Mobility Transistors"

We have found that there is a critical drain-to-gate voltage beyond which GaN high-electron mobility transistors start to degrade in electrical-stress experiments. The critical voltage depends on the detailed voltage biasing of the device during electrical stress. It is higher in the OFF state and high-power state than at VDS= 0. In addition, as |VGS| increases, the critical voltage decreases. We have also found that the stress current does not affect the critical voltage although soft degradation at low voltages takes place at high stress currents. All of our findings are consistent with a degradation mechanism based on crystallographic-defect formation due to the inverse piezoelectric effect. Hot-electron-based mechanisms seem to be in contradiction with our experimental

results. [J256]

"High Efficiency RF Power Amplifier Designed With Harmonic Real-Time Active Load-Pull"

In this work, a high efficiency p-HEMT radio frequency power amplifier (PA) is designed using a new multiharmonic real-time active load-pull using the large signal network analyzer. This technique synthesizes a large set of instantaneous load mismatches to quickly find the optimal harmonic impedances, so as to achieve high PA efficiency in a shortened design cycle. At 2 GHz a demo power amplifier implemented with a p-HEMT demonstrated a power added efficiency (PAE) of 68.5% for 18.0 dBm output power, while achieving a maximum PAE of 75% below the 1 dB compression point for 18.6 dBm output power. [J257]

"Degradation Uniformity of RF-Power GaAs PHEMTs Under Electrical Stress"

We have studied the electrical degradation of RF-power PHEMTs by means of in situ 2-D light-emission measurements. Electroluminescence originates in the recombination of holes that have been generated by impact ionization. The local light intensity, thus, maps the electric-field distribution at the drain side of the device. This allows us to probe the uniformity of electrical degradation due to electric-field-driven mechanisms. We find that electrical degradation proceeds in a highly nonuniform manner across the width of the device. In an initial phase, degradation takes place preferentially toward the center of the gate finger. In advanced stages of degradation, the edges of the device degrade at a preferential rate. We identify the origin of this behavior as a small systematic nonuniformity in the recess geometry that impacts the magnitude of the electric field on the drain of the device. Our research suggests that a close examination of the width distribution of electric field in RF-power PHEMTs (and FETs in general) is essential to enhance their long-term reliability. [J258]

"AlGaN/GaN Metal-Oxide-Semiconductor High-Electron Mobility Transistors Using Oxide Insulator Grown by Photoelectrochemical Oxidation Method"

A photoelectrochemical oxidation method was used to directly grow oxide layer on AlGaN surface. The annealed oxide layer exhibited beta-Ga2O3and alpha-Al2O3crystalline phases. Using a photoassisted capacitance-voltage method, a low average interface-state density of 5.1 times 1011cm-2. eV-1was estimated. The directly grown oxide layer was used as gate insulator for AlGaN/GaN MOS high-electron mobility transistors (MOS-HEMTs). The threshold voltage of MOS-HEMT devices is -5 V. The gate leakage currents are 50 and 2 pA at forward gate bias of VGS = 10 V and reverse gate bias of VGS= -10 V, respectively. The maximum value of gmis 50 mS/mm of VGs biased at -2.09 V. [J259]

"Terahertz imaging with GaAS field-effect transistors"

Imaging at 0.6 THz is tested with a commercial GaAs high-electron-mobility transistor (HEMT) operated at room temperature. The results allow the assessment of the potential of future antenna-fitted HEMT arrays for real-time imaging. [J260]

"A GaN HEMT amplifier with 6-W output power and >85% power-added efficiency [JStudent Designs]"

This article presents the winning power amplifier implemented with a gallium nitride (GaN) high electron mobility transistor (HEMT) and having power-added efficiency (PAE) greater than 85%. It will be shown that computer-aided design (CAD) simulation tools, accurate device models, and sensible design rules can produce first-pass power amplifier design success. An overview of design, fabrication, and testing processes is presented here together with measured results. [J261]

"A Two-Step-Recess Process Based on Atomic-Layer Etching for High-Performance p-HEMTs"

We investigated 60-nm In0.52Al0.48As/In0.53Ga0.47As pseudomorphic high-electron mobility transistors (p-HEMTs) fabricated by using a Ne-based atomic-layer-etching (ALET) technology. The ALET process produced a reproducible etch rate of 1.47 Aring/cycle for an InP etch stop layer, an excellent InP etch selectivity of 70 against an In0.52Al0.48As barrier layer, and an rms surface-roughness value of 1.37 Aring for the exposed In0.52Al0.48As barrier after removing the InP etch stop layer. The application of the ALET technology for the gate recess of 60-nm In0.52Al0.48As/In0.53Ga0.47As p-HEMTs produced improved device parameters, including transconductance (GM), cutoff frequencies (fT)> and electron saturation velocity (vsat) in the channel layer, which is mainly due to the high etch selectivity and low plasma-induced damage to the gate area. The 60-nm In0.52Al0.48As/In0.53Ga0.47As p-HEMTs fabricated by using the ALET technology exhibited GM,Max= 1-17 S/mm, fT= 398 GHz, and vsat= 2.5 X 107cm/s. [J262]

"Investigation of High-Electric-Field Degradation Effects in AlGaN/GaN HEMTs"

High-electric-field degradation phenomena are investigated in GaN-capped AlGaN/GaN HEMTs by comparing experimental data with numerical device simulations. Under power- and OFF-state conditions, 150-h DC stresses were carried out. Degradation effects characterizing both stress experiments were as follows: a drop in the dc drain current, the amplification of gate-lag effects, and a decrease in the reverse gate leakage current. Numerical simulations indicate that the simultaneous generation of surface (and/or barrier) and buffer traps can account for all of the aforementioned degradation modes. Experiments also showed that the power-state stress induced a drop in the transconductance at high gate-source voltages only, whereas the OFF-state stress led to a uniform transconductance drop over the entire gate-source-voltage range. This behavior can be reproduced by simulations provided that, under the power-state stress, traps are assumed to accumulate over a wide region extending laterally from the gate edge toward the drain contact, whereas, under the OFF-state stress, trap generation is supposed to take place in a narrower portion of the drain-access region close to the gate edge and to be accompanied by a significant degradation of the channel transport parameters. [J263]

"An Improved Small-Signal Parameter-Extraction Algorithm for GaN HEMT Devices"

A highly efficient and accurate extraction algorithm for the small-signal equivalent-circuit parameters of a GaN high electron-mobility transistor device is presented. Elements of the extrinsic equivalent-circuit topology are evaluated using a modified "cold field-effect transistor" approach whereby the undesirable need to forward bias the device's gate terminal is avoided. Intrinsic elements are determined based on a circuit topology, which identifies, for the first time, a time delay in the output conductance of GaN-based devices. The validity of the proposed algorithm has been thoroughly verified with excellent correlation between the measured and modeled S-parameters up to 50 GHz. [J264]

"Methodology for Small-Signal Model Extraction of AlGaN HEMTs"

Both large- and small-periphery AlGaN high- electron mobility transistors (HEMTs) will find applications in microwave systems from 2 to 40 GHz because of their superior power handling capability. A self-consistent approach is presented for the linear model's parameter extraction from measured S-parameters. The model for parasitics is selected to reflect loading from both the probe pads and the interconnect regions, including the air bridges. The objective is to accurately extract intrinsic model parameters as the device periphery is increased from 50 mum to 1 mm and to isolate the effects of device layouts, including air bridging the source regions. To accurately extract the shunt and series parasitics, the device must be represented in its ON- and OFF-states determined by the gate and drain bias. The intrinsic device capacitances are not negligible in the forward and beyond-pinchoff reverse bias states at zero drain bias and must be accounted for. With these corrections to the measured S-parameters, consistent results for the intrinsic device parameters are obtained with both small- and large-periphery AlGaN HEMTs. [J265]

"A Simple Current Collapse Measurement Technique for GaN High-Electron Mobility Transistors"

Current collapse in GaN high-electron mobility transistors (HEMTs) is a temporary reduction of drain-current immediately after the application of high voltage. Current collapse limits the output power of the device at high frequencies. Oftentimes, a signature of device degradation is an increase in current collapse. In order to improve the GaN HEMT performance and reliability, understanding the current collapse phenomenon is critical. In this letter, we propose a simple technique to measure current collapse that utilizes common dc device characterization equipment. Our proposed technique produces consistent measurements when compared with the conventional but highly specialized pulse technique. Underlying our proposed technique is the recognition that in a transient current measurement, the traps that produce current collapse have detrapping time constants on the order of seconds. [J266]

"55% PAE and High Power Ka-Band GaN HEMTs With Linearized Transconductance via GaN Source Contact Ledge"

We report small- and large-signal performances of 140-nm gatelength field-plated GaN HEMTs at Ka-band frequencies, in which the GaN HEMTs were fabricated with n+ source contact ledge. The parasitic channel resistance is reduced by ~ 50%, whereas the peak extrinsic transconductance is improved by 20% from 370 to 445 mS/mm. The GaN HEMTs with n+ source ledge exhibit improvement of maximum stable gain by at least 0.7 dB over reference devices without n+ ledge. At 30 GHz, CW output power density of 10 W/mm is measured with peak PAE of 40% and associated gain of 8.4 dB at Vds = 42 V. At Vds = 30 V, the output power density is measured as 7.3 W/mm with peak PAE of 50%, peak DE of 58%, and associated gain of 8.5 dB. The best PAE was measured as 55% at 5 W/mm at 30, 33, and 36 GHz, where the associated gains were 7.9, 7.6, and 8.2

dB, respectively. [J267]

"Surface Acoustic Waves in Reverse-Biased AlGaN/GaN Heterostructures"

Properties of surface acoustic waves (SAWs) in reverse-biased AlGaN/GaN heterostructures on (0001) sapphire substrates were studied by examining the characteristics of SAW filters composed of interdigital Schottky and ohmic contacts. The fundamental and higher frequency SAW signals in measured -parameters were attributed to Rayleigh and Sezawa modes, respectively. The onsets of the SAW signals, which were close to the threshold voltage of HEMTs in the vicinities of the respective filters, changed in response to the spatial variation of the threshold voltage. The onset of Sezawa mode was deeper than that of Rayleigh mode, and the difference in onset was larger for longer SAW wavelengths. These results are possibly explained by the change of the input capacitance of interdigital transducers due to the reverse-bias voltages or by the difference in the distribution of SAW energy between the two modes. [J268]

"Comparison Between the Noise Performance of Double- and Single-Gate InP-Based HEMTs"

The noise performance of InAlAs/InGaAs double-gate (DG) and standard high-electron-mobility transistors (HEMTs) is analyzed by means of an ensemble 2-D Monte Carlo simulator. The DG-HEMT is found to have a better noise behavior than the single-gate (SG) device. The results show a moderate decrease of the and noise parameters for the DG HEMT with respect to that of the SG device, since current fluctuations due to electrons injected into the buffer are eliminated. Moreover, the DG HEMT reveals a significantly lower extrinsic minimum noise figure and a higher associated gain, not only due to the better intrinsic performance but also to the lower contact resistances. [J269]

"Metamorphic AlInAs/GaInAs HEMTs on GaAs Substrates by MOCVD"

Metamorphic AlInAs/GaInAs high-electron mobility transistors with very good device performance have been grown by metal-organic chemical vapor deposition (MOCVD), with the introduction of an effective multistage buffering scheme. Measured room-temperature Hall mobilities of the 2-DEG were over 8000 cm2/V ldr s with sheet carrier densities larger than 4 times 1012cm-2. Transistors with 1-mum gate length exhibited transconductance up to 626 mS/mm. The unity current gain cutoff frequency fTand the maximum oscillation frequency fmaxwere 39.1 and 71 GHz, respectively. These results are very encouraging toward the manufacturing of metamorphic devices on GaAs substrates by MOCVD. [J270]

"A Submillimeter-Wave HEMT Amplifier Module With Integrated Waveguide Transitions Operating Above 300 GHz"

In this paper, we report on the first demonstration of monolithically integrated waveguide transitions in a submillimeter-wave monolithic integrated circuit (S-MMIC) amplifier module. We designed the module for a targeted frequency range of 300-350 GHz, using WR2.2 for the input and output waveguides. The waveguide module utilizes radial -plane transitions from S-MMIC to waveguide. We designed back-to-back radial probe transitions separated by thru transmission lines to characterize the module, and have incorporated the radial -plane transitions with an S-MMIC amplifier, fabricated monolithically as a single chip. The chip makes use of an S-MMIC process and amplifier design from the Northrop Grumman Corporation, Redondo Beach, CA, using 35-nm gate-length InP transistors. The integrated module design eliminates the need for wire bonds in the RF signal path, and enables a drop-in approach for minimal assembly. The waveguide module includes a channel design, which optimizes the -plane probe bandwidth to compensate for an S-MMIC width, which is larger than the waveguide dimension, and is compatible with S-MMIC fabrication and design rules. This paper demonstrates for the first time that waveguide-based S-MMIC amplifier modules with integrated waveguide transitions can be successfully operated at submillimeter-wave frequencies. [J271]

"A Ka Band Balanced Third LO-Harmonic Mixer Using a Lumped-Elements Quadrature Hybrid"

A novel configuration of a subharmonic mixer utilizing third local oscillation (LO) harmonic is presented. The mixer is capable of down-converting a Ka-Band radio frequency (RF) signal with the third harmonic of an X-band LO signal to produce a 2 GHz intermediate frequency signal. It is fabricated on a 4 mil substrate using a 0.15 mum GaAs PHEMT process. A novel quadrature hybrid is realized by using compact lumped elements, and it is beneficial for the reduction of chip size for an LO at a relatively low frequency in this topology. This is because it does not need any bulky via holes. Compared with published subharmonic mixers, it provides a more flexible requirement for an LO source at a relatively low frequency for an overall communication system design. The measured results show that the best conversion loss is about 13.2 dB at a RF frequency of 29 GHz as a 10.5 dBm 9 GHz LO signal is pumped. The chip area of the mixer is less than 3.14 mm2. [J272]

"Effect of fluoride plasma treatment on InAlN/GaN HEMTs"

Fluoride plasma treatment similar to that used in AlGaN/GaN HEMTs has been applied to InAlN/GaN HEMTs. Enhancement mode of operation is obtained with a pinch-off voltage shifted by 3 V. Owing to the fluoride treatment an increase of the forward gate threshold to 3.5 V is observed. The small-signal performances are essentially unchanged. The thermal stability of this process has been assessed for the first time and appears to be limited to approximately 500degC. [J273]

"Topology Analysis and Design of Passive HEMT Millimeter-Wave Multiple-Port Switches"

This paper discusses different topologies for millimeter-wave (MMW) multiple-port switches, and analyzes the insertion loss, isolation, and limitation of bandwidth. It is observed the performances of a MMW multiple-port switch are decided by both multiple-port topology and the structure of the constituted unit single-pole-single-throw switches, but dominated by its topology. To verify the analysis, two types of multiple-port switch are designed, one is a distributed switch and the other is based on a filter-integrated switch, using different topologies. The net-type multiple-port topology based on a distributed switch demonstrates a measured insertion loss of 4-5 dB with isolation better than 25 dB in 48-65 GHz. In 43-66 GHz, the binary-ring multiple-port topology based on a filter-integrated switch shows a measured insertion loss of 3-4.5 dB with isolation better than 30 dB. [J274]

"First On-Wafer Power Characterization of MMIC Amplifiers at Sub-Millimeter Wave Frequencies"

We present on-wafer power measurements of 35 nm gate length InP HEMT amplifiers at 330 GHz. Various amplifiers are examined. The maximum output power of 1.78 mW is measured from a three stage amplifier. Additional output power may be possible but limited by our input power source level to saturate amplifiers. This result is the highest frequency on-wafer power measurement we are aware of reported to date, and demonstrates the technique we utilize to be a fast method of evaluating power performance of submillimeter wave amplifiers without the need to package devices. [J275]

"First microwave power performance of AlGaN/GaN HEMTs on SopSiC composite substrate"

The first results obtained from AlGaN/GaN HEMT devices on MBE epitaxial structures grown on 'composite' substrates are presented. These substrates are based on innovative structures in which a thin Si single crystal layer is transferred on top of a thick polycrystalline SiC wafer. The fabrication of the transistors is based on a process flow close to those used on epitaxy on Si bulk substrates. The results show the capabilities of such composite devices, providing HEMT devices for microwave power applications. [J276]

"AlGaN/GaN MIS-HEMTs with fT of 194 GHz at 16 K"

45 nm-gate AlGaN/GaN MIS-HEMTs on SiC substrates have been fabricated and their DC and RF characteristics measured at 300 and 16 K. A source-drain spacing Lsdof 1.5 mum was used to reduce parasitic resistances, which was 0.5 mum shorter than that in previous work. High cutoff frequency fTvalues of 156 GHz at 300 K and 194 GHz at 16 K were obtained. These fTvalues are about 10% higher than those of AlGaN/GaN MIS-HEMTs with an Lsdof 2 mum. [J277]

"High-Efficiency Class-F GaN HEMT Amplifier With Simple Parasitic-Compensation Circuit"

This letter presents a highly efficient class-F power amplifier (PA) using a GaN high electron mobility transistor, which is designed at WCDMA band of 2.14 GHz. The simple and effective compensation circuit consisting of a series capacitor and a shunt inductor is used to compensate for the internal parasitic components of the packaged transistor. Also, the composite right/left-handed transmission lines are used as the harmonic tuner of the class-F PA. From the measured results for a continuous wave, the drain efficiency and power-added efficiency of 75.4% and 70.9% with a gain of 12.2 dB are achieved at an output power of 40.2 dBm. [J278]

"Effects of Plasma Pretreatment on the SiN Passivation of AlGaN/GaN HEMT"

The impact of in situ low-power plasma pretreatment, prior to silicon-nitride (SiN) deposition, was investigated in AlGaN/GaN high-electron mobility transistors (HEMTs). These studies reveal that the use of plasma in HEMT passivation reduces current-collapse and gate-lag effects. Such treatment is also beneficial to improve gate leakage, and from RF measurements, no degradation of was observed. These beneficial effects of the plasma pretreatment seem to be due to a significant reduction in interface charge density, as shown in this letter using GaN MIS devices, where a decrease of 60% was observed. [J279]

"A Closed-Form Model for Thermionic Trap-Assisted Tunneling"

Recently, we proposed a trap-assisted tunneling model (2006) that includes tunneling of thermally activated electrons above the metal Fermi level for explaining the temperature-dependent leakage current in some semiconductor devices. In the present paper, we develop a closed-form version of this model, which provides physical insight by revealing the peak, energy location and spread of emitted electron distribution. The model also yields characteristic field parameters to identify the thermally activated regime of current versus field behavior and the location of peak emission. The closed-form solution of a complicated equation has been achieved using a geometrical interpretation of the integration operation, and by bisecting the range of trap energies, adopting separate approximations for the bisected segments, and then mathematically combining the two segments into a single continuous function valid for the entire range of trap energies. The closed-form model calculations match well with numerical integration results. [J280]

"Balanced AlGaN/GaN HEMT cascode cells: design method for wideband distributed amplifiers"

A report is presented on the specific design of a GaN HEMT cascode cell demonstrating significant improvement for flip-chip distributed power amplifiers. The active device is a 8 times 50 mum AlGaN/GaN HEMT grown on SiC substrate. The GaN-based wafer integrating the active part is flip-chipped onto an A1N substrate via electrical and mechanical bumps. The cascode cell integrates matching elements for power optimisation of wideband distributed amplifiers up to their maximum frequency and for intrinsic power balance of the cascode cell. Additional resistors are integrated to ensure bias path and stability, this last one being decisive for the studied application. [J281]

"High-efficiency ultra-wideband power amplifier in GaN technology"

The experimental results of an ultra-wideband high-efficiency power amplifier (PA) in GaN technology are presented. The active device is a HEMT with 1 mm of gate periphery. The realised PA operates from 0.8 to 4 GHz, showing a drain efficiency greater than 40% with an output power higher than 32 dBm in the overall bandwidth. [J282]

"MOSFETs RF Noise Optimization via Channel Engineering"

In this letter, we propose a design methodology to enhance the High Frequency noise performance of the traditional CMOS technology via channel engineering. We show that the intrinsic noise correlation coefficient (C) of the conventional CMOS (~0.4 or lower) limits the noise performance. By lateral nonuniformly doping the channel, this value of C can be enhanced to as high as ~0.9 in the weak inversion regime and this in turn improves the NFminof the device. Key noise parameters are carefully compared and analyzed in detail with the state-of-the-art GaAs-based pHEMT and nanoscaled CMOS technology. This letter offers another viable option for achieving CMOS with low power, low voltage, and with much improved noise performance without the need to scale the device. [J283]

"A 120-W Boost Converter Operation Using a High-Voltage GaN-HEMT"

A boost converter with a 940-V/4.4 A GaN-HEMT as the main switching device was demonstrated to show the possibility of using high-voltage GaN-HEMTs in power electronic applications. The demonstrated circuit achieved an output power of 122 W and a power efficiency of 94.2% under a drain peak voltage as high as 350 V and a switching frequency of 1 MHz. The dual field-plate structure realized high-voltage switching operation with high power efficiency as dynamic on-resistance was suppressed by an increase of the current collapse phenomena. [J284]

"Volterra-Series-Based Distortion Analysis for Optimization of Out-of-Band Terminations in GaN HEMT Devices"

This letter focuses on the critical device-level linearity issues resulting from out-of-band terminations for reliable distortion characterization in future Universal Mobile Telecommunications System-Long Term Evolution (UMTS-LTE). Using Volterra series technique, the key distortion sources arising from the envelope and harmonic components in 0.5-mm GaN HEMT were identified using commercial and in-house bias tees. With the designed in-house bias tee, the baseband performance, in comparison with the commercial bias tee, is tested through drain-bias sensing. In reference to the commercial bias tee, up to 99.3% reduction in drain modulation is achieved using the in-house bias tee. Memory-effect characterization of GaN HEMT exemplified the implications of baseband and second-harmonic load terminations, which was theoretically confirmed through Volterra series technique. Using the in-house bias tee, under two-carrier wideband code-division multiple-access excitation, up to 47-dBc 3rd-order intermodulation ratio (IMR3) is achieved at 13.5-dB backoff. This has resulted in a 5-dB IMR

suppression together with the minimization of intermodulation-distortion asymmetry, confirming the possibility to achieve the 3rd Generation Partnership Project linearity specification at the device level. [J285]

"0.25 μm Self-Aligned AlGaN/GaN High Electron Mobility Transistors"

Self-aligned AlGaN/GaN high electron mobility transistors grown on semiinsulating SiC substrates with a 0.25 mum gate-length were fabricated using a single-step ohmic process. Our recently developed Mo/Al/Mo/Au-based ohmic contact requiring annealing temperatures between 500degC and 600degC was utilized. Ohmic contact resistances between 0.35-0.6 Omega ldr mm were achieved. These 0.25 mum gate-length devices exhibited drain current density as high as 1.05 A/mm at a gate bias of 0 V and a drain bias of 10 V. A knee voltage of less than 2 V and a peak extrinsic transconductance (gm) of 321 mS/mm were measured. For their microwave characteristics, a unity gain cutoff frequency (fT) of 82 GHz and maximum frequency of oscillation (fmax) of 103 GHz were measured. [J286]

"Electrical Characteristics of Passivated Pseudomorphic HEMTs With Pretreatment"

This paper elucidates the dc, pulse I-V, microwave, flicker noise, and power properties of AlGaAs/InGaAs pseudomorphic high electron mobility transistors (pHEMTs) after various ex situ sulfur pretreatments. The pHEMTs were pretreated with NH4OH, (NH4)2SX, and P2S5/(NH4)2SXsolutions before SiO2passivation to reduce the GaAs native oxide-related surface states. Stable phosphorus oxides and sulfur bound to the Ga and As species can be efficiently obtained using P2S5/(NH4)2SXpretreatment; therefore, the leakage current in pHEMT was reduced following this process. Atomic force microscopy measurements indicated that the phosphorus oxides formed by P2S5/(NH4)2SXtreatment also provided a better surface roughness than obtained following traditional (NH4)2SX-only pretreatment, reducing mobility degradation after sulfur pretreatment. Based on the dc and 1 mus pulse I-V measurement results, P2S5/(NH4)2SX-treated pHEMT exhibited very similar Idstrends, especially at high currents; however, NH4OH, (NH4)2SXtreatments clearly reduced the current upon pulse measurement because of the presence of surface traps. Hence, this novel pretreatment method has great potential for highly linear microwave power transistor applications. [J287]

"Asymmetrically Recessed 50-nm Gate-Length Metamorphic High Electron-Mobility Transistor With Enhanced Gain Performance"

We report the design, fabrication and characterization of ultrahigh gain metamorphic high electron-mobility transistors. In this letter, a high-yield 50-nm T-gate process was successfully developed and applied to epitaxial layers containing high indium mole fraction InGaAs channels grown on GaAs substrates. A unique gate recess process was adopted to significantly increase device gain by effectively suppressing output conductance and feedback capacitance. Coupled with extremely small 10 mum times 25 mum via holes on substrates thinned to 1 mil, we achieved a 13.5 dB maximum stable gain (MSG) at 110 GHz for a 30-mum gate-width device. To our knowledge, this is the highest gain performance reported for microwave high electron-mobility transistor devices of similar gate periphery at this frequency, and equivalent circuit modeling indicates that this device will operate at frequencies beyond 300 GHz. [J288]

"Submillimeter-Wave InP MMIC Amplifiers From 300-345 GHz"

In this letter, we describe the design, fabrication, simulation, and measured performance of a single-stage and three-stage 320 GHz amplifier using Northrop Grumman Corporation's (NGC) 35-nm InP high electron mobility transistor submillimeter-wave monolithic integrated circuit (S-MMIC) process. On-wafer S-parameter measurements using an extended waveguide band WR3 vector network analyzer system were performed from 210-345 GHz. We measured 5 dB of gain for the single-stage amplifier at 340 GHz and 13-15 of gain from 300-345 GHz for the three-stage S-MMIC amplifier. [J289]

"Temperature-Dependent Characterization of AlGaN/GaN HEMTs: Thermal and Source/Drain Resistances"

This paper shows the application of simple dc techniques to the temperature-dependent characterization of AlGaN/ GaN HEMTs in terms of the following: 1) thermal resistance and 2) ohmic series resistance (at low drain bias). Despite their simplicity, these measurement techniques are shown to give valuable information about the device behavior over a wide range of ambient/channel temperatures. The experimental results are validated by comparison with independent measurements and numerical simulations. [J290]

"A 220 GHz (G-Band) Microstrip MMIC Single-Ended Resistive Mixer"

This letter presents the design and characterization of a 220 GHz microstrip monolithic microwave integrated

circuit single-ended resistive mixer in a 0.1 GaAs mHEMT technology. A conversion loss as low as 8.7 dB is obtained, limited by the available local oscillator (LO) power (1.5 dBm) in the measurement setup. The radio frequency (RF) bandwidth is also limited by the measurement setup, but the mixer demonstrates a flat response over the measured 200 to 220 GHz frequency range. Furthermore, measured intermediate frequency bandwidth, 1-dB input compression point, LO-to-RF isolation, and reflection coefficients are presented and discussed. [J291]

"RF and Logic Performance Improvement of Composite-Channel HEMT Using Gate-Sinking Technology"

Eighty-nanometer-gate In0.7Ga0.3As/InAs/In0.7Ga0.3As composite-channel high-electron mobility transistors (HEMTs), which are fabricated using platinum buried gate as the Schottky contact metal, were evaluated for RF and logic application. After gate sinking at 250degC for 3 min, the device exhibited a high gmvalue of 1590 mS/mm at Vd= 0.5 V, the current-gain cutoff frequency fTwas increased from 390 to 494 GHz, and the gate-delay time was decreased from 0.83 to 0.78 ps at supply voltage of 0.6 V. This is the highest fTachieved for 80-nm-gate-length HEMT devices. These superior performances are attributed to the reduction of distance between gate and channel and the reduction of parasitic gate capacitances during the gate-sinking process. Moreover, such superior performances were achieved through a very simple and straightforward fabrication process with optimal epistructure of the device. [J292]

"Analysis and Design of a Novel 4 Subharmonically Pumped Resistive HEMT Mixer"

In this paper, a novel topology of an HEMT-based subharmonically pumped resistive mixer (SHPRM) is presented, i.e., the times4SHPRM. The presented topology requires only a quarter of the local oscillator (LO) frequency compared to a fundamentally pumped mixer (e.g., 15 instead of 60 GHz in a 60-GHz system). This reduction in required LO frequency provides a significant reduction in complexity of the overall radio front-end and reduces the dc power consumption as well as the occupied chip area. Thus, the times4SHPRM provides a significant cost reduction for a millimeter-wave system. Furthermore, the times4SHPRM can be used for both up- and down-conversion and it can be implemented in any field-effect transistor technology. The principle of the times4SHPRM is presented and wave analysis is applied in order to investigate the fundamental limitations of this mixer topology. For an evaluation of the times4SHPRM topology, three different monolithic microwave integrated circuits (MMICs) were designed and manufactured in the same MMIC metamorphic HEMT technology. Besides measured performance of the times4SHPRM, a traditional times2SHPRM and a single-ended resistive mixer were implemented and their performances are presented and compared. All of these MMICs operate with a 60-GHz RF frequency and employ LO signals close to 15, 30, and 60 GHz, respectively. [J293]

"Scalable Nonlinear FET Model Based on a Distributed Parasitic Network Description"

Electron device modeling requires accurate descriptions of parasitic passive structures connecting the intrinsic electron device to the external world. In conventional approaches, the parasitic phenomena are described by a network of lumped elements. As an alternative, a distributed description can be conveniently adopted. This choice has been proven very appropriate when dealing with device scaling and very high operating frequencies. In this paper, a novel approach to distributed parasitic modeling is adopted for the very first time in association with a nonlinear electron device model. In particular, it is shown how an equivalent intrinsic device and a suitably defined distributed parasitic network can be accurately defined and modeled on the basis of standard measurements and easy electromagnetic simulations. Wide experimental validation based on GaAs pseudomorphic HEMTs is provided, showing accurate prediction capabilities both under small- and large-signal conditions. The proposed model is shown to perform optimally even after periphery scaling. [J294]

"A New Millimeter-Wave Small-Signal Modeling Approach for pHEMTs Accounting for the Output Conductance Time Delay"

A new technique is developed for determining analytically a millimeter-wave small-signal equivalent-circuit model of GaAs pseudomorphic HEMTs from scattering parameter measurements. In order to obtain a good agreement between model simulations and measurements up to 90 GHz, the conventional intrinsic output conductance is substituted by a voltage-controlled current source with a time delay. Consequently, a simple and accurate extraction procedure is proposed for taking into account the introduction of the output conductance time delay. [J295]

"Effect of Al Composition and Gate Recess on Power Performance of AlGaN/GaN High-Electron Mobility Transistors"

AlGaN/GaN high-electron mobility transistors with different Al compositions and barrier thicknesses were

compared. The samples with higher Al composition and similar 2D electron gas density showed higher gate leakage, utilizing a slant field plate gate process. By applying a gate recess etch and a slant field plate gate process, gate leakage was improved to a similar level for all the devices, and the power density and PAE were much improved. [J296]

"Analytical HFET-Model in Presence of Current Collapse"

A compact analytical model of short-channel AlGaN/GaN HEMTs in the presence of a current collapse is presented. The model is based on an experimentally established trapping mechanism at the gate edges and relies on significant differences between the characteristic carrier capture-escape times and typical RF signal periods. For the first time, we implement the theory describing electric field distributions in the HEMT gate-to-drain spacing region, with and without trapped charge distributions. By consequently accounting for velocity saturation effects in gated and trapped regions of the device, the presented model shows good agreement with the experimental data. The model uses a minimal number of fitting parameters, most of which are physical parameters describing velocity-field dependence of the carriers. [J297]

"Channel Temperature Determination in High-Power AlGaN/GaN HFETs Using Electrical Methods and Raman Spectroscopy"

Self-heating in AlGaN/GaN HFETs was investigated using electrical analysis and micro-Raman thermography. Two typically employed electrical methods were assessed to provide a simple means of extracting average channel temperatures in devices. To quantify the accuracy of these electrical temperature measurements, micro-Raman thermography was used to provide submicron resolution temperature information in the source-drain opening of the devices. We find that electrical methods significantly underestimate peak channel temperatures, due to the fact that electrical techniques measure an average temperature over the entire active device area. These results show that, although electrical techniques can be used to provide qualitative comparisons between different devices, they have challenges for the accurate estimation of peak channel temperatures. This needs to be taken into account for lifetime testing and reliability studies based on electrical temperature measurements. [J298]

"Analysis of a Fully Matched Saturated Doherty Amplifier With Excellent Efficiency"

A saturated Doherty amplifier based on class-F amplifiers is analyzed in terms of its load modulation behavior, efficiency, and linearity. Simulations included the amplitude ratio and phase difference between the fundamental and third harmonic voltages, the current/voltage waveforms, load lines, and the third-order intermodulation amplitudes/phases of the carrier and peaking amplifiers. The saturated doherty power amplifier was implemented using two Eudyna EGN010MK GaN HEMTs with a 10-W peak envelope power. For a 2.14-GHz forward-fink wideband code-division multiple-access signal, the doherty amplifier delivers an excellent efficiency of 52.4% with an acceptable linearity of -28.3 dBc at an average output power of 36 dBm. Moreover, the amplifier can provide the high linearity performance of -50 dBc using the digital feedback predistortion technique. [J299]

"GaN-Based RF Power Devices and Amplifiers"

The rapid development of the RF power electronics requires the introduction of wide bandgap material due to its potential in high output power density, high operation voltage and high input impedance. GaN-based RF power devices have made substantial progresses in the last decade. This paper attempts to review the latest developments of the GaN HEMT technologies, including material growth, processing technologies, device epitaxial structures and MMIC designs, to achieve the state-of-the-art microwave and millimeter-wave performance. The reliability and manufacturing challenges are also discussed. [J300]

"Micro-Raman/Infrared Temperature Monitoring of Gunn Diodes"

Temperature measurements have been made on Gunn diode samples, using both infrared (IR) and micro-Raman spectroscopy. Micro-Raman spectroscopy was used to give high-resolution temperature measurements on the active transit region of the Gunn diode. These were directly compared with IR thermal measurements made across the mesa region and also on the metallized top contact of the diode. [J301]

"Technology and Performance of InAlN/AlN/GaN HEMTs With Gate Insulation and Current Collapse Suppression Using Zr or Hf"

We present the technology and performance of InAlN/AlN/GaN MOS HEMTs with gate insulation and surface passivation using Zr or Hf . About 10-nm-thick high- dielectrics were deposited by MOCVD before the ohmic contact processing. Plasma pretreatment allowed the reduction of the temperature of the ohmic contact

annealing at 600degC. The insulation and passivation of 2-m gate-length MOS HEMTs lead to a gate leakage current reduction by four orders of magnitude and a 2.5 increase of the pulsed drain-current if compared with a Schottky barrier (SB) HEMT. A dc characterization shows 110 mS mm transconductance and 0.9 A mm drain--currents that represent improvements in comparison to the similar SB HEMT and that is explained by a mobility-dependent carrier depletion effect. [J302]

"Epitaxial Optimization of 130-nm Gate-Length InGaAs/InAlAs/InP HEMTs for High-Frequency Applications"

In this paper, the influence of epitaxial-layer design on high-frequency properties of 130-nm gate-length InGaAs/InAlAs/InP high-electron-mobility transistors (InP HEMTs) has been investigated. The In channel content ([In]: 53%, 70%, and 80%), the J-doping concentration (delta: 3, 5, and 7times1012cm-2), and the Schottky-layer thickness (dSL: 9,11, and 13 nm) have been varied. The maximum frequency of oscillation fmax, the cutoff frequency fT, the drain-to-source current JDS, and the transconductance gmhave been analyzed for InP HEMTs. All devices exhibited an increase in IDSwith increasing [In], delta, and dSL. An increase in fmax, fT, and gmwere observed with increasing [In]. When changing [In] from 53% to 80%, fTand fmaximproved by 14% and 21%, respectively. For the delta parameter, an increase in fTand gm. was found. However, fmaxwas drastically reduced for the highest delta. This is suggested to be due to the formation of a parasitic conduction channel located at the doping plane in the HEMT structure for delta > 6.3 times 1012cm-2. For the dSLparameter, an optimum with respect to fmax, fT, and gm. was observed. The optimized HEMT exhibited an extrinsic fTand fmaxof 250 and 300 GHz, respectively. [J303]

"An SiC/GaN Detector/Front-End Detection System for High-Resolution Alpha-Particle Spectroscopy"

An alpha-particle spectrometer has been assembled, consisting of an epitaxial 50 mum thick 4H silicon carbide (SiC) detector connected to a gallium-nitride (GaN) high-electron mobility transistor (HEMT) used as input transistor of the front-end electronics. The depleted layer of the SiC diode detector was sufficient to stop all alpha particles in the 4.8-MeV to 5.8-MeV energy range. An excellent energy resolution of ~ 0.9% has been obtained in this energy range at a temperature of 55degC. The energy-resolution limiting factor is found to be the dispersion of the energy loss in the gold Schottky contact, which acts as entrance window to the detector. We used a GaN front-end transistor because this material offers two important advantages over silicon: (1) it is a wide bandgap semiconductor and therefore is intrinsically more desirable for room and above-room temperature operation and (2) it can be grown on SiC substrates so as to realize SiC/GaN integrated systems. SiC-detector spectrometers are interesting in many nuclear applications where the operation environment is hostile, both in terms of ionising radiations and of high temperatures. Such applications include monitoring of ionising radiations in nuclear power plants and beam diagnostic in fundamental nuclear physics experiments. [J304]

"Utilizing Diode Characteristics for GaN HEMT Channel Temperature Prediction"

Measuring channel temperature in GaN high-electron mobility transistors (HEMTs) is challenging due to the submicrometer dimensions of the gate fingers. The HEMT characteristics are electrically and thermally dependent. The channel temperature is measured using the Schottky gate-diode forward characteristics and compared with results of simulation, theory, and experimental evidence. The pulsed gate-diode forward resistance and threshold voltage predict channel temperatures that agree well with other methods. The technique presented provides a fast, easily implementable methodology for estimating channel temperature. [J305]

"Low Insertion-Loss Single-Pole-Double-Throw Reduced-Size Quarter-Wavelength HEMT Bandpass Filter Integrated Switches"

This paper proposes a circuit topology which reduces the chip size of single-pole-double-throw (SPDT) quarter-wavelength bandpass filter-integrated switches (FIS). A 40-GHz mHEMT MMIC SPDT switch has been implemented and demonstrates a measured insertion loss lower than 1 dB and an isolation better than 30 dB. Another 50-GHz pHEMT MMIC SPDT achieves 1.5 dB insertion loss and 22 dB isolation. The low insertion loss and high isolation shows that the circuit performance is improved along with the reduction of the size. The systematic design approach of the reduced-size FIS is described, together with the analysis of the insertion loss and isolation. [J306]

"Huge positive magnetoresistance in a gated Al Ga As /Ga As high electron mobility transistor structure at high temperatures"

Magnetoresistivity measurements on a gated AlGaAs/GaAshigh electron mobility transistor (HEMT) structure were performed at high temperatures T. By changing the applied gate voltage Vg, we can investigate the observed huge positive magnetoresistance (PMR) at different effective disorder and density inhomogeneity within the same HEMT structure. The observed PMR value increases with increasing disorder in the depletion mode (Vg≤0). Moreover, the PMR value is not limited by the quality of the HEMT structure at T=80K. Such results pave the way for low-cost, high-throughput GaAs-based HEMT fabrication for future magnetic sensing and recording devices fully compatible with the mature HEMT technology. [J307]

"Detection of chloride ions using an integrated Ag /Ag Cl electrode with Al Ga N /Ga N high electron mobility transistors"

AlGaN/GaNhigh electron mobility transistors (HEMTs) with an Ag/AgClgate exhibit significant changes in channel conductance upon exposing the gate region to various concentrations of chloride (Cl-)ion. The Ag/AgClgate electrode, prepared by potentiostatic anodization, changes electrical potential when it encounters Cl-ions. This gate potential changes lead to a change of surface charge in the gate region of the HEMT, inducing a higher positive charge on the AlGaN surface, and increasing the piezoinduced charge density in the HEMT channel. These anions create an image positive charge on the Ag gate metal for the required neutrality, thus increasing the drain current of the HEMT. The HEMT source-drain current was highly dependent on Cl-ion concentration. The limit of detection achieved was 1Ч10-8Musing a 20Ч50mcm2gate sensing area. [J308]

"c-erbB-2 sensing using Al Ga N /Ga N high electron mobility transistors for breast cancer detection"

Antibody-functionalized, Au-gated AlGaN/GaNhigh electron mobility transistors (HEMTs) were used to detect c-erbB-2, which is a breast cancer marker. The antibody was anchored to the gate area through immobilized thioglycolic acid. The AlGaN/GaNHEMT drain-source current showed a rapid response of less than 5swhen target c-erbB-2 antigen in a buffer at clinically relevant concentrations was added to the antibody-immobilized surface. We could detect a range of concentrations from 16.7to0.25mu g/ml. These results clearly demonstrate the promise of portable electronic biological sensors based on AlGaN/GaNHEMTs for breast cancer screening. [J309]

"Electron heating and huge positive magnetoresistance in an Al Ga As /Ga As high electron mobility transistor structure at high temperatures"

We have performed magnetoresistivity measurements rho xx(B)on an AlGaAs/GaAshigh electron mobility transistor (HEMT) structure at high temperatures T. The observed positive magnetoresistance (MR) in the HEMT structure can be greatly enhanced simply by increasing the driving current. At T=80Kand B=6T, the MR value can be increased from 150%to 4000%, almost a 30-fold increase when a large current of 40mu Ais applied. Such results are due to electron heating effects and our data lay the foundation for practical magnetic device applications which can be readily combined with high-speed electronics, high-frequency amplifiers, and radar using the mature GaAs-based HEMT technology. [J310]

"Inverse Class-F AlGaN/GaN HEMT Microwave Amplifier Based on Lumped Element Circuit Synthesis Method"

A lumped element design method considering more than third-order higher harmonic frequencies for a microwave AlGaN/GaN HEMT inverse class-F amplifier has been developed. The load circuit consists of a series reactance network having zero impedance at the odd order harmonic frequencies and poles at the even order higher harmonic frequencies as well as a shunt reactance network having zero impedance at the odd order harmonic frequencies. A fabricated AlGaN/GaN HEMT inverse class-F amplifier delivered a power-added efficiency of 76.3% and a drain efficiency of 78.3% at 879 MHz. [J311]

"Self-aligned AlGaN/GaN high electron mobility transistors with 0.18 μm gate-length"

To complement the gate scaling of HEMTs and also to reduce access resistance, self-aligned devices with a gate-length of 0.18 mum have been fabricated on 6H-SiC substrates using a single-step ohmic process. An Mo/Al/Mo/Au-based ohmic contact, requiring annealing temperatures around ~deg550degC, was utilised. These 0.18 mum devices exhibited maximum drain current density of 900 mA/mm at a gate bias of 0 V and a drain bias of 10 V. The knee voltage was less than 2 V, showing the excellent nature of the ohmic contact. A peak extrinsic transconductance (gm) of 290 mS/mm was measured at Vgs= -2.6=V and a drain bias of 8=V. A unity gain cutoff frequency, fTof 92 GHz, and unilateral power gain frequency, fmax, were measured on these devices. [J312]

"Demonstration of AlGaN/GaN High-Electron-Mobility Transistors Grown by Molecular Beam Epitaxy on Si(110)"

The growth of AlGaN/GaN-based heterostructure on Si(110) substrates by molecular beam epitaxy using ammonia as the nitrogen precursor is reported. The structural, optical, and electrical properties of such heterostructure are assessed and are quite similar to the ones obtained on Si(111). A 2-D electron gas is formed at the Al0.3Ga0.7N/GaN interface with a sheet carrier density of 9.6 times 1012cm-2and a mobility of 1980 cm2/V middots at room temperature. Preliminary results concerning high-electron-mobility-transistor static characteristics are presented and compared with that of devices realized on other orientations of silicon. [J313]

"On an InGaP/InGaAs Double Channel Pseudomorphic High Electron Mobility Transistor With Graded Triple -Doped Sheets"

An interesting InGaP/InGaAs double channel pseudomorphic high electron mobility transistor is fabricated and demonstrated. Due to the employed InGaP Schottky and buffer layers, InGaAs double channel structure, and graded triple delta-doped sheets, both DC and RF performances are improved. From experimental results, the studied device, with a gate dimension of 0.8 x 100 mum2, shows a drain saturation current of 176 mA/mm, a maximum extrinsic transconductance of 176 mS/mm, a unity current gain cutoff frequency of 16 GHz, and a maximum oscillation frequency of 33.2 GHz at room temperature. Moreover, a theoretical analysis based on a 2-D semiconductor simulation package is used to study the device properties and compare the experimental results. Good agreement between the theoretical analyses and experimental results is found. [J314]

"An Efficient Technique for Designing High-Performance Millimeter-Wave Vector Modulators With Low Temperature Drift"

Recently the demand for high-performance low-cost vector modulators for millimeter-wave direct carrier modulation applications is increasing. An efficient technique to improve the performance of the vector modulators has been proposed in this paper accordingly. This technique highlights the effect of the Lange coupler characteristic impedance and the cold pseudomorphic HEMT (pHEMT) total gatewidth on the performance. It is demonstrated by investigating two types of vector modulators, which employ unbalanced and balanced topologies. Furthermore, to reduce the temperature drift, a concise analysis of the thermal behavior of the vector modulators has been carried out. Based on the proposed technique, two types of monolithic vector modulators have been realized at 40 GHz on a 100-mum -thick GaAs substrate with 0.15-mum cold-pHEMT devices. The static constellations were obtained by using an automatic measurement system, and the temperature drifts were characterized by the measurement data from -55degC to 70degC . The results show that the technique is suitable for millimeter-wave vector modulator designs. [J315]

"Electrical Characterization and Small-Signal Modeling of InAs/AlSb HEMTs for Low-Noise and High-Frequency Applications"

Electrical characterization and modeling of 2 times 50 mum gatewidth InAs/AlSb HEMTs with 225 nm gate-length have been performed. The fabricated devices exhibited a transconductance gmof 650 mS/mm, an extrinsic cutoff frequency fTand an extrinsic maximum frequency of oscillation fmaxof 120 and 90 GHz, respectively, already at a low VDSof 0.2 V. A minimum noise figure less than 1 dB between 2-18 GHz was achieved at a dc power consumption of only 10 mW/mm. This demonstrates the potential of InAs/AlSb HEMTs for low-power, low-noise applications. To account for the elevated gate-leakage current IGin the narrow-bandgap InAs/AlSb HEMT, the conventional field-effect transistor small-signal model has been extended. The relatively high IGwas modeled by shunting both Cgsand Cgdwith Rgsand .Rgd, respectively. As a result, the small-signal S-parameters were more accurately modeled, especially for frequencies below 10 GHz. Utilizing this modeling approach, excellent agreement was obtained between measured and modeled S-parameters, unilateral power gain U (Mason's gain) and stability factor K. [J316]

"Punchthrough-Voltage Enhancement of AlGaN/GaN HEMTs Using AlGaN Double-Heterojunction Confinement"

In this paper, we present an enhancement of punchthrough voltage in AlGaN/GaN high-electron-mobility-transistor devices by increasing the electron confinement in the transistor channel using an AlGaN buffer-layer structure. An optimized electron confinement results in a scaling of punchthrough voltage with device geometry and a significantly reduced subthreshold drain leakage current. These beneficial properties are pronounced even further if gate-recess technology is applied for device fabrication. Physical-based device simulations give insight in the respective electronic mechanisms. [J317]

"Assessment of surface damage and sidewall implantation in AlGaN-based high electron mobility transistor devices caused during focused-ion-beam milling"

The surface amorphization and ion implantation in AlGaN-based high electron mobility transistor (HEMT) model structures caused by ionized gallium during focused-ion-beam milling have been investigated. The extent of Ga+surface implantation likely to occur during deposition of the surface Pt protective layer was simulated for 30, 5, and 2 keV ion beams. Electron-transparent cross sections of AlGaN/GaN and AlGaN/AlN/GaN HEMT structures were then prepared for electron microscope observation using a dual-beam focused-ion-beam instrument operated at different beam energies. Experimental studies revealed that the upper 9 nm of the AlGaN layer had been amorphized during Pt deposition. Nanoprobe x-ray microanalysis confirmed intermixing with Pt as well as implantation of Ga ions into the upper regions of the foil. Deposition of the first few hundred nanometers of Pt using an electron beam, rather than the usual Ga+beam, enabled surface damage and ion implantation to be completely avoided. Sidewall damage for specially prepared cross sections was assessed from bright-field and high-angle annular-dark-field images. For final membrane thinning at 30, 5, and 2 keV, the thicknesses of visibly damaged layers were approximately 20, 8, and 4 nm, respectively, roughly twice as large as predicted by simulations. [J318]

"Suppression of the intermode plasmon scattering due to total internal reflection of oblique plasmons in a multichannel high-electron-mobility transistor"

Terahertz radiation impinging on multichannel high-electron-mobility transistors (HEMTs) with comparable lateral and transverse gated-channel dimensions excites oblique plasmons modes that experience the total internal reflection from the gate edges. This reflection prevents leakage of the gated plasmon energy into the ungated plasmons modes of ungated device regions. These results can explain significant shrinking of the gated plasmon resonance linewidth in the multichannel HEMT. [J319]

"Very high channel conductivity in low-defect AlN/GaN high electron mobility transistor structures"

Low defect AlN/GaN high electron mobility transistor (HEMT) structures, with very high values of electron mobility (1800cm2/V s)and sheet charge density (3Ч1013cm-2), were grown by rf plasma-assisted molecular beam epitaxy (MBE) on sapphire and SiC, resulting in sheet resistivity values down to 100Omega / at room temperature. Fabricated 1.2mcmgate devices showed excellent current-voltage characteristics, including a zero gate saturation current density of 1.3A/mmand a peak transconductance of 260mS/mm. Here, an all MBE growth of optimized AlN/GaN HEMT structures plus the results of thin-film characterizations and device measurements are presented. [J320]

"Analysis of resonant detection of terahertz radiation in high-electron mobility transistor with a nanostring/carbon nanotube as the mechanically floating gate"

We develop a device model for a resonant detector of electromagnetic radiation with a frequency in the terahertz (THz) range modulated by megahertz (MHz) or gigahertz (GHz) signals based on a micromachined high-electron mobility transistor (HEMT) with a metallized nanostring (NS) or metallic carbon nanotube (CNT) as mechanically the floating gate and analyze the detector operation. The device model describes both the NS/CNT mechanical motion and plasma effects in the HEMT two-dimensional electron channel. Using this model, we calculate the output gate alternating current and the detector responsivity as functions of the carrier (in the THz range) and modulation frequencies, which are in the THz and MHz (or GHz range), respectively. It is shown that the THz detector responsivity exhibits sharp and high maxima under the conditions of both mechanical and plasma resonances. [J321]

"Molecular beam epitaxy growth of metamorphic high electron mobility transistors and metamorphic heterojunction bipolar transistors on Ge and Ge-on-insulator/Si substrates"

A direct growth approach using composite metamorphic buffers was employed for monolithic integration of InP-based high electron mobility transistors (HEMTs) and heterojunction bipolar transistors (HBTs) on Ge and Ge-on-insulator (GeOI)/Si substrates using molecular beam epitaxy. GaAs layers nucleated on these substrates and grown to a thickness of 0.5mcmwere optimized to minimize the nucleation and propagation of antiphase boundaries and threading dislocations, and exhibited an atomic force microscopy rms roughness of 9Eand x-ray full width at half maximum of 36arcsec. A 1.1mcmthick graded InAlAs buffer was used to transition from the GaAs to InP lattice parameters. The density of threading dislocations at the upper interface of this InAlAs buffer was 107cm-2based on cross-sectional transmission electron microscopy analyses. HEMT structures grown metamorphically on GeOI/Si substrates using these buffer layers demonstrated transport properties equivalent to base line structures grown on InP substrates, with room temperature mobility greater than 10000cm2/Vs.

Similarly, double heterojunction bipolar transistors (D-HBTs) grown metamorphically on GeOI/Si substrates and fabricated into large area devices exhibited dc parameters close to reference D-HBTs grown on InP substrates. [J322]

"Study of interface barrier of SiN x /GaN interface for nitrogen-polar GaN based high electron mobility transistors"

The SiNx/GaNinterface barrier height for N-polar GaN based metal-insulator-semiconductor high electron mobility transistors (MISHEMTs) was investigated. N-polar SiNx/GaN/AlGaN/GaNMISHEMT structures with different GaN cap thicknesses were grown by metal-organic chemical vapor deposition. The properties of the SiNx/GaNinterface are of critical importance to device operation and modeling in these devices. An analytical expression for the pinch-off voltage of the HEMT was obtained, and capacitance-voltage (C-V)measurements with different Schottky metals were used to extract the barrier height. The Fermi level at the interface was found to be pinned at approximately 1 eV with respect to GaN conduction band edge, irrespective of the work function of the gate metal. Hall measurements of the two-dimensional electron gas density were found to corroborate the predicted interface barrier height. An approximate value for interface charge causing this pinning was calculated to be 4.5Ч1012cm-2. [J323]

"Electrical detection of biomaterials using AlGaN/GaN high electron mobility transistors"

Chemical sensors can be used to analyze a wide variety of environmental and biological gases and liquids and may need to be able to selectively detect a target analyte. Different methods, including gas chromatography, chemiluminescence, selected ion flow tube, and mass spectroscopy, have been used to measure biomarkers. These methods show variable results in terms of sensitivity for some applications and may not meet the requirements for a handheld biosensor. A promising sensing technology utilizes AlGaN/GaN high electron mobility transistors (HEMTs). HEMT structures have been developed for use in microwave power amplifiers due to their high two dimensional electron gas (2DEG) mobility and saturation velocity. The conducting 2DEG channel of AlGaN/GaN HEMTs is very close to the surface and extremely sensitive to adsorption of analytes. HEMT sensors can be used for detecting gases, ions, pHvalues, proteins, and DNA. In this paper we review recent progress on functionalizing the surface of HEMTs for specific detection of glucose, kidney marker injury molecules, prostate cancer, and other common substances of interest in the biomedical field. [J324]

"Effect of image charges in the drain delay of Al Ga N /Ga N high electron mobility transistors"

The drain delay in AlGaN/GaNsubmicron high electron mobility transistors (HEMTs) accounts for almost 25% of the total electron delay. This long delay significantly limits the maximum frequency performance and linearity of these devices. This paper studies the origin of this important delay assuming that it is inversely proportional to alpha, a parameter related to how injected channel electrons image at different contacts in the HEMT. Through analysis and two-dimensional simulations, we have found that alpha equals 3 in a standard HEMT. This value has been confirmed experimentally through the coupling of Monte Carlo simulations and drain delay measurements. [J325]

"Remarkable breakdown voltage enhancement in AlGaN channel high electron mobility transistors"

The channel layer substitution of a wider bandgap AlGaN for a conventional GaN in high electron mobility transistors (HEMTs) is an effective method of enhancing the breakdown voltage. We demonstrated a remarkable breakdown voltage enhancement in these AlGaN channel HEMTs. The obtained maximum breakdown voltages were 463 and 1650Vin the Al0.53Ga0.47N/Al0.38Ga0.62NHEMT with the gate-drain distances of 3 and 10mcm, respectively. This result is very promising for the further higher power operation of high-frequency HEMTs. [J326]

"High-performance Al Ga N /Ga N lateral field-effect rectifiers compatible with high electron mobility transistors"

A high electron mobility transistor (HEMT)-compatible power lateral field-effect rectifier (L-FER) with low turn-on voltage is demonstrated using the same fabrication process as that for normally off AlGaN/GaNHEMT, providing a low-cost solution for GaN power integrated circuits. The power rectifier features a Schottky-gate-controlled two-dimensional electron gas channel between the cathode and anode. By tying up the Schottky gate and anode together, the forward turn-on voltage of the rectifier is determined by the threshold voltage of the channel instead of the Schottky barrier. The L-FER with a drift length of 10mcmfeatures a forward turn-on voltage of 0.63Vat a current density of 100A/cm2. This device also exhibits a reverse breakdown voltage (BV) of 390Vat a current level of 1mA/mmand a specific on resistance (RON,sp)of 1.4mOmega cm2, yielding a figure of merit

(BV2/RON,sp)of 108MW/cm2. The excellent device performance, coupled with the lateral device structure and process compatibility with AlGaN/GaNHEMT, make the proposed L-FER a promising candidate for GaN power integrated circuits. [J327]

"Ti-based nonalloyed Ohmic contacts for Al 0.15 Ga 0.85 N /Ga N high electron mobility transistors using regrown n+ -Ga N by plasma assisted molecular beam epitaxy"

A technique for regrowing n+-GaNlayers has been developed to realize nonalloyed Ohmic contacts using plasma assisted molecular beam epitaxy. The contact resistance and device performance were measured of a recessed-gate with the regrowth and of recessed-source/drain AlGaN/GaNhigh electron mobility transistors (HEMTs). With the regrown n+-GaNlayers and recessed drain/source, a low contact resistance of 0.6Omega mmwas obtained for Ti/Aucontacts to AlGaN. The peak drain current (IDS,max)and maximum transconductance (gm,max)of the AlGaN/GaNHEMTs with nonalloyed Ohmic contacts were 573mA/mmand 60mS/mm, respectively. These results demonstrate that the regrowth of highly doped GaN layers is crucial in achieving low-resistance nonalloyed Ohmic contacts for the HEMT structures. [J328]

"Enzyme-based lactic acid detection using Al Ga N /Ga N high electron mobility transistors with ZnO nanorods grown on the gate region"

The detection of lactic acid with ZnO nanorod-gated AlGaN/GaNhigh electron mobility transistors (HEMTs) was demonstrated. The array of ZnO nanorods provided a large effective surface area with a high surface-to-volume ratio and a favorable environment for the immobilization of lactate oxidase. The HEMT drain-source current showed a rapid response when various concentrations of lactic acid solutions were introduced to the gate area of the HEMT sensor. The HEMT could detect lactic acid concentrations from 167nMto 139mcm. Our results show that portable, fast response, and wireless-based lactic acid detectors can be realized with AlGaN/GaNHEMT based sensors. [J329]

"Botulinum toxin detection using Al Ga N /Ga N high electron mobility transistors"

Antibody-functionalized, Au-gated AlGaN/GaNhigh electron mobility transistors (HEMTs) were used to detect botulinum toxin. The antibody was anchored to the gate area through immobilized thioglycolic acid. The AlGaN/GaNHEMT drain-source current showed a rapid response of less than 5swhen the target toxin in a buffer was added to the antibody-immobilized surface. We could detect a range of concentrations from 1to10ng/ml. These results clearly demonstrate the promise of field-deployable electronic biological sensors based on AlGaN/GaNHEMTs for botulinum toxin detection. [J330]

"Surface strain and its impact on the electrical resistivity of GaN channel in AlGaN/GaN high electron mobility transistor"

Localized strain in AlGaN/GaN high electron mobility transistor (HEMT) device structures was studied by high resolution x-ray diffraction and rocking curve measurements, and the results were compared with the corresponding channel sheet resistance measurements. The map of in-plane tensile strain on the HEMT wafer showed a near one-to-one correspondence with the electrical resistivity. The in-plane strain variation in the range of (2.295-3.539)Ч10-4resulted in a corresponding sheet resistance variation between 345 and 411Omega / . [J331]

"Highly Efficient Three-Way Saturated Doherty Amplifier With Digital Feedback Predistortion"

A three-way saturated Doherty power amplifier (S-DPA) based on class-F topology is proposed to improve efficiency at large backed-off output power regions. The high efficiency is demonstrated by implementing the amplifier using Eudyna EGN010MK GaN HEMTs and testing it with a continuous wave (CW) signal and a forward-link wide-band code division multiple access (WCDMA) 1-FA signal at 2.14 GHz. The proposed S-DPA has a power-added efficiency (PAE) of 50% for the CW signal at 10 dB backed-off output power region, while a two-way S-DPA and class-F PA have PAEs of 39% and 25%, respectively. Also, the proposed S-DPA has a PAE of 46.7% for the WCDMA 1-FA signal with peak-to-average power ratio of 10 dB, while the two-way S-DPA and the class-F PA have PAEs of 42.7% and 28.7%, respectively. Moreover, the proposed S-DPA, when linearized by a digital feedback predistorter, delivers an adjacent channel leakage ratio of 49.2 dBc at a 2.5 MHz offset with a PAE of 45.9%. [J332]

"Unequal-Cells-Based GaN HEMT Doherty Amplifier With an Extended Efficiency Range"

This letter reports an extended GaN HEMT Doherty power amplifier (DPA). For high efficiency over a wide output power range, the DPA is designed using two cells with unequal saturation power (Psat). A cell with lower

Psatis used as the carrier cell. For experimental validations, the carrier and peaking cells are designed and implemented with 25 W GaN HEMTs at wide-band code division multiple access (WCDMA) of 2.14 GHz, and then show the Psatof 41.3 dBm and 43.6 dBm, respectively. For the proposed DPA, the single-tone results show the power-added efficiency (PAE) of 50% at an output power of 37.3 dBm (9 dB back-off power from Psat). For a one-carrier WCDMA signal, the PAE of 47.9% with an adjacent channel leakage ratio of -35.8 dBc is obtained at 37.3 dBm, which is 7.9% improvement compared to the conventional DPA. The PAE of 40% is maintained over an 11.4 dB back-off power. [J333]

"AlGaN/GaN MOS-HEMT With Dielectric and Interfacial Passivation Layer Grown by Atomic Layer Deposition"

We have developed a novel AlGaN/GaN metal-oxide-semiconductor high-electron mobility transistor using a stack gate HfO2/Al2O3structure grown by atomic layer deposition. The stack gate consists of a thin HfO2(30-A) gate dielectric and a thin Al2O3(20- A) interfacial passivation layer (IPL). For the 50-A stack gate, no measurable C-Vhysteresis and a smaller threshold voltage shift were observed, indicating that a high-quality interface can be achieved using a Al2O3IPL on an AlGaN substrate. Good surface passivation effects of the Al2O3IPL have also been confirmed by pulsed gate measurements. Devices with 1- mum gate lengths exhibit a cutoff frequency (fT) of 12 GHz and a maximum frequency of oscillation (fMAX) of 34 GHz, as well as a maximum drain current of 800 mA/mm and a peak transconductance of 150 mS/mm, whereas the gate leakage current is at least six orders of magnitude lower than that of the reference high-electron mobility transistors at a positive gate bias. [J334]

"A New Sub-Millimeter Wave Power Amplifier Topology Using Large Transistors"

In this letter, a new power amplifier topology is demonstrated which allows the use of large (120 mum/transistors) at extremely high frequency. This is accomplished by using compact matching networks consisting of coplanar waveguide transmission lines and metal-insulator-metal capacitors to match each of the three amplifier stages. The resulting amplifier achieves a peak gain of 16.5 dB at 260 GHz. Power measurements indicate that the chip achieves >5.9 mW (unsaturated) of output power and 4% power added efficiency at a frequency of 270 GHz, where the output power is limited by the available source drive power. This power level from a single transistor represents a significant improvement at this frequency band. [J335]

"When self-consistency makes a difference"

Compound semiconductor power RF and microwave device modeling requires, in many cases, the use of self-consistent electrothermal equivalent circuits. The slow thermal dynamics and the thermal nonlinearity should be accurately included in the model; otherwise, some response features subtly related to the detailed frequency behavior of the slow thermal dynamics would be inaccurately reproduced or completely distorted. Two examples have been shown, concerning current collapse in HBTs and modeling of IMPs in GaN HEMTs. Accurate thermal modeling can be made compatible with circuit-oriented CAD tools through a proper choice of system-level approximation; in the discussion presented it exploited a Wiener approach, but of course the strategy should be tailored to the specific problem under consideration. [J336]

"Reduced gate leakage current in AlGaN/GaN HEMT by oxygen passivation of AlGaN surface"

A remarkable reduction of the gate leakage current for AlGaN/GaN high electron mobility transistors (HEMT) is reported. The oxygen plasma treatment of the fabricated HEMT at 200degC reduced the gate leakage current by four orders of magnitude without degrading the transconductance and the drain current characteristics of the HEMT. X-ray photoelectron spectroscopy analysis showed that the binding of oxygen at the AlGaN surface is related to the reduction in the leakage current. [J337]

"V-Gate GaN HEMTs for X-Band Power Applications"

GaN high electron mobility transistors (HEMTs) with novel V-shaped gates were developed. The V-gate GaN HEMTs feature two key technologies: One is the use of an epitaxially grown GaN cap layer to isolate the surface charging from affecting the 2DEG channel; the other one is the adoption of a V-shaped gate-recess geometry that effectively mitigates the electric-field crowding at the gate edge. The combination of these two technologies enables high-voltage and dispersion-free operation without significantly sacrificing the devices' bandwidth. At 10-GHz frequency and 48-V drain bias, the V-gate devices exhibited an output power density of 12.2 W/mm with the associated power added efficiency as high as 65%. This result represents, to date, the highest reported efficiency at this frequency and operating voltage, indicating that the V-gate GaN HEMTs are suitable for X-band power applications. [J338]

"An AlGaN/GaN HEMT-Based Microstrip MMIC Process for Advanced Transceiver Design"

A MMIC process in AlGaN/GaN technology for advanced transceiver design has been developed. The process is based on microstrip technology with a complete model library of passive elements and AlGaN/GaN HEMTs. The transistor technology in this process is suitable for both power and low noise design, demonstrated with a power density of 5 W/mm, and an NFminof 1.4 dB at X-band. Process stability of subcircuits, complementary to power amplifiers and LNAs, in a transceiver system have been investigated. The results indicate that an all AlGaN/GaN MMIC transceiver is realizable using this technology. [J339]

"Alternative approach to dynamic I/V characterisation of microwave FETs"

A new and simple approach for the measurement of active device dynamic output I/V characteristics is presented. Device characterisation is performed making use of multi-harmonic exciting signal and variable loads at the output port. The measurement bench has been used to characterise a GaAs 1 mm gate periphery PHEMT as a test vehicle. The results, obtained making use of the proposed setup, successfully compare with those obtained via traditional pulsed measurement systems. [J340]

"AlN/GaN Insulated-Gate HEMTs With 2.3 A/mm Output Current and 480 mS/mm Transconductance"

High-electron mobility transistors (HEMTs) based on ultrathin AlN/GaN heterostructures with a 3.5-nm AlN barrier and a 3-nm Al2O3gate dielectric have been investigated. Owing to the optimized AlN/GaN interface, very high carrier mobility (~1400 cm2/V ldr s) and high 2-D electron-gas density (~2.7times1013/cm2) resulted in a record low sheet resistance (~165 Omega/sq). The resultant HEMTs showed a maximum dc output current density of ~2.3 A/mm and a peak extrinsic transconductance gm,ext~480 mS/mm (corresponding to gm,int~1 S/mm). An fT/fmaxof 52/60 GHz was measured on 0.25times60 mum2gate HEMTs. With further improvements of the ohmic contacts, the gate dielectric, and the lowering of the buffer leakage, the presented results suggest that, by using AlN/GaN heterojunctions, it may be possible to push the performance of nitride HEMTs to current, power, and speed levels that are currently unachievable in AlGaN/GaN technology. [J341]

"High-power monolithic AlGaN/GaN HEMT switch for X-band applications"

The design, fabrication and test of X-band high-power monolithic SPDT switches in microstrip GaN technology are presented. Such switches have demonstrated state-of-the-art performance: they exhibit 1 dB on-state insertion loss and better than 37 dB isolation. Power- handling measurements have shown that no compression phenomenon occurs with an input power equal to 39.5 dBm at 10 GHz. [J342]

"30-nm InAs Pseudomorphic HEMTs on an InP Substrate With a Current-Gain Cutoff Frequency of 628 GHz"

We report on InAs pseudomorphic high-electron mobility transistors (PHEMTs) on an InP substrate with record cutoff frequency characteristics. This result was achieved by paying attention to minimizing resistive and capacitive parasitics and improving short-channel effects, which play a key role in high-frequency response. Toward this, the device design features a very thin channel and is fabricated through a three-step recess process that yields a scaled-down barrier thickness. A 30-nm InAs PHEMT with tins= 4 nm and tch= 10 nm exhibits excellent gm, maxof 1.62 S/mm, fTof 628 GHz, and fmaxof 331 GHz at VDS= 0.6 V . To the knowledge of the authors, the obtained fTis the highest ever reported in any FET on any material system. In addition, a 50-nm device shows the best combination of fT= 557 GHz and fmax= 718 GHz of any transistor technology. [J343]

"Low-Frequency Noise Characteristics in Ion-Implanted GaN-Based HEMTs"

Low-frequency noise characteristics in ion-implanted GaN/AlGaN/GaN and AlGaN/GaN HEMTs were investigated. The normalized spectral noise density was about 6 dB lower in GaN/AlGaN/GaN HEMTs than in AlGaN/GaN HEMTs. The normalized spectral noise density dependence on the gate length Lgindicates that the main origin of low-frequency noise is at the region under the gate in both devices. The Hooge parameters alphaHfor both devices are on the order of 10-1-10-2. The ion implantation process introduces a lot of defects in the source/drain regions, but the values of alphaHare comparable with those for conventional GaN-based HEMT devices. The values of alphaHare also lower in GaN/AlGaN/GaN HEMTs than in AlGaN/GaN HEMTs, which is due to the decrease of surface potential fluctuations in GaN/AlGaN/GaN HEMTs. [J344]

"A 97.8% Efficient GaN HEMT Boost Converter With 300-W Output Power at 1 MHz"

A 175-to-350 V hard-switched boost converter was constructed using a high-voltage GaN high-electron-mobility

transistor grown on SiC substrate. The high speed and low on-resistance of the wide-band-gap device enabled extremely fast switching transients and low losses, resulting in a high conversion efficiency of 97.8% with 300-W output power at 1 MHz. The maximum efficiency was 98.0% at 214-W output power, well exceeding the state of the art of Si-based converters at similar frequencies. [J345]

"V-Gate GaN HEMTs With Engineered Buffer for Normally Off Operation"

We propose and demonstrate V-gate GaN high electron mobility transistors (HEMTs) with engineered buffers for normally off operation. By incorporating an AlGaN buffer under the GaN channel, net negative polarization charges are generated under the channel. These negative charges shift the threshold voltage of the GaN HEMT toward positive and therefore favor the realization of normally off operation. Using the engineered-buffer design coupled with our deep-recess V-gate structure, true normally off operation with reduced dc-RF dispersion was achieved. [J346]

"A Single-Ended Resistive -Band AlGaN/GaN HEMT MMIC Mixer"

A broadband highly linear X-band mixer in AlGaN/GaN monolithic microwave integrated circuit technology has been designed, processed, and characterized. The design is based on a 4 times 100 mum AlGaN/GaN HEMT in a single-ended circuit topology. The mixer has an IF bandwidth of 2 GHz with a conversion loss (CL) of < 8 dB across the X-band with a minimum CL of 6.9 dB at 11 GHz. The large-signal performance is exemplified by IIP 3 levels of 22 and 30 dBm at local oscillator drive levels of 15 and 23 dBm, respectively. A minimum noise figure of 9 dB is achieved at 11.6 GHz. [J347]

"Simulation of Life Testing Procedures for Estimating Long-Term Degradation and Lifetime of AlGaN/GaN HEMTs"

Finite element 3-D thermal simulations of long-term degradation in AlGaN/GaN HEMTs for high-power applications are reported on, in which temperature evolves over time as the local degradation rate varies within the modeled device based on the local temperature of the degrading region (i.e., the channel). Specifically, hotter regions within a device are modeled as degrading faster due to a thermal component to the degradation rate equation. This allows self-consistent simulation of life testing, commonly used to estimate long-term reliability by extrapolating failure times seen at elevated channel temperatures to a lower "use" temperature. We find that it is necessary to consider the entire distribution of temperatures within the device instead of at one characteristic location to get the most accurate estimates for long-term device life. The effect of device geometry, assumed degradation mode, incorrect thermal resistance data, and dissipated power level on this lifetime estimation error is investigated. It is found that the error in the extrapolated failure time is greatly increased when both the thermal resistance is in error and the dissipated power of the life test does not match the expected power during operation, compared to when only one of these is off. [J348]

"Effect of Gate Leakage in the Subthreshold Characteristics of AlGaN/GaN HEMTs"

This letter studies the effect of gate leakage on the subthreshold slope and ON/OFF current ratio of AlGaN/GaN high-electron mobility transistors (HEMTs). We found a strong correlation between the gate leakage current and the transistor subthreshold characteristics: the lower the gate leakage, the higher the ON/OFF ratio and the steeper the subthreshold slope. To improve the subthreshold characteristics in GaN HEMTs, the gate leakage current was reduced with an O2plasma treatment prior to the gate metallization. The O2plasma treatment effectively reduces the gate leakage current by more than four orders of magnitude, it increases the ON/OFF ratio to more than seven orders of magnitude and the improved AlGaN/GaN HEMT shows a nearly ideal subthreshold slope of 64 mV/dec. [J349]

"A Design Technique for Concurrent Dual-Band Harmonic Tuned Power Amplifier"

In this paper, a novel technique to design concurrent dual-band high-efficiency harmonic tuned (HT) power amplifiers (PAs) is presented. The proposed approach is based on a methodology developed to design multifrequency passive matching networks, which allows concurrent operability. The network design criterion is heavily investigated and later generalized both from the theoretical and practical point of view. The design, realization, and the complete characterization of a concurrent dual-band high-efficiency HT PA is finally described. A 1-mm gate periphery GaN HEMT device was used for the design and realization of the PA operating concurrently at 2.45 and 3.3 GHz. The measurement results have shown 53% and 46% drain efficiency at 33- and 32.5-dBm output power in the two targeted bands if operated in continuous wave single mode. In concurrent mode, 35% average efficiency was achieved with two simultaneously applied orthogonal frequency-division multiplexing signals. [J350]

"Metamorphic HEMT MMICs and Modules for Use in a High-Bandwidth 210 GHz Radar"

In this paper, we present the development of advanced W-band and G-band millimeter-wave monolithic integrated circuits (MMICs) and modules for use in a high-resolution radar system operating at 210 GHz. A W-band frequency multiplier by six as well as a subharmonically pumped 210 GHz dual-gate field-effect transistor (FET) mixer and a 105 GHz power amplifier circuit have been successfully realized using our 0.1 mum InAlAs/InGaAs based depletion-type metamorphic high electron mobility transistor (mHEMT) technology in combination with grounded coplanar circuit topology (GCPW). Additionally, a 210 GHz low-noise amplifier MMIC was fabricated using our advanced 0.05 mum mHEMT technology. To package the circuits, a set of waveguide-to-microstrip transitions has been realized on 50 mum thick quartz substrates, covering the frequency range between 75 and 220 GHz. The presented millimeter-wave components were developed for use in a novel 210 GHz radar demonstrator COBRA-210, which delivers an instantaneous bandwidth of 8 GHz and an outstanding spatial resolution of 1.8 cm. [J351]

"Electrostatic Mechanisms Responsible for Device Degradation in Proton Irradiated AlGaN/AlN/GaN HEMTs"

Displacement-damage induced degradation in AlGaN/AlN/GaN HEMTs with polarization charge induced 2DEGs is examined using simulations and experiments. Carrier removal in the unintentionally doped AlGaN layer changes the space charge in the structure and this changes the band bending. The band bending decreases the 2DEG density, which in turn reduces the drain current in the device. The effect of the defect energy levels on the 2DEG density is also studied. The interplay between carrier removal, mobility degradation, and the charged defects is analyzed and quantified. [J352]

"GaN HEMT Potential for Low-Noise Highly Linear RF Applications"

This paper presents a study of the capability of gallium-nitride (GaN) high-electron mobility transistors (HEMTs) to achieve low noise and high linearity performance. A packaged GaN HEMT was measured in a 50-Omega system at 2 GHz. Noise figures slightly above 1.8 dB were achieved together with a record third-order intercept point of 54 dBm. The same configuration yields a maximum output power of 30 W, with 50% power-added efficiency. This combination of high power and low-noise performance allows the realization of highly linear low-noise amplifiers, which could significantly reduce protection and filter efforts at receiver inputs. [J353]

"N-Face Metal-Insulator-Semiconductor High-Electron-Mobility Transistors With AlN Back-Barrier"

We present a high-performance SiN/AlGaN (cap)/GaN (channel)/AlN (barrier)/GaN (buffer) metal-insulator-semiconductor high-electron-mobility transistor grown on the N-face, in which the 2-D electron gas (2DEG) is induced at the top GaN/AlN interface. The use of AlN eliminates alloy disorder scattering to the 2DEG and provides strong back-barrier confinement of the 2DEG under high electric fields for device scaling. Devices with 0.7-mum gate length showed a current-gain cutoff frequency (fT) of 17 GHz and a power-gain cutoff frequency (fmax) of 37 GHz. A continuous-wave output power density of 7.1 W/mm was measured at 4 GHz, with 58% power-added efficiency and a large-signal gain of 15.3 dB at a drain bias of 35 V. [J354]

"TEM Observation of Crack- and Pit-Shaped Defects in Electrically Degraded GaN HEMTs"

AlGaN/GaN high-electron mobility transistors stressed under dc bias at various channel temperatures were studied using transmission electron microscopy for evidence of physical damage. Stressed devices consistently developed crack- and pit-shaped defects in the AlGaN/GaN crystal material under the drain-side edge of the gate, whereas side-by-side as-processed unstressed devices did not show these features. Furthermore, the amount of physical damage was found to correlate to the amount of electrical degradation as measured by the change in IDmax from before and after stress. The formation of these defects is consistent with the theory of damage from the inverse piezoelectric effect. [J355]

"Highly Efficient Doherty Amplifier Based on Class-E Topology for WCDMA Applications"

This letter reports a high-efficiency gallium nitride (GaN) high-electron mobility transistor (HEMT) Doherty power amplifier (DPA) based on the class-E topology for wideband code-division multiple-access (WCDMA) applications. The class-E topology is employed as the carrier and peaking cells of the Doherty configuration. For validations, the proposed DPA is designed and implemented with 25-W GaN HEMTs at 2.14 GHz. For the proposed DPA, the power-added efficiency (PAE) and drain efficiency of 56.1% and 61.2% are achieved at 40 dBm (6-dB backoff power from Psat) for a continuous wave. For a 1-carrier WCDMA signal, the PAE of 44.8% is obtained with an adjacent channel leakage ratio (ACLR) of -31 dBc at 37 dBm, which is an 8.9% improvement over the conventional DPA with an ACLR of -36.4 dBc. [J356]

"Lateral and Vertical Scaling of HEMTs for Post-Si-CMOS Logic Applications"

In this paper, we have experimentally investigated the impact of lateral and vertical scaling of In0.7Ga0.3As high-electron-mobility transistors (HEMTs) onto their logic performance. We have found that reducing the In0.52Al0.48As insulator thickness results in much better electrostatic integrity and improved short-channel behavior down to a gate length of around 60 nm. Our nearly enhancement-mode 60-nm HEMTs feature VT= -0.02 V, DIBL = 93 mV/V, S= 88 mV/V, and ION/IOFF= 1.6 times104, at VDD= 0.5 V. We also estimate a gate delay of CV/I = 1.6 ps at VDD= 0.5 V. We have benchmarked these devices against state-of-the-art Si CMOS. For the same leakage current, which includes the gate leakage current, the InGaAs HEMTs exhibit 1.2times more current drive (ION) than the state-of-the-art 65-nm low-power CMOS technology at VDD= 0.5 V. [J357]

"A 3-50 GHz Ultra-Wideband PHEMT MMIC Balanced Frequency Doubler"

A novel configuration of ultra-wideband (UWB) GaAs PHEMT monolithic microwave integrated circuit balanced frequency doubler is presented. By using two different terminal impedances of the common-source/common-gate active balun, the doubler exhibits UWB characteristic with more than a four octave frequency range. From 3 to 50 GHz, the measured conversion gain and fundamental frequency suppression of the doubler are better than -4 dB and 15 dB. [J358]

"A 26-38 GHz Monolithic Doubly Balanced Mixer"

A novel configuration of doubly balanced mixer is presented for operating over the 26-38 GHz band. The monolithic microwave integrated circuit (MMIC) was implemented by GaAs 0.15 mum pHEMT technology with the compact size of 1times2.5 mm2. A 180deg hybrid circuit and two identical Marchand baluns were employed to achieve good port-to-port isolation. They also have wide band performance, make the mixer more compact, and simplify IF extraction. This mixer has a conversion loss of better than 6 dB, a dc-10 GHz IF bandwidth, and the LO-to-RF and LO-to-IF isolations are better than 20 dB and 29 dB, respectively. [J359]

"A GaN HEMT Class F Amplifier at 2 GHz With > 80% PAE"

A Class F amplifier has been designed, fabricated, and tested using a GaN HEMT transistor and hybrid printed circuit board (PCB) packaging. The amplifier has a peak power-added efficiency (PAE) of 85% with an output power of 16.5 W. A gate-connected field-plated and a source-connected field-plated device of the same size and layout were measured in this topology. An output power and drain efficiency tradeoff, dependant on the drain impedance at the fundamental frequency due to the on-state resistance, is explored. A comparison between Class F and Inverse F, given particular operating conditions for this device, is made. [J360]

"Linearized Darlington Cascode Amplifier Employing GaAs PHEMT and GaN HEMT Technologies"

This paper reports on the results of a new Darlington cascode (DCAS) feedback amplifier topology implemented with 0.5 mum E-mode GaAs PHEMT technology. The Darlington cascode employs active self-bias and a linearizing Darlington cascode circuit for achieving enhanced gain and IP3-bandwidth performance. The Darlington cascode achieves 12.5 dB gain with a 16 GHz 3 dB bandwidth (BW)-a 60% BW improvement over an equivalent conventional Darlington amplifier design. The DCAS obtains an IP3 of 29 dBm with a 13 GHz BW-an 80% improvement in IP3-BW over the conventional Darlington approach. These improvements have been obtained without significantly compromising noise figure, stability, or bias robustness. The DCAS amplifier design approach was also successfully applied to a high-voltage GaN HEMT technology and resulted in greater than 1 W output power over a multi-octave 1-4GHz band. The DCAS topology offers an approach for compacting high microwave performance into a small area without the use of distributed or reactive matching techniques. [J361]

"Logic Suitability of 50-nm In0.7 Ga0.3 As HEMTs for Beyond-CMOS Applications"

We have experimentally studied the suitability of nanometer-scale In0.7Ga0.3As high-electron mobility transistors (HEMTs) as an n-channel device for a future high-speed and low-power logic technology for beyond-CMOS applications. To this end, we have fabricated 50- to 150-nm gate-length In0.7Ga0.3As HEMTs with different gate stack designs. This has allowed us to investigate the role of Schottky barrier height (PhiB) and insulator thickness (tins) on the logic characteristics of In0.7Ga0.3As HEMTs. The best 50-nm HEMTs with the highest PhiBand the smallest tinsexhibit an ION/IOFFratio in excess of 104and a subthreshold slope (S) below 86 mV/dec. These nonoptimized 50-nm In0.7Ga0.3As HEMTs also show a logic gate delay (CV/I) of around 1 ps at a supply voltage of 0.5 V, while maintaining an ION/IOFFratio above 104, which is comparable to state-of-the-art Si MOSFETs. As one of the alternatives for beyond-CMOS technologies, we believe that InAs-rich InGaAs HEMTs hold a considerable promise. [J362]

"Short-Channel Effect Limitations on High-Frequency Operation of AlGaN/GaN HEMTs for T-Gate Devices"

AlGaN/GaN high-electron mobility transistors (HEMTs) were fabricated on SiC substrates with epitaxial layers grown by multiple suppliers and methods. Devices with gate lengths varying from 0.50 to 0.09 mum were fabricated on each sample. We demonstrate the impact of varying the gate lengths and show that the unity current gain frequency response (fT) is limited by short-channel effects for all samples measured. We present an empirically based physical model that can predict the expected extrinsic fTfor many combinations of gate length and commonly used barrier layer thickness (tbar) on silicon nitride passivated T-gated AlGaN/GaN HEMTs. The result is that even typical high-aspect-ratio (gate length to barrier thickness) devices show device performance limitations due to short-channel effects. We present the design tradeoffs and show the parameter space required to achieve optimal frequency performance for GaN technology. These design rules differ from the traditional GaAs technology by requiring a significantly higher aspect ratio to mitigate the short-channel effects. [J363]

"Design and Analysis of Broadband Dual-Gate Balanced Low-Noise Amplifiers"

In this paper, we present three MMIC low-noise amplifiers using dual-gate GaAs HEMT devices in a balanced amplifier configuration. The designs target three different frequency bands including 4-9 GHz, 9-20 GHz, and 20-40 GHz. These dual-gate balanced designs demonstrate the excellent qualities of balanced amplifiers in terms of stability and matched characteristics, while demonstrating higher bandwidth than designs with a single-stage common-source device. Additionally, noise performance is excellent, with the 4-9 GHz LNA demonstrating <1.75 dB noise figure (NF), the 9-20 GHz LNA <2.75 dB NF and the 20-40 GHz LNA <2.5 dB NF. Demonstrating high gain and excellent bandwidth, the dual-gate devices seem a logical choice for the balanced amplifier topology. [J364]

"A 23-37 GHz Miniature MMIC Subharmonic Mixer"

A novel configuration of subharmonic mixer using an anti-parallel diode pair is presented for operating over the 23-37 GHz band. The monolithic microwave integrated circuit is implemented by GaAs 0.15 mum PHEMT technology with the compact size of 0.85 times 0.85 mm2. This mixer employs a directional coupler, LC low-pass filter, and a short stub for isolating three ports corresponding to radio frequency (RF), local oscillation (LO) input, and intermediate frequency (IF) output ports. The directional coupler also provides impedance transformation between the diode pair, RF, and LO ports. This makes the subharmonic mixer more compact and flexible. The best conversion loss of the subharmonic mixer is 9.4 dB, and the LO-to-RF and LO-to-IF isolations are better than 22 and 31 dB, respectively. [J365]

"Simulation of Ultrasubmicrometer-Gate Pseudomorphic HEMTs Using a Full-Band Monte Carlo Simulator"

Pseudomorphic delta-doped ultrasubmicrometer-gate high-electron mobility transistors have been modeled using a full-band cellular Monte Carlo simulator. Reasonable agreement between experimental and numerical results is obtained for a 70-nm gate length. We discuss the scaling of this device to shorter gate lengths and the role played by various dimensions in the structure. Devices with 20-nm gate lengths should produce fTs above 1.5 THz without difficulty. This paper demonstrates the power of particle-based simulation tools in capturing the relevant physics responsible for device operation and key to performance optimization. [J366]

"Investigation of Impact Ionization in InAs-Channel HEMT for High-Speed and Low-Power Applications"

An 80-nm InP high electron mobility transistor (HEMT) with InAs channel and InGaAs subchannels has been fabricated. The high current gain cutoff frequency (ft) of 310 GHz and the maximum oscillation frequency (fmax) of 330 GHz were obtained at VDS= 0.7 V due to the high electron mobility in the InAs channel. Performance degradation was observed on the cutoff frequency (ft) and the corresponding gate delay time caused by impact ionization due to a low energy bandgap in the InAs channel. DC and RF characterizations on the device have been performed to determine the proper bias conditions in avoidance of performance degradations due to the impact ionization. With the design of InGaAs/InAs/InGaAs composite channel, the impact ionization was not observed until the drain bias reached 0.7 V, and at this bias, the device demonstrated very low gate delay time of 0.63 ps. The high performance of the InAs/InGaAs HEMTs demonstrated in this letter shows great potential for high-speed and very low-power logic applications. [J367]

"Self-Consistent Electrothermal Modeling of Class A, AB, and B Power GaN HEMTs Under

Modulated RF Excitation"

This paper presents an accurate and flexible approach to the self-consistent electrothermal modeling of III-N-based HEMTs, combining a temperature-dependent electrical compact model with a novel behavioral nonlinear dynamic thermal model, suitable for circuit-level simulations. The behavioral thermal model is extracted, according to a Wiener-like approach, from a full-scale, finite-element-method-based time-domain 3-D solution of the heat equation. The electrothermal model, validated against dc, pulsed dc, -parameter and large-signal nonlinear measurements, is exploited to assess the impact of thermal memory effects on the device RF performances. In particular, the model allows for a detailed analysis and interpretation of the thermal memory effects on intermodulation distortion. Finally, the proposed approach enables to analyze such features for different thermal mountings, thus providing useful indications for technology assessment. [J368]

"A 30-130 GHz Ultra Broadband Direct-Conversion BPSK Modulator Using a 0.5- m E/D-PHEMT Process"

A 30-130 GHz ultra broadband direct-conversion binary phase shift keying (BPSK) modulator using a 0.5-mum enhancement/depletion-pseudomorphic high-electron mobility transistor (E/D-PHEMT) process is presented in this letter. The BPSK modulator was designed using a modified reflection-type topology with E-mode PHEMT devices. An advantage for the E-mode PHEMT process is positive gate bias, and therefore the bias circuit for the modulation would be less complicated. Moreover, the BPSK modulator demonstrates an error vector magnitude of within 5.5%, an adjacent channel power ratio of better than -35 dBc, and an on-off isolation of greater than 20 dB from 30 to 130 GHz. The chip size of the BPSK modulator is only 0.8x0.7 mm2. To the best of the authors' knowledge, this work is the highest operation frequency with the widest bandwidth among all the reported monolithic microwave integrated circuit-based BPSK modulators. [J369]

"A Variable Conversion Gain Star Mixer for Ka-Band Applications"

A variable conversion gain star mixer for Ka-band applications has been presented. This monolithic microwave integrated circuit was implemented on AlGaAs/InGaAs/GaAs pseudomorphic high-electron-mobility transistor process with a chip size of 1.7times1.7 mm2. The mixer is modified from conventional star mixer to apply dc bias. The conversion gain of the mixer, controlled by the voltage of the diodes, could be applied to meet gain compensation requirements in communication systems. From the measured results, the circuit can provide 11.9 dB conversion gain and 9.3 dB gain adjustment by controlling voltage from 0 to 0.7 V at 30 GHz. [J370]

"Comparison of GaN HEMTs on Diamond and SiC Substrates"

The performance of AlGaN/GaN high-electron-mobility transistors (HEMTs) on diamond and SiC substrates is examined. We demonstrate GaN-on-diamond transistors with periphery WG= 250 mum, exhibiting ft= 27.4 GHz and yielding a power density of 2.79 W/mm at 10 GHz. Additionally, the temperature rise in similar devices on diamond and SiC substrates is reported. To the best of our knowledge, these represent the highest frequency of operation and first-reported thermal and X-band power measurements of GaN-on-diamond HEMTs. [J371]

"Design of Cryogenic SiGe Low-Noise Amplifiers"

This paper describes a method for designing cryogenic silicon-germanium (SiGe) transistor low-noise amplifiers and reports record microwave noise temperature, i.e., 2 K, measured at the module connector interface with a 50-Omega generator. A theory for the relevant noise sources in the transistor is derived from first principles to give the minimum possible noise temperature and optimum generator impedance in terms of dc measured current gain and transconductance. These measured dc quantities are then reported for an IBM SiGe BiCMOS-8HP transistor at temperatures from 295 to 15 K. The measured and modeled noise and gain for both a single- and two-transistor cascode amplifier in the 0.2-3-GHz range are then presented. The noise model is then combined with the transistor equivalent-circuit elements in a circuit simulator and the noise in the frequency range up to 20 GHz is compared with that of a typical InP HEMT. [J372]

"An Integrated Wideband Power Amplifier for Cognitive Radio"

This paper presents the development of the wideband power amplifier (PA) for application to intelligent cognitive radios. The load-tracking based on the frequency-varied load-pull technique is proposed for the PA design. The load impedance tracking is realized by filter network synthesis. A 3-7.5-GHz broadband PA is demonstrated in 0.15-mum InGaAs pseudomorphic HEMT technology. Operated at 3.5 V, the P1dBand power-added efficiency of the PA are better than 21.4 dBm and 20%, respectively. [J373]

"Analysis and Design of Millimeter-Wave FET-Based Image Reject Mixers"

In this paper, wave analysis is applied to a field-effect transistor (FET)-based image reject mixer (IRM) in order to enhance the classical IRM theory and investigate the fundamental limitations in terms of conversion loss (LC) and image rejection ratio (IRR). Furthermore, it is also described how different FET technologies can be benchmarked versus each other regarding their suitability for use in resistive mixers. This benchmarking allows the designer to predict the performance, i.e., LC, of resistive mixers based on dc measurements, which facilitate the use of the presented method early in the design process. Three different versions of a 60-GHz IRM is also presented. Two of the IRMs demonstrate a measured state-of-the-art IRR of 30 dB in the 60-GHz band. The IRM employs an integrated ultra-wideband IF hybrid and has been designed, fabricated, and characterized in both pseudomorphic HEMT (pHEMT) and metamorphic HEMT (mHEMT) monolithic-microwave integrated-circuit processes. The different versions were designed to investigate the influence of the selected technology (pHEMT/mHEMT), but also to investigate the effect of the layout on the measured performance of the IRM. [J374]

"Edge Effects on Gate Tunneling Current in HEMTs"

We elucidate five considerations for accurate estimation of electron tunneling from the gate edges of high-electron mobility transistors (HEMTs). These considerations are listed as follows: 1) edge roughness; 2) net charge at the AlGaN/passivation interface; 3) dielectric constant of the medium above the HEMT surface; 4) nontriangular potential barrier; and 5) negligible angular tunneling from the gate edge. Using these considerations, we calculate the reverse gate current IGof AlGaN/GaN HEMTs based on thermionic trap-assisted tunneling (TTT) and direct tunneling (DT) mechanisms. These calculations establish that the observed rise in IGfor a gate voltage beyond the threshold is due to tunneling from the gate edges. The calculations also show that the TTT mechanism can predict the measured IGof AlGaN/GaN HEMTs over a wide range of gate voltages and temperatures and point to the possibility of a rapid rise in IGat high gate voltages due to the DT mechanism. [J375]

"Electron Device Model Parameter Identification Through Large-Signal-Predictive Small-Signal-Based Error Functions"

Empirical electron device models based on lumped equivalent circuits are usually identified through nonlinear optimization procedures, which are based on the best fitting between the extrinsic model behavior and measurements carried out under multibias static and small-signal excitations. In this paper, a new error function is proposed for equivalent circuit model parameter optimization. Although still being defined through standard static and small-signal measurement data, the new error function can be configured so as to obtain models tailored to specific large-signal applications. Experimental results, which confirm the validity of the proposed identification approach, are provided for a GaAs microwave pseudomorphic HEMT model aimed at the design of highly linear power amplifiers. [J376]

"Microwave Parametric Frequency Dividers With Conversion Gain"

A novel active parametric frequency divider configuration using coupled microstrip transmission lines and two balanced pseudomorphic HEMTs (pHEMTs) is presented. The analysis of the divide-by-2 circuit presented applies the principles of subharmonic generation using a nonlinear reactance to an active semiconductor device such as a pHEMT. A 2-1-GHz active analog frequency divider is designed and fabricated, with measurements showing a 20% bandwidth, 13.5-dB conversion gain, and harmonic rejection levels of more than 22 dBc. A maximum conversion gain of 18 dB is also achieved. These higher conversion efficiencies and the ability to cascade dividers allow for higher order division ratios to be achieved with the same topology. [J377]

"Suppression of Dynamic On-Resistance Increase and Gate Charge Measurements in High-Voltage GaN-HEMTs With Optimized Field-Plate Structure"

The dynamic on-resistance increase associated with the current collapse phenomena in high-voltage GaN high-electron-mobility transistors (HEMTs) has been suppressed by employing an optimized field-plate (FP) structure. The fabricated GaN-HEMTs of 600 V/4.7 A and 940 V/4.4 A for power-electronics applications employ a dual-FP structure consisting of a short-gate FP underneath a long-source FP. The measured on-resistance shows minimal increase during high-voltage switching due to increased electric-field uniformity between the gate and drain as a result of using the dual FP. The gate-drain charge Qgdfor the fabricated devices has also been measured to provide a basis for discussion of the ability of high-speed switching operation. Although Qgd/A(A: active device area) was almost the same as that of the conventional Si-power MOSFETs, RonA was dramatically reduced to about a seventh of the reported 600-V Si-MOSFET value. Therefore, RonQgdfor 600-V device was reduced to 0.32 OmeganC, which was approximately a sixth of that for the Si-power MOSFETs. The high-voltage GaN-HEMTs have significant advantages over silicon-power MOSFETs in terms of both the

reduced on-resistance and the high-speed switching capability. [J378]

"Dual-Gate E/E- and E/D-Mode AlGaAs/InGaAs pHEMTs for Microwave Circuit Applications"

In this paper, we developed dual-gate enhancement/enhancement-mode (E/E-mode) and enhancement/depletion-mode (E/D-mode) AlGaAs/InGaAs pHEMTs for high-voltage and high-power device applications. These dual-gate devices had a higher breakdown voltage (Vbr) and maximum oscillation frequency (fmax). This could be obtained because there were two depletion regions, and the total electrical field was shared between the two regions, leading to lower output conductance (go) and lower gate-to-drain capacitance (Cgd). The dual-gate device can be operated at a higher drain-to-source voltage (Vds), resulting in better linear gain and output power performance, as compared to a conventional single-gate E-mode GaAs pHEMT device. The maximum oscillation frequency obtained using the dual-gate E/E-mode device increased from 78 to 123 GHz. When operated at 2.4 GHz, the maximum RF output power of the single-gate E-mode and dual-gate E/D-mode devices increased from 636 to 810 mW/mm, respectively. We also produced a 2.4-GHz high-gain and high-power density two-stage power amplifier using dual-gate E/E and E/D-mode transistors. A linear gain of 40 dB and a maximum output power of 24 dBm were obtained. [J379]

"Ultrahigh-Speed 0.5 V Supply Voltage In0.7 Ga0.3 As Quantum-Well Transistors on Silicon Substrate"

The direct epitaxial growth of ultrahigh-mobility InGaAs/InAlAs quantum-well (QW) device layers onto silicon substrates using metamorphic buffer layers is demonstrated for the first time. In this letter, 80 nm physical gate length depletion-mode InGaAs QW transistors with saturated transconductance gmof 930 muS / mum and fTof 260 GHz at VDS= 0.5 V are achieved on 3.2 mum thick buffers. We expect that compound semiconductor-based advanced QW transistors could become available in the future as very high-speed and ultralow-power device technology for heterogeneous integration with the mainstream silicon CMOS. [J380]

"High-Resolution Raman Temperature Measurements in GaAs p-HEMT Multifinger Devices"

Self-heating in multifinger GaAs pseudomorphic-HEMT devices was investigated by micro-Raman spectroscopy. The device temperature was probed on the die as a function of applied bias, external heating, and device geometry. The temperature of the top GaAs layer was recorded inside the source-drain gap, as well as on the device periphery using 488-nm laser excitation. Obtained Raman temperatures were found to be higher than infrared thermography results, which is due to the improved spatial resolution of micro-Raman spectroscopy. Thermal resistance and crosstalk in the multifinger devices was evaluated as a function of thermal stress and finger pitch. [J381]

"Cryogenic Phase Detector for Superconducting Integrated Receiver"

New superconducting element, a cryogenic phase detector (CPD) has been proposed and preliminary tested. The CPD is based on a superconductor-insulator-superconductor junction and initially intended for phase locking of a flux-flow oscillator in a superconducting integrated receiver. First results of the CPD development and study are very encouraging; a sinusoidal response of the CPD has been measured at the variation of the phase shift between input signals. Dependences of the output signal and phase response on the CPD bias voltage have been studied; main parameters of this new device are estimated. Important that the CPD output current well above 10 has been measured at the input signal provided by the harmonic mixer of the integrated receiver and amplified by the existing HEMT-amplifier. Due to the large conversion coefficient this current being supplied to the flux-flow oscillator (FFO) control line is sufficient to directly tune FFO frequency. Obtained data demonstrate that the CPD intrinsically could operate with effective bandwidth more than 100 MHz. Preliminary results of the CPD implementation for the FFO phase locking are presented; possible advantages of such combination are discussed. [J382]

"Accurate large-signal single current source thermal model for GaAs MESFET/HEMT"

An accurate approach to the simulation of the DC and pulsed IV characteristics of GaAs MESFETs over the -70 to -+70degC temperature range is presented. The new approach, suitably modified can be applied to existing DC models to increase their accuracy and range of operation. [J383]

"On the Substrate Thermal Optimization in SiC-Based Backside-Mounted High-Power GaN FETs"

This paper presents a discussion on the substrate thermal design of backside-mounted power GaN high-electron mobility transistors. After a review on the thermal properties of the relevant materials and their temperature dependences, design guidelines are proposed on the basis of 3-D thermal simulations; the results presented

suggest that in SiC-based devices, substrate thinning does not typically improve the thermal resistance or the dynamic thermal behavior. Contrary to what happens in III-V GaAs- or InP-based discrete or integrated devices, therefore, microstrip design on a thinned substrate (as opposed to coplanar design on a comparatively thick substrate) is generally not thermally superior. This should make possible, from the thermal standpoint, the realization of coplanar multifunctional GaN-based monolithic microwave integrated circuits integrating, e.g., low-noise and power stages and avoiding the use of via holes. [J384]

"Characterization of a Cryogenic RF-Preamplifier for Superconducting Photodetector Readout"

This work addresses the problem of designing superconducting photodetector readout circuits. A preliminary investigation of a selection of commercially available components to implement a radio-frequency, broadband, low-noise preamplifier operated in a cryogenic environment is presented. Wide band, high gain, low noise and stability under input mismatching load conditions have been the leading criteria taken into account to choose the devices. A set of monolithic microwave integrated circuits (MMIC) based on different technologies (GaAs, InP, HEMT, HBT) has been considered. The prototypes have been characterized at room temperature and low temperature by means of a cryocooler; their main parameters, gain and noise figure, have been measured. [J385]

"In situ SiN passivation of AlGaN/GaN HEMTs by molecular beam epitaxy"

To improve the passivation process of AlGaN/GaN HEMTs, a unique passivation process has been developed in which an SiN passivation layer is deposited by MBE immediately following epitaxial growth of the HEMT structure. The effectiveness of this in situ passivation process is evaluated by comparing devices fabricated with this process to the conventional PECVD passivation process in which the SiN is deposited after gate metallisation. The improved material quality and the protection offered by the MBE-grown SiN may contribute to the significantly reduced dispersion and improved power performance measured for the wafer fabricated with the in situ passivation process. [J386]

"Transient Response of Semiconductor Electronics to Ionizing Radiation. Recent Developments in Charge-Collection Measurement"

Recent measurements of heavy-ion-induced charge- collection transients are presented. These measurements are possible for the first time because of recent developments in high- bandwidth, single-shot measurement technology, and exhibit several significant advantages over conventional (charge-sensitive preamplifier) charge-collection measurements. Heavy-ion induced transient measurements are presented for InGaAs/InAlAs HEMTs, AlSb/InAs HEMTs, GaAs HFETs and for SOI NMOS devices, and the significant advantages of this approach are described. [J387]

"Analysis and Design of Bandpass Single-Pole-Double-Throw FET Filter-Integrated Switches"

This paper proposes a method to integrate a single-pole-double-throw (SPDT) switch and a quarter-wavelength bandpass filter. A 1-GHz SPDT hybrid switch and a 60-GHz pseudomorphic HEMT monolithic-microwave integrated-circuit SPDT switch with 30% fractional bandwidth are demonstrated. The 1-GHz SPDT switch achieves 1.5-dB insertion loss and 20-dB isolation at center frequency. For the 60-GHz SPDT switch, the measured insertion loss is lower than 2.5 dB and the isolation is higher than 27 dB. The low insertion loss and high isolation show that no performance is degraded when integrating the filter function. The analysis of the power performance is also described. Using the device dc-IV curves, the power compression point can be predicted. [J388]

"Silicon Dioxide-Encapsulated High-Voltage AlGaN/GaN HFETs for Power-Switching Applications"

In this letter, new approach in achieving high breakdown voltages in AlGaN/GaN heterostructure field-effect transistors (HFETs) by suppressing surface flashover using solid encapsulation material is presented. Surface flashover in III-Nitride-based HFETs limits the operating voltages at levels well below breakdown voltages of GaN. This premature gate-drain breakdown can be suppressed by immersing devices in high-dielectric-strength liquids (e.g., Fluorinert); however, such a technique is not practical. In this letter, AlGaN/GaN HFETs encapsulated with PECVD-deposited SiO2films demonstrated breakdown voltage of 900 V, very similar to that of devices immersed in Fluorinert liquid. Simultaneously, low dynamic ON-resistance of 2.43 mOmega ldr cm2has been achieved, making the developed AlGaN/GaN HFETs practical high-voltage high-power switches for power-electronics applications. [J389]

"Hot-Phonon Effect on the Electrothermal Behavior of Submicrometer III-V HEMTs"

An investigation of the effect of hot phonons on the electrothermal behavior of GaAs- and GaN-based high electron mobility transistors is carried out using both standard isothermal and self-consistent electrothermal Monte Carlo simulations. The influence of the hot-phonon effect is found to be significantly overestimated when the isothermal approximation is used. The full electrothermal simulations highlight the importance of correctly accounting for the internal temperature profiles of the devices: when this is done, the hot-phonon effect itself has relatively little impact on the electronic and thermal response. [J390]

"50nm In0.8 GaP/In/ sub 0.4/AlAs/In0.35 GaAs metamorphic HEMTs with ZEP=UV5 bilayer T-gate"

By using a novel bilayer resist process, 50 nm In0.8GaP/In0.4AlAs/In0.35GaAs metamorphic HEMTs on GaAs substrate have been successfully fabricated with high yield and uniformity. This process has an advantage over the conventional T-gate process. After definition of the bottom layer, the top layer is exposed, which prevents widening of the bottom layer. The devices with a novel bilayer T-gate exhibited excellent characteristics such as a maximum extrinsic transconductance (gmldrmax) of 800 mS/mm, an on-state breakdown voltage (BVon) of 3 V, a current-gain-cutoff frequency (fT) of 254 GHz, and a maximum oscillation frequency (fmax) of 360 GHz in spite of low indium content of 35% in the channel. [J391]

"On -Resistance Modulation of High Voltage GaN HEMT on Sapphire Substrate Under High Applied Voltage"

The 620-V/1.4-A GaN high-electron mobility transistors on sapphire substrate were fabricated and the ON-resistance modulations caused by current collapse phenomena were measured under high applied voltage. Since the fabricated devices had insulating substrates, no field-plate (FP) effect was expected and the ON-resistance increases of these devices were larger than those on an n-SiC substrate even with the same source-FP structure. The dual-FP structure, which was a combination of gate FP and source FP, was effective in suppressing the ON -resistance increase due to minimization of the gate-edge electric field concentration. The ON-resistance after the applied voltage of 250 V decreased by twice that at low drain voltage by the dual-FP structure. Gallium nitride (GaN), high-electron mobility transistor (HEMT), high voltage, power semiconductor device. [J392]

"35-nm Zigzag T-Gate Metamorphic GaAs HEMTs With an Ultrahigh of 520 GHz"

Metamorphic GaAs high electron mobility transistors (mHEMTs) with the highest-fmaxreported to date are presented here. The 35-nm zigzag T-gate In0.52Al0.48As/In0.53Ga0.47As metamorphic GaAs HEMTs show fmaxof 520 GHz, fTof 440 GHz, and maximum transconductance (gm) of 1100 mS/mm at a drain current of 333 mA/mm. The combinations of fmaxand fTare the highest data yet reported for mHEMTs. These devices are promising candidates for aggressively scaled sub-35-nm T-gate mHEMTs. [J393]

"A High-Efficiency Class-E GaN HEMT Power Amplifier for WCDMA Applications"

This letter reports a high efficiency class-E power amplifier using a GaN high electron mobility transistor (HEMT), which is designed at WCDMA band of 2.14 GHz. To improve output power and efficiency by suppressing harmonic powers, an output network using transmission lines is used. For a single tone, the proposed output network suppresses all harmonic power levels below -60 dBc for the whole output power range. The peak power-added efficiency (PAE) of 70% with a power gain of 13 dB is achieved at an output power of 43 d Bin. The broadband performance with a power gain over 12 dB and PAE over 60% is maintained through 200 MHz. [J394]

"Enhanced Gate Swing in InP HEMTs With High Threshold Voltage by Means of InAlAsSb Barrier"

We demonstrated the suitability of the InP HEMTs with the InAlAsSb Schottky barrier to realize the high threshold voltage (enhancement mode), low gate current, and low power consumption. This quaternary compound material increases the conduction band discontinuity to the InGaAs channel by introducing only 10% of antimony to InAlAs. The gate current is reduced by an order of the magnitude (or even more) at gate voltage range from 0.4 to 0.8 V. On the other hand, the large conduction band discontinuity causes larger parasitic source and drain resistance, which decreases the extrinsic transconductance. Nevertheless, the high-frequency performance is comparable to the device with the conventional InAlAs barrier layer. Therefore, the InAlAsSb barrier is a promising option for logic applications, which requires reduced gate current. FETs, gate current, high-electron mobility transistors (HEMTs), high frequency. [J395]

"Huge positive magnetoresistance of Ga As /Al Ga As high electron mobility transistor structures at high temperatures"

The authors have performed magnetoresistivity measurements rho xx(B)on GaAs/AlGaAshigh electron mobility transistor (HEMT) structures at high temperatures T. These HEMT structures show huge positive magnetoresistance (MR). For B=±6T, the MR values are 1300%and 200%at T=20and 80K, respectively. Since a GaAs-based HEMT structure is not susceptible to ferromagnetic noise which appears to represent a fundamental challenge to the scalability of magnetic MR devices to ultrahigh area densities, the experimental results pave the way for the integration of scalable nonmagnetic MR devices with the mature HEMT technology using the same material system. [J396]

"Growth of very-high-mobility Al Ga Sb /In As high-electron-mobility transistor structure on si substrate for high speed electronic applications"

The growth of the AlGaSb/InAshigh-electron-mobility transistor (HEMT) epitaxial structure on the Si substrate is investigated. Buffer layers consisted of UHV/chemical vapor deposited grown Ge/GeSiand molecular beam epitaxy-grown AlGaSb/AlSb/GaAswere used to accommodate the strain induced by the large lattice mismatch between the AlGaSb/InAsHEMT structure and the Si substrate. The crystalline quality of the structure grown was examined by x-ray diffraction, transmission electron microscopy, and atomic force microscopy. Finally, very high room-temperature electron mobility of 27300cm2/Vswas achieved. It is demonstrated that a very-high-mobility AlGaSb/InAsHEMT structure on the Si substrate can be achieved with the properly designed buffer layers. [J397]

"Prostate specific antigen detection using Al Ga N /Ga N high electron mobility transistors"

Antibody-functionalized Au-gated AlGaN/GaNhigh electron mobility transistors (HEMTs) were used to detect prostate specific antigen (PSA). The PSA antibody was anchored to the gate area through the formation of carboxylate succinimdyl ester bonds with immobilized thioglycolic acid. The AlGaN/GaNHEMT drain-source current showed a rapid response of less than 5swhen target PSA in a buffer at clinical concentrations was added to the antibody-immobilized surface. The authors could detect a wide range of concentrations from 10pg/mlto1mu g/ml. The lowest detectable concentration was two orders of magnitude lower than the cutoff value of PSA measurements for clinical detection of prostate cancer. These results clearly demonstrate the promise of portable electronic biological sensors based on AlGaN/GaNHEMTs for PSA screening. [J398]

"pH sensor using Al Ga N /Ga N high electron mobility transistors with Sc 2 O 3 in the gate region"

Ungated AlGaN/GaNhigh electron mobility transistors (HEMTs) exhibit large changes in current upon exposing the gate region to polar liquids. The polar nature of the electrolyte introduced leds to a change of surface charges, producing a change in surface potential at the semiconductor/liquid interface. The use of Sc2O3gate dielectric produced superior results to either a native oxide or UV ozone-induced oxide in the gate region. The ungated HEMTs with Sc2O3in the gate region exhibited a linear change in current between pH3 and 10 of 37mu A/pH. The HEMT pHsensors show stable operation with a resolution of 0.1pHover the entire pHrange. The results indicate that the HEMTs may have application in monitoring pHsolution changes between 7 and 8, the range of interest for testing human blood. [J399]

"Electron-electron interactions in Al 0.15 Ga 0.85 N /Ga N high electron mobility transistor structures grown on Si substrates"

We report on magnetotransport studies of Al0.15Ga0.85N/GaNhigh electron mobility transistor (HEMT) structures grown on p-type Si (111) substrates. A small but significant decrease of the Hall slope with increasing temperature is observed. Moreover, the converted conductivities reveal that the mobility of the HEMT shows a linear dependence on temperature. All these experimental results can be ascribed to electron-electron interaction (EEI) effects in AlxGa1-xN/GaNHEMT structures grown on Si. The existence of EEI effects can be utilized to design and optimize GaN-based quantum devices on Si such as single-electron transistors and quantum point contacts since EEI effects can strongly modify the transport in semiconductor devices. [J400]

"First-layer Si metallizations for thermally stable and smooth Ohmic contacts for Al Ga N /Ga N high electron mobility transistors"

First-layer Si (FL-Si) Si/Ti/Al/Mo/Aucontact metallizations are demonstrated to form low resistance and high temperature thermally stable Ohmic contacts on AlGaN/GaNhigh electron mobility transistor (HEMT) structures. Electrical and surface morphology characterizations have indicated that contact behavior significantly depends on the thickness of FL-Si used, where FL-Si (5nm)scheme showed the most optimal behavior. The contact resistances of FL-Si schemes are stable for up to 300hduring thermal aging at 500 and 600°C. Aging at 700°Cresulted in gradual degradation of contact resistance with values less than 1Omega mmOhmic behavior still maintained after 50hof thermal treatment. No deterioration in the sheet resistance of the heterostructure has

been detected upon thermal aging. Atomic force microscopy, Auger electron spectroscopy, and transmission electron microscopy characterizations have been utilized to identify the effect of FL-Si incorporation on the nature of intermetallic and interfacial reactions. Results from this study demonstrate that FL-Si-based metallizations have the potential to meet the critical requirements of low resistance, high temperature thermal stability and smooth surface morphology for the fabrication of AlGaN/GaNHEMTs. [J401]

"C-doped semi-insulating GaN HFETs on sapphire substrates with a high breakdown voltage and low specific on-resistance"

High breakdown voltage (BV) AlGaN/GaNheterojunction field effect transistors (HFETs) with a low specific on-resistance (ARDS(on))were successfully fabricated using intentionally C-doped semi-insulating GaN buffers with a high resistivity on sapphire substrates. With the improvement of not only the resistivity of a C-doped GaN buffer but also the layout design near the gate feeding region, the fabricated devices exhibited a high BV of 1600Vand low ARDS(on)of 3.9mOmega cm2. This result even reaches the 4H-SiCtheoretical limit and the best ever reported for the high-power GaN-based HFETs realized on sapphire substrates to the best of our knowledge. [J402]

"Al N /Al Ga N /Ga N metal-insulator-semiconductor high-electron-mobility transistor on 4 in. silicon substrate for high breakdown characteristics"

AlN/AlGaN/GaNmetal-insulator-semiconductor high-electron-mobility transistors (MIS-HEMTs) grown on 4in.silicon substrate have been demonstrated. The heterostructure exhibited high sheet carrier density with small surface roughness. AlN/AlGaN/GaNMIS-HEMT exhibited maximum drain current density (IDSmax)of 361mA/mmand maximum extrinsic transconductance (gmmax)of 152mS/mm. Due to the increase of sheet carrier density, the 2DEG channel shifts towards the AlGaN/GaN interface resulting in positive shift of the threshold voltage (-2.6to-1.8V). Two orders of magnitude low gate leakage current and reduced drain current collapse with high breakdown voltage of 230Vhave been observed on AlN/AlGaN/GaNMIS-HEMTs. [J403]

"Reactive ion etching technique for via-hole applications in thick GaAs wafers"

The dry etching technique has been developed to etch via holes through a 5-mil-thick GaAs wafer by rf power and reactive gas pressures in a reactive ion etching system. The etching parameters are optimized for a slope profile suitable for power field effect transistors and monolithic microwave integrated circuit applications. The selectivity between GaAs and photoresist and the average etching rate can be higher than 30 and 1.1mcm/min, respectively. Furthermore, the slope angle measured from the vertical is larger than 11°, which is well suited for a thick GaAs via-hole etching process. Before the metal for the via-hole substrate is sputtered, the wet chemical etching solution based on HCl-H2O2/H2Oat room temperature is used to smooth the sidewall for a better connection. To probe these source pads, the via-hole resistances of the pseudomorphic high electron mobility transistors (PHEMTs) are measured to be less than 0.5Omega with more than 97.2% yield in a 4in.diameter GaAs wafer. It is found that the rf performance for low-noise and power PHEMTs can be further improved. [J404]

"Fast electrical detection of Hg(II) ions with Al Ga N /Ga N high electron mobility transistors"

Bare Au gated and thioglycolic acid functionalized Au-gated AlGaN/GaNhigh electron mobility transistors (HEMTs) were used to detect mercury (II) ions. Fast detection of less than 5swas achieved for thioglycolic acid functionalized sensors. This is the shortest response time ever reported for mercury detection. Thioglycolic acid functionalized Au-gated AlGaN/GaNHEMT based sensors showed 2.5 times larger response than bare Au-gated based sensors. The sensors were able to detect mercury (II) ion concentration as low as 10-7M. The sensors showed an excellent sensing selectivity of more than 100 for detecting mercury ions over sodium or magnesium ions. The dimensions of the active area of the sensor and the entire sensor chip are 50Ч50mcm2and 1Ч5mm2, respectively. Therefore, portable, fast response, and wireless based heavy metal ion detectors can be realized with AlGaN/GaNHEMT based sensors. [J405]

"Enzymatic glucose detection using ZnO nanorods on the gate region of Al Ga N /Ga N high electron mobility transistors"

ZnO nanorod-gated AlGaN/GaNhigh electron mobility transistors (HEMTs) are demonstrated for the detection of glucose. A ZnO nanorod array was selectively grown on the gate area using low temperature hydrothermal decomposition to immobilize glucose oxidase (GOx). The one-dimensional ZnO nanorods provide a large effective surface area with high surface-to-volume ratio and provide a favorable environment for the immobilization of GOx. The AlGaN/GaNHEMT drain-source current showed a rapid response of less than

5swhen target glucose in a buffer with a pHvalue of 7.4 was added to the GOximmobilized on the ZnO nanorod surface. We could detect a wide range of concentrations from 0.5nMto125mcm. The sensor exhibited a linear range from 0.5nMto14.5mcmand an experiment limit of detection of 0.5nM. This demonstrates the possibility of using AlGaN/GaNHEMTs for noninvasive exhaled breath condensate based glucose detection of diabetic application. [J406]

"High temperature power performance of Al Ga N /Ga N high-electron-mobility transistors on high-resistivity silicon"

High temperature power performance of AlGaN/GaNhigh-electron-mobility transistor (HEMT) on high-resistivity-(HR) Si for different microwave frequencies of 3, 6, and 8GHzwas studied. The device output power density (Pout)reduction with temperature for HR-Si-based AlGaN/GaNHEMTs is almost equivalent to the Poutreduction with temperature for semi-insulating-SiC substrate based AlGaN/GaNHEMTs. After high temperature stress, very small degradation was observed in the power performance at 3GHz. Moreover, the rate of Poutdecrease with the temperature is not much affected by measurement frequencies. The conduction mechanism of trap assisted impact ionization and temperature assisted tunneling were identified on Si3N4passivated AlGaN/GaNHEMTs. The AlGaN/GaNHEMTs on HR-Si can also be used for high-power and high-frequency applications at elevated temperatures. [J407]

"Gate insulation and drain current saturation mechanism in In Al N /Ga N metal-oxide-semiconductor high-electron-mobility transistors"

The authors investigate 2mcmgate-length InAlN/GaNmetal-oxide-semiconductor high-electron-mobility transistors (MOS HEMTs) with 12nmthick Al2O3gate insulation. Compared to the Schottky barrier (SB) HEMT with similar design, the MOS HEMT exhibits a gate leakage reduction by six to ten orders of magnitude. A maximal drain current density (IDS=0.9A/mm)and an extrinsic transconductance (gme=115mS/mm)of the MOS HEMT also show improvements despite the threshold voltage shift. An analytical modeling shows that a higher mobility of electrons in the channel of the MOS HEMT and consequently a higher number of electrons attaining the velocity saturation may explain the observed increase in gmeafter the gate insulation. [J408]

"Low nonalloyed Ohmic contact resistance to nitride high electron mobility transistors using N-face growth"

Nonalloyed Ohmic contacts on Ga-face n+-GaN/AlGaN/GaNhigh electron mobility transistor (HEMT) structures typically have significant contact resistance to the two-dimensional electron gas (2DEG) due to the AlGaN barrier. By growing the HEMT structure inverted on the N-face, electrons from the contacts were able to access the 2DEG without going through an AlGaN layer. A low contact resistance of 0.16Omega mmand specific contact resistivity of 5.5Ч10-7Omega cm2were achieved without contact annealing on the inverted HEMT structure. [J409]

"Analysis of plasma oscillations in high-electron mobility transistorlike structures: Distributed circuit approach"

We develop simple distributed circuit model of the high-electron mobility transistor (HEMT)-like structure for the analysis of the effects associated with plasma oscillations excited in its two-dimensional electron gas (2DEG) channel. Circuit components of the model are related to physical and geometrical parameters of the structure. Developed model accounts for dependence of resistance and inductance of 2DEG channel gated region on gate voltage. Such an approach facilitates and improves understanding of HEMT-like structures' behavior in the regime of excitation of plasma oscillation and is applicable for their performance evaluation and optimization as well. [J410]

"Cryogenic amplifier for fast real-time detection of single-electron tunneling"

The authors employ a cryogenic high electron mobility transistor (HEMT) amplifier to increase the bandwidth of a charge detection setup with a quantum point contact (QPC) charge sensor. The HEMT is operating at 1Kand the circuit has a bandwidth of 1MHz. The noise contribution of the HEMT at high frequencies is only a few times higher than that of the QPC shot noise. The authors use this setup to monitor single-electron tunneling to and from an adjacent quantum dot. The authors measure fluctuations in the dot occupation as short as 400ns, 20 times faster than in previous work. [J411]

"Electrical detection of kidney injury molecule-1 with Al Ga N /Ga N high electron mobility transistors"

AlGaN/GaNhigh electron mobility transistors (HEMTs) were used to detect kidney injury molecule-1 (KIM-1), an important biomarker for early kidney injury detection. The gate region consisted of 5nmgold deposited onto the AlGaN surface. The gold was conjugated to highly specific KIM-1 antibodies through a self-assembled monolayer of thioglycolic acid. The HEMT source-drain current showed a clear dependence on the KIM-1 concentration in phosphate-buffered saline solution. The limit of detection was 1ng/mlusing a 20Ч50mcm2gate sensing area. This approach shows potential for both preclinical and clinical kidney injury diagnosis with accurate, rapid, noninvasive, and high throughput capabilities. [J412]

"Enhancement-mode GaAs metal-oxide-semiconductor high-electron-mobility transistors with atomic layer deposited Al 2 O 3 as gate dielectric"

Enhancement-mode GaAs metal-oxide-semiconductor high-electron-mobility transistors (MOS-HEMTs) with ex situ atomic-layer-deposited Al2O3as gate dielectrics are studied. Maximum drain currents of 211 and 263mA/mmare obtained for 1mcmgate-length Al2O3MOS-HEMTs with 3 and 6nmthick gate oxide, respectively. C-Vcharacteristic shows negligible hysteresis and frequency dispersion. The gate leakage current density of the MOS-HEMTs is 3-5 orders of magnitude lower than the conventional HEMTs under similar bias conditions. The drain current on-off ratio of MOS-HEMTs is 3Ч103with a subthreshold swing of 90mV/decade. A maximum cutoff frequency (fT)of 27.3GHzand maximum oscillation frequency (fmax)of 39.9GHzand an effective channel mobility of 4250cm2/Vsare measured for the 1mcmgate-length Al2O3MOS-HEMT with 6nmgate oxide. Hooge's constant measured by low frequency noise spectral density characterization is 3.7Ч10-5for the same device. [J413]

"An Electrothermal Model for AlGaN/GaN Power HEMTs Including Trapping Effects to Improve Large-Signal Simulation Results on High VSWR"

A large-signal electrothermal model for AlGaN/GaN HEMTs including gate and drain related trapping effects is proposed here. This nonlinear model is well formulated to preserve convergence capabilities and simulation times. Extensive measurements have demonstrated the impact of trapping effects on the shapes of I(V) characteristics, as well as load cycles. It is shown that accurate modeling of gate-and drain-lag effects dramatically improves the large-signal simulation results. This is particularly true when the output loads deviate from the optimum matching conditions corresponding to real-world simulations. This new model and its modeling approach are presented here. Large-signal simulation results are then reported and compared to load-pull and large-signal network analyzer measurements for several load impedances at high voltage standing wave ratio and at two frequencies. [J414]

"40-GHz MMIC SPDT and Multiple-Port Bandpass Filter-Integrated Switches"

A 40-GHz monolithic microwave integrated circuit (MMIC) single-pole-double-throw and multiple-port bandpass filter-integrated switches based on electronically switchable resonators are proposed. The proposed multifunction chip integrates a multiple-port switch with bandpass filter functions in a single chip. The switchable resonators are formed by quarter-wavelength stepped-impedance resonators with passive HEMT loading at one end. By properly allocating the resonant frequencies of the resonators in their on and off modes, a filter-integrated switch can perform a bandpass response with spurious suppression in the on state and achieve wideband isolation in the off state. The technique of using shared resonators is also introduced in the circuit design to reduce the overall circuit size. The results show the proposed circuits successfully integrate a MMIC switch with bandpass filter functions into a single circuit component. [J415]

"Effect of a Two-Step Recess Process Using Atomic Layer Etching on the Performance of In0.52 Al0.48 As/In0.53 Ga0.47 As p-HEMTs"

The characteristics of 0.15- mum InAlAs/InGaAs pseudomorphic high-electron mobility transistors (p-HEMTs) that were fabricated using the Ne-based atomic layer etching (ALET) technology and the Ar-based conventional reactive ion etching (RIE) technology were investigated. As compared with the RIE, the ALET used a much lower plasma energy and thus produced much lower plasma-induced damages to the surface and bulk of the In0.52Al0.48As barrier and showed a much higher etch selectivity (~70) of the InP spacer against the In0.52Al0.48As barrier. The 0.15-mum InAlAs/InGaAs p-HEMTs that were fabricated using the ALET exhibited improved Gm,max(1.38 S/mm), IONn/IOFF(1.18X104), drain-induced barrier lowering (80 mWV), threshold voltage uniformity (Vth,avg= -190 mV and alpha = 15 mV), and ftau (233 GHz), mainly due to the extremely low plasma-induced damage in the Schottky gate area. [J416]

"Development of Sub-Millimeter-Wave Power Amplifiers"

In this paper, we present the framework for developing the first working power amplifiers at sub-millimeter-wave frequencies. The technology is made possible by an advanced InP HEMT transistor. A three-stage power amplifier is presented, which uses a binary combiner to realize a total output periphery of 80 mum and demonstrates 12-dB gain at 335 GHz, making, this the first demonstrated sub-millimeter-wave power amplifier. Measured saturated power of 2 mW at 330 GHz is also presented, which provides a transistor power benchmark of 25 mW/mm at 330 GHz. Finally, single-stage amplifier data with large periphery transistors are presented, which demonstrates 5-dB measured gain at 230 GHz and positive measured S21gain to ~300 GHz, demonstrating that power amplifiers using larger transistors are feasible at these frequencies as well. [J417]

"Comparison Between the Dynamic Performance of Double- and Single-Gate AlInAs/InGaAs HEMTs"

The static and dynamic behavior of InAlAs/InGaAs double-gate high-electron mobility transistors (DG-HEMTs) is studied by means of an ensemble 2-D Monte Carlo simulator. The model allows us to satisfactorily reproduce the experimental performance of this novel device and to go deeply into its physical behavior. A complete comparison between DG and similar standard HEMTs has been performed, and devices with different gate lengths have been analyzed in order to check the attenuation of short-channel effects expected in the DG-structures. We have confirmed that, for very small gate lengths, short-channel effects are less significant in the DG-HEMTs, leading to a better intrinsic dynamic performance. Moreover, the higher values of the transconductance over drain conductance ratio gm/gd, and, especially, the lower gate resistance Rgalso provide a significant improvement of the extrinsic fmax. [J418]

"Power Performance of AlGaN/GaN HEMTs Grown on SiC by Ammonia-MBE at 4 and 10 GHz"

In this letter, we report on the microwave power and efficiency performance of AlGaN/GaN high-electron mobility transistors (HEMTs) grown by ammonia molecular beam epitaxy (ammonia-MBE) on SiC substrates. At 4 GHz, an output power density of 11.1 W/mm with an associated power-added efficiency (PAE) of 63% was measured at Vds= 48 V on passivated devices. At 10 GHz, an output power density of 11.2 W/mm with a PAE of 58% was achieved for Vds= 48 V. These results are the highest reported power performance for AlGaN/GaN HEMTs grown by ammonia-MBE and the first reported for ammonia-MBE on SiC substrates. [J419]

"Remarkable Reduction of On-Resistance by Ion Implantation in GaN/AlGaN/GaN HEMTs With Low Gate Leakage Current"

We demonstrate Si ion-implanted GaN/AlGaN/GaN high-electron mobility transistors with extremely low gate leakage current and low source resistance without any recess etching process. The source/drain (S/D) regions were formed using Si ion implantation into undoped GaN/AlGaN/GaN on sapphire substrate. Using ion implantation into S/D regions with an energy of 80 keV, the performances were significantly improved. On-resistance decreased from 26.2 to 4.3 Omegaldrmm. Saturation drain current and maximum transconductance increased from 284 to 723 mA/mm and from 48 to 147 mS/mm. [J420]

"Large-Signal Model for AlGaN/GaN HEMTs Accurately Predicts Trapping- and Self-Heating-Induced Dispersion and Intermodulation Distortion"

In this paper, an accurate table-based large-signal model for AlGaN/GaN HEMTs accounting for trapping- and self-heating-induced current dispersion is presented. The B-spline-approximation technique is used for the model-element construction, which improves the intermodulation-distortion (IMD) simulation. The dynamic behavior of the trapping and self-heating processes is taken into account in the implementation of the model. The model validity is verified by comparing the simulated and measured outputs of the device tested under pulsed and continuous large-signal excitations for devices of 1-mm gate width. Single- and two-tone simulation results show that the model can efficiently predict the output power and its harmonics and the associated IMD under different input-power and bias conditions. [J421]

"AlGaN/GaN HEMTs on a (001)-Oriented Silicon Substrate Based on 100-nm SiN Recessed Gate Technology for Microwave Power Amplification"

AlGaN/GaN high-electron mobility transistors on (001)-oriented silicon substrates with a 0.1-mum gamma-shaped gate length are fabricated. The gate technology is based on a silicon nitride (SiN) thin film and uses a digital etching technique to perform the recess through the SiN mask. An output current density of 420 mA/mm and an extrinsic transconductance gmof 228 mS/mm are measured on 300-mum gate-periphery devices. An extrinsic cutoff frequency ftof 28 GHz and a maximum oscillation frequency fmaxof 46 GHz are deduced from S-parameter measurements. At 2.15 GHz, an output power density of 1 W/mm that is associated to a power-

added efficiency of 17% and a linear gain of 24 dB are achieved at VDS= 30 V and VGS= -1.2 V. [J422]

"Deep submicron AlGaN/GaN HEMTs with ion implanted source/drain regions and non-alloyed ohmic contacts"

Silicon ions were implanted to source-drain regions to achieve a non- alloyed ohmic contact resistance as low as 0.2 Omegaldrmm. Based on this technology, T-shaped deep submicron HEMTs were fabricated. An extrinsic fTof 92 GHz and an extrinsic fmaxof 148 GHz have been measured in a passivated 0.15 x 150 mum device. Power measurements at 10 GHz showed 70.7% power-added-efficiency and 4.1 W/mm power density at 20 V drain bias. [J423]

"Temperature Dependent Electrical Characteristics of Neutron Irradiated AlGaN/GaN HFETs"

Low temperature neutron irradiated Al0.27Ga0.73N/GaN heterostructures reveal a complex temperature dependent displacement damage formation process. This process results in differences in drain currents at low (80 K) versus high (294 K) temperatures. Irradiation increases the gate and drain currents at 80 K, and decreases the drain current at room temperature. These effects saturate at ~ 3 times 1010n/cm2indicating complexing with a native impurity. After a room temperature anneal, the effect on the gate current persists and the drain current partially recovers. A two-step persistent interface trap formation model is presented that explains these results. This model is further supported by CV measurements at 80 K and 294 K after annealing. [J424]

"Highly selective zero-bias plasma etching of GaN over AlGaN"

Highly selective, low-damage etching of GaN over AlGaN is realized by zero-bias, nitrogen-rich N2/Cl2/O2inductively coupled plasma, affording sub-10-nm/minetch rates and rms roughness of 3E, favorable for gate recessing of GaN-based high electron mobility transistors (HEMTs). Selectivity is tuned by varying the O2fraction, source power, and pressure. No AlGaN etching is detectable even after 30min, so the etching selectivity is considered to be infinite. The authors demonstrate linear recessing of a n+-GaN/Al0.3Ga0.7N/GaNdevice structure, which stops abruptly upon clearing the 10-nm-thick cap. SiO2masking used in this study is compatible with HEMT processes, where a masking dielectric is used for passivation, gate footprint definition, and mechanical gate support. Current-voltage measurements on recessed Schottky diodes show a 40x decrease in reverse leakage current and a three-fold increase in forward saturation current, when compared to non-recessed diodes, as well as lack of sensitivity to etch duration. Diodes on this device structure also showed breakdown voltages greater than -200V, compared to -90Vfor nonrecessed diodes. [J425]

"Switching voltage, dynamic power dissipation and on-to-off conductance ratio of a spin field effect transistor"

The metal-insulator-semiconductor (MIS) and high electron mobility transistor (HEMT) implementations of the spin field effect transistor (SpinFET) proposed by Datta and Das are considered. In both configurations, the SpinFET's switching voltage (for switching on or off) and power dissipation are found to be larger than those of the traditional MISFET or HEMT if the channel length is les 90 nm. This is a consequence of the fact that spin orbit interaction strengths in semiconductors are too weak to impart any significant advantage to the SpinFET. The issue of non-ideal spin injection and detection at the source and drain contacts is also considered. The SpinFET's on-to-off conductance ratio rapidly degrades with decreasing spin injection/detection efficiency, dropping from infinity (for a one-dimensional channel) to as low as ~9.5, if the spin injection/detection efficiency drops from 100% to 90%. The transconductance has a quadratic dependence on the spin injection efficiency. These analyses are valid at arbitrary temperatures. [J426]

"A W-band Injection-Locked Frequency Divider Using GaAs pHEMTs and Cascode Circuit Topology"

This study presents a W-band injection-locked frequency divider (ILFD) with a wide locking range characteristic by using 0.15 mum GaAs pHEMT techniques. Based on the cascode circuit topology, the oscillation and the injection parts can be designed individually without the trade-off between the input matching and the oscillation condition. Including with a characteristic of the active capacitance in this ILFD, a free-running oscillation frequency about 50 GHz was obtained with a frequency tuning function, in which the tuning range was about 1.2 GHz (50.5-49.3 GHz). By injecting a signal of around 100 GHz into this ILFD, the maximum locking range was measured up to 400 MHz, while the injected power was set to -5 dBm under a 3 V supply with a power consumption of 21 mW in the ILFD core. [J427]

"X-band power characterisation of AlInN/AlN/GaN HEMT grown on SiC substrate"

AlInN/AlN/GaN based HEMTs were fabricated on SiC substrate to demonstrate the high potentiality of these heterostructures. The presented results confirm the high performances reachable by AlInN based technology with an output power of 6.8 W/mm at 10 GHz with a gate length of 0.25 mum. A good extrinsic transconductance value of 400 mS/mm was also measured on these transistors. The results are believed to be the best power results published about AlInN/GaN HEMTs. [J428]

"Impact of selective Al2 O3 passivation on current collapse in AlGaN/GaN HEMTs"

Current collapse in AlGaN/GaN HEMTs is normally attributed to charged surface states which deplete the channel in the extrinsic gate- to-drain region due to the highest electric fields in the devices. It is demonstrated that the gate-source region also plays a significant role in current collapse through the selective passivation of transistors using evaporated Al2O3patterned via a lift-off process. The approach allows discriminating between the respective contributions of the source and drain regions to the current collapse. [J429]

"A Compact Ka-Band Planar Three-Way Power Divider"

A Ka-band planar three-way power divider which uses the coupled line instead of the transmission line is proposed to reduce chip size. The proposed planar topology, different from the conventional Wilkinson power divider, is analyzed and can provide not only compact but also dc block characteristics, which are very suitable for monolithic microwave integrated circuit applications. The divider implemented by a pHEMT process shows an insertion loss less than 5.1 dB and an output isolation better than 17 dB. A return loss less than 18 dB and a phase difference of 4.2deg at 30 GHz can be achieved. Finally, good agreements between the simulation and experimental results are shown. [J430]

"A Low-Loss 74-110-GHz Faraday Polarization Rotator"

We have developed a switchable Faraday polarization rotator for 74-110 GHz with a typical room-temperature insertion loss of 0.6 dB and a maximum of ~1.3 dB. The device uses a cylindrical ferrite rod in the mode with an axial magnetic field applied by a solenoid. The ports are square metallic waveguides transitioning to ceramic tapers, which then couple to the ferrite rod. The device is designed for use at a temperature of 20 K, where typical loss is <0.5 dB. The design rotation is about plusmn45deg the zero-bias value, but up to 90deg is possible. The switching time is <10 s. [J431]

"AlGaN/GaN HEMTs With Thin InGaN Cap Layer for Normally Off Operation"

AlGaN/GaN HEMTs with a thin InGaN cap layer have been proposed to implement the normally off HEMTs. The key idea is to employ the polarization-induced field in the InGaN cap layer, by which the conduction band is raised, which leads to the normally off operation. The fabricated HEMT with an In0.2Ga0.8N cap layer with a thickness of 5 nm showed normally off operation with a threshold voltage of 0.4 V and a maximum transconductance of 85 mS/mm for the device with a 1.9-mum-long gate. By etching off the In0.2Ga0.8N cap layer at the access region using gate electrode as an etching mask, the maximum transconductance has increased from 85 to 130 mS/mm due to a reduction of the parasitic source resistance. [J432]

"A Systematic State–Space Approach to Large-Signal Transistor Modeling"

A state-space approach to large-signal (LS) modeling of high-speed transistors is presented and used as a general framework for various model descriptions of the dispersive features frequently observed for HEMTs at low frequency. Ensuring unrestricted LS-small-signal (SS) model compatibility, the approach allows to construct LS models from multibias SS S-parameter measurements. A general transformation between state-space models is derived, which are equivalent in the SS limit, but nonequivalent under LS stimuli. This transformation has the potential to compensate deviations observed by comparing model predictions with LS measurements and to find an optimum state linear LS model without any change of the SS behavior [J433]

"Selectively Doped High-Power AlGaN/InGaN/GaN MOS-DHFET"

We describe a novel AlGaN/InGaN/GaN metal-oxide-semiconductor double heterostructure field-effect transistor with peak drain current of 1.67 A/mm and 2-GHz RF power of 15 W/mm at a drain bias as low as 35 V. These high values of peak currents and high RF powers at relatively low drain bias resulted from an additional selective area doping of the access regions during the device fabrication. The RF-output power of 12.5 W/mm (at a drain bias of VD=30 V) was stable within a 0.5-dB variations during a 100-h continuous-wave stress test [J434]

"A Compact 6.5-W PHEMT MMIC Power Amplifier for Ku-Band Applications"

A compact 6.5-W AlGaAs/InGaAs/GaAs PHEMT monolithic microwave integrated circuit (MMIC) power amplifier (PA) for Ku-band applications is proposed. This two-stage amplifier with chip size of 8.554mm2 (3.64mmtimes2.35mm) is designed to fully match 50-Omega input and output impedance. Under 8V and 2000mA dc bias condition, the PA deliver 38.1dBm (6.5W) saturated output power, 10.5-dB small signal gain and peak power added efficiency of 24.6% from 13.6 to 14.2GHz. This MMIC also achieved the best power densities (760mW/mm2) at Ku band reported to date [J435]

"SPDT GaAs Switches With Copper Metallized Interconnects"

Copper metallized AlGaAs/InGaAs pseudomorphic high-electron-mobility transistor (PHEMT) single-pole-double-throw (SPDT) switches utilizing platinum (Pt, 70nm) as the diffusion barrier is reported for the first time. In comparison with the Au metallized switches, the Cu metallized SPDT switches exhibited comparable performance with insertion loss of less than 0.5dB, isolation larger than 35dB and the input power for one dB compression (input P1dB) of 27dBm at 2.5GHz. These switches were annealed at 250deg for 20h for thermal stability test and showed no degradation of the dc characteristics after the annealing. Also, after 144h of high temperature storage life (HTSL) environment test, these switches still remained excellent and reliable radio frequency (RF) characteristics. It is successfully demonstrated for the first time that the copper metallization using Pt as the diffusion barrier could be applied to the GaAs monolithic microwave integrated circuits switch fabrication with good RF performance and reliability [J436]

"Normally Off AlGaN/GaN Low-Density Drain HEMT (LDD-HEMT) With Enhanced Breakdown Voltage and Reduced Current Collapse"

We report a low-density drain high-electron mobility transistor (LDD-HEMT) that exhibits enhanced breakdown voltage and reduced current collapse. The LDD region is created by introducing negatively charged fluorine ions in the region between the gate and drain electrodes, effectively modifying the surface field distribution on the drain side of the HEMT without using field plate electrodes. Without changing the device physical dimensions, the breakdown voltage can be improved by 50% in LDD-HEMT, and the current collapse can be reduced. No degradation of current cutoff frequency (ft) and slight improvement in power gain cutoff frequency (fmax) are achieved in the LDD-HEMT, owing to the absence of any additional field plate electrode [J437]

"Improvement of Impact Ionization Effect and Subthreshold Current in InAlAs/InGaAs Metal–Oxide–Semiconductor Metamorphic HEMT With a Liquid-Phase Oxidized InAlAs as Gate Insulator"

The oxidation of InAlAs and its application to InAlAs/InGaAs metal-oxide-semiconductor metamorphic high-electron mobility transistors (MOS-MHEMTs) are demonstrated in this study. After the highly selective gate recessing of InGaAs/InAlAs using citric buffer etchant, the gate dielectric is obtained directly by oxidizing the InAlAs layer in a liquid-phase solution at near room temperature. As compared to its counterpart MHEMT, the fabricated InAlAs/InGaAs MOS-MHEMT exhibits a larger tolerance to gate bias, higher breakdown voltage, lower subthreshold current, improved gate leakage current with the effectively suppressed impact ionization effect, and improved radio-frequency performance. Consequently, the liquid-phase oxidation may also be used to produce gate oxides and as an effective passivation on III-V compound semiconductor devices [J438]

"Lateral Scale Down of InGaAs/InAs Composite-Channel HEMTs With Tungsten-Based Tiered Ohmic Structure for 2-S/mm gm and 500-GHz fT"

A laterally scaled-down ohmic structure and an InGaAs/InAs composite channel improve the dc and RF characteristics of InP-based HEMTs. We reduced the distance between the gate and ohmic metal to less than 100 nm and to form sub-100-nm-long gate simultaneously, and also introduced device passivation for future construction of subterahertz-band integrated circuits. A 50-nm-gate HEMT exhibiting extrinsic transconductance of 2.0 S/mm and extrinsic current gain cutoff frequency (fT) of 496 GHz was successfully fabricated with this technology. This is the first report of a transistor with both 500-GHz-class fTand large current drivability [J439]

"A 50-Gbit/s 450-mW Full-Rate 4:1 Multiplexer With Multiphase Clock Architecture in 0.13- InP HEMT Technology"

A full-rate multiplexer (MUX) with a multiphase clock architecture for over 40 Gbit/s optical communication systems is presented. The 4:1 MUX is comprised of a re-timer based on a D-type flip-flop (DFF) and a clock tree system that uses EXOR-type delay buffers to match its skews well to those of the data. The supply voltage is reduced to -1.5 V by analyzing the voltage allocation. Fabricated in a 0.13-mum InP HEMT technology, a DFF

test circuit achieved 75-Gbit/s operation and exhibited performance sufficient to re-time 50-Gbit/s serialized data. The 4:1 MUX measurement results demonstrate successful 50-Gbit/s operation at room temperature, and 40-Gbit/s operation, which has 10-11error free for 231- 1 pseudorandom bit stream (PRBS) data, up to an ambient temperature of 90 degrees or down to-1.24 V of supply voltage. The circuit consumes 450 mW at a-1.5-V supply and exhibits an output jitter of 283 fs rms at 50-Gbit/s operation. We also propose a multiphase clock generator for a MUX that has a serialization of more than four channels. [J440]

"SThM Temperature Mapping and Nonlinear Thermal Resistance Evolution With Bias on AlGaN/GaN HEMT Devices"

Channel temperature has a strong impact on the performance of a microwave power transistor. In particular, it has a strong influence on the power gain, energetic efficiency, and reliability of the device. The thermal optimization of device geometry is therefore a key issue, together with precise measurements of temperature within the channel area. In this paper, we have used scanning thermal microscopy to perform temperature mapping, at variable dc bias points, on an AlGaN/GaN high-electron mobility transistor made on epilayers grown on silicon carbide substrate. We have analyzed the variation of the thermal resistance values, which are deduced from these measurements, with bias conditions VGSand VDS. The observed nonlinear behavior is found to be in excellent agreement with physical simulations, strongly pointing out the large variability of the extension of the dissipation area with the dc bias conditions [J441]

"A 9.1–10.7 GHz 10-W, 40-dB Gain Four-Stage PHEMT MMIC Power Amplifier"

This letter presents a compact X-band high gain and high power four-stage AlGaAs/InGaAs/GaAs pseudomorphic high electron mobility transistor (PHEMT) monolithic microwave integrated circuit (MMIC) high power amplifier (PA). This amplifier is designed to fully match a 50-Omega input and output impedance. Based on 0.35-mum gate-length power PHEMT technology, this PA MMIC is fabricated on a 3-mil thick wafer. While operating under 8 V and 2700-mA dc bias condition, the characteristics of 40-dB small-signal gain, a 10-W continuous-wave saturation output power, and 33% power added efficiency at 9.7GHz can be achieved [J442]

"DC and RF Characteristics of AlGaN/GaN/InGaN/GaN Double-Heterojunction HEMTs"

We present the detailed dc and radio-frequency characteristics of an Al0.3Ga0.7N/GaN/In0.1Ga0.9 N/GaN double-heterojunction HEMT (DH-HEMT) structure. This structure incorporates a thin (3 nm) In0.1Ga0.9N notch layer inserted at a location that is 6-nm away from the AlGaN/GaN heterointerface. The In0.1Ga0.9N layer provides a unique piezoelectric polarization field which results in a higher potential barrier at the backside of the two-dimensional electron gas channel, effectively improving the carrier confinement and then reducing the buffer leakage. Both depletion-mode (D-mode) and enhancement-mode (E-mode) devices were fabricated on this new structure. Compared with the baseline AlGaN/GaN HEMTs, the DH-HEMT shows lower drain leakage current. The gate leakage current is also found to be reduced, owing to an improved surface morphology in InGaN-incorporated epitaxial structures. DC and small- and large-signal microwave characteristics, together with the linearity performances, have been investigated. The channel transit delay time analysis also revealed that there was a minor channel in the InGaN layer in which the electrons exhibited a mobility slightly lower than the GaN channel. The E-mode DH-HEMTs were also fabricated using our recently developed CF4-based plasma treatment technique. The large-signal operation of the E-mode GaN-based HEMTs was reported for the first time. At 2 GHz, a 1times100 mum E-mode device demonstrated a maximum output power of 3.12 W/mm and a power-added efficiency of 49% with single-polarity biases (a gate bias of +0.5 V and a drain bias of 35 V). An output third-order interception point of 34.7 dBm was obtained in the E-mode HEMTs [J443]

"Transient Thermal Analysis of GaN Heterojunction Transistors (HFETs) for High-Power Applications"

Transient thermal analysis of GaN heterojunction field-effect transistors (HFETs) was carried out in this letter, with a hybrid nonlinear finite element method (FEM) employed, i.e., combining the element-by-element FEM with the preconditioned conjugated gradient technique. The maximum temperature of the HFETs, strongly depending on the input power density and the duration time of the pulsed heat source, was captured numerically. The effects of temperature-dependent thermal conductivities of the substrates on the maximum temperature were also examined and compared for different substrate materials, such as sapphire, silicon, and SiC [J444]

"Power Stability of AlGaN/GaN HFETs at 20 W/mm in the Pinched-Off Operation Mode"

High power-added efficiency (PAE) (ap74%) and rf-power (20 W/mm) operation of Schottky and insulated-gate AlGaN/GaN heterostructure field-effect transistors (HFETs) is reported at 2 GHz. In the pinched-off mode of

operation, the PAE increases from a value of 55% to 74% when the drain bias is changed from 35 to 60 V. While both the Schottky and the insulated HFETs show high powers and PAE values, only the insulated-gate devices are stable at 20-W/mm output powers during a 60-h continuous wave rf-stress test. Their power drop of less than 0.1 dB is much smaller than the 0.8-dB drop for identical geometry Schottky-gate HFETs. The superior stability of the insulated-gate HFETs is attributed to the low forward gate currents [J445]

"RF-Enhanced Contacts to Wide-Bandgap Devices"

This letter proposes a novel approach to fabricate high-performance heterostructure microwave devices with nonohmic contacts. The contact can be as-deposited or made by "shallow" low-temperature annealing to form a low-height Schottky barrier while preserving the two-dimensional electron-gas layer (2DEG) at the heterointerface. Coupling between the metal and the 2DEG occurs via two paths: dc current injects through the barrier leakage current and ac-current component injects through capacitive coupling. Contacts with resistive/capacitive coupling have low microwave impedance and enhance the heterostructure field-effect transistor's maximum oscillation frequency, output power, and power-added efficiency as compared to resistive ohmic contacts [J446]

"A Low Phase-Noise -Band MMIC VCO Using High-Linearity and Low-Noise Composite-Channel HEMTs"

A low phase-noise X-band monolithic-microwave integrated-circuit voltage-controlled oscillator (VCO) based on a novel high-linearity and low-noise composite-channel Al0.3Ga0.7N/Al0.05Ga0.95 N/GaN high electron mobility transistor (HEMT) is presented. The HEMT has a 1 mumtimes100 mum gate. A planar inter-digitated metal-semiconductor-metal varactor is used to tune the VCO's frequency. The polyimide dielectric layer is inserted between a metal and GaN buffer to improve the Q factor of spiral inductors. The VCO exhibits a frequency tuning range from 9.11 to 9.55 GHz with the varactor's voltage from 4 to 6 V, an average output power of 3.3 dBm, and an average efficiency of 7% at a gate bias of -3 V and a drain bias of 5 V. The measured phase noise is -82 dBc/Hz and -110 dBc/Hz at offsets of 100 kHz and 1 MHz at a varactor's voltage (Vtune)=5 V. The phase noise is the lowest reported thus far in VCOs made of GaN-based HEMTs. In addition, the VCO also exhibits the minimum second harmonic suppression of 47 dBc. The chip size is 1.2times1.05 mm2 [J447]

"A Novel Dilute Antimony Channel In0.2 Ga0.8 AsSb/GaAs HEMT"

This letter reports, for the first time, a high-electron mobility transistor (HEMT) using a dilute antimony In0.2Ga0.8 AsSb channel, which is grown by a molecular-beam epitaxy system. The interfacial quality within the InGaAsSb/GaAs quantum well of the HEMT device was effectively improved by introducing the surfactantlike Sb atoms during the growth of the InGaAs layer. The improved heterostructural quality and electron transport properties have also been verified by various surface characterization techniques. In comparison, the proposed HEMT with (without) the incorporation of Sb atoms has demonstrated the maximum extrinsic transconductance gm,maxof 227 (180) mS/mm, a drain saturation current density IDSSof 218 (170) mA/mm, a gate-voltage swing of 1.215 (1.15) V, a cutoff frequency fTof 25 (20.6) GHz, and the maximum oscillation frequency fmaxof 28.3 (25.6) GHz at 300 K with gate dimensions of 1.2times200 mum2 [J448]

"A 4–41 GHz Singly Balanced Distributed Mixer Using GaAs pHEMT Technology"

A broadband singly balanced distributed mixer is developed using a 0.15-mum GaAs pHEMT foundry process. It is the first time that the charge-injection approach is applied to a distributed mixer. With the advantage of charge-injection, the mixer achieves a high conversion gain with low dc consumption. The fabricated distributed mixer with an integrated broadband transformer has a compact chip size of 2mmtimes1mm. Measurement results show that the mixer achieves a conversion gain of better than 3.5dB over a broadband frequency from 4-41GHz, with a relatively low dc power consumption of 100mW [J449]

"Electrothermal Monte Carlo Simulation of Submicrometer Si/SiGe MODFETs"

In this paper, we present results from the simulation of submicrometer Si/SiGe modulation-doped field-effect transistors (MODFETs) using an electrothermal Monte Carlo method. The relationships between the thermal droop effect observed in the electrothermal Id -Vdscharacteristics of the devices and the microscopic properties of electron transport and the temperature profiles are studied. The effects of varying the effective semiconductor die dimensions and the thickness of the SiGe buffers on the electrothermal behavior of the devices are also investigated. A comparison of the electrothermal performance of the simulated Si/SiGe MODFET with that of a GaAs-based HEMT is also carried out [J450]

"Monolithic 10 GHz TDR/TDT analyser with novel architecture"

A simple and low-cost time-domain reflectometer using two pulse generators and a high bandwidth sample and hold amplifier is presented. The design has been achieved using an MMIC commercial foundry process from OMMIC (pHEMT ft=100 GHz). The bandwidth of the sampler is more than 10 GHz and the minimum pulse width generated is less than 50 ps. The total active area is less than 3 mm2 [J451]

"A 38–46 GHz MMIC Doherty Power Amplifier Using Post-Distortion Linearization"

This letter describes the first demonstration of a fully integrated Doherty power amplifier (PA) monolithic microwave integrated circuit (MMIC) with post-distortion linearization at millimeter-wave (MMW) frequency band. The Doherty amplifier MMIC, using a 0.15-mum GaAs HEMT process, achieves a small signal gain of 7dB from 38 to 46GHz with a compact chip size of 2mm2. The saturation output power of the Doherty amplifier is 21.8dBm. The similar topology between the Doherty amplifier and post-distortion linearization makes it possible to improve efficiency and linearity simultaneously in MMW PA designs. After gate bias optimization of the main and peaking amplifier, the drain efficiency improved 6% at 6-dB output back-off and the inter-modulation distortion (IMD) of quasi Doherty amplifier can be improved 18dB at 42GHz compared with the balanced amplifier operation [J452]

"Accurate prediction of large-signal harmonic distortion in gallium nitride HEMTs"

A nonlinear device modelling methodology capable of accurately predicting large-signal harmonic distortion in gallium nitride (GaN) HEMTs is presented. Harmonic balance simulation predicts the correct load target for maximum output power, with good agreement between measured and simulated load-pull data at 8 GHz. Fundamental output power at 8 GHz as well as second- and third-order harmonic distortion products at 16 and 24 GHz, respectively, are precisely predicted into 10 dB compression for a 2 W 150 mum GaN transistor [J453]

"Influence of the Source–Gate Distance on the AlGaN/GaN HEMT Performance"

In this paper, we present Monte Carlo simulation results on the source-gate (S-G) scaling effects in GaN-based HEMTs. The results show that a downscaling of the S-G distance can improve device performance, enhancing the output current and the device transconductance. The main reason for this effect is related to the peculiar dynamic of electrons in the GaN-based HEMTs, which leads to a nonsaturated velocity regime in the source access region, even for high drain applied voltages. On the contrary, the gate-drain distance does not affect the output current within the analyzed device geometries. Based on these results, new optimization strategies for GaN HEMTs could be defined [J454]

"Demonstration of a 270-GHz MMIC Amplifier Using 35-nm InP HEMT Technology"

In this letter, the first 270-GHz millimeter-wave integrated circuit (MMIC) amplifier is demonstrated. Peak measured gain of 11.6-dB is measured for the three stage amplifier realized in coplanar waveguide. Further, positive S21 gain is measured to 340GHz making this the highest frequency MMIC amplifier reported to date. The high frequency circuit performance is enabled through a 35-nm InP high electron mobility transistor capable of extremely high frequency operation [J455]

"35-nm InP HEMT SMMIC Amplifier With 4.4-dB Gain at 308 GHz"

rdquoWe report the first submillimeter-wave monolithic microwave integrated circuit (MMIC) amplifier with 4.4-dB measured gain at 308-GHz frequency, making it the highest frequency MMIC amplifier reported to date. In this letter, a 35-nm InP high-electron mobility transistor process has been successfully developed with a projected maximum available gain of greater than 7 dB at 300 GHz. The excellent dc and RF performance makes it suitable for applications at frequencies well into the millimeter-wave band and, for the first time, in the submillimeter- wave band as well. [J456]

"Characteristics of Al2 O3 /AlInN /GaN MOSHEMT"

InAlN/GaN is a new heterostructure system for HEMTs with thin barrier layers and high channel current densities well above 1 A/mm. To improve the leakage characteristics of such thin-barrier devices, AlInN/GaN MOSHEMT devices with a 11 nm InAlN barrier and an additional 5 nm Al2O3barrier (deposited by ALD) were fabricated and evaluated. Gate leakage in reverse direction could be reduced by one order of magnitude and the forward gate voltage swing increased to 4 V without gate breakdown. Compared to HEMT devices of similar geometry, no degradation of the current gain cutoff frequency was observed. The results showed that InAlN/GaN FETs with high channel current densities can be realised with low gate leakage characteristics and high structural aspect ratio by insertion of a thin Al2O 3gate dielectric layer [J457]

"50-nm T-Gate InAlAs/InGaAs Metamorphic HEMTs With Low Noise and High fT Characteristics"

We report 50-nm T-gate metamorphic high-electron mobility transistors (MHEMTs) with low noise figure and high characteristics. The 30 mumtimes2 MHEMT shows a drain current density of 690 mA/mm, a gm,maxof 1270 mS/mm, an fTof 489 GHz, and an of 422 GHz. In the frequency range of 59-61 GHz, the noise figure is less than 0.7 dB, and the associated gain was greater than 9 dB at a drain voltage of 1.3 V and a gate voltage of -0.8 V. To our knowledge, the MHEMT shows the best performance in terms of and noise figure among GaAs-based HEMTs. [J458]

"Oxygen Ion Implantation Isolation Planar Process for AlGaN/GaN HEMTs"

A multienergy oxygen ion implantation process was demonstrated to be compatible with the processing of high-power microwave AlGaN/GaN high electron mobility transistors (HEMTs). HEMTs that are isolated by this process exhibited gate-lag- and drain-lag-free operation. A maximum output power density of 5.3 W/mm at Vgs= -4 V and Vds= 50 V and a maximum power added efficiency of 51.5% at Vgs= -4 V and Vds= 30 V at 3 GHz were demonstrated on HEMTs without field plates on sapphire substrate. This isolation process results in planar HEMTs, circumventing potential problems with enhanced gate leakage due to the gate contacting the 2-D electron gas at the mesa sidewall. [J459]

"Global Modeling Analysis of HEMTs by the Spectral Balance Technique"

A global physical/electromagnetic high electron-mobility transistor (HEMT) simulation approach, entirely in the frequency domain, is here described for microwave computer-aided design applications. The frequency-domain spectral balance technique for the solution of steady-state nonlinear differential equations is applied to the moments of Boltzmann's transport equation for the analysis of the intrinsic active part of the device, yielding a very simple formulation. A numerical electromagnetic solver in the frequency domain is used for the analysis of the extrinsic passive embedding and access structure. The two analyzes are coupled, and give a self-consistent global description of the device. The frequency-domain formulation allows easy inclusion of frequency-dependent parameters of the semiconductor, and a natural extension to multitone analysis, without the need for cumbersome time-frequency transformations. The technique is applied to a quasi-2-D hydrodynamic modeling of the active device for simplicity, but is suitable for more comprehensive approaches as well. DC and small-signal microwave results up to 40 GHz are obtained for a 0.3-mum gate-length AlGaAs-InGaAs-GaAs pseudomorphic HEMT transistor, and compared to experimental data. [J460]

"Low-Frequency Noise in AlSb/InAs and Related HEMTs"

A comprehensive examination of the low-frequency noise characteristics of AlSb/InAs and related high-electron mobility transistors (HEMTs) in the 6.1-Aring-lattice-constant material system is reported. The effect of gate bias on the noise of devices in this technology is reported for the first time. The slope of the noise level in all the devices examined is nearly 1/f below 100 Hz, but some have significant generation-recombination Lorentzian components at higher frequencies, with an activation energy between 0.30 and 0.40 eV. The Hooge parameter alphaHfor open-channel measurements is in the range between 5times10-4and 5times10-3based on measurements at low drain voltage. Comparisons are made to the noise performance of several earlier InAs-based HEMTs with considerably different layer structure and channel composition [J461]

"Evaluation of AlInN=GaN HEMTs on sapphire substrate in microwave, time and temperature domains"

AlInN/GaN high electron mobility transistors (HEMTs) on sapphire substrate have yielded a maximum drain current density of 1.26 A/mm with a current gain cutoff and maximum oscillation frequencies about 26 and 40 GHz, respectively, for a 0.25 mum gate length device. Pulsed characterisations indicate absence of the virtual gate effect and reveal that the drain current dispersion is mainly due to thermal effects. Temperature stress experiments up to 800degC indicate that surface and hetero-interface are inherently stable. The reasons for the behaviour are discussed [J462]

"Thermal Maps of GaAs P-HEMT: A Novel System Based on the Photocurrent Spectral Analysis"

In this brief, we present a novel noninvasive method for spatially resolved thermal measurement of HEMT devices based on microphotoconductance analysis. This approach is used to obtain the temperature distribution in the active regions of a GaAs P-HEMT. Through 1D and 2D thermal maps, we are able to measure the temperature inside each single channel, and owing to the improved spatial resolution of the developed technique, it is possible to observe the hottest region of the device which is placed at the drain side of the gate. Moreover,

the resolution of the temperature measurements allows defining a local thermal resistance which is not uniform over the device due to the mutual heating between the channels [J463]

"Trapping Effects in the Transient Response of AlGaN/GaN HEMT Devices"

In this paper, the transient analysis of an AlGaN/GaN high-electron mobility transistor (HEMT) device is presented. Drain-current dispersion effects are investigated when gate or drain voltages are pulsed. Gate-lag and drain-lag turn-on measurements are analyzed, revealing clear mechanisms of current collapse and related dispersion effects. Numerical 2-D transient simulations considering surface traps effects in a physical HEMT model have also been carried out. A comparison between experimental and theoretical results is shown. The presence of donor-type traps acting as hole traps, due to their low energy level of 0.25 eV relative to the valence band, with densities >1e20 cm-3(>5e12 cm-2), uniformly distributed at the HEMT surface, and interacting with the free holes that accumulated at the top surface due to piezoelectric fields, accounts for the experimentally observed effects. Time constants next to 10 ms are deduced. Some additional features in the measured transient currents, with faster time constants, could not be associated with surface states [J464]

"Demonstration of Sub-Millimeter Wave Fundamental Oscillators Using 35-nm InP HEMT Technology"

In this letter, 254-, 314-, and 346-GHz fundamental oscillators are demonstrated. These are the highest frequency oscillators using three-terminal devices reported to date. The performance is enabled through a 35-nm InP HEMT process with maximum frequency of oscillation (fmax) of 600GHz. These first-pass designs use coplanar waveguide (CPW) technology and include on-chip resonator and output matching. The maximum available gain (MAG) of these devices has been measured to be ~9.6dB at 200GHz [J465]

"High-Temperature Operation of AlGaN/GaN HEMTs Direct-Coupled FET Logic (DCFL) Integrated Circuits"

This letter presents the high-temperature performance of AlGaN/GaN HEMT direct-coupled FET logic (DCFL) integrated circuits. At 375 degC, enhancement-mode (E-mode) AlGaN/GaN HEMTs which are used as drivers in DCFL circuits exhibit proper E-mode operation with a threshold voltage (VTH) of 0.24 V and a peak current density of 56 mA/mm. The monolithically integrated E/D-mode AlGaN/GaN HEMTs DCFL circuits deliver stable operations at 375 degC: An E/D-HEMT inverter with a drive/load ratio of 10 exhibits 0.1 V for logic-low noise margin (NML) and 0.3 V for logic-high-noise margin (NMH) at a supply voltage (VDD) of 3.0 V; a 17-stage ring oscillator exhibits a maximum oscillation frequency of 66 MHz, corresponding to a minimum propagation delay (taupd) of 446 ps/stage at VDDof 3.0 V [J466]

"A New Method for Identification and Minimization of Distortion Sources in GaN HEMT Devices Based on Volterra Series Analysis"

This letter mainly focuses on providing theoretical justification for possible gallium-nitride (GaN) device linearity improvement, interpreting the key physical origins of third-order distortion (IMD3). Based on the bias-dependent S-parameter measurement data of field-plate (FP)-free 8times125 mum GaN high-electron mobility transistor (HEMT), IMD3 is modeled using classical Volterra series theory. Through this technique, device diagnosis is carried out for efficiently localizing the distortion behavior. Further, device linearity is shown to improve by appropriately tuning the gate-drain feedback capacitance by taking advantage of FP technology proving the analysis to be a powerful tool for developing GaN HEMT technology [J467]

"60 GHz Single-Chip Front-End MMICs and Systems for Multi-Gb/s Wireless Communication"

Single-chip 60 GHz transmitter (TX) and receiver (RX) MMICs have been designed and characterized in a 0.15mum (fT~ 120 GHz/f MAX> 200 GHz) GaAs mHEMT MMIC process. This paper describes the second generation of single-chip TX and RX MMICs together with work on packaging (e.g., flip-chip) and system measurements. Compared to the first generation of the designs in a commercial pHEMT technology, the MMICs presented in this paper show the same high level of integration but occupy smaller chip area and have higher gain and output power at only half the DC power consumption. The system operates with a LO signal in the range of 7-8 GHz. This LO signal is multiplied in an integrated multiply-by-eight (X8) LO multiplier chain, resulting in an IF center frequency of 2.5 GHz. Packaging and interconnects are discussed and as an alternative to wire bonding, flip-chip assembly tests are presented and discussed. System measurements are also described where bit error rate (BER) and eye diagrams are measured when the presented TX and RX MMICs transmits and receives a modulated signal. A data rate of 1.5 Gb/s with simple ASK modulation was achieved, restricted by the measurement setup rather than the TX and RX MMICs. These tests indicate that the presented MMICs

are especially well suited for transmission and reception of wireless signals at data rates of several Gb/s [J468]

"Compact Model of Current Collapse in Heterostructure Field-Effect Transistors"

In this paper, compact analytical model for the heterostructure field-effect transistor (HFET) current-voltage (I-V) characteristics, accounting for the large-signal dispersion, also referred to as current collapse, is presented. The model is based upon an experimentally established fact that the dispersion is mainly due to carrier trapping at the source and drain sides of the gate edges. In wide-bandgap heterostructures like AlGaN/GaN, the characteristic trapping-generation times are several orders of magnitude longer than the signal period at typical operating frequencies. Thus, the radio frequency signal "sees" an averaged I-V characteristic resulting from carrier trapping-generation. The approach, based on this difference, leads to a compact quasi-steady-state analytical model of the HFET I -V characteristics that can be easily implemented in device-circuit simulators. The model shows close agreement with the experimental data [J469]

"RF Power Measurements of InAlN/GaN Unstrained HEMTs on SiC Substrates at 10 GHz"

Unstrained high-electron mobility transistors (HEMTs) were fabricated from InAlN/GaN on semi-insulating SiC substrates. The devices had 0.24-mum T-gates with a total width of 2times150 mum. Final passivated performance values for these devices are Imax=1279 mA/mm, IDSS=1182 mA/mm, Rc=0.43 Omegamiddotmm, rhos=315 Omega/sq, fT=45 GHz, fmax(MAG) =64 GHz, and gm=268 mS/mm. Continuous-wave power measurements at 10 GHz produced Psat=3.8 W/mm, Gt=8.6 dB, and PAE=30% at VDS=20 V at 25% IDSS. To our knowledge, these are the first power measurements reported at 10 GHz for this material [J470]

"A high-efficiency class-E GaN HEMT power amplifier at 1.9 GHz"

A single stage class-E power amplifier in GaN high electron mobility transistor (HEMT) technology is reported. The circuit operates at 1.9 GHz. At 30-V drain bias, a power-added-efficiency (PAE) of 57% and a maximum output power of over 37dBm was achieved, corresponding to a power density of 5.25W/mm. At 40-V drain bias, an output power of 38.7dBm is achieved at 50% PAE corresponding to a power density of 7.4W/mm [J471]

"An optically clocked transistor array with dual serial-to-parallel and parallel-to-serial conversion capability for optical label swapping"

We propose an optically clocked transistor array optoelectronic integrated circuit (OEIC) for both serial-to-parallel and parallel-to-serial conversion (demux/mux), enabling an interface between high-speed asynchronous burst optical labels and CMOS circuitry for optical label swapping. Dual functionality of the OEIC reduces size, power, and cost of the optical label swapper. The capability for greater than 20-Gb/s conversion operation is demonstrated. [J472]

"Improved Thermal Performance of AlGaN/GaN HEMTs by an Optimized Flip-Chip Design"

AlGaN/GaN high electron mobility transistors (HEMT) on sapphire substrates have been studied for their potential application in RF power applications; however, the low thermal conductivity of the sapphire substrate is a major drawback. Aiming at RF system-in-a-package, the authors propose a flip-chip-integration approach, where the generated heat is dissipated to an AlN carrier substrate. Different flip-chip-bump designs are compared, using thermal simulations, electrical measurements, micro-Raman spectroscopy, and infrared thermography. The authors show that a novel bump design, where bumps are placed directly onto both source and drain ohmic contacts, improves the thermal performance of the HEMT [J473]

"Two-stage quasi-class-E power amplifier in GaN HEMT technology"

This letter presents a two-stage quasi-class-E monolithic microwave integrated circuit power amplifier at 2.0GHz, which is based on field-plated GaN high electron mobility transistor technology. It consists of a driver stage and a power stage. The circuit schematic is described. The amplifier achieves an output power of 37.5dBm into a 50-Omega load, a power added efficiency (PAE) of 50%, and a gain of 18.2dB. A power density of 5.6W/mm is achieved [J474]

"Output power density of 5.1/mm at 18 GHz with an AlGaN/GaN HEMT on Si substrate"

Microwave frequency capabilities of AlGaN/GaN high electron mobility transistors (HEMTs) on high resistive silicon (111) substrate for power applications are demonstrated in this letter. A maximum dc current density of 1 A/mm and an extrinsic current gain cutoff frequency (FT) of 50 GHz are achieved for a 0.25 μm gate length device. Pulsed and large signal measurements show the good quality of the epilayer and the device processing.

The trapping phenomena are minimized and consequently an output power density of 5.1 W/mm is reached at 18 GHz on a 2Ч50Ч0.25 μm2HEMT with a power gain of 9.1dB. [J475]

"Thermally stable Ge/Ag/Ni Ohmic contact for InAlAs/InGaAs/InP HEMTs"

Excellent annealed ohmic contacts based on Ge/Ag/Ni metallization have been realized in a temperature range between 385 and 500°C, with a minimum contact resistance of 0.06 Ω·mm and a specific contact resistivity of 2.62 Ч10-7Ω·cm2obtained at an annealing temperature of 425°C for 60 s in a rapid thermal annealing (RTA) system. Thermal storage tests at temperatures of 215 and 250°C in a nitrogen ambient showed that the Ge/Ag/Ni based ohmic contacts with an overlay of Ti/Pt/Au had far superior thermal stabilities than the conventional annealed AuGe/Ni ohmic contacts for InAlAs/InGaAs high electron mobility transistors (HEMTs). During the storage test at 215°C, the ohmic contacts showed no degradation after 200 h. At 250°C, the contact resistance value of the Ge/Ag/Ni ohmic contact increased only to a value of 0.1 Ω·mm over a 250-h period. Depletion-mode HEMTs (D-HEMTs) with a gate length of 0.2 μm fabricated using Ge/Ag/Ni ohmic contacts with an overlay of Ti/Pt/Au demonstrated excellent dc and RF characteristics. [J476]

"Low-power W-band CPWG InAs/AlSb HEMT low-noise amplifier"

We present the development of a low-power W-band low-noise amplifier (LNA) designed in a 200-nm InAs/AlSb high electron mobility transistor (HEMT) technology fabricated on a 50-mum GaAs substrate. A single-stage coplanar waveguide with ground (CPWG) LNA is described. The LNA exhibits a noise figure of 2.5 dB and an associated gain of 5.6 dB at 90 GHz while consuming 2.0 mW of total dc power. This is, to the best of our knowledge, the lowest reported noise figure for an InAs/AlSb HEMT LNA at 90 GHz. Biased for maximum gain, the single-stage amplifier presents 6.7-dB gain and an output 1-dB gain compression point (P1dB) of -6.7dBm at 90 GHz. The amplifier provides broad-band gain, greater than 5dB over the entire W-band [J477]

"700-V 1.0- Buried Gate SiC-SIT (SiC-BGSIT)"

Ultralow on-resistance silicon carbide static induction transistors with buried gate structures (SiC-BGSITs) have been successfully developed through innovative fabrication process. A submicrometer buried p+gate structure was fabricated by the combination of submicrometer trench dry etching and epitaxial growth on a trench structure. The breakdown voltage VBRand specific on-resistance RonSof the fabricated SiC-BGSIT were 700 V at a gate voltage VG=-12V, and 1.0 mOmegamiddotcm2at a current density JD=200A/cm2and VG=2.5V, respectively. This RonSis the lowest on-resistance for ~600 V class power switching devices, including other SiC devices and GaN HEMTs [J478]

"Liquid-phase sensors using open-gate Al Ga N /Ga N high electron mobility transistor structure"

Liquid-phase sensing characteristics of open-gate AlGaN/GaNhigh electron mobility transistor (HEMT) structures were investigated in aqueous solutions and polar liquids. In de-ionized water, the open-gate HEMT clearly showed good drain I-Vcharacteristics with current saturation and pinch-off behavior, very similar to I-Vcharacteristics of typical Schottky-gate HEMTs. We observed a fine parallel shift in the transfer curves according to change in the pHvalue in a solution, indicating the corresponding potential change at the AlGaN surface. The sensitivity for the potential change was 57.5mV/pH, very close to the theoretical value of 58.9mV/pHat 24°Cfor the Nernstian response to H+ions. In the low drain bias region, the drain current linearly decreased with the pHvalue. This also indicated a systematic potential change at the AlGaN surface due to pHchange. The present open-gate device showed a fast response to the pHchange and a stable operation at fixed pHvalues. A possible mechanism for the pHresponse of the AlGaN surface is discussed in terms of equilibrium reactions of hydroxyls at the AlGaN surface with H+in a solution. It was also found that the device was quite sensitive to changes in the electrostatic boundary conditions of the open-gate area by exposure to polar liquids. The drain current linearly decreased with increasing normalized liquid dipole moment. [J479]

"Influence of silicon nitride passivation on transport properties in In Al As /In Ga As /In P composite channel high electron mobility transistor structures"

The influence of silicon nitride (SiN) passivation on the electron mobility of InGaAs/InPcomposite channel high electron mobility transistor (HEMT) structures has been studied. Hall measurements were used to characterize the influence of SiN passivation on electrical properties. An increase in effective mobility mu ewith a negligible change of sheet carrier density nsafter SiN deposition is clearly observed. This behavior is different from the previous report on the single InGaAs channel HEMT structure, in which the increase in sheet carrier density with a negligible change of electron mobility was found. Photoluminescence (PL) measurements were carried out to evaluate the effects of SiN passivation on electrical and optical properties. The variations of the PL peak position, the transition intensity, and the linewidth of different passivated samples were analyzed to clarify the

mechanism for the change in electrical properties. Our results suggest that the enhancement of mu ecould be explained under the framework of electron transfer from the InP subchannel into the InGaAs channel region due to energy band bending at the surface region caused by the SiN passivation. [J480]

"Reaction of molecular beam epitaxial grown AlN nucleation layers with SiC substrates"

GaN high electron mobility transistor (HEMT) structures containing AlN nucleation layers were grown on SiC substrates by molecular beam epitaxy. Deleterious charge is observed near the GaN/AlNinterface when the AlN layer is grown using aluminum-rich growth conditions which promote AlN material quality. The unwanted charge is correlated with nondestructive mercury probe buffer leakage measurements and degraded capacitance-voltage profiles. Secondary ion mass spectrometry measurements on a HEMT structure with a thick AlN layer grown aluminum rich confirm that the unintentional dopant is silicon which rapidly migrates through the AlN layer to the GaN buffer layer. Leakage current measurements on aluminum-rich AlN layers indicate that the conduction is in the initial GaN layers near the GaN/AlNinterface. It is proposed that under aluminum-rich conditions the excess aluminum present on the growth surface in the liquid state is reacting with the substrate surface resulting in dissolved silicon that rapidly travels with the growth surface. Thermodynamic calculations and aluminum-silicon phase diagrams support this mechanism. By careful adjustment of the aluminum to nitrogen flux ratio, silicon outmigration is significantly reduced with a concomitant reduction in leakage current by four orders of magnitude. [J481]

"Laser ablation of via holes in GaN and Al Ga N /Ga N high electron mobility transistor structures"

Laser drilling for through-via holes was performed with a Nd:YVO4laser for an AlGaN/GaNhigh electron mobility transistor (HEMT) structure on a SiC substrate. Current-voltage (I-V)characteristics, transconductance, and small signal characteristics before and after laser drilling were compared to examine the effect of laser drilling on device performance. The electrical characteristics of the HEMTs did not show significant change after laser drilling, even when performed in close proximity to the device. Laser drilling was found to be a fast and safe technique to drill via hole in AlGaN/GaNHEMT structure and provides an alternative to dry etching for creation of these vias. [J482]

"Study of Impact of Access Resistance on High-Frequency Performance of AlGaN/GaN HEMTs by Measurements at Low Temperatures"

This letter studies the effect of access resistance on the high-frequency performance of AlGaN/GaN high-electron-mobility transistors. To systematically reduce the sheet access resistance, the transistors were measured at different temperatures. The increase of mobility at lower temperatures allowed more than four-fold reduction in the sheet access resistances. Both the current- and power-gain cutoff frequencies are observed to increase at low temperatures. Also, the intrinsic effective velocity has been estimated in these devices, as well as the parasitic delays involved in the final performance. Channel charging delay, which was expected to be most sensitive to parasitics, is observed to decrease at low temperatures. However, the drain delay, intrinsic delay, and effective electron velocity remain unaffected by temperature [J483]

"0.15- -Gate InAlAs/InGaAs/InP E-HEMTs Utilizing Ir/Ti/Pt/Au Gate Structure"

High-current 0.15-mum-gate enhancement-mode high-electron mobility transistors utilizing Ir/Ti/Pt/Au gate metallization were fabricated using a new process including a high-temperature gate anneal that is required for Schottky-barrier height enhancement for the Ir-based gate contact. SiNxencapsulation was employed to prevent thermal degradation of device layer during the high-temperature gate anneal. Excellent enhancement-mode operation, with a threshold voltage of 0.1 V and IDSSof 2.1 mA/mm, was realized. Both the annealed and unannealed devices exhibited high gm,maxand ID,maxof 800 mS/mm and 430 mA/mm, respectively. A unity current-gain cutoff frequency fTof 151 GHz and a maximum oscillation frequency fMAXof 172 GHz were achieved. From the dc and RF characteristics, it can be deduced that there was no degradation of the gate contact and the heterostructure due to gate annealing. Furthermore, it was found that the gate diffusion during gate annealing was negligible since no increase in gm,maxwas observed [J484]

"Suppression of surface segregation of silicon dopants during molecular beam epitaxy of (411)A In 0.75 Ga 0.25 As /In 0.52 Al 0.48 As pseudomorphic high electron mobility transistor structures"

The authors achieved considerable suppression of surface segregation of Si dopants in In0.75Ga0.25As/In0.52Al0.48Ashigh electron mobility transistor (HEMT) structures grown on (411)AInP substrates by molecular beam epitaxy (MBE). The (411)AHEMT structures were conventionally grown at a high substrate temperature (Ts)of 540°Cin order to form the extremely flat (411)Aheterointerfaces. This results in

considerable surface segregation of Si dopants. Surface segregation of Si dopants was suppressed by lowering growth temperature of the top InAlAs barrier layer (TB)down to 450°Cwith keeping Tsof 540°Cfor other parts. Sheet carrier concentration (Ns)of two-dimensional electron gas (2DEG) was measured as a function of thickness (Lb)of the top InAlAs barrier for TB=450and 540°Csamples. Observed Nsof the TB=540°Csample vanished when Lbapproached to 7nm, while 2DEG with of Ns 2Ч1012cm-2remained for the TB=450°Csample. Surface segregation of Si-sheet-doped (411)AInAlAs layers grown at TBwas also characterized by secondary ion m--ass spectrometry measurements. Si segregation length (lambda Si:1/edecay length of Si concentration) observed for TB=450°Csample was 2.3nm, which is 56% smaller than that for TB=540°C(lambda Si=5.2nm). [J485]

"AlGaN/GaN/InGaN/GaN DH-HEMTs with an InGaN notch for enhanced carrier confinement"

We report an AlGaN/GaN/InGaN/GaN double heterojunction high electron mobility transistors (DH-HEMTs) with high-mobility two-dimensional electron gas (2-DEG) and reduced buffer leakage. The device features a 3-nm thin InxGa1-xN(x=0.1) layer inserted into the conventional AlGaN/GaN HEMT structure. Assisted by the InGaN layers polarization field that is opposite to that in the AlGaN layer, an additional potential barrier is introduced between the 2-DEG channel and buffer, leading to enhanced carrier confinement and improved buffer isolation. For a sample grown on sapphire substrate with MOCVD-grown GaN buffer, a 2-DEG mobility of around 1300 cm2/V·s and a sheet resistance of 420 Ω/sq were obtained on this new DH-HEMT structure at room temperature. A peak transconductance of 230 mS/mm, a peak current gain cutoff frequency (fT) of 14.5 GHz, and a peak power gain cutoff frequency (fmax) of 45.4 GHz were achieved on a 1Ч100 μm device. The off-state source-drain leakage current is as low as 5 μ A/mm at VDS=10 V. For the devices on sapphire substrate, maximum power density of 3.4 W/mm and PAE of 41% were obtained at 2 GHz. [J486]

"High-efficiency power amplifier design including input harmonic termination"

This letter presents the design of a high-efficiency Class-F power amplifier in pseudomorphic high electron mobility transistor technology using a novel load-pull/source-pull simulation-based approach. The second harmonic input termination is shown to have a critical influence on performance, which is justified by the shape of the simulated waveforms. Experimental validation is carried out on a 2-GHz practical circuit using a medium-power packaged device. Two cases are compared both theoretically and experimentally: for the best and worst case second harmonic input terminations, 76% and 42% saturated power-added efficiency are measured, respectively. In addition, the worst case termination degrades the saturated C/I3 by 7.5dB. [J487]

"Low-power InP-HEMT switch ICs integrating miniaturized 2Ч2 switches for 10-Gb/s systems"

This paper presents a wideband cold-FET switch with virtually zero power dissipation. The use of InP HEMTs with a low Ron·Coffproduct enables us to configure a DC-to-over-10-GHz single-pole double-throw (SPDT) switch without using a shunt FET. The series-FET configuration offers a logic-level-independent interface and makes possible positive control voltage operation in spite of using depletion-mode FETs. A miniaturized 2Ч2 switch using two SPDT switches yields an insertion loss of less than 1.16 dB and isolation of more than 21.2 dB below 10 GHz, which allows us to increase the scale of the switch in a single chip easily. The add-drop operation combining two 2Ч2 switches in a single chip and a 4Ч4 switch IC integrating four 2Ч2 switches are presented. The packaged ICs achieve error-free operation up to 12.5 Gb/s with either positive or negative logic-level input. Extremely fast switching of 140 ps is also successfully demonstrated. [J488]

"AlGaN/GaN HEMTs on [J001] silicon substrates"

AlGaN/GaN high electron mobility transistors have been realised on resistive Si(001) substrate. The heterostructure was grown by molecular beam epitaxy. The 2D electron gas formed at the AlGaN/GaN interface exhibits a sheet carrier density of 7.1Ч1012cm-2and a Hall mobility of 1500 cm2/V s at room temperature. High electron mobility transistors with a gate length of 3 μm have been processed and DC characteristics have been achieved. A maximum drain current of more than 440 mA/mm and a transconductance gmof 120 mS/mm have been obtained. These encouraging results open the way for GaN-based electronic applications on Si(001) substrates. [J489]

"Performance improvement in tensile-strained In0.5 Al0.5 As/Inx Ga1-x As/In0.5 Al0.5 As metamorphic HEMT"

This paper proposes a In0.5Al0.5As/InxGa1-xAs/In0.5Al0.5As (x=0.3-0.5-0.3) metamorphic high-electron mobility transistor with tensile-strained channel. The tensile-strained channel structure exhibits significant improvements in dc and RF characteristics, including extrinsic transconductance, current driving capability, thermal stability, unity-gain cutoff frequency, maximum oscillation frequency, output power, power gain, and power added

efficiency. [J490]

"On the temperature and carrier density dependence of electron saturation velocity in an AlGaN/GaN HEMT"

The temperature and carrier density dependence of electron intrinsic saturation velocity (vsi) in a 0.3-μm gate length AlGaN/GaN HEMT was extracted from multibias S-parameter measurements. It was found that vsifell rapidly with increasing sheet carrier concentration (ns), but was only a very weak function of ambient temperature (Tamb). This behavior is consistent with the hot-phonon model of carrier transport. [J491]

"Use of double-channel heterostructures to improve the access resistance and linearity in GaN-based HEMTs"

Double-channel structures have been used in AlGaN/GaN high electron mobility transistors to reduce the access resistance. Carrier densities as high as 2.9Ч1013cm-2and mobilities in the 1300 cm2/V·s range have been obtained in the access region. Also, the correct design of the potential barrier between the different channels allowed tailoring the differential access resistance to enhance the linearity of the transistors. This increase in linearity has been measured as a flatter profile of the transconductance and cutoff frequency versus current and as an improvement of more than 2 dB in large-signal two-tone linearity measurements. [J492]

"InAlN/GaN HEMTs: a first insight into technological optimization"

High-electron mobility transistors (HEMTs) were fabricated from heterostructures consisting of undoped In0.2Al0.8N barrier and GaN channel layers grown by metal-organic vapor phase epitaxy on (0001) sapphire substrates. The polarization-induced two-dimensional electron gas (2DEG) density and mobility at the In0.2Al0.8N/GaN heterojunction were 2Ч1013cm-2and 260 cm2V-1s-1, respectively. A tradeoff was determined for the annealing temperature of Ti/Al/Ni/Au ohmic contacts in order to achieve a low contact resistance (ρC=2.4Ч10-5Ω·cm2) without degradation of the channels sheet resistance. Schottky barrier heights were 0.63 and 0.84 eV for Ni- and Pt-based contacts, respectively. The obtained dc parameters of 1-μm gate-length HEMT were 0.64 A/mm drain current at VGS=3 V and 122 mS/mm transconductance, respectively. An HEMT analytical model was used to identify the effects of various material and device parameters on the InAlN/GaN HEMT performance. It is concluded that the increase in the channel mobility is urgently needed in order to benefit from the high 2DEG density. [J493]

"Punch-through in short-channel AlGaN/GaN HFETs"

Short-channel punch-through effects are demonstrated in 0.17 μm gate length AlGaN/GaN single heterojunction field-effect transistors. These take the form of a high output conductance and the strong dependence of pinch-off voltage on drain voltage. It is shown by simulation that they can be explained by poor confinement of charge at the AlGaN/GaN interface resulting in current flow within the bulk of the GaN layer. This is caused by there being a concentration of only 1.5Ч1016cm-3deep levels in the insulating GaN buffer layer. It is found that a net acceptor density of around 1017cm-3is required to ensure suppression of short-channel effects. [J494]

"High-performance 94-GHz single balanced mixer using 70-nm MHEMTs and surface micromachined technology"

We reported 94-GHz, low conversion loss, and high isolation single balanced active gate mixer based on 70-nm gate length InGaAs/InAlAs metamorphic high-electron mobility transistors (MHEMTs). This mixer showed that the conversion loss and isolation characteristics were 2.5 3.5 dB and under -29 dB in the range of 92.95 94.5 GHz, respectively. The low conversion loss of the mixer is mainly attributed to the high-performance of the MHEMTs exhibiting a maximum drain current density of 607 mA/mm, an extrinsic transconductance of 1015 mS/mm, a current gain cutoff frequency (ft) of 330 GHz, and a maximum oscillation frequency (fmax) of 425 GHz. High isolation characteristics are due to hybrid ring coupler which adopted dielectric-supported air-gapped microstrip line structure using surface micromachined technology. To our knowledge, these results are the best performance demonstrated from 94 GHz single balanced mixer utilizing GaAs-based HEMTs in terms of conversion loss as well as isolation characteristics. [J495]

"The effect of gate leakage on the noise figure of AlGaN/GaN HEMTs"

The effect of gate leakage on the noise figure of AlGaN/GaN high electron mobility transistor (HEMTs) is explored. It is shown that these devices have a sizable amount of gate leakage that cannot be ignored when measuring their noise performance. Measurements across a single sample have more than 1 dB of variation in

minimum noise figure. We will show this variation is because of gate leakage. A modified van der Ziel model is used to predict this large variation and allows easy noise figure prediction of HEMT and MESFET devices. [J496]

"AlGaN/GaN high electron mobility transistors with InGaN back-barriers"

A GaN/ultrathin InGaN/GaN heterojunction has been used to provide a back-barrier to the electrons in an AlGaN/GaN high-electron mobility transistor (HEMT). The polarization-induced electric fields in the InGaN layer raise the conduction band in the GaN buffer with respect to the GaN channel, increasing the confinement of the two-dimensional electron gas under high electric field conditions. The enhanced confinement is especially useful in deep-submicrometer devices where an important improvement in the pinchoff and 50% increase in the output resistance have been observed. These devices also showed excellent high-frequency performance, with a current gain cut-off frequency (fT) of 153 GHz and power gain cut-off frequency (fmax) of 198 GHz for a gate length of 100 nm. At a different bias, a record fmaxof 230 GHz was obtained. [J497]

"Hybrid rectenna and monolithic integrated zero-bias microwave rectifier"

In this study, we have developed a hybrid sensitive rectenna (rectifier + antenna) system at 2.45 GHz. To achieve this system, we have first optimized and validated a zero-bias microwave sensitive rectifier using commercial Schottky diodes. We have then optimized and achieved a 2times2 patch antenna array, which is associated to the microwave rectifier in order to validate the rectenna system, where an RF-dc conversion efficiency of 56% has been observed experimentally. In order to minimize the rectenna dimensions, we have conducted a study using the OMMIC ED02AH 0.20-mum GaAs pseudomorphic high electron-mobility transistor process to develop and achieve a monolithic rectifier at 2.45 GHz with RF-dc conversion efficiency of 65% [J498]

"Recessed-gate structure approach toward normally off high-Voltage AlGaN/GaN HEMT for power electronics applications"

A recessed-gate structure has been studied with a view to realizing normally off operation of high-voltage AlGaN/GaN high-electron mobility transistors (HEMTs) for power electronics applications. The recessed-gate structure is very attractive for realizing normally off high-voltage AlGaN/GaN HEMTs because the gate threshold voltage can be controlled by the etching depth of the recess without significant increase in on-resistance characteristics. With this structure the threshold voltage can be increased with the reduction of two-dimensional electron gas (2DEG) density only under the gate electrode without reduction of 2DEG density in the other channel regions such as the channel between drain and gate. The threshold-voltage increase was experimentally demonstrated. The threshold voltage of fabricated recessed-gate device increased to -0.14 V while the threshold voltage without the recessed-gate structure was about -4 V. The specific on-resistance of the device was maintained as low as 4 mΩ·cm2and the breakdown voltage was 435 V. The on-resistance and the breakdown voltage tradeoff characteristics were the same as those of normally on devices. From the viewpoint of device design, the on-resistance for the normally off device was modeled using the relationship between the AlGaN layer thickness under the gate electrode and the 2DEG density. It is found that the MIS gate structure and the recess etching without the offset region between recess edge and gate electrode will further improve the on-resistance. The simulation results show the possibility of the on-resistance below 1 mΩ·cm2for normally off AlGaN/GaN HEMTs operating at several hundred volts with threshold voltage up to +1 V. [J499]

"On the resolution of the mechanism for reverse gate leakage in AlGaN/GaN HEMTs"

We provide following important clues for resolving the reverse gate leakage mechanism in AlGaN/GaN high-electron mobility transistors (HEMTs), based on two-dimensional (2-D) simulation and analysis. First, measurement of the gate current-voltage, IG-VG, characteristics on devices having different gate structures, passivation layers and interface charges, can reveal the field sensitivity of this mechanism. Second, of the different mechanisms proposed so far, namely-direct tunneling (DT), direct tunneling through a thin surface barrier (DTTSB) and trap-assisted tunneling (TT), DT/DTTSB is sensitive to the 2-D field, while the TT is not. Finally, the DT/DTTSB mechanism appears unlikely, since its 2-D calculations fit the measured IG-VGshape, only if we assume a physically unrealistic voltage-variable charge at the interface and/or the TSB layer. [J500]

"Evaluation of ACPR in mixers based on a parametric harmonic-balance approach"

This paper reports an extension of parametric harmonic balance (PHB) to efficiently analyze mixers excited by communications signals. In the case of digitally modulated signals, PHB is demonstrated in this paper, exhibiting reduced simulation times and memory resources. For validation purposes, a high electron-mobility transistor mixer has been constructed and characterized with single- and two-tone 2-GHz input RF signals, and also the output spectra under Universal Mobile Telecommunications System-wide-band code-division multiple-access signal excitations above the 1-dB compression point have been obtained. In addition to its fast convergence

properties, the presented simulations demonstrate a very good agreement with experimental results. The close correspondence between calculated and measured spectral regrowth permitted a reliable prediction of adjacent channel power rejection [J501]

"A 2.8-W Q-Band High-Efficiency Power Amplifier"

A highly efficient and high-power monolithic power amplifier operating at Q-band is presented utilizing 0.15-mum pseudomorphic InGaAs/GaAs HEMT production process on 2-mil-thick substrate. Over 42-46 GHz frequency range, the amplifier demonstrated maximum power of 2.8 W (34.5 dBm) and power-added efficiency (PAE) of 23% to 26% when operated at 5 V and 250 mA/mm. The amplifier attained maximum PAE of 24% to 29% and power of 33.6-34 dBm when biased at 5 V and 125 mA/mm. At these power levels and PAEs, the amplifier exhibited power densities in excess of 430 mW/mm. With device periphery ratio of 1:2.857, effective phase compensation of the input feed network, and low-loss output-combining network, the power amplifier has been able to attain state-of-the-art efficiency and power performance [J502]

"A Capless p-HEMT Having a Self-Aligned Gate Structure"

Characteristics of a 0.2-mum capless InAlAs/InGaAs pseudomorphic high electron mobility transistor (p-HEMT) having a self-aligned gate (SAG) were investigated. The 0.2-mum SAG capless p-HEMT showed a source resistance comparable to that of a conventional recessed p-HEMT having a heavily n-doped In0.53Ga0.47As cap layer primarily due to the SAG and optimized ohmic-metallization processes and excellent characteristics of Gm,max, fT, and fmaxof 1.12 S/mm, 185 GHz, and 225 GHz, respectively, even without a heavily doped InGaAs cap layer. The capless device exhibited much better device parameters for digital logic applications including I ON/IOFFand subthreshold slope (1.27times104and 78 mV/dec) compared with those (5.1times103and 120 mV/dec) of the conventional recessed device, respectively [J503]

"The 1.6-kV AlGaN/GaN HFETs"

The breakdown voltages in unpassivated nonfield-plated AlGaN/GaN HFETs on sapphire substrates were studied. These studies reveal that the breakdown is limited by the surface flashover rather than by the AlGaN/GaN channel. After elimination of the surface flashover in air, the breakdown voltage scaled linearly with the gate-drain spacing reaching 1.6 kV at 20 mum. The corresponding static ON-resistance was as low as 3.4 mOmegamiddotcm2. This translates to a power device figure-of-merit VBR2/RON=7.5times108V2middotOmega-1cm-2, which, to date, is among the best reported values for an AlGaN/GaN HFET [J504]

"A closed-form model of the drain-voltage dependence of the off-state channel electric field in a HEMT with a field plate"

The channel-field distribution under the field plate in a high-electron mobility transistor (HEMT) in the off-state is modeled in terms of drain-voltage and physical parameters. Depending upon the drain-voltage and device structure, this distribution can have up to three peaks-one each at the two ends of the field plate and at the drain. It is shown that the complete distribution can be approximated as superposition of triangular distributions, which are analogous to that in the depletion layer of a p-n junction; consequently, the peaks increase as square root of the drain-voltage. The model fits into two-dimensional simulation results and allows estimation of the minimum drain-gate separation, the electric-field reduction, the breakdown-voltage improvement, and critical field for the onset of a parasitic phenomenon in a HEMT with a field plate [J505]

"Characteristics of 0.2 µm depletion and quasi-enhancement mode self-aligned gate capless p-HEMTs"

Characteristics of 0.2 mum depletion mode (D) and quasi-enhancement mode (QE) capless InAlAs/InGaAs p-HEMTs having a self-aligned gate (SAG) are reported. The QE SAG capless p-HEMT showed improved output conductance and sub-threshold characteristics owing to the increased gate-to-channel aspect ratio implemented by using a buried Pt technology. The maximum gm, ION/IOFF, sub-threshold slope, fT, and fmaxof the QE SAG capless p-HEMT were 1.22 S/mm, 2.11times105, 65 mV/dec, 210 GHz and 250 GHz, and those of the D SAG capless p-HEMT were 1.12 S/mm, 1.27times104, 78 mV/dec, 185 GHz and 225 GHz. The QE SAG capless p-HEMT also exhibited a shorter drain delay time than the D SAG capless p-HEMT by about 46% [J506]

"Accurate Multibias Equivalent-Circuit Extraction for GaN HEMTs"

This paper focuses on the determination and analysis of an accurate small-signal equivalent circuit for gallium-nitride high electron-mobility transistors under different bias conditions. Our experimental results show that a channel capacitance has to be added to the conventional forward "cold" model for modeling the device-under-

test. The validity of the proposed extraction procedure has been verified by the very good agreement between simulated and measured scattering parameters up to 50 GHz [J507]

"Implant-free high-mobility flatband MOSFET: principles of operation"

Principles of operation of implant-free enhancement-mode MOSFETs (flatband MOSFET) are discussed. Epitaxial-layer structures designed for use in implant-free enhancement-mode devices and employing a high-kappa dielectric (kappacong20) and a strained InGaAs channel layer with a thickness of 10 nm have been manufactured on GaAs substrate. Proceeding from measured electron mobility mu as a function of the sheet-carrier concentration, enhancement-mode design considerations, saturation current IDss, and mobility requirements are discussed using two-dimensional device simulations. For the flatband MOSFET to compete successfully with other device designs, certain minimum channel mobilities are required. For RF applications, mu should exceed 5000 cm2/Vs while high-performance MOSFETs for digital applications may require even higher mobility for optimum operation. Finally, measured data of first 1-mum-GaAs-flatband enhancement-mode MOSFETs are presented; the saturation velocity of the InGaAs channel layer is derived; and measured IDssdata are compared to the results obtained by simulations [J508]

"High Breakdown Voltage Achieved on AlGaN/GaN HEMTs With Integrated Slant Field Plates"

A self-aligned "slant-field-plate" technology is presented as an improvement over the discrete multiple field plates for high breakdown voltage AlGaN/GaN HEMTs. Devices were tested in Fluorinert to eliminate the breakdown of air, which was identified to limit the breakdown voltage in AlGaN/GaN HEMTs. A single integrated field plate, which is self-aligned with the gate, is shown to support more than a kilovolt breakdown voltage (Vbrup to 1900 V was measured with Fluorinert). Devices made with this technology show a good large signal-frequency behavior. Various issues regarding breakdown measurements and interpretation of measurement results are presented [J509]

"Control of Threshold Voltage of AlGaN/GaN HEMTs by Fluoride-Based Plasma Treatment: From Depletion Mode to Enhancement Mode"

This paper presents a method with an accurate control of threshold voltages (Vth) of AlGaN/GaN high-electron mobility transistors (HEMTs) using a fluoride-based plasma treatment. Using this method, the Vthof AlGaN/GaN HEMTs can be continuously shifted from -4 V in a conventional depletion-mode (D-mode) AlGaN/GaN HEMT to 0.9 V in an enhancement-mode AlGaN/GaN HEMT. It was found that the plasma-induced damages result in a mobility degradation of two-dimensional electron gas. The damages can be repaired and the mobility can be recovered by a post-gate annealing step at 400 degC. At the same time, the shift in Vthshows a good thermal stability and is not affected by the post-gate annealing. The enhancement-mode HEMTs show a performance (transconductance, cutoff frequencies) comparable to the D-mode HEMTs. Experimental results confirm that the threshold-voltage shift originates from the incorporation of F ions in the AlGaN barrier. In addition, the fluoride-based plasma treatment was also found to be effective in lowering the gate-leakage current, in both forward and reverse bias regions. A physical model of the threshold voltage is proposed to explain the effects of the fluoride-based plasma treatment on AlGaN/GaN HEMTs [J510]

"Compact Noise Models for MOSFETs"

A physical understanding of both intrinsic and extrinsic noise mechanisms in a MOSFET is developed. Intrinsic noise mechanisms fundamental to device operation include channel thermal noise, induced gate noise, and induced substrate noise. While the effect of channel thermal noise is observable at zero drain-to-source voltage, the induced gate and substrate noise do not manifest themselves under these conditions. However, the attendant fluctuations in the channel charge are observable by the passage of electric current through the device. Extrinsic noise mechanisms manifested due to structural evolution of the MOSFET include the distributed gate resistance noise, distributed substrate resistance noise, bulk charge effects, substrate current supershot noise, gate current noise, excess channel noise, and 1/f noise. Where available, compact noise models covering these noise mechanisms are explained. Also, where possible, methods of suppression of these mechanisms are highlighted. A survey of current public domain MOS models is presented, and a lack of comprehensive coverage of noise models is noted. Open areas of MOSFET noise research in the sub-hundred-nanometer regime are also highlighted. With suitable adaptation, noise concepts elucidated in the context of MOS transistors have a much wider applicability to the operation of HEMTs, JFETs, MESFETs, and other field-effect devices [J511]

"Simulation of Electron Transport in InGaAs/AlGaAs HEMTs Using an Electrothermal Monte Carlo Method"

The electrothermal simulator developed in this work uses an iterative procedure that self-consistently couples a Monte Carlo electronic trajectory simulation with a fast Fourier series solution of the heat diffusion equation. Results presented in this paper are obtained from the simulation of In0.15Ga0.85As/Al 0.28Ga0.72As HEMTs. The negative differential output conductance (thermal droop) is observed in the electrothermal I ds-Vdscharacteristics of the simulated devices. Temperature profiles across the simulated region corresponding to different heat generation distributions are shown to be nonuniform with peak temperature and temperature range values dependent upon the device bias. The microscopic details of charge transport are studied, and the relationship between the thermal droop and the microscopic velocity properties is analyzed. The reduction in the length of the semiconductor die is shown to affect the peak temperature values without significantly altering the temperature range. The distribution of heat generation across the devices is simulated using a microscopic level count of phonon emission and absorption events and compared with that obtained using the current density-electric field (JmiddotE) dot product. The J middot E calculation was found to overestimate the local heat generation in the most electrically active regions of the device [J512]

"Monolithically Integrated Enhancement/Depletion-Mode AlGaN/GaN HEMT Inverters and Ring Oscillators Using Plasma Treatment"

Fabrication and characterization of AlGaN/GaN HEMT inverters and ring oscillators utilizing integrated enhancement/depletion-mode (E/D-mode) AlGaN/GaN HEMTs are presented. The core technique is a CF4plasma treatment that can effectively convert a D-mode AlGaN/GaN heterostructure to an E-mode heterostructure. A significant advantage of the plasma-treated E-mode HEMTs is that the gate current is reduced in both reverse- and forward-bias regions due to the effectively enhanced barrier height induced by the negatively charged fluorine ions in the AlGaN barrier. As a result, the input voltage swing is expanded by about 1 V for the E-mode HEMT, enabling convenient input/output logic level matching for multistage logic circuits such as ring oscillators. The fabricated 17-stage direct-coupled field-effect transistor logic ring oscillator using the 1-mum-gate technology can operate properly at a larger supply voltage of 3.5 V, and a minimum propagation delay of 130 ps/stage is achieved [J513]

"Enhancement-mode quaternary AlInGaN/GaN HEMT with non-recessed-gate on sapphire substrate"

A non-recessed-gate enhancement-mode HEMT was fabricated on an undoped quaternary AlInGaN/GaN heterostructure with a thin barrier AlInGaN layer. The maximum drain current of 252 mA/mm and peak transconductance of 175 mS/mm were obtained on a 2 μm-length-gate HEMT with a large threshold voltage of 0.57 V. The enhancement-mode operation was observed in a large source-drain voltage range up to 40 V. The results imply that AlInGaN is a promising candidate for high power and high frequency applications. [J514]

"3 S/mm extrinsic transconductance of InP-based high electron mobility transistor by vertical and lateral scale-down"

Record extrinsic transconductance (gmext) of 3 S/mm at room temperature for an InP-based high electron mobility transistor with an In0.53Ga0.47As/InAs composite channel is reported. Markedly enhanced gmextwas achieved by reducing a gate-to-channel distance for improving intrinsic transconductance and a gate-to-ohmic distance for minimising series source resistance. [J515]

"Comparison of the DC and Microwave Performance of AlGaN/GaN HEMTs Grown on SiC by MOCVD With Fe-Doped or Unintentionally Doped GaN Buffer Layers"

In this brief, the authors present a comparative and comprehensive investigation of the effect of the type of resistive GaN buffers on the dc, dynamic, microwave, and power performance of AlGaN/GaN high electron mobility transistors (HEMTs). Two types of buffer layers were investigated: 1) a nonintentionally doped resistive GaN buffer and 2) an Fe-compensated buffer. The Fe modulation-doped buffer is shown to be favorable for better dc isolation. The RF small-signal performance of the HEMTs does not exhibit any significant dependence on the type of resistive GaN buffer. However, the type of GaN buffer influences considerably the dynamic large-signal characteristics of the processed AlGaN/GaN HEMTs. The continuous-wave output power density of the AlGaN/GaN HEMTs at 3 GHz was increased from 3.4 to 9.7 W/mm by using a nonintentionally doped buffer instead of an Fe-doped one. Based on this observation combined with pulsed current-voltage measurements, we ascribe this difference to the deep trapping of electrons by defects in the GaN buffer introduced by the incorporation of Fe [J516]

"Robust detection of hydrogen using differential Al Ga N /Ga N high electron mobility transistor

sensing diodes"

The use of AlGaN/GaNhigh electron mobility transistor (HEMT) differential sensing diodes is shown to provide robust detection of 1% H2in air at 25°C. The active device in the differential pair is coated with 10nmof Pt to enhance catalytic dissociation of molecular hydrogen, while the reference diode is coated with Ti/Au. The active diode in the pair shows an increase in forward current of several milliamperes at a bias voltage of 2.5Vwhen exposed to 1% H2in air. The HEMT diodes show a response approximately twice that of GaN Schottky diodes, due to the presence of piezoelectric and spontaneous polarization in the heterostructure. The use of the differential pair removes false alarms due to ambient temperature variations. [J517]

"A thermal model for static current characteristics of Al Ga N /Ga N high electron mobility transistors including self-heating effect"

A thermal model of AlGaN/GaNhigh electron mobility transistors (HEMTs) has been developed based on a quasi-two-dimensional numerical solution of Schrodinger's equation coupled with Poisson's equation. The static current characteristics of HEMT devices have been obtained with the consideration of the self-heating effect on related parameters including polarization, electron mobility, saturation velocity, thermal conductivity, drain and source resistance, and conduction-band discontinuity at the interface between AlGaN and GaN. The simulation results agree well with our experimental data. It has also been demonstrated that the reduction of the saturation drain current at high power dissipation is primarily due to the decrease of electron mobility in the channel. The proposed model is valuable for predicting and evaluating the performance of different device structures and packages for various applications. [J518]

"Experimental evidence for dislocation-related gettering in metamorphic InP /InGaAs high electron mobility transistor (HEMT) structures on GaAs substrate"

The thermal stability of metamorphic InP/InGaAshigh electron mobility transistor (HEMT) structures on GaAssubstrate subjected to rapid thermal annealing (RTA) has been systematically investigated in the temperature range of 350-700°C. Based on the characterization of the electrical and optical properties, we observed that the metamorphic structures, in which the HEMT structures are grown on a metamorphic stain-relief buffer, exhibit better thermal stability when compared to a lattice-matched structure (control) at annealing temperatures higher than 550°C. An improved photoluminescence (PL) intensity in the temperature range of 550-650°Cfor metamorphic samples was observed. This behavior is absent in lattice-matched control structures. The better thermal stability and enhanced PL intensity at high RTA temperatures observed in metamorphic structures can be explained as a consequence of the possible dislocation-related gettering effect due to the presence of the dislocation network (gettering sink) located immediately beneath the device zone. Our experimental observation may partially ease the potential concerns about the thermal stability of metamorphic HEMTs. [J519]

"Correlation between optical and electrical properties in In 0.52 Al 0.48 As /In x Ga 1-x As metamorphic high-electron-mobility-transistor structures on GaAs substrates"

4.2Kphotoluminescence (PL) and 77Kstandard Hall-effect measurements were performed for In0.52Al0.48As/InxGa1-xAsmetamorphic high-electron-mobility-transistor (HEMT) structures grown on GaAs substrates with different indium contents in the InxGa1-xAswell or different Si delta-doping concentrations. It was found that electron concentrations increased with increasing PL intensity ratio of the "forbidden" transition (the second electron subband to the first heavy-hole subband) to the sum of the "allowed" transition (the first electron subband to the first heavy-hole subband) and the forbidden transition. And electron mobilities decreased with increasing product of the average full width at half maximum of allowed and forbidden transitions and the electron effective mass in the InxGa1-xAsquantum well. These results show that PL measurements are a good supplemental tool to Hall-effect measurements in optimization of the HEMT layer structure. [J520]

"Utilization of magnetoelectric potential in ballistic nanodevices"

We propose a ballistic, coherent transmission system that utilizes the magnetic and electric barriers as Boolean input variables to realize functions similar in principle to the conventional logic gates. For practical implementation of these functions, we propose to use a device construct based on the high-electron-mobility transistor (HEMT) with ferromagnetic (FM) and nonmagnetic (NM) metal gates deposited on top of the HEMT heterostructure. This device system can be manipulated to realize multiple logic functions such as OR, AND, and their inverse by applying different magnetic and electric field configurations on the FM and the NM gates. The charge transport simulation is based on the single particle effective mass Hamiltonian and ballistic charge transport. The calculation results demonstrate clear binary outputs corresponding to various logic functions, with "high" ("low") state having transmission probability of T 90%(T 10%). [J521]

"ZrO 2 gate dielectrics produced by ultraviolet ozone oxidation for GaN and AlGaN /GaN transistors"

We investigated the suitability of ZrO2as a high-kdielectric for GaNmaterial systems. Thin Zr films (4nm)were deposited by electron-beam evaporation at room temperature on n-type GaNand Al0.22Ga0.78N(29nm)/GaNhigh electron mobility transistor (HEMT) structures. The Zr-coated samples were subsequently oxidized at temperatures in the range of 200-400 °C in an ozone environment. Atomic force microscopy studies after oxidation show that the ZrO2forms a conformal layer on the underlying GaNtemplate. Cross-section transmission electron microscopy studies showed little intermixing of the ZrO2with the AlGaN/GaN. The relative dielectric constant of the ZrO2was determined to be 23. In comparison with HEMTs with bare gates (no dielectric between the gate metal and AlGaN), the HEMTs with ZrO2showed two to three order of magnitude reduction in gate leakage current. Optimization of the HEMT process on sapphire substrates with ZrO2under the gates yielded devices with powers of 3.8W/mmand 58% power-added efficiency at 4GHz. [J522]

"Effect of rapid thermal annealing on the optical and electrical properties of metamorphic high electron mobility transistor structures with composite In Ga As /In P channel"

The electrical and optical properties of metamorphic InGaAs/InPcomposite channel high electron mobility transistor (HEMT) structures subjected to rapid thermal annealing (RTA) are systematically investigated in the temperature range of 350-650°C. The metamorphic structures exhibit different degradation behaviors in different temperature ranges as compared to lattice-matched (control) structure. For the samples annealed at temperature lower than 550°C, increase in annealing temperature results in a larger degradation of sheet carrier density (ns)and photoluminescence (PL) intensity. However, no further reduction of nswas observed in the metamorphic samples after RTA at temperature higher than 550°C. An improvement of PL intensity in the temperature range of 550-650°Cfor metamorphic samples was even observed. This behavior is absent in the lattice-matched HEMT structures. Possible mechanisms governing the change of the electrical and optical properties in metamorphice HEMT structures are discussed. Our experimental results reveal that, compared to the lattice-matched structures, the InP HEMT structures grown on GaAs using metamorphic structure could present similar thermal stability up to 650°Ceven though a metamorphic strain-relief buffer is included. This may partially ease the concerns on the thermal stability of the metamorphic HEMT structures. [J523]

"Plasma oscillations in high-electron-mobility transistors with recessed gate"

We calculate the plasma oscillation spectrum in high-electron-mobility transistors (HEMTs) with recessed gate having the highly doped caps adjacent to the source and drain contacts and the windows between the caps and the gate. The resonant plasma frequencies are found as functions of the lengths of the gate, cap, and window regions, the electron concentration in the transistor channel, and the gate voltage. We demonstrate that the effect of cap region can result in a significant reduction of the resonant frequencies in comparison with those calculated for simplified HEMT model. This can provide a plausible explanation of the data obtained in recent experimental studies of the detection of terahertz radiation in and its emission from HEMTs. [J524]

"Growth of high crystalline quality semi-insulating GaN layers for high electron mobility transistor applications"

Semi-insulating character (sheet resistivity of 3.26Ч1011Omega /sq) of thick GaN layers was developed for AlGaN/GaNhigh electron mobility transistor (HEMT) applications on an AlN buffer layer. Electrical and structural properties were characterized by a dark current-voltage transmission line model, x-ray diffraction, and atomic force microscope measurements. The experimental results showed that compared to semi-insulating GaN grown on low temperature GaN nucleation, the crystal quality as well as surface morphology were remarkably improved. It was ascribed to the utilization of a high quality insulating AlN buffer layer and the GaN initial coalescence growth mode. Moreover, the significant increase of electron mobility in a HEMT structure suggests that this is a very promising method to obtain high performance AlGaN/GaNHEMT structures on sapphire substrates. [J525]

"Enhancement of drain current density by inserting 3 nm Al layer in the gate of Al Ga N /Ga N high-electron-mobility transistors on 4 in. silicon"

AlGaN/GaNhigh-electron-mobility transistors (HEMTs) on 4in.Si were fabricated by inserting 3nmof Al metal as a gate prior to the deposition of Pd/Ti/Au. The increase of drain current (IDSmax)density and decrease of extrinsic transconductance (gmmax)have been observed in the Al-gated AlGaN/GaNHEMTs. The increase of IDmaxis due to the increase of two-dimensional electron gas sheet carrier density, which was confirmed by capacitance-

voltage (C-V)measurements. Moreover, the Al layer inserted-gate HEMT exhibited negative threshold voltage (Vth)shift. The Al and AlGaN interface shows Al-based oxide layer which was confirmed by Auger electron spectrum and x-ray photoelectron spectrum. [J526]

"Correlating the Schottky barrier height with the interfacial reactions of Ir gates for In Al As /In Ga As high electron mobility transistors"

The characteristics of Ir on InAlAs and on InAlAs/InGaAs/InPhigh electron mobility transistor (HEMT) heterostructures were characterized. A maximum Schottky barrier height (phi B)of 825meVwas achieved for Ir/InAlAsafter annealing at 400°C. Transmission electron microscopy investigations confirmed that an amorphous layer (alayer) exists at the Ir/InAlAsinterface at that temperature. Results indicate that enhancement of phi Bis associated with the alayer, while beyond 400°C, the decrease of phi Bis due to the crystallization of the alayer and the formation of IrAs2. The enhancement of phi Bfor Ir/InAlAsand the slow diffusion of Ir in IrAlAs make it a superior thermally stable gate metal for InAlAs/InGaAsHEMTs. [J527]

"S F 6 /O 2 plasma effects on silicon nitride passivation of Al Ga N /Ga N high electron mobility transistors"

The effects of various plasma and wet chemical surface pretreatments on the electrical characteristics of AlGaN/GaNhigh electron mobility transistors (HEMTs) passivated with plasma-deposited silicon nitride were investigated. The results of pulsed IVmeasurements show that samples exposed to various SF6/O2plasma treatments have markedly better rf dispersion characteristics compared to samples that were either untreated or treated in wet buffered oxide etch prior to encapsulation. The improvement in these characteristics correlates with the reduction of carbon on the semiconductor surface as measured with x-ray photoelectron spectroscopy. HEMT channel sheet resistance was also affected by varying silicon nitride deposition parameters. [J528]

"Al 0.15 Ga 0.85 N /Ga N high electron mobility transistor structures grown on p -type Si substrates"

We report on experimental studies of Al0.15Ga0.85N/GaNhigh electron mobility transistor (HEMT) structures grown on p-type Si (111) substrates. By introducing an ultrathin SiN layer during the crystal growth, the Hall mobility of the HEMT structure can be greatly enhanced (greater than three times). This SiN treatment technique also allows the observation of Shubnikov-de Haas oscillations which is not possible in the untreated HEMT structure. Our experimental results pave the way for the integration of AlxGa1-xN/GaNHEMT structures with the mature Si technology in industry. [J529]

"Bendable GaN high electron mobility transistors on plastic substrates"

A procedure for fabricating flexible forms of high electron mobility transistors (HEMTs) supported on plastic substrates is described. The process uses a combination of conventional top-down, wafer scale fabrication protocols to define a printable form of ultrathin, device quality multilayer AlGaN/GaNsingle crystalline microstructures-a so-called microstructured semiconductor ink-and soft-lithographic printing methods to effect their registered transfer to a plastic substrate. These procedures yield high performance, bendable HEMT arrays that are mechanically durable-ones with effective transconductances exceeding nearly all reported forms of printed thin-film transistors. [J530]

"Self-heating and the temperature dependence of the dc characteristics of GaN heterostructure field effect transistors"

Self-heating is an important issue for GaN heterostructure field effect transistors (HFETs), especially in high power applications. Here we report the temperature dependence of the dc characteristics of some GaN HFETs including the variation of the transconductance. We present the characteristics as a function of added power, instead of voltage bias, and use the temperature data to transform the power dependence into a dependence on the average device temperature. For similar devices on sapphire and SiC, at 20 V VDSand 0 V VG, the temperature increase for the same added power is 2.7times greater in the sapphire-based device. [J531]

"Electrical detection of deoxyribonucleic acid hybridization with Al Ga N /Ga N high electron mobility transistors"

Au-gated AlGaN/GaNhigh electron mobility transistor (HEMT) structures were functionalized in the gate region with label-free 3'-thiol-modified oligonucleotides. This serves as a binding layer to the AlGaN surface for hybridization of matched target deoxyribonucleic acid (DNA). X-ray photoelectron spectroscopy shows the

immobilization of thiol-modified DNA covalently bonded with gold on the gated region. Hybridization between probe DNA and matched or mismatched target DNA on the Au-gated HEMT was detected by electrical measurements. The HEMT drain-source current showed a clear decrease of 115mu Aas this matched target DNA was introduced to the probe DNA on the surface, showing the promise of the DNA sequence detection approach for biological sensing. [J532]

"A low power and low noise p-HEMT ku band VCO"

In this letter, we report a differential 12-GHz voltage-controlled oscillator (VCO) implemented using a commercial GaAs pseudomorphic high electron mobility transistor (p-HEMT) process. The VCO can operate with 3mW of dc power. The single-side-band phase noise at 1-MHz offset from the carrier is -116dBc and is achieved with 15mW of dc power consumption. This VCO has a figure of merit of -190.5dBc which is the best that has been reported for a p-HEMT VCO in the authors' knowledge [J533]

"A Q-band low phase noise monolithic AlGaN/GaN HEMT VCO"

A Q-band 40-GHz GaN monolithic microwave integrated circuit voltage controlled oscillator (VCO) based on AlGaN/GaN high electron mobility transistor technology has been demonstrated. The GaN VCO delivered an output power of +25dBm with phase noise of -92dBc/Hz at 100-KHz offset, and -120dBc/Hz at 1-MHz offset. To the best of our knowledge, this represents the state-of-the-art for GaN VCOs in terms of frequency, output power, and phase noise performance. This work demonstrates the potential for the use of GaN technology for high frequency, high power, and low phase noise frequency sources for military and commercial applications [J534]

"Effect of ohmic contacts on buffer leakage of GaN transistors"

The effect of ohmic contacts on the buffer leakage of GaN transistors is presented. The buffer leakage for AlGaN/GaN high-electron mobility transistors and GaN MESFETs grown on the same underlying buffer was observed to be different. Controlled experiments show that the increased buffer leakage is due to the nature of the alloyed ohmic contacts and can be minimized if they are screened by the Si doping or by the two-dimensional electron gas. [J535]

"A 45-dB variable-gain low-noise MMIC amplifier"

A variable-gain amplifier (VGA) operating at 2.5 GHz based on single-ended topology has been designed and characterized. Three such stages were cascaded and preceded by a single-stage low-noise amplifier. A source follower was used at the output in order to achieve excellent output match. The variation gain is 45 dB with a maximum gain of 47 dB. The -3-dB bandwidth is 0.8 GHz. Minimum noise figure of 0.81 dB is obtained in the highest gain mode. The highest output power, corresponding to 1-dB compression point is -7.2 dBm and the corresponding output third-order intercept point is +2 dBm. The circuit is implemented in a GaAs 0.15-mum pseudomorphic high electron-mobility transistor technology. The combined area occupied by the multistage low-noise VGA and the single-ended VGA is 3.5 mm times 3 mm [J536]

"High-purity 60-GHz-band single-chip /spl times/8 multipliers in pHEMT and mHEMT technology"

Two single-chip multiplier by eight (times8) monolithic microwave integrated circuits (MMICs) for 52-62-GHz output frequency are presented. The MMICs are designed and manufactured in commercial 0.15-mum pseudomorphic high-electron mobility transistor (pHEMT) and metamorphic HEMT (mHEMT) processes for the comparison of functionality and performance. The multipliers consist of a quadrupler stage followed by a high-pass filter, an interstage amplifier, and a doubler stage. The required output power is achieved by a buffer amplifier on the output. An output power of 8 dBm is achieved in both designs at 7.35-GHz input frequency with 0-dBm input power. The detected degradation of phase noise due to the circuit is less than 1 dB at 100-kHz offset from the carrier compared to the theoretical value for a multiplier by eight. The total power dissipation of the pHEMT design is 450 mW. The mHEMT-based multiplier has significantly lower power dissipation of only 210 mW. To the best of our knowledge, these are the first reported multiplier-by-eight MMICs based on pHEMT and mHEMT technology [J537]

"Small-signal characteristics of AlInN/GaN HEMTs"

DC and RF measurements of an emerging AlInN/GaN high electron mobility transistor (HEMT) technology for power performances are reported. High electron transport properties in this structure attributed to the material quality are demonstrated. Indeed, in spite of a basic technology which provides high access resistances, high frequency performances with a cutoff and maximum oscillation frequencies about 26 and 40 GHz, respectively,

at VDS=10 V were achieved. A maximum drain current density more than 1.3 A/mm with a pinch-off breakdown voltage about 40 V without any passivation was obtained. These results show that this device is very promising for high power performances at high frequency. [J538]

"G-band metamorphic HEMT-based frequency multipliers"

Two monolithic G-band active frequency multipliers have been designed and fabricated using coplanar-waveguide technology. The monolithic microwave integrated circuits are a frequency tripler for an output frequency of 140 GHz and a 110-220-GHz frequency doubler. The tripler demonstrates a maximum conversion gain of -11 dB for an input power of 9 dBm, whereas the doubler achieves a conversion gain of -7 dB for a 2.5-dBm input signal. The circuits have been realized using two InAlAs/InGaAs-based metamorphic high electron-mobility transistor processes with different gate lengths of 100 and 50 nm, respectively. [J539]

"Analysis and synthesis of pHEMT class-E amplifiers with shunt inductor including ON-state active-device resistance effects"

In this theoretical paper, the analysis of the effect that ON-state active-device resistance has on the performance of a Class-E tuned power amplifier using a shunt inductor topology is presented. The work is focused on the relatively unexplored area of design facilitation of Class-E tuned amplifiers where intrinsically low-output-capacitance monolithic microwave integrated circuit switching devices such as pseudomorphic high electron mobility transistors are used. In the paper, the switching voltage and current waveforms in the presence of ON-resistance are analyzed in order to provide insight into circuit properties such as RF output power, drain efficiency, and power-output capability. For a given amplifier specification, a design procedure is illustrated whereby it is possible to compute optimal circuit component values which account for prescribed switch resistance loss. Furthermore, insight into how ON-resistance affects transistor selection in terms of peak switch voltage and current requirements is described. Finally, a design example is given in order to validate the theoretical analysis against numerical simulation. [J540]

"Microwave power performance of MBE-grown AlGaN/GaN HEMTs on HVPE GaN substrates"

AlGaN/GaN high electron mobility transistors (HEMTs) by plasma-assisted molecular beam epitaxy on free-standing GaN substrates grown by hydride vapour phase epitaxy (HVPE) have been fabricated. Hall measurements yielded typical electron mobilities of 1750 cm2/Vs with sheet densities of 1.1Ч1013cm-2. Off-state breakdown voltages as high as 200 V were measured on unpassivated devices. Output power density at 4 GHz was measured to be 5.1 W/mm at a power-added efficiency of 46% and an associated gain of 13.4 dB. This constitutes significant improvement of RF performance by MBE-grown AlGaN/GaN HEMTs on free-standing HVPE GaN. [J541]

"A low gate bias model extraction technique for AlGaN/GaN HEMTs"

The small-signal equivalent circuit of AlGaN/GaN high electron-mobility transistors is discussed. A new modeling procedure is introduced in this paper that does not bias the device at a untenable high gate voltage in order to extract the parasitic inductance and resistance. Simulated results show good agreement with measurements up to 40 GHz. [J542]

"Field-plated 0.25-μm gate-length AlGaN/GaN HEMTs with varying field-plate length"

Metal-organic chemical vapor deposition-grown field-plated 0.25-μm gate-length AlGaN/GaN high-electron mobility transistors (HEMTs) with field-plate lengths of 0.5, 0.8, and 1.1 μm have been fabricated on 6H-SiC substrates. These 0.25-μm gate-length devices exhibited maximum drain current density of more than 1.4 A/mm and peak extrinsic transconductance of 437 mS/mm. No dependence of dc I-V as well as transfer characteristics on field-plate length was observed. With increase of field-plate length, degradation in the value of unity current gain frequency fTand maximum frequency of oscillation fmaxwas observed, but there is significant improvement in breakdown voltage and power densities. Also, at 18 GHz, a continuous-wave output power density of 9.1 W/mm with power added efficiency of 23.7% was obtained for device with field-plate length of 1.1 μm, yielding the highest reported power performance of AlGaN/GaN HEMTs at 18 GHz. [J543]

"InAs HEMT narrowband amplifier with ultra-low power dissipation"

The design, fabrication and performance of a prototype narrowband amplifier using InAs-channel HEMTs are reported. The amplifier, which is realised on an RT/Duroid circuit board with a combination of transmission lines and lumped components, is intended for a long-life battery-powered application. The two-stage amplifier has 20 dB of gain with a bandwidth of 4% in S-band and dissipates a total power of only 365 μW. [J544]

"Stress-related hydrogen degradation of 0.1-μm InP HEMTs and GaAs PHEMTs"

Hydrogen degradation of III-V field-effect transistors (FETs) is a serious reliability concern. Previous work has shown that threshold-voltage shifts induced by H2exposure in 1-μm-channel InP high-electron mobility transitors (HEMTs) can be attributed to compressive stress in the gate due to the formation of TiHxin Ti/Pt/Au gates. The compressive stress affects the device characteristics through the piezoelectric effect. This paper examined the H2sensitivity of 0.1-μm strained-channel InP HEMTs and GaAs pseudomorphic HEMTs. After exposure to H2, the threshold voltage VTof both types of devices shifted positive. This positive shift in VTis predicted by a model for hydrogen-induced piezoelectric effect. In situ VTmeasurements reveal distinct time dependences of the VTshifts, which are also consistent with stress-related phenomena. [J545]

"Enhancement-mode AlGaN/GaN HEMTs on silicon substrate"

High-performance enhancement-mode AlGaN/GaN HEMTs (E-HEMTs) were demonstrated with samples grown on a low-cost silicon substrate for the first time. The fabrication process is based on a fluoride-based plasma treatment of the gate region and postgate annealing at 450 °C. The fabricated E-HEMTs have nearly the same peak transconductance (Gm) and cutoff frequencies as the conventional depletion-mode HEMTs fabricated on the same wafer, suggesting little mobility degradation caused by the plasma treatment. [J546]

"Gallium-nitride microwave Doherty power amplifier with 40 W PEP and 68% PAE"

A 40 W gallium-nitride microwave Doherty power amplifier for WCDMA repeater applications is presented. The main amplifier and peaking amplifier are implemented using two 20 W PEP GaN HEMTs. Performance is evaluated for broadband gain, power efficiency and adjacent-channel-power-ratio (ACPR). Experimental results of the GaN Doherty amplifier yielded a power gain of over 11 dB from 1.8 to 2.5 GHz, 68% power added efficiency at 40 W peak power. Good linearity performance of -48 dBc ACPR is obtained at a peak-to-average ratio of 9.8 dB. [J547]

"Velocity Enhancement in Cryogenically Cooled InP-Based HEMTs on (411)A-Oriented Substrates"

An extremely high maximum transconductance gmmaxof 2.25 S/mm and a cutoff frequency fTof 310 GHz was achieved at a cryogenic temperature (16 K) in a 195-nm-gate In0.75Ga 0.25As/In0.52Al0.48As high electron mobility transistor (HEMT) fabricated on a (411)A-oriented InP substrate by molecular beam epitaxy, compared with room temperature values (gmmax=1.78 S/mm and fT=245 GHz). These significantly enhanced gmmaxand fTvalues are attributed to a high electron velocity of up to 4.9times107cm/s due to suppressing phonon scattering in the In0.75Ga0.25As/In0.52Al0.48 As HEMT with (411) A super-flat InGaAs/InAlAs interfaces (effectively atomically flat heterointerfaces over a wafer-size area) [J548]

"A novel wideband MMIC voltage controlled attenuator with a bandpass filter topology"

The theory, analysis, and systematic design guidelines for a novel wideband monolithic bandpass pi-network voltage controlled attenuator (VCA) are presented. A 24-32-GHz VCA was designed and manufactured using 0.15-mum GaAs pseudomorphic high electron-mobility transistor (pHEMT) technology. This is the first reported VCA to use a bandpass filter topology to achieve the required operating frequency band and eliminate the effects of parasitic capacitances of the pHEMTs. The bandpass filter absorbs the parasitic capacitances and thereby eliminates their detrimental effects. The measured attenuation dynamic range is 12 dB plusmn 0.5 dB with minimum insertion loss of 2-3 dB. The input power handling capability is up to 0 dBm. The VCA is well matched and may be placed in a 50-Omega system [J549]

"Coupled electrothermal, electromagnetic, and physical modeling of microwave power FETs"

This paper presents a coupled electrothermal, electromagnetic, and physical model for microwave power field-effect transistors (FETs). The resulting model is used to investigate large gate periphery pseudomorphic high electron-mobility transistor devices. The contribution to the output power of each cell of the transistor is simulated, as well as their contribution to the heating of the device. This approach allows the investigation of the interaction between the thermal behavior, the dc bias, and the microwave circuit operating conditions. This paper reveals for the first time a more complex interaction between the thermal and microwave behavior of large-power FETs [J550]

"Design and analysis of a 44-GHz MMIC low-loss built-in linearizer for high-linearity medium power amplifiers"

A 44-GHz monolithic microwave integrated circuit (MMIC) low-loss built-in linearizer using a shunt cold-mode high-electron mobility transistor (HEMT), based on the predistortion techniques, is presented in this paper. The proposed cold-mode HEMT linearizer can enhance the linearity of the power amplifier (PA) with a low insertion loss (IL<2 dB), a compact die-size, and no additional dc power consumption. These advantages make the linearizer more suitable for millimeter-wave (MMW) applications. The physical mechanism of the gain expansion characteristics of the proposed linearizer is analyzed. A systematic design procedure for a low-loss linearizer is developed, which includes: 1) insertion loss minimization through a device-size selection and 2) linearity optimization through a two-tone test. To demonstrate the general usefulness of the proposed linearizer, the linearizer was applied to a two-stage 44-GHz MMIC medium PA and a commercial MMW PA module. After linearization, the output spectrum regrowth is suppressed by 7-9 dB. To keep the adjacent channel power ratio below -40 dBc, the output power has been doubled from 15 to 18 dBm at 44 GHz. The error vector magnitude of the 16-quadrature amplitude modulation signal can be reduced from 6.11% to 3.87% after linearization. To the best of our knowledge, this is the first multistage MMW PA with a low-loss built-in linearizer [J551]

"A Unified Approach to Charge-Conservative Capacitance Modelling in HEMTs"

The voltage dependence of high electron mobility transistor (HEMT) gate-source- and gate-drain capacitance is described by a set of equations based on a unified charge-conservative model approach. The model is applied to a low-noise GaAs pseudomorphic-HEMT (pHEMT) technology as well as its power variant. In terms of topology and parameters, the new expressions resemble the Curtice drain current model. They provide a globally accurate description of nonlinearities in HEMT capacitance [J552]

"AlGaN/GaN -Band 5-W MMIC Amplifier"

A broadband Ka-band AlGaN/GaN on SiC high electron-mobility transistor monolithic-microwave integrated-circuit (MMIC) power amplifier was developed for millimeter-wave antenna applications. The 0.18-mum gate two-stage 50-Omega matched MMIC produces 13plusmn1 dB of gain from 26 to 36 GHz. At 35 GHz, the measured continuous wave (CW) saturated output power (Pout) was 4 W (5 W pulsed), indicating a CW power density of 3.3 W/mm (4.2 W/mm pulsed). The CW power-added efficiency was 23%. Across the band, the measured CW Poutwas >2 W (2.5 W pulsed). While individual (or partially matched single stage) devices have been demonstrated with good output power, to the best of our knowledge, this is the first report of a 10-GHz-bandwidth Ka-band GaN MMIC with high output power and gain. A unique aspect of the design, contributing to the wide bandwidth, is the use of positive feedback in the first stage to increase the gain. RF power stress test and detailed investigation of the channel temperature effect are presented. A preliminary RF power stress test indicates a lifetime of 1000 h at 191 degC channel temperature, and elevated temperature operation indicates that Poutdecreases by 0.013 dB/degC [J553]

"Investigation of Self-Heating Effects in Submicrometer GaN/AlGaN HEMTs Using an Electrothermal Monte Carlo Method"

An electrothermal Monte Carlo (MC) method is applied in this paper to investigate electron transport in submicrometer wurtzite GaN/AlGaN high-electron mobility transistors (HEMTs) grown on various substrate materials including SiC, Si, GaN, and sapphire. The simulation method is an iterative technique that alternately runs an MC electronic simulation and solves the heat diffusion equation using an analytical thermal resistance matrix method. Results demonstrate how the extent of the thermal droop in the Id-Vdscharacteristics and the device peak temperature depend upon both the biasing conditions and the substrate material type. Polarization effects are considered in the simulations, as they greatly influence electron transport in GaN/AlGaN HEMTs by creating a highly concentrated two-dimensional electron gas (2DEG) at the GaN/AlGaN interface. It is shown that a higher 2DEG density provides the devices with a better current handling capability but also increases the importance of the thermal effects [J554]

"Effective Suppression of IV Knee Walk-Out in AlGaN/GaN HEMTs for Pulsed-IV Pulsed-RF With a Large Signal Network Analyzer"

IV knee walk-out in AlGaN/GaN high electron mobility transistors (HEMTs) on a Sapphire substrate is analyzed using dynamic radio frequency (RF) load-lines acquired with a large signal network analyzer (LSNA) for both continuous-wave (CW) and pulsed-IV/RF excitations. When thermal effects and traps are bypassed using pulsed-IV biasing and pulsed-RF excitations, the IV knee walk-out observed in CW load-lines is found to be effectively suppressed and the device delivers the maximum output power expected for class A operation. It is also demonstrated using pulsed-IV/RF measurements at various substrate temperatures that the IV knee walk-out primarily arises from thermal effects at high bias rather than trapping in the on-wafer devices characterized [J555]

"RF Chipset for Impulse UWB Radar Using 0.13- InP-HEMT Technology"

A novel ultra-wideband impulse radar architecture for 24-GHz-band short-range radar was developed using 0.13-mum InP high electron-mobility technology. The transmitter part generates an extremely wideband impulse from a pulse generator and then filters it through a bandpass filter. The obtained impulse had a full width at half maximum of 9 ps. Its frequency spectrum spread from dc to over 40 GHz and achieved sufficient flatness in the target band. The power amplifier (PA) for the transmitter had a gain of 15 plusmn0.1 dB, and the low-noise amplifier (LNA) for the receiver had a gain of 40 plusmn1 dB and a minimum noise figure of 1.9 dB. The achieved flatness of integration gain including the PA, LNA, and RF switch was less than plusmn1.2 dB. These RF circuits with gain flatness make a simple matched filter configuration possible without the use of a conventional correlator composed of a local oscillator. An ultra high-speed sample and hold circuit having an ultra-long hold time of more than 3 ns was also developed to detect the output pulses from the matched filter [J556]

"60 GHz MMIC double balanced Gilbert mixer in mHEMT technology with integrated RF, LO and IF baluns"

A 60 GHz MMIC double balanced Gilbert mixer (DBGM) with integrated RF, LO and IF baluns has been designed, fabricated in an mHEMT MMIC technology and characterised with probed measurements. Although a standard mixer topology for integrated circuits in the low gigahertz region, the DBGM has had very little impact in the millimetre-wave range. To the authors' knowledge, the presented DBGM operates at the highest RF frequency ever published for any FET-based Gilbert type mixer, double or single balanced. A measured down conversion gain of 1.5 dB at 60 GHz is obtained with a DC power consumption of 300 mW. Further, IF bandwidth, isolation between the LO, RF and IF ports, 1 dB compression point for the RF input, and LO input power is presented [J557]

"Active Broad X-Band Circular Patch Antenna"

This letter presents the results of experimental study of omnidirectional circular patch antenna operating in the TM010mode. Antenna geometrical parameters have been selected on the basis of theoretical calculations. It has been shown that the antenna of this kind with VSWR les 2 and bandwidth of 18% has a conical radiation pattern with maximum oriented 36deg to the zenith. The antenna has a side radiation level of -15 dB and a cross-component level of less than -25 dB. The experimental results are in good agreement with the theoretical calculations. Employment of the one-stage HEMT amplifier makes it possible to obtain the total gain of an active antenna of no less than 10 dB. This antenna can be successfully used for mobile systems, wireless indoor communications, as well as for array applications [J558]

"InAs/AlSb HEMT and Its Application to Ultra-Low-Power Wideband High-Gain Low-Noise Amplifiers"

Two antimonide-based compound semiconductor (ABCS) microstrip monolithic microwave integrated circuits (MMICs), i.e., single- and three-stage ultra-low-power wideband 0.3-11-GHz low-noise amplifiers (LNAs) using 0.1-mum gate-length InAs/AlSb metamorphic high electron-mobility transistors (HEMTs), have been fabricated and characterized on a GaAs substrate. The single-stage wideband LNA demonstrated a typical associated gain of 16 dB (0.3-11 GHz) with less than a 1.7-dB noise figure (2-11 GHz) at 5-mW dc power dissipation, and the three-stage wideband LNA demonstrated a typical associated gain of 30 dB (0.3-11 GHz) with less than a 2.6-dB noise figure (2-11 GHz) at 7.5-mW dc power dissipation. We believe these wideband LNA MMICs demonstrate the lowest dc power consumption with the highest gain-bandwidth product of any MMIC to date. These results demonstrate the outstanding potential of ABCS HEMT technology for ultra-low-power wideband applications [J559]

"Very Compact High-Gain Broadband Low-Noise Amplifier in InP HEMT Technology"

This paper presents the practical design methodology of an InP high electron-mobility transistor broadband low-noise amplifier (LNA) using multilayer transmission lines. The LNA consists of high-pass reactive matching circuits and resistive-feedback circuits in order to achieve both low-noise and broadband characteristics. The fabricated five-stage LNA successfully delivered a 43-dB gain with a noise figure of 1.9 dB at 23 GHz, and a gain of more than 40 dB from 18 to 43 GHz. The maximum gain was 49.5 dB at 32 GHz and the chip size was only 1.8 times 0.9 mm2, resulting in a gain density of 30.5 dB/mm 2. To the best of our knowledge, this gain density is the highest performance in any Ka-band LNA reported to date. In addition, a more compact LNA using spiral inductors was also demonstrated [J560]

"Planar integration of E/D-mode AlGaN/GaN HEMTs using fluoride-based plasma treatment"

A planar-fabrication technology for integrating enhancement/depletion (E/D)-mode AlGaN/GaN high-electron mobility transistors (HEMTs) has been developed. The technology relies heavily on CF4plasma treatment, which is used in two separate steps to achieve two objectives: 1) active device isolation and 2) threshold-voltage control for the enhancement-mode HEMT formation. Using the planar process, depletion- and enhancement-mode AlGaN/GaN HEMTs are integrated on the same chip, and a direct-coupled FET logic inverter is demonstrated. Compared with the devices fabricated by a standard mesa-etching technique, the HEMTs by a planar process have comparable dc and RF characteristics with no obvious difference in the device isolation. The device isolation by a plasma treatment remains the same after 400 degC annealing, indicating a good thermal stability. At a supply voltage (VDD) of 3.3 V, the E/D-mode inverters show an output swing of 2.85 V, with the logic-low and logic-high noise margins at 0.34 and 1.47 V, respectively [J561]

"Copper-Airbridged Low-Noise GaAs PHEMT With Diffusion Barrier for High-Frequency Applications"

A GaAs pseudomorphic HEMT (PHEMT) with Cu-metallized interconnects was successfully developed. Sputtered WNxwas used as the diffusion barrier and Ti was used as the adhesion layer to improve the adhesion between WNx/Cu interface in the thin-metal structure. After copper metallization, the PHEMTs were passivated with silicon nitride to avoid copper oxidation. The Cu-airbridged PHEMT showed the saturation IDSwas 250 mA/mm and the gmwas 456 mS/mm. The Ti adhesion layer plays a significant role on the g mand Vpuniformity of the Cu-metallized PHEMTs. The GaAs PHEMTs with Ti/WNx/Ti/Cu multilayer have better noise figure and associated gain than those of the devices without the Ti adhesion layer. The fabricated Cu-metallized GaAs PHEMT with Ti/WN x/Ti/Cu multilayer has a noise figure of 0.76 dB and an associated gain of 8.8 dB at 16 GHz. The cutoff frequency (fT) is 70 GHz when biased at VDS=1.5V. These results show that the Ti/WNx/Ti multilayer can serve as a good diffusion barrier for Cu metallization process of airbridge interconnects on GaAs lownoise PHEMTs [J562]

"A Novel 94-GHz MHEMT Resistive Mixer Using a Micromachined Ring Coupler"

In this letter, we present a high performance 94-GHz millimeter-wave monolithic integrated circuit resistive mixer using a 70-nm metamorphic high electron mobility transistor (MHEMT) and micromachined ring coupler. A novel three-dimensional structure of a resistive mixer was proposed in this work, and the ring coupler with the surface micromachined dielectric-supported air-gap microstrip line structure was used for high local oscillator/radio frequency (LO-RF) isolation. Also, the LO-RF isolation was optimized through the simulation. The fabricated mixer has excellent LO-RF isolation, greater than 29 dB, in 2-GHz bandwidth of 93-95GHz. The good conversion loss of 8.9dB was measured at 94GHz. To our knowledge, compared to previously reported W-band mixers, the proposed MHEMT-based resistive mixer using a micromachined ring coupler has shown superior LO-RF isolation and conversion loss [J563]

"V-Band GaAs pHEMT Cross-Coupled Sub-Harmonic Oscillator"

A V-band cross-coupled sub-harmonic injection-locked oscillator has been designed and fabricated using 0.15-mum GaAs pHMET technology. Based on the known harmonic injecting circuit topology, this oscillator was designed by a differential output approach, a low-Q microstrip-line resonator, and a current mirror, which has a free-running oscillation frequency around 60GHz with a tuning range of 2.5GHz (from 57.8GHz to 60.3GHz). The maximum single-end output power is 3.8dBm with a dc dissipation of 225mW under a -3V supply voltage. Within the input matching network for second (30GHz) and fourth (15GHz) sub-harmonic signals injection, it demonstrates the maximum locking ranges close to 120MHz and 30MHz, respectively [J564]

"A Single Supply, High Linearity 2-W PA MMIC for WLAN Applications Using Quasi-Enhancement Mode PHEMTs"

A fully matched, 2-W high linearity amplifier monolithic microwave integrated circuit, by using quasi-enhancement mode technology of AlGaAs/InGaAs/ GaAs pseudomorphic high electron mobility transistors, is demonstrated for wireless local area network applications. At Vgs= 0 V, Vds= 5 V, this power amplifier has achieved 14-dB small-signal gain, 33-dBm output power at 1-dB gain compression point, and 34.5-dBm saturated output power with 35% power added efficiency at 5.8 GHz. Moreover, high-linearity with 45.2-dBm third-order intercept point is also achieved [J565]

"Current Collapse and High-Electric-Field Reliability of Unpassivated GaN/AlGaN/GaN HEMTs"

Long-term ON-state and OFF-state high-electric-field stress results are presented for unpassivated GaN/AlGaN/GaN high-electron-mobility transistors on SiC substrates. Because of the thin GaN cap layer, devices show minimal current-collapse effects prior to high-electric-field stress, despite the fact that they are not passivated. This comes at the price of a relatively high gate-leakage current. Under the assumption that donor-like electron traps are present within the GaN cap, two-dimensional numerical device simulations provide an explanation for the influence of the GaN cap layer on current collapse and for the correlation between the latter and the gate-leakage current. Both ON-state and OFF-state stresses produce simultaneous current-collapse increase and gate-leakage-current decrease, which can be interpreted to be the result of gate-drain surface degradation and reduced gate electron injection. This study shows that although the thin GaN cap layer is effective in suppressing surface-related dispersion effects in virgin devices, it does not, per se, protect the device from high-electric-field degradation, and it should, to this aim, be adopted in conjunction with other technological solutions like surface passivation, prepassivation surface treatments, and/or field-plate gate [J566]

"50-nm Self-Aligned and “Standard” T-gate InP pHEMT Comparison: The Influence of Parasitics on Performance at the 50-nm Node"

Continued research into the development of III-V high-electron mobility transistors (HEMTs), specifically the minimization of the device gate length, has yielded the fastest performance reported for any three terminal devices to date. In addition, more recent research has begun to focus on reducing the parasitic device elements such as access resistance and gate fringing capacitance, which become crucial for short gate length device performance maximization. Adopting a self-aligned T-gate architecture is one method used to reduce parasitic device access resistance, but at the cost of increasing parasitic gate fringing capacitances. As the device gate length is then reduced, the benefits of the self-aligned gate process come into question, as at these ultrashort-gate dimensions, the magnitude of the static fringing capacitances will have a greater impact on performance. To better understand the influence of these issues on the dc and RF performance of short gate length InP pHEMTs, the authors present a comparison between In0.7Ga0.3As channel 50-nm self-aligned and "standard" T-gate devices. Figures of merit for these devices include transconductance greater than 1.9 S/mm, drive current in the range 1.4 A/mm, and fT up to 490 GHz. Simulation of the parasitic capacitances associated with the self-aligned gate structure then leads a discussion concerning the realistic benefits of incorporating the self-aligned gate process into a sub-50-nm HEMT system [J567]

"The Effect of an Fe-doped GaN Buffer on off -State Breakdown Characteristics in AlGaN/GaN HEMTs on Si Substrate"

An Fe-doped GaN buffer layer was employed in the growth of AlGaN/GaN high-electron mobility transistors (HEMTs) on Si substrates. In order to investigate the effects of an Fe-doped GaN buffer on OFF-state breakdown characteristics, HEMT devices with an Fe-doped GaN buffer on Si substrates were fabricated along with conventional devices utilizing an unintentionally doped GaN buffer on Si substrates. The device characteristics were compared. While HEMT devices with the conventional structure showed an extremely unstable OFF-state breakdown behavior due to punchthrough to the Si substrate, it was demonstrated that an Fe-doped GaN buffer layer on a Si substrate successfully suppressed the premature failure caused by Si-induced breakdown. As a result, the AlGaN/GaN HEMTs with an Fe-doped GaN buffer on Si substrates exhibited much more consistent and enhanced breakdown voltages, when compared with the conventional devices. Consequently, it is highly desirable that AlGaN/GaN HEMTs on Si substrates have an Fe-doped GaN buffer layer in order to achieve stable and robust OFF-state breakdown characteristics [J568]

"At-Bias Extraction of Access Parasitic Resistances in AlGaN/GaN HEMTs: Impact on Device Linearity and Channel Electron Velocity"

AlGaN/GaN high-electron mobility transistor "hot" parasitic source and drain resistances RS,Dare determined under operating biases through wideband S-parameter measurements, without the use of "ColdFET" biasing conditions. Both RSand RDare found to increase dramatically over ColdFET values, both for biases approaching threshold and for open-channel conditions. Parasitic resistance values have a significant effect on the extracted small-signal equivalent circuit model elements, as well as on the apparent device linearity. The bias dependence of access resistances modifies the understanding of the transistor physical operation: A revised delay time analysis accounting for the bias dependence of parasitic resistances shows that the effective average electron velocity in the AlGaN/GaN two-dimensional electron-gas channel is approximately equal to 1.9 times 107cm/s. This new value of channel velocity is also consistent with the CGS/gMOratio obtained when the bias dependence of RSand RDis accounted for during the extraction of the transistor small-signal equivalent circuit model [J569]

"High-performance E-mode AlGaN/GaN HEMTs"

Enhancement-mode AlGaN/GaN high electron-mobility transistors have been fabricated with a gate length of 160 nm. The use of gate recess combined with a fluorine-based surface treatment under the gate produced devices with a threshold voltage of +0.1 V. The combination of very high transconductance (>400 mS/mm) and low gate leakage allows unprecedented output current levels in excess of 1.2 A/mm. The small signal performance of these enhancement-mode devices shows a record current cutoff frequency (fT) of 85 GHz and a power gain cutoff frequency (fmax) of 150 GHz. [J570]

"A fully integrated V-band PLL MMIC using 0.15-μm GaAs pHEMT technology"

A fully integrated V-band phase-locked loop (PLL) MMIC with good phase noise and low-power consumption is developed using 0.15-μm GaAs pHEMTs. For V-band frequency division,a wideband divide-by-3 frequency divider is proposed using cascode FET-based harmonic injection locking. The fourth subharmonic mixer using anti-parallel diode pair is employed as a high-frequency phase detector. In this way, the required frequency of the reference oscillator is lowered to one twelfth of V-band output signal. An RC low-pass filter and DC amplifier are also integrated to effectively suppress the spurious and harmonic signals, and to increase the loop gain. To reduce the circuit interactions and frequency pulling effect, buffer amplifiers are used at the output of VCO and frequency divider. The fabricated V-band PLL MMIC shows the locking range of 840 MHz around 60.1GHz under a very low power dissipation of 370 mW. Good phase noise of -95.5 dBc/Hz is measured at 100 kHz offset. The chip size is as small as 2.35Ч1.80 mm2. To the best of our knowledge, the PLL MMIC of this work is one of the highest frequency monolithic PLLs that integrates all the required elements on a single chip. [J571]

"High-mobility ultrathin strained Ge MOSFETs on bulk and SOI with low band-to-band tunneling leakage: experiments"

For the first time, the tradeoffs between higher mobility (smaller bandgap) channel and lower band-to-band tunneling (BTBT) leakage have been investigated. In particular, through detailed experiments and simulations, the transport and leakage in ultrathin (UT) strained germanium (Ge) MOSFETs on bulk and silicon-on-insulator (SOI) have been examined. In the case of strained Ge MOSFETs on bulk Si, the resulting optimal structure obtained was a UT low-defect 2-nm fully strained Ge epi channel on relaxed Si, with a 4-nm Si cap layer. The fabricated device shows very high mobility enhancements >3.5Ч over bulk Si devices, 2Ч mobility enhancement and >10Ч BTBT reduction over 4-nm strained Ge, and surface channel 50% strained SiGe devices. Strained SiGe MOSFETs having UT (TGeSi capSOI=9 nm). The tradeoffs in obtaining a high-mobility (smaller bandgap) channel with low tunneling leakage on UT-SOI have been investigated in detail. The fabricated device shows very high mobility enhancements of >4Ч over bulk Si devices, >2.5Ч over strained silicon directly on insulator (SSDOI; strained to 20% relaxed SiGe) devices, and >1.5Ч over 60% strained SiGe (on relaxed bulk Si) devices. [J572]

"Self-gating controlled pronounced threshold hysteresis in electron Y-branch switch with quantum dots"

A novel compact, monolithic memory device based on Y-branched junctions with embedded quantum dots is demonstrated. Up sweeps and down sweeps of the voltage difference between the branches lead to a pronounced threshold hysteresis exceeding 0.5 V. It is concluded that the charge state of the quantum dots and thus the hysteresis is also controlled by the self-gating in an electron Y-branch switch. [J573]

"Low cost X-band power amplifier MMIC"

A family of X-band MMIC power amplifiers using a low cost GaAs pHEMT process is reported. The stepper-based volume 0.5 micron and 0.25 micron GaAs pHEMT processes utilize 4 inter-level metallisation and four dielectric layers for high frequency performance whilst maintaining the economies of scale of 150mm (6") diameter substrates. The fabricated GaAs X-Band PA MMICs exhibit SW to low NY output power under pulsed conditions; 16dB of power gain and power added efficiencies approaching 40%. Excellent repeatability and high yields over a number of wafers have been demonstrated. The design and GaAs process approach taken here with DUV stepper and 150 mm wafer diameter will lead to a significant cost reduction for high performance power amplifier MMICs up to 30GHz. [J574]

"High-gain multi-finger power n-MODFET on Si substrate"

A multi-finger n-type Si/SiGe modulation-doped field-effect transistor fabricated on Si substrate for RF power amplification is demonstrated for the first time. Load-pull measurements performed at 2 GHz on a ten-finger device with a gate length of 0.3 μm and a gate width of 750 μm show a maximum output power of 14 dBm and

power gain of 16 dB at 1 dB compression point with power added efficiency of 15%. [J575]

"Unpassivated high power deeply recessed GaN HEMTs with fluorine-plasma surface treatment"

In this letter, unpassivated high power deeply recessed GaN-based high electron mobility transistors (HEMTs) are reported. The introduction of a thick graded AlGaN cap layer and a novel fluorine-plasma surface treatment reduced the gate-leakage current and increased breakdown voltage significantly, enabling the application of much higher drain biases. Due to excellent dispersion suppression achieved at an epitaxial level, an output power density of more than 17 W/mm with an associated power added efficiency (PAE) of 50% was measured at 4 GHz and VDS=80 V without SiNxpassivation. These results demonstrate the great potential of this novel epitaxial approach for passivation-free GaN-based HEMTs for high-power applications. [J576]

"Power measurement setup for large signal microwave characterization at 94 GHz"

We report the development of a power measurement setup in order to characterize devices at 94GHz. A very careful calibration of the setup has been performed in order to take into account in a most accurate way the losses through the different parts of the bench and in particular through the tuner. These aware power measurements have allowed to demonstrate state of the art power results on two different devices. We reached at 94GHz an output power of 876mW/mm associated to a 7.5-dB power gain and a power added efficiency (PAE) of 33% on a pseudomorphic high electron mobility transistor (PHEMT) on GaAs substrate. We achieved a 260-mW/mm maximum output power density with 5.9-dB power gain and 11% PAE on an InAsP channel HEMT on InP substrate. [J577]

"Three-terminal-controlled resistor-type hydrogen sensor"

A novel and interesting three-terminal-controlled active resistor-type hydrogen sensor, based on good properties in the linear region of an AlGaAs-based pseudomorphic high electron mobility transistor in combination with the catalytic Pd metal, is demonstrated. The experimental results show that the gate-source voltage VGSexhibits significant influence on the hydrogen-sensing properties, including resistance sensitivity, detection limit of hydrogen concentration, conductance variation, current variation and dynamic response. Consequently, under an appropriate applied VGSbias, a smart active resistor-type hydrogen sensor can be achieved. [J578]

"Demonstration of 13.56-MHz class-E amplifier using a high-Voltage GaN power-HEMT"

A 13.56-MHz class-E amplifier with a high-voltage GaN HEMT as the main switching device is demonstrated to show the possibility of using GaN HEMTs in high-frequency switching power applications such as RF power-supply applications. The 380-V/1.9-A GaN power HEMT was designed and fabricated for high-voltage power-electronics applications. The demonstrated circuit achieved the output power of 13.4 W and the power efficiency of 91% under a drain-peak voltage as high as 330 V. This result shows that high-voltage GaN devices are suitable for high-frequency switching applications under high dc input voltages of over 100 V. [J579]

"High performance deeply-recessed GaN power HEMTs without surface passivation"

An improved deeply-recessed GaN-based HEMT was demonstrated and shown to produce high microwave power without SiNxpassivation. The introduction of a thick graded AlGaN cap layer decreased the gate leakage current and increased the breakdown voltage. An output power density of 15.2 W/mm with a PAE of 45% at 4 GHz (VDS=70 V) was achieved on a SiC substrate with no SiNxpassivation. [J580]

"FET-integrated CPW and the application in filter synthesis design method on traveling-wave switch above 100 GHz"

A new transmission-line concept, called the field-effect transistor (FET)-integrated coplanar waveguide (CPW), is proposed. This concept treats the passive two-finger FET as CPW and, thus, the scaling rule is more accurate than the previous model, especially in high frequency. The extraction approach of the parameters of the FET-integrated CPW is also included. With this concept, the design procedure of traveling-wave switches can be equivalent to a filter synthesis problem. Based on this design procedure, a single-pole single-throw and a single-pole double-throw traveling-wave switch have been realized and measured using 0.15-μm high-linearity AlGaAs/InGaAs/GaAs pseudomorphic high electron-mobility transistors. Finally, the frequency limitation of the traveling-wave switches is also discussed. The results show the FET-integrated CPW is the most efficient way to overcome the frequency limitations of traveling-wave switches, achieving operation frequency to 135 GHz, the highest frequency reported to date. [J581]

"Piezoelectric GaN sensor structures"

Free-standing GaN and AlGaN/GaN cantilevers have been fabricated on (111) silicon substrate using dry etching. On these cantilevers, a piezoresistor and a high-electron-mobility transistor (HEMT) structure have been realized, and the piezoresponse has been characterized. Cantilever bending experiments resulted in a Young's modulus of approximately 250 GPa, a sensitivity of K 90, and a modulation of the HEMT current of up to 50%. It is seen that the piezoresponse could be related to both the bulk properties and the properties of the heterostructure interface. [J582]

"High-mobility low band-to-band-tunneling strained-Germanium double-gate heterostructure FETs: Simulations"

Large band-to-band tunneling (BTBT) leakage currents can ultimately limit the scalability of high-mobility (small-bandgap) materials. This paper presents a novel heterostructure double-gate FET (DGFET) that can significantly reduce BTBT leakage currents while retaining its high mobility, making it suitable for scaling into the sub-20-nm regime. In particular, through one-dimensional Poisson-Schrodinger, full-band Monte Carlo, and detailed BTBT simulations, the tradeoffs between carrier transport, electrostatics, and BTBT leakage in high-mobility sub-20-nm Si-strained SiGe-Si (high germanium concentration) heterostructure PMOS DGFETs are thoroughly analyzed. The results show a dramatic (>100Ч) reduction in BTBT and an excellent electrostatic control of the channel while maintaining very high drive currents and switching frequencies in these nanoscale transistors. [J583]

"GaAs cryo-cooled LNA for C-band radioastronomy applications"

The design procedure and measurements of a C-band high-performance GaAs cryo-cooled low noise amplifier (LNA) are presented. The latter provides 30 dB gain, a noise figure (NF) lower than 0.12 dB (i.e. 8 K equivalent noise temperature) at 25 K operating temperature, with 35 mW DC bias power only. An appropriate scaling of the device gate periphery has been adopted to trade-off the LNA's NF and DC power consumption. [J584]

"Threshold voltage shifts in decananometre-gate AlGaN/GaN HEMTs"

Decananometre-T-shaped-Ni/Pt/Au-gate AlGaN/GaN HEMTs on sapphire substrates are fabricated and their DC characteristics measured. The negative shifts of threshold voltages occur below 5-6 of channel aspect ratio Lg/d, where Lgis the gate length and d is the AlGaN barrier layer thickness. This is a similar trend as observed in AlGaAs/GaAs HEMTs. The negative threshold voltage shifts are enhanced with increasing d, which results from the increase of the two-dimensional electron gas thickness. [J585]

"W-band waveguide-packaged InP HEMT reflection grid amplifier"

This letter presents a 79-GHz broadband reflection-type grid amplifier using spatial power combining to combine the power of 64 unit cells. Each unit cell uses a two-stage cascade configuration with InP HEMTs arranged as a differential pair. A broadband orthogonal mode transducer (OMT) separates two orthogonally polarized input and output signals over a 75 to 85GHz range. In conjunction with the OMT, a mode converter with quadruple-ridged apertures was designed to enhance the field uniformity over the active grid. Measurements show 5-dB small signal gain at 79GHz and an 800-MHz 3-dB bandwidth. The amplifier generates an output power of 264mW with little evidence of saturation. [J586]

"100 W C-band single-chip GaN FET power amplifier"

A single-chip GaN-FET amplifier exhibits record output powers of C-band solid-state amplifiers under continuous-wave (CW) and pulsed operation conditions. At 5.0 GHz, the developed GaN-FET amplifier with 24 mm gate periphery delivered a CW 100 W output power with 12.9 dB linear gain and 31% power-added efficiency and a pulsed 155 W output power with 13.0 dB linear gain. [J587]

"A single-supply Ku-band 1-W power amplifier MMIC with compact self-bias PHEMTs"

In this letter, the design of a self-bias 1.8-mm AlGaAs/InGaAs/GaAs pseudomorphic high electron mobility transistor with a compact source capacitor for operation in Ku-band frequency is described. Based on the proposed device, a self-bias Ku-band 1-W two-stage power amplifier monolithic microwave integrated circuit (MMIC) is also demonstrated. Under a single bias condition of 8 V and 630 mA, the self-bias MMIC possesses 14.2-dB small-signal gain, 30.2-dBm output power at 1-dB gain compression point with 19.2% power added efficiency and 31.3-dBm saturated output power with 22.5% power added efficiency at 14GHz. With the performance comparable to the dual-bias MMIC counterpart, the proposed self-bias MMIC is more attractive to system designers on very small aperture terminal applications. [J588]

"Laser-assisted processing of VIAs for AlGaN/GaN HEMTs on SiC substrates"

Vertical interconnect accesses (VIAs) were fabricated between the source electrode on the front and the ground on the backside of high-power microwave AlGaN/GaN high-electron mobility transistors (HEMTs) on 400-μm-thick silicon carbide substrates. Through-wafer microholes with an aspect ratio of up to 8 were drilled using pulsed UV-laser machining and subsequently metallized using electroplating. The successful implementation of the laser-assisted VIA technology into device processing was proven by dc and RF characterization. When biased at 26 V, a saturated output power of 41.6 W with an associated power-added efficiency of 55% at 2 GHz was achieved for a 20-mm AlGaN/GaN HEMT with through-wafer VIAs. [J589]

"An accurate small-signal model for AlGaN-GaNHEMT suitable for scalable large-signal model construction"

The validity of the proposed small-signal model (SSM) and the developed extraction method in for large GaN devices is investigated. Extraction of parasitic elements is performed for different size devices to show the scaling of these elements with the gate width. The model shows a very good result for describing the parasitic distributed effect, which is considerable for large devices. [J590]

"Microwave characterization and modeling of packaged HEMTs by a direct extraction procedure down to 30 K"

The knowledge of the small-signal equivalent circuit of microwave GaAs field effect transistors (FETs) is crucial for the design of low-noise amplifiers and is very useful to support the analysis of the transistor performance. This paper reports the results of our experimental activity concerning the application of an improved procedure for the direct extraction of the model element values from scattering (S-) parameter measurements. This analytical procedure was tested on low-noise pseudomorphic high electron mobility transistors (pHEMTs) up to 6 GHz and at cryogenic temperatures without any optimization or tuning adjustment. This paper reports the behavior of the intrinsic elements versus bias condition; the experimental results were found to match the theoretical expectations. The very good agreement between the simulated and measured S-parameters confirms the validity of the proposed method. To carry out the experimental activity, a properly designed cryogenic setup operating in our laboratory, which allows performing direct current (dc) and microwave characterization down to 30 K, was employed. [J591]

"Offset wide-recessed In0.49 GaP/Al0.45 GaAs barrier E-pHEMT with high current density"

An offset wide-recessed In0.49GaP/Al0.45GaAs barrier enhancement-mode p-HEMT (E-pHEMT) with high drain current density has been developed. Achieving high gate-turn-on voltage and reducing source access resistance (RS) were the aims for the high current density E-pHEMT. The wide bandgap Al0.45GaAs barrier enabled the application of high VGSto the gate. RSwas reduced by using an In0.49GaP etch stop layer with low surface defect density and reducing the source to gate spacing (LSG). An offset wide-recess to the E-pHEMT was applied to enhance breakdown voltage without increasing RS. The offset wide-recessed 0.5 μm gate E-pHEMT showed a drain current density of 440 mA/mm at VGS=1.5 V and an off-state breakdown voltage of over 21 V. [J592]

"A compact low-power label swapper for asynchronous burst optical packets based on an optically clocked transistor array"

We have constructed a prototype optical label swapper module by integrating an optically clocked transistor array InP optoelectronic integrated circuit (OEIC) with complimentary metal-oxide-semiconductor electronics. Dual serial-to-parallel and parallel-to-serial conversion (demultiplexer/multiplexer) capability of the OEIC enables a compact low-power low-cost label swapper. With the prototype, we demonstrate label swapping of 10-Gb/s 16-bit asynchronous burst preamble-free optical labels. [J593]

"In0.53 Ga0.47 As/InAs0.3 P0.7 composite channel high electron mobility transistors"

An In0.53Ga0.47As/InAs0.3P0.7composite channel high electron mobility transistor (HEMT) structure was grown by molecular beam epitaxy. Room-temperature Hall measurement showed that the device wafer had an electron mobility of 7300 cm2/V s and a sheet electron density of 3Ч1012cm-2. The fabricated HEMT devices with a gate length of 0.25 μm exhibited excellent DC and microwave performance with a peak extrinsic transconductance of 888.3 mS/mm, a cutoff frequency (fT) of 115 GHz, and a maximum frequency of oscillation of 137 GHz. This is believed to be the first report of InGaAs/InAsP composite channel HEMTs. The fTis the highest ever reported for any composite channel HEMTs with the same gate length. [J594]

"Pd-oxide- Al0.24 Ga0.76 As (MOS) high electron mobility transistor (HEMT)-based hydrogen sensor"

An interesting hydrogen sensor based on an Al0.24Ga0.76As Schottky barrier high-electron mobility transistor with a catalytic Pd metal/oxide/semiconductor is fabricated and demonstrated. In comparison with traditional Schottky diodes or capacitance-voltage type hydrogen sensors, the studied device exhibits larger current variation, lower hydrogen detection limit, and shorter transient hydrogen response time. Besides, good hydrogen-sensing properties, such as significant drain current change, threshold voltage shift, and transconductance change of transistor behaviors, are obtained. Therefore, the studied device provides the promise for high-performance solid-state hydrogen sensors, optoelectronic integrated circuits, and microelectromechanical system applications. [J595]

"Table-based nonlinear HEMT model extracted from time-domain large-signal measurements"

This paper presents an empirical table-based nonlinear HEMT model fully extracted from time-domain large-signal measurements. A simple and direct extraction procedure, based on a vector nonlinear network analyzer measurement system with load-pull facilities, demonstrates by experimental results on microwave transistors how a very reduced number of measurements is enough to obtain the current and charge generators to fill a lookup model. Table-based model extraction, implementation, and validation are described in this paper. [J596]

"Ion implanted AlGaN-GaN HEMTs with nonalloyed Ohmic contacts"

In this letter, the incorporation of Si implantation into AlGaN-GaN high-electron mobility transistor (HEMT) processing has been demonstrated. An ultrahigh-temperature (1500°C) rapid thermal annealing technique was developed for the activation of Si dopants implanted in the source and drain. In comparison to control devices processed by conventional fabrication, the implanted device with nonalloyed ohmic contact showed comparable device performance with a contact resistance of 0.4 Ω·mm, Imaxof 730 mA/mm, ft/fmaxof 26/62 GHz, and a power of 3.4 W/mm on sapphire. These early results demonstrate the feasibility of implantation incorporation into GaN-based device processing as well as the potential to increase yield, reproducibility, and reliability in AlGaN-GaN HEMTs. [J597]

"80-Gb/s InP-based waveguide-integrated photoreceiver"

A waveguide-integrated photoreceiver, comprising a waveguide-integrated photodiode and a distributed amplifier, is presented. Its optical to electrical conversion capability for nonreturn to zero modulated data rates up to 80 Gb/s is demonstrated. The receiver optoelectronic integrated circuit was packaged into a pig-tailed module with a 1 mm connector output. [J598]

"Analytical approach to evaluate thermal reduction effects of peripheral structures on microwave power GaAs device chips"

Thermal analysis of microwave power GaAs device chips has been presented that features analytical simplicity yet gives quantitative evaluation of thermal reduction effects of two kinds of chip peripheral structures, via-holes and bumps. To calculate Tmax(maximum temperature) and Rth(thermal resistance), the Laplace equation has been solved for a basic chip model under boundary conditions appropriate to peripheral structures. The chip model consisted of three layers features having heat sources at interface of layer 2 and 3. An approximate method for the analysis of field effect transistor (FET) unit with bumps has been newly proposed. A good agreement has been found between the calculated and measured Rthand its reduction effect, verifying the usefulness of the present analysis in the thermal design of device chips. [J599]

"40 Gbit/s/ch 2Ч2 switch IC using InP HEMTs"

A low-power 2Ч2 switch IC using InP HEMTs as cold FETs is presented. It has a logic-level-independent interface since no signal line is grounded. The IC yields low insertion loss of 1.5-2.7 dB and high isolation of >21.2 dB below 30 GHz. When two 40 Gbit/s signals were input, error-free operation was confirmed with virtually zero power dissipation. [J600]

"Gate-recessed AlGaN-GaN HEMTs for high-performance millimeter-wave applications"

We report deep-submicrometer gate-recessed and field-plated AlGaN-GaN HEMTs and their state-of-the-art continuous wave (CW) power performance measured at 30 GHz. The AlGaN-GaN HEMTs exhibit a CW power density of 5.7 W/mm with a power-added efficiency (PAE) of 45% and drain-efficiency of 58% at Vds=20 V. At Vds=28 V, the output power density is measured as high as 6.9 W/mm with both PAE and output power

increasing with input power level. Compared to conventional T-gated AlGaN-GaN HEMTs, the output power density and PAE of gate-recessed AlGaN-GaN HFETs are improved greatly, along with the excellent pulsed IVs. We attribute the improvement to both a field-plating effect and a vertical separation of the gate plane from surface states. [J601]

"Experimental class-F power amplifier design using computationally efficient and accurate large-signal pHEMT model"

This paper presents an experimental high-efficiency class-F power amplifier (PA) design, which integrates Rhodes's efficient low-pass matching network topology with the charge conservative, robust, and accurate WREN/COBRA nonlinear pseudomorphic high electron-mobility transistor (pHEMT) model for optimal drain efficiency. Large-signal model verification is undertaken where one-tone, load-pull, and wireless code-division multiple-access baseband time-domain tests are compared for simulated and experimental cases. Following a detailed theoretical analysis, a class-F matching network is proposed that suppresses the necessary load harmonics and delivers maximum drain efficiency. Utilizing the GaAs pHEMT model in computer-aided design, a microstrip matching network layout was generated and built at 2 GHz. The drain efficiency recorded for the first-pass effort was 70.5% with the use of no post-fabrication circuit tuning. Excellent agreement is also observed between the PAs simulated and measured performance, thus highlighting the advantages of an accurate device model in PA design. [J602]

"Performance enhancement by using the n+ -GaN cap layer and gate recess technology on the AlGaN-GaN HEMT fabrication"

Due to the low mobility and wide bandgap characteristics of the undoped AlGaN layer used in the conventional AlGaN-GaN HEMT as a cap layer, the RF performance of this device will be limited by its high contact resistance and high knee voltage. In this letter, we propose using the n+-GaN cap layer and the selective gate recess etching technology on the AlGaN-GaN HEMTs fabrication. With this n+-GaN instead of the undoped AlGaN as a cap layer, the device contact resistance is reduced from 1.0 to 0.4 Ω·mm. The 0.3 μm gate-length device demonstrates an Ids,maxof 1.1 A/mm, a gm,maxof 220 mS/mm, an fTof 43 GHz, an fmaxof 68 GHz, and an output power density of 4 W/mm at 2.4 GHz. [J603]

"Design optimization of high breakdown voltage AlGaN-GaN power HEMT on an insulating substrate for RON A-VB tradeoff characteristics"

High breakdown voltage AlGaN-GaN power high-electron mobility transistors (HEMTs) on an insulating substrate were designed for the power electronics application. The field plate structure was employed for high breakdown voltage. The field plate length, the insulator thickness and AlGaN layer doping concentration were design parameters for the breakdown voltage. The optimization of the contact length and contact resistivity reduction were effective to reduce the specific on-resistance. The tradeoff characteristics between the on-resistance and the breakdown voltage can be improved by the optimization of the above design parameters, and the on-resistance can be estimated to be about 0.6 mΩ·cm2for the breakdown voltage of 600 V. This on-resistance is almost the same as that for the device on a conductive substrate. [J604]

"A Ka-band InP MMIC 180° phase switch"

A new type of Ka band (26 to 36 GHz) 180 degree phase switch (bi-phase modulator) monolithic microwave integrated circuit has been developed for the EC funded FARADAY radio astronomy project. This integral component forms part of a chip set for a very low noise switching radiometer operating at a temperature of approximately 15 K. To maximize the sensitivity of the radiometer lattice-matched indium phosphide HEMT technology has been used: all of the active components of the radiometer, with the exception of the detectors, have been manufactured on a single wafer process. Design principles are described, together with a comparison of modeled and measured results. The results show an average insertion loss of 3.5 dB, return loss of better than 10 dB and an average phase difference close to 170°±10° the 26-36 GHz band. [J605]

"Characteristics of In0.425 Al0.575 As-InxGa1-x As metamorphic HEMTs with pseudomorphic and symmetrically graded channels"

In0.425Al0.575As-InxGa1-xAs metamorphic high electron mobility transistors (MHEMTs) with two different channel designs, grown by molecular beam epitaxy (MBE) system, have been successfully investigated. Comprehensive dc and high-frequency characteristics, including the extrinsic transconductance, current driving capability, device linearity, pinch-off property, gate-voltage swing, breakdown performance, unity-gain cutoff frequency, max. oscillation frequency, output power, and power gain, etc., have been characterized and

compared. In addition, complete parametric information of the small-signal device model has also been extracted and discussed for the pseudomorphic channel MHEMT (PC-MHEMT) and the V-shaped symmetrically graded channel MHEMT (SGC-MHEMT), respectively. [J606]

"Sources of transconductance collapse in III-V nitrides-consequences of velocity-field relations and source/gate design"

Experimental results from submicrometer devices in III-V nitride devices often exhibit a significant decrease in the transconductance when gate bias is increased. This creates new challenges for circuit design in III-V nitride technology. In this paper, we discuss possible sources of this collapse from a theoretical and computational standpoint. We find that polar optical phonon emission related velocity-field nonlinearities in 5-40 kV/cm region are the primary reason for the decrease in the transconductance. We also discuss possible solutions to this problem and examine the practicality of each solution. Shorter S/G spacing and higher doping in the source gate region are predicted to remove much of the transconductance collapse. [J607]

"AlGaN-GaN HEMTs on patterned silicon (111) substrate"

We report the AlGaN-GaN high-electron mobility transistors (HEMTs) grown and fabricated on patterned silicon (111) substrates. A crack-free AlGaN-GaN HEMT heterostructure was grown on top of rectangular silicon ridges patterned on the silicon substrate. Fabrication of HEMT on the ridges was demonstrated using a polyimide planarization process. Maximum drain current density of 1.05 A/mm and peak transconductance of 150 mS/mm were achieved with 1.0 μm gate-length. The current gain cutoff frequency and maximum frequency of oscillation were 9.7 and 20.5 GHz, respectively, for the 1 μm Ч 300 μm devices. [J608]

"Effects of AlGaN/GaN HEMT structure on RF reliability"

A comparison of RF reliability at 10 GHz on four different undoped AlGaN/GaN HEMT structures with AlGaN barrier thickness variation is presented. The output power degradation characteristics during RF stress for each structure are shown, and the results indicate a strong dependence of reliability on AlGaN thickness. A device from the structure with the thinnest AlGaN in the study, with initial output power of 8.8 W/mm at 40 V, showed only a change of 0.55 dB in output power after 185 h of RF stress at 40 V. The results demonstrate excellent RF reliability of high-power devices and the potential of stable high-power operation of undoped AlGaN/GaN HEMTs on SiC [J609]

"Growth and characterization of plasma-assisted molecular beam epitaxial-grown AlGaN/GaN heterostructures on free-standing hydride vapor phase epitaxy GaN substrates"

We have grown AlGaN/GaN high electron mobility transistor (HEMT) structures by plasma-assisted molecular beam epitaxy on free-standing n-GaN substrates grown by hydride vapor phase epitaxy. Reflection high energy electron diffraction patterns of the as-loaded wafers exhibit narrow streaks which persist throughout the growth. Atomic force microscopy shows smooth AlGaN surfaces with root-mean-square roughness of 10 E over a 20Ч20mcm2area. High resolution x-ray diffractometry indicates that the AlGaN peak is 20%narrower than for similar structures grown on SiC. Hall mobilities, electron sheet densities, and sheet resistances were measured on ten 60Ч60mcm2Hall test patterns defined photolithographically across the surface of the 10Ч10mm2sample. Buffer leakage measurements demonstrate that a Be:GaN layer effectively isolates the channel from the conductive substrate. Average sheet resistances and sheet densities were 380Omega / and 0.94Ч1013cm-2, respectively. These HEMT structures exhibit room-temperature Hall mobilities in excess of 1900cm2/Vs. In addition, devices on these structures exhibit excellent pinch-off, low gate leakage, and saturated drain current densities of almost 700 mA/mm. Further details regarding the structural and electrical properties will be described along with device testing. [J610]

"Influence of surface defect charge at AlGaN-GaN-HEMT upon Schottky gate leakage current and breakdown voltage"

The relation between Schottky gate leakage current and the breakdown voltage of AlGaN-GaN high-electron mobility transistors (HEMTs) is discussed based on the newly introduced simple, yet useful, surface defect charge model. This model represents the leakage current caused by the positive charge in the surface portion of AlGaN layer induced by process damage such as nitrogen vacancies. The new model has been implemented into a two-dimensional device simulator, and the relationship between the gate leakage current and the breakdown voltage was simulated. The simulation results reproduced the relationship obtained experimentally between the leakage current and the breakdown voltage. Further simulation and experiment results show that the breakdown voltage is maintained even if the defect charge exists up to the defect charge density of

2.5Ч1012cm-2, provided the field plate structure is adopted, while the breakdown voltage shows a sudden drop for the defect density over 5Ч1011cm-2without the field plate. This result shows that the field plate structure is effective for suppressing the surface charge influence on breakdown voltage due to the relaxation of the electric field concentration in the surface portion of the AlGaN layer. [J611]

"Highly linear Al0.3 Ga0.7 N-Al0.05 Ga0.95 N-GaN composite-channel HEMTs"

We report an Al0.3Ga0.7N-Al0.05Ga0.95N-GaN composite-channel HEMT with enhanced linearity. By engineering the channel region, i.e., inserting a 6-nm-thick AlGaN layer with 5% Al composition in the channel region, a composite-channel HEMT was demonstrated. Transconductance and cutoff frequencies of a 1 Ч100 μm HEMT are kept near their peak values throughout the low- and high-current operating levels, a desirable feature for linear power amplifiers. The composite-channel HEMT exhibits a peak transconductance of 150 mS/mm, a peak current gain cutoff frequency (fT) of 12 GHz and a peak power gain cutoff frequency (fmax) of 30 GHz. For devices grown on sapphire substrate, maximum power density of 3.38 W/mm, power-added efficiency of 45% are obtained at 2 GHz. The output third-order intercept point (OIP3) is 33.2 dBm from two-tone measurement at 2 GHz. [J612]

"2 V-operated InGaP-AlGaAs-InGaAs enhancement-mode pseudomorphic HEMT"

A low-voltage single power supply enhancement-mode InGaP-AlGaAs-InGaAs pseudomorphic high-electron mobility transistor (PHEMT) is reported for the first time. The fabricated 0.5Ч160 μm2device shows low knee voltage of 0.3 V, drain-source current (IDS) of 375 mA/mm and maximum transconductance of 550 mS/mm when drain-source voltage (VDS) was 2.5 V. High-frequency performance was also achieved; the cut-off frequency(Ft) is 60 GHz and maximum oscillation frequency(Fmax) is 128 GHz. The noise figure of the 160-μm gate width device at 17 GHz was measured to be 1.02 dB with 10.12 dB associated gain. The E-mode InGaP-AlGaAs-InGaAs PHEMT exhibits a high output power density of 453 mW/mm with a high linear gain of 30.5 dB at 2.4 GHz. The E-mode PHEMT can also achieve a high maximum power added efficiency (PAE) of 70%, when tuned for maximum PAE. [J613]

"High-temperature thermal stability performance in δ-doped In0.425 Al0.575 As--In0.65 Ga0.35 As metamorphic HEMT"

We report, to our knowledge, the best high-temperature characteristics and thermal stability of a novel δ-doped In0.425Al0.575As--In0.65Ga0.35As--GaAs metamorphic high-electron mobility transistor. High-temperature device characteristics, including extrinsic transconductance (gm), drain saturation current density (IDSS), on/off-state breakdown voltages (BVon/BVGD), turn-on voltage (Von), and the gate-voltage swing have been extensively investigated for the gate dimensions of 0.65Ч200 μm2. The cutoff frequency (fT) and maximum oscillation frequency (fmax), at 300 K, are 55.4 and 77.5 GHz at VDS=2 V, respectively. Moreover, the distinguished positive thermal threshold coefficient (∂Vth/∂T) is superiorly as low as to 0.45 mV/K. [J614]

"Influence of AlN nucleation layer on the epitaxy of GaN/AlGaN high electron mobility transistor structure and wafer curvature"

Significant wafer curvature has been observed for AlGaN/GaN high electron mobility transistor (HEMT) structures grown on SiC substrates by rf plasma molecular-beam epitaxy. The curvature is caused by residual compressive strain in the films, due primarily to the lattice mismatch between substrate and epilayer. The wafers exhibit more bow when an AlN nucleation layer is used, than when GaN/AlGaN is grown directly on SiC. However, in test structures, AlN nucleation layers are found to impart tensile strain in the wafer that is small due to the AlN thickness. Using high resolution x-ray diffraction with reciprocal space maps, thin GaN films are found to relax more readily when grown directly on SiC substrates than on AlN buffer layers. The compressive strain in the thick GaN buffer layer grown on AlN bows the wafer and increases the substrate x-ray diffraction (XRD) linewidth. The GaN buffer, despite its thickness, does not relax fully but retains some residual strain. [J615]

"Measurements of unity gain cutoff frequency and saturation velocity of a GaN HEMT transistor"

The measured intrinsic saturation velocity (vsi) of carriers in a gallium nitride (GaN) high electron mobility transistor (HEMT) is very much lower than that predicted using Monte Carlo simulation. A novel method of extraction of the intrinsic saturation velocity (vsi) of carriers has been developed utilising the deembedded s-parameters, thus enabling the calculation of vsiover a wide range of bias conditions. The method is equally applicable for gallium arsenide (GaAs) and indium phosphide (InP) based transistors. The measurements indicate for GaN-based HEMT a maximum deembedded saturation velocity of 1.1Ч105m/s close to the pinchoff voltage (VP). It was found that self-heating had only a weak effect on the saturation velocity up to junction

temperatures approaching 140°C above ambient. [J616]

"High power and linearity performances of gallium nitride HEMT devices on sapphire substrate"

The benefit of high drain-source bias voltages of GaN devices on sapphire substrates for high linearity applications is demonstrated. Whatever the output power densities considered, the corresponding intermodulation ratio is at least 20 dB better than usual PHEMT devices on GaAs substrates for the same power density. This study demonstrates that GaN devices are ideal candidates for applications requiring high power and high linearity behaviours simultaneously. [J617]

"Influence of epitaxial structure in the noise figure of AlGaN/GaN HEMTs"

The effect of noise figure of different AlGaN/GaN high electron-mobility transistor (HEMT) epitaxy structures is reported. The addition of a thin AlN layer between the barrier and channel gives better performance at biasings other than the best for minimum noise figure. However, varying Al composition in the HEMT barrier does not change the noise performance, contrary to a 2003 study by Lu et al. The measurements are checked with both the Pospieszalski and van der Ziel (Pucel) models. The models are used on six different samples, helping to reinforce the measurements and showing the strengths and weaknesses of each [J618]

"Study of hydrogen-sensing characteristics of a Pt-oxide-AlGaAs metal-oxide-semiconductor high electron mobility transistor"

A new hydrogen sensor based on a GaAs-based high electron mobility transistor (HEMT) with a catalytic Pt-oxide-Al0.24Ga0.76As(MOS) gate structure is fabricated and demonstrated. The threshold voltage shift, hydrogen detection sensitivity, and transient responses of the device under different hydrogen concentrations and temperature are measured and studied. Based on the transistor amplification action, even at an extremely low hydrogen concentration of 14ppmH2/air, the studied device shows significant drain current variation (about 0.12mA). Furthermore, the studied device can be operated under wider operating temperature regimes with remarkable hydrogen-sensing properties. The decreased hydrogen detection capability with increasing operating temperature demonstrates the exothermic reaction of the hydrogen adsorption and desorption processes. [J619]

"Molecular beam epitaxy of In Al N /Ga N heterostructures for high electron mobility transistors"

We describe the growth of InAlN/GaNheterostructures by rf-plasma molecular beam epitaxy. Due to the weak In-N bond, the InAlN growth temperature must be below about 460°Cfor In to incorporate reliably into the film. Thus far, a thin AlN spacer layer has been required to form a low resistance two dimensional electron gas (2DEG) at the InAlN/GaNinterface. The thin AlN barrier is believed to reduce alloy scattering of carriers in the 2DEG. The best HEMT material with an InAlN barrier and a thin AlN spacer layer has a sheet resistance of 980Omega / with a sheet electron density of 1.96Ч1013cm-2. [J620]

"Growth of InAsSb-channel high electron mobility transistor structures"

We discuss the molecular beam epitaxial growth of the random alloy InAsSb for use as the channel in high electron mobility transistors (HEMTs). Room-temperature mobilities of 22000cm2/Vshave been achieved at a sheet carrier density of 1.4Ч1012/cm2. This is a marked improvement over the mobility of 13000cm2/Vsat the same carrier density obtained in previous attempts to grow the InAsSb channel using a digital alloy procedure [J. B. Boos, M. J. Yang, B. R. Bennett, D. Park, W. Kruppa, R. Bass, Electron. Lett. 35, 847 (1999)]. We have also implemented different barriers and buffer layers to enhance the transport properties and overall performance of the HEMT structure. [J621]

"120-nm -T-shaped-Mo /Pt /Au -gate Al Ga N /Ga N high electron mobility transistors"

We fabricated 120-nm-T-shaped-Mo/Pt/Au-gate AlGaN/GaNhigh electron mobility transistors (HEMTs) on sapphire substrates. The gate leakage current Igsof the Mo/Pt/Au-gate HEMT at a gate-source voltage Vgsof -5Vwas as much as five orders of magnitude lower than that of the Ni/Pt/Au-gate HEMT under the as-deposited condition. The off-state breakdown voltage, defined as the gate-source voltage when the gate-source current is -1mA/mm, was about -60Vfor the Mo/Pt/Au-gate HEMT. These dc performances are comparable to those of the Ni/Pt/Au-gate HEMTs in which the Schottky contacts were improved with rapid thermal annealing at 500°C. The Mo/Pt/Au-gate HEMTs also exhibited good rf performance without RTA. The cutoff frequency fTwas more than 50GHzand the maximum oscillation frequency fmaxwas about 100GHz. [J622]

"Phototransistors based on InP HEMTs and their applications to millimeter-wave radio-on-fiber

systems"

Phototransistors based on InP high electron-mobility transistors (HEMTs) are investigated for millimeter-wave radio-on-fiber system applications. By clarifying the photodetection mechanism in InP HEMTs, the phototransistor internal gain is determined. We present their use as millimeter-wave harmonic optoelectronic mixers and characterize them at the 60-GHz band. In order to evaluate the InP HEMT optoelectronic mixer performance, internal conversion gain is introduced and a maximum of 17 dB is obtained for 60-GHz harmonic optoelectronic up-conversion. Utilizing them, we construct a 60-GHz radio-on-fiber system and demonstrate 622-Mb/s data transmission over 30-km single-mode fiber and 3-m free space at 60-GHz band. [J623]

"GaN metal-oxide-semiconductor high-electron-mobility-transistor with atomic layer deposited Al 2 O 3 as gate dielectric"

We report on a GaN metal-oxide-semiconductor high-electron-mobility-transistor (MOS-HEMT) using atomic-layer-deposited (ALD) Al2O3as the gate dielectric. Compared to a conventional GaN high-electron-mobility-transistor (HEMT) of similar design, the MOS-HEMT exhibits several orders of magnitude lower gate leakage and several times higher breakdown voltage and channel current. This implies that the ALD Al2O3/AlGaN interface is of high quality and the ALD Al2O3/AlGaN/GaN MOS-HEMT is of high potential for high-power rf applications. In addition, the high-quality ALD Al2O3gate dielectric allows the effective two-dimensional (2D) electron mobility at the AlGaN/GaN heterojunction to be measured under a high transverse field. The resulting effective 2D electron mobility is much higher than that typical of Si, GaAs or InGaAs metal-oxide-semiconductor field-effect-transistors (MOSFETs). [J624]

"Recessed-gate enhancement-mode GaN HEMT with high threshold voltage"

Fabrication of enhancement-mode high electron mobility transistors (E-HEMTs) on GaN/AlGaN heterostructures grown on SiC substrates is reported. Enhancement-mode operation was achieved with high threshold voltage (VT) through the combination of low-damage and controllable dry gate-recessing and the annealing of the Ni/Au gates. As-recessed E-HEMTs with 1.0 μm gates exhibited a threshold voltage (VT) of 0.35 V, maximum drain current (ID,max) of 505 mA/mm, and maximum transconductance (gm,max) of 345 mS/mm; the corresponding post-gate anneal characteristics were 0.47 V, 455 mA/mm and 310 mS/mm, respectively. The RF performance is unaffected by the post-gate anneal process with a unity current gain cutoff frequency (fT) of 10 GHz. [J625]

"Resistive HEMT mixers for 60-GHz broad-band telecommunication"

We report two resistive mixers, i.e., a balanced and a balanced image-rejection (IR) mixer for the 60-GHz frequency range. A compact and wide-band method for the local-oscillator (LO) power division is presented. The 56-GHz LO signal, which propagates in a coplanar-waveguide mode, is divided in between the lines of two spiral baluns. Consequently, a smooth and compact transition from even-to-odd propagation mode and an in-phase power division for two singly balanced unit mixers is achieved. As a result, the developed IR mixer occupies only 1.41mm2of chip area. The balanced design achieved 11.5 dB of conversion loss from 57 to 67 GHz with a fixed IF of 5.3 GHz. The corresponding LO suppression was better than 34 dB with 8 dBm of LO power. The IR mixer achieved better than 19 dB of IR ratio and better than 36 dB of LO suppression for an RF frequency from 57 to 66 GHz. The corresponding conversion loss varies from 13 to 16 dB. The measured 1-dB compression point of the IR mixer was at a -13-dBm output power level and the third-order intercept point was at a 4-dBm level. [J626]

"Capacitance pressure sensor based on GaN high-electron-mobility transistor-on-Si membrane"

The changes in the capacitance of the channel of an AlGaN/GaNhigh-electron-mobility transistor (HEMT) membrane structure fabricated on a Si substrate were measured during the application of both tensile and compressive strain through changes in the ambient pressure. The capacitance of the channel displays a change of 7.19±0.45Ч10-3pF/mcmas a function of the radius of the membrane at a fixed pressure of +9.5barand exhibits a linear characteristic response between -0.5and +1barwith a sensitivity of 0.86pF/barfor a 600mcmradius membrane. The hysteresis was 0.4% in the linear range. These AlGaN/GaNHEMT membrane-based sensors appear to be promising for both room-temperature and elevated-temperature pressure-sensing applications. [J627]

"Hydrogen sensing properties of a Pt -oxide -Al 0.24 Ga 0.76 As high-electron-mobility transistor"

The interesting hydrogen sensing performances of a Pt-oxide-AlGaAs (MOS) high electron mobility transistor (HEMT) are studied and demonstrated. The effects of hydrogen adsorption on device performances such as the threshold voltage shift Delta Vth, drain saturation current variation Delta IDS, and transient response are

presented. Delta Vthand Delta IDSdecreased with increasing operating temperature. This suggests that, at higher temperature, less hydrogen atoms diffuse through the Pt bulk and reach the interface between the Pt metal and oxide layer resulting from the relatively faster formation rate of hydroxyl on the Pt surface. The response curves of the studied Pt-AlGaAs MOS HEMT show various profiles at different temperatures. The influences of hydrogen concentration and temperature on the interface sites occupied by adsorbed atoms are also studied. [J628]

"High-power AlGaN /InGaN /AlGaN /GaN recessed gate heterostructure field-effect transistors"

We demonstrate the use of high-quality thin InGaNfilms as the reactive ion etching (RIE) stop layer for fabrication of recessed gate high-microwave-power AlGaN/InGaN/AlGaN/GaNheterostructure field-effect transistors. We used migration-enhanced-metalorganic-chemical-vapor-deposition grown InGaNlayer sandwiched in AlGaNbarrier yields better than 10 times RIE selectivity of AlGaNand InGaNcompared to our conventional standard AlGaN/GaNhigh electron mobility transistors. The fabricated devices exhibited a 50% increase in the breakdown voltage, which is attributed primarily due to the improved electric field distribution at the gate edge and to the increased distance between the AlGaNsurface and the device channel. The continuous wave microwave power was measured at the drain bias as high as 60V. The maximum output power and power added efficiency were 8.9W/mmand 40%, respectively. The obtained results demonstrate a potential of this technique for development of the next-generation high-power transistors. [J629]

"Detection of halide ions with Al Ga N /Ga N high electron mobility transistors"

AlGaN/GaNhigh electron mobility transistors (HEMTs) both with and without a Au gate are found to exhibit significant changes in channel conductance upon exposing the gate region to various halide ions. The polar nature of the halide ions leads to a change of surface charge in the gate region on the HEMT, producing a change in the surface potential at the semiconductor/liquid interface. HEMTs with a Au-gate electrode not only doubled the sensitivity of changing the channel conductance as compared to gateless HEMT, but also showed the opposite conductance behavior. When anions adsorbed on the Au, they produced a counter charge for electrovalence. These anions drag some counter ions from the bulk solution or create an image positive charge on the metal for the required neutrality. The gateless HEMTs can be used as sensors for a range of chemicals through appropriate modification with covalently bonded halide functional groups on the Au surface. This creates many possibilities to functionalize the surface for a wide range of integrated biological, chemical, and fluid monitoring sensors. [J630]

"A W-band InAs/AlSb low-noise/low-power amplifier"

The first W-band antimonide based compound semiconductor low-noise amplifier has been demonstrated. The compact 1.4-mm2three-stage co-planar waveguide amplifier with 0.1-μm InAs/AlSb high electron mobility transistor devices is fabricated on a 100-μm GaAs substrate. Minimum noise-figure of 5.4dB with an associated gain of 11.1 dB is demonstrated at a total chip dissipation of 1.8 mW at 94 GHz. Biased for higher gain, 16±1 dB is measured over a 77-103 GHz frequency band. [J631]

"Hydrogen sensitivity of InP HEMTs with WSiN-based gate stack"

We have experimentally investigated the hydrogen sensitivity of InP high-electron mobility transistors (HEMTs) with a WSiN-Ti-Pt-Au gate stack. We have found that exposure to hydrogen produces a shift in the threshold voltage of these devices that is one order of magnitude smaller than published data on conventional Ti-Pt-Au gate HEMTs. We have studied this markedly improved reliability through a set of quasi-two-dimensional mechanical and electrostatic simulations. These showed that there are two main causes for the improvement of the hydrogen sensitivity. First, the separation of the Ti-layer from the semiconductor by a thick WSiN layer significantly reduces the stress in the heterostructure underneath the gate. Additionally, the relatively thinner heterostructure used in this study and the presence of an InP etch-stop layer with a small piezoelectric constant underneath the gate reduces the amount of threshold voltage shift that is caused by the mechanical stress. [J632]

"K-band MMIC active band-pass filters"

Two K-band active band-pass filters using 0.15-μm GaAs pHEMT technology, with one fixed-frequency and the other tunable, are designed, fabricated, and tested. The fixed-frequency filter has its central frequency at 22.6 GHz, with 900-MHz bandwidth (4%). The tunable filter can be tuned from 19.5 to 21.5 GHz with the same bandwidth. Both circuits have a common size of 1 mm Ч 1 mm. To our knowledge, the tunable filter is the highest frequency tunable active filter ever reported. [J633]

"Signal generation, control, and frequency conversion AlGaN/GaN HEMT MMICs"

We review the design and experimental results of three new AlGaN/GaN high electron-mobility transistor monolithic microwave integrated circuits: a voltage-controlled oscillator (VCO), a single-pole-double-throw switch (SPDT), and a resistive field-effect transistor mixer. The VCO exhibits frequency range between 8.5-9.5 GHz with maximum output power of 35 dBm (at Vds=30 V) across a 50-Ω load. The L/S band SPDT switch at 0.9, 1.8, and 2.1 GHz was measured to have 0.87-, 0.96-, 1-dB insertion loss and 46-, 42-, and 41-dB isolation, respectively. The switch also shows linear performance for the power levels up to 1 W in the insertion mode. A singly ended X-band resistive mixer has exhibited very low intermodulation, less than -60 dBc for the second and third harmonics of the IF at the RF power level of 10 dBm, and high power handling, P1 dBis estimated to be at least 1 W, with the conversion loss of 17 dB. [J634]

"Modeling of a ferromagnetic two-dimensional electron gas device"

We present a realistic modeling of ballistic electron transport in a hybrid ferromagnetic (FM) two-dimensional electron gas (2DEG) device, consisting of an FM gate on an AlGaAs-GaAs or AlSb-InAs high electron mobility transistor (HEMT) heterostructure. The carriers within the 2DEG are spin-polarized by a combination of magnetic and electrostatic barriers. The magnetic barriers are supplied by a composite FM gate, consisting of two domains made of magnetically hard and soft materials. This gate arrangement breaks the antisymmetry of the fringe B field, and results in a finite spin polarization of the 2DEG current. The B field strength is calculated by considering the pole strength at the gate surfaces and domain boundary, and is significantly weaker than normally assumed. We obtain parameters such as the electrostatic barrier height, Fermi level, and carrier concentration within the 2DEG by a finite-element Poisson calculation, which is self-consistent with the Fermi-Dirac distribution. We calculate the transmission probability and conductance through the 2DEG from these parameter values, assuming a single particle effective mass Hamiltonian and purely ballistic transport. We show that the spin polarization ratio PGis extremely sensitive to the gate bias and HEMT doping concentration. However, the maximum PGis extremely low for AlGaAs-GaAs (0.003%) and even for AlSb-InAs (0.12%) devices, despite a large Lande g factor. These values are many orders of magnitude smaller than previous predictions of close to 100% polarization, obtained by using simpler models. [J635]

"MMIC yield optimisation by design centring and off-chip controllers [Jcentring read as centering]"

The use of short-length III-V technologies is required to design circuits for microwave and millimetre-wave applications showing state-of-the-art performance. The parameter dispersion of such processes requires design techniques to achieve the best trade-off between performance and yield. External control of MMIC bias, based on process parameters estimation, allows yield enhancement even when design centering or feedback-based controls are not effective. A methodology to perform yield-oriented design of MMICs in III-V technologies is proposed. A set of on-chip circuits is used to estimate the value of process parameters; an external controller corrects the bias point in order to achieve the design centring in a parameter region around the estimated values. The proposed technique corrects circuit performance in the presence of parameter values belonging to the distribution tail, where standard techniques fail. The design centering approach and a distance-dependent correlated statistical model of HEMTs are used to design the external controller. The proposed methodology has been applied to design both a transimpedance amplifier and a distributed amplifier for multi-gigabit applications, showing a yield improvement of more than 10% with respect to the design centering approach, and encouraging the use of the proposed methodology for circuit design with short-length III-V technologies. [J636]

"AlGaN-GaN double-channel HEMTs"

We present the design, fabrication, and characterization of AlGaN-GaN double-channel HEMTs. Two carrier channels are formed in an AlGaN-GaN-AlGaN-GaN multilayer structure grown on a sapphire substrate. Polarization field in the lower AlGaN layer fosters formation of a second carrier channel at the lower AlGaN-GaN interface, without creating any parasitic conduction path in the AlGaN barrier layer. Unambiguous double-channel behaviors are observed at both dc and RF. Bias dependent RF small-signal characterization and parameter extraction were performed. Gain compression at a high current level was attributed to electron velocity degradation induced by interface scattering. Dynamic IV measurement was carried out to analyze large-signal behaviors of the double-channel high-electron mobility transistors. It was found that current collapse mainly occurs in the channel closer to device surface, while the lower channel suffers minimal current collapse, suggesting that trapping/detrapping of surface states is mainly responsible for current collapse. This argument is supported by RF large-signal measurement results. [J637]

"Improved reliability of AlGaN-GaN HEMTs using an NH3 plasma treatment prior to SiN passivation"

A passivation method has been developed which reduces the degradation of AlGaN-GaN high electron mobility transistor (HEMT) electrical properties caused by extended dc bias or microwave power operation. The key aspect of this passivation technique is exposure to a low-power NH3plasma prior to SiN deposition. Devices fabricated with the NH3treatment prior to SiN passivation show minimal gate lag and current collapse after extended dc bias operation. In addition, the rate of degradation of the microwave power output while under continuous microwave operation is improved by at least 100 times as compared to SiN passivated HEMTs that were not treated with the NH3plasma. [J638]

"Iridium Schottky contact on In0.52 Al0.48 As"

The Schottky barrier properties of Ir on In0.52Al0.48As have been measured after annealing up to 500°C. The barrier height increases to 818 meV for samples annealed at 475°C, while that of Pt quickly saturates at 800 meV beyond 200°C. The result indicates a potential for Ir as a stable gate metallisation for InAlAs/InGaAs HEMTs. [J639]

"Relationships between common source, common gate, and common drain FETs"

This paper comprehensively analyzes the relationship between common source (CS), common gate (CG), and common drain (CD) field-effect transistors (FETs). The signal and noise parameters of the CG and CD configuration can be obtained directly by using a simple set of formulas from CS signal and noise parameters. All the relationships provide a bi-directional bridge for the transformation between CS, CG, and CD FETs. This technique is based on the combination of an equivalent-circuit model and conventional two-port network signal/noise correlation matrix technique. The derived relationships have universal validity, but they have been verified at 2Ч40 μm gatewidth (number of gate fingers Ч unit gatewidth) double-heterojunction δ-doped AlGaAs/InGaAs/GaAs pseudomorphic high electron-mobility transistor with 0.25-μm gate length. Good agreement has been obtained between calculated and measured results. [J640]

"Investigation of drain-line loss and the S22 kink effect in capacitively coupled distributed amplifiers"

This paper investigates the practical limits of the capacitively coupled distributed amplifier (DA) in terms of common-source output impedance. It is shown that the output impedance of the common-source device is considerably affected by the input coupling circuit. The S22 kink effect is more pronounced in the case of the capacitively coupled circuit. The effect on drain-line loss is very marked, and becomes the practical limitation of the technique. The effect is clearly illustrated by practical measurements on a 45-MHz-20-GHz GaAs monolithic-microwave integrated-circuit amplifier. The kink effect is also shown to be relevant to the output impedance and stability of the common-gate stage in the cascode DA topology. [J641]

"Strained epilayers effectively reduce plasma-induced fluorine damage in P-HEMTs"

We intentionally inserted several strained epilayers, namely In0.5Ga0.5As, InAs, and InSb, as fluorine-trapping barriers in a conventional pseudomorphic high electron mobility transistor (P-HEMT) structure and investigated their effectiveness against plasma-induced fluorine damage using Hall measurements and secondary ion mass spectrometry (SIMS) analysis. The strained barriers effectively diminished plasma-induced fluorine incorporation into deeper layers than the δ-doped layer and improved the carrier density and electron mobility compared with those of the conventional P-HEMT. In particular, when the most strained InSb barrier was inserted into the P-HEMT using post-thermal annealing, the carrier density and electron mobility remarkably recovered to 85% and 97% of their respective values before processing because of diminished fluorine incorporation and reduction of incorporated fluorine from the channel layer to the upper layers. This confirms that highly strained barriers are very effective at suppressing plasma-induced fluorine damage in P-HEMTs. [J642]

"High performances of InP channel power HEMT at 94 GHz"

High power performances at 94 GHz using a large bandgap InP channel high electron mobility transistor (HEMT) on InP substrate containing an InP/AlInAs composite barrier are reported. This 0.1 μm gate HEMT exhibits excellent RF characteristics with cutoff frequencies Ftof 105 GHz and Fmagof 340 GHz which represent the highest frequency performances ever reached for an InP channel HEMT. The first power results demonstrated a maximum output power of 200 mW/mm at 2.5 V of drain voltage with 3.8 dB power gain and power added efficiency of 13.7%. This structure is very promising at such frequency. [J643]

"Beyond G-band: a 235 GHz InP MMIC amplifier"

We present results on an InP monolithic millimeter-wave integrated circuit (MMIC) amplifier having 10-dB gain at

235GHz. We designed this circuit and fabricated the chip in Northrop Grumman Space Technology's (NGST) 0.07-μm InP high electron mobility transistor (HEMT) process. Using a WR3 (220-325GHz) waveguide vector network analyzer system interfaced to waveguide wafer probes, we measured this chip on-wafer for S-parameters. To our knowledge, this is the first time a WR3 waveguide on-wafer measurement system has been used to measure gain in a MMIC amplifier above 230GHz. [J644]

"High breakdown voltage (Al0.3 Ga0.7)0.5 In0.5 P/InGaAs quasi-enhancement-mode pHEMT with field-plate technology"

A high breakdown voltage and a high turn-on voltage (Al0.3Ga0.7)0.5In0.5P/InGaAs quasi-enhancement-mode (E-mode) pseudomorphic HEMT (pHEMTs) with field-plate (FP) process is reported for the first time. Between gate and drain terminal, the transistor has a FP metal of 1 μm, which is connected to a source terminal. The fabricated 0.5Ч150 μm2device can be operated with gate voltage up to 1.6 V owing to its high Schottky turn-on voltage (VON=0.85 V), which corresponds to a high drain-to-source current (Ids) of 420 mA/mm when drain-to-source voltage (Vds) is 3.5 V. By adopting the FP technology and large barrier height (Al0.3Ga0.7)0.5In0.5P layer design, the device achieved a high breakdown voltage of -47 V. The measured maximum transconductance, current gain cutoff frequency and maximum oscillation frequency are 370 mS/mm, 22 GHz, and 85 GHz, respectively. Under 5.2-GHz operation, a 15.2 dBm (220 mW/mm) and a 17.8 dBm (405 mW/mm) saturated output power can be achieved when drain voltage are 3.5 and 20 V. These characteristics demonstrate that the field-plated (Al0.3Ga0.7)0.5In0.5P E-mode pHEMTs have great potential for microwave power device applications. [J645]

"Mechanism of current collapse removal in field-plated nitride HFETs"

An experimental study of the mechanism of RF current collapse removal in high-power nitride-based HFETs is presented. The results show that the conductivity of the dielectric material under the field plate plays a crucial role in the current collapse removal. Identical geometry field plated HFETs differing only in the FP dielectric conductivity show varying degree of current collapse removal. Devices with semiconducting dielectric layers exhibit perfectly linear RF power-drain bias dependence with the output powers of 20 W/mm at 55 V drain bias with essentially no current collapse. A trapped charge discharging model is presented to explain the removal of current collapse in FPd devices. [J646]

"A 90-GHz InP-HEMT lossy match amplifier with a 20-dB gain using a broadband matching technique"

We demonstrated a 90-GHz InP-HEMT lossy match amplifier (LMA) with a 20-dB gain for the first time. The power consumption was 220 mW, which is the smallest ever reported for a broadband amplifier with a bandwidth of over 80 GHz. The amplifier acts as a C-R coupled amplifier in the low to medium frequency range and as an L-C match amplifier at high frequencies. This configuration provides both high gain and wide bandwidth. The key to achieving a bandwidth of over 80 GHz is broadband matching in the L-C match amplifier. In this paper, we propose a broadband matching technique with a low-Q network and describe the design guideline we used to get excellent performance. [J647]

"W-band divide-by-3 frequency divider using 0.1 μm InAlAs/InGaAs metamorphic HEMT technology"

A W-band divide-by-3 frequency divider with wide bandwidth and low power dissipation is presented using harmonic injection-locking technique. A cascode FET is employed for a self-oscillating second-harmonic mixer which is injection-locked by third-harmonic input to obtain the division order of three. The fabricated frequency divider using 0.1 μm GaAs metamorphic HEMT technology shows superior performance such as large bandwidth of 6.1 GHz around 83.1 GHz (7.3%) under small DC power consumption of 12 mW. [J648]

"Wideband balanced AiGaN/GaN HEMT MMIC low noise amplifier"

{no data available} [J649]

"Thermal stability of mo-based schottky contact for AiGaN/GaN HEMT"

{no data available} [J650]

"Enhancement-mode In0.52 Al0.48 As/In0.53 Ga0.47 As/InP HEMT utilising Ir/Ti/Pt/Au gate"

InAlAs/InGaAs/InP enhancement-mode high electron mobility transistors utilising Ir/Ti/Pt/Au gates have been

fabricated and compared to devices with conventional Pt/Ti/Pt/Au gates. Enhancement-mode operation with threshold voltage of 134 mV was achieved for Ir-based devices with 0.25 μm gate length after a short anneal at 250°C. No change was observed in the magnitude of gmbefore and after anneal, indicating low metal diffusivity and high thermal stability for Ir-based devices. [J651]

"Simple, low-cost, subsystem fabrication"

We have successfully developed a simple and low-cost 1.9-GHz, 25-W power amplifier by using only one prematched 50-mm PHEMT with external matching circuits on a FR-4 PCB. As the output stage integrated with other driver stages and dc control circuits, a completed four-stage power-amplifier subsystem is also demonstrated. When operating at 38.5-dBm output power with pi/4-DQPSK signal, the proposed power amplifier subsystem shows low distortion, with better than 75-dBc ACPR (adjacent-channel leakage power ratio) at 600 kHz and 79-dBc ACPR at 900 kHz offset from the center frequency, and is suitable for PHS 500-mW base-station applications. [J652]

"Fabrication and characterization of 100-nm In0.53 Ga0.47 As-In0.52 Al0.48 As double-gate HEMTs with two separate gate controls"

In this letter, we demonstrate successful operation of 100-nm T-gates double-gate high electron mobility transistors with two separate gate controls (Vg1s≠ Vg2s). These devices are fabricated by means of adhesive bonding technique using enzocyclocbutene polymer. The additional gate enables the variation of the threshold voltage Vthin a wide range from -0.68 to -0.12V while keeping high cutoff frequency ftof about 170 GHz and high maximum oscillation frequency fmaxof about 200 GHz. These devices are considered as being very effective for millimeter-wave mixing applications and are promising devices for the fabrication of velocity modulation transistor (VMT) (Sakaki et al., 1982). [J653]

"Efficient analytical formulation and sensitivity analysis of neuro-space mapping for nonlinear microwave device modeling"

A new computer-aided design (CAD) method for automated enhancement of nonlinear device models is presented, advancing the concept of Neuro-space mapping (Neuro-SM). It is a systematic computational method to address the situation where an existing device model cannot fit new device data well. By modifying the current and voltage relationships in the model, Neuro-SM produces a new model exceeding the accuracy limit of the existing model. In this paper, a novel analytical formulation of Neuro-SM is proposed to achieve the same accuracy as the basic formulation of Neuro-SM (known as circuit-based Neuro-SM) with much higher computational efficiency. Through our derivations, the mapping between the existing (coarse) model and the overall Neuro-SM model is analytically achieved for dc, small-signal, and large-signal simulation and sensitivity analysis. The proposed analytical formulation is a significant advance over the circuit-based Neuro-SM, due to the elimination of extra circuit equations needed in the circuit-based formulation. A two-phase training algorithm utilizing gradient optimization is also developed for fast training of the analytical Neuro-SM models. Application examples on modeling heterojunction bipolar transistor (HBT), metal-semiconductor-field-effect transistor (MESFET), and high-electron mobility transmistor (HEMT) devices and the use of Neuro-SM models in harmonic balance simulations demonstrate that the analytical Neuro-SM is an efficient approach for modeling various types of microwave devices. It is useful for systematic and automated update of nonlinear device model library for existing circuit simulators. [J654]

"220-GHz metamorphic HEMT amplifier MMICs for high-resolution imaging applications"

In this paper, the development of 220-GHz low-noise amplifier (LNA) MMICs for use in high-resolution active and passive millimeter-wave imaging systems is presented. The amplifier circuits have been realized using a well-proven 0.1-μm gate length and an advanced 0.05-μm gate length InAlAs/InGaAs based depletion-type metamorphic high electron mobility transistor technology. Furthermore, coplanar circuit topology in combination with cascode transistors was applied, leading to a compact chip size and an excellent gain performance at high millimeter-wave frequencies. A realized single-stage 0.05-μm cascode LNA exhibited a small-signal gain of 10 dB at 222 GHz, while a 0.1-μm four-stage amplifier circuit achieved a linear gain of 20 dB at the frequency of operation and more than 10 dB over the bandwidth from 180 to 225 GHz. [J655]

"Improved low-frequency-noise characteristic of selectively hydrogen-pretreated quasi-enhancement HEMTs"

A quasi-enhancement-mode (QE) HEMT having an improved low-frequency-noise characteristic was fabricated using a selective hydrogen pretreatment (SHP). The QE HEMT showed a reduction of low-frequency noise

bulges compared with those of depletion-mode HEMT without an SHP, leading to a one-order smaller input noise spectral density at 100 Hz. [J656]

"Si-induced enhancement of ohmic performance of Ti/Al/Mo/Au metallisation for AlGaN/GaN HEMTs"

Incorporation of Si is shown to induce an improvement in the ohmic performance of Ti/Al/Mo/Au metallisation on MOCVD-grown AlGaN/GaN heterostructures. Optimised contact resistance (Rc) and specific contact resistivity (ρc) of Ti/Si/Al/Si/Mo/Au metallisation are 0.16 Ω · mm and 6.77Ч10-7Ω · cm2in comparison to 0.41 Ω · mm and 4.78Ч10-6Ω · cm2obtained for Ti/Al/Mo/Au metallisation. Auger electron spectroscopy analysis indicates that Si containing inter-metallics formation is responsible for enhancement of ohmic performance. [J657]

"High switching performance 0.1-μm metamorphic HEMTs for low conversion loss 94-GHz resistive mixers"

We report high switching performance of 0.1-μm metamorphic high-electron mobility transistors (HEMTs) for microwave/millimeter-wave monolithic integrated circuit (MMIC) resistive mixer applications. Very low source/drain resistances and gate capacitances, which are 56 and 31% lower than those of conventional pseudomorphic HEMTs, are due to the optimized epitaxial and device structure. Based on these high-performance metamorphic HEMTs, a 94-GHz MMIC resistive mixer was designed and fabricated, and a very low conversion loss of 8.2 dB at a local oscillator power of 7 dBm was obtained. This is the best performing W-band resistive field-effect transistor mixer in terms of conversion loss utilizing GaAs-based HEMTs reported to date. [J658]

"High-performance 0.1-μm In0.4 AlAs/In0.35 GaAs MHEMTs with Ar plasma treatment"

High-performance 0.1-μm In0.4AlAs/In0.35GaAs metamorphic high-electron mobility transistors (MHEMTs) on GaAs substrate have been successfully fabricated with Ar plasma treatment. Before the gate Schottky metallization, the devices were treated with Ar plasma, which might clean and improve the surface of exposed barrier layer. The devices fabricated with Ar plasma treatment exhibited the excellent characteristics such as 50% reduction of the reverse gate leakage currents, the improved Schottky ideality factor of 1.37, high extrinsic transconductance of 700 mS/mm, and high maximum drain current density of 780 mA/mm. And the cutoff frequency fTas high as 210 GHz was achieved. To our knowledge, this is the best reported cutoff frequency for a 0.1-μm MHEMT with an indium content of 35% in the channel. [J659]

"Highly integrated 60 GHz transmitter and receiver MMICs in a GaAs pHEMT technology"

Highly integrated transmitter and receiver MMICs have been designed in a commercial 0.15 μm, 88 GHz fT/183 GHz fMAXGaAs pHEMT MMIC process and characterized on both chip and system level. These chips show the highest level of integration yet presented in the 60 GHz band and are true multipurpose front-end designs. The system operates with an LO signal in the range 7-8 GHz. This LO signal is multiplied in an integrated multiply-by-eight (X8) LO chain, resulting in an IF center frequency of 2.5 GHz. Although the chips are inherently multipurpose designs, they are especially suitable for high-speed wireless data transmission due to their very broadband IF characteristics. The single-chip transmitter MMIC consists of a balanced resistive mixer with an integrated ultra-wideband IF balun, a three-stage power amplifier, and the X8 LO chain. The X8 is a multifunction design by itself consisting of a quadrupler, a feedback amplifier, a doubler, and a buffer amplifier. The transmitter chip delivers 3.7±1.5 dBm over the RF frequency range of 54-61 GHz with a peak output power of 5.2 dBm at 57 GHz. The single-chip receiver MMIC contains a three-stage low-noise amplifier, an image reject mixer with an integrated ultra-wideband IF hybrid and the same X8 as used in the transmitter chip. The receiver chip has 7.1±1.5 dB gain between 55 and 63 GHz, more than 20 dB of image rejection ratio between 59.5 and 64.5 GHz, 10.5 dB of noise figure, and -11 dBm of input-referred third-order intercept point (IIP3). [J660]

"High-power AlGaN/GaN HEMTs for Ka-band applications"

We report on the fabrication and high-frequency characterization of AlGaN/GaN high-electron mobility transistors (HEMTs) grown by molecular beam epitaxy (MBE) and metal-organic chemical vapor deposition (MOCVD). In devices with a gate length of 160 nm, a record power density of 10.5 W/mm with 34% power added efficiency (PAE) has been measured at 40 GHz in MOCVD-grown HEMTs biased at VDS=30 V. Under similar bias conditions, more than 8.6 W/mm, with 32% PAE, were obtained on the MBE-grown sample. The dependence of output power, gain, and PAE on gate and drain voltages, and frequency have also been analyzed. [J661]

"50-nm T-gate metamorphic GaAs HEMTs with fT of 440 GHz and noise figure of 0.7 dB at 26 GHz"

GaAs-based transistors with the highest fTand lowest noise figure reported to date are presented in this letter. A 50-nm T-gate In0.52Al0.48As/In0.53Ga0.47As metamorphic high-electron mobility transistors (mHEMTs) on a GaAs substrate show fTof 440 GHz, fmaxof 400 GHz, a minimum noise figure of 0.7 dB and an associated gain of 13 dB at 26 GHz, the latter at a drain current of 185 mA/mm and gmof 950 mS/mm. In addition, a noise figure of below 1.2 dB with 10.5 dB or higher associated gain at 26 GHz was demonstrated for drain currents in the range 40 to 470 mA/mm at a drain bias of 0.8 V. These devices are ideal for low noise and medium power applications at millimeter-wave frequencies. [J662]

"A new small-signal modeling approach applied to GaN devices"

A new small-signal modeling approach applied to GaN-based devices is presented. In this approach, a new method for extracting the parasitic elements of the GaN device is developed. This method is based on two steps, which are: 1) using cold S-parameter measurements, high-quality starting values for the extrinsic parameters that would place the extraction close to the global minimum of the objective function for the distributed equivalent circuit model are generated and 2) the optimal model parameter values are searched through optimization using the starting values already obtained. The bias-dependent intrinsic parameter extraction procedure is improved for optimal extraction. The validity of the developed modeling approach and the proposed small-signal model is verified by comparing the simulated wide-band small-signal S-parameter, over a wide bias range, with measured data of a 0.5-μm GaN high electron-mobility transistor with a 2Ч50 μm gatewidth. [J663]

"Enhanced-performance of AlGaN-GaN HEMTs grown on grooved sapphire substrates"

We report significantly improved dc characteristics and RF performance of AlGaN-GaN HEMTs grown on grooved sapphire substrates. Grooves 60 nm deep with 2-μm-wide ridges and 4-μm-wide trenches were created along the orientation of the substrate by inductively coupled-plasma reactive ion etching. Device mesas were defined over the trench regions where superior crystalline quality was observed by other characterization techniques. Compared to conventional HEMTs grown on the planar area, the devices on the grooved substrate show increased drain saturation current and peak transconductance. Their reverse gate leakage current is over three orders of magnitude lower. These devices also show increased off-state breakdown voltage with hard breakdown characteristics. For nominal 1-μm-gate-length HEMTs, the best current gain and power gain cutoff frequencies were 15 and 54 GHz, respectively. The on-wafer output power, gain, and power-added efficiency of an unpassivated device measured at 4 GHz were 3.26 W/mm, 25.7 dB, and 55.6%. The enhanced performance is attributed to low-density mixed dislocations and high crystalline quality over the trench regions. [J664]

"Direct integration of GaAs HEMTs on AlN ceramic substrates using fluidic self-assembly"

Direct integration of AlGaAs/GaAs HEMTs on AlN ceramic substrates has been demonstrated based on the fluidic self-assembly (FSA) technology. The FSA is a unique technology to arrange small device blocks (around a few tens of microns) onto the other substrates. With this technology the core part of the HEMT having no pad can be mounted on the ceramic substrate. The HEMT core can then be connected electrically with the circuit on a ceramic substrate using a planar wiring process. This eliminates large stray capacitance and inductance in the conventional technology. It has been demonstrated that the good FET characteristics are obtained even after FSA process. [J665]

"High-power operation of III-N MOSHFET RF switches"

We describe a large-signal performance of novel high-power radio frequency (RF) switches based on III-nitride insulated gate metal-oxide semiconductor heterostructure field-effect transistors (MOSHFETs). The maximum switching powers for a single MOSHFET with only 1-mm gate width exceed 50W at 10GHz, more than an order of magnitude higher than those achievable using GaAs transistors. In the ON state, the highest powers are determined by the device peak drain currents, 1-2A/mm for the state-of-the art III-N MOSHFETs; in the OFF state their maximum powers are limited by the breakdown voltage, normally well above 100V. Our experimental data are in close agreement with large-signal simulations and the proposed simple analytical model. We also show that the insulating gate design allows for broader bandwidth and higher switching powers and better stability as compared to conventional Schottky gate transistors. [J666]

"Simulations of direct-die-attached microchannel coolers for the thermal management of GaN-on-SiC microwave amplifiers"

This paper presents finite-element thermo-mechanical simulation studies of microchannel-based techniques to cool AlGaN/GaN high electron mobility rf transistors grown on SiC substrates. A number of problems are considered, including standard thickness dies on both oxygen-free-high-conductivity (OFHC) copper and AlN microchannel coolers, as well as thinned dies on a hybrid diamond/silicon microchannel cooler. The active device sizes and cooling strategies selected are relevant to X-band (10 GHz) amplifiers dissipating 50-100 W of steady-state waste heat. The effects of die attach materials on device temperature and mechanical stresses are studied. The plastic yielding behaviors of the die attach material and other metallic portions of the package are incorporated into the analysis. The removal of 100 W of steady-state waste heat in an example X-band compatible device is found to be consistent with 140-185°C maximum transistor junction temperatures and tolerable mechanical stresses. [J667]

"InP HEMT downscaling for power applications at W band"

We have developed new solutions for InP high-electron mobility transistor (HEMT) scaling for power applications at W band. We have shown that the use of a small barrier thickness in order to respect the aspect ratio for a 70-nm gate length results in a significant kink effect and high gate source capacitances. We have also shown through a theoretical study that a structure containing an InP layer between the cap layer and the barrier would support both the frequency performances and the breakdown voltage. Thus, we propose an HEMT structure containing a thick InP/AlInAs composite barrier and where the gate is buried into the barrier. This enables us to respect the aspect ratio and simultaneously to obtain an important drain current density without observing any kink effect. Moreover, we have applied this process to structures containing innovative large band-gap InP and InAsP channels. We have achieved the best frequency performances ever reached for an InP channel HEMT structure. Power measurements at 94 GHz were performed on these devices. The InAsP channel HEMT demonstrated a maximum output power of 260 mW/mm at 3 V of drain voltage with 5.9-dB power gain and a power-added efficiency of 11%. These results are favorably comparable to the state-of-the-art of InP-based HEMT at this frequency. [J668]

"A fully matched high linearity 2-W PHEMT MMIC power amplifier for 3.5 GHz applications"

A 2-W monolithic microwave integrated circuit power amplifier, operating between 3.3 and 3.8GHz by implementing AlGaAs/InGaAs/GaAs pseudomorphic high electronic mobility transistor for the applications of wideband code division multiple access, wireless local loop, and multichannel multipoint distribution service, is demonstrated. This two-stage amplifier is designed to fully match 50Ω input and output impedances. With a dual-bias configuration, the amplifier possesses the characteristics of 30.4dB small-signal gain and 34dBm 1-dB gain compression power with 37.1% power added efficiency. Moreover, with a single carrier output power level of 24dBm, high linearity with a 43.5-dBm third-order intercept point operating at 3.5GHz is also achieved. [J669]

"Transient pulsed analysis on GaN HEMTs at cryogenic temperatures"

A pulsed measurement of AlGaN/GaN high electron mobility transistors (HEMTs) current-voltage (I-V) output characteristics from 100 to 300 K temperatures has been systematically investigated, and a significant kink is clearly observed, which is more severe at cryogenic temperatures. By comparing the pulsed and dc I-V curves, the kink effect is more significant in the pulsed mode evaluation, which indicates a time constant related mechanism involved in the carrier transport. Moreover, a weak impact ionization by monitoring the gate current in the on-state of device has also been observed, and it is more significant at cryogenic temperatures. [J670]

"Influence of the dynamic access resistance in the gm and fT linearity of AlGaN/GaN HEMTs"

The decrease of transconductance gmand current gain cutoff frequency fTat high drain current levels in AlGaN/GaN high-electron mobility transistors (HEMTs) severely limits the linearity and power performance of these devices at high frequencies. In this paper, the increase of the differential source access resistance rs, with drain current is shown to play an important role in the fall of gmand fT. The increase of rsoccurs due to the quasi-saturation of the electron velocity in the source region of the channel at electric fields higher than 10 kV/cm. This has been confirmed by both experimental measurements and two-dimensional drift-diffusion simulations. Through simulations, we have identified HEMT structures with source implanted regions (or n++cap layers) as good candidates in order to increase the linearity of the gmand fTversus current profile. [J671]

"Field-plated 0.25 μm gate-length AlGaN/GaN HEMTs on 6H-SiC with power density of 9.1 W/mm at 18 GHz"

MOCVD-grown field-plated 0.25 μm gate-length AlGaN/GaN high electron mobility transistors (HEMTs) have been fabricated on 6H-SiC substrates. The devices exhibited maximum drain current density as high as 1.42 A/mm, peak extrinsic transconductance of 437 mS/mm, unity current gain cutoff frequency (fT) of 41 GHz, and

maximum frequency of oscillation (fmax) of 63 GHz. At 18 GHz, a continuous-wave output power density of 9.1 W/mm with power-added-efficiency (PAE) of 23.7% was obtained, yielding the highest reported power performance of AlGaN/GaN HEMTs at 18 GHz. [J672]

"Voltage-driven class E amplifier and applications"

A voltage-driven class E power amplifier topology is presented. The operating principle of the circuit is explained, and measurement results for a MIC implementation using an OMMIC ED02AH 6Ч50 μm pHEMT as the active device are given. At the nominal operating frequency of 870 MHz, the MIC achieves 18 dB maximum gain, produces 18 dBm output power, and a maximum power added efficiency of 93%. [J673]

"Unified analytical model of HEMTs for analogue and digital applications"

A unified model for the I-V characteristics of HEMTs valid for the subthreshold, linear and saturation regions of operation is presented. There is a smooth transition in the current from subthreshold to above threshold and also from linear to saturation. This results in highly continuous channel conductance (gds) and transconductance (gm), which are important circuit parameters in small signal analysis. Comparisons with experimental data show that the model is accurate and valid over a wide range. Further, it is established that the model holds good promise for analogue circuit design by subjecting it to a few benchmark tests. In addition, the model, which was originally developed for n-channel HEMTs, has been suitably modified to predict the I-V characteristics of p-channel HEMTs as well. Finally, an inverter circuit using p-channel HEMT as load and n-channel HEMT as driver has been successfully simulated using the circuit simulator SABER and the nature of the inverter characteristics are found to agree well with the experimental results. [J674]

"Sb-based HEMTs with InAlSb/InAs heterojunction"

Antimonide-based HEMTs with a 0.35 μm gate length have been fabricated with an InAlSb/InAs heterojunction. The new Te-doped MBE material, which does not contain highly-reactive AlSb, exhibits a Hall mobility of 23,500 cm2/V-s and a sheet density of 1.7Ч1012cm-2. The devices have a DC transconductance of 1000 mS/mm and an fTLgproduct of 32 GHz-μm at VDS=0.35 V. [J675]

"10-Gb/s driver amplifier using a tapered gate line for improved input matching"

The use of a tapered gate line in a distributed amplifier (DA) is investigated and applied to the design of a GaAs monolithic microwave integrated circuit 10-Gb/s optical driver amplifier. Improved input matching is achieved near the cutoff frequency by reducing the characteristic impedance successively along the gate line toward the termination. With the improved matching conditions, the voltage ripple on the final resistor termination is reduced. The degree of tapering that can be employed is limited by the low-frequency gain and matching requirements. Detailed analysis and simulation results are used to investigate the advantage of this technique. To demonstrate its practical use, the performance of a 10-Gb/s DA fabricated with Filtronic Compound Semiconductor's 0.5-μm pseudomorphic high electron-mobility transistor technology is presented. [J676]

"Transient thermal characterization of AlGaN/GaN HEMTs grown on silicon"

We studied a temperature increase and a heat transfer into a substrate in a pulsed operation of 0.5 length and 150 μm gate width AlGaN/GaN HEMTs grown on silicon. A new transient electrical characterization method is described. In combination with an optical transient interferometric mapping technique and two-dimensional thermal modeling, these methods determine the device thermal resistance to be 70 K/W after 400 ns from the start of a pulse. We also localized the high-electron mobility transistor heat source experimentally and we extracted a thermal boundary resistance at the silicon-nitride interface of about 7Ч10-8m2K/W. Thermal coupling at this interface may substantially influence the device thermal resistance. [J677]

"Hydrogen-induced changes in the breakdown voltage of InP HEMTs"

In this work, electrical measurements show that the breakdown voltage, BVDG, of InP HEMTs increases following exposure to H2. This BVDGshift is nonrecoverable. The increase in BVDGis found to be due to a decrease in the carrier concentration in the extrinsic portion of the device. We provide evidence that H2reacts with the exposed InAlAs surface in the extrinsic region next to the gate, changing the underlying carrier concentration. Hall measurements of capped and uncapped HEMT samples show that the decrease in sheet carrier concentration can be attributed to a modification of the exposed InAlAs surface. Consistent with this, XPS experiments on uncapped heterostructures give evidence of As loss from the InAlAs surface upon exposure to hydrogen. [J678]

"A coplanar X-band AlGaN/GaN power amplifier MMIC on s.i. SiC substrate"

This work presents a two-stage high-power amplifier monolithic microwave integrated circuit (MMIC) operating between 9 GHz and 11 GHz based on a fully integrated AlGaN/GaN high electron mobility transistor (HEMT) technology on s.i. SiC substrate and is suitable for radar applications. The MMIC device with a chip size of 4.5Ч3 mm2yields a linear gain of 20 dB and a maximum pulsed saturated output power of 13.4 W at 10 GHz equivalent to 3.3 W/mm at VDS=35V, 10% duty cycle, and a gain compression level of 5 dB. Further, dc reliability data are given for the MMIC HEMT technology. [J679]

"High radiation tolerance of In As /Al Sb high-electron-mobility transistors"

InAs/AlSb-based high-electron-mobility transistors (HEMTs) were irradiated with 2MeVprotons. Radiation damage caused the source-drain current Idsto decrease nearly linearly with fluence Phi at a rate of Delta [Ids(Phi)/Ids(0)]/Delta Phi ≈7Ч10-16cm2. Radiation-induced decreases in Idshave been observed for other HEMT material systems, and have been attributed to high-efficiency defect-induced scattering of carriers out of the two-dimensional electron gas. However, in the InAs/AlSbsystem the rate of decrease of Idsis about 140 times less than that for typical GaAs/AlGaAsHEMTs. An explanation is presented in which the high radiation tolerance of InAs/AlSbHEMTs is related to carrier reinjection and the unusually large energy offset between the AlSb barriers and the InAs quantum well. [J680]

"Improved oxide passivation of Al Ga N /Ga N high electron mobility transistors"

MgO has proven effective in the past as a surface passivation layer to minimize current collapse in AlGaN/GaNhigh electron mobility transistors (HEMTs). However, MgO is not environmentally stable and more stable oxides need to be developed. MgCaO can be produced that is lattice matched to the GaN. Three samples were grown with 0%, 50% and 75% of Ca, which had respective lattice mismatches of -6.5%for MgO, -1%for Mg0.50Ca0.50Oand +4%for Mg0.25Ca0.75O. Drain saturation current in HENTs had increases of 4.5% and 1%, respectively, for Mg0.5Ca0.5Oand Mg0.25Ca0.75Opassivated devices. However, there was a 10% decrease for the device passivated with pure MgO. This was due to strain applied on the nitride HEMT by the oxide, which is consistent with the piezoelectric effect in the nitride HEMT by the oxide, which is consistent with the piezoelectric effect in the nitride form the lattice mismatch between AlGaN and GaN. From pulsed measurements, HEMTs passivated with Mg0.5Ca0.5Oand Mg0.25Ca0.75Oshowed higher passivation effectiveness (90% of dc current) then the MgO passivated HEMTs (83% dc current). This is due to the closer lattice matching of these calcium containing oxides and the reduction in interface traps associated with lattice mismatch. [J681]

"High transconductance of 2.25 S/mm observed at 16 K for 195-nm-gate In0.75 Ga0.25 As/In0.52 Al0.48 As HEMT fabricated on [J411]A-oriented InP substrate"

We achieved a maximum transconductance (gm) of 2.25 S/mm at 16 K for a 195-nm-gate In0.75Ga0.25As/In0.52Al0.48As pseudomorphic high-electron mobility transistor (PHEMT) fabricated on a [411]A-oriented InP substrate, which is the highest value ever reported for HEMTs. This PHEMT also showed a much enhanced cutoff frequency (fT) of 310 GHz at 16 K, compared with its room temperature value (245 GHz). The significantly enhanced gmand fTat 16 K can be attributed to the higher saturation velocity in the region "under the gate," which is caused not only by suppressing the phonon scattering, but also by suppressing the interface roughness scattering due to the "(411)A super-flat InGaAs/InAlAs interfaces" (effectively atomically flat heterointerfaces over a wafer-size area). [J682]

"Q-factor characterization of RF GaN-based metal-semiconductor-metal planar interdigitated varactor"

We report the characterization of quality (Q)-factor of RF metal-semiconductor-metal (MSM) planar interdigitated varactors fabricated by standard AlGaN/GaN HEMT process. The MSM varactors have wide tuning range and exhibit high quality-factor at both the maximum and minimum capacitance values. The fundamental limitation of the Q-factor in the medium capacitance range is also revealed. The elimination of ohmic contact resistance in the MSM varactor configuration pushed up the peak Q-factor to 92 at 0.5 GHz and 41 at 1.1 GHz. The operation of the MSM varactor is modeled by a physical equivalent circuit, with which the dependence of the Q-factor over the entire tuning voltage range can be explained. [J683]

"A GaN differential oscillator with improved harmonic performance"

The first AlGaN/GaN HEMT based differential oscillator is reported. The MMIC oscillates at a frequency of 4.16

GHz and provides 22.9 dBm of power from one side at a biasing of Vgs-1 V and Vds20 V. The HEMTs each have a 0.7 µmЧ200 µm gate. The second harmonic is 45 dB below the carrier and the third harmonic is more than 70 dB below the carrier. To our knowledge, this is the best reported harmonic performance for a GaN oscillator. The oscillator efficiency is between 4% and 9.4% depending on bias. The measured phase noise is -86.3 dBc and -115.7 dBc at offsets of 100 kHz and 1 MHz respectively. The phase noise at a 1 MHz offset is similar to the noise performance of FET based differential oscillators in other technologies. [J684]

"A D-band frequency doubler MMIC based on a 100-nm metamorphic HEMT technology"

A coplanar single-ended frequency doubler based on a 100 nm metamorphic HEMT technology is presented. For an input power of 4.8 dBm, this doubler demonstrates an output power between 2.6 and -0.3 dBm over the bandwidth from 105 to 145 GHz, that is, a 3-dB bandwidth of 32% has been achieved. To the knowledge of the authors, this is the first reported multiplier based on MHEMT technology at D-band or higher frequencies. [J685]

"Room-temperature InAlAs /InGaAs /InP planar resonant tunneling-coupled transistor"

We report an experimental demonstration of room-temperature InAlAs/InGaAs/InPplanar two-dimensional to two-dimensional resonant tunneling-coupled transistors, in which the tunneling characteristics such as negative differential resistance and peak current are controlled by a surface Schottky gate similar to the state-of-the-art high-electron-mobility transistors (HEMT) with high gain. The tunneling peak voltage was modulated linearly with the Schottky gate voltage with a ratio of nearly unity. Functionality of the device can also be switched between HEMT and tunneling transistor mode. The fabrication process is fully compatible with conventional HEMT processes, offering a fully integrable and scalable tunneling transistor technology. [J686]

"40-Gb/s wide-band MMIC pHEMT modulator driver amplifiers designed with the real frequency technique"

With the use GaAs pseudomorphic high electron-mobility transistor technology, the bandwidth performances of Cherry-Hooper driver amplifiers need to be improved. To fulfill these requirements, we propose an original driver circuit topology dedicated to 40-Gb/s optical communication systems. To flatten the transducer gain response of the circuit, passive networks have been added in the design. These networks have been optimized by means of the real frequency technique (RFT). A modified procedure of the classical RFT is introduced to perform the optimization in the presence of an overall resistive feedback. [J687]

"Novel multimode J-pHEMT front-end architecture with power-control scheme for maximum efficiency"

Based upon a unique junction pseudomorphic high electron-mobility transistor (J-pHEMT) device, a novel method of providing high-efficiency power amplifier (PA) power control for variable envelope modulation schemes is demonstrated for enhanced data rates for global system for mobile communications evolution and wide-band code division multiple access. This new technique, based upon the use of a linear PA, was extended to provide a simple, but highly effective method of PA efficiency enhancement based upon dynamic adaptive bias control. Together, the architecture allows for substantially higher efficiency levels compared with conventional linear solutions over the entire range of handset operating conditions, while avoiding the necessity for complex control loops and linearization schemes. Furthermore, it is shown that the characteristics of the J-pHEMT, when used with this architecture, can be exploited to facilitate an efficient and completely novel single-chip PA plus antenna switch to substantially reduce the RF complexity of a cellular handset. [J688]

"An X-band front-end module using HTS technique for a commercial dual mode radar"

A front end module of receiver has been designed to eliminate the interference between the tracking and searching radar used in commercial radar application. The module is located at the receiving path of the searching radar. The proposed module includes two parts, the HTS superconducting filter and cryogenic low noise amplifier. The bandwidth of the eight-resonator HTS hairpin filter is 2% at the X-band frequency. Low insertion loss (below1 dB) and good skirt rejection (down to 60 dB at 50 MHz from the pass-band edge) are obtained. The two-stage low noise amplifier is designed by commercial low noise HEMT devices, NE321000. Two Lange couplers are located at output and input port of each amplifier stage to improve the return loss and to make LNA easily match to optimal low noise impedence. The cryogenic amplifier shows 30 dB gain and 0.4 dB NF at 77 K in X-band. A very high rejection is necessary for the elimination of unwanted spurious signals. The acceptable specification is 110 dB down at 500 MHz away from the band-edge of the filter. In general, the skirt rejection of a hairpin HTS filter is pretty good near the pass-band edge, but may become worse far from the pass-band edge. To meet the requirement of this commercial radar application, a high rejection suspended

stripline filter is put after the low noise amplifier. The whole module shows an maximal NF of 1.5 dB, a gain of 25 dB around pass-band frequencies, and a rejection of better than 110 dB at 500 MHz away from the band edge of the filter. It totally solves the interference problem in this dual mode radar. [J689]

"V-band high-order harmonic injection-locked frequency-divider MMICs with wide bandwidth and low-power dissipation"

In this paper, V-band high-order frequency divider monolithic microwave integrated circuits (MMICs) showing wide bandwidth and low-power dissipation are presented. For high-order (divide-by-four) frequency division, a super-harmonic signal is injected into a self-oscillating subharmonic mixer loop consisting of cascode field-effect transistors (FETs). Cascode FET-based harmonic injection locking allows high-frequency operation, simple circuit configuration, reduced FET count, and thus, low dc power consumption. Bias circuits and quarter-wavelength stubs are used to effectively suppress unwanted harmonic and spurious signals in the oscillation loop. A simple analysis method employing two-tone harmonic-balance simulation and an ideal directional coupler is developed to optimize the performance of the high-order divider. The designed V-band frequency dividers are fabricated with a commercial 0.15-μm GaAs pseudomorphic high electron-mobility transistor foundry. The measurement of a divide-by-four MMIC shows a bandwidth of 2.81 GHz around 64.0 GHz under very small dc power consumption of 7.5 mW. The circuit concept has been extended to a divide-by-five MMIC by adding a frequency doubler in the feedback loop, which shows the bandwidth of 1.02 GHz at V-band. To the best of our knowledge, the frequency dividers of this study show the best performance in terms of division order and dc power consumption among the reported millimeter-wave analog frequency dividers at V-band and above. [J690]

"Electrical detection of immobilized proteins with ungated AlGaN /GaN high-electron-mobility Transistors"

Ungated AlGaN/GaNhigh-electron-mobility transistor (HEMT) structures were functionalized in the gate region with aminopropyl silane. This serves as a binding layer to the AlGaN surface for attachment of fluorescent biological probes. Fluorescence microscopy shows that the chemical treatment creates sites for specific absorption of probes. Biotin was then added to the functionalized surface to bind with high affinity to streptavidin proteins. The HEMT drain-source current showed a clear decrease of 4mu Aas this protein was introduced to the surface, showing the promise of this all-electronic detection approach for biological sensing. [J691]

"Dynamic redistribution of the electric field of the channel in Al Ga N /Ga N high electron mobility transistor with nanometer-scale gate length"

Transport peculiarities and the physical origin of noise properties in AlGaN/GaN-based high electron mobility transistors (HEMTs) with a large ratio of channel length to gate length were investigated. Dependence of deviations of low-frequency noise spectra from the 1/flaw on applied gate voltages was studied in an extended range of frequencies. The behavior is explained in terms of a model based on the dynamic redistribution of the electric field along the two-dimensional channel of the HEMT. The results show that the main contribution to the noise originates from the region under the gate and adjacent to the gate channel regions. [J692]

"Reliability of 50 nm low-noise metamorphic HEMTs and LNAs"

The long-term stability of a 50 nm low-noise metamorphic HEMT technology has been investigated by biased accelerated lifetime tests on both MHEMT devices and two-stage LNAs for W-band applications. The lifetime tests were performed at three channel temperatures, a drain voltage of 1 V and a power density of 0.3 W/mm in air. Based on a -10% degradation of gm maxfailure criterion an activation energy of 1.6 eV and a projected median lifetime of 2.7Ч106h at Tch=125°C were determined. The two-stage LNAs were stressed at a channel temperature of 185°C for 4000 h. The S-parameters did not show any significant degradation after 4000 h of stress time if the positive threshold voltage shift was compensated for by a corresponding increase of the gate voltage. The reliability results demonstrate the stable operation of 50 nm MHEMTs and LNAs for W-band applications and beyond. [J693]

"Measurements of thermally induced nanometer-scale diffusion depth of Pt /Ti /Pt /Au gate metallization on InAlAs /InGaAs high-electron-mobility transistors"

Platinum diffusion in InAlAs was investigated utilizing a Pt/Ti/Pt/Augate contact on an In0.52Al0.48As/In0.53Ga0.47As/InPhigh-electron-mobility transistor (HEMT) structure. Capacitance-voltage measurements on large gate field-effect transistors and high-resolution cross-sectional transmission electron microscopy enabled the measurement of Pt diffusion depth with nanometer-scale accuracy. A continuous increase in Pt diffusion depth was observed at an annealing temperature of 250 °C with increasing time. After a

40 min anneal, a diffusion depth of 8 nm was measured. Such a deep Pt diffusion in a HEMT structure not only changes device parameters but also constitutes a serious reliability problem during device operation. [J694]

"AlGaN/GaN-based diodes and gateless HEMTs for gas and chemical sensing"

The characteristics of Pt/GaN Schottky diodes and Sc2O3/AlGaN/GaN metal-oxide semiconductor (MOS) diodes as hydrogen and ethylene gas sensors and of gateless AlGaN/GaN high-electron mobility transistors (HEMTs) as polar liquid sensors are reported. At 25°C, a change in forward current of 6 mA at a bias of 2 V was obtained in the MOS diodes in response to a change in ambient from pure N2to 10% H2/ 90% N2. This is approximately double the change in forward current obtained in Pt/GaN Schottky diodes measured under the same conditions. The mechanism appears to be formation of a dipole layer at the oxide/GaN interface that screens some of the piezo-induced channel charge. The MOS-diode response time is limited by the mass transport of gas into the test chamber and not by the diffusion of atomic hydrogen through the metal/oxide stack, even at 25°C. Gateless AlGaN/GaN HEMT structures exhibit large changes in source-drain current upon exposing the gate region to various polar liquids, including block co-polymer solutions. The polar nature of some of these polymer chains lead to a change of surface charges in gate region on the HEMT, producing a change in surface potential at the semiconductor/liquid interface. The nitride sensors appear to be promising for a wide range of chemicals, combustion gases and liquids. [J695]

"Broadband microwave noise characteristics of high-linearity composite-channel Al0.3 Ga0.7 N/Al0.05 Ga0.95 N/GaN HEMTs"

We report broadband microwave noise characteristics of a high-linearity composite-channel HEMT (CC-HEMT). Owing to the novel composite-channel design, the CC-HEMT exhibits high gain and high linearity such as an output third-order intercept point (OIP3) of 33.2 dBm at 2 GHz. The CC-HEMT also exhibits excellent microwave noise performance. For 1-μm gate-length devices, a minimum noise figure (NFmin) of 0.7 dB and an associated gain (Ga) of 19 dB were observed at 1 GHz, and an (NFmi) of 3.3 dB and a Gaof 10.8 dB were observed at 10 GHz. The dependence of the noise characteristics on the physical design parameters, such as the gate-source and gate-drain spacing, is also presented. [J696]

"High-performance enhancement-mode AlGaN/GaN HEMTs using fluoride-based plasma treatment"

We report a novel approach in fabricating high-performance enhancement mode (E-mode) AlGaN/GaN HEMTs. The fabrication technique is based on fluoride-based plasma treatment of the gate region in AlGaN/GaN HEMTs and post-gate rapid thermal annealing with an annealing temperature lower than 500°C. Starting with a conventional depletion-mode HEMT sample, we found that fluoride-based plasma treatment can effectively shift the threshold voltage from -4.0 to 0.9 V. Most importantly, a zero transconductance (gm) was obtained at Vgs=0 V, demonstrating for the first time true E-mode operation in an AlGaN/GaN HEMT. At Vgs=0 V, the off-state drain leakage current is 28 μA/mm at a drain-source bias of 6 V. The fabricated E-mode AlGaN/GaN HEMTs with 1 μm-long gate exhibit a maximum drain current density of 310 mA/mm, a peak gmof 148 mS/mm, a current gain cutoff frequency fTof 10.1 GHz and a maximum oscillation frequency fmaxof 34.3 GHz. [J697]

"94 GHz high power performances of InAs0.4 P0.6 channel HEMTs on InP"

High power performances at 94 GHz using an innovating large bandgap InAsP channel high electron mobility transistor on InP substrate containing an InP/AlInAs composite barrier are reported. This 100 nm gate HEMT exhibits a high current density of 600 mA/mm, and an extrinsic transconductance of 850 mS/mm. The off state breakdown is greater than 5.5 V and defined at a gate current density of 1 mA/mm. At 94 GHz, they demonstrated a maximum output power of 260 mW/mm at 3 V of drain voltage with 5.9 dB power gain and a power added efficiency (PAE) of 11%. This is believed to be the best combination between output power density and power gain of any InP HEMT reported at this frequency. [J698]

"A high-power W-band pseudomorphic InGaAs channel PHEMT"

In this letter, we present the process and power microwave measurements of 0.07-μm Al0.25Ga0.75As/In0.22Ga0.78As pseudomorphic high-electron mobility transistors (PHEMTs). These devices are passivated and exhibit a Ft of 125 GHz, a current density of 750 mA/mm associated to a high breakdown voltage of 4 V at open channel. Careful power measurements performed at 94 GHz have allowed to demonstrate for the first time an output power of 876 mW/mm associated with 5.7-dB power gain and a power added efficiency of 29% on a PHEMT on GaAs substrate. [J699]

"Large-signal performance of deep submicrometer AlGaN/AlN/GaNHEMTs with a field-modulating plate"

This is the first time that the microwave performance of a 0.1-μm gate in a silicon nitride window opening, with a field-modulating plate on an AlGaN/AlN/GaN heterojunction structure, is reported. The material structure was grown by organometallic vapor phase epitaxy on SiC substrates with an averaged channel sheet resistance of 313.5 ohms/square. Approximately 80-nm-thick plasma-enhanced chemical vapor deposition silicon nitride is used as the dielectric between gate metal extension and semiconductor surface. Transistors of a total gate width of 250 μm and a 0.1 μm gate footprint, with a 0.36 μm long overhang on top of the silicon nitride, can be operated at a drain bias of 40-V high. Output power density of 9.5 W/mm, with 36% power-added efficiency in class AB regime, was demonstrated at 10 GHz in a continuous wave power measurement. [J700]

"Stable CW operation of field-plated GaN-AlGaN MOSHFETs at 19 W/mm"

We report for the first time the dc and radio frequency (RF) operation of a field-plated GaN-AlGaN metal-oxide-semiconductor heterostructure field effect transistor (MOSHFET). At 2 GHz and an RF output power level of 19 W/mm (drain bias 55 V), the device exhibited a remarkably stable operation for times in excess of 100 h. In contrast, a similar geometry HFET from the same wafer continuously degraded from 17 W/mm down to 14 W/mm within the first 20 h. We attribute the stable performance of the MOSHFET at high microwave powers to the extremely low gate-leakage currents and the current collapse-free operation resulting from the field-plated design. [J701]

"AlGaN/GaN HEMTs on Si substrate with 7 W/mm output power density at 10 GHz"

The first 10 GHz power performance of AlGaN/GaN HEMTs on silicon substrate is reported. Molecular beam epitaxy grown AlGaN/GaN heterostructure and field-plate gates with 0.3 μm length are employed to fabricate the devices on 2-inch Si (111) substrates. A maximum current density of 850 mA/mm and an extrinsic transconductance of 220 mS/mm are achieved. Load pull measurements at 10 GHz demonstrate a continuous-wave output power density of 7 W/mm, which is the highest power density reported to date for an Si-based transistor. A peak power added efficiency of 52% is achieved for these devices at 10 GHz. [J702]

"Behaviour of logic gates fabricated on Si/SiGe MODFET technology"

The behaviour of two fabricated logic gates using n-type Si/SiGe MODFETs is reported. S-parameter measurements show that the voltage separation between states at 20 GHz is 15 dB for the NAND gate and 8 dB for the NOR gate. The measured DC levels of the outputs allow the possibility of cascading the gates for use in more complex circuits. [J703]

"10 Gbit/s series-connected voltage-balancing pulse driver with high-speed input buffer"

A series-connected voltage-balancing pulse driver employing direct-coupled current switch architecture with a high-driving-capability input buffer and 0.1 μm InP HEMTs is presented. By connecting two HEMTs in series the driver can output 3.6 Vppvoltage swing. With the input buffer, the -3 dB limiting bandwidth of the driver increases from 11 to 30 GHz, and the rise and fall times decrease from 33 to 16 and from 37 to 16 ps, respectively. These short rise and fall times enable the driver to output clear 10 Gbit/s eye opening. [J704]

"A Ku-band monolithic receiver for DVB-S applications"

Despite the incessant progress observed in fixed and wireless terrestrial communication networks, satellite systems remain an appealing solution for broadcasting, point-to-point, and multicasting telecommunications, because of undemanding customer equipment and wide coverage capability. In this scenario, digital video broadcasting via satellite (DVB-S) is recognized as one of the main market-attractive telecommunication fields. Up to now, expensive discrete GaAs HEMT or FET devices have been used to build up circuitry for satellite applications at Ku-band. This article presents the first 12-GHz monolithic receiver for DVB-S applications, implemented in a low-cost silicon bipolar technology. The receiver is based on a superheterodyne architecture, employing a fully integrated LO. To comply with the severe LO phase noise requirement of -101 dBc/Hz at a 100 kHz offset from the carrier, an innovative VCO topology was used implementing a three-metal-layer integrated transformer. The performance parameters of the integrated receiver fulfill DVB-S standard specifications. [J705]

"InAlAs-InGaAs double-gate HEMTs on transferred substrate"

We report the fabrication and the dc characterization of the first In0.52Al0.48As-In0.53Ga0.47As long double-

gate (DG) high-electron mobility transistors (HEMTs). These devices have been obtained using a transferred substrate technique. Although the layer structure has not been optimized, a maximum extrinsic transconductance gm of 450 mS/mm is obtained. At the same bias voltage, the drain current Idis 120 mA/mm, which gives a large ratio gm/Idof 3.8 V-, indicating the improvement of the charge control efficiency due to the DG structure. [J706]

"High-order derivatives in measurement of mobility in HEMT devices"

A novel and more accurate approach to the measurement of mobility of GaAs HEMT devices is presented. The new approach employs high-order derivatives as a means of determining the parameters of the proposed new mobility equation. The results presented consider the behaviour of mobility in the linear and saturation bias regions. [J707]

"AlGaN-GaN HEMTs on Si with power density performance of 1.9 W/mm at 10 GHz"

AlGaN-GaN high electron mobility transistors (HEMTs) on silicon substrate are fabricated. The device with a gate length of 0.3-μm and a total gate periphery of 300 μm, exhibits a maximum drain current density of 925 mA/mm at VGS=0 V and VDS=5 V with an extrinsic transconductance (gm) of about 250 mS/mm. At 10 GHz, an output power density of 1.9 W/mm associated to a power-added efficiency of 18% and a linear gain of 16 dB are achieved at a drain bias of 30 V. To our knowledge, these power results represent the highest output power density ever reported at this frequency on GaN HEMT grown on silicon substrates. [J708]

"High-power AlGaN/GaN dual-gate high electron mobility transistor mixers on SiC substrates"

The first demonstration of dual-gate AlGaN/GaN high-electron-mobility transistors (HEMTs) for high-power mixers is presented. The 0.7Ч300 μm gate device achieved the maximum output power of 19.6 dBm and upconversion gain of 11 dB at 2 GHz and 13 dBm and 5 dB at 5 GHz. [J709]

"The effects of isoelectronic Al doping and process optimization for the fabrication of high-power AlGaN-GaN HEMTs"

In order to improve the electrical characteristics of AlGaN-GaN heterostructures for applications in high electron mobility transistors (HEMTs), high-quality AlGaN-GaN was grown by way of metal-organic chemical vapor deposition on sapphire. We applied isoelectronic Al doping into the GaN-channel layers of modified AlGaN-Al-doped GaN channel-GaN heterostructures. We then compared the electrical performance of the fabricated heterostructures with those of conventional AlGaN-GaN heterostructures. The AlGaN-GaN HEMTs that were fabricated achieved power densities of up to 4.2 W/mm, some of the highest values ever reported for 0.25-μm gate length AlGaN-GaN HEMTs. These devices exhibited a maximum drain current density of 1370 mA/mm, a high transconductance of 230 mS/mm, a short-circuit current gain cutoff frequency (fT) of 67 GHz, and a maximum frequency of oscillation (fmax) of 102 GHz. [J710]

"Resonant response of a FET to an AC signal: influence of magnetic field, device length, and temperature"

A theoretical investigation is made of the response of a field-effect transistor (FET) to an incoming electromagnetic radiation in the presence of a perpendicular, weak magnetic field. The influence of an external friction due to electron scattering by impurities and/or phonons, and of the internal friction due to electron-electron scattering, is taken into account. The treatment is valid for a nondegenerate electron gas in which the mean-free path for electron-electron scattering λeeis much smaller than the device length L and than the mean-free path due to collisions with impurities and/or phonons λcoll. These requirements, written as λee≪L≪λcoll, are fulfilled for magnetic fields sufficiently weak that Landau quantization is absent and the electron motion is described within the framework of hydrodynamics. It is demonstrated that a high-electron mobility transistor (HEMT), with a short (long) channel, yields a resonant (nonresonant) response to an ac signal induced by the incoming electromagnetic radiation at the plasma oscillation frequencies of the two-dimensional electrons in the device. Keeping the device length and temperature at control, an applied magnetic field can be tuned to achieve the desired effect on the response of the device. It is observed that the lower the temperature, i.e., the higher the mobility, the higher the responsivity of the device. Such response makes the FET a promising device for new types of sources, detectors, mixers, and multipliers. The HEMT-based devices should, in principle, operate at much higher frequencies than the conventional transit time-limited devices, since the plasma waves propagate much faster than electrons. [J711]

"SiGe HMODFET "KAIST" micropower model and amplifier realization"

The recently published small-signal KAIST model is used successfully to fit the measured RF characteristics of a

novel SiGe n-HMODFET device operating at micropower levels and extracted small-signal model parameters for this device under micropower operation are presented here for the first time. This model is then used to predict the performance of a simple micropower amplifier (sub 300-μW total power consumption), realized in SiGe technology, and a comparison of modeled versus measured data is included. [J712]

"Simulation of quantum transport in monolithic ICs based on In0.53 Ga0.47 As-In0.52 Al0.48 As RTDs and HEMTs with a quantum hydrodynamic transport model"

A new quantum hydrodynamic transport model based on a quantum fluid model is used for numerical calculations of different quantum sized devices. The simulation of monolithic integrated circuits of resonant tunneling structures and high electron mobility transistors (HEMT) based on In053Ga0.47As-In052Al0.48As-InP is demonstrated. With the new model, it is possible to describe quantum mechanical transport phenomena like resonant tunneling of carriers through potential barriers and particle accumulation in quantum wells. Different structure variations, especially the resonant tunneling diode area and the gate width of the HEMT structure, show variable modulations in the output characteristics of the monolithic integrated device. [J713]

"12 W/mm AlGaN-GaN HFETs on silicon substrates"

Al0.26Ga0.74N-GaN heterojunction field-effect transistors were grown by metal-organic chemical vapor deposition on high-resistivity 100-mm Si (111) substrates. Van der Pauw sheet resistance of the two-dimensional electron gas was 300 Ω/square with a standard deviation of 10 Ω/square. Maximum drain current density of 1 A/mm was achieved with a three-terminal breakdown voltage of 200 V. The cutoff frequency and maximum frequency of oscillation were 18 and 31 GHz, respectively, for 0.7-μm gate-length devices. When biased at 50 V, a 2.14-GHz continuous wave power density of 12 W/mm was achieved with associated large-signal gain of 15.3 dB and a power-added efficiency of 52.7%. This is the highest power density ever reported from a GaN-based device grown on a silicon substrate, and is competitive with the best results obtained from conventional device designs on any substrate. [J714]

"Microwave noise characteristics of AlGaN/GaN HEMTs on SiC substrates for broad-band low-noise amplifiers"

This letter reports high-performance passivated AlGaN/GaN high electron-mobility transistors (HEMTs) with 0.25-μm gate-length for low noise applications. The devices exhibited a minimum noise figure (NFmin) of 0.98 dB and an associated gain (Ga) of 8.97 dB at 18 GHz. The noise resistance (Rn), the measure of noise sensitivity to source mismatch, is 31Ω at 18 GHz, which is relatively low and suitable for broad-band low noise amplifiers. The noise modeling analysis shows that the minimum noise figure of the GaN HEMT can be reduced further by reducing noise contributions from parasitics. These results demonstrate the viability of AlGaN/GaN HEMTs for low-noise as well as high power amplifiers. [J715]

"A C-band high-dynamic range GaN HEMT low-noise amplifier"

A C-band low-noise amplifier (LNA) is designed and fabricated using GAN HEMT power devices. The one-stage amplifier has a measured noise figure of 1.6 dB at 6 GHz, with an associated gain of 10.9 dB and IIP3 of 13 dBm. it also exhibits broadband operation from 4-8 GHz with noise figure less than 1.9 dB. The circuit can endure up to 31 dBm power from the input port. Compared to circuits based on other material and technology, the circuit shows comparable noise figure with improved dynamic range and survivability. [J716]

"AlGaN/InGaN HEMTs for RF current collapse suppression"

A report is made on the DC, RF and large-signal pulsed characteristics of unpassivated AlGaN/InGaN/GaN high electron-mobility transistors (HEMTs) grown by molecular beam epitaxy on sapphire substrates. The devices with a 0.5 μm gate-length exhibited relatively flat transconductance (gm) with a maximum drain current of 880 mA/mm, a peak gmof 156 mS/mm, an fTof 17.3 GHz, and an fMAXof 28.7 GHz. In addition to promising DC and RF results, pulsed I-V measurements reveal that there is little current collapse in the AlGaN/InGaN HEMTs. These results indicate that the output power of InGaN channel HEMTs should not be limited by surface-state-related current collapse. [J717]

"Design optimization of AlInAs-GaInAs HEMTs for low-noise applications"

In order to optimize the low-noise performance of 50-nm-gate AlInAs-GaInAs high-electron mobility transistors (HEMTs), by using an ensemble Monte Carlo simulation we study the influence of three important technological parameters on their noise level: the doping of the δ-doped layer, the width of the devices and the length of the recess. The noise behavior of the devices is firstly analyzed in terms of the physics-based P, R, and C

parameters, and then characterized from a practical (circuit oriented) point of view through their four noise parameters: minimum noise figure, Fmin, noise resistance, Rn, and complex input admittance, Yopt(or reflection coefficient, Γopt). We have observed an enhancement of the noise when the δ-doping or the device width are increased (a deterioration parallel to that of fmax). Thus, the optimum noise operation is obtained for the lowest possible values of the δ-doping and device width. However, for small width the effect of the offset parasitic capacitances makes Fminincrease, thus, imposing a limit for the reduction of the noise. Moreover, the increase of Rnfor small W makes the noise tuning condition critical to reach the optimum low-noise operation. We have also confirmed that when shortening the recess length from 100 to 20 nm at each side of the gate Fminis reduced, with a slight deterioration of fmax, while the static characteristics are not modified. [J718]

"Millimeter-wave MMIC passive HEMT switches using traveling-wave concept"

This paper describes the design of millimeter-wave wide-band monolithic GaAs passive high electron-mobility transistor (HEMT) switches using the traveling-wave concept. This type of switch combined the off-state shunt transistors and series microstrip lines to form an artificial transmission line with 50-Ω characteristic impedance. A 15-80-GHz single-pole double-throw (SPDT) switch in conjunction with quarter-wavelength impedance transformers demonstrates an insertion loss of less than 3.6 dB and an isolation of better than 25 dB. Another type of wide-band switch was designed by using a series HEMT switch to replace the quarter-wavelength transformer, and the operating band can be extended to dc. With this scheme, dc-80-GHz single-pole single-throw (SPST) and dc-60-GHz SPDT switches are also developed with compact chip size. From dc to 80 GHz, the insertion loss and isolation of the SPST switch are better than 3 and 24 dB, respectively. The SPDT switch has an insertion loss of better than 3 dB and an isolation of better than 25 dB from dc to 60 GHz. The analysis of circuit characteristics and design procedures are also included. It is concluded that the device periphery can be selected for the desired bandwidth, while the number of transistors is decided to achieve the isolation. [J719]

"High-directivity photonic emitter using photodiode module integrated with HEMT amplifier for 10-Gbit/s wireless link"

We present a high-directivity photonic emitter with a high-gain antenna and waveguide-output photodiode module (WG-PM) for extending the transmission distance of a wireless link that uses a 120-GHz millimeter wave. The module employs a uni-traveling-carrier photodiode, broad-band high electron-mobility transistor (HEMT) amplifier, and planar-circuit-to-waveguide transition substrate. The maximum output power of the WG-PM is 8 dBm at a frequency of 120 GHz, and it has a 3-dB bandwidth of over 16 GHz. The wireless link with the high-directivity photonic emitter achieved 10-Gbit/s wireless data transmission, and using a high-gain Gaussian optic lens antenna and an HEMT amplifier reduced the input optical power necessary for error-free transmission. The transmission characteristics of the link showed that its transmission distance can be extended to over 100 m. [J720]

"Drain current DLTS of AlGaN-GaN MIS-HEMTs"

The transient behavior of AlGaN-GaN MIS-HEMTs were studied by drain current deep level transient spectroscopy. Two electron traps were observed, one of which had similar activation energy to that of defect that was commonly observed in epitaxial GaN. We compared the results with those of AlGaN-GaN HEMTs. The hole-trap-like positive peaks in the DLTS, which were observed in the HEMTs, were not observed in the MIS-HEMTs. It has been pointed out that the positive peaks did not originate from change in hole trap population in the channel but reflected the change in the electron population in the surface states of the HEMT access regions. The gate insulator was effective to suppress not only the gate leakage current but also the surface-state-related signals. [J721]

"A W-band subharmonically pumped monolithic GaAs-based HEMT gate mixer"

A W-band high electron mobility transistor (HEMT) subharmonically pumped (SHP) gate mixer is designed with fixed LO frequency operation. it is fabricated on a 4-mil substrate using 0.15-μm GaAs pHEMT monolithic microwave integrated circuit (MMIC) process. the on-wafer measurement results show that the best conversion loss is about 4.7 dB in the W-band, as a 11-dbm 42-GHz low observable (LO) signal is pumped. To our knowledge, this is the first result on low conversion-loss W-band MMIC SHP HEMT gate mixer. [J722]

"MMIC implementation of non-reciprocal couplers using pHEMT devices"

The distributed amplifier topology has been adapted to form a non-reciprocal coupler which is small in size and broadband. The coupler has been implemented in MMIC form using pHEMT devices and a coupling factor of 5 dB is demonstrated over 2-20 GHz bandwidth. [J723]

"Analysis and modeling of low-frequency noise in resistive FET mixers"

A complete analysis of the low-frequency (LF) noise is performed on resistive field-effect transistor (FET) mixers, where LF noise is created due to the self-mixing process of the local oscillator. First, a new scalable noise model for FETs in an ohmic channel bias regime (Uds≈0 V) has been developed, which uses fluctuating resistances, instead of noise voltage or noise current sources. Measurements on a hybrid single-ended mixer prove a good accuracy of the proposed model and reveal a method to distinguish between the different noise sources. Further investigations discuss the LF noise in balanced mixers and explain the mechanisms of noise generation. All mixers under test operate in X-band (8, ..., 12 GHz) with IF below 1 MHz. [J724]

"A new nonlinear capacitance model of millimeter wave power PHEMT for accurate AM/AM-AM/PM simulations"

A new one-dimensional (1-D) nonlinear gate-source Cgs and gate-drain Cgd capacitance model designed for power-PHEMT transistors is presented. The capacitance values are extracted from measured [S] parameters, along a load-line corresponding to a power performance of an optimum amplifier design. The reliable resulting model predicts adequate power performances with small or large signals in reduced CPU time. This new model is validated by comparisons between load-pull power measurements at 25.5 GHz and harmonic balance simulations. It reveals good accuracy for AM/AM and AM/PM predictions. [J725]

"High-power polarization-engineered GaN/AlGaN/GaN HEMTs without surface passivation"

In this paper, a high-power GaN/AlGaN/GaN high electron mobility transistor (HEMT) has been demonstrated. A thick cap layer has been used to screen surface states and reduce dispersion. A deep gate recess was used to achieve the desired transconductance. A thin SiO2layer was deposited on the drain side of the gate recess in order to reduce gate leakage current and improve breakdown voltage. No surface passivation layer was used. A breakdown voltage of 90 V was achieved. A record output power density of 12 W/mm with an associated power-added efficiency (PAE) of 40.5% was measured at 10 GHz. These results demonstrate the potential of the technique as a controllable and repeatable solution to decrease dispersion and produce power from GaN-based HEMTs without surface passivation. [J726]

"Integration of Bax Sr1-x TiO3 thin films with AlGaN/GaN HEMT circuits"

BaxSr1-xTiO3(BST) thin films have large dielectric constants that can be varied by as much as a factor of 3 with an applied field, making them attractive for radio frequency (RF) circuits as small-area ac bypass/dc blocking capacitors, or high-power varactors. However, BST must be deposited at relatively high temperatures in an oxidizing environment, presenting significant integration challenges for MMIC applications. This letter describes the successful integration of BST films on AlGaN/GaN high electron-mobility transistor (HEMT) monolithic microwave integrated circuits on sapphire substrates. A sacrificial SiO2buffer layer is used to protect the underlying AlGaN during the RF magnetron sputtering of the BST film at an elevated temperature, with a carefully controlled heater ramp rate to avoid degradation of the ohmic contacts on the HEMT. [J727]

"Low damage, Cl2 -based gate recess etching for 0.3-μm gate-length AlGaN/GaN HEMT fabrication"

The traditional dry etching for GaN using the Ar/Cl2mixture gas in the reactive ion etching system has been developed. In order to reduce the surface damage, the additional CH4gas is introduced. However, this approach still has the problems of the residual surface damage and low etching selectivity between the AlGaN and GaN materials. Therefore, the following rapid thermal annealing (RTA) at 700°C is necessary to recover the surface properties. In this study, we proposed the Ar/Cl2/CH4/O2for the GaN gate-recess etching in AlGaN/GaN HEMTs fabrication, which achieves a low surface damage and a high etching selectivity simultaneously. The 0.3 μm gate-length AlGaN/GaN HEMTs present a transconductance of 230 mS/mm, an fTof 48 GHz, and fmaxof 60 GHz, respectively. [J728]

"Method for measuring source resistance Rs in saturation region of GaN HEMT device over bias conditions (Vgs ,Vds)"

To accurately model distortion effects using a large signal model the variation of all the elements of the equivalent circuit model under bias conditions are required. A technique is presented to extract the source resistance Rsunder bias conditions for the aluminium gallium nitride/gallium nitride (AlGaN/GaN) HEMT. The source resistance Rsis found to decrease as Vgsis increased, implying that the conduction channel becomes wider, which indicates a parallel conduction path to the 2D electron-gas. [J729]

"High breakdown voltage AlGaN-GaN HEMTs achieved by multiple field plates"

High-voltage Al0.22Ga0.78N-GaN high-electron mobility transistors have been fabricated using multiple field plates over dielectric passivation layers. The device breakdown voltage was found to increase with the addition of the field plates. With two field plates, the device showed a breakdown voltage as high as 900 V. This technique is easy to apply, based on the standard planar transistor fabrication, and especially attractive for the power switching applications. [J730]

"A 20 mW, 150 GHz InP HEMT MMIC power amplifier module"

This paper describes a power amplifier (PA) module containing an InP high electron mobility transistor (HEMT) monolithic millimeter-wave integrated circuit (MMIC) amplifier chip, designed, and packaged at the Jet Propulsion Laboratory, and fabricated at HRL Laboratories. The module features 20 mW of output power at 150 GHz, with more than 10 mW available in the 148-160 GHz frequency range. [J731]

"30-W/mm GaN HEMTs by field plate optimization"

GaN high-electron-mobility-transistors (HEMTs) on SiC were fabricated with field plates of various dimensions for optimum performance. Great enhancement in radio frequency (RF) current-voltage swings was achieved with acceptable compromise in gain, through both reduction in the trapping effect and increase in breakdown voltages. When biased at 120 V, a continuous wave output power density of 32.2 W/mm and power-added efficiency (PAE) of 54.8% at 4 GHz were obtained using devices with dimensions of 0.55Ч246 μm2and a field-plate length of 1.1 μm. Devices with a shorter field plate of 0.9 μm also generated 30.6 W/mm with 49.6% PAE at 8 GHz. Such ultrahigh power densities are a dramatic improvement over the 10-12 W/mm values attained by conventional gate GaN-based HEMTs. [J732]

"Impact of layer structure on performance of unpassivated AlGaN/GaN/SiC HEMTs"

The performance of unpassivated AlGaN/GaN/SiC HEMTs prepared on different MOVPE grown layer structures is reported. An overall improvement of device characteristics using doped structures in comparison to undoped counterpart is observed. This can be demonstrated by IDSof 0.86 and 1.33 A/mm, gmof 220 and 273 mS/mm, fTof 33 and 43 GHz and fmaxof 54 and 61 GHz for 0.3 μm gate length devices on undoped and doped structures, respectively. The DC/pulsed I-V characteristics as well as power measurements show insignificant RF dispersion of HEMTs on doped structures. These results underline the advantage of doped layer structures for preparation of high-performance AlGaN/GaN HEMTs. [J733]

"Microwave noise performances of AlGaN/GaN HEMTs on semi-insulating 6H-SiC substrates"

High-performance, low-noise AlGaN/GaN high electron mobility transistors (HEMTs) with 0.25 μm gate-length have been fabricated on semi-insulating 6H-SiC substrates. The devices exhibited a unity current gain cutoff frequency (fT) of 52.3 GHz, and maximum frequency of oscillation (fMAX) of 112 GHz. At 10 GHz, a minimum noise figure (NFmin) of 0.75 dB and an associated gain (Ga) of 10.84 dB was obtained when biased at VDS=10 V and IDS=40.6 mA/mm. The corresponding values were 1.15 and 7.49 dB at 18 GHz. These results are the first reported microwave noise characteristics obtained from 0.25 μm gate-length GaN HEMTs on 6H-SiC substrates. The use of 6H-SiC substrates provides an alternative solution to the full commercialisation of GaN-based technologies for low-noise and high-power electronics. [J734]

"Measurement of mobility in HEMT devices using high-order derivatives"

In this paper, a novel approach to the measurement of mobility of GaAs HEMT devices is presented. The new approach employs high-order derivatives as a means of determining the parameters of the proposed new mobility equation. The new approach is compared to established mobility measurement methods, and shown to offer better accuracy. The results presented also consider the behavior of mobility in the linear and saturation bias regions. The mobility value extracted by this new method has permitted improvements to the MESFET/HEMT model when simulating the behavior of the device in the linear region. This is critical in many applications, such as in low current linear-mixing applications. [J735]

"12 W/mm power density AlGaN/GaN HEMTs on sapphire substrate"

Record power performance at 4 GHz has been obtained using field-plated AlGaN/GaN HEMTs on sapphire substrate. High power density (12 W/mm) as well as high efficiency (58%) have been measured. A comparison between devices with and without field plate on the same sample showed a significant reduction in knee-voltage walk-out for the field-plated device, thus enabling high power and efficiency operation. [J736]

"A temperature-dependent nonlinear analytic model for AlGaN-GaN HEMTs on SiC"

A temperature-dependent large-signal model for continuous-wave (CW) and pulsed-mode operation is presented and applied to aluminum gallium nitride, gallium nitride (AlGaN-GaN) high electron-mobility transistors (HEMTs) on silicon-carbide (SiC) substrates. The model includes thermal, RF dispersion, and bias-dependent capacitance model elements, and is suitable for application with a harmonic-balance simulator. Temperature- and bias-dependent on-wafer pulsed I-V and S-parameter measurements from 27°C to 200°C are used to examine trapping and thermal effects, and to determine temperature- and bias-dependent parameterized model coefficients for the nonlinear model. Large-signal measurement and model results are presented for 2 Ч 0.35 μm Ч 125 μm and 12 Ч 0.35 μm Ч 125 μm GaN HEMTs fabricated on SiC. The nonlinear model shows good agreement with measured CW power sweep data at an elevated temperature of 150°C under more than 5-W power dissipation, and with measured pulsed load-pull data. [J737]

"W-band multiplier chipset"

A broadband MMIC multiplier chain has been designed and fabricated using a 0.13 μm pHEMT process. The chipset consists of two broadband multipliers and two power amplifiers. Excellent performance has been obtained from the MMICs, which are targeted at emerging applications in W-band requiring millimetre-wave power over a broad frequency range. [J738]

"100-Gb/s multiplexing and demultiplexing IC operations in InP HEMT technology"

This paper describes the 100-Gb/s multiplexing operation of a selector IC and demultiplexing operation of a D-type flip-flop (D-FF) using production-level 0.1-μm-gate-length InP HEMT IC technology. To boost the operating speed of the selector IC, a selector core circuit directly drives an external 50-Ω load, and is included in the output stage. In addition, a test chip containing the selector and a D-FF to confirm error-free operation of these circuits was designed. The fabricated selector IC exhibited clear eye openings at 100 Gb/s, and its error-free operation was confirmed by using the test chip. [J739]

"Performance of the AlGaN HEMT structure with a gate extension"

The microwave performance of AlGaN/GaN HEMTs at large drain bias is reported. The device structures were grown by organometallic vapor phase epitaxy on SiC substrates with a channel sheet resistance less than 280 ohms/square. The breakdown voltage of the HEMT was improved by the composite gate structure consisting of a 0.35 μm long silicon nitride window with a 0.18 μm long metal overhang on either side. This produced an metal-insulator-semiconductor (MIS) gate extension toward the drain with the insulator, silicon nitride, approximately 40-nm-thick. Transistors with a 150 μm total gate width have demonstrated a continuous wave (CW) 10 GHz output power density and power added efficiency of 16.5 W/mm and 47%, respectively when operated at 60 V drain bias. Small-signal measurements yielded an fTand fmaxof 25.7 GHz and 48.8 GHz respectively. Maximum drain current was 1.3 A/mm at +4 V on the gate, with a knee voltage of 5 V. This brief demonstrates that AlGaN/GaN HEMTs with an optimized gate structure can extend the device operation to higher drain biases yielding higher power levels and efficiencies than have previously been observed. [J740]

"Analysis of surface charging effects in passivated AlGaN-GaN FETs using a MOS test electrode"

Passivated AlGaN-GaN high electron mobility transistor (HEMT) structures are modified by adding a MOS test gate placed between gate and drain to identify surface charge phenomena by stress experiments. A new method is described to identify the vertical position of the charge centroid of charge injected from the gate. In the case investigated, this is within the passivation layer. [J741]

"K-band HBT and HEMT monolithic active phase shifters using vector sum method"

Two monolithic 3-bit active phase shifters using the vector sum method to K-band frequencies are reported in this paper. They are separately implemented using commercial 6-in GaAs HBT and high electron-mobility transistor (HEMT) monolithic-microwave integrated-circuit (MMIC) foundry processes. The MMIC HBT active phase shifter demonstrates an average gain of 8.87 dB and a maximum phase error of 11° at 18 GHz, while the HEMT phase shifter has 3.85-dB average measured gain with 11° maximum phase error at 20 GHz. The 20-GHz operation frequency of this HEMT MMIC is the highest among all the reported active phase shifters. The analysis for gain deviation and phase error of the active phase shifter using the vector sum method due to the individual variable gain amplifiers is also presented. The theoretical analysis can predict the measured minimum root-mean-square phase error 4.7° within 1° accuracy. [J742]

"Power and linearity characteristics of field-plated recessed-gate AlGaN-GaN HEMTs"

Record power density and high-efficiency operation with AlGaN-GaN high-electron mobility transistor (HEMT) devices have been achieved by adopting a field-plated gate-recessed structure. Devices grown on SiC substrate yielded very high power density (18.8 W/mm with 43% power-added efficiency (PAE) as well as high efficiency (74% with 6 W/mm) under single-tone continuous-wave testing at 4 GHz. Devices also showed excellent linearity characteristics when measured under two-tone continuous-wave signals at 4 GHz. When biased in deep-class AB (33 mA/mm, 3% Imax) device maintained a carrier to third-order intermodulation ratio of 30 dBc up to a power level of 2.4 W/mm with 53% PAE; increasing bias current to 66 mA/mm (6% Imax) allowed high linear operation (45 dBc) up to a power level of 1.4 W/mm with 38% PAE. [J743]

"Power performance of AlGaN-GaN HEMTs grown on SiC by plasma-assisted MBE"

We report AlGaN-GaN high electron mobility transistors (HEMTs) grown by molecular beam epitaxy (MBE) on SiC substrates with excellent microwave power and efficiency performance. The GaN buffers in these samples were doped with carbon to make them insulating. To reduce gate leakage, a thin silicon nitride film was deposited on the AlGaN surface by chemical vapor deposition. At 4 GHz, an output power density of 6.6 W/mm was obtained with 57% power-added efficiency (PAE) and a gain of 10 dB at a drain bias of 35 V. This is the highest PAE reported until now at 4 GHz in AlGaN-GaN HEMTs grown by MBE. At 10 GHz, we measured an output power density of 7.3 W/mm with a PAE of 36% and gain of 7.6 dB at 40-V drain bias. [J744]

"Low-noise metamorphic HEMTs with reflowed 0.1-μm T-gate"

A 0.1-μm T-gate fabricated using e-beam lithography and thermally reflow process was developed and applied to the manufacture of the low-noise metamorphic high electron-mobility transistors (MHEMTs). The T-gate developed using the thermally reflowed e-beam resist technique had a gate length of 0.1 μm and compatible with the MHEMT fabrication process. The MHEMT manufactured demonstrates a cutoff frequency fTof 154 GHz and a maximum frequency fmaxof 300 GHz. The noise figure for the 160 μm gate-width device is less than 1 dB and the associated gain is up to 14 dB at 18 GHz. This is the first report of a 0.1 μm MHEMT device manufactured using the reflowed e-beam resist process for T-gate formation. [J745]

"The effect of gate metal interdiffusion on reliability performance in GaAs PHEMTs"

While Ti metal interdiffusion of Ti-Pt-Au gate metal stacks in GaAs pseudomorphic HEMT (PHEMTs) has been explored, the effect of Ti metal interdiffusion on the reliability performance is still lacking. We use a scanning transmission electron microscopy technique to correlate Ti-metal-InGaAs-channel-separation and Ti-sinking-depth with a threshold voltage VT. It has been found that Ti-sinking-depth is insensitive to VT. However, Ti metal interdiffusion reduces the separation of the gate metal and InGaAs channel, thus affecting the Idssdegradation rate. Accordingly, we observe the dependence of ΔIdsson VT. Devices with less negative VTexhibit inferior reliability performance to those devices with more negative VT. The results provide insight into a critical device parameter, VT, for optimizing reliability performance based on Idssdegradation. [J746]

"A broadband PHEMT MMIC distributed doubler using high-pass drain line topology"

A broadband frequency doubler, based on distributed amplifier techniques, has been designed to operate from 11 to 21 GHz. In order to reject the fundamental signal over a broadband frequency range, the conventional low-pass drain line structure was replaced with the high-pass structure. This topology can suppress fundamental signals over broadband without any balanced structure so that the chip size can be more compact. Measured conversion losses of better than 10 dB from 11 to 21 GHz input frequencies are achieved with fundamental signal rejection better than 12 dB. To the best of our knowledge, this is the first demonstration of distributed doubler using the high-pass drain line topology. [J747]

"MMIC power amplifier based on AlGaN/GaN HEMTs at 10 GHz"

A monolithic microwave integrated circuit power amplifier consisting of one 8Ч100 μm AlGaN/GaN transistor has been realised. At 10 GHz the coplanar amplifier delivers 35.7 dBm continuous-wave (CW) output power corresponding to a power density of 4.6 W/mm with 26% maximum power added efficiency (PAE) at the bias point VDS=40 V. Reducing the bias to VDS=25 V results in 34.2 dBm maximum CW output power with 32% PAE at 10 GHz. [J748]

"The energy dependence of proton-induced degradation in AlGaN/GaN high electron mobility transistors"

The effects of proton irradiation at various energies are reported for AlGaN/GaN high electron mobility transistors (HEMTs). The devices exhibit little degradation when irradiated with 15-, 40-, and 105-MeV protons at fluences up to 1013cm-2, and the damage completely recovers after annealing at room temperature. For 1.8-MeV proton irradiation, the drain saturation current decreases 10.6% and the maximum transconductance decreases 6.1% at a fluence of 1012cm-2. The greater degradation measured at the lowest proton energy considered here is caused by the much larger nonionizing energy loss of the 1.8-MeV protons. [J749]

"Monolithic distributed amplifier with active control schemes for optimum gain and group-delay flatness, bandwidth, and stability"

In this paper, active control schemes are presented to optimize the performance of the distributed amplifier (DA) subject to the process variation. A detailed analysis of the DA with mismatched termination loads has been performed, which reveals that pronounced gain and group-delay ripple arises at the low-frequency end from the reflected waves in the artificial transmission line. To solve this problem, an active variable resistor is proposed as the gate-line termination load. The gain and stability of the cascode DA has also been analyzed, which identifies the most critical component determining the tradeoff between the gain-bandwidth product (GBP) and the stability to be the gate feedback resistor of common-gate field-effect transistor. It is also replaced with the active resistor to maximize GBP, while avoiding oscillations. A nine-section cascode DA with active control features is designed and fabricated using commercial GaAs pseudomorphic high electron-mobility transistor foundry. The measurement shows that the gain and group-delay ripple can be minimized, and GBP can be maximized without oscillations by the active bias controls. Active control schemes allow the monolithic DAs to be fine tuned after the fabrication and, thus, can be a robust DA design methodology against process variation and inaccurate device models. [J750]

"High microwave and noise performance of 0.17-µm AlGaN-GaN HEMTs on high-resistivity silicon substrates"

AlGaN-GaN high-electron mobility transistors (HEMTs) based on high-resistivity silicon substrate with a 0.17-µm T-shape gate length are fabricated. The device exhibits a high drain current density of 550 mA/mm at VGS=1 V and VDS=10 V with an intrinsic transconductance (gm) of 215 mS/mm. A unity current gain cutoff frequency (ft) of 46 GHz and a maximum oscillation frequency (fmax) of 92 GHz are measured at VDS=10 V and IDS=171 mA/mm. The radio-frequency microwave noise performance of the device is obtained at 10 GHz for different drain currents. At VDS=10 V and IDS=92 mA/mm, the device exhibits a minimum-noise figure (NFmin) of 1.1 dB and an associated gain (Gass) of 12 dB. To our knowledge, these results are the best ft, fmaxand microwave noise performance ever reported on GaN HEMT grown on Silicon substrate. [J751]

"Off-state breakdown of GaAs PHEMTs: review and new data"

This paper reviews the literature dealing with off-state gate-drain breakdown in MESFET and HEMT structures, with particular emphasis on GaAs PHEMTs, in terms of: 1) the physics of the breakdown phenomenon; 2) the breakdown walkout effect; 3) the impact of design and process choices on the breakdown behavior; and 4) the experimental techniques used for breakdown characterization. A thorough temperature-dependent breakdown characterization of commercial PHEMTs is also shown and discussed. It is found that different physical mechanisms may dominate the gate-drain leakage depending on the reverse bias and temperature range considered, and the particular PHEMT technology. The main results shown here tell us the following. 1) The breakdown voltages are decreasing functions of temperature between room temperature and 160°C. 2) Between room temperature and 90-100°C, thermionic-field emission seems be dominant, with low activation energies below 0.15 eV; as a consequence, the temperature dependence of the breakdown voltage is weak. 3) Between 110°C and 160°C, higher activation energy mechanisms (possibly trap-assisted tunneling and thermionic emission over a field-dependent barrier) tend to dominate, and the temperature dependence of the breakdown voltages is stronger. [J752]

"An ultra-low power InAs/AlSb HEMT Ka-band low-noise amplifier"

The first antimonide-based compound semiconductor (ABCS) MMIC, a Ka-Band low-noise amplifier using 0.25-µm gate length InAs/AlSb metamorphic HEMTs, has been fabricated and characterized on a 75 µm GaAs substrate. The compact 1.1 mm2three-stage Ka-band LNA demonstrated an average of 2.1 dB noise-figure between 34-36 GHz with an associated gain of 22 dB. The measured dc power dissipation of the ABCS LNA was an ultra-low 1.5 mW per stage, or 4.5 mW total. This is less than one-tenth the dc power dissipation of a typical equivalent InGaAs/AlGaAs/GaAs HEMT LNA. Operation with degraded gain and noise figure at 1.1 mW total dc power dissipation is also verified. These results demonstrate the outstanding potential of ABCS HEMT technology for mobile and space-based millimeter-wave applications. [J753]

"New percentage linearization measures of the degree of linearization of HPA nonlinearity"

A percentage linearization (PL) and a percentage linearization area (PLA) are defined and proposed as two new measures of the degree of AM-to-AM linearization, achieved by a linearization scheme, of the saturating region of nonlinear high power amplifiers (HPAs). The measures are based on defining a HPA saturation power point which is very close to the asymptotic output saturation power (AOSP) line. Here the point where the first derivative of the AM-to-AM dB power characteristic drops to 0.1 is so defined. Employing the passage through a typical pseudomorphic high electron mobility transistor solid-state power amplifier (PHEMT SSPA) of an UWC-136 8-PSK signal, as a test signal, an introductory insight into the usefulness of these linearization measures is presented. [J754]

"Joint optimization of the power-added efficiency and the error-vector measurement of 20-GHz pHEMT amplifier through a new dynamic bias-control method"

This paper presents a method for the optimization of the power-added efficiency (PAE), as well as the error-vector measurement (EVM) of a 20-GHz power amplifier (PA) applied in this case to the M quadrature and amplitude modulations. A first key point lies in that both input and output biasing voltages of the solid-state power amplifiers (SSPAs) are dynamically controlled according to the RF power level associated with the symbol to be transmitted. The leading idea is that the dynamic biasing control is designed and implemented to keep fixed amplitude (AM/AM) and phase (AM/PM) conversion values, while the RF input power level changes. The power gain of the PAs can then be dynamically tuned to a fixed power gain corresponding to the compression gain behavior for which the PAE is optimum at low-, medium-, and high-input RF power levels. As a main consequence, PAE performances can be drastically improved as compared to classical backoff solutions and optimized while keeping a very good EVM. A Ka-band hybrid amplifier has been realized using an 8Ч75 μm power pseudomorphic high electron-mobility transistor. The proposed linearization technique is validated by comparisons between measured PAE and EVM on the SSPA when a fixed and controlled bias are used. [J755]

"A flip-chip packaged coplanar 94 GHz amplifier module with efficient suppression of parasitic substrate effects"

A flip-chip mounted W-band amplifier module with more than 15 dB gain between 82 and 105 GHz has been developed, based on a 0.15 μm GaAs PHEMT technology. To predict the influence of the flip-chip transition, an equivalent circuit model of the flip-chip interconnects was developed. Lossy silicon (n-Si) flip-chip carriers were used to successfully minimize parasitic substrate modes and feed back effects. The flip-chip assembled coplanar 94 GHz amplifier MMIC was packaged in a WR-10 waveguide mount, using CPW-to-waveguide transitions realized on quartz substrates. [J756]

"9.4-W/mm power density AlGaN-GaN HEMTs on free-standing GaN substrates"

High power microwave AlGaN-GaN high electron-mobility transistors (HEMTs) on free-standing GaN substrates are demonstrated for the first time. Measured gate leakage was -2.2 μA/mm at -20 V and -10 μA/mm at -45 V gate bias. When operated at a drain bias of 50 V, devices showed a record continuous-wave output power density of 9.4 W/mm at 10 GHz with an associated power-added efficiency of 40%. Long-term stability of device RF operation was also examined. Under room conditions, devices driven at 25 V and 3-dB gain compression remained stable in 200 h, degrading only by 0.18 dB in output power. Such results illustrate the potential of GaN substrate technology in supporting reliable, high performance AlGaN-GaN HEMTs for microwave power applications. [J757]

"Tuned transition from a quantum well to a quantum wire investigated by magnetophonon resonance"

This article describes experimental investigations of the transition from a two-dimensional electron gas to a quasi-one-dimensional quantum wire by the magnetophonon effect, tuned by Schottky gates in GaAs/AlGaAs. We present a model of the depletion region linked to the gates. The measurements allow the band-edge effective mass to be determined from two to one dimension between 89.5 and 348 K. We performed the measurements with a single, isolated quantum wire in magnetic fields up to 17 T. copyright 2004 American Institute of Physics. [J758]

"A PHEMT frequency doubling active antenna with BPSK modulation capability"

The letter presents a novel frequency doubling active antenna, based on a PHEMT device, with BPSK modulation capability. A dedicated nonlinear transistor characterization reveals the existence of two biasing

regions, where the second harmonic could be generated with maximum level and phase opposition. Taking advantage of this issue, a low frequency data signal applied to the gate terminal may be used to create a BPSK modulated signal, centered at twice the carrier frequency. An adequate integration of this modulator in a dual-frequency and dual-polarization slot coupled patch, results in a compact and high performance solution. In order to characterize the integrated active radiating structure, a specific test setup was implemented in an anechoic chamber, reproducing a sort of RFID architecture. [J759]

"Noise performance of the radio-frequency single-electron transistor"

We have analyzed a radio-frequency single-electron-transistor (RF-SET) circuit that includes a high-electron-mobility-transistor (HEMT) amplifier, coupled to the single-electron-transistor (SET) via an impedance transformer. We consider how power is transferred between different components of the circuit, model noise components, and analyze the operating conditions of practical importance. The results are compared with experimental data on SETs. Good agreement is obtained between our noise model and the experimental results. Our analysis shows, also, that the biggest improvement to the present RF-SETs will be achieved by increasing the charging energy and by lowering the HEMT amplifier noise contribution. copyright 2004 American Institute of Physics. [J760]

"Characteristics of a terahertz photomixer based on a high-electron mobility transistor structure with optical input through the ungated regions"

We develop a device model for a terahertz photomixer that utilizes the excitation of plasma oscillations in the channel of a device similar to a high-electron mobility transistor (HEMT). The device design assumes vertical optical input through the ungated source-gate and gate-drain regions. Using this model, we calculate the characteristics of the HEMT photomixer: the responsivity as a function of the signal frequency for devices with different geometrical and physical parameters, and the dependence of resonant frequency on the length of the gated and ungated portions of the channel and the gate voltage. We compare also the performance of the HEMT photomixer with that of a similar device but one in which the optical input is through the substrate. copyright 2004 American Institute of Physics. [J761]

"Procedure for accurate noise modelling of microwave FETs against temperature"

A procedure for accurate prediction of noise parameters of microwave MESFETs/HEMTs against temperature is proposed. The error correction functions calculated for one temperature are used for efficient transistor noise parameter modelling for various device ambient temperatures, as is shown by an example of packaged HEMT noise modelling. [J762]

"Effects of RF stress on power and pulsed IV characteristics of AlGaN/GaN HEMTs with field-plate gates"

The effects of RF stress on power and pulsed IV characteristics of field-plated AlGaN/GaN HEMTs fabricated on two different epitaxial structures are presented. The power degradation characteristics are shown. The RF stress resulted in different degrees of RF voltage and current swing reduction on the two wafers. The current dispersion became more aggravated after RF stress under high quiescent drain bias conditions in one of the structures. [J763]

"Transient response of III-V field-effect transistors to heavy-ion irradiation"

The single-event effects response of three different III-V field-effect transistor technologies (GaAs MESFET, InAlAs/InGaAs HEMT, and AlSb/InAs HEMT) is measured for MeV and GeV heavy-ion irradiation. These measurements reveal significant charge enhancement and very slow, microsecond-timescale relaxation times for the GaAs and InAlAs/InGaAs devices, with a much faster recovery from the ionizing event observed for the AlSb/InAs HEMTs. [J764]

"RF reliability performance of AlGaN/GaN HEMTs on Si substrate at 10 GHz"

RF reliability performance of AlGaN/GaN HEMTs on Si substrate at 10 GHz is presented for the first time. Devices were fabricated in MBE-grown AlGaN/GaN on a two- inch Si (111) substrate. Devices demonstrating continuous wave output power between 3.9 and 6.2 W/mm are used in this study. Drifts in output power, PAE, drain current and gate current under RF stress at various biases are measured. A device biased at a drain voltage of 40 V for initial output power of 6.2 W/mm showed a small power drift of about 0.5 dB in 125 h of stress, indicating a promising reliability of GaN HEMTs on Si. [J765]

"Materials growth for InAs high electron mobility transistors and circuits"

High electron mobility transistors (HEMTs) with InAs channels and antimonide barriers were grown by molecular beam epitaxy. Both Si and Te were successfully employed as n-type dopants. Sheet resistances of 90-150Omega / were routinely achieved on a variety of heterostructures with nonuniformities as low as 1.5% across a 75 mm wafer. X-ray diffraction measurements show that the InAs channels are in tension, coherently strained to the Al(Ga)Sb buffer layers. Atomic force microscopy measurements demonstrate that the surfaces are relatively smooth, with rms roughness of 8-26 E over a 5Ч5mcm2area. These results demonstrate that the growth of InAs HEMTs has progressed to the point that the fabrication of circuits should be feasible. copyright 2004 American Vacuum Society. [J766]

"Enhancement-mode In 0.52 Al 0.48 As/In 0.6 Ga 0.4 As tunneling real space transfer high electron mobility transistor"

An enhancement-mode In0.52Al0.48As/In0.6Ga0.4Astunneling real-space transfer high electron mobility transistor (HEMT) was fabricated. The studied device operates as a conventional enhancement-mode HEMT under a low gate electrode bias. As the gate electrode bias increases, the electric field applied between the gate electrode and the InGaAs channel increases and the electrons in the channel become "hot." If the transverse field is sufficiently large, then the electrons in the InGaAs channel layer may have enough energy to overcome the barrier and tunnel into the gate electrode, thus IDSdecreases as IGincreases. Therefore, pronounced N-shaped negative differential resistance phenomenon and negative transconductance are observed in the studied device. copyright 2004 American Vacuum Society. [J767]

"Pressure-induced changes in the conductivity of AlGaN /GaN high-electron mobility-transistor membranes"

AlGaN/GaNhigh-electron-mobility transistors (HEMTs) show a strong dependence of source/drain current on the piezoelectric-polarization-induced two-dimensional electron gas. The spontaneous and piezoelectric-polarization-induced surface and interface charges can be used to develop very sensitive but robust sensors for the detection of pressure changes. The changes in the conductance of the channel of a AlGaN/GaNhigh electron mobility transistor (HEMT) membrane structure fabricated on a Sisubstrate were measured during the application of both tensile and compressive strain through changes in the ambient pressure. The conductivity of the channel shows a linear change of -(+)6.4Ч10-2mS/barfor application of compressive (tensile) strain. The AlGaN/GaNHEMT membrane-based sensors appear to be promising for pressure sensing applications. [J768]

"Microwave SQUID multiplexer"

We describe a superconducting quantum interference device (SQUID) multiplexer operated at microwave frequencies. The outputs of multiple SQUIDs are simultaneously modulated at different frequencies and summed into the input of one high electron mobility transistor (HEMT). The large bandwidth and dynamic range provided by HEMT amplifiers should make it possible to frequency-division multiplex a large number of SQUIDs in one output coaxial cable. We measure low SQUID noise (0.5mu Phi 0/√Hzat 4K) and demonstrate the multiplexed readout of two direct current (dc) SQUIDs at different resonant frequencies. In this work, dc SQUIDs are used, but this approach is equally applicable to radio-frequency SQUIDs. [J769]

"Surface photovoltage spectroscopy of metamorphic high electron mobility transistor structures"

InAlAs/InGaAsmetamorphic high electron mobility transistor (MHEMT) epitaxial structures have been characterized using surface photovoltage spectroscopy (SPS). The measurements have been extended to pseudomorphic high electron mobility transistor (PHEMT) epitaxial structures and to complete devices. The direct current characteristics of the latter were also measured. An empirical model, which correlates the top and bottom delta-doping concentrations (delta topand delta bot) and the surface charge density Qsurwith spectral features, has been applied to the MHEMT and PHEMT structures before and after processing. The results show correlations between extracted Qsurand the measured threshold voltage and drain saturation current of the devices. The analysis shows general correlations between epistructure parameters and final device performance and indicates the universality of the model for the different HEMT structures. Thus, SPS is sensitive not only to epitaxial structure parameters but to final device performance and may be used for technology evaluation from the wafer incoming inspection stage to the final device. [J770]

"Annealing temperature stability of Ir and Ni-based Ohmic contacts on Al Ga N /Ga N high electron mobility transistors"

Ti/Al/Ir/AuOhmic contacts on AlGaN/GaNhigh electron mobility transistors (HEMTs) show promising electrical performance, with lower specific contact resistance than obtained with the more conventional Ti/Al/Ni/Aumetallization. HEMTs with both types of metallization have been measured up to 550°C. We find that the dc performance of devices with Ir-based contacts is significantly better at each temperature up to this maximum value, with higher transconductance (gm), saturated drain-source current (IDSS), and more stable threshold voltage (Vth). These contacts look very promising for HEMT power amplifier applications involving high temperature operation. [J771]

"Material properties and performance of metamorphic optoelectronic integrated circuits grown by molecular beam epitaxy on GaAs substrates"

Solid source molecular beam epitaxy was used to deposit in a continuous process an integrated metamorphic high electron mobility transistor (HEMT) and PIN photodiode structure. A metamorphic buffer layer was first grown on a GaAs substrate to expand the lattice constant to that of In0.53Ga0.47Asused in the device layers. The HEMT layers were subsequently grown followed by the PIN diode structure. Cross-sectional and plan-view transmission electron micrographs showed planar layer interfaces and a dislocation density in the device layers of 1Ч106 cm-2.The device characteristics of the HEMT transistors were not adversely affected by growth of the PIN structure on top. Also the bandwidth and responsivity of the metamorphic PIN photodiode were comparable to an InP PIN photodiode with similar dark currents. The integrated HEMT/PIN diode circuit had a 3 dB bandwidth 20% greater than a hybrid combination of devices due to a decrease in parasitic losses from device interconnects. The frequency performances of circuits fabricated from the same wafer exhibited a high degree of uniformity. copyright 2004 American Vacuum Society. [J772]

"Comparison of As- and P-based metamorphic buffers for high performance InP heterojunction bipolar transistor and high electron mobility transistor applications"

Metamorphic buffers (M-buffers) consisting of graded InAlAs or bulk InP were employed for the production of InP-based epiwafers on GaAs substrates by molecular-beam epitaxy. The graded InAlAs is the standard for production metamorphic high electron mobility transistors (M-HEMTs), while the bulk InP offers superior thermal properties for higher current density circuits. The surface morphology and crystal structure of the two M-buffers showed different relaxation mechanisms. The graded InAlAs gave a cross-hatched pattern with nearly full relaxation and very effective dislocation filtering, while the bulk InP had a uniform isotropic surface with dislocations propagating further up towards the active layers. Both types of M-buffers had atomic force microscopy root-mean-square roughness values around 20-30 E. The Hall transport properties of high electron mobility transistors (HEMTs) grown on the InAlAs M-buffer, and a baseline HEMT grown lattice matched on InP, both had room-temperature mobilities 10 000 cm2/V s, while the M-HEMT on the InP M-buffer showed a decrease to 9000 cm2/V s. Similarly, the dc parameters of a double heterojunction bipolar transistor (DHBT) grown on the InAlAs M-buffer were much closer to the baseline heterojunction bipolar transistor than a DHBT grown on the InP M-buffer. A high breakdown voltage of 11.3 V was achieved on an M-DHBT with the InAlAs M-buffer. We speculate that the degradation in device characteristics on the InP M-buffer was related to the incomplete dislocation filtering. copyright 2004 American Vacuum Society. [J773]

"A 80-gbit/s D-type flip-flop circuit using InP HEMT technology"

80-Gbit/s operation of a static D-type flip-flop (D-FF) circuit was achieved using InP-based HEMT technology, which has a cut-off frequency of 245 GHz and a transconductance of 1500 mS/mm. The circuit was designed with differential operation based on source-coupled FET logic (SCFL). To overcome deterioration of the 80-GHz clock signals in a single-ended to differential signal converter in the input buffer, a rat-race circuit was used as a converter. Measurements showed that the circuit achieved a gain of over 2 dB higher than a conventional converter using a differential pair circuit, and power consumption was reduced from 380 to 260 mW. The power supply voltage was -5.7 V, and total power consumption was 1.2 W. Since there is no commercially available 80-Gbit/s-pulse pattern generator, we developed a selector module to measure the D-FF. These measurements showed that the D-FF successfully operated at 80 Gbit/s, which is almost twice the speed reported to date. [J774]

"Photoreceiver module using an InP HEMT transimpedance amplifier for over 40 gb/s"

We developed a photoreceiver module for over 40 Gb/s that uses two ultrahigh- speed device technologies: an InP HEMT transimpedance amplifier (TIA) and a uni-traveling-carrier photodiode (UTC-PD). The TIA was designed to have a wide dynamic range by using cascade HEMT topology for the output buffer. We found that reducing the standing wave at the PD-TIA interface by decreasing the change of arg(S11) of the TIA within the required frequency region is important for increasing the bandwidth of the module. We obtained a minimum

sensitivity of -7.6 dBm and a dynamic range of 11 dB for 43-Gb/s nonreturn-to-zero optical input signal. Error-free operation of the module was confirmed at a data rate of 50 Gb/s. [J775]

"A novel two-color photodetector based on an InAlAs-InGaAs HEMT Layer structure"

The spectral responsivity of an InAlAs-InGaAs metal-semiconductor-metal diode above a two-dimensional electron gas (2DEG) is investigated as a function of the applied bias. At low voltages, only the InAlAs layer above the 2DEG contributes to the photocurrent, while the InGaAs channel layer is activated at higher bias. This results in a voltage-dependent spectral response of the photodetector. The ratio of the responsivities at 1300 and 850 nm changes from 0.03- at 1-V to 0.44- at 1.6-V bias. This property makes the device a candidate suitable to detect and to separate optical information originated both from the GaAs (850 nm) and in the InGaAs (1300, 1550 nm)-based optoelectronic technology. [J776]

"Surface-related drain current dispersion effects in AlGaN-GaN HEMTs"

Drain current dispersion effects are investigated in AlGaN-GaN HEMTs by means of pulsed, transient, and small-signal measurements. Gate- and drain-lag effects characterized by time constants in the order of 10-5-10-4s cause dispersion between dc and pulsed output characteristics when the gate or the drain voltage are pulsed. An activation energy of 0.3 eV is extracted from temperature-dependent gate-lag measurements. We show that two-dimensional numerical device simulations accounting only for polarization charges and donor-like traps at the ungated AlGaN surface can quantitatively reproduce all dispersion effects observed experimentally in the different pulsing modes, provided that the measured activation energy is adopted as the energetic distance of surface traps from the valence-band edge. Within this hypothesis, simulations show that surface traps behave as hole traps during transients, interacting with holes attracted at the AlGaN surface by the negative polarization charge. [J777]

"Stability of AlGaN/GaN high-power HEMTs under DC and RF stresses"

The stability of high-power AlGaN/GaN HEMTs under DC and RF stresses was evaluated. For 50 hours of DC stresses, 100 μm devices exhibited 3% full-channel drain current degradation within the first few minutes and another 1% current loss during the rest of the stress period. In response to the RF stresses under pulsed conditions at 2.8 GHz, the output power of 1.5 mm devices degraded by 13% after 108 hours of stress. Current DLTS measurements revealed the creation of a 0.4 eV trap from the stressed and aged devices. [J778]

"Room temperature Hall mobilities above 1900 cm2 /V s in MBE-grown AlGaN/GaN HEMT structures"

An AlGaN/GaN high electron mobility transistor (HEMT) structure has been grown by plasma-assisted molecular beam epitaxy (MBE) on a free-standing hydride vapour phase epitaxy-grown GaN substrate with a threading dislocation density of 8Ч106cm-2. A room temperature Hall mobility of 1920 cm2/V s with a sheet carrier density of 0.91Ч1013cm-2was measured. This is the highest room temperature electron mobility reported for an MBE-grown AlGaN/GaN structure. HEMTs fabricated on this material displayed excellent pinch-off, low gate leakage currents, and an off-state breakdown of 90 V. [J779]

"Development of 60-GHz front-end circuits for a high-data-rate communication system"

Recent results from a Swedish program for development of 60-GHz monolithic microwave integrated circuits (MMICs) for high-data-rate communication links are presented. Front-end circuits such as mixers, amplifiers, frequency multipliers, IF amplifiers with gain control, and voltage-controlled oscillators (VCOs) have been realized utilizing GaAs PHEMT and MHEMT technologies. A newly developed 7.5-GHz coupled Colpitt VCO shows a minimum phase noise of -95 dBc at 100 kHz offset. A second-harmonic 14-GHz VCO shows a minimum phase noise of less than -90 dBc at 100 kHz. A novel balanced 7-28-GHz MMIC frequency quadrupler is described and compared with a single-ended quadrupler at the same input frequencies. To demonstrate its feasibility and potential application, the quadrupler is combined with the Colpitt VCO and the output characteristics of the resulting 30-GHz MMIC source are measured. A three-stage MHEMT wide-band amplifier covering 43-64 GHz with a gain of 24 dB, a minimum noise figure of 2.5 dB, and a passband ripple of 2 dB is also described. In future 60-GHz systems for mass markets where cost is of utmost importance, Si-based technologies, especially CMOS, are highly interesting. Some recent circuit results based on a 90-nm CMOS technology are also reported. [J780]

"An intrinsic delay extraction method for Schottky gate field effect transistors"

This letter reports a new method for extracting the intrinsic transit delay associated with the carrier transport

under the gate of field-effect transistors (FETs). With this method, the parasitic charging time is ruled out by the de-embedding used to strip the pad parasitics. Therefore, the intrinsic transit delay and the drain delay associated with the extended depletion region toward drain electrode can be separated without the influence of the parasitic charging time, as proven by an analysis of short-channel InP-based high electron mobility transistors. The method is applicable to any type of Schottky-gate FETs and could be helpful for studying the effective carrier velocity in the gate region of FETs. [J781]

"Thermal resistance calculation of AlGaN-GaN devices"

We present an original accurate closed-form expression for the thermal resistance of a multifinger AlGaN-GaN high electron-mobility transistor (HEMT) device on a variety of host substrates including SiC, Si, and sapphire, as well as the case of a single-crystal GaN wafer. The model takes into account the thickness of GaN and host substrate layers, the gate pitch, length, width, and thermal conductivity of GaN, and host substrate. The model's validity is verified by comparing it with experimental observations. In addition, the model compares favorably with the results of numerical simulations for many different devices; very close (1%-2%) agreement is observed. Having an analytical expression for the channel temperature is of great importance for designers of power devices and monolithic microwave integrated circuits. In addition, it facilitates a number of investigations that are not practical or possible using time-consuming numerical simulations. The closed-form expression facilitates the concurrent optimization of electrical and thermal properties using standard computer-aided design tools. [J782]

"Nonlinear device model of microwave power GaN HEMTs for high power-amplifier design"

This paper presents a nonlinear equivalent circuit model of microwave power GaN high electron-mobility transistors (HEMTs), amenable for integration into commercial harmonic balance or transient simulators. All the steps taken to extract its parameter set are explained, from the extrinsic linear elements up to the intrinsic nonlinear ones. The predictive model capabilities are illustrated with measured and simulated output power and intermodulation-distortion data of a GaN HEMT. The model is then fully validated in a real application environment by comparing experimental and simulated results of output power, power-added efficiency, and nonlinear distortion obtained from a power amplifier. [J783]

"High breakdown Voltage undoped AlGaN-GaN power HEMT on sapphire substrate and its demonstration for DC-DC converter application"

Undoped AlGaN-GaN power high electron mobility transistors (HEMTs) on sapphire substrate with 470-V breakdown voltage were fabricated and demonstrated as a main switching device for a high-voltage dc-dc converter. The fabricated power HEMT realized a high breakdown voltage with a field plate structure and a low on-state resistance of 3.9 mΩ·cm2, which is 10 Ч lower than that of conventional Si MOSFETs. The dc-dc converter operation of a down chopper circuit was demonstrated using the fabricated device at the input voltage of 300 V. These results show the promising possibilities of the AlGaN-GaN power HEMTs on sapphire substrate for future switching power devices. [J784]

"Two-stage broadband high-gain W-band amplifier using 0.1-μm metamorphic HEMT technology"

We report broadband high-gain W-band monolithic microwave integrated circuit amplifiers based on 0.1-μm InGaAs-InAlAs-GaAs metamorphic high electron mobility transistor (MHEMT) technology. The amplifiers show excellent S21gains greater than 10 dB in a very broad W-band frequency range of 75-100 GHz, thereby exhibiting a S21gain of 10.1 dB, a S11of -5.1 dB and a S22of -5.2 dB at 100 GHz, respectively. The high gain of the amplifier is mainly attributed to the performance of the MHEMTs exhibiting a maximum transconductance of 691 mS/mm, a current gain cutoff frequency of 189 GHz, and a maximum oscillation frequency of 334 GHz. [J785]

"Low-κ BCB passivation on AlGaN-GaN HEMT fabrication"

Due to the stress-induced polarization effect on the GaN HEMTs, the surface passivation of the device is critical and is deserved to conduct a detailed study. It has been proven that the GaN HEMTs demonstrate nondispersive pulsed current-voltage (I-V) characteristics and better microwave power performances after passivating the Si3N4film on the GaN surface. In this letter, we proposed to use the BCB material, a negative photoresist with a low-κ characteristic, as the surface passivation layer on GaN HEMTs fabrication. After comparing the dc I-V, pulsed I-V, RF small-signal, microwave power characteristics, and device reliability, this BCB-passivated GaN HEMT achieved better performance than the Si3N4passivated device. [J786]

"Monolithically integrated high-power broad-band RF switch based on III-N insulated gate

transistors"

We report on the high-performance monolithically integrated RF switch based on metal-oxide-semiconductor III-N heterostructure field-effect transistors (MOSHFETs). The radio frequency (RF) switch microwave monolithic integrated circuit (MMIC) consists of three submicron-gate MOSHFETs connected into pi-type configuration. In the 0-10 GHz frequency range, the insertion loss is less than 1dB and the isolation is better than 20 dB. The switching powers well exceed 20 W per 1mm of the active element width. The high performance parameters of the switch are achieved due to unique properties of III-nitride MOSHFET, which combines a low channel resistance and high breakdown voltage features of AlGaN/GaN HFETs and extremely low gate leakage currents, large gate voltage swing and low gate capacitance specific to insulated gate design. The combination of these parameters makes MOSHFETs excellent candidates for high-power switching. The experimental data obtained from the RF switch are in close agreement with the results of simulations. [J787]

"Thermal modeling and measurement of AlGaN-GaN HFETs built on sapphire and SiC substrates"

We present thermal modeling and measurement results of AlGaN-GaN heterojunction field effect transistors fabricated on sapphire and SiC substrates, respectively. The device structures are identical except for the substrate material used to grow the AlGaN-GaN heterostructure. One objective is to study the effect of substrate material on the thermal and electrical performance of the resulting devices. To compute the temperature profiles, in-house PAMICE code developed for a three-dimensional structure was used. To measure the temperatures on the chip surface, nematic liquid crystal thermography was used. This technique is nondestructive and can be performed in realtime during device operation. It has submicrometer spatial resolution and ±1°C temperature accuracy. The measured temperatures agree well with the calculated ones. The relationship between the measured temperature and power is almost linear for both types of devices. The junction-to-case thermal resistance of the device fabricated on sapphire substrate is 4.4 times that of the device built on SiC substrate. [J788]

"Ionization-induced carrier transport in InAlAs/InGaAs high electron mobility transistors"

Time resolved charge-collection measurements and two-dimensional device simulations performed on InAlAs/InGaAs high electron mobility transistors (HEMTs) for ion and pulsed laser excitation address the mechanisms of charge collection and enhancement in these heterostructure devices. The results are compared to those for bulk GaAs field-effect transistors. In the HEMTs, the ionization-induced enhancement current is associated with a significant lowering of the source/channel barrier, and is largely confined to the InGaAs well. The simulations suggest that the primary contributor to the barrier lowering is an excess hole density that develops in the InAlAs buffer layer. [J789]

"AlGaN/GaN HEMTs on Si(111) with 6.6 W/mm output power density"

Al0.27Ga0.73N/GaN HEMTs have been realised on resistive Si(111) substrates. The epitaxial structure was grown by MBE yielding a channel mobility of 1440 cm2/Vs (room temperature) and a sheet carrier density of 9.6e12 cm-2. Large signal evaluation of transistors with gate length of 0.25 μm and gate width of 2Ч125 μm yields up to 1.65 W CW output power at 2 GHz corresponding to a power density of 6.6 W/mm. These results are thought to represent the highest output power density so far achieved for GaN-based HEMTs on silicon substrates. [J790]

"Statistical nonlinear model of MESFET and HEMT devices"

Accurate statistical models of FET devices are needed for yield-oriented MMIC design. In particular, currently used linear statistical models are not adequate in applications where bias point variations have a strong impact on overall yield. The paper describes a nonlinear statistical model of MESFET and HEMT devices in which statistical parameters are considered as Gaussian multivariate random variables. An automatic procedure is developed to achieve extraction of the statistical model of a FET device from a database of DC Ids and S-parameter measurements, and it is checked on a GaAs HEMT monolithic process. A statistical model has been extracted for Philips PML-D02AH GaAs HEMT devices and accurate evaluation of the S-parameters covariance matrix has been made. Statistical pair-wise tests on mean values, standard deviations and correlation coefficients show that the proposed methodology has the capability of reproducing statistical population distributions. [J791]

"2.1 A/mm current density AlGaN/GaN HEMT"

The electrical performance of high current density AlGaN/GaN HEMTs is reported. 2 Ч 75 μm Ч 0.7 μm devices grown on sapphire substrates showed current densities up to 2.1 A/mm under 200 ns pulse condition. RF power

measurements at 8 GHz and VDS=15 V exhibited a saturated output power of 3.66 W/mm with a 47.8% peak PAE. [J792]

"On-wafer noise-parameter measurements at W-band"

A wide-band on-wafer noise-parameter measurement setup has been developed for W-band. The system is based on a cold-source method and uses a simple manual impedance tuner. In addition to noise parameters, S-parameters can be measured with the same setup. Using the developed system, noise parameters of an InP high electron-mobility transistor have been measured and results are shown in the 79-94-GHz frequency band. This is the first comprehensive report of noise-parameter measurements made on active devices at W-band. [J793]

"Planck satellite 70 GHz EBB-version back end module"

The first complete 70 GHz back end module (BEM) of the coming Planck satellite is described. It includes an H-plane waveguide band pass filter, an InP HEMT amplifier, a diode detector made on 0.1 mm alumina substrate, and video amplifiers. RF parts are designed, manufactured, and measured individually and then the complete BEM is tested. Stringent requirements are set through the mechanical layout of the entire functional unit. Most specifications have already been met with the exception of conversion loss in band ripple which must be further reduced. [J794]

"Unpassivated AlGaN/GaN HEMTs with CW power density of 3.2 W/mm at 25 GHz grown by plasma-assisted MBE"

The Ka-band power performance of unpassivated AlGaN/GaN HEMTs grown by plasma-assisted molecular beam epitaxy on 6H-SiC substrates is reported. Transistors with a gate length of 0.2 μm, source-drain spacing of 2 μm, and 100 μm periphery displayed maximum drain currents greater than 1.6 A/mm. Small signal S-parameter measurements yielded an fTof 53 GHz and fMAXof 109 GHz. Passive load pull measurements at 25 GHz of 0.2Ч100 μm transistors yielded a power density of 3.2 W/mm with 30% PAE and 44% drain efficiency at 1.8 dB gain compression. To the knowledge of the authors, this is the first report of RF output power above 20 GHz from MBE-grown AlGaN/GaN HEMTs. [J795]

"Elimination of kink phenomena and drain current hysteresis in InP-based HEMTs with a direct ohmic structure"

We eliminated kink phenomena and Ids hysteresis in a double-doped InP-based HEMT without degrading its frequency performance by fabricating direct ohmic contacts in the InGaAs channel. A direct ohmic structure lets us control current paths in the device and relax the electric field at the recess edge of the drain side. As a result, we can suppress impact ionization and decrease the hole currents that originate from the high electric field region at the recess edge of the drain side. Kink phenomena are eliminated in the direct ohmic structure. We also suggest a hole trap mechanism to explain the appearance of hysteresis in the I-V characteristic of the conventional nonalloyed ohmic structure device. [J796]

"Theoretical study of a GaN-AlGaN high electron mobility transistor including a nonlinear polarization model"

We present a theoretical model of an AlGaN-GaN high electron mobility field effect transistor (HEMT) that includes a nonlinear model of the strain polarization fields produced at the heterointerface. Recent experimental work has indicated that the macroscopic polarization in III-nitride alloys is a nonlinear function of the material composition. It is well known that the behavior of a GaN-AlGaN HEMT depends greatly upon the properties of the strain-induced polarization fields formed at the GaN-AlGaN heterointerface. It is the purpose of this paper to provide a detailed model of a GaN-AlGaN HEMT that includes a nonlinear formulation of the polarization. The model is found to agree well with recent experimental measurements made for GaN-AlGaN HEMTs when the nonlinear polarization model is included. The cutoff frequency, transconductance, and current-voltage characteristics are computed. The effect of the nonlinear polarization model on the sheet carrier density is also presented. [J797]

"Unpassivated AlGaN-GaN HEMTs with minimal RF dispersion grown by plasma-assisted MBE on semi-insulating 6H-SiC substrates"

High electron mobility transistors (HEMTs) are fabricated from AlGaN-GaN heterostructures grown by plasma-assisted molecular beam epitaxy (MBE) on semi-insulating 6H-SiC substrates. At a sheet charge density of 1.3

Ч 1013cm-2, we have repeatedly obtained electron mobilities in excess of 1350 cm2/Vs. HEMT devices with a gate length of 1μm, a gate width of 200 μm, and a source-drain spacing of 5 μm show a maximum drain current of 1.1 A/mm and a peak transconductance of 125 mS/mm. For unpassivated HEMTs, we measured a saturated power output of 8.2-W/mm continuous wave (cw) at 2 GHz with an associated gain of 11.2 dB and a power-added efficiency of 41%. The achievement of high-power operation without a surface passivation layer suggests that free surface may not be the dominant source of radio-frequency (RF) dispersion in these MBE-grown structures. This data may help discriminate between possible physical mechanisms of RF dispersion in AlGaN-GaN HEMTs grown by different techniques. [J798]

"A wide-band on-wafer noise parameter measurement system at 50-75 GHz"

A wide-band on-wafer noise parameter measurement system at 50-75 GHz is presented. This measurement system is based on the cold-source method with a computer-controlled waveguide tuner. Calibrations and measurement methods are discussed and measured results for passive and active on-wafer devices are shown over a 50-75 GHz range. An InP high electron-mobility transistor device is used as a test item for the active device. A Monte Carlo analysis to study measurement uncertainties is also shown. The measurement system is a useful tool in the development and verification of device noise models, as well as in device characterization. [J799]

"Impact ionization measurements and modeling for power PHEMT"

A systematic study of impact ionization in pseudomorphic high electron mobility transistors (PHEMTs) has been carried out using temperature-dependent electrical measurements as well as modeling for optimizing the power performance of the devices through the best layout parameters. A measurement procedure makes it possible to define a safe transistor operation region is proposed. Impact ionization in the channel is parameterized by specific gate current and voltage values. Temperature-dependent measurements are shown to provide distinction between the impact ionization current and the thermionic field emission current. A methodology for defining an optimum vertical structure and a lateral layout for a given application and operational conditions is developed. Empirical models for optimum lateral layout for a power application were developed based on a statistical "Device Zoo" approach. The results point to an optimal gate-to-drain distance for minimum impact ionization current. [J800]

"Cryogenic wide-band ultra-low-noise IF amplifiers operating at ultra-low DC power"

This paper describes cryogenic broad-band amplifiers with very low power consumption and very low noise for the 4-8-GHz frequency range. At room temperature, the two-stage InP-based amplifier has a gain of 27 dB and a noise temperature of 31 K with a power consumption of 14.4 mW per stage, including bias circuitry. When cooled to 15 K, an input noise temperature of 1.4 K is obtained at 5.7 mW per stage. At 0.51 mW per stage, the input noise increases to 2.4 K. The noise measurements have been repeated at different laboratories using different methods and are found consistent. [J801]

"108 GHz dynamic frequency divider in 100 nm metamorphic enhancement HEMT technology"

Based on a 100 nm metamorphic HEMT process with 220 GHz transit frequency, fT, an optimised dynamic 2:1 frequency divider has been designed. The implemented symmetrical design and optimised three-metal interconnect technology with a BCB dielectric layer result in a very small core size which leads to a maximum operation frequency of 108 GHz. [J802]

"High-linearity class B power amplifiers in GaN HEMT technology"

A 36-dBm, high-linearity, single-ended class B MMIC power amplifier is reported in GaN HEMT technology. The circuit demonstrates high linearity, greater than 35 dBc of third-order intermodulation (IM3) suppression and high power added efficiency (PAE) of 34%. We demonstrate experimentally that class B power amplifiers can achieve IM3 suppression comparable to class A, while providing approximately 10% improved power added efficiency. [J803]

"Reliability investigation of 0.07-μm InGaAs-InAlAs-InP HEMT MMICs with pseudomorphic In0.75 Ga0.25 As channel"

The authors have investigated the reliability performance of G-band (183 GHz) monolithic microwave integrated circuit (MMIC) amplifiers fabricated using 0.07-μm T-gate InGaAs-InAlAs-InP HEMTs with pseudomorphic In0.75Ga0.25As channel on 3-in wafers. Life test was performed at two temperatures (T1= 200 °C and T2= 215 °C), and the amplifiers were stressed at Vdsof 1 V and Idsof 250 mA/mm in a N2ambient. The activation energy

is as high as 1.7 eV, achieving a projected median-time-to-failure (MTTF) ≈ 2 Ч 106h at a junction temperature of 125 °C. MTTF was determined by 2-temperature constant current stress using ΔGmp= -20% as the failure criteria. The difference of reliability performance between 0.07-μm InGaAs-InAlAs-InP HEMT MMICs with pseudomorphic In0.75Ga0.25As channel and 0.1-μm InGaAs-InAlAs-InP HEMT MMICs with In0.6Ga0.4As channel is also discussed. The achieved high-reliability result demonstrates a robust 0.07-μm pseudomorphic InGaAs-InAlAs-InP HEMT MMICs production technology for G-band applications. [J804]

"Highly uniform InAlAs-InGaAs HEMT technology for high-speed optical communication system ICs"

The authors have developed a highly uniform, InP-based high-electron-mobility transistor (HEMT) technology for high-speed optical communication system integrated circuits (ICs). Special attention was paid to obtaining a high yield and uniformity without degrading the high-frequency characteristics of these HEMTs. An InP etch-stopper layer was employed to control the gate recess etching. The authors successfully fabricated InAlAs-InGaAs HEMTs with a cutoff frequency of 175 GHz after interconnection, which is sufficiently high for application in 40-Gb/s optical communication ICs. The standard deviation of the threshold voltage was only 13 mV across a 3-in wafer. They also developed a fabrication process for a Y-shaped gate to maintain high uniformity, enabling us to integrate more than a thousand transistors with a 0.1-μm-class gate length. With this technology, ICs with over 1000 transistors were successfully fabricated and operated at over 40 Gb/s. Furthermore, the authors fabricated a 2:1 multiplexer that had more than 200 transistors and reached an operating speed of 90 Gb/s. They have thus concluded that their InAlAs-InGaAs HEMT technology can be applied to fabricate high-speed ICs for optical communication systems. [J805]

"Copper gate AlGaN/GaN HEMT with low gate leakage current"

Copper (Cu) gate AlGaN/GaN high electron mobility transistors (HEMTs) with low gate leakage current were demonstrated. For comparison, nickel/gold (Ni/Au) gate devices were also fabricated with the same process conditions except the gate metals. Comparable extrinsic transconductance was obtained for the two kinds of devices. At gate voltage of -15 V, typical gate leakage currents are found to be as low as 3.5Ч10-8A for a Cu-gate device with gate length of 2 μm and width of 50 μm, which is much lower than that of Ni/Au-gate device. No adhesion problem occurred during these experiments. Gate resistance of Cu-gate is found to be about 60% as that of NiAu. The Schottky barrier height of Cu on n-GaN is 0.18 eV higher than that of Ni/Au obtained from Schottky diode experiments. No Cu diffusion was found at the Cu and AlGaN interface by secondary ion mass spectrometry determination. These results indicate that copper is a promising candidate as gate metallization for high-performance power AlGaN/GaN HEMT. [J806]

"Ballistic transport in high electron mobility transistors"

A general ballistic FET model that was previously used for ballistic MOSFETs is applied to ballistic high electron mobility transistors (HEMTs), and the results are compared with experimental data for a sub-50 nm InAlAs-InGaAs HEMT. The results show that nanoscale HEMTs can be modeled as an intrinsic ballistic transistor with extrinsic source/drain series resistances. We also examine the "ballistic mobility" concept, a technique proposed for extending the drift-diffusion model to the quasi-ballistic regime. Comparison with a rigorous ballistic model shows that under low drain bias the ballistic mobility concept, although nonphysical, can be used to understand the experimental phenomena related to quasi-ballistic transport, such as the degradation of the apparent carrier mobility in short channel devices. We also point out that the ballistic mobility concept loses validity under high drain bias. The conclusions of this paper should be also applicable to other nanoscale transistors with high carrier mobility, such as carbon nanotube FETs and strained silicon MOSFETs. [J807]

"An HTS X-band DC SQUID based amplifier: modeling and development concepts"

We present an X-band amplifier concept based on a HTS grain boundary dc SQUID, which allow for extended dynamic range for use with SIS mixers, e.g., as a buffer amplifier in front of an RSFQ ADC, or possibly for satellite and cellular phone communications. The proposed RF design is based on a combination of single-layer slot and coplanar lines forming novel input and output circuits. The following parameters (per stage) are obtained via simulation for central frequency 11 GHz: bandwidth 0.5-1 GHz, power gain 11-12 dB, noise temperature 5-10 K. A saturation product as high as 500-1000 K·GHz is estimated for a characteristic voltage of 1-2 mV. The realization of these parameters makes HTS SQA competitive with existing coolable HEMT-amplifiers for radio astronomy and satellite communication. [J808]

"Simple K-band MMIC VCO utilizing a miniaturized hairpin resonator and a three-terminal p-HEMT varactor with low phase noise and high output power properties"

Presents a fully monolithic K-band MMIC voltage-controlled oscillator (VCO) implemented by using a 0.25 μm AlGaAs/InGaAs pseudomorphic HEMT (p-HEMT) technology. The use of a half-wavelength miniaturized hairpin-shaped resonator and a three-terminal p-HEMT varactor was effective in reducing the chip size and simplifying fabrication processes of the microwave MMIC VCO without impairing the performance of the circuit. The VCO provides a typical output power of 11.5 dBm at 20.8 GHz and a free-running phase noise of -82 dBc/Hz at 100 kHz offset and -95 dBc/Hz at 1 MHz offset. It also shows a tuning range of 70 MHz with little reduction in output power and high yield properties. The chip size of the MMIC VCO is 1.5 Ч 2.0 mm2. [J809]

"A V-band up-converting InP HEMT active mixer with low LO-power requirements"

In this letter, we present a monolithically integrated up-converting active mixer that shifts a signal in the 16 GHz range up to the V-band using a 48 GHz local oscillator (LO) signal. The circuit was realized with the 0.2 μm InP HEMT in-house process of the Swiss Federal Institute of Technology in Zurich using coplanar-waveguide technology. Measurements of the fabricated circuit show a peak conversion gain of 1 dB at 64.5 GHz for -1.7 dBm LO power, LO suppression better than 30 dB and input third-order intercept point of -1.6 dBm. This mixer will be employed in the signal up-conversion path of a 60 GHz transceiver for indoor wireless LANs. [J810]

"The epHEMT gate at microwave frequencies"

This paper examines the high-frequency behavior of the enhancement-mode pseudomorphic high electron-mobility transistor (epHEMT) gate. During this study, no bias was applied between the drain and source. Rather, the gate was forward biased with either the drain, source, or channel (drain and source connected together) grounded. While applying positive voltage Vgto the gate, one-port S-parameters were measured from 0.1 to 10 GHz and then converted to Z-parameters. Plotting the real part R of the impedance reveals two sharp peaks. The first peak occurs near the device threshold voltage for conduction in the InGaAs well. A second peak occurs at higher voltages where conduction begins to occur in the surface AlGaAs layer. An equivalent-circuit model is proposed to account for the epHEMT gate's high-frequency behavior and the proposed model is shown to be in good agreement with the experimental data. [J811]

"High-field effects in silicon nitride passivated GaN MODFETs"

This paper presents a detailed study of high-field effects in GaN MODFETs. Degradation of DC characteristics and change of flicker noise due to hot electron and high-reverse current stresses in Si3N4passivated GaN MODFETs have been investigated. The authors observe that during hot electron stress, electron trapping in the barrier layer and interface state creation occur. These cause a positive shift of Vt, reduce ID, skew the transfer characteristics, and degrade gm. Flicker noise (1/f) measurements show that after hot electron stress, the scaled drain current noise spectrum (SI(D)/ID2) decreases in depletion, but increases only slightly in strong accumulation, corroborating the creation of interface states but only a small creation of transition-layer tunnel traps that contribute to 1/f noise. During high-reverse current stress, electron trapping dominates for the first 50-60 s and then hole trapping and trap creation begin to manifest. However, there still is net electron trapping under the gate after one hour of stress. The degradation processes bring about a positive shift of Vt, degrade IDand gm, and increase reverse leakage. After high-reverse current stress, SI(D)/ID2increases substantially in strong accumulation, indicating the creation of transition layer tunnel traps. [J812]

"10 Gbit/s series-connected voltage-balancing pulse driver with direct-coupled current switches"

A series-connected voltage-balancing circuit can output more than twice the voltage amplitude that can be output by a single transistor. This circuit makes it possible to apply high-speed low-breakdown-voltage transistors to large-voltage-amplitude pulse drivers. The first operation of this type of driver at 10 Gbit/s is reported. [J813]

"Monolithic micropower amplifier using SiGe n-MODFET device"

A micropower-relevant model is extracted from the DC characteristics of an n-type buried channel Si/SiGe hetero-junction modulation doped FET (HMODFET). This model is then used to design a novel monolithic SiGe single-stage class-A power amplifier for micropower operation (sub 500 μW). The amplifier is fabricated and measured data of the power-gain against operating power are presented for the first time. [J814]

"A miniature broad-band pHEMT MMIC balanced distributed doubler"

A miniature broad-band balanced frequency doubler has been designed to operate from 30 to 50 GHz. It comprises a reduced-size 180° rat-race hybrid and two distributed doublers to form a balanced doubler configuration. The balanced distributed doubler suppresses the 180° out-of-phase fundamental and third harmonic signals at the output port while combining the in-phase second harmonic signal. A measured

conversion loss of 5-7 dB from 30- to 50-GHz output frequencies is achieved with fundamental and third harmonic signals rejection better than 13 and 25 dB, respectively. The chip size is only 1.5Ч1 mm2. [J815]

"40 Gbit/s low-voltage distributed limiting drivers for optical modulators"

The development of a monolithic modulator driver designed on a 0.15 μm GaInAs pHEMT technology for 40 Gbit/s optical communications is presented. The driver consists of a differential limiting predriver and a differential distributed postamplifier to achieve enough gain-bandwidth product. The driver achieves an output of 2.4 V with 0.5 Vpp input. [J816]

"Bias and frequency dependence of FET characteristics"

A novel measurement of the dynamics of high electron-mobility transistor (HEMT) and MESFET behavior permits classification of rate-dependence mechanisms and identification of operating regions that they affect. This reveals a simple structure to the otherwise complicated behavior that has concerned circuit designers. Heating, impact ionization, and trapping contribute to transient behavior through rate-dependence mechanisms. These are illustrated by a simple description. Each has an effect on specific regions of bias and operating frequency. With this insight, it is possible to determine true isodyamic characteristics of HEMTs and MESFETs and to predict operating conditions that will or will not be affected by rate dependence. It is interesting to note that, for some devices, rate dependence can be seen to exist at microwave frequencies and may, therefore, contribute to intermodulation distortion. [J817]

"A 110-GHz large-signal lookup-table model for InP HEMTs including impact ionization effects"

We developed an efficient method to extract a large-signal lookup table model for InP high electron-mobility transistors that takes impact ionization into account. By measuring the device on a logarithmic frequency scale, we obtain high resolution at lower frequencies to accurately characterize impact ionization, and a sufficient number of data points at millimeter-wave frequencies to extract the nonquasi-static parameters. Model validation through linear and nonlinear device measurements and its application to monolithic-microwave integrated-circuit design are presented. [J818]

"Enhancement-mode p-HEMT using selective hydrogen treatment"

A simple novel enhancement-mode p-HEMT has been fabricated using a selective hydrogen treatment. The DC and RF characteristics of the enhancement-mode p-HEMT, with a threshold voltage of 0.26 V and IDSS 0.9 mA/mm, show a selective hydrogen treatment is an effective method to implement an enhancement operation of any HEMT structure without degradation of DC and RF performance except the linearity. [J819]

"Channel temperature measurement of PHEMT by means of optical probes"

A novel technique for precise temperature measurement of high power PHEMTs is presented. The method, based on the measurement of photogenerated current, is used to extract the temperature of the PHEMT channel. Evaluation of thermal resistance is presented. [J820]

"9.2 W/mm (13.8 W) AlGaN/GaN HEMTs at 10 GHz and 55 V drain bias"

1.5 mm gate periphery AlGaN/GaN HEMTs were fabricated and tested. 9.2 W/mm (total 13.8 W) power was obtained at 10 GHz under pulsed conditions without active cooling. The pulse width was 50 μs with 5% duty cycle. This is the state-of-the-art power density demonstrated from the similar size devices. The device was biased at up to 55 V drain bias. At the above pulse conditions and drain bias, the simulated maximum junction temperature was 170°C, indicating that device performance was limited by the self-heating effect. [J821]

"Microwave power limits of AlGaN/GaN HEMTs under pulsed-bias conditions"

Dynamic loadline analysis illustrating the microwave performance limits of state-of-the-art AlGaN/GaN high electron-mobility transistors (HEMTs) under pulsed RF biasing and drive conditions are presented. Calculation of dynamic loadlines concurrent with load-pull measurements show the increase of the device RF knee voltage with increasing drain voltage as the cause of reduced output power-added efficiency (PAE) at high drain biases. In this study, an 8-GHz saturated output power of 14.1 W (9.4 W/mm) is achieved on a 1500 Ч 0.25 Ч μm2AlGaN/GaN HEMT at a pulsed drain bias of VD=40 V. The pulsed-bias conditions considered here preclude device self-heating as a mechanism responsible for the lower than expected output power and decrease in PAE with increasing drain bias. These data suggest electron trapping associated with the surface of the device between the gate and drain as the mechanism that limits the ultimate power, PAE, and linearity of AlGaN/GaN

HEMTs. [J822]

"Comprehensive analysis of small-signal parameters of fully strained and partially relaxed high Al-content lattice mismatched Alm Ga1-m N/GaN HEMTs"

Proposes an accurate model to investigate the small-signal microwave parameters of fully strained (FS) and partially relaxed (PR) AlmGa1-mN/GaN high electron-mobility transistors (HEMTs). It is observed that elastic strain relaxation of the AlmGa1-mN layer imposes an upper limit on the maximum two-dimensional electron-gas sheet charge density and is, thus, extremely critical in determining the microwave performance of high Al-content AlmGa1-mN/GaN HEMTs. The model incorporates the effects of strain relaxation of the barrier layer, field-dependent mobility, parasitic source/drain resistance, and velocity saturation to evaluate drain current, transconductance, drain conductance, cutoff frequency, and transit time of FS and PR AlmGa1-mN/GaN HEMTs with different Al mole fractions. The proposed model predicts a high drain current of 5.94 A/mm for a PR 0.3-μm Al0.4Ga0.6N/GaN HEMT, which is in close proximity with previously published simulated results. A peak transconductance of 154 mS/mm is also estimated for a 1-μm gate-length device with aluminum concentration of 15% (FS), which is in close agreement with previously published measured data. A high cutoff frequency of 21.09 GHz was predicted for a 0.6-μm device with an Al mole fraction of 0.5 (PR), thus showing the potential of AlGaN/GaN HEMTs for microwave applications. [J823]

"Design and characterization of an all-cryogenic low phase-noise sapphire K-band oscillator for satellite communication"

An all-cryogenic oscillator consisting of a frequency-tunable sapphire resonator, a high-temperature superconducting filter and a pseudomorphic high electron-mobility transistor amplifier was designed for the K-band frequency range. The high quality factor of the resonator above 1 000 000 and the low amplifier phase noise of approximately -133 dBc/Hz at a frequency offset of 1 kHz from the carrier, gave oscillator phase-noise values superior to quartz-stabilized oscillators at the same carrier frequency for offset frequencies higher than 100 Hz. In addition to low phase noise, the oscillator possesses mechanical and electrical frequency tunability. We have implemented a two-step electrical tuning arrangement consisting of a varactor phase shifter integrated within the amplifier circuit (fine tuning by 5 kHz) and a dielectric plunger moved by a piezomechanical transducer inside the resonator housing (coarse tuning by 50 kHz). This tuning range is sufficient for phase locking and for electronic compensation of temperature drifts occurring during operation of the device employing a miniaturized closed-cycle Stirling-type cryocooler. [J824]

"AlGaN/GaN HEMTs-operation in the K-band and above"

Reports on the power and microwave noise performance of AlGaN/GaN high electron-mobility transistors (HEMTs) at frequencies f>18 GHz (K- and Ka-bands). At 20 GHz, a record continuous-wave output power of 1.6 W has been achieved on an eight-finger 500-μm total gate-periphery device. At 29 GHz, a 120-μm gate-periphery device showed a pulsed output density of 1.6 W/mm with an associated gain of 6.7 dB and power-added efficiency of 26%. Minimum noise figure of 1.5 dB has been achieved on a 0.2 μm Ч 200 μm device at 26 GHz. The data demonstrate the viability of AlGaN/GaN HEMTs for high-frequency power and low-noise amplifier applications. [J825]

"Linearity characteristics of microwave-power GaN HEMTs"

The RF linearity of a 9-mm 10-W GaN high electron-mobility transistor (HEMT) grown on a 100-mm silicon substrate is presented. The quantitative results display promising device linearity as measured by intermodulation distortion and adjacent channel power ratio at 2.0 GHz for various power backoff levels and different quiescent points. These initial results demonstrate that larger periphery GaN HEMTs grown on silicon provide device linearity commensurate with current semiconductor device technology used for power-amplifier applications. [J826]

"High linearity and high efficiency of class-B power amplifiers in GaN HEMT technology"

A 36-dBm high-linearity single-ended common-source class-B monolithic-microwave integrated-circuit power amplifier is reported in GaN high electron-mobility transistor technology. We also describe the design and simulation of highly linear and highly efficient common-source and common-drain class-B power amplifiers. Single-ended class-B amplifiers with bandpass filtering have equivalent efficiency and linearity to push-pull configurations. The common-source class-B circuit demonstrates high linearity, greater than 35 dBc of third-order intermodulation (IM3) suppression and high power-added efficiency (PAE) of 34%. Simulations of common-drain class-B designs predict a PAE of 54% with a superior IM3 suppression of more than 45 dBc over a wider

range of bias due to the strong series-series negative feedback offered by the load resistance. [J827]

"A novel InGaP/InGaAs/GaAs double δ-doped pHEMT with camel-like gate structure"

The author reports a novel InGaP/InGaAs/GaAs double delta-doped pseudomorphic high-electron mobility transistor (pHEMT) with n+-GaAs/p+-InGaP/n-InGaP camel-like gate structure grown by MOCVD. Due to the p-n depletion from the p+-InGaP gate to the channel region and the presence of ΔEc at the InGaP/InGaAs heterostructure, the turn-on voltage of gate is larger than 1.7 V. For a 1Ч100-μm2device, the experimental results show an extrinsic transconductance of 107 mS/mm and a saturation current density of 850 mA/mm. Significantly, an extremely broad gate voltage swing larger than 6 V with above 80% maximum gmis obtained. Furthermore, the unit current cut-off frequency fTand maximum oscillation frequency are up to 20 and 32 GHz, respectively. The excellent device performance provides a promise for linear and large signal amplifiers and high-frequency circuit applications. [J828]

"High power 0.25 μm gate GaN HEMTs on sapphire with power density 4.2 W/mm at 10 GHz"

Metal organic chemical vapour deposition-grown AlGaN/GaN high electron mobility transistors (HEMTs) with power density up to 4.2 W/mm, one of the highest values ever reported for 0.25 μm gate-length AlGaN/GaN HEMTs, were fabricated on sapphire substrates. The devices exhibited maximum drain current density as high as 1370 mA/mm, high transconductance up to 223 mS/mm, short-circuit current gain cutoff frequency (fT) of 67 GHz, and maximum frequency of oscillation (fmax) of 102 GHz. [J829]

"40 Gbit/s lumped-element modulator driver in GaAs pHEMTs"

A high-speed and high-gain modulator driver circuit using 0.15 μm gate length GaAs pHEMT technology is presented. The IC was developed for driving electroabsorption modulators in 40 Gbit/s optical fibre systems. To meet application requirements a lumped-element approach was used with differential configuration. Measured results show the circuit operates at 40 Gbit/s with a swing of 3 Vp-pfor single-ended and 6 Vp-pfor differential output, and 8/10 ps rise/fall times. [J830]

"Physical/electromagnetic pHEMT modeling"

An effective technique, which is based only on geometrical and physical data, is presented for the analysis of high-frequency FETs. The intrinsic part of this electron device is described by a quasi-two-dimensional hydrodynamic transport model, coupled to a numerical electromagnetic field time domain solver in three dimensions that analyzes the passive part of the FET. Such an analysis is entirely performed in the time domain, thus allowing linear and nonlinear operations. The obtained data give insights to some parameters affecting the signal distribution through the entire device structure; a comprehensive discussion of these is given for a test device. In order to prove the validity of the approach, the bias-dependent small-signal analysis is compared with the corresponding measurements up to 50 GHz for two 0.3-μm gate-length AlGaAs-InGaAs-GaAs pseudomorphic high electron-mobility transistors, each having two gate fingers of 25-μm and 100-μm width, at bias points ranging from Idss to the pinchoff regime. The accuracy and the efficiency of the approach make it suitable for device optimization. [J831]

"Millimeter-wave MMIC single-pole-double-throw passive HEMT switches using impedance-transformation networks"

This paper proposes a new design method for passive FET switches in the millimeter-wave (MMW) regime. In contrast to the conventional resonant-type switch design method, this passive FET switch circuit utilizes impedance transformation to compensate the drain-source capacitance effect for the off state at high frequencies. By means of this new design concept, a Q- and V-band monolithic-microwave integrated-circuit single-pole double-throw (SPDT) switches using a GaAs pseudomorphic high electron-mobility-transistor process are demonstrated. The Q-band SPDT switch has a measured isolation better than 30 dB for the off state and 2-dB insertion loss for the on state from 38 to 45 GHz, while the V-band switch also shows a measured isolation better than 30 dB for the off state and 4-dB insertion loss for the on state from 53 to 61 GHz. The obtained isolation performance using this design approach outmatches previously published FET switches in the MMW frequency range. [J832]

"A 77-GHz MMIC power amplifier for automotive radar applications"

A MMIC 77-GHz two-stage power amplifier (PA) is reported in this letter. This MMIC chip demonstrated a measured small signal gain of over 10 dB from 75 GHz to 80 GHz with 18.5-dBm output power at 1 dB compression. The maximum small signal gain is above 12 dB from 77 to 78 GHz. The saturated output power is

better than 21.5 dBm and the maximum power added efficiency is 10% between 75 GHz and 78 GHz. This chip is fabricated using 0.1-μm AlGaAs/InGaAs/GaAs PHEMT MMIC process on 4-mil GaAs substrate. The output power performance is the highest among the reported 4-mil MMIC GaAs HEMT PAs at this frequency and therefore it is suitable for the 77-GHz automotive radar systems and related transmitter applications in W-band. [J833]

"Static frequency divider circuit using 0.15 μm gate length Si0.2 Ge0.8 /Si0.7 Ge0.3 p-MODFETs"

The first demonstration of an integrated circuit using high mobility p-channel modulation doped field effect transistors (MODFETs) is reported. A static frequency divider was fabricated on Si0.7Ge0.3/Si0.2Ge0.8/Si0.7Ge0.3strained heterostructures grown epitaxially on Si using ultra-high vacuum chemical vapour deposition; divide-by-two operation was achieved for clock frequencies of up to 2.9 GHz. [J834]

"Power results at 4 GHz of AlGaN/GaN HEMTs on high resistive silicon [J111] substrate"

The high potential at microwave frequencies of AlGaN/GaN high electron mobility transistors (HEMTs) on high resistive silicon [111] substrate for power applications has been demonstrated in this letter. For the first time, an output power density close to 1.8 W/mm and an associated power added efficiency of 32% have been measured on a 2 Ч 50 Ч 0.5 μm2HEMT with a linear power gain of 16 dB. These results constitute the state of the art. [J835]

"GaAs HEMT low-noise cryogenic amplifiers from C-band to X-band with 0.7-K/GHz noise temperature"

Cryogenic low-noise two-stage amplifiers were developed for frequency bands of 3.4-4.6 GHz, 4-8 GHz, and 8-9 GHz using commercial GaAs high electron mobility transistor. The performances are in very good agreement with simulations, and at a cryogenic temperature of 12 K, input noise temperatures get as low as 0.6 K/GHz (2.8 K for the 3.4-4.6 GHz LNA and 5 K for the 4-8 GHz and 8-9 GHz LNAs). Gain ranges from 25 to 28 dB. Ultralow noise temperature, low-power consumption, high reliability, and reproducibility make these devices adequate for series production and receiver arrays in, e.g., telescopes. [J836]

"Millimeter-wave high-power 0.25-μm gate-length AlGaN/GaN HEMTs on SiC substrates"

Reports on the CW power performance at 20 and 30 GHz of 0.25 μm Ч 100 μm AlGaN/GaN high electron mobility transistors (HEMTs) grown by MOCVD on semi-insulating SiC substrates. The devices exhibited current density of 1300 mA/mm, peak dc extrinsic transconductance of 275 mS/mm, unity current gain cutoff (fT) of 65 GHz, and maximum frequency of oscillation (fmax) of 110 GHz. Saturated output power at 20 GHz was 6.4 W/mm with 16% power added efficiency (PAE), and output power at 1-dB compression at 30 GHz was 4.0 W/mm with 20% PAE. This is the highest power reported for 0.25-μm gate-length devices at 20 GHz, and the 30 GHz results represent the highest frequency power data published to date on GaN-based devices. [J837]

"High-performance V-band cascode HEMT mixer and downconverter module"

A high-performance V-band cascode HEMT mixer is presented together with a compact downconverter module integrating the mixer with other receiver MMICs. The cascode mixer was optimized for conversion gain and/or linearity by employing the low-pass interstage networks and by optimizing the bias voltages. The low-pass interstage network effectively filters out the unwanted harmonics and spurious signals, and therefore, enhances the gain and the linearity of the cascode mixer. On a two-tone test, the cascode mixer showed a high conversion gain of 6.3 dB with an LO power of 2.6 dBm at 60 GHz. When the gate bias to the upper common-gate HEMT was tuned for the intermodulation distortion "sweet spot" theoretically predicted by the authors, the mixer showed a high third-order intercept point of 11.2 dBm with a decent gain of 4.1 dB under a small DC power consumption of 8 mW. To benchmark the performance of the cascode mixer of this work, a waveguide-based compact V-band downconverter module was built by integrating the mixer with an MMIC LNA, a VCO, and a LO driving amplifier. The downconverter module showed a conversion gain higher than 20 dB from 57.5 to 61.7 GHz. This paper shows the potential of the cascode FET mixer for high-performance compact downconverter applications at millimeter-wave frequencies. [J838]

"A compact and low-phase-noise Ka-band pHEMT-based VCO"

A low phase-noise Ka-band monolithic voltage-controlled oscillator (VCO) designed using the negative resistance concept is reported. A circuit fabricated using the three-dimensional monolithic microwave integrated circuit technology exhibits a high integration level; its size is a record at just 0.5 mm2. On-wafer measurements demonstrate a low phase noise of -102 dBc/Hz at a 1-MHz offset. The VCO delivers an output power of 11.8

dBm at the center frequency of 28.3 GHz. The frequency tuning range is more than 3.8 GHz. Dependence of the circuit performance on the bias conditions is also reported and suggests that an optimum phase-noise characteristic can be achieved when biasing the transistor to optimize its transconductance and noise figure. [J839]

"Phase noise characterisation of planar magnetostatic wave oscillators"

The phase noise performances of a planar configuration of a magnetostatic wave oscillator have been investigated. The behaviour of the output signal has been studied in terms of the single sideband power spectral density. Values as low as -100 dBc at 100 kHz of offset from the carrier frequency have been measured in the whole range of tunability, by using two different resonators. [J840]

"50-gbit/s InP HEMT 4: 1 multiplexer/1: 4 demultiplexer chip set with a multiphase clock architecture"

A 50-Gbit/s InP high electron-mobility transistor (HEMT) chip set of 4: 1 multiplexer (MUX) and 1: 4 demultiplexer (DMUX) integrated circuits (ICs) with a multiphase clock (MPC) architecture is described. The MPC architecture employs a quarter-rate four-phase clock generated by a toggle flip-flop inside the ICs, which reduces the number of circuit elements and lowers the power consumption. The fabricated 4: 1 MUX and 1: 4 DMUX ICs exhibited 50-Gbit/s error-free operations for 231-1 pseudorandom bit sequences with 1.71- and 1.42-W power consumption, respectively. Compared to conventional tree-type 4: 1 MUX and 1: 4 DMUX ICs using InP HEMTs, the MPC 4: 1 MUX and 1: 4 DMUX ICs operate at the same operating speed with less than one-third power consumption. [J841]

"A V-band quasi-optical GaAs HEMT monolithic integrated antenna and receiver front end"

A single-chip monolithic integrated V-band folded-slot antenna with two Schottky-barrier diodes and a local oscillator source is developed as a quasi-optical receiver for the first time. The monolithic microwave integrated circuit consists of a voltage-controlled oscillator (VCO), a coplanar waveguide (CPW)-to-slotline transition, a low-pass filter, a folded-slot antenna, and a 180° single balanced mixer. The chip is fabricated based on the 0.15-μm GaAs high electron-mobility transistor technology and the overall chip size is 3Ч1.5 mm2. A finite-difference time-domain method solver is also developed for analyzing the embedded impedance characteristics of the folded-slot antenna to design the mixer. The chip is placed on an extended hemispherical silicon substrate lens to be a quasi-optical receiver. The performance of the receiver is verified by experimental measurements. The VCO has achieved a tuning range from 61.9 to 62.5 GHz and approximately 9.3-dBm output power. The CPW-to-slotline transition has bandwidth from 50 to 70 GHz. The mixer results in 15-dB single-sideband conversion loss and the receiving patterns of the IF power are also measured. [J842]

"pH response of GaN surfaces and its application for pH-sensitive field-effect transistors"

The pH-sensitivity of GaN surfaces in electrolyte solutions has been determined. For this purpose, GaN field-effect transistors and AlGaN/GaN high-electron-mobility transistor (HEMT) structures were used to measure the response of nonmetallized GaN gate regions to changes of the H+-concentration in an ambient electrolyte. We found a linear response to changes in the pHbetween pH=2and pH=12for both as-deposited and thermally oxidized GaN surfaces. Both surfaces showed an almost Nernstian behavior with sensitivities of 57.3 mV/pHfor GaN:Si/GaN:Mg and 56.0 mV/pHfor GaN/AlGaN/GaN HEMT structures. This suggests that the native metal oxide on the III-nitride surface is responsible for pH-sensitivity. The investigated devices showed stable operation with a resolution better than 0.05 pHover the entire pHrange. copyright 2003 American Institute of Physics. [J843]

"Investigation of buffer traps in an AlGaN/GaN/Si high electron mobility transistor by backgating current deep level transient spectroscopy"

The influence of a substrate voltage on the dc characteristics of an AlGaN/GaN high electron mobility transistor (HEMT) on silicon (111) substrate is profited to investigate traps that are located between the substrate and the two-dimensional electron gas channel. The transient of the drain current after applying a negative substrate voltage is evaluated in the temperature range from 30 to 100 °C.With this method, known as backgating current deep level transient spectroscopy, majority carrier traps with activation energy of 200 meV as well as minority carrier traps at 370 meV are identified. The experiments are performed on completed HEMTs, allowing the investigation of the influence of device fabrication technology. copyright 2003 American Institute of Physics. [J844]

"High breakdown voltage AlGaN-GaN power-HEMT design and high current density switching

behavior"

AlGaN-GaN power high-electron mobility transistors (HEMTs) with 600-V breakdown voltage are fabricated and demonstrated as switching power devices for motor drive and power supply applications. The fabricated power HEMT realized the high breakdown voltage by optimized field plate technique and the low on-state resistance of 3.3 mΩcm2, which is 20 times lower than that or silicon MOSFETs, thanks to the high critical field of GaN material and the high mobility in 2DEG channel. The fabricated devices also demonstrated the high current density switching of 850 A/cm2turn-off. These results show that AlGaN-GaN power-HEMTs are one of the most promising candidates for future switching power device for power electronics applications. [J845]

"High performance 0.25 μm gate-length AlGaN/GaN HEMTs on 6H-SiC with power density of 6.7 W/mm at 18 GHz"

MOCVD-grown 0.25 μm gate-length AlGaN/GaN high electron mobility transistors (HEMTs) have been fabricated on 6H-SiC substrates. These 0.25 μm gate-length devices exhibited maximum drain current density as high as 1.28 A/mm, peak extrinsic transconductance of 310 mS/mm, unity current gain cutoff frequency (fT) of 51 GHz, and maximum frequency of oscillation (fmax) of 115 GHz. At 18 GHz, a continuous-wave output power density of 6.7 W/mm with power-added efficiency of 26.6% was obtained, yielding the highest reported power performance of AlGaN/GaN HEMTs at 18 GHz. [J846]

"A gallium-nitride push-pull microwave power amplifier"

A highly efficient linear, broad-band AlGaN-GaN high electron-mobility transistor (HEMT) push-pull microwave power amplifier has been achieved using discrete devices. Instrumental was a low-loss planar three-coupled-line balun with integrated biasing. Using two 1.5-mm GaN HEMTs, a push-pull amplifier yielded 42% power-added efficiency with 28.5-dBm input power at 5.2 GHz, and a 3-dB bandwidth of 4-8.5 GHz was achieved with class-B bias. The output power at 3-dB gain compression was 36 dBm under continuous-wave operation. Along with the high efficiency, good linearity was obtained compared to single-ended operation. The second harmonic content of the amplifier was more than 30 dB down over the 4-8.5-GHz band, and a two-tone excitation measurement gave an input third-order intercept point of 31.5 dBm at 8 GHz. These experimental results and an analysis of the periodic load presented by the output balun suggest the plausibility of broad-band push-pull operation for microwave systems with frequency diversity. [J847]

"High transconductance enhancement-mode AlGaN/GaN HEMTs on SiC substrate"

Using inductively-coupled-plasma reactive ion etching (ICP-RIE), recessed 1 μm gate-length enhancement-mode (E-mode) AlGaN/GaN high electron mobility transistors (HEMTs) were fabricated. These 1 μm gate-length devices exhibited maximum drain current density of 470 mA/mm, extrinsic transconductance of 248 mS/mm and threshold voltage of 75 mV. These characteristics are much higher than previously reported values for GaN-based E-mode HEMTs. A unity gain cutoff frequency (fT) of 8 GHz and a maximum frequency of oscillation (fmax) of 26 GHz were also measured on these devices. [J848]

"Unpassivated p-GaN/AlGaN/GaN HEMTs with 7.1 W/mm at 10 GHz"

A novel gate process utilising SiO2to cover the recess sidewall on the drain side of a p-GaN/AlGaN/GaN high electron mobility transistor is presented. Improvements in breakdown voltage and output power are demonstrated with no degradation in small-signal performance. [J849]

"Depletion- and enhancement-mode In 0.49 Ga 0.51 P /InGaAs /AlGaAs high-electron-mobility transistors with high-breakdown voltage"

A high-breakdown delta -doped In0.49Ga0.51P/InGaAs/AlGaAshigh-electron-mobility transistor (HEMT) grown by low-pressure metalorganic chemical vapor deposition has been fabricated and demonstrated successfully. By using a wet etching gate process, we obtained depletion- and enhancement-mode HEMTs. The fabricated devices (1.5Ч125 mcm2)show that the measured maximum drain saturation current density and extrinsic transconductance are 215 mA/mm and 82 mS/mm for depletion-mode and are 100 mA/mm and 75 mS/mm for enhancement-mode devices, respectively. The gate-to-drain breakdown voltage for both types is over 40 V. The high-breakdown voltage is attributed to the use of an In0.49Ga0.51PSchottky layer, delta -doping, and GaAs subspacer layer. copyright 2003 American Vacuum Society. [J850]

"Characterization of different-Al-content Al x Ga 1-x N/GaN heterostructures and high-electron-mobility transistors on sapphire"

AlxGa1-xN/GaN(0.20≤x≤0.52)heterostructures (HSs) were grown on a sapphire substrate by atmospheric pressure metalorganic chemical vapor deposition with good uniformity and two-dimensional-electron-gas (2DEG) mobilities of 936, 1163, 1310, 1274, and 911cm2/V sfor different-Al-contents of 20%, 27%, 34%, 42%, and 52%, respectively. 2DEG mobility increase up to the Al content of 34% and then it slowly decreases for high Al-content AlGaN/GaN HSs. An increase of sheet carrier density with the increase of Al content has been observed. A small hump photoluminescence peak of e2DEG1-hhas been observed in both 34% and 42% Al-content AlGaN/GaN heterostructures. High Al-content (52%) heterostructure has exhibited a distinguished e2DEG1-hpeak. The increase of surface roughness and granular size of AlGaN/GaN heterostructures with the increase of Al content is due to the increase of lattice mismatch between GaN and AlGaN layers. High-electron-mobility transistors (HEMTs) have been fabricated and characterized using AlxGa1-xN/GaNheterostructures with different-gate lengths (2.0-5.0 mcm). An increase of extrinsic transconductance (gm)and drain current density has been observed up to the Al content of 34% and it slowly decreases for higher Al-content AlxGa1-xN/GaNHEMTs. The maximum gmof 202 mS/mm with maximum drain-source current density of 525 mA/mm has been observed for 2.0-mcm-gate-l--ength Al0.34Ga0.66N/GaNHEMT structure. About 3-4 orders of magnitude, low gate-leakage current has been observed on 42% and 52% Al-content AlGaN/GaN HEMTs when compared with the low Al-content (20%) AlGaN/GaN HEMTs. copyright 2003 American Vacuum Society. [J851]

"Thermal stability of InP-based high electron mobility transistor epitaxial wafers"

Systematic annealing of the InP-based high electron mobility transistor (HEMT) structure was performed. The thermal stability of the sheet carrier concentration (Ns)and its relation to fluorine contamination were investigated by using van der Pauw-Hall effect measurements, secondary ion mass spectroscopy (SIMS), and photoluminescence (PL) measurement. The Nsdecreased after annealing at 450 °C in nitrogen ambient, which was due to fluorine contamination of the carrier-supply layer (CSL). The PL spectra from the InGaAs channel reflected the Nsreduction. In addition, the PL spectra from the Si delta-doped InAlAs CSL drastically changed in line shape as the fluorine concentration increased. Such changes of PL and Nswere not observed in the samples after annealing at 350 °C, where the CSL was scarcely contaminated by fluorine. The series of PL characterization and Hall effect and SIMS measurements can effectively analyze how fluorine contamination affects the Ns in the InP-based HEMT structures. copyright 2003 American Institute of Physics. [J852]

"Low noise, low power consumption high electron mobility transistors amplifier, for temperatures below 1 K"

Low noise three-stage pseudomorphic high electron mobility field-effect transistors amplifier were designed for the temperature range below 1 K. A minimum noise temperature TN≈100 mKwas measured at an ambient temperature of about 380 mK at frequencies between 1 and 4 MHz for a source resistance of 10 kOmega . The gain of the amplifier was 50 at a power consumption of about 200 mu W. The noise parameters of the amplifier are stable to within 30%, for a power consumption in the range of 100-300 mu W. Minimum voltage spectral noise density of the amplifier with respect to the input is about 200 pV/Hz1/2and the corner frequency of the 1/fnoise is close to 300 kHz. copyright 2003 American Institute of Physics. [J853]

"Electrical, spectral, and chemical properties of 1.8 MeV proton irradiated AlGaN/GaN HEMT structures as a function of proton fluence"

We have characterized high-electron mobility transistors and corresponding unprocessed material as a function of 1.8 MeV proton fluence. Electrical data shows degradation of the electrical contacts at low fluences (1011-1014p+/cm2) and degradation of the channel properties for higher fluences. In conjunction with the electrical data, cathodoluminescence and secondary-ion mass spectrometry results suggest mechanisms for the higher fluence degradation. [J854]

"Surface photovoltage spectroscopy of epitaxial structures for high electron mobility transistors"

AlGaN/GaN high electron mobility transistor, AlGaAs/InGAs/GaAs pseudomorphic HEMT, and InAlAs/InGaAs metamorphic HEMT (MHEMT) epitaxial structures have been characterized using surface photovoltage spectroscopy. The effects of the transistor top and bottom delta-doping levels delta top,delta bot,and surface charge Qsuron the spectrum features have been studied using numerical simulations. Based on the latter, an empirical model has been developed, which allows extraction and comparison of delta top,delta bot,and Qsurand is applicable for both double-sided and single-sided delta-doped structures. Prediction of the final device performance by the model is shown for two MHEMT structures. Devices produced on these structures show maximum drain currents, which correlate well with delta topvalues calculated using the model. copyright 2003 American Institute of Physics. [J855]

"A high-performance 40-85 GHz MMIC SPDT switch using FET-integrated transmission line structure"

A compact ultra-broadband distributed SPDT switch has been developed using GaAs PHEMTs. An FET-integrated transmission line structure, where the source pad of the shunt FET has been integrated into the signal line while the drain has been grounded to a via-hole with minimum parasitic inductance, has been proposed to extend the operating bandwidth of the distributed switches. SPDT and SPST switches using this structure have been fabricated using a commercial GaAs PHEMT foundry. The SPDT switch showed low insertion loss (30 dB) over an octave bandwidth from 40 to 85 GHz. At 77 GHz, the SPDT switch showed extremely low insertion loss of 1.4 dB and high isolation of 38 dB. The chip size was as small as 1.45Ч1.0 mm2. To the best of our knowledge, this is among the best performance ever reported for an octave-band SPDT switch at this frequency range. SPST switch also showed the excellent performance with the insertion loss of 0.4 dB and isolation of 34 dB at 60 GHz. [J856]

"Generation of coherent gigahertz acoustic phonons in AlGaN/GaN microwave field-effect transistors"

We apply an optical probing technique on AlGaN/GaN field-effect transistors to demonstrate that coherent gigahertz phonons are generated copiously under large signal operation. The phonon generation originates from time varying electron screening of the piezoelectric polarization fields in the active region, and may provide a nondiffusive means of energy dissipation for high power devices. copyright 2003 American Institute of Physics. [J857]

"Electrostatic discharge effects in AlGaN/GaN high-electron-mobility transistors"

We investigate 50 mcm gate width/0.45 mcm length AlGaN/GaN high-electron-mobility transistors (HEMTs) subjected to 100 ns long current pulses that simulate an electrostatic discharge. After source-drain breakdown at around 90 V, the pulsed I-Vsource-drain characteristic is S shaped with an abrupt snap back to about 20 V at stress current of Istress=0.2 A.Backside interferometric thermal mapping of the HEMT shows that current filamentation accompanies the transition to the low-voltage/high-current region. The shift in transistor threshold voltage is explained by electron trapping in the buffer. It is assumed that breakdown in the regime of electrostatic discharge can be explained as an avalanche-injection event that forms a current filament through the device buffer layer. copyright 2003 American Institute of Physics. [J858]

"Design and analysis of novel high-gain and broad-band GaAs pHEMT MMIC distributed amplifiers with traveling-wave gain stages"

Using the concept of traveling-wave gain stages, novel GaAs pseudomorphic high electron-mobility transistor monolithic-microwave integrated-circuit (MMIC) distributed amplifiers (DAs) are demonstrated to achieve high gain and over several octaves of bandwidth performance simultaneously for microwave and millimeter-wave frequency applications. The cascaded single-stage distributed amplifier (CSSDA) is used as traveling-wave gain stages to improve the gain performance of the conventional distributed amplifier (CDA). By adopting the low-pass filter topology between the CDA and CSSDA and tuning the gain shape of CDA and CSSDA separately, a broad-band and high-gain DA, called CDA-CSSDA-2, was accomplished. The detailed design equations are derived for the broad-band matching design of this CDA-CSSDA-2. Two other MMICs, namely, a two-stage CSSDA called 2-CSSDA, and another two-stage design called CDA-CSSDA-1, are also included in this paper. This CDA-CSSDA-2 achieves 22±1.5-dB small-signal gain from 0.1 to 40 GHz with a chip size of 1.5Ч2 mm2. It also produces a gain-bandwidth product of 503 GHz, which is the highest among all reported GaAs-based DAs. The flat group delay also demonstrates the feasibility of this design for future digital optical communications and broad-band pulse applications. [J859]

"High-power monolithic AlGaN/GaN HEMT oscillator"

A monolithic X-band oscillator based on an AlGaN/GaN high electron mobility transistor (HEMT) has been designed, fabricated, and characterized. A common-gate HEMT with 1.5 mm of gate width in conjunction with inductive feedback is used to generate negative resistance. A high Q resonator is implemented with a short-circuit low-loss coplanar waveguide transmission line. The oscillator delivers 1.7 W at 9.556 GHz into 50-Ω load when biased at Vds=30 V and Vgs=-5 V, with dc-to-RF efficiency of 16%. Phase noise was estimated to be -87 dBc/Hz at 100-kHz offset. Low-frequency noise, pushing and pulling figures, and time-domain characterization have been performed. Experimental results show great promise for AlGaN/GaN HEMT MMIC technology to be used in future high-power microwave source applications. [J860]

"A 4-W X-band compact coplanar high-power amplifier MMIC with 18-dB gain and 25% PAE"

The performance of a compact coplanar microwave monolithic integrated circuit (MMIC) amplifier with high output power in the X-band is presented. Based on our 0.3-μm gate-length GaAs power pseudomorphic high electron mobility transistor (PHEMT) process on 4-in wafer, this two-stage amplifier, having a chip size of 16 mm2, averages 4-W continuous-wave (CW) and 25% mean power-added efficiency (PAE) in the X-band, with more than 18-dB linear gain. Peak output powers of P-1dB=36.3dBm (4.3 W) and Psatof 36.9 dBm (4.9 W) at 10 GHz with a PAE of 50% were also measured. Compared to previously reported X-band coplanar high-power amplifiers, this represents a chip size reduction of 20%, comparable to the size of compact state-of-the-art microstrip power amplifiers. [J861]

"An over-110-GHz InP HEMT flip-chip distributed baseband amplifier with inverted microstrip line structure for optical transmission system"

We successfully developed state-of-the-art InP high electron mobility transistor (HEMT) distributed amplifiers by using inverted microstrip line (IMSL) technology. The IMSL has minor frequency dispersion characteristics and a simple equivalent circuit model can embody its discontinuity, such as a T-junction, because it has a large ground plane at the surface of the chip. For one distributed amplifier, we achieved a gain of 14.5 dB and a 94-GHz 3-dB bandwidth resulting in a gain-bandwidth product of 500 GHz, and for the other we achieved a gain of 7.5 dB and a 3-dB bandwidth of over 110 GHz. Furthermore, this technology also offers the capability of fabricating ultra-broad-band packaged ICs with flip-chip assembly for operation up to the W-band. In this paper, we focus on the advantage of IMSL technology for circuit design. We used an IMSL structure to design and fabricate a distributed amplifier to verify the advantages of IMSL. Our results show that this is an accurate technique for designing broad-band circuits up to 110 GHz. [J862]

"Electrical bias stress related degradation of AlGaN/GaN HEMTs"

Effects of electrical bias stress applied for an extended period of time to unpassivated AlGaN/GaN HEMTs have been studied by surface potential and drain current transient measurements. The transient magnitudes were much increased after stress, indicating a larger accumulation of surface charge under the same measurement conditions. In correlation with the increase in transient magnitudes, a permanent reduction in microwave output power of the devices, following stress, was observed. [J863]

"50-Gb/s 4-b multiplexer/demultiplexer chip set using InP HEMTs"

A 50-Gb/s 4:1 multiplexer (MUX) and 1:4 demultiplexer (DEMUX) chip set using InP high electron mobility transistors (HEMTs) is described. In order to achieve wide-range bit-rate operation from several to 50 Gb/s, timing design inside the ICs was precisely executed. The packaged MUX operated from 4 to 50Gb/s with >1-Vppoutput amplitude, and the DEMUX exhibited >180° phase margin from 4 to 50 Gb/s for 231-1 pseudorandom bit sequence (PRBS). Furthermore, 50-Gb/s back-to-back error-free operation for 231-1 PRBS was confirmed with the packaged MUX and DEMUX. [J864]

"System control and management for low-cost high-volume GaAs manufacturing"

With a portfolio consisting of Metal Semiconductor Field Effect Transistors (MESFET), Pseudomorphic High Electron Mobility Transistors (pHEMT), Heterojunction Insulated Gate Field Effect Transistors (HIGFET), and Indium Gallium Phosphide Heterojunction Bipolar Transistors (InGaP-HBT) technology, one factory has embarked on a mission to become a leader of cost and volume gallium arsenide (GaAs) manufacturing. Separate new product and new technology introduction systems have been developed and employed. Furthermore, several manufacturing and yield improvement systems, designed primarily for high-volume silicon factories, have been implemented. Additionally, a comprehensive cost-reduction project was implemented to bring wafer costs to benchmark levels. [J865]

"GaAs pHEMT-based technology for microwave applications in a volume MMIC production environment on 150-mm wafers"

The establishment of a 150-mm (6-in) gallium arsenide (GaAs) facility is described together with the development of very high yielding and cost-effective semiconductor device technologies and a manufacturing capacity of over 40000 wafers/annum. The background to the demand for very high volumes of RF products for this market is discussed, together with the prospects for future growth. The paper describes recent process development by the utilization of a data-driven yield management system to support the delivery of high-quality RF products to customers. Finally, "end of line" DC and RF testing of finished 150-mm GaAs pHEMT foundry

wafers is described, enabling scalar measurements of power, noise, and intermodulation products as well as vector measurements of S-parameters and noise parameters at frequencies of up to 40 GHz. [J866]

"Influence of SiO2 and Si3 N4 passivation on AlGaN/GaN/Si HEMT performance"

The different influences of SiO2and Si3N4passivation on the performance of AlGaN/GaN/Si HEMTs are reported. DC characteristics are less enhanced by using SiO2than Si3N4. This is in agreement with carrier concentration changes after passivation, as follows from Hall data. Small signal RF performance is degraded after applying SiO2and enhanced after Si3N4passivation, e.g. for unpassivated devices fT 17 GHz which decreases to 9 GHz and increases to 28 GHz for SiO2and Si3N4, respectively. The fmax/fTratio does not change after passivation. [J867]

"Effect of the surface and barrier defects on the AlGaN/GaN HEMT low-frequency noise performance"

We report on the effect of Si3N4passivation of the surface of AlGaN/GaN transistors on low-frequency noise performance. Low-frequency noise measurements were performed on the device before and after the passivation by a Si3N4film. A lower level of the low-frequency noise was observed from the device after the passivation. The passivation layer improved high-frequency, large-signal device performance, but introduced parasitic leakage current from the gate. A lower level of flicker noise is explained by the fact that noise is mostly originated from the fluctuation of sheet charge and mobility in the ungated region of the device due to the defects on the surface and in the barrier of the unpassivated device. Passivation eliminates part of the defects and higher leakage current increases the number of electrons on the surface and in the vicinity of the barrier defects, lowering the contribution to the low-frequency noise according to Hooge's law. [J868]

"40-Gbit/s OEIC on GaAs substrate through metamorphic buffer technology"

An optoelectronic integrated circuit operating in the 1.55-μm wavelength range was realized on GaAs substrate through metamorphic technology. High indium content layers, metamorphically grown on a GaAs substrate, were used to fabricate the optoelectronic integrated circuits (OEICs) with -3 dB bandwidth of 40 GHz and 210 V/W of calculated responsivity. The analog OEIC photoreceiver consists of a 12-μm, top-illuminated p-i-n photodiode, and a traveling wave amplifier (TWA). This receiver shows 6 GHz wider bandwidth than a hybrid photoreceiver, which was built using comparable, but stand-alone metamorphic p-i-n diode and TWA. With the addition of a buffer amplifier, the OEIC shows 7 dB more gain than the hybrid counterpart. To our knowledge, this is the first 40 Gbit/s OEIC achieved on a GaAs substrate operating at 1.55 μm. [J869]

"Channel thickness dependence of breakdown dynamic in InP-based lattice-matched HEMTs"

We have investigated, by using Monte Carlo simulations, the effects of channel thickness on the breakdown dynamics in InP-based lattice-matched HEMTs (LM-HEMTs). Breakdown is due to the parasitic bipolar action of holes generated by impact ionization and accumulated in the low electric field regions near the source. Our results show that channel shrinking results in an increase in time-to-breakdown values due to holes real-space-transfer effects occurring in thin channel devices. The breakdown behavior of thin-channel devices (channel thickness ≤20 nm) is dominated by the accumulation of holes in the InAlAs buffer layer; in thick-channel devices breakdown is due to the parasitic bipolar action of holes accumulating in the InGaAs channel. These results suggest a frequency dependence of breakdown which can be relevant for power rf device applications and/or in the study of device survivability to rf overstress. [J870]

"AlGaN-GaN HEMTs on SiC with CW power performance of >4 W/mm and 23% PAE at 35 GHz"

In this work, continuous wave Ka-band power performance of AlGaN-GaN high electron-mobility transistors grown on semi-insulating SiC substrates are reported. The devices, with gate lengths of 0.25 μm, exhibited maximum drain current density of 1.1 A/mm and peak extrinsic transconductance of 285 mS/mm. At 35 GHz, an output power density of 4.13 W/mm with 23% of power-added efficiency (PAE) and 7.54 dB of linear gain were achieved at a drain bias of 30 V. These power results represent the best power density, PAE, and gain combination reported at this frequency. The drain bias dependence of the Ka-band power performance of these devices is also presented. [J871]

"Photodetectors based on heterostructures for opto-electronic applications"

In this paper, we present four photodetector devices that have the benefit of compatibility with established high electron-mobility transistor technology and are, thus, more conducive to monolithic integration with high-speed opto-electronic integrated circuitry. These AlGaAs-GaAs heterojunction-based planar devices all use the wide-

gap material to enhance the Schottky barrier height between metal and semiconductor. We show that doping of this layer produces an internal electric field that aids in the transport and collection of photoelectrons. Addition of a resonant optical cavity by means of a distributed Bragg reflector reduces the required thickness of the absorption layer, thus achieving good responsivity and high speed, as well as wavelength selectivity. Current-voltage, current-temperature, photocurrent spectra, high-speed time response, and on-wafer frequency-domain measurements are presented, which point out that the often contradictory requirements of responsivity, noise, and speed may be addressed by proper engineering of the internal electric field and optical properties. Numerical simulations are performed to describe internal electric and optical behavior and a small-signal model based on frequency-domain data is extracted in order to facilitate photoreceiver design. The low dark current, in tens of femtoamps per square micrometer, full-width at half-maximum time responses below 10 ps, and high bandwidth in tens of gigahertz, make these devices of interest for applications ranging from optical communications to imaging systems. [J872]

"High performance 0.14 μm gate-length AlGaN/GaN power HEMTs on SiC"

High electron mobility transistors (HEMTs) were fabricated from AlGaN/GaN on semi-insulating SiC substrates with excellent performance and high yield. The devices had 0.14 μm T-gates with a total width of 300 μm. Extrinsic, unpassivated peak performance values for these HEMTs include transconductance of 338 mS/mm, maximum drain current of 1481 mA/mm, unity current gain cutoff frequency of 91 GHz, and maximum frequency of oscillation of 122 GHz. Saturated CW power measurements of these devices at 10 GHz result in 4.6 W/mm with PAE at 46% when optimized for power and 3.0 W/mm with PAE at 65% when optimized for efficiency. [J873]

"A study on current collapse in AlGaN/GaN HEMTs induced by bias stress"

Drain current collapse in AlGaN/GaN HEMTs has been studied systematically by applying bias stress to the device. The collapse was suppressed by light illumination with energy smaller than the bandgap. The position dependence of the light illumination and the measurement of series source and drain resistances revealed that the collapse was caused by the surface states between the gate and drain electrodes, which captured electrons injected from the gate. The current collapse was eliminated by the passivation of the device surface with Si3N4film. [J874]

"88 GHz dynamic 2:1 frequency divider using resonant tunnelling chaos circuit"

Ultra-high frequency operation at 88 GHz was demonstrated for the frequency divider based on the resonant tunnelling chaos circuit. It was also shown that the phase noise is comparable to that of the conventional circuits in spite of the novel operating principle. [J875]

"Active planar inverted-F antennas for wireless applications"

We present an electrically small antenna for use with high efficiency power amplifiers for wireless applications. A planar inverted-F antenna design is described that can be optimized as a class-F termination for use as a load at the output of a field effect transistor (FET) for optimum output power and efficiency. An active planar inverted-F antenna is shown to have greater than 50% power-added efficiency at several frequencies between 1 GHz and 2 GHz by scaling the radiating element. These antennas are also shown to provide a copolarized field component in the azimuth plane and a cross-polarized field component in the elevation plane. [J876]

"32 GHz MMIC distributed amplifier based on n-channel SiGe MODFETs"

For the first time the fabrication of a distributed amplifier based on n-type Si/SiGe-MODFETs is presented. The realised amplifier consists of six identical stages and has a gain of 5.5 dB. The bandwidth of this amplifier is 32 GHz. The gain ripple up to this frequency is ±0.8 dB. The return losses at the input and output are better than 10 dB. Using a coplanar waveguide layout for the amplifier no via-holes and backside processing is needed. The MMIC has a size of 0.9Ч3.2 mm2. [J877]

"A 54-GHz distributed amplifier with 6-VPP output for a 40-Gb/s LiNbO3 modulator driver"

We have developed a distributed amplifier for a LiNbO3modulator driver using double-doped AlGaAs-InGaAs-AlGaAs pseudomorphic high electron mobility transistors (p-HEMTs). By using a stabilization and negative resistance control technique with source inductance and grounded coplanar waveguided lines, we obtained a gain of 15 dB, a bandwidth of 54 GHz, and 6-VPPoutput. These results indicate that our circuit is a leading candidate for use as a LiNbO3modulator driver in 40-Gb/s fiber-optic communication systems. [J878]

"An updated temperature-dependent breakdown coupling model including both impact ionization and tunneling mechanisms for AlGaAs/InGaAs HEMTs"

An updated model on the temperature dependent two-terminal breakdown mechanisms coupling both impact ionization (II) and thermionic field emission (TFE) for HEMTs is presented in this paper. This model depicts the interplay between TFE and II mechanisms. Examples of temperature dependence of reverse gate current are discussed. It is important that the coupling mechanism between TFE and II at elevated temperature should be considered, particularly when designing devices for high-power applications [J879]

"AlGaN/GaN HEMTs-an overview of device operation and applications"

Wide bandgap semiconductors are extremely attractive for the gamut of power electronics applications from power conditioning to microwave transmitters for communications and radar. Of the various materials and device technologies, the AlGaN/GaN high-electron mobility transistor seems the most promising. This paper attempts to present the status of the technology and the market with a view of highlighting both the progress and the remaining problems. [J880]

"High linearity performances of GaN HEMT devices on silicon substrate at 4 GHz"

In this letter, we demonstrate that, for high linearity application, GaN devices benefit from their high drain-source bias voltages. An improvement up to 20 dB in intermodulation ratio can be observed at high power levels compared to usual GaAs PHEMT devices. This study demonstrates that the high bandgap GaN devices are ideal candidates for the applications requiring high power and linearity simultaneously. [J881]

"A tunable all-pass MMIC active phase shifter"

This paper describes a novel structure for a monolithic-microwave integrated-circuit active phase shifter based on a bridge all-pass network. The design procedure has been developed, leading to a fixed-frequency circuit with large tunable phase variation, associated to a low-gain ripple, and requiring nearly no design optimization. Simulated results predicted an analog tunable 180° phase variation, at 5-GHz operation frequency. The circuit was implemented using GEC-Marconi pseudomorphic high electron-mobility transistor H40 technology, and measured results validated the proposed design method and circuit structure. [J882]

"Trapping effects in GaN and SiC microwave FETs"

It is well known that trapping effects can limit the output power performance of microwave field-effect transistors (FETs). This is particularly true for the wide bandgap devices. In this paper we review the various trapping phenomena observed in SiC- and GaN-based FETs that contribute to compromised power performance. For both of these material systems, trapping effects associated with both the surface and with the layers underlying the active channel have been identified. The measurement techniques utilized to identify these traps and some of the steps taken to minimize their effects, such as modified buffer layer designs and surface passivation, are described. Since similar defect-related phenomena were addressed during the development of the GaAs technology, relevant GaAs work is briefly summarized. [J883]

"Effects of Sc2 O3 and MgO passivation layers on the output power of AlGaN/GaN HEMTs"

The low temperature (100°C) deposition of Sc2O3or MgO layers is found to significantly increase the output power of AlGaN/GaN HEMTs. At 4 GHz, there was a better than 3 dB increase in output power of 0.5Ч100 μm2 HEMTs for both types of oxide passivation layers. Both Sc2 O3and MgO produced larger output power increases at 4 GHz than conventional plasma-enhanced chemical vapor deposited (PECVD) SiNxpassivation which typically showed ⩽2 dB increase on the same types of devices. The HEMT gain also in general remained linear over a wider input power range with the Sc2O3or MgO passivation. These films appear promising for reducing the effects of surface states on the DC and RF performance of AlGaN/GaN HEMTs [J884]

"p-capped GaN-AlGaN-GaN high-electron mobility transistors (HEMTs)"

A novel p-capped GaN-AlGaN-GaN high-electron mobility transistor has been developed to minimize radio-frequency-to-dc (RF-DC) dispersion before passivation. The novel device uses a p-GaN cap layer to screen the channel from surface potential fluctuations. A low-power reactive ion etching gate recess combined with angle evaporation of the gate metal has been used to prevent gate extension and maintain breakdown voltage. Devices with gate lengths of 0.7 μm have been produced on sapphire. Current-gain cutoff frequencies (fт) of 20 GHz and maximum frequencies of oscillation (fmax) of 38 GHz have been achieved. Unpassivated devices demonstrated a saturated output power of 3.0 W/mm and peak power-added efficiency of 40% at 4.2 GHz

(VDS= +20 V). [J885]

"Pseudomorphic In0.52 Al0.48 As/In0.7 Ga0.3 As HEMTs with an ultrahigh fT of 562 GHz"

We fabricated decananometer-gate pseudomorphic In0.52Al0.48As/In0.7Ga0.3As high-electron mobility transistors (HEMTs) with a very short gate-channel distance. We obtained a cutoff frequency fTof 562 GHz for a 25-nm-gate HEMT. This fTis the highest value ever reported for any transistor. The ultrahigh fTof our HEMT can be explained by an enhanced electron velocity under the gate, which was a result of reducing the gate-channel distance. [J886]

"Charge-collection dynamics of InP-based high electron mobility transistors (HEMTs)"

Time-resolved charge-collection measurements are performed on InAlAs/InGaAs HEMTs with pulsed laser excitation as a function of device bias conditions and the incident laser pulse energy. The results provide clear evidence for the presence of charge-enhancement processes that, in many ways, are analogous to those observed previously for GaAs FET technology. [J887]

"DC-92 GHz ultra-broadband high gain InP HEMT amplifier with 410 GHz gain-bandwidth product"

A coplanar distributed amplifier, fabricated in a double channel InP HEMT technology, is presented. It exhibits a 13 dB gain and a 92 GHz -3 dB cutoff frequency that corresponds to a gain-bandwidth product of 410 GHz. Key aspects for distributed and coplanar design around 100 GHz are highlighted [J888]

"A compact-size microstrip spiral resonator and its application to microwave oscillator"

This letter presents a compact size microstrip spiral resonator and its application to a low phase noise oscillator. This resonator has stopband characteristics to be used in the series feedback oscillator topology. The whole circuit area of the proposed resonator is within 1/10 wavelength, which results in the reduction of the circuit area and cost. A 10-GHz oscillator incorporated with this resonator was designed, fabricated and measured. It shows low phase noise performance of -95.4-dBc/Hz at 100 kHz offset. [J889]

"Equivalent-voltage approach for modeling low-frequency dispersive effects in microwave FETs"

In this paper, a simple and efficient approach for the modeling of low-frequency dispersive phenomena in FETs is proposed. The method is based on the definition of a virtual, nondispersive associated device controlled by equivalent port voltages and it is justified on the basis of a physically-consistent, charge-controlled description of the device. Dispersive effects in FETs are accounted for by means of an intuitive circuit solution in the framework of any existing nonlinear dynamic model. The new equivalent-voltage model is identified on the basis of conventional measurements carried out under static and small signal dynamic operating conditions. Nonlinear experimental tests confirm the validity of the proposed approach. [J890]

"Low ballistic mobility in submicron HEMTs"

Ballistic effects in short channel high electron mobility transistors (HEMTs) greatly reduce the field effect mobility compared to that in long gate structures. This reduction is related to a finite electron acceleration time in the channel under the device gate. As an example, the field effect mobility at room temperature in 0.15-μm gate AlGaAs/GaAs HEMTs cannot exceed 3000 cm2/V-s. These predictions are consistent with the values of the field effect mobility extracted from the measured AlGaAs/GaAs HEMT current-voltage characteristics [J891]

"High power Al0.3 Ga0.7 As/In0.2 Ga 0.8 As enhancement-mode PHEMT for low-voltage wireless communication systems"

A 20 mm-wide enhancement-mode pseudomorphic high-electron-mobility transistor (E-PHEMT) has been developed. The device has high transconductance of 490 mS/mm, and high maximum drain current of 350 mA/mm due to the use of an Al0.3Ga0.7As/In0.2 Ga0.8As-based structure for carrier confinement. At 1.9 GHz and 3.0 V, the E-PHEMT shows 34.1 dBm (128 mW/mm) output power with power-added efficiency (PAE) of 64.5%. At 2.4 V, the maximum saturated output power is 32.25 dBm and maximum PAE is 78.5%. The E-PHEMT demonstrates excellent power performance at 1.9 GHz and below 3 V [J892]

"Straightforward and accurate nonlinear device model parameter-estimation method based on vectorial large-signal measurements"

To model nonlinear device behavior at microwave frequencies, accurate large-signal models are required.

However, the standard procedure to estimate model parameters is often cumbersome, as it involves several measurement systems (DC, vector network analyzer, etc.). Therefore, we propose a new nonlinear modeling technique, which reduces the complexity of the model generation tremendously and only requires full two-port vectorial large-signal measurements. This paper reports on the results obtained with this new modeling technique applied to both empirical and artificial-neural-network device models. Experimental results are given for high electron-mobility transistors and MOSFETs. We also show that realistic signal excitations can easily be included in the optimization process. [J893]

"State-of-art CW power density achieved at 26 GHz by AlGaN/GaN HEMTs"

The DC and microwave power performance of metal organic chemical vapour deposition-grown AlGaN/GaN HEMTs on SiC substrate is reported. The devices exhibited high maximum current density of 1.1 A/mm with high peak extrinsic transconductance of 234 mS/mm. At 26 GHz, the devices achieved continuous-wave (CW) power density of 5 W/mm with power-added-efficiency of 30.1%, which represents the highest output power density and associated power-added efficiency reported above 20 GHz [J894]

"AlGaN/GaN HEMTs on resistive Si(111) substrate grown by gas-source MBE"

Al0.3Ga0.7N/GaN high electron mobility transistor (HEMT) structures have been grown on resistive Si(111) substrate by molecular beam epitaxy (MBE) using ammonia (NH3). The use of an AlN/GaN intermediate layer allows a resistive buffer layer to be obtained. High sheet carrier density and high electron mobility arc obtained in the channel. A device with 0.5 μm gate length has been realised exhibiting a maximum extrinsic transconductance of 160 mS/mm and drain-source current exceeding 600 mA/mm. Small-signal measurements show ftof 17 GHz and fmaxof 40 GHz [J895]

"Systematic characterization of Cl2 reactive ion etching for improved ohmics in AlGaN/GaN HEMTs"

Pre-metal-deposition reactive ion etching (RIE) was performed on an Al0.3Ga0.7N/AlN/GaN heterostructure in order to improve the metal-to-semiconductor contact resistance. An optimum AlGaN thickness for minimizing contact resistance was determined. An initial decrease in contact resistance with etching time was explained in terms of removal of an oxide surface layer and/or by an increase in tunnelling current with the decrease of the AlGaN thickness. The presence of a dissimilar surface layer was confirmed by an initial nonuniform etch depth rate. An increase in contact resistance for deeper etches was experienced. The increase was related to depletion of the two-dimensional (2-D) electron gas (2-DEG) under the ohmics. Etch depths were measured by atomic force microscopy (AFM). The contact resistance decreased from about 0.45 Ωmm for unetched ohmics to a minimum of 0.27 Ωmm for 70 E etched ohmics. The initial thickness of the AlGaN layer was 250 E. The decrease in contact resistance, without excessive complications on device processing, supports RIE etching as a viable solution to improve ohmic contact resistance in AlGaN/GaN HEMTs [J896]

"Molecular beam epitaxy growth and characterization of InGaP/InGaAs pseudomorphic high electron mobility transistors (HEMTs) having a channel layer over critical layer thickness"

In0.5Ga0.5P/InxGa1-xAs (x=0.33 and 0.40), pseudomorphic high electron mobility transistors (p-HEMTs) having a channel layer over the critical layer thickness were grown on patterned and nonpatterned GaAs substrates by using a compound-source molecular beam epitaxy (MBE). Characteristics of the highly strained InGaP/InxGa1-xAs (x=0.33 and 0.40) p-HEMTs grown on patterned substrates were compared with those of conventional InGaP/In0.22Ga0.78As p-HEMTs grown on a nonpatterned substrate. The highly strained InGaP/In0.33Ga 0.67As p-HEMT showed substantial improvements in device performances including DC (drain saturation current and transconductance), microwave (fTand fmax), low-frequency noise (Hooge parameter), and high-frequency noise (minimum noise figure and associated gain) characteristics compared with those of the conventional InGaP/In0.22Ga0.78As p-HEMT. The improvements in device performances of the highly strained InGaP/In0.33Ga0.67As p-HEMT are attributed to the improved transport property of the high-quality highly strained In0.33Ga0.67As channel layer achieved by the use of the patterned substrate growth. The results indicate the potential of highly strained InGaP/InxGa1-xAs p-HEMTs having a channel layer in excess of the critical layer thickness grown on patterned GaAs substrates for use in high-performance microwave device applications [J897]

"A novel phase noise reduction technique in oscillators using defected ground structure"

A new technique to reduce the phase noise in microwave oscillators is developed using the resonant characteristic of the defected ground structure (DGS). Two kinds of oscillators have been designed and

measured for the examination of the reduction of phase noise by the DGS. The first adopts the DGS section under the microstrip line at the gate circuit, while the second has only the conventional microstrip line. Measurement shows reduced phase noise by 10-15 dB in the oscillator with the DGS compared to the conventional one [J898]

"High breakdown characteristic δ-doped InGaP/InGaAs/AlGaAs tunneling real-space transfer HEMT"

A novel δ-doped InGaP/InGaAs/AlGaAs tunneling real-space transfer high-electron mobility transistor (TRST-HEMT) has been successfully fabricated by low-pressure metal organic chemical vapor deposition (LP-MOCVD). Three-terminal N-shaped negative differential resistance (NDR) phenomenon due to the hot electrons real-space transfer (RST) at high electric field is observed. Two-terminal gate-to-drain breakdown voltage is more than 40 V with a leakage current as low as 0.27 mA/mm. High three-terminal on-state breakdown voltage as high as 19.2 V and broad plateau of current valley as high as 15 V are achieved. These characteristics are attributed to the use of high Schottky barrier height, high bandgap of InGaP Schottky layer, δ-doping, and GaAs subspacer layers. The measured maximum peak-to-valley ratio (PVR) value is 2.7 [J899]

"GaN-based high electron-mobility transistors for microwave and RF control applications"

Heterojunction FETs or high electron-mobility transistors (HEMTs) based on AlxGa1-xN/GaN are studied for their use as control components for high-power microwave and RF control devices (switches, phase-shifters, etc.). A linear operation model was developed for these components so that optimum transistor geometry and operation parameters may be determined for their use in control applications. The model was verified with experimental data taken on test HEMT devices. It was experimentally established that the HEMT resistance is low for voltages of +1.0 V, and that the capacitive reactance increases for de gate voltages below the threshold voltage of approximately -1.5 V [J900]

"A new model for enhancement-mode power pHEMT"

Optimum loading for a power enhancement-mode pseudomorphic high electron-mobility transistor (E-pHEMT) is determined by a systematic harmonic load-pull simulation. The simulation uses a modified Angelov-Parker model that can accurately predict DC, small-signal RF, and power performance of the devices. The optimum second harmonic loading for a 2-mm device is found to be open circuit and the optimum third harmonic is at the third quadrant, which is about 1 210°. The measured versus modeled results show very good agreement and, therefore, verify the model. The simulation predicts that as high as 80% power-added efficiency can be achieved for E-pHEMT under optimum source and load termination with harmonic tuning [J901]

"43 Gbit/s, 200 km unrepeatered transmission experiment using high-sensitivity digital OEIC receiver module"

The first transmission results using a monolithic digital optoelectronic integrated circuit (OEIC), which consists of a uni-travelling-carrier photodiode and an InP high electron mobility transistor decision circuit, are presented. High receiver sensitivity of -30.2 dBm was obtained at the bit rate of 43 Gbit/s with 150 km dispersion-shifted fibre transmission. It is confirmed that the transmission distance can be extended to over 200 km by employing forward error correction code [J902]

"The early history of the high electron mobility transistor (HEMT)"

The early history of the high electron mobility transistor illustrates the way in which a new device idea occurs and is developed towards commercialization. The events which took place in our laboratory are described in this paper [J903]

"66 GHz 2:1 static frequency divider using 100 nm metamorphic enhancement HEMT technology"

A static frequency divider with a maximum operating frequency of up to 66 GHz was developed for applications in high-speed digital systems. To the authors' knowledge, this is the highest operation frequency obtained for a static divider based on high electron mobility transistor (HEMT) technology. The complete circuit has a power consumption of 450 mW at supply voltages Vcc=2 V and Vss =-3 V. The input signal is single-ended. The differential output driver is designed in current mode logic (CML) and is able to drive a 50 Ω external load [J904]

"Application of defected ground structure in reducing the size of amplifiers"

This letter presents a new technique to reduce the size of microwave amplifiers using a defected ground

structure (DGS). The DGS on the ground plane of a microstrip line provides an additional effective inductive component, which enables a microstrip line with very high impedance to be realized and shows slow-wave characteristics. The resultant electrical length of the microstrip line with DGS is longer than that of a conventional line for the same physical length. Therefore, the microstrip line with DGS can be shortened in order to maintain the same electrical length, matching, and performances of the basic (original) amplifier. To confirm the validity of this idea, two amplifiers, one of which is designed using a conventional microstrip line and the other is reduced using DGS, are fabricated, measured, and compared. The performance of the reduced amplifier with DGS is quite similar to that of the basic amplifier, even though the series microstrip lines with DGS are much smaller than those of the basic amplifier by 53.8% and 55.6% at input and output matching networks, respectively [J905]

"Determination of channel temperature in AlGaN/GaN HEMTs grown on sapphire and silicon substrates using DC characterization method"

Self-heating effects and temperature rise in AlGaN/GaN HEMTs grown on silicon and sapphire substrates are studied, exploiting transistor DC characterization methods. A negative differential output resistance is observed for high dissipated power levels. An analytical formula for a source-drain current drop as a function of parasitic source resistance and threshold voltage changes is proposed to explain this behavior. The transistor source resistance and threshold voltage is determined experimentally at different elevated temperatures to construct channel temperature versus dissipated power transfer characteristic. It is found that the HEMT channel temperature increases rapidly with dissipated power and at 6 W/mm reaches values of 320°C for sapphire and 95°C for silicon substrate, respectively. [J906]

"High-power AlGaN/GaN HEMTs on resistive silicon substrate"

A process to fabricate AlGaN/GaN HEMTs based on (111) silicon substrate is developed. The device structure is grown on a resistive (111) silicon substrate. The frequency Ftis 28 GHz and the frequency Fmaxis 50 GHz. At 4 GHz, the power density is 1 W/mm for a 150 Ч 1 μm2device [J907]

"AlGaN/GaN HEMTs on silicon substrates with fT of 32/20 GHz and fmax of 27/22 GHz for 0.5/0.7 μm gate length"

AlGaN/GaN HEMTs on silicon substrates have been realised and their static and small signal characteristics investigated. The AlGaN/GaN (x=0.23) material structures were grown on (111) p-Si by LP-MOVPE. Devices exhibit a saturation current density of 0.53 to 0.68 A/mm and a peak extrinsic transconductance of 110 mS/mm. A unity gain frequency of 20 and 32 GHz and a maximum frequency of oscillation of 22 and 27 GHz are obtained for devices with a gate length of 0.7 and 0.5 μm, respectively. These values are the highest reported so far on AlGaN/GaN/Si HEMTs and are comparable to those known for devices using sapphire and SiC substrates [J908]

"Cavity coupling structure for planar oscillators showing DR-like reflective characteristics"

A new cavity coupling structure has been developed for low-phase noise oscillator applications. Unlike the conventional cavity coupling structures that show absorption at the resonant frequency, the new structure shows high reflection at resonance similar to dielectric resonators, making it suitable for the reflective oscillators. The fabricated cavity resonator showed a loaded Q-factor of 1200 and the X-band oscillator using the new resonator showed phase noise proper-ties of -57 and -83 dBc/Hz at 1 and 10 kHz offset, respectively. This is comparable to the best results of dielectric resonator oscillators using HEMTs at this frequency range [J909]

"A 78-114 GHz monolithic subharmonically pumped GaAs-based HEMT diode mixer"

A W-band subharmonically pumped (SHP) diode mixer is designed for fixed LO frequency operation. It is fabricated on a 4-mil substrate using 0.15 μm GaAs PHEMT MMIC process. The on-wafer measurement results show that the conversion loss is about 10 to 14 dB across the W band, as a 10 dBm 48 GHz LO signal is pumped. To our knowledge, this is the state-of-the-art result on low-conversion-loss wideband MMIC SHP diode mixer. The packaged module measurement shows a similar result. Both the simulation and measurement results are shown to be in good agreement [J910]

"Intermodulation analysis of dual-gate FET mixers"

A detailed intermodulation analysis of dual-gate FET (DG-FET) mixers is presented. The analysis method is based on a large-signal/small-signal analysis using time-varying Volterra-series methods. The analysis program allows one to probe the internal nodes of DG-FETs to evaluate the nonlinear current components. Therefore, it helps physical understanding of intermodulation distortion (IMD) mechanisms in DG-FET mixers. The program

was used to identify the major sources of IMD generation. It was found from the analysis that the nonlinearities due to the output conductance (Gd3and Gd2) of the lower common-source FET were most responsible for IMD generation. The impact of the upper common-gate FET on IMD generation was also found to be nonnegligible, especially at high local oscillator (LO) power levels. The analysis also predicted the presence of MM "sweet spots" using bias optimization, which was experimentally proved by the fabricated mixers at X- and Ka-bands. The optimized X-band hybrid mixer showed measured intermodulation characteristics (OIP3 ~13.6 dBm) comparable to those of the resistive mixers (OIP3 ~15.3 dBm) with low LO and dc power conditions [J911]

"Quantitative measurement of channel temperature of GaAs devices for reliable life-time prediction"

The channel temperature of Gallium Arsenide (GaAs) devices was quantitatively measured using scanning thermal microscopy (SThM), which is a variation of atomic force microscopy (AFM). The temperature of the devices was also characterized by infrared (IR) imaging and thermal modeling. The measured SThM temperature values were close to the calculated values from the model, and were higher than those found by IR, as predicted. In contrast to most published AFM results which have reported only qualitative and indirect semi-quantitative thermal information about the sample, the results presented here can be used directly to determine accurately the device-temperature. These results are useful to the reliability community in that they help to predict a more accurate semiconductor device lifetime. By careful calibration of an AFM thermistor probe tip, a quantitative temperature measurement of the channel temperature of the GaAs PHEMTs and MESFETs can be made. The result of the measurement can be substantiated by applying a suitable thermal calculation, such as the Cooke model. A secondary measurement technique, such as IR microscopy, can also be useful in providing further information about the thermal response of the device. Published results using AFM techniques have been unable to determine the channel temperature quantitatively. The method in this paper applies to other types of electronic devices for which the channel (or junction) temperature can be probed from the top surface of the device. [J912]

"A simple low-dissipation amplifier for cryogenic STM"

A current sensitive preamplifier designed for low-temperature scanning tunneling microscopy applications is presented. It combines the dc current measurement necessary for the feedback loop operation with a low noise ac measurement used for spectroscopy. The active device is a high electron mobility transistor which was chosen for its low input capacitance and excellent low-temperature performance. The power dissipation of the transistor can be kept at about 10 mu W making it compatible with a variety of cryogenic systems. The ac current sensitivity is about 4 fA/√Hz at 4.2 K. copyright 2002 American Institute of Physics. [J913]

"Rapid thermal annealing effects on step-graded InAlAs buffer layer and In 0.52 Al 0.48 As/In 0.53 Ga 0.47 As metamorphic high electron mobility transistor structures on GaAs substrates"

A step-graded InAlAs buffer layer and an In0.52Al0.48As/In0.53Ga0.47Asmetamorphic high electron mobility transistor (MM-HEMT) structures were grown by molecular beam epitaxy on GaAs (001) substrates, and rapid thermal annealing was performed on them in the temperature range 500-800 °Cfor 30 s. The as-grown and annealed samples were investigated with Hall measurements, and 77 K photoluminescence. After rapid thermal annealing, the resistivities of step-graded InAlAs buffer layer structures became high. This can avoid leaky characteristics and parasitic capacitance for MM-HEMT devices. The highest sheet carrier density nsand mobility mu for MM-HEMT structures were achieved by annealing at 600 and 650°C,respectively. The relative intensities of the transitions between the second electron subband to the first heavy-hole subband and the first electron subband to the first heavy-hole subband in the MM-HEMT InGaAs well layer were compared under different annealing temperatures. copyright 2002 American Institute of Physics. [J914]

"Surface and interface characterization of GaN/AlGaN high electron mobility transistor structures by x-ray and atomic force microscopy"

We report on the characterization of GaN/AlGaN high electron mobility transistor (HEMT) structures grown by molecular beam epitaxy and metal-organic chemical vapor deposition techniques on semi-insulating SiC substrates. We have exploited the surface and interface sensitivity of the grazing incidence x-ray reflectivity (GIXA) technique and combined it with atomic force microscopy (AFM) and x-ray diffraction to obtain an accurate evaluation of the surfaces and channel interfaces for HEMT structures. The presence of smooth interfaces is responsible for the observation of intensity oscillation in GIXA, which is well correlated to step flow observation in AFM images of the surface. While GIXA provides a macroscopic average of the surface and interface roughness, the AFM provides us with a microscopic view of surface roughness. Further, the x-ray diffraction results have been combined with reflectivity data to evaluate the layer thickness and Al mole fraction in the AlGaN layer. The capacitance-voltage (C-V) technique is used to determine the electrical properties of two-

dimensional electron gas depth and hence the AlGaN layer thickness. The C-V results are in good agreement with the x-ray data. copyright 2002 American Vacuum Society. [J915]

"Simple and high-precision asymmetric gate-recess process for ultrafast InP-based high electron mobility transistors"

We present a simple and high-precision process technology for ultrafast InP-based high electron mobility transistors (HEMTs) having an asymmetrically recessed T-shaped gate. This technology is beneficial in fabricating high-performance InP-HEMTs because it enables us to independently optimize source- and drain-side recess lengths (Lrs,Lrd)while using a very short gate length (Lg).The process utilizes a conventional trilayer resist exposed by electron beam lithography, which has additional slit patterns beside a gate-foot pattern in the bottom layer. The gate metal is evaporated at a tilted angle to avoid evaporation through the slit patterns. The Lrsand Lrdcan be precisely controlled by the etching time, and by the size and position of the slits, while keeping a constant recess depth. A 60 nm gate HEMT with a longer Lrdexhibits a much-enhanced maximum oscillation frequency (fmax)of 428 GHz mainly by reducing the drain conductance (gd)and the gate-to-drain capacitance (Cgd),as compared to that (244 GHz) for a conventional HEMT with a symmetric recess structure. copyright 2002 American Vacuum Society. [J916]

"Design of an opto-electronic modulator driver amplifier for 40-Gb/s data rate systems"

This paper describes the design and performance of a broad-band driver amplifier for 40-Gb/s noreturn-to-zero system applications. The function of the amplifier is to raise the output from a multiplexer (nominally 0.4 V peak to peak) to a level of 5 Vp-p, which is suitable to drive a GaAs-based Mach-Zehnder optoelectronic modulator. The amplifier module contains two GaAs pseudomorphic high-electron mobility transistor traveling-wave MMICs fabricated on a 0.2-µm gate process. The design issues relating to the specific requirements of a modulator driver amplifier and the techniques to resolve them are described. [J917]

"Submicron AlGaN/GaN HEMTs with very high drain current density grown by plasma-assisted MBE on 6H-SiC"

High electron mobility transistors (HEMTs) were fabricated from AlGaN/-GaN layers grown by plasma-assisted molecular beam epitaxy on semi-insulating 6H-SiC substrates. Room-temperature Hall effect measurements yielded a polarization-induced 2DEG sheet charge of 1.3·1013cm-2and a low-field mobility of 1300 cm2/V·s. Submicron gates were defined with electron beam lithography using an optimized two-layer resist scheme. HEMT devices repeatedly yielded drain current densities up to 1798 mA/mm, and a maximum transconductance of 193 mS/mm. This is the highest drain current density in any AlGaN-GaN HEMT structure delivering significant microwave power reported thus far. Small-signal testing of 50-µm wide devices revealed a current gain cutoff frequency fTof 52 GHz, and a maximum frequency of oscillation fmaxof 109 GHz. Output power densities of 5 W/mm at 2 GHz, and 4.9 W/mm at 7 GHz were recorded from 200-µm wide unpassivated HEMTs with a load-pull setup under optimum matching conditions in class A device operation. [J918]

"Microwave response of a high electron mobility transistor in the presence of a Dyakonov-Shur instability"

The plasma-wave response of the two-dimensional electron gas that forms the active layer of a high-electron mobility transistor (HEMTs) makes a contribution to the high-frequency behavior of these devices that is distinct from their adiabatic response, i.e., unrelated to low-frequency parameters such as dc transconductance, capacitances, and channel resistance, which are usually derived from dc IV curves. Since the plasma-wave response has the potential to make the HEMT active at very high (terahertz) frequencies, it is important to frame its description within the standard language of microwave device engineering, i.e., as admittance or S-parameters of the device. In this paper a full set of microwave admittance parameters is derived for a real HEMT, based on recent work by the author [J. Appl. Phys. 87, 8056-8064 (2000)]. [J919]

"40 Gb/s postamplifier and p-i-n/preamplifier modules for next generation optical front-end systems"

Postamplifier and p-i-n/preamplifier modules suitable for 40-Gb/s short-haul and long-haul optical communication systems are presented. The postamplifier module consists of two stages of pseudomorphic high-electron mobility transistor (PHEMT) GaAs amplifiers mounted in a housing. A test fixture is used to provide bias supplies that control the output signal. The postamplifier has a 20-dB gain and 4.5-dB noise figure. The input voltage swing of the postamplifier can be varied from 10 to 148 mV p-p while providing an open output eye-pattern response over the complete range. The p-i-n/preamplifier module consists of a waveguide p-i-n/photodetector, with a

polarization insensitive spot-size converter and a PHEMT-based GaAs transimpedance amplifier. The components are integrated inside a hermetically sealed compact package using hybrid techniques. The p-i-n/preamplifier module having 150-Ω transimpedance exhibits a linear output voltage swing over 800 mV p-p and a responsivity of 0.8 A/W. The receiver module has a 3-dB bandwidth as high as 45 GHz, and the input equivalent noise current density is less than 15 pA/√(Hz). The electrical sensitivity of the postamplifier is found to be 7.8 mV p-p for a 40 Gb/s, 27-1 pseudorandom binary sequence nonreturn-to-zero signal. When used in combination with a 150-Ω 40-Gb/s p-i-n/preamplifier module, a sensitivity of less than -11.2 dBm is achieved. These results indicate that the postamplifier module, in combination with the p-i-n/preamplifier module, can be used in 40-Gb/s short-haul systems, while the p-i-n/preamplifier module itself can be used for long-haul front-end receiver systems. [J920]

"Analysis of balanced active doubler for broad-band operation-the frequency-tuning concept"

A comprehensive analysis of an active balanced frequency doubler is described and proposed as a new concept: tuning the center frequency at which the doubler exhibits its highest performance to extend the usable bandwidth of the device. The concept is validated using a fabricated V-band pseudomorphic high electron-mobility transistor frequency doubler. For this device, a substantial improvement in the usable bandwidth (more than double) is achieved, demonstrating that the proposed concept is particularly suitable for the realization of high spectral purity and widely tunable V-band frequency sources [J921]

"Negative differential conductance in the tunnel Schottky contact with two-dimensional channel"

A semiconductor tunnel structure with negative differential conductance (NDC) is proposed and analyzed theoretically. NDC appears due to tunneling through a Schottky barrier into a quantum well. That can be realized in the structures similar to high electron-mobility transistor (HEMT) with tunneling between the gate and two-dimensional channel. Both diodes (two-terminal devices) and transistors (in particular, HEMTs) with NDC could be realized on the basis of the structures. Such structures could be used for generation of high-frequency radiation. The proposed structure should also have the current-voltage characteristic of Ntype. copyright 2002 American Institute of Physics. [J922]

"Load impedance influence on the ID (YDS) characteristics of AlGaN/GaN HEMTs in large signal regime at 4 GHz"

A measurement system allowing one to put in evidence the trap effects on the power performance of Al0.1Ga0.9N/GaN high electron mobility transistors (HEMTs) made on sapphire substrate is presented in this paper. This setup permits simultaneous measurements of the output power supplied by the device under test (DUT) and the ID(VDS) characteristic in large signal regime at 4 GHz for different load impedances. It shows the traps influence on the maximum drain-current at 4 GHz for different load impedances under large signal operating conditions. The measurements carried out on a device (2Ч50Ч1 μm2) have shown a linear decrease of the maximum drain-current when the load impedance increases. These observations make it possible to determine the origin of the power performances difference obtained at microwave frequencies opposite to the static regime [J923]

"A study of subbands in AlGaN/GaN high-electron-mobility transistor structures using low-temperature photoluminescence spectroscopy"

Al0.15Ga0.85N/GaNhigh-electron-mobility transistor (HEMT) structures with various delta -doping concentrations and spacer thicknesses grown on sapphire by metalorganic chemical-vapor deposition are investigated. The Hall mobility is as high as 1333cm2/V sat room temperature and 6330cm2/V sat 77 K. Two-dimensional electron gas (2DEG) phenomena, which have not been clearly resolved in the literature, are observed by photoluminescence (PL) spectra at low temperature in this study. The PL spectra peaks of the interband transitions from 2DEG subbands to the valence band are in the range from 3.486 to 3.312 eV. The effects of the strain caused by different Al fractions of the top layer, and that of the spacer thickness on the 2DEG phenomena are discussed. Redshifts due to temperature variations for various HEMT structures are observed in 2DEG subbands and in the band-edge emission, which is believed to be evidence of interband transitions from 2DEG subbands to valence bands. copyright 2002 American Institute of Physics. [J924]

"Comparative study of drain-current collapse in AlGaN/GaN high-electron-mobility transistors on sapphire and semi-insulating SiC"

The drain-current collapse at high drain voltage has been studied in AlGaN/GaN high-electron-mobility transistors (HEMTs) on both semi-insulating (SI)-SiC and sapphire substrates using small frequency (120 Hz) sinusoidal

wave superimposed dc IDS-VDScharacteristics. Low drain-current collapses were observed in AlGaN/GaN HEMTs on SI-SiC substrate when compared with the HEMTs on sapphire substrates. Two and three thermally activated deep traps were observed on SiC-based and sapphire-based HEMTs, respectively. The existence of an additional deep trap (Delta E=0.61 eV)could be associated with the material defects/ dislocations responsible for the severe drain current collapse in sapphire-based HEMTs. The white-light illuminated IDS-VDScharacteristics support the existence of more number of deep traps in the sapphire-based HEMTs. copyright 2002 American Institute of Physics. [J925]

"58-82 GHz 4: 1 dynamic frequency divider using 100 nm metamorphic enhancement HEMT technology"

The design and performance of a dynamic divider by four based on a 100 nm metamorphic enhancement HEMT technology operating in the range 58 to 82 GHz is presented. To the knowledge of the authors, this is the highest operation frequency obtained for a dynamic divider based on HEMT technology. The complete circuit has a power consumption of approximately 500 mW for a supply voltage of -3.5 V The input signal is single-ended. The output driver is able to drive a 50 Ω external load [J926]

"50 GHz frequency divider using resonant tunnelling chaos circuit"

An ultra-high-speed frequency divider using a resonant tunnelling chaos circuit is fabricated, which monolithically integrates a resonant tunnelling diode and a high electron mobility transistor. This frequency divider is based on the long-period behaviour of the nonlinear circuits generating chaos. The various frequency dividing operations are observed at the input frequency of 50 GHz. Chaotic operation is also observed [J927]

"Enhanced power performance of enhancement-mode Al0.5 Ga 0.5 As/In0.15 Ga0.85 As pHEMTs using a low-k BCB passivation"

Surface passivation technology plays an important role, especially in E-mode pHEMTs applications, and a new passivation technology has been proposed in this study. This novel benzocyclobutene (BCB) passivation layer takes advantage of the low dielectric permittivity (2.7) and a low loss tangent (0.0008). In this letter, we not only suppress the gate-to-drain leakage current but also improve the device power performance under a high input power swing by using a BCB passivation layer. The passivated 1.0 μm-long gate pHEMTs exhibit a better off-state performance than the unpassivated ones. The maximum output power under a 2.4-GHz operation is 118 mW/mm, with a linear power gain of 11.1 dB and a power-added efficiency is 60% [J928]

"fmax of 490 GHz metamorphic In0.52 Al0.48 As/In0.53 Ga0.47 As HEMTs on GaAs substrate"

Metamorphic In0.52Al0.48As/In0.53Ga0.47 As HEMTs on GaAs substrate with 60 nm gate length have been fabricated. Drain-to-source current Idsof 600 mA/mm and extrinsic transconductance of 850 mS/mm were obtained with these devices. The cutoff frequency fTof extrinsic current gain |h 21|2and maximum oscillation frequency fmax deduced from Mason's unilateral gain are 260 GHz and 490 GHz respectively. To the authors' knowledge, this frequency performance is the highest ever reported for HEMTs on GaAs substrate [J929]

"Linearity of low microwave noise AlGaN/GaN HEMTs"

The linearity of low microwave noise AlGaN/GaN HEMTs was evaluated with two-tone excitation measurements at optimum low noise biases. A 0.15 Ч 100 μm2device yields an output third-order intercept point (OIP3) of 23 dBm at Vds= 3 V, and Vgs= -5V, where a noise figure (NF) of 1.0 and 1.75 dB was obtained at 10 and 20 GHz, respectively. The C/IM3, linearity figure-of-merit under the large RF signals, saturates near -28 dBc as Vdsbecomes greater than the knee voltage. Both applied bias and gate periphery dependence of the linearity were evaluated. Realisation of highly linear low-noise GaN HEMTs is feasible. [J930]

"A phase noise reduction technique in microwave oscillator using high-Q active filter"

The authors present a 10 GHz oscillator that uses a high-Q active filter to reduce the phase noise. The loaded Q of active filter is obtained at about 500. This oscillator is compared with another oscillator which uses a passive filter. The difference of two oscillators' Q is estimated at 12.5 times the open-loop gain simulation. The measured result of phase noise at 100 kHz offset shows maximum 10 dB reduction with high-Q active filter. [J931]

"A 43-Gb/s full-rate-clock 4:1 multiplexer in InP-based HEMT technology"

This paper describes a full-rate-clock 4:1 multiplexer (MUX) in a 0.13-μm InP-based HEMT technology for 40-

Gb/s and above optical fiber link systems. To reduce output jitter, the serialized data are retimed at the final stage by a retimer, a D-type flip-flop, which has a symmetric layout with an optimized spacing to the ground that minimizes coupling capacitances. A phase adjuster, composed of an exclusive OR and a delay switch, uses external control signals to change each phase of the serialized data and clock entering the retimer and gives a correct timing for the clock to drive the retimer. A clock distributor with a simple wired splitter divides the clock into two clocks with high gain and low current. The MUX integrates 1355 HEMTs formed using electron beam lithography. A chip mounted in a test module operated at up to 47 Gb/s with a power consumption of 7.9 W for a single supply voltage of -5.2 V. [J932]

"Light-controlled frequency-shift keying modulator using millimetre-wave monolithic integrated circuit oscillator"

A light-controlled frequency-shift keying modulator for a fibre-optic wireless broad-band download system using millimetre waves has been investigated. In it, intensity-modulated infrared signals are adopted for modulating the carrier frequency of the 37 GHz band. The modulation principle is based on the impedance change under illumination in an InP-based millimetre-wave monolithic integrated circuit oscillator. Using the modulator, fibre-optic wireless transmission with a bit error rate of 10-11was obtained at a data rate of 155.52 Mbit/s. [J933]

"Ka-band direct digital receiver"

A new direct-conversion wideband (26-28.5 GHz) six-port receiver is proposed for mass-market wireless communications. This six-port receiver is designed to operate without the need for precise power reading and the use of a digital signal processor that is usually required in other receivers. The proposed receiver architecture is chosen to satisfy requirements of hardware receivers used in high-speed QPSK communications. The receiver contains a receiver front-end, QPSK demodulator, and carrier recovery module. A reverse modulation loop was used to provide a rapid carrier recovery. The maximum bit rate is determined solely by the limiting speed of the baseband module. This new hardware receiver is proposed as a robust, rugged, low-cost receiver for use in wide Ka-band wireless mass-market QPSK communications such as local multipoint distribution system services, which is a prime example of communication equipment requiring such receivers. Bit-error-rate results are presented versus the noise and reference signal phase shift. [J934]

"Influence of the calibration kit on the estimation of parasitic effects in HEMT devices at microwave frequencies"

In this paper, we investigate how critical the calibration kit is in an accurate estimation of microwave device parasitic elements. The semiempirical cold FET method has been applied to the extraction of the small signal equivalent circuit of several HEMT devices. Two different measurements were made on the same devices by using two calibration kits. The first kit is a commercial one based on the LRM method, whereas the second kit was designed by the authors and fabricated on the same chip of the devices. The discrepancies found in the calculated parasitic elements provided information on the sensitivity of the elements with respect to the calibration kit, and, therefore, on the physical origin of the parasitics. These discrepancies. show that it is possible to evaluate the influence of the contact pads on the electrical behavior of on-chip semiconductor devices by making measurements with different calibration standards. [J935]

"Effects of output harmonic termination on PAE and output power of AlGaN/GaN HEMT power amplifier"

The authors experimentally investigate and discuss the effects of output harmonic termination on power added efficiency (PAE) and output power of an AlGaN/GaN high electron mobility transistor (HEMT) power amplifier (PA). The AlGaN/GaN HEMT PA with gate periphery of 1 mm was built and tested at L-band. Large-signal measurements and comparisons of the PAE and output power were carried out at different DC bias conditions from 50% of saturated drain current (Idss) to 1% of Id., for the PA with and without output harmonic termination. For class-AB operation at 25% of Idss, an increase of about 10% in peak PAE and 1 dBm in output power were observed in saturated output power range. Improvements of up to 9% in PAE and 1.2 dBm in output power were achieved over the measured DC bias conditions provided the output harmonics are properly terminated. [J936]

"A new "active" predistorter with high gain and programmable gain and phase characteristics using cascode-FET structures"

A MMIC-compatible miniaturized "active" predistorter using cascode FET structures is presented. The predistorter has added functionality of gain, as well as programmable gain and phase variation characteristics, which are required to compensate or the nonlinear distortion of a wide range of power amplifiers (PAs). Thanks

to the inherent gain of the predistorter, a need for an additional buffer amplifier is eliminated. Furthermore, it can eventually replace the first-stage amplifier in the multistage PAs, making this approach well suited to MMIC implementation. A simple analysis is performed to understand the phase variation mechanisms in the proposed predistorter and to identify the dominant sources of phase variation. To demonstrate the general usefulness of this predistorter, the cascode predistorter was applied to linearize watt-level MMIC amplifiers for CDMA handset applications, as well as 30 W high power amplifiers for base-station applications. Adjacent channel power ratio (ACPR) improvement of 3-5 dB was achieved with off-chip predistorter when applied to 0.9 W monolithic amplifiers. The predistorter was also integrated with a 1.6 W MMIC PA on a single chip, replacing the first-stage transistor of the amplifier. [J937]

"Global coupled EM-electrical-thermal simulation and experimental validation for a spatial power combining MMIC array"

A unique electromagnetic (EM)-electrothermal global simulation tool based on a universal error concept is presented. The advantages of this electrothermal model are illustrated by comparison with a commercial electrothermal circuit simulator. The first description of a fully physical, electrothermal, microwave circuit simulation, based on coupling of the Leeds Physical Model of MESFETs and high electron-mobility transistors, to a microwave circuit simulator, fREEDA (NCSU), is presented. The modeling effort is supported by parallel developments in electrooptic and thermal measurement. The first fully coupled EM-electrothermal global simulation of a large microwave subsystem, here a whole spatial power combining monolithic-microwave integrated-circuit (MMIC) array, is described. The simulation is partially validated by measurements of MMIC array temperature rise and temperature dependent S-parameters. Electrothermal issues for spatial power combiner operation and modeling are discussed. The computer-aided-design tools and experimental characterization described, provide a unique capability for the design of quasi-optical systems and for the exploration of the fundamental physics of spatial power combining devices. [J938]

"Characterization of 1.8-MeV proton-irradiated AlGaN/GaN field-effect transistor structures by nanoscale depth-resolved luminescence spectroscopy"

We have used depth-resolved cathodoluminescence spectroscopy to examine AlGaN/GaN modulation-doped field-effect transistors that display degraded source-drain current characteristics after 1.8-MeV proton irradiation, along with bulk heterojunction field-effect transistor material after similar proton irradiation. For both cases, we have observed distinct changes in spectral emission features due to decreased internal electric-field strength and new point defects within different layers of the device structure with nanometer-scale depth resolution. These changes can account for the degraded electrical characteristics. [J939]

"Push-push oscillator with simplified circuit structure"

A push-push oscillator with simplified circuit structure is proposed. The power combiner circuit required in conventional push-push oscillators is eliminated in this circuit. Therefore, the circuit structure is simplified, and the circuit size can also be miniaturised. Performance measures such as the output power of the desired signal (2f0) in K-band and suppression of the undesired odd harmonics are also remarkably higher. [J940]

"Carrier-removal rate and mobility degradation in heterojunction field-effect transistor structures"

In this paper, we report experimental results and theoretical investigations of neutron irradiation-induced carrier-removal rate and mobility degradation in AlGaAs/GaAs heterojunction field-effect transistor structures. The measured two-dimensional (2-D) carrier removal rate of 6.0 Ч 10-3is found to be consistent with a net (volume) introduction rate of 20 cm-1acceptor-like defects in the GaAs layer. Radiation-induced acceptors in the GaAs layer have the most significant effect on the 2-D electron concentration, whereas the acceptors in AlGaAs layer have negligible effect for neutron fluence up to 5 Ч 1014cm-2. The measured 77-K mobility degradation, which is very sensitive to ionized impurity scattering, however, suggests that the introduction rate of the combined donor-like and acceptor-like defects is almost an order of magnitude higher (200 cm-1). The 300-K mobility, which is dominated by polar-optic phonon scattering, shows only marginal degradation. [J941]

"MBE growth of AlGaN/GaN HEMTs with high power density"

RF-plasma MBE has been used for the growth of undoped Al0.25Ga0.75N/GaN HEMT structures on semi-insulating SiC substrates. Devices with a 1.5 μm gate length have an fTof 10 GHz and have demonstrated an output power density of 6.3 W/mm at 2 GHz. Details of the growth process and device results are presented. [J942]

"65 GHz bandwidth optical receiver combining a flip-chip mounted waveguide photodiode and GaAs-based HEMT distributed amplifier"

Hybrid integrated photoreceivers with up to 65 GHz bandwidth are presented. They consist of GaInAs/AlGaInAs/AlInAs multimode waveguide photodiodes, flip-chip bonded on GaAs-based pseudomorphic HEMT distributed amplifiers with a very low input impedance. The overall O/E conversion gain is as high as 120 V/W at 1.55 μm wavelength. [J943]

"Ultralow DC power VCO based on InP-HEMT and heterojunction interband tunnel diode for wireless applications"

The monolithic integration of tunneling diodes (TDs) with other semiconductor devices such as high electron-mobility transistors (HEMTs) or HBTs, creates novel quantum functional nonlinear devices and circuits with unique properties: the negative differential resistance and the extremely low dc power consumption. In this paper, we present a family of InP-HEMT-TD-based voltage-controlled oscillators operating in the 4-6-GHz band suitable for wireless applications, along with an effective analytical treatment of the stability issues. Prototypes having different circuit topologies of HEMT-TD devices have been designed and fabricated. The circuits generated an output power in the range of -11 to -18 dBm when operated at a bias current of 1.75 mA at 500 mV. Phase noise characteristics and tuning capability of the circuit configuration have been experimentally determined. The maximum tuning range of 150 MHz and the maximum single sideband-to-carrier ratio of -97 dBc/Hz at 200 kHz have been achieved. [J944]

"Compact single-chip W-band FMCW radar modules for commercial high-resolution sensor applications"

Two compact single-chip 94-GHz frequency-modulated continuous-wave (FMCW) radar modules have been developed for high-resolution sensing under adverse conditions and environments. The first module contains a monolithic microwave integrated circuit (MMIC) consisting of a mechanically and electrically tunable voltage-controlled oscillator (VCO) with a buffer amplifier, 10-dB coupler, medium-power and a low-noise amplifier, balanced rat-race high electron-mobility transistor (HEMT) diode mixer, and a driver amplifier to increase the local-oscillator signal level. The overall chip-size of the FMCW radar MMIC is 2Ч3.5 mm2. For use with a single transmit-receive antenna, a 94-GHz microstrip hexaferrite circulator was implemented in the module. The radar sensor achieved a tuning range of 1 GHz, an output signal power of 1.5 mW, and a conversion loss of 2 dB. The second FMCW radar sensor uses an MMIC consisting of a varactor-tuned VCO with injection port, very compact transmit and receive amplifiers, and a single-ended resistive mixer. To enable single-antenna operation, the external circulator was replaced by a combination of a Wilkinson divider and a Lange coupler integrated on the MMIC. The circuit features coplanar technology and cascode HEMTs for compact size and low cost. These techniques result in a particularly small overall chip-size of only 2Ч3 mm2. The packaged 94-GHz FMCW radar module achieved a tuning range of 6 GHz, an output signal power of 1.5 mW, and a conversion loss of 5 dB. The RF performance of the radar module was successfully verified by real-time monitoring the time flow of a gas-assisted injection molding process. [J945]

"100 Gbit/s multiplexing and demultiplexing IC operations in InP HEMT technology"

The 100 Gbit/s multiplexing operation of a selector IC and the demultiplexing operation of a D-type flip-flop (D-FF) using a production-level 0.1 μm-gate InP HEMT IC technology is described. Eye-openings of the selector IC at 100 Gbit/s and its error-free operation were confirmed using a test chip containing the selector and the D-FF. To the authors' best knowledge, this is the first report of 100 Gbit/s operation of a transistor-based integrated circuit. [J946]

"Design of narrow-band photoreceivers by means of the photodiode intrinsic conductance"

The photodiode intrinsic conductance is a versatile parameter for designing photoreceivers used in lightwave-microwave systems. A short review is given on how the transimpedance and equivalent input noise current of an optical receiver can be calculated. The design of monolithically integrated narrow-band photoreceivers for microwave-via-fiber applications at 10 GHz is demonstrated. The photoreceivers were fabricated using GaAs-based pseudomorphic high electron-mobility transistor monolithically integrated with metamorphic InGaAs photodiodes. For such a photoreceiver, a very low equivalent input noise current of 5.7 pA per square-root hertz and a high optoelectronic conversion gain of 64.1 dBV/W were measured in good agreement with simulations [J947]

"AlGaN/AlN/GaN high-power microwave HEMT"

In this letter, a novel heterojunction AlGaN/AlN/GaN high-electron mobility transistor (HEMT) is discussed. Contrary to normal HEMTs, the insertion of the very thin AlN interfacial layer (~1 nm) maintains high mobility at high sheet charge densities by increasing the effective ΔECand decreasing alloy scattering. Devices based on this structure exhibited good DC and RF performance. A high peak current 1 A/mm at VGS=2 V was obtained and an output power density of 8.4 W/mm with a power added efficiency of 28% at 8 GHz was achieved [J948]

"Broadband GaN HEMT push-pull microwave power amplifier"

We report a broadband, linear, push-pull amplifier that utilizes GaN-based HEMTs grown on SiC substrates. The high power density capabilities of these devices can be enhanced by the high efficiency achievable with push-pull operation. Good amplifier performance is facilitated by use of a new low-loss balun that is implemented with three symmetric coupled lines and which showed insertion loss of less than 0.5 dB per balun. The bias was injected through the baluns, thereby simplifying the amplifier design and reducing loss associated with dc decoupling capacitors. Using two 1.5 mm HEMTs with 0.35-μm gate length, a push-pull amplifier produced a small-signal gain of 8 dB at 5 GH2, a 3 dB bandwidth of 3.5-10.5 GHz, and a PAE of 25% [J949]

"High power wideband AlGaN/GaN HEMT feedback amplifier module with drain and feedback loop inductances"

A high power wideband feedback amplifier module using AlGaN/ GaN high electron mobility transistor has been developed that covers the frequency range of DC to 5 GHz with small signal gain of 9 dB. Shunt feedback topology is introduced by adding inductances to increase the bandwidth. At mid-band frequency, power added efficiency of 20% and a saturation power level of 29.5 dBm were obtained at a drain voltage of 12V (Vds) and a gate voltage of -3 V (Vgs) [J950]

"MMIC development for millimeter-wave space application"

The latest millimeter-wave monolithic-microwave integrated-circuit (MMIC) developments and technologies at the Mitsubishi Electric Corporation, Kanagawa, Japan, concerning high power amplifiers, low-noise amplifiers and phase shifters have been summarized. It has been shown that high-efficiency, low-noise, and low-loss performance for millimeter-wave space applications can be achieved by employing pseudomorphic high electron-mobility transistor (p-HEMT) MMIC technology. The investigation for gamma-ray irradiation hardness has cleared that millimeter wave p-HEMT MMICs have over a 100 years of life against gamma-ray irradiation in the space environment [J951]

"Power electronics on InAlN/(In)GaN: Prospect for a record performance"

We compare basic physical parameters of Al0.2Ga0.8 N-GaN quantum well with In0.17Al0.83N/GaN and In0.17Al0.83N/In0.10Ga0.90 N quantum well parameters, respectively. It is shown that in comparison to conventional AlGaN/GaN approach, structures based on InAlN/(In)GaN should exhibit two to three times higher quantum well polarization-induced charge. We use high electron mobility transistors (HEMT) analytical model to calculate InAlN(In)GaN HEMTs drain currents and transconductances. A 3.3 A/mm and 2.2 A/mm drain current was calculated for In0.17Al0.83N/In0.10Ga 0.90N and In0.17Al0.83N/GaN HEMTs, respectively. This represents up to 205% current increase if compared with AlGaN/GaN HEMT and a record power performance can be expected for new structures [J952]

"Fully monolithic integrated 43 Gbit/s clock and data recovery circuit in InP HEMT technology"

A fully monolithic integrated 43 Gbit/s clock and data recovery circuit for optical fibre communication systems is described. The circuit is based on a phase-locked loop technique, and the input data signal is regenerated with the data-rate clock signal. The circuit was fabricated with 0.1 μm gate-length InAlAs/InGaAs/InP HEMTs, and error-free operation was confirmed for 231-1 PRBS data signal at 43 Gbit/s [J953]

"Influence of barrier thickness on the high-power performance of AlGaN/GaN HEMTs"

The dependence of current slump in AlGaN/GaN HEMTs on the thickness of the AlGaN barrier was observed. Power measurements on a 2Ч125Ч0.3 μm AlGaN/GaN HEMT made on Silicon Carbide (SiC) substrates with an AlGaN thickness of 10 nm gave a saturated output power of 1.23 W/mm at 8 GHz whereas a device with the same dimensions fabricated on samples with an AlGaN barrier of 20 nm gave a saturated output power of 2.65 W/mm at the same frequency. RF load line measurements clearly show the reduction of RF full channel current as compared to dc full channel current and the increase in the RF knee voltage compared to the dc knee voltage, with the effect being more pronounced in thin barrier samples. Passivation improved the large signal performance of these devices. A 1Ч150Ч0.3 μm transistor made on AlGaN(20 nm)/GaN structure gave a

saturated output power of 10.7 W/mm (40% power added efficiency) at 10 GHz after passivation. This represents the state of the art microwave power density for AlGaN/GaN HEMTs. Heating of the transistors during high-power operation of these devices becomes the important factor in limiting their performance after passivation [J954]

"RF and microwave phase shifter using complementary bias techniques"

A novel method for the design of an RF phase shifter using a standard foundry process is described. This phase shift achieves very low and near-constant insertion loss. The proposed method uses `complementary' control techniques to keep variable parasitic resistance in a standard transistor to a minimum. Using an only single stage reflection configuration which employs N varactor diodes as a reflection terminator and M varactor diodes, a minimum insertion loss variation can be obtained. The technique is verified by measurement when N=M=1 [J955]

"Integrated HEMT-based charge amplifier-design and experiment"

We have designed and tested a fully integrated high electron mobility transistor (HEMT)-based charge amplifier suitable for applications in high-energy physics experiments and compatible to be directly integrated on the detector chip for compact high-performance X- and γ-ray imagers for medical diagnostics. The width of the input HEMT has been optimized within the constraint of fixed low-power dissipation. The direct current and noise characteristics of different sample transistors have been carried out in order to determine the relevant parameters for the proper design and simulation of the whole charge amplifier. A SPICE model was developed ad hoc to simulate the behavior of the HEMT in the biasing conditions of the designed amplifier. The circuit performances have been characterized in terms of output response, linearity, and noise. For a detector capacitance of 5 pF and a feedback capacitance of 1 pF, the measured rise time is 1.89 ns, while the measured ENC is 627 electrons r.m.s. at 20-ns shaping time. For this condition, the dissipated power is 7 mW [J956]

"80 GHz MMIC HEMT VCO"

In this letter a monolithic voltage-controlled oscillator (VCO) operating in the 77.5-83.5 GHz range is presented. InP HEMTs are used for both the active device and varactor. The VCO demonstrated a tuning range of 6 GHz and an output power better than 12.5 dBm in the entire tuning range [J957]

"Full-wave modeling of linear FETs for millimeter waves"

Current monolithic-microwave integrated-circuit design, involving frequencies far in the millimeter and sub-millimeter ranges, is faced with the problem of the distributed nature of the devices. In this paper, we introduce a full-wave approach to the modeling of FETs under the small-signal hypothesis. The method is applied to MESFETs and pseudomorphic high electron-mobility transistors of different topologies and validated by comparison with available experimental data [J958]

"Vector modulator for W-band software radar techniques"

Direct-carrier modulation is an attractive technique for low-cost high-performance radar transceivers. In this paper, it is shown that, when the technique is applied to a generic homodyne radar architecture, the signaling waveform can be software adapted without requiring any hardware modifications. The key circuit in this novel software radar is a W-band monolithic I-Q vector modulator employing two push-pull (bi-phase) amplitude modulators. To fully exploit this circuit's capacity to generate accurate constellations at millimeter-wave frequencies, a generalized theoretical analysis of the I-Q (push-pull) vector modulator is presented. This is a comprehensive analysis of the topology and does not assume ideal components. As a demonstration of the vector modulator's flexibility, a 76.5-GHz MMIC version has been fabricated and characterized by means of static S-parameter measurements and by several modulation spectra. Based on the theoretical model and the measured results, the I-Q (push-pull) vector modulator promises to be a vital component for the realization of future software radar [J959]

"A 49-GHz preamplifier with a transimpedance gain of 52 dBΩ using InP HEMTs"

This paper describes a new preamplifier IC with 0,15-μm gate InP-based high electron mobility transistors (HEMTs) for a high-speed fiber optic communication system. The preamplifier consists of a lumped-element transimpedance amplifier (TIA) for the input stage and a highly stabilized distributed amplifier with cascode-configured unit cells for the gain stage. A gain-peaking technique for a distributed amplifier was employed to enhance the bandwidth and gain flatness of the preamplifier. This gain peaking profile compensates for a lack of bandwidth of a TIA. As a result, we achieved a flat transimpedance gain of 52 dBΩ and a bandwidth of 49 GHz

[J960]

"A 10-Gb/s laser/modulator driver IC with a dual-mode actively matched output buffer"

A laser/modulator driver IC for 10-Gb/s-SONET OC-192-fiber optic transmitters is described. Depending on the user application, the IC is capable of driving more than 100 mA of current into a laser diode or over 50 mA into an electro-absorption or Mach-Zehnder modulator. Rise and fall times below 20 pS are achieved. The driver employs a novel dual-mode actively matched output buffer that provides a dc-coupled back termination of either 25 or 50 Ω. Compared to an output buffer with a resistive termination, this buffer dissipates only half as much power. In addition, the buffer has the the ability to reject external bias and will therefore not load bias sources used to set laser threshold currents and modulator offset voltages. The low power consumption makes the IC most suitable for co-packaging with uncooled lasers and electro-absorption modulators. The driver is fabricated in a 0.25-µm gate length production GaAs PHEMT process with substrate thru vias, thin-film resistors, and MIM capacitors [J961]

"A temperature-dependent nonlinear analysis of GaN/AlGaN HEMTs using Volterra series"

Gain and intermodulation distortion of an AlGaN/GaN device operating at RF have been analyzed using a general Volterra series representation. The circuit model to represent the GaN FET is obtained from a physics-based analysis. Theoretical current-voltage characteristics are in excellent agreement with the experimental data. For a 1 µmЧ500 µm Al0.15Ga0.85N/GaN FET, the calculated output power, power-added efficiency, and gain are 25 dBm, 13%, and 10.1 dB, respectively, at 15-dBm input power, and are in excellent agreement with experimental data. The output referred third-order intercept point (OIP3) is 39.9 dBm at 350 K and 33 dBm at 650 K. These are in agreement with the simulated results from Cadence, which are 39.34 and 35.7 dBm, respectively. At 3 GHz, third-order intermodulation distortion IM3for 10-dBm output power is -72 dB at 300 K and -56 dB at 600 K. At 300 K, IM3is -66 dB at 5 GHz and -51 dB at 10 GHz. For the same frequencies, IM 3increases to -49.3 and -40 dB, respectively, at 600 K [J962]

"An auto-gain control transimpedance amplifier with low noise and wide input dynamic range for 10-Gb/s optical communication systems"

This paper describes a 10-Gb/s transimpedance amplifier (TIA), fabricated in a 0.1-µm-p-HEMT technology. To improve the optical overload characteristics, an automatic gain control (AGC) circuit is included. The measured results show excellent performance, transimpedance of 63.3 dBΩ (1.46 kΩ), bandwidth of 8.0 GHz, and equivalent input noise current density of 6.5 pA/rtHz. When the bit error rate is 10-9, the minimum sensitivity and the optical overload are -21.2 dBm, +4.3 dBm, respectively, using a 0.8 A/W pin photodiode (PD). The power dissipation is about 0.5 W from a single -5-V supply. The die area is 1.3Ч1.6 mm2 [J963]

"Determining dominant breakdown mechanisms in InP HEMTs"

We present a new technique for determining the dominant breakdown mechanism in InAlAs-InGaAs high-electron mobility transistors. By exploiting both the temperature dependence and the bias dependence of different physical mechanisms, we are able to discriminate impact ionization gate current from tunneling and thermionic field emission gate current in these devices. Our results suggest that the doping level of the supply layers plays a key role in determining the relative importance of these two effects [J964]

"Fabrication and operation of a velocity modulation transistor"

The velocity modulation transistor (VMT) has two channels with differing velocities. Small vertical distances between these channels can be achieved using epitaxial growth, opening the opportunity for higher speed than the high electron mobility transistor (HEMT). Experimental results from a VMT realized using the AlGaAs/GaAs system are given. The VMT channel carrier population as a function of input gate voltage is calculated for HEMTs and VMTs using a one-dimensional (1-D) numerical model. This supports a proposed equivalent circuit model for the VMT, which is used to compare VMT performance to that of HEMTs. A noise model for the VMT is developed, and this model suggests that HEMT-like noise is achievable with good carrier confinement. The dual gate, dual-channel VMT, while more complex than the HEMT, may be useful in applications such as analog-to-digital converters (ADCs) and microwave amplifiers [J965]

"Effect of deep traps on sheet charge in AlGaN/GaN high electron mobility transistors"

The same traps that produce current collapse in AlGaN/GaN high electron mobility transistors are also shown to limit the sheet charge that is attainable in these devices by the trapping of channel carriers at equilibrium (no applied bias). In the present case, this reduction in sheet charge was found comparable to that induced by

current collapse [J966]

"A dual-beam asymmetrically scanning leaky-wave antenna by utilizing a HEMT resistive upconverter"

A dual-beam asymmetrical scanning microstrip leaky-wave antenna (LWA) has been demonstrated in this paper. A HEMT resistive upconverter output is connected to one terminal of the LWA, and a local oscillator (LO) signal is connected to the other terminal. In this experiment, we set the LO frequency at 9.5 GHz so that the right beam is fixed at 48°. By changing the IF frequency from 0.7 GHz to 1.5 GHz, the module of the LWA can steer the left main beam of the far-field pattern from 136° to 158° (the total scanning angle of 22°). Comparisons between the measured and theoretical results indicate that the design can achieve the asymmetrically scanning capability and agree well over the tuning bandwidth of 0.8 GHz [J967]

"Neural networks for large- and small-signal modeling of MESFET/HEMT transistors"

In this paper, we present a comparative study of three neural networks-based solutions for large- and small-signal modeling of MESFET and HEMT transistors. The first two neural architectures are specific for this modeling problem: the generalized radial basis function (GRBF) network, and the smoothed piecewise linear (SPWL) model. These models are compared with the well-known multilayer perceptron (MLP) network. Results are presented for both the large- and small-signal regimes separately. Finally, a global model is proposed that is able to accurately characterize the whole behavior of the transistors. This model is based on a simple combination of the best models obtained for the two kinds of regimes [J968]

"Charge-collection dynamics of AlSb-InAs-GaSb resonant interband tunneling diodes (RITDs) [Jfor MOBILE logic circuits]"

Time-resolved charge-collection measurements performed on AlSb/InAs/GaSb resonant interband tunneling diodes (RITDs) with pulsed laser excitation exhibit complex behavior as a function of the device operating point. A model considering conventional charge-collection principles in combination with transient band-bending effects is proposed to describe the experimental results. In the proposed model, a transient distortion of the band structure of the device (transient band bending) induced by holes trapped in the GaSb valence band well modulates the DC current through the RITD. The manner in which this transient modulation is manifested in the experimental observable depends sensitively on the operating point of the device, giving rise to qualitatively different temporal signatures under different DC bias conditions [J969]

"(Alx Ga1-x)0.5 In0.5 P/In 0.15 Ga0.85 As (x=0, 0. 3, 1. 0) heterostructure doped-channel FETs for microwave power applications"

The quaternary (AlxGa1-x)0.5In 0.5P (0⩽Ч⩽1) compounds on GaAs substrates are important materials used as a Schottky layer in microwave devices. In this report, we systematically investigated the electrical properties of quaternary (AlxGa1-x)0.5In0.5P materials and concluded that the best composition for improving the device performance is by substituting 30% (x=0.3) of Ga atoms for Al atoms in GaInP material. The Schottky barrier heights (φB) of (Al xGa1-x)0.5In0.5P layers were 0.85~1.00 eV. We successfully realized the (AlxGa1-x)0.5In0.5P/In0.15Ga0.85 As (x=0, 0.3, 1.0) doped-channel FETs (DCFETs) and demonstrated excellent dc, microwave, and power characteristics [J970]

"Planck satellite 70 GHz receiver noise tests"

The LFI (Low Frequency Instruments) receivers in the coming Planck satellite are of continuous comparison type and use low noise amplifiers based on high electron mobility transistors manufactured from indium phosphide substrate (INP-HEMT-MMIC-LNAs). This article describes the 1/f-noise tests and the associated test system for the 70 GHz demonstrator receiver, which can either use single or dual channel phase switcher methods. The 1/f knee frequency is shown to depend on the calculation method of the r-value. A minimum 1/f knee frequency around 10 mHz has been achieved with full two channel foxtrot and individually adopted r-values for each phase states while a straightforward single phase technology cannot go below 40 mHz [J971]

"New design method of uniform and nonuniform distributed power amplifiers"

A new design methodology of uniform and nonuniform distributed power amplifiers is reported in this paper. This method is based on analytical expressions of the optimum input and output artificial lines making up the uniform and nonuniform distributed architectures. These relationships are derived from the load-line requirement of each transistor size for optimum power operation. Furthermore, specific design criteria are presented to enable an efficient choice between uniform and nonuniform distributed architectures. To validate this new design

methodology, a nonuniform distributed power amplifier has been manufactured at the TriQuint Semiconductor Foundry, Richardson, TX, using a 0.25-µm power pseudomorphic high electron-mobility process. This single-stage monolithic-microwave integrated-circuit amplifier is made of six nonuniform cells and demonstrates 1-W output power with 7-dB associated gain and 20% power-added efficiency over a multioctave bandwidth [J972]

"AlGaN/GaN Round-HEMTs on (111) silicon substrates"

AlGaN/GaN Round-HEMTs on silicon substrates have been realised and their static characteristics investigated. The AlGaN/GaN (x=0.23) material structures were grown on (111) p-Si by LP-MOVPE. Devices with 0.3 µm gate length exhibit a saturation current of 0.82 A/mm, a good pinch-off and a peak extrinsic transconductance of 110 mS/mm. Highest saturation current reported so far and static output characteristics up to 20 V demonstrate that the devices are capable of handling 16 W/mm of static heat dissipation without any degradation of their performance [J973]

"6 Vpp-66 GHz-ultrabroadband amplifier for fibre-optical transmission systems"

A large amount of bandwidth has been achieved with advanced construction methods developed for ultra-high bandwidth distributed amplifiers. A 66 GHz-bandwidth GaAs device with more than 6 Vpp of voltage swing has been manufactured [J974]

"Analog MMICs for millimeter-wave applications based on a commercial 0.14-µm pHEMT technology"

This paper describes recent results obtained from the monolithic-microwave integrated-circuit design activity at Chalmers University, Goteborg, Sweden. The goal is to design all circuits needed for the front end of a 60-GHz wireless local area network and to build various system demonstrators. Some recent experimental results from this activity like different 60-GHz amplifiers, a general-purpose IF amplifier, a 60-GHz resistive mixer, and frequency multipliers are reported in this paper. Parameters such as the gain, conversion loss, noise figure, dc-power dissipation, as well as the model used in the simulations are reported and discussed [J975]

"Measurement and characterization of HEMT dynamics"

The variation of high electron-mobility transistor (HEMT) large-signal behavior with a change in operating condition is examined with a view to understanding the dynamics involved and developing a modeling strategy. The observed variation exhibits the dynamics of thermal, impact ionization, and trapping effects. A novel measurement of drain characteristic transients gives time-evolution information that clearly shows these as separate quantifiable phenomena with significant dependence on initial operating conditions. A drain-current model that describes high-frequency characteristics with pinchoff, gain, and drain feedback parameters is adapted to describe the variation of the characteristics with changing operating conditions. The results reported give insight and grounding for simulation of HEMT circuits [J976]

"K-band receiver front-ends in a GaAs metamorphic HEMT process"

In this paper, we present K-band receiver blocks fabricated in a state-of-the-art 0.18-µm GaAs metamorphic high electron-mobility transistor (MHEMT) process using a 60% indium-content InGaAs channel. Several circuits are developed to demonstrate the superior noise performance and successful integration of K-band receiver components in such a process. We show a low-power three-stage low-noise amplifier (LNA) with a gain of 23 dB and a noise figure (NF) of less than 1.6 dB at 30 GHz. This LNA shows InP-like performance on a GaAs substrate with a high RF yield of 84%. This is the first report of a statistical yield analysis of an MHEMT integrated circuit. We also demonstrate on-chip integration of a single-stage amplifier with a diode subharmonic mixer for low-power and broad-band receiver performance. This down-converter exhibits a conversion loss of 3 dB, overall NF of 5 dB, and third-order input intercept point of -5 dBm from 26 to 30 GHz [J977]

"High-power broad-band AlGaN/GaN HEMT MMICs on SiC substrates"

Broad-band high-power cascode AlGaN/GaN high electron-mobility transistor monolithic-microwave integrated-circuit (MMIC) amplifiers with high gain and power-added efficiency (PAE) have been fabricated on high-thermal conductivity SiC substrates. A cascode gain cell exhibiting 5 W of power at 8 GHz with a small-signal gain of 19 dB was realized. A nonuniform distributed amplifier (NDA) based on this process was designed, fabricated, and tested, yielding a saturated output power of 3-6 W over a dc-8-GHz bandwidth with an associated PAE of 13%-31%. A broad-band amplifier MMIC using cascode cells in conjunction with a lossy-match input matching network showed a useful operating range of dc-8 GHz with an output power of 5-7.5 W and a PAE of 20%-33.% over this range. The third-order intermodulation products of the amplifiers under two-tone excitation were

studied and third-order-intercept values of 42 and 43 dBm (computed using two-tone carrier power) for the lossy match and NDA amplifiers were obtained [J978]

"AlGaN/GaN varactor diode for integration in HEMT circuits"

The fabrication and characterisation of metal-semiconductor-metal (MSM) diodes above an AlGaN/GaN HEMT layer system for varactor applications are reported. Device fabrication uses standard HEMT processing steps, allowing integration in HEMT circuits without the need of sophisticated growth or etching techniques. Capacitance-voltage measurements exhibit CMAX/CMINratios up to 100, tunable by the electrode geometry. These results exceed best values for published heterostructure varactor diodes. Fabrication of AlGaN/GaN HEMTs on the same layer system with identical technology prove the potential for monolithic integration [J979]

"Study of self-heating effects, temperature-dependent modeling, and pulsed load-pull measurements on GaN HEMTs"

On-wafer RF and IV characterizations are performed for the first time on power GaN high electron-mobility transistors (HEMTs) under pulse and continuous conditions at different temperatures. These measurements give an in-depth understanding of self-heating effects and allow one to investigate the possibility of improving heat-dissipation mechanisms. A pulsed load-pull system that measures the power gain of the device-under-test (DUT) under pulsed RF and bias condition has been developed. To the best of our knowledge, this is the first time that the reflected power at the DUT is measured under the pulse mode of operation. Additionally, an improved small-signal model for power GaN HEMTs that incorporates the geometry of the device is developed at various temperatures. This is the basis for empirical large-signal modeling [J980]

"Spontaneous and piezoelectric polarization effects on the output characteristics of AlGaN/GaN heterojunction modulation doped FETs"

We report on the calculation of electrical characteristics of AlGaN/GaN heterojunction field effect transistors (HFETs). The model is based on the self-consistent solution of the Schrodinger and Poisson equations coupled to a quasi-2D model for the current flow. Both single and double heterojunction devices are analyzed for [0001] or [000-1] growth directions. The onset of a parasitic p-channel for particular growth directions and alloy concentrations is also shown [J981]

"Trapping effects and microwave power performance in AlGaN/GaN HEMTs"

The dc small-signal, and microwave power output characteristics of AlGaN/GaN HEMTs are presented. A maximum drain current greater than 1 A/mm and a gate-drain breakdown voltage over 80 V have been attained. For a 0.4 μm gate length, an fTof 30 GHz and an fmax of 70 GHz have been demonstrated. Trapping effects, attributed to surface and buffer layers, and their relationship to microwave power performance are discussed. It is demonstrated that gate lag is related to surface trapping and drain current collapse is associated with the properties of the GaN buffer layer. Through a reduction of these trapping effects, a CW power density of 3.3 W/mm and a pulsed power density of 6.7 W/mm have been achieved at 3.8 GHz [J982]

"Undoped AlGaN/GaN HEMTs for microwave power amplification"

Undoped AlGaN/GaN structures are used to fabricate high electron mobility transistors (HEMTs). Using the strong spontaneous and piezoelectric polarization inherent in this crystal structure a two-dimensional electron gas (2DEG) is induced. Three-dimensional (3-D) nonlinear thermal simulations are made to determine the temperature rise from heat dissipation in various geometries. Epitaxial growth by MBE and OMVPE are described, reaching electron mobilities of 1500 and 1700 cm 2/Ns, respectively, For electron sheet density near 1Ч1013/cm2, Device fabrication is described, including surface passivation used to sharply reduce the problematic current slump (dc to rf dispersion) in these HEMTs. The frequency response, reaching an intrinsic ftof 106 GHz for 0.15 μm gates, and drain-source breakdown voltage dependence on gate length are presented. Small periphery devices on sapphire substrates have normalized microwave output power of ~4 W/mm, while large periphery devices have ~2 W/mm, both thermally limited. Performance, without and with Si3N4passivation are presented. On SiC substrates, large periphery devices have electrical limits of 4 W/mm, due in part to the limited development of the substrates [J983]

"Optical injection locking of a 38-GHz-band InP-based HEMT oscillator using a 1.55-/spl mu/m DSB-SC modulated lightwave"

Optical injection locking was experimentally performed using a 38-GHz-band InP-based HEMT MMIC oscillator and a 1.55-\μm lightwave. Two optical modulation schemes were compared for optical injection locking, and no

difference was found except for the optical modulation frequency. With suppressed carrier modulation of the lightwave, phase noise of less than -73.2 dBc/Hz at a 10-kHz frequency offset and a 14-MHz locking range were achieved. [J984]

"Influence of AlGaN deep level defects on AlGaN/GaN 2-DEG carrier confinement"

We have used low energy electron-excited nanoscale luminescence spectroscopy (LEEN) to detect the defects in each layer of AlGaN/GaN HEMT device structures and to correlate their effect on two-dimensional electron gas (2-DEG) confinement. We investigated AlGaN/GaN heterostructures with different electrical properties using incident electron beam energies of 0.5 to 15 keV to probe electronic state transitions within each of the heterostructure layers. AlGaN heterostructures of 25 nm thickness and nominal 30% Al concentration grown on GaN buffer layers on sapphire substrates by plasma-assisted molecular beam epitaxy exhibited a range of polarization-induced electron densities and room temperature mobilities. In general, the spectra exhibit AlGaN band edge emission at ~3.8 eV or ~4.0 eV, GaN band edge emission at ~3.4 eV, yellow luminescence (YL) features at 2.18 eV and 2.34 eV, and a large emission in the infrared (<1.6 eV) from the GaN cap layer used to passivate the AlGaN outer surface. These heterostructures also show high strain in the 2 nm-thick GaN layer with evidence for a Franz-Keldysh red shift due to piezoelectric charging. The LEEN depth profiles reveal differences between the structures with and without 2-DEG confinement and highlight the importance of AlGaN defects in the near 2-DEG region [J985]

"AlGaN/GaN high electron mobility transistors on Si(111) substrates"

AlGaN/GaN high electron mobility transistors (HEMTs) on silicon substrates have for the first time been realized using organometallic vapor phase epitaxy (OMVPE). Using 1 Ω-cm p-Si(111), these devices exhibited static output characteristics with low output conductance and isolation approaching 80 V. Under microwave rf operation, the substrate charge becomes capacitively coupled and parasitically loads these devices thereby limiting their performance. As a result, typical 0.3 μm gate length devices show a 25 GHz cutoff frequency, with near unity fmax/fTratio and 0.55 W/mm output power. A small-signal equivalent circuit incorporating elements representing the parasitic substrate loading accurately models the measured S-parameters. Removal of the conductive substrate is one way to effectively eliminate this parasitic loading. Through backside processing, freestanding 0.4-mm HEMT membranes with no thermal management were demonstrated and exhibited a significant improvement in their fmax/fT ratio up to 2.5 at the cost of lower fTand fmax along with an almost four-fold reduction of Idss [J986]

"Very-high power density AlGaN/GaN HEMTs"

Research work focusing on the enhancement of large-signal current-voltage (I-V) capabilities has resulted in significant performance improvement for AlGaN/GaN HEMT's. 100-150 μm wide devices grown on SiC substrates demonstrated a record power density of 9.8 W/mm at 8 GHz, which is about ten times higher than GaAs-based FETs; similar devices grown on sapphire substrates showed 6.5 W/mm, which was thermally limited, 2-mm-wide devices flip-chip mounted on to AlN substrates produced 9.2-9.8 W output power at 8 GHz with 44-47% PAE. A flip-chip amplifier IC using a 4-mm device generated 14 W at 8 GHz, representing the highest CW power obtained from GaN-based integrated circuits to date [J987]

"Characterizations of recessed gate AlGaN/GaN HEMTs on sapphire"

A recessed gate high electron mobility transistor (HEMT) has been fabricated with AlGaN/GaN heterostructure on a sapphire substrate using metalorganic chemical vapor deposition. Capacitance-voltage (C-V) and Shubnikov-de Haas measurements have shown the formation of two-dimensional (2-D) electron gas (2DEG) at Al0.11Ga0.89N/GaN heterointerface. A 2DEG mobility 12000 cm2/V-s with a sheet carrier density 2.8Ч1012cm-2was measured on Al0.11 Ga0.89N/GaN heterostructure at 8.9 K. The recessed gate Al0.26Ga0.74N/GaN HEMT structure showed maximum extrinsic transconductance 181 mS/mm and drain-source current 1120 mA/mm for a gate length 1.5 μm at 25°C. The device exhibited stable operation characteristics at 350°C for long time (500 h). No interfacial change has been observed at metal/AlGaN interface even after 350°C for 500 h treatment. The threshold voltage of device does not depend very much on operating temperature (25 to 350°C) [J988]

"A subharmonic self-oscillating mixer with integrated antenna for 60-GHz wireless applications"

A balanced integrated-antenna self-oscillating mixer at 60 GHz is presented in this paper. The modal radiation characteristics of a dual-feed planar quasi-Yagi antenna are used to achieve RF-local oscillator (RF-LO) isolation between closely spaced frequencies. The balanced mixer is symmetric, inherently broad band, and does not need an RF balun. Pseudomorphic high electron-mobility transistors are used in a 30-GHz push-pull circuit

to generate the second harmonic and a 30-GHz dielectric resonator was used to stabilize the fundamental oscillation frequency. This allows the possibility of building a balanced low-cost self-contained antenna integrated receiver with low LO leakage for short-range narrow-band communication. Phase locking can be done with half of the RF frequency. The circuit exhibits a conversion loss less than 15 dB from 60 to 61.5 GHz, radiation leakage of -26 dBm at 60 GHz, and IF phase noise of -95 dBc/Hz at 100-kHz offset [J989]

"An X-band GaN HEMT power amplifier design using an artificial neural network modeling technique"

In this paper, the first gallium nitride (GaN) based high electron mobility transistor (HEMT) power amplifier design using an artificial neural network (ANN) modeling technique is presented. The ANN technique was used to model the small signal behavior of a device with a gate periphery of 1 mm and a gate length of 1 μm over the broad frequency range from 1 GHz to 26 GHz with multiple bias points, based on fitting calculated S-parameters to measured S-parameters. A single stage amplifier constructed using these parameters showed a gain of about 7 dB and an output power of 1.2 W at 8 GHz when biased at Vds= 20 V and Ids220 mA in class AB mode. The good agreement between measured and simulated results was shown in both S-parameter modeling and in amplifier design [J990]

"Gallium nitride based high power heterojunction field effect transistors: process development and present status at UCSB"

The development of GaN based devices for microwave power electronics at the University of California, Santa Barbara (UCSB), is reviewed. From 1995 to 2000, the power performance of AlGaN/GaN-on-sapphire heterojunction field effect transistors improved from 1.1 W/mm to 6.6 W/mm, respectively. Compensating the disadvantages of the low thermal conductivity of the sapphire substrate through heat management via flip chip bonding onto AlN substrates, large periphery devices with an output power of 7.6 W were demonstrated. UCSB also fabricated the first GaN based amplifier integrated circuits. Critical issues involved in the growth of high quality AlGaN/GaN heterostructures by metal-organic chemical vapor deposition and the device fabrication are discussed [J991]

"The impact of surface states on the DC and RF characteristics of AlGaN/GaN HFETs"

GaN based HFETs are of tremendous interest in applications requiring high power at microwave frequencies. Although excellent current-voltage (I-V) characteristics and record high output power densities at microwave frequencies have been achieved, the origin of the 2DEG and the factors limiting the output power and reliability of the devices under high power operation remain uncertain. Drain current collapse has been the major obstacle in the development of reliable high power devices. We show that the cause of current collapse is a charging up of a second virtual gate, physically located in the gate drain access region. Due to the large bias voltages present on the device during a microwave power measurement, surface states in the vicinity of the gate trap electrons, thus acting as a negatively charged virtual gate. The maximum current available from a device during a microwave power measurement is limited by the discharging of this virtual gate. Passivated devices located adjacent to unpassivated devices on the same wafer show almost no current collapse, thus demonstrating that proper surface passivation prevents the formation of the virtual gate. The possible mechanisms by which a surface passivant reduces current collapse and the factors affecting reliability and stability of such a passivant are discussed [J992]

"110 GHz vector modulator for adaptive software-controlled transmitters"

A 110 GHz MMIC vector modulator for use in low-cost, high-performance, radar and communication transmitters is presented. The circuit consists of two push-pull (bi-phase) attenuators arranged in phase quadrature and has dimensions of 1.7times 1.4 mm2. The fabricated MMIC has been characterized by means of static S-parameter measurements and shows a minimum insertion loss of 12 dB at 110 GHz, Using these measurements, the required baseband input levels for a 64-QAM static constellation were determined. These levels were then applied at 10 MSample/s, by an arbitrary waveform generator, to demonstrate a 60 Mb/s data rate transmitter operating at 110 GHz. To date, this represents the highest reported RF frequency for direct multilevel carrier modulation using monolithic technology. [J993]

"Mobility enhancement by reduced remote impurity scattering in a pseudomorphic In 0.7 Ga 0.3 As/In 0.52 Al 0.48 As quantum well high electron mobility transistor structure with (411)A super-flat interfaces grown by molecular-beam epitaxy"

We have carried out a Shubnikov-de Haas (SdH) measurement at 4 K and investigated the electronic properties

and scattering mechanisms in a pseudomorphic In0.7Ga0.3As/In0.52Al0.48Asquantum well high electron mobility transistor (QW-HEMT) structure with a thin spacer thickness of 3 nm grown on a (411)A-oriented InP substrate by molecular-beam epitaxy (MBE). Electrons occupied the zeroth and first subbands in the 12-nm-thick In0.7Ga0.3Aschannel layer at two-dimensional electron gas (2DEG) densities of 3.10Ч1012and 0.99Ч1012cm-2,respectively. 2DEG mobilities of the (411)Asample for the zeroth and first subbands were mu 0=52 000and mu 1=66 000cm2/V s,which were much higher than those of the (100) QW-HEMT structure (mu 0=22 000and mu 1=26 000cm2/V s).The result indicates that the electron mobility of the (411)Asample is enhanced by reduction of remote impurity scattering because the spacer thickness (Lsp=3nm) and distribution of sheet doped impurities are laterally uniform in the (411)AIn0.7Ga0.3As/In0.52Al0.--48AsQW-HEMT structure. copyright 2001 American Vacuum Society. [J994]

"Molecular beam epitaxial growth and characterization of strain-compensated Al 0.3 In 0.7 P/InP/Al 0.3 In 0.7 P metamorphic-pseudomorphic high electron mobility transistors on GaAs substrates"

A novel metamorphic high electron mobility transistor (HEMT) structure was grown on GaAs substrates by solid-source molecular-beam epitaxy for potential microwave power applications. The HEMT device layers were strain compensated with pseudomorphic (tensile-strained) Al0.3In0.7Pdonor-barrier layers and a pseudomorphic (compressive-strained) InP channel layer. Atomic force microscopy measurements of the metamorphic structure yielded a root-mean-square surface roughness of 8 E. Transmission electron micrographs of the device layers exhibited flat interfaces with the dislocation density estimated to be less than 1Ч106 cm-2.Room temperature photoluminescence measurements of metamorphic AlInP layers indicated large direct band gaps up to 2.10 eV. Due to the larger conduction band discontinuity at the Al0.3In0.7P/InPheterojunction than the AlGaAs/InGaAs heterojunction in GaAs pseudomorphic HEMTs, significantly higher channel sheet densities were obtained. For Al0.3In0.7P/InPHEMTs, channel sheet densities (cm-2) exceeding 3Ч1012for single-pulse-doped, and greater than 4Ч1012for double-pulse-doped, structures were readily obtained. Hall measurements on a double-pulse-doped Al0.3In0.7P/InP/Al0.3In0.7PHEMT gave mobilities (cm2/V s) of 4450 at 300 K an--d 18 500 at 77 K, which are consistent with a high quality InP channel layer. Secondary ion mass spectroscopy depth profiles of a double-pulse-doped structure displayed sharp doping pulses and interfaces indicating that metamorphic growth was not leading to enhanced diffusion or migration. Initial and nonoptimized devices with a gate length of 0.15 mcm exhibited a maximum current density of 500 mA/mm and a transconductance of 520 mS/mm, which compare favorably to mature AlGaAs/InGaAs pseudomorphic HEMTs. copyright 2001 American Vacuum Society. [J995]

"Metamorphic In 0.52 Al 0.48 As/In 0.53 Ga 0.47 As high electron mobility transistors on GaAs with In x Ga 1-x P graded buffer"

A new metamorphic In0.52Al0.48As/In0.53Ga0.47Ashigh electron mobility transistor (HEMT) structure was grown on a GaAs substrate with a InxGa1-xPgraded buffer layer by solid-source molecular beam epitaxy. The In0.53Ga0.47Aschannel layer was grown on the InGaP buffer layer directly without an InAlAs buffer as in the conventional design. High-resolution x-ray diffraction reveals that the whole layer structure is nearly fully relaxed. Hall measurement showed that this new layer design exhibits higher electron mobility and carrier concentration as well as lower light sensitivity compared to the reference sample with the conventional design. The promising device performance demonstrates the potential of using this metamorphic HEMT device in high speed and high frequency applications. copyright 2001 American Vacuum Society. [J996]

"Terahertz detection by high-electron-mobility transistor: Enhancement by drain bias"

We report on a regime of operation of high-electron-mobility-transistor (HEMT) terahertz detectors, in which we apply a constant drain bias. The drain bias dependence of the gate-to-source and gate-to-drain capacitances results in a much greater asymmetry in the boundary conditions for plasma waves and greatly enhances the HEMT detector responsivity. The measured responsivity increases with the drain current by more than an order of magnitude and saturates at a saturation drain current for a given gate bias. These results confirm our model linking the responsivity increase to the drain bias dependence of the HEMT capacitances. copyright 2001 American Institute of Physics. [J997]

"Effect of growth termination conditions on the performance of AlGaN/GaN high electron mobility transistors"

The effect of the growth conditions of the top 2.5 nm thick AlGaN cap layer and wafer cool down conditions on AlGaN/GaN high electron mobility transistor performance was investigated. The AlGaN/GaN heterostructures were deposited on sapphire by metalorganic chemical vapor deposition and consisted of a 3 mcm thick semi-insulating GaN layer and an 18 nm thick Al0.33Ga0.67Nlayer, the top 2.5 nm of which was deposited under

various conditions. The power performance of the devices severely degraded for all samples where the Al content of the top 2.5 nm of AlGaN was increased and/or the ammonia flow during growth of the top layer was decreased. A modest improvement in the output power density was observed when the growth conditions of the cap layer were identical of those of the rest of the AlGaN layer, but when the wafer was cooled down in pure nitrogen. copyright 2001 American Institute of Physics. [J998]

"Photovoltaic effects on pinch-off voltage and open-circuit voltage in high-electron-mobility-transistor and Schottky-diode configurations"

Photovoltaic effects on the pinch-off voltage (VP)in the high-electron-mobility-transistor (HEMT) and the open-circuit photovoltage (Vopt,OC)in the Schottky-diode configurations are characterized as a function of the optical input (Popt).The open-circuit photovoltage (Vopt,OC)in a Schottky-diode configuration, which has only a vertical field and every photogenerated excess minority carrier contributes to the photovoltage, can be described by Vopt,OC=nVth ln(Popt/Pref).However, the photovoltage (Vopt,FET≡|VP-VPO|)in HEMT configuration, which has a lateral field as well as a vertical field to drift excess minority carriers to the source contact and results in reduced photovoltage development, can be modeled as Vopt,FET=V0(Popt/Prefo)gamma .copyright 2001 American Institute of Physics. [J999]

"Highly strained InGaP/InGaAs p-HEMT using reduced area growth"

Highly strained InGaP/In0.33Ga0.67As pseudomorphic high electron mobility transistor (p-HEMT) structures were grown on patterned GaAs substrates. Performance of the highly strained p-HEMTs grown on patterned substrates was compared with that of highly strained p-HEMTs and conventional InGaP/In0.22Ga0.78 As p-HEMTs grown on nonpatterned substrates. The highly strained p-HEMTs grown on patterned substrates showed substantial improvements in dc (transconductance and drain saturation current) and rf (cutoff frequency: fTand maximum oscillation frequency: fmax) performances as compared with those of the p-HEMTs grown on nonpatterned substrates. The results indicate the potential of highly strained p-HEMTs using reduced area growth for high-speed device applications [J1000]

"Smoothing the canonical piecewise-linear model: an efficient and derivable large-signal model for MESFET/HEMT transistors"

In this paper we present the smoothed piecewise-linear (SPWL) model as a useful tool in the device modeling field. The SPWL model is an extension of the well-known canonical piecewise-linear model proposed by Chua, which substitutes the abrupt absolute value function for a smoothing function (the logarithm of hyperbolic cosine), thus providing the model with several interesting properties. In particular, this function makes the model derivable, which is important to predict the intermodulation distortion behavior. Moreover, it allows one to control the smoothness of the global model by means of a single smoothing parameter. The parameters of the model are adapted to fit the nonlinear function, while the smoothing parameter is selected according to derivative constraints. The applied learning algorithm is a second-order gradient method. The proposed SPWL model is successfully applied to model a microwave HEMT transistor under optical illumination using real measurements. The model receives as input the bias voltages of the transistor, the instantaneous voltages, and the optical power and provides the drain to source current. The performance and computational burden of the SPWL model is compared with an empirical model and with some neural networks-based alternatives [J1001]

"An indium phosphide MMIC amplifier for 180-205 GHz"

This paper describes a high-performance indium phosphide (InP) monolithic microwave integrated circuit (MMIC) amplifier, which has been developed for application in radioastronomy and imaging-array receivers. Implemented using coplanar waveguide, the six-stage amplifier exhibits 15 db gain, 10 dB input and output return loss, and low noise figure over the 180-205 GHz frequency range. Only one design pass was needed to obtain excellent agreement between the predicted and measured characteristics of the circuit, a unique achievement in this frequency band. The circuit is also the first 180-205 GHz amplifier designed for and successfully fabricated using TRW's standard 0.1-\μm InP HEMT process. [J1002]

"Small signal and power measurements of AlGaN/GaN HEMT with SiN passivation"

Small signal S-parameters and loadpull measurements are reported for AlGaN/GaN HEMT devices with 200 nm SiN passivation. The maximum output power increases from 0.59 W/mm to 1.45 W/mm and the efficiency is also enhanced from 16 to 27% for 2Ч50 μm HEMT devices after SiN passivation. Small signal equivalent circuit parameters including parasitic and intrinsic parameters have been extracted from the measured S-parameters and are used to explain the effect of SiN on the power characteristics [J1003]

"Power-amplifier modules covering 70-113 GHz using MMICs"

A set of W-band power amplifier (PA) modules using monolithic microwave integrated circuits (MMICs) have been developed for the local oscillators of the far-infrared and sub-millimeter telescope (FIRST). The MMIC PA chips include three driver and three PAs, designed using microstrip lines, and another two smaller driver amplifiers using coplanar waveguides, covering the entire W-band. The highest frequency PA, which covers 100-113 GHz, has a peak power of greater than 250 mW (25 dBm) at 105 GHz, which is the best output power performance for a monolithic amplifier above 100 GHz to date. These monolithic PA chips are fabricated using 0.1-μm AlGaAs/InGaAs/GaAs pseudomorphic T-gate power high electron-mobility transistors on a 2-mil GaAs substrate. The module assembly and testing, together with the system applications, is also addressed in this paper [J1004]

"A compact manufacturable 76-77-GHz radar module for commercial ACC applications"

The design and measured results of a single-substrate transceiver module suitable for 76-77-GHz pulsed-Doppler radar applications are presented. Emphasis on ease of manufacture and cost reduction of commercial millimeter-wave systems is employed throughout as a design parameter. The importance of using predictive modeling techniques in understanding the robustness of the circuit design is stressed. Manufacturing techniques that conform to standard high-volume assembly constraints have been used. The packaged transceiver module, including three waveguide ports and intermediate-frequency output, measures 20 mmЧ22 mmЧ8 mm. The circuit is implemented using discrete GaAs/AlGaAs pseudomorphic high electron mobility transistors (pHEMTs), GaAs Schottky diodes, and varactor diodes, as well as GaAs p-i-n and pHEMT monolithic microwave integrated circuits mounted on a low-cost 127-μm-thick glass substrate. A novel microstrip-to-waveguide transition is described to transform the planar microstrip signal into the waveguide launch. The module is integrated with a quasi-optical antenna. The measured performance of both the component parts and the complete radar transceiver module is described [J1005]

"Enhancement mode Al0.25 Ga0.75 As/In0.2 Ga0.8 As nanowire HEMTs"

Enhancement mode Al0.25Ga0.75As/In0.2 Ga0.8As nanowire high electron mobility transistors (NW-HEMTs) are fabricated successfully by using selective wet etching and the depletion characteristic of a Schottky wrap gate (WPG). The devices exhibit very good modulation and saturation characteristics. For an NWHEMT with an estimated channel width of 250 nm, the maximum transconductance is ~450 mS/mm at a drain voltage of 1.5 V [J1006]

"Wide-band balanced active HEMT mixer"

The design and characteristics of a balanced active high electron-mobility transistor (HEMT) mixer operating in the 4.5-10-GHz frequency band are described in this paper. It consists of two parts implemented as independent hybrid circuits, namely, an microwave part fabricated by using a uniplanar technology and comprising a 180° hybrid ring coupler, HEMTs, and input-output matching circuits, and a low-frequency part consisting of an L-C balun and a low-pass filter built of discrete elements. The design of the microwave part of the mixer ensures a high degree of isolation between the signal and local-oscillator (LO) inputs within a wide frequency band at low IF. The measurements show a conversion gain of 5-7 dB, noise figure of 5-7.5 dB, and isolation between the signal and LO ports greater than 20 dB within the 4.5-10-GHz range [J1007]

"A monolithic MEMS switched dual-path power amplifier"

RF MEMS switches have been successfully integrated with HEMT MMIC circuits on a GaAs substrate to construct a dual-path power amplifier at X-band. The amplifier uses two MEMS switches at the input to guide the RF signal between two paths. Each path provides single-stage amplification using different size HEMT devices, one with 80-μm width and the other with 640-μm. Depending on the required output power level, one of the two paths is selected to minimize the dc power consumption. Measurements showed the amplifier producing similar small signal gains of 13.2 and 11.5 dB at 10 GHz for the small and the large devices, respectively. The best PAE was 28.1 percent with 8.5 dBm of output power for the small device, and 15.3 percent with 14.6 dBm for the large device [J1008]

"High performance 0.35 μm gate-length monolithic enhancement/depletion-mode metamorphic In0.52 Al0.48 As/In0.53 Ga0.47 As HEMTs on GaAs substrates"

Monolithic integration of enhancement (E)- and depletion (D)-mode metamorphic In0.52Al0.48As/In0.53Ga0.47 As/GaAs HEMTs with 0.35 μm gate-length is presented for the first time. Epilayers are grown on 3-inch SI GaAs substrates using molecular beam epitaxy. A mobility of 9550 cm2/V-s and a sheet density of 1.12Ч1012-2are

achieved at room temperature. Buried Pt-gate was employed for E-mode devices to achieve a positive shift in the threshold voltage. Excellent characteristics are achieved with threshold voltage, maximum drain current, and extrinsic transconductance of 100 mV, 370 mA/mm and 660 mS/mm, respectively for E-mode devices, and -550 mV, 390 mA/mm and 510 mS/mm, respectively for D-mode devices. The unity current gain cutoff frequencies of 75 GHz for E-mode and 80 GHz for D-mode are reported [J1009]

"Digital integrated circuit using integrated InAlAs/InGaAs/InP HEMTs and InAs/AlSb/GaSb RITDs"

The demonstration of the first integrated circuit using monolithically integrated InAs/AlSb/GaSb resonant interband tunnelling diodes (RITDs) and InAlAs/InGaAs/InP high electron mobility transistors (HEMTs) is reported. A D-flip-flop (D-FF) was implemented using the monostable/bistable logic element (MOBILE) circuit architecture, with a measured effective voltage gain in excess of 380. Power dissipation of less than 2.8 mW/gate was measured [J1010]

"A novel InGaAs/InAlAs insulated gate pseudomorphic HEMT with a silicon interface control layer showing high DC- and RF-performance"

A novel InGaAs/InAlAs insulated gate pseudomorphic HEMT (IG-PHEMT) utilizing a silicon interface control layer (Si ICL) was successfully fabricated and its DC and RF performances were characterized. The device showed high transconductance of 177 mS/mm even for a gate length of 1.6 μm. As compared with the conventional Schottky gate PHEMTs, the gate leakage current was reduced by 4 orders of magnitudes and the gate breakdown voltage was increased up to 39 V. Well-behaved RF characteristics with the current gain cutoff frequency, fT, of 9 GHz and the maximum oscillation frequency, fmax, of 38 GHz were obtained for the 1.6 μm-gate-length device [J1011]

"Wide-band MMIC Kowari mixer/phase shifters"

A series of wide-band image-reject monolithic-microwave integrated-circuit mixer/phase shifters were designed, fabricated, and tested for operation in the microwave and millimeter-wave bands. Mixers based on diode and resistive-high electron-mobility transistor (HEMT) nonlinear elements are presented and compared in this paper. The diode-based Kowari mixers have a bandwidth of approximately 45%, with up- and down-conversion loss [RF to/from IF (in this paper, we use “IF,” “LO,” and “RF” to label the ports associated with particular signals, not necessarily to describe the nature of the signals themselves)] less than 10 dB and up-conversion output power greater than 0 dBm. At band center, the down-conversion loss is approximately 7 dB. The novel resistive-HEMT-based Kowari mixers have a measured IF-to-RF up-conversion loss of approximately 2 dB and LO-to-RF conversion loss of approximately 13 dB over 17-25.5 GHz. While both circuit types realize wide-band 360° phase shifters when appropriate control voltages are applied, the resistive-HEMT-based Kowari has better linearity and a smaller insertion loss [J1012]

"Super self-aligned GaAs RF switch IC with 0.25 dB extremely low insertion loss for mobile communication systems"

An extremely low loss switch IC has been implemented by using a 0.15 μm-gate super self-aligned FET with reduced drain/source area. Both off-state-capacitance and the specific on-resistance of the implemented FET have been dramatically reduced by the novel device structure. The experimentally fabricated switch IC showed the low insertion loss of 0.25 dB at an added power of 35 dBm at a frequency of 0.9 GHz, which is the lowest value ever reported [J1013]

"Enhancement of breakdown voltage in AlGaN/GaN high electron mobility transistors using a field plate"

We investigate the breakdown (Vbr) enhancement potential of the field plate (FP) technique in the context of AlGaN/GaN power HEMTs. A comprehensive account of the critical geometrical and material variables controlling the field distribution under the FP is provided. A systematic procedure is given for designing a FP device, using two-dimensional (2-D) simulation, to obtain the maximum Vbr, with minimum degradation in on-resistance and frequency response. It is found that significantly higher Vbrcan be achieved by raising the dielectric constant (εi) of the insulator beneath the FP. Simulation gave the following estimates. The FP can improve the Vbrby a factor of 2.8-5.1, depending on the 2-DEG concentration (ns) and εi. For n s=1Ч1013/cm2, the Vbrcan be raised from 123 V to 630 V, using a 2.2 μm FP on a 0.8 μm silicon nitride, and 4.7 μm gate-drain separation. The methodology of this paper can be extended to the design of FP structures in other lateral FETs, such as MESFETs and LD-MOSFETs [J1014]

"Improved microwave and noise performances of InGaP/In0.33 Ga0.67 As p-HEMT grown on patterned GaAs substrate"

Microwave and noise performances of a highly strained InGaP/In0.33Ga0.67As pseudomorphic high electron mobility transistor (p-HEMT) grown on a patterned GaAs substrate and a conventional InGaP/In0.22Ga0.78As p-HEMT grown on a non-patterned GaAs substrate were compared. The highly strained InGaP/In0.33Ga0.67As p-HEMT grown on the patterned GaAs substrates showed substantial improvements in DC (drain saturation current and transconductance), microwave (fTand fmax), and low-frequency and high-frequency noise performances compared with those of the conventional InGaP/In0.22Ga0.78As p-HEMT grown on the non-patterned GaAs substrate [J1015]

"Ultra-short 25-nm-gate lattice-matched InAlAs/InGaAs HEMTs within the range of 400 GHz cutoff frequency"

We have succeeded in fabricating ultra-short 25-nm-gate InAlAs/InGaAs high electron mobility transistors (HEMTs) lattice-matched to InP substrates. The two-step-recessed gate technology and low temperature processing at below 300°C allowed the fabrication of such ultra-short gates. DC measurements showed that the 25-nm-gate HEMT had good pinchoff behavior. We obtained a cutoff frequency fTof 396 GHz, within the range of 400 GHz fT, for the 25-nm-gate HEMT. This fTis the highest value get reported for any type of transistor, and the gate length of 25 nm is the shortest value ever reported for any compound semiconductor transistor that exhibits device operation [J1016]

"RESURF AlGaN/GaN HEMT for high voltage power switching"

A novel HEMT configuration based on the RESURF technique is proposed for very high voltage power switching applications. It employs a p-n junction below the 2-DEG channel and two field plates, one extending from the gate and the other from the drain, to distribute the electric field over the gate to drain separation. 2-D simulations indicate a breakdown voltage >1 KV at on-resistance of ~1 mΩ·cm2(neglecting contact resistances) for the device [J1017]

"High-frequency measurements of AlGaN/GaN HEMTs at high temperatures"

High-frequency measurements of the 1.3-μm-long gate AlGaN-GaN HEMTs have been performed at temperatures ranging from 23 to 187°C. The cutoff frequency fTdecreased with increasing temperature. It was 13.7 and 8.7 GHz at 23 and 187°C, respectively. The effective electron velocities υeffin the channel evaluated from the total delay time versus ID-inverse relation were 1.2 and 0.8Ч107cm/s at 23 and 187°C, respectively [J1018]

"Low-phase noise AlGaN/GaN FET-based voltage controlled oscillators (VCOs)"

The first report of AlGaN/GaN HEMT-based voltage controlled oscillators (VCOs) is presented. Varactor-tuned oscillators implemented using distributed networks oscillate at 6 GHz with high output power (0.5 W), low-phase noise (-92 dBc/Hz SSB noise at 100 kHz offset), and high-tuning bandwidth (10%). The measured phase noise of AlGaN/GaN FETs is compared to the phase noise of GaAs FET and GaAs HBTs at 6 GHz, indicating the AlGaN/GaN FET exhibits equivalent SSB noise to GaAs FETs. These results indicate high power AlGaN/GaN-based VCOs may be used to simplify the line up in a communication radio, while improving the overall efficiency of the radio [J1019]

"GaN/AlGaN HEMTs operating at 20 GHz with continuous-wave power density >6 W/mm"

MBE-grown GaN/AlGaN HEMTs have been fabricated on a 2° SiC wafer, where the source-drain spacing was 2 μm and the gate length was 0.15 μm. A peak extrinsic transconductance of 350 mS/mm and a maximum drain current density greater than 1.5 A/mm were obtained. Small-signal S-parameter measurement showed frof 85 GHz and fMANapproaching 140 GHz. At 20 GHz, a continuous-wave output power density of 6.6 W/mm was obtained with power-added-efficiency of 35%, yielding the highest reported power performance at 20 GHz [J1020]

"Gunn instabilities in power HEMTs"

Experimental and theoretical evidence of the formation of `transverse' Gunn dipoles in an Al0.23Ga0.77As/In 0.23Ga0.77As delta doped HEMT is presented. Monte Carlo simulations predicted that the dipoles would first cause a sudden reduction in current followed by a gradual upturn. These predictions were in excellent agreement with the experimental observations [J1021]

"Single-ended HEMT multiplier design using reflector networks"

Microwave and RF frequency multipliers are employed in a large number of communications, radar, civilian, and military systems. This paper presents the development of active doublers operating in S and C frequency bands. These devices are unique in that high electron-mobility transistors (Fujitsu FHX35LG) are employed in an unbalanced configuration utilizing “reflector” networks simultaneously on the input and output to reflect the second harmonic signal into the gate of the device and the fundamental signal into the drain simultaneously at appropriate phase angles to optimize performance. Measured and simulated results are presented on over 20 multiplier designs to verify the design philosophy. Conversion gains of approximately 7 dB are presented for narrow-band designs (5% bandwidth), 5 dB for medium-bandwidth designs (15%), and 4 dB for wide-bandwidth designs (35%). The fundamental and third harmonic rejection is approximately 40 dBc for the narrow-band designs and greater than 50 dBc for the medium and wide-band designs [J1022]

"Intermodulation nulling in HEMT common source amplifiers"

A new model of the second- and third-order intermodulation products from HEMT and MESFET small-signal amplifiers, resulting from nonlinear drain-source current has been proposed in our previous publications. Based on this model, intermodulation nulling conditions in terms of the Taylor series coefficients, hence in terms of bias, have been investigated. This paper now examines the load dependence of the second- and third-order intermodulation products in HEMT small-signal common source amplifiers. Intermodulation nulling conditions are proposed and validated. This is useful in designing a high performance amplifier by calculation of optimum load for minimum distortion and studying distortion generation as a function of circuit topology [J1023]

"Cryogenic noise parameter measurements of microwave devices"

A robust measurement technique, the seven-state method, which is well suited to noise parameter measurements at cryogenic temperatures is presented. In contrast to existing concepts, the seven-state method makes it possible to determine the minimum noise figure Fminand the equivalent noise resistance Rnexcept for a constant term m with the help of noise power measurements with a noise source operated at ambient temperature only. The optimum generator admittance Y optand the input admittance Yinof the device under test are completely calculable from cold noise power measurements. An additional measurement of Yinwith a network analyser as needed for other techniques is not necessary. In order to determine the unknown factor m, one further noise power measurement with a hot noise source has to be performed. A measurement system as well as measurements which were performed on AlGaAs/InGaAs HEMT transistors at ambient and cryogenic temperatures are presented [J1024]

"InGaAs zero bias backward diodes for millimeter wave direct detection"

Backward diodes are a version of Esaki tunnel diodes that are useful for mixing and detection. Ge backward diodes in particular have been used as temperature insensitive, zero bias square law detectors, capable of translating input RF power into dc voltage or current with extreme linearity and low noise. However, Ge diodes are difficult to reproducibly manufacture and are physically fragile. Here we demonstrate specially designed InGaAs-based backward diodes grown by molecular beam epitaxy. These diodes have superior figures of merit compared to Ge diodes, are reproducible and physically rugged, and are compatible with InGaAs high electron mobility transistor (HEMT) low noise amplifier fabrication technology. In addition, the flexibility of MBE growth allows easy tailoring of the layer structure to maximize the desired figure of merit for a given application [J1025]

"Fabrication of monolithically-integrated InAlAs/InGaAs/InP HEMTs and InAs/AlSb/GaSb resonant interband tunneling diodes"

The integration of InAs/AlSb/GaSb resonant interband tunneling diodes (RITDs) with InAlAs/InGaAs/InP high electron mobility transistors (HEMTs) is reported. The integrated devices exhibit nearly identical performance to discrete control devices from DC through microwave frequencies. RITDs with peak current densities of 24.5 kA/cm2and peak voltages of 0.12 V have been demonstrated for devices with 1.2-nm thick AlSb barriers. HEMTs with 0.2-μm gates have been fabricated, and fts of 127 GHz and fmaxof 183 GHz have been obtained. To the authors' knowledge, this is the first report of the monolithic integration of RITDs with HEMTs on InP [J1026]

"Active dual-beam leaky-wave antenna with asymmetrically scanning capability"

An active microstrip leaky-wave antenna possessing asymmetrically dual-beam scanning capability is demonstrated. An active HEMT up-converter is integrated at the right terminal of the two-terminal feeding

microstrip leaky-wave antenna. This approach creates dual-beam asymmetrically scanning radiation patterns. When the right beam is fixed in one position, the other beam can be scanned electronically by varying the IF frequency. The measured results show that when the position of the right beam was fixed (48°), a scanning angle of 22° for the left beam could be achieved as the IF input frequency was varied from 0.7 to 2 GHz (UHF band) [J1027]

"164-GHz MMIC HEMT doubler"

In this paper, a MMIC frequency doubler based on an InP HEMT and grounded CPW (GCPW) technology is reported. The doubler demonstrated a conversion loss of only 2 dB and output power of 5 dBm at 164 GHz. The 3 dB output power bandwidth is 14 GHz, or 8.5%. This is the best reported result for a MMIC HEMT doubler above 100 GHz [J1028]

"Investigation of traps producing current collapse in AlGaN/GaN high electron mobility transistors"

Current collapse in AlGaN/GaN HEMTs has been investigated using photo-ionisation spectroscopy techniques to probe the spatial origins of the traps producing this effect. The results indicate that the responsible traps reside in the high-resistivity GaN buffer layer and are identical to those traps causing current collapse in GaN MESFETs [J1029]

"A 0.15-μm 60-GHz high-power composite channel GaInAs/InP HEMT with low gate current"

This letter presents recent improvements and experimental results provided by GaInAs/InP composite channel high electron mobility transistors (HEMT). The devices exhibit good dc and rf performance. The 0.15-μm gate length devices have saturation current density of 750 mA/mm at VGS=+0 V. The Schottky characteristic is a typical reverse gate-to-drain breakdown voltage of -8 V. Gate current issued from impact ionization has been studied in these devices, in the first instance, versus drain extension. At 60 GHz, an output power of 385 mW/mm has been obtained in such a device with a 5.3 dB linear gain and 41% drain efficiency which constitutes the state-of-the-art. These results studied are the first reported for a composite channel Al0.65In0.35As/Ga0.47In0.53 As/InP HEMT on an InP substrate [J1030]

"Enhancement-mode Al0.66 In0.34 As/Ga0.67 In0.33 As metamorphic HEMT, modeling and measurements"

This paper exhibits experimental and theoretical results on metamorphic high-electron mobility transistor (MM-HEMT). Modeling and measurements provide a better knowledge of device physics which allows us to optimize device structures. We present 10-GHz power performances, pulse and gate measurements, and two-dimensional (2-D) hydrodynamic modeling of enhancement-mode (E-mode) Al0.66In0.34As/Ga0.67In0.33 As NM-HEMT devices. It is the first time that cap layer thickness has been studied for a MM-HEMT. A typical reverse breakdown voltage of 16 V has been obtained. Gate current issued from impact ionization has been shown, for the first time, in such a device. The 2-D hydrodynamic model is a useful tool for cost engineering because it brings more information in terms of physical quantity distributions, necessary to predict breakdown behavior of FET. The 10-GHz measurements with a load-pull power set-up demonstrate the capabilities for a thick cap device with large gate-to-drain extension since an output power of 140 mW/mm have been obtained which is the state-of-the-art for such a device. These results obtained confirm the great interest of the structures for power application systems. The only work reported, to our knowledge, using a MM-HEMT structure in E-mode with an indium content close to 50% has been studied by Eisenbeiser et al.. Their typical gate-to-drain breakdown voltage was 5.2 V. The 0.6 μm Ч3 mm devices exhibited 30 mW/mm at 850 MHz [J1031]

СПИСОК ЛИТЕРАТУРЫ

J1. Singisetti U. Enhancement-Mode N-Polar GaN MISFETs With Self-Aligned Source/Drain Regrowth. / Singisetti U., Man Hoi Wong, Dasgupta S., Nidhi, Swenson B., Thibeault B.J., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 2. - P. 137-139. ↑

J2. Hong-Yeh Chang. Design and Analysis of a DC-43.5-GHz Fully Integrated Distributed Amplifier Using GaAs HEMT-HBT Cascode Gain Stage. / Hong-Yeh Chang, Yu-Cheng Liu, Shou-Hsien Weng, Chi-Hsien Lin, Yeh-Liang Yeh, Yu-Chi Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2011. - Vol. 59,

No. 2. - P. 443-455.

J3. Kolluri S. RF Performance of Deep-Recessed N-Polar GaN MIS-HEMTs Using a Selective Etch Technology Without Ex Situ Surface Passivation. / Kolluri S., Brown D.F., Man Hoi Wong, Dasgupta S., Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 2. - P. 134-136.

J4. Ramadan A. Two-Stage GaN HEMT Amplifier With Gate-Source Voltage Shaping for Efficiency Versus Bandwidth Enhancements. / Ramadan A., Reveyrand T., Martin A., Nebus J.-M., Bouysse P., Lapierre L., Villemazet J.-F., Forestier S. // IEEE Transactions on Microwave Theory and Techniques. - 2011. - Vol. 59, No. 3. - P. 699-706.

J5. Moon J.S. Sub-1-dB Noise Figure Performance of High-Power Field-Plated GaN HEMTs. / Moon J.S., Wong D., Hashimoto P., Hu M., Milosavljevic I., Willadsen P., McGuire C., Burnham S., Micovic M., Wetzel M., Chow D. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 3. - P. 297-299.

J6. Ronghua Wang. Enhancement-Mode InAlN/AlN/GaN HEMTs With Leakage Current and on/off Current Ratio. / Ronghua Wang, Saunier P., Yong Tang, Tian Fang, Xiang Gao, Shiping Guo, Snider G., Fay P., Jena D., Huili Xing. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 3. - P. 309-311.

J7. Li Yuan. Normally Off AlGaN/GaN Metal-2DEG Tunnel-Junction Field-Effect Transistors. / Li Yuan, Hongwei Chen, Chen K.J. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 3. - P. 303-305.

J8. Jarndal A. Improved Modeling of GaN HEMTs on Si Substrate for Design of RF Power Amplifiers. / Jarndal A., Markos A. Z., Kompa G. // IEEE Transactions on Microwave Theory and Techniques. - 2011. - Vol. 59, No. 3. - P. 644-651.

J9. Chang C.-Y. Electric-Field-Driven Degradation in off-State Step-Stressed AlGaN/GaN High-Electron Mobility Transistors. / Chang C.-Y., Douglas E. A., Kim J., Lu L., Lo C.-F., Chu B.-H., Cheney D. J., Gila B. P., Ren F., Via G. D., Cullen D. A., Zhou L., Smith D. J., Jang S., Pearton S. J. // IEEE Transactions on Device and Materials Reliability. - 2011. - Vol. 11, No. 1. - P. 187-193.

J10. Abbasi M. Single-Chip 220-GHz Active Heterodyne Receiver and Transmitter MMICs With On-Chip Integrated Antenna. / Abbasi M., Gunnarsson S.E., Wadefalk N., Kozhuharov R., Svedin J., Cherednichenko S., Angelov I., Kallfass I., Leuther A., Zirath H. // IEEE Transactions on Microwave Theory and Techniques. - 2011. - Vol. 59, No. 2. - P. 466-478.

J11. Xiaosen Liu. GaN Single-Polarity Power Supply Bootstrapped Comparator for High-Temperature Electronics. / Xiaosen Liu, Chen K.J. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 1. - P. 27-29.

J12. Junghwan Moon. Efficiency Enhancement of Doherty Amplifier Through Mitigation of the Knee Voltage Effect. / Junghwan Moon, Jangheon Kim, Jungjoon Kim, Ildu Kim, Bumman Kim. // IEEE Transactions on Microwave Theory and Techniques. - 2011. - Vol. 59, No. 1. - P. 143-152.

J13. Jungwoo Joh. A Current-Transient Methodology for Trap Analysis for GaN High Electron Mobility Transistors. / Jungwoo Joh, del Alamo J.A. // IEEE Transactions on Electron Devices. - 2011. - Vol. 58, No. 1. - P. 132-140.

J14. Nidhi. Self-Aligned Technology for N-Polar GaN/Al(Ga)N MIS-HEMTs. / Nidhi, Dasgupta S., Brown D.F., Singisetti U., Keller S., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 1. - P. 33-35.

J15. Maojun Wang. Improvement of the Off-State Breakdown Voltage With Fluorine Ion Implantation in AlGaN/GaN HEMTs. / Maojun Wang, Chen K.J. // IEEE Transactions on Electron Devices. - 2011. - Vol. 58, No. 2. - P. 460-465.

J16. Ching-Sung Lee. -Gate MOS-HEMTs by Methods of Ozone Water Oxidation and Shifted Exposure. / Ching-Sung Lee, Sheng-Han Yang, Ming-Yuan Lin. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 2. - P. 152-154.

J17. Zhi Hong Liu. Comprehensive Study on the Bias-Dependent Equivalent-Circuit Elements Affected by PECVD SiN Passivation in AlGaN/GaN HEMTs. / Zhi Hong Liu, Geok Ing Ng, Arulkumaran S., Ye Kyaw Thu Maung, Khoon Leng Teo, Siew Chuen Foo, Sahmuganathan V. // IEEE Transactions on Electron Devices. -

2011. - Vol. 58, No. 2. - P. 473-479.

J18. Thorsell M. Electrothermal Access Resistance Model for GaN-Based HEMTs. / Thorsell M., Andersson K., Hjelmgren H., Rorsman N. // IEEE Transactions on Electron Devices. - 2011. - Vol. 58, No. 2. - P. 466-472.

J19. Dyer G.C. Novel Tunable Millimeter-Wave Grating-Gated Plasmonic Detectors. / Dyer G.C., Aizin G.R., Reno J.L., Shaner E.A., Allen S.J. // IEEE Journal of Selected Topics in Quantum Electronics. - 2011. - Vol. 17, No. 1. - P. 85-91.

J20. Wong M.H. X-band power performance of N-face GaN MIS-HEMTs. / Wong M.H., Brown D.F., Schuette M.L., Kim H., Balasubramanian V., Lu W., Speck J.S., Mishra U.K. // Electronics Letters. - 2011. - Vol. 47, No. 3. - P. 214-215.

J21. Fagotti R. Concurrent Hex-Band GaN Power Amplifier for Wireless Communication Systems. / Fagotti R., Cidronali A., Manes G. // IEEE Microwave and Wireless Components Letters. - 2011. - Vol. 21, No. 2. - P. 89-91.

J22. Lecourt F. RF performance of InAlN/AlN/GaN HEMTs on sapphire substrate. / Lecourt F., Ketteniss N., Behmenburg H., Defrance N., Hoel V., Eickelkamp M., Vescan A., Giesen C., Heuken M., De Jaeger J.C. // Electronics Letters. - 2011. - Vol. 47, No. 3. - P. 212-214.

J23. Kuzmik J. Proposal of High-Electron Mobility Transistors With Strained InN Channel. / Kuzmik J., Georgakilas A. // IEEE Transactions on Electron Devices. - 2011. - Vol. 58, No. 3. - P. 720-724.

J24. Yamashita Y. Effect of source-drain spacing on DC and RF characteristics of 45 nm-gate AlGaN/GaN MIS-HEMTs. / Yamashita Y., Watanabe I., Endoh A., Hirose N., Mimura T., Matsui T. // Electronics Letters. - 2011. - Vol. 47, No. 3. - P. 211-212.

J25. Kim T.-W. InGaAs HEMT with InAs-rich InAlAs barrier spacer for reduced source resistance. / Kim T.-W., Kim D.-H., Del Alamo J.A. // Electronics Letters. - 2011. - Vol. 47, No. 6. - P. 406-407.

J26. Liu Z. H. Reduced surface leakage current and trapping effects in AlGaN/GaN high electron mobility transistors on silicon with SiN /Al 2 O 3 passivation. / Liu Z. H., Ng G. I., Zhou H., Arulkumaran S., Maung Y. K. T. // Applied Physics Letters. - 2011. - Vol. 98, No. 11. - P. 113506-113506-3.

J27. Heller E. R. Development of a Versatile Physics-Based Finite-Element Model of an AlGaN/GaN HEMT Capable of Accommodating Process and Epitaxy Variations and Calibrated Using Multiple DC Parameters. / Heller E. R., Vetury R., Green D. S. // IEEE Transactions on Electron Devices. - 2011. - Vol. 58, No. 4. - P. 1091-1095.

J28. Quay R. Dual-Gate GaN MMICs for MM-Wave Operation. / Quay R., Tessmann A., Kiefer R., Maroldt S., Haupt C., Nowotny U., Weber R., Massler H., Schwantuschke D., Seelmann-Eggebert M., Leuther A., Mikulla M., Ambacher O. // IEEE Microwave and Wireless Components Letters. - 2011. - Vol. 21, No. 2. - P. 95-97.

J29. Wang M. Kink Effect in AlGaN/GaN HEMTs Induced by Drain and Gate Pumping. / Wang M., Chen K. J. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 4. - P. 482-484.

J30. Nemati H.M. High-Efficiency Power Amplifier. / Nemati H.M., Saad P., Fager C., Andersson K. // IEEE Microwave Magazine. - 2011. - Vol. 12, No. 1. - P. 81-84.

J31. Pil Sung Park. Simulation of Short-Channel Effects in N- and Ga-Polar AlGaN/GaN HEMTs. / Pil Sung Park, Rajan S. // IEEE Transactions on Electron Devices. - 2011. - Vol. 58, No. 3. - P. 704-708.

J32. Ching-Sung Lee. A Novel Transparent AZO-Gated pHEMT and Photosensing Characteristics Thereof. / Ching-Sung Lee, Bo-Yi Chou, Wei-Chou Hsu. // IEEE Transactions on Electron Devices. - 2011. - Vol. 58, No. 3. - P. 725-731.

J33. Junxia Shi. Correlation Between AlGaN/GaN MISHFET Performance and Insulation Layer Quality. / Junxia Shi, Eastman L.F. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 3. - P. 312-314.

J34. Korolev A. M. Note: Ultra-high frequency ultra-low dc power consumption HEMT amplifier for quantum measurements in millikelvin temperature range. / Korolev A. M., Shnyrkov V. I., Shulga V. M. // Review of

Scientific Instruments. - 2011. - Vol. 82, No. 1. - P. 016101-016101-3.

J35. Ebrahimi M.M. Analytical approach to optimise the efficiency of switching mode power amplifiers loaded with distributed matching networks. / Ebrahimi M.M., Helaoui M., Ghannouchi F. // IET Microwaves, Antennas & Propagation. - 2011. - Vol. 5, No. 1. - P. 57-67.

J36. Kuo N.-C. A 60-GHz Frequency Tripler With Gain and Dynamic-Range Enhancement. / Kuo N.-C., Kao J.-C., Tsai Z.-M., Lin K.-Y., Wang H. // IEEE Transactions on Microwave Theory and Techniques. - 2011. - Vol. 59, No. 3. - P. 660-671.

J37. Liu Z.H. Temperature-Dependent Microwave Noise Characteristics in ALD /AlGaN/GaN MISHEMTs on Silicon Substrate. / Liu Z.H., Ng G.I., Arulkumaran S., Maung Y.K.T., Teo K.L., Foo S.C., Vicknesh S. // IEEE Electron Device Letters. - 2011. - Vol. 32, No. 3. - P. 318-320.

J38. Hoke W. E. AlGaN/GaN high electron mobility transistors on 100 mm silicon substrates by plasma molecular beam epitaxy. / Hoke W. E., Kennedy T. D., Mosca J. J., Kerr A. J., Torabi A., Davis-Hearns S., LaRoche J. R. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2011. - Vol. 29, No. 3. - P. 03C107-03C107-5.

J39. T. Integrated Optical and Electrical Analysis: Identifying Location and Properties of Traps in AlGaN/GaN HEMTs During Electrical Stress. / T,apajna M., Simms R.J.T., Yi Pei, Mishra U.K., Kuball M. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 7. - P. 662-664.

J40. Zhi Hong Liu. Analytical Modeling of High-Frequency Noise Including Temperature Effects in GaN HEMTs on High-Resistivity Si Substrates. / Zhi Hong Liu, Geok Ing Ng, Arulkumaran S. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 7. - P. 1485-1491.

J41. Saito W. Field-Plate Structure Dependence of Current Collapse Phenomena in High-Voltage GaN-HEMTs. / Saito W., Kakiuchi Y., Nitta T., Saito Y., Noda T., Fujimoto H., Yoshioka A., Ohno T., Yamaguchi M. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 7. - P. 659-661.

J42. Gerbedoen J.-C. AlGaN/GaN HEMTs on (001) Silicon Substrate With Power Density Performance of 2.9 W/mm at 10 GHz. / Gerbedoen J.-C., Soltani A., Joblot S., De Jaeger J.-C., Gaquiere C., Cordier Y., Semond F. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 7. - P. 1497-1503.

J43. Koehler A.D. Extraction of AlGaN/GaN HEMT Gauge Factor in the Presence of Traps. / Koehler A.D., Gupta A., Min Chu, Parthasarathy S., Linthicum K.J., Johnson J.W., Nishida T., Thompson S.E. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 7. - P. 665-667.

J44. Maojun Wang. Off-State Breakdown Characterization in AlGaN/GaN HEMT Using Drain Injection Technique. / Maojun Wang, Chen K.J. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 7. - P. 1492-1496.

J45. Ikeda N. GaN Power Transistors on Si Substrates for Switching Applications. / Ikeda N., Niiyama Y., Kambayashi H., Sato Y., Nomura T., Kato S., Yoshida S. // Proceedings of the IEEE. - 2010. - Vol. 98, No. 7. - P. 1151-1161.

J46. Deal W.R. Demonstration of a 0.48 THz Amplifier Module Using InP HEMT Transistors. / Deal W.R., Mei X.B., Radisic V., Leong K., Sarkozy S., Gorospe B., Lee J., Liu P.H., Yoshida W., Zhou J., Lange M., Uyeda J., Lai R. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 5. - P. 289-291.

J47. Qi Zhou. Wide-Dynamic-Range Zero-Bias Microwave Detector Using AlGaN/GaN Heterojunction Field-Effect Diode. / Qi Zhou, King-Yuen Wong, Wanjun Chen, Chen K.J. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 5. - P. 277-279.

J48. Abouchahine M. Broadband Time-Domain Measurement System for the Characterization of Nonlinear Microwave Devices With Memory. / Abouchahine M., Saleh A., Neveux G., Reveyrand T., Teyssier J.-P., Rousset D., Barataud D., Nebus J.-M. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 4. - P. 1038-1045.

J49. Chieh Kai Yang. Pulsed-IV Pulsed-RF Cold-FET Parasitic Extraction of Biased AlGaN/GaN HEMTs Using Large Signal Network Analyzer. / Chieh Kai Yang, Roblin P., De Groote F., Ringel S.A., Rajan S., Teyssier J.P.,

Poblenz C., Yi Pei, Speck J., Mishra U.K. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 5. - P. 1077-1088.

J50. Ramadan A. Experimental study on effect of second-harmonic injection at input of classes F and F-1 GaN power amplifiers. / Ramadan A., Reveyrand T., Martin A., Nebus J.M., Bouysse P., Lapierre L., Villemazet J.F., Forestier S. // Electronics Letters. - 2010. - Vol. 46, No. 8. - P. 570-572.

J51. Chabak K.D. Strained AlInN/GaN HEMTs on SiC With 2.1-A/mm Output Current and 104-GHz Cutoff Frequency. / Chabak K.D., Trejo M., Crespo A., Walker D.E., Jinwei Yang, Gaska R., Kossler M., Gillespie J.K., Jessen G.H., Trimble V., Via G.D. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 6. - P. 561-563.

J52. Bahat-Treidel E. AlGaN/GaN/AlGaN DH-HEMTs Breakdown Voltage Enhancement Using Multiple Grating Field Plates (MGFPs). / Bahat-Treidel E., Hilt O., Brunner F., Sidorov V., Wujrfl J., Trajnkle G. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 6. - P. 1208-1216.

J53. Che-Kai Lin. Optoelectronic Mixer Based on Composite Transparent Gate InAlAs-InGaAs Metamorphic HEMTs. / Che-Kai Lin, Hsien-Chin Chiu, Chao-Wei Lin, Hsiang-Chun Wang, Yi-Chun Wu. // Journal of Lightwave Technology. - 2010. - Vol. 28, No. 15. - P. 2153-2161.

J54. Miao Zhao. Thermal Storage of AlGaN/GaN High-Electron-Mobility Transistors. / Miao Zhao, Xinhua Wang, Xinyu Liu, Jun Huang, Yingkui Zheng, Ke Wei. // IEEE Transactions on Device and Materials Reliability. - 2010. - Vol. 10, No. 3. - P. 360-365.

J55. Noude. Sb-HEMT: Toward 100-mV Cryogenic Electronics. / Noude,viwa A., Roelens Y., Danneville F., Olivier A., Wichmann N., Waldhoff N., Lepilliet S., Dambrine G., Desplanque L., Wallart X., Moschetti G., Grahn J., Bollaert S. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 8. - P. 1903-1909.

J56. Dyball H. Balance of power. Electronics Letters. - 2010. - Vol. 46, No. 13. - P. 876.

J57. Brown D.F. N-Polar InAlN/AlN/GaN MIS-HEMTs. / Brown D.F., Nidhi, Feng Wu, Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 8. - P. 800-802.

J58. Defrance N. Thermal resistance of AlGaN/GaN HEMTs on SopSiC composite substrate. / Defrance N., Douvry Y., Hoel V., Gerbedoen J.-C., Soltani A., Rousseau M., De Jaeger J.C., Langer R., Lahreche H. // Electronics Letters. - 2010. - Vol. 46, No. 13. - P. 949-950.

J59. Dumka D.C. GaN on Si HEMT with 65% power added efficiency at 10 GHz. / Dumka D.C., Saunier P. // Electronics Letters. - 2010. - Vol. 46, No. 13. - P. 946-947.

J60. Lim T. GaN-Based Submicrometer HEMTs With Lattice-Matched InAlGaN Barrier Grown by MBE. / Lim T., Aidam R., Waltereit P., Henkel T., Quay R., Lozar R., Maier T., Kirste L., Ambacher O. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 7. - P. 671-673.

J61. Saad P. Design of a Highly Efficient 2-4-GHz Octave Bandwidth GaN-HEMT Power Amplifier. / Saad P., Fager C., Haiying Cao, Zirath H., Andersson K. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 7. - P. 1677-1685.

J62. Chunhua Zhou. Schottky-Ohmic Drain AlGaN/GaN Normally Off HEMT With Reverse Drain Blocking Capability. / Chunhua Zhou, Chen W., Piner E.L., Chen K.J. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 7. - P. 668-670.

J63. Dae-Hyun Kim. Scalability of Sub-100 nm InAs HEMTs on InP Substrate for Future Logic Applications. / Dae-Hyun Kim, del Alamo J.A. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 7. - P. 1504-1511.

J64. Xing Lan. An Ultra-Wideband Balun Using Multi-Metal GaAs MMIC Technology. / Xing Lan, Fong F., Kintis M., Kono K., Yamauchi D., Wen-Ben Luo, Farkas D. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 8. - P. 474-476.

J65. Sato M. 68-110-GHz-Band Low-Noise Amplifier Using Current Reuse Topology. / Sato M., Takahashi T., Hirose T. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 7. - P. 1910-1916.

J66. Radisic V. A 10-mW Submillimeter-Wave Solid-State Power-Amplifier Module. / Radisic V., Deal W.R., Leong K.M.K.H., Mei X.B., Yoshida W., Po-Hsin Liu, Uyeda J., Fung A., Samoska L., Gaier T., Lai R. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 7. - P. 1903-1909.

J67. Zhi Hong Liu. High Microwave-Noise Performance of AlGaN/GaN MISHEMTs on Silicon With Gate Insulator Grown by ALD. / Zhi Hong Liu, Geok Ing Ng, Arulkumaran S., Ye Maung, Khoon Leng Teo, Siew Chuen Foo, Sahmuganathan V., Tao Xu, Chee How Lee. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 2. - P. 96-98.

J68. Chabak K.D. Full-Wafer Characterization of AlGaN/GaN HEMTs on Free-Standing CVD Diamond Substrates. / Chabak K.D., Gillespie J.K., Miller V., Crespo A., Roussos J., Trejo M., Walker D.E., Via G.D., Jessen G.H., Wasserbauer J., Faili F., Babic D.I., Francis D., Ejeckam F. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 2. - P. 99-101.

J69. Yu-Syuan Lin. AlGaN/GaN HEMTs With Low Leakage Current and High On/Off Current Ratio. / Yu-Syuan Lin, Yi-Wei Lain, Hsu S.S.H. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 2. - P. 102-104.

J70. Chia-Ta Chang. 30-GHz Low-Noise Performance of 100-nm-Gate-Recessed n-GaN/AlGaN/GaN HEMTs. / Chia-Ta Chang, Heng-Tung Hsu, Chang E.Y., Chien-I Kuo, Jui-Chien Huang, Chung-Yu Lu, Miyamoto Y. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 2. - P. 105-107.

J71. Lo C. F. Passivation of Al N /Ga N high electron mobility transistor using ozone treatment. / Lo C. F., Chang C. Y., Pearton S. J., Kravchenko I. I., Dabiran A. M., Wowchak A. M., Cui B., Chow P. P., Ren F. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2010. - Vol. 28, No. 1. - P. 52-55.

J72. Chu Byung Hwan. Detection of an endocrine disrupter biomarker, vitellogenin, in largemouth bass serum using AlGaN/GaN high electron mobility transistors. / Chu Byung Hwan, Chang C. Y., Kroll Kevin, Denslow Nancy, Wang Yu-Lin, Pearton S. J., Dabiran A. M., Wowchak A. M., Cui B., Chow P. P., Ren Fan. // Applied Physics Letters. - 2010. - Vol. 96, No. 1. - P. 013701-013701-3.

J73. Ying Chen. Design of -Band and -Band Colpitts Oscillators Using a Parasitic Cancellation Technique. / Ying Chen, Mouthaan K., Fujiang Lin. // IEEE Transactions on Circuits and Systems I: Regular Papers. - 2010. - Vol. 57, No. 8. - P. 1817-1828.

J74. Thorsell M. An X-Band AlGaN/GaN MMIC Receiver Front-End. / Thorsell M., Fagerlind M., Andersson K., Billstrom N., Rorsman N. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 1. - P. 55-57.

J75. Waldron N. A Self-Aligned InGaAs HEMT Architecture for Logic Applications. / Waldron N., Dae-Hyun Kim, del Alamo J.A. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 1. - P. 297-304.

J76. Sarazin N. AlInN/AlN/GaN HEMT Technology on SiC With 10-W/mm and 50% PAE at 10 GHz. / Sarazin N., Morvan E., di Forte Poisson M.A., Oualli M., Gaquiere C., Jardel O., Drisse O., Tordjman M., Magis M., Delage S.L. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 1. - P. 11-13.

J77. Marino F.A. Effects of Threading Dislocations on AlGaN/GaN High-Electron Mobility Transistors. / Marino F.A., Faralli N., Palacios T., Ferry D.K., Goodnick S.M., Saraniti M. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 1. - P. 353-360.

J78. Byung Hwan Chu. Wireless Detection System for Glucose and pH Sensing in Exhaled Breath Condensate Using AlGaN/GaN High Electron Mobility Transistors. / Byung Hwan Chu, Kang B.S., Chang C.Y., Ren F., Goh A., Sciullo A., Wu W., Lin J., Gila B.P., Pearton S.J., Johnson J.W., Piner E.L., Linthicum K.J. // IEEE Sensors Journal. - 2010. - Vol. 10, No. 1. - P. 64-70.

J79. Chao Fang. High-Voltage High-Efficiency Ultrawideband Pulse Synthesizer. / Chao Fang, Law C.L., Hwang J. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 1. - P. 49-51.

J80. Crespo A. High-Power Ka-Band Performance of AlInN/GaN HEMT With 9.8-nm-Thin Barrier. / Crespo A., Bellot M.M., Chabak K.D., Gillespie J.K., Jessen G.H., Miller V., Trejo M., Via G.D., Walker D.E., Winningham B.W., Smith H.E., Cooper T.A., Gao X., Guo S. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 1. - P. 2-4.

J81. Ashok A. Electrothermal Monte Carlo Simulation of GaN HEMTs Including Electron-Electron Interactions. / Ashok A., Vasileska D., Hartin O.L., Goodnick S.M. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 3. - P. 562-570.

J82. Haifeng Sun. 100-nm-Gate (Al,In)N/GaN HEMTs Grown on SiC With. / Haifeng Sun, Alt A.R., Benedickter H., Feltin E., Carlin J.-F., Gonschorek M., Grandjean N., Bolognesi C.R. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 4. - P. 293-295.

J83. Taking S. Surface passivation of aln/gan mos-hemts using ultra-thin al2 o3 formed by thermal oxidation of evaporated aluminium. / Taking S., Banerjee A., Zhou H., Li X., Khokhar A.Z., Oxland R., McGregor I., Bentley S., Rahman F., Thayne I., Dabiran A.M., Wowchak A.M., Cui B., Wasige E. // Electronics Letters. - 2010. - Vol. 46, No. 4. - P. 301-302.

J84. Alomari M. AlGaN/GaN HEMT on (111) single crystalline diamond. / Alomari M., Dussaigne A., Martin D., Grandjean N., Gaquiere C., Kohn E. // Electronics Letters. - 2010. - Vol. 46, No. 4. - P. 299-301.

J85. Tirelli S. 107-GHz (Al,Ga)N/GaN HEMTs on Silicon With Improved Maximum Oscillation Frequencies. / Tirelli S., Marti D., Haifeng Sun, Alt A.R., Benedickter H., Piner E.L., Bolognesi C.R. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 4. - P. 296-298.

J86. Liero A. On the Recovery Time of Highly Robust Low-Noise Amplifiers. / Liero A., Dewitz M., Kuhn S., Chaturvedi N., Jijun Xu, Rudolph M. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 4. - P. 781-787.

J87. King-Yuen Wong. Integrated Voltage Reference Generator for GaN Smart Power Chip Technology. / King-Yuen Wong, Wanjun Chen, Chen K.J. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 4. - P. 952-955.

J88. Bin Lu. Schottky-Drain Technology for AlGaN/GaN High-Electron Mobility Transistors. / Bin Lu, Piner E.L., Palacios T. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 4. - P. 302-304.

J89. Gawande R. Low-Noise Amplifier at 2.45 GHz [TC Contests]. / Gawande R., Bradley R. // IEEE Microwave Magazine. - 2010. - Vol. 11, No. 1. - P. 122-126.

J90. Hsien-Chin Chiu. On-State and Off-State Breakdown Voltages in GaAs PHEMTs With Various Field-Plate and Gate-Recess Extension Structures. / Hsien-Chin Chiu, Chia-Shih Cheng. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 3. - P. 186-188.

J91. Chu Byung-Hwan. Chloride ion detection by InN gated Al Ga N /Ga N high electron mobility transistors. / Chu Byung-Hwan, Lin Hon-Way, Gwo Shangjr, Wang Yu-Lin, Pearton S. J., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicuni K. J., Ren Fan. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2010. - Vol. 28, No. 1. - P. L5-L8.

J92. Chung J.W. AlGaN/GaN HEMT With 300-GHz. / Chung J.W., Hoke W.E., Chumbes E.M., Palacios T. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 3. - P. 195-197.

J93. Kanamura M. Enhancement-Mode GaN MIS-HEMTs With n-GaN/i-AlN/n-GaN Triple Cap Layer and High- Gate Dielectrics. / Kanamura M., Ohki T., Kikkawa T., Imanishi K., Imada T., Yamada A., Hara N. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 3. - P. 189-191.

J94. Majumdar K. HFinFET: A Scalable, High Performance, Low Leakage Hybrid n-Channel FET. / Majumdar K., Majhi P., Bhat N., Jammy R. // IEEE Transactions on Nanotechnology. - 2010. - Vol. 9, No. 3. - P. 342-344.

J95. Muravjov A. V. Temperature dependence of plasmonic terahertz absorption in grating-gate gallium-nitride transistor structures. / Muravjov A. V., Veksler D. B., Popov V. V., Polischuk O. V., Pala N., Hu X., Gaska R., Saxena H., Peale R. E., Shur M. S. // Applied Physics Letters. - 2010. - Vol. 96, No. 4. - P. 042105-042105-3.

J96. DasGupta S. Process and Contamination Effects on the Single-Event Response of AlSb/InAs HEMTs. / DasGupta S., McMorrow D., Reed R.A., Schrimpf R.D., Boos J.B., Ramachandran V. // IEEE Transactions on Nuclear Science. - 2010. - Vol. 57, No. 6. - P. 3262-3266.

J97. Chi-Jeon Hwang. An Ultra-Low-Power MMIC Amplifier Using 50-nm -Doped Metamorphic HEMT. / Chi-Jeon Hwang, Lai Bun Lok, Chong H.M.H., Holland M., Thayne I.G., Elgaid K. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 11. - P. 1230-1232.

J98. Basu S. Effects of Short-Term DC-Bias-Induced Stress on n-GaN/AlGaN/GaN MOSHEMTs With Liquid-Phase-Deposited as a Gate Dielectric. / Basu S., Singh P.K., Shun-Kuan Lin, Po-Wen Sze, Yeong-Her Wang. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 11. - P. 2978-2987.

J99. Ronghua Wang. Gate-Recessed Enhancement-Mode InAlN/AlN/GaN HEMTs With 1.9-A/mm Drain Current Density and 800-mS/mm Transconductance. / Ronghua Wang, Saunier P., Xiu Xing, Chuanxin Lian, Xiang Gao, Shiping Guo, Snider G., Fay P., Jena D., Huili Xing. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 12. - P. 1383-1385.

J100. Sattu A. AlGaN/GaN Microwave Switch With Hybrid Slow and Fast Gate Design. / Sattu A., Yang J., Shur M., Gaska R., Simin G. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 12. - P. 1389-1391.

J101. Nemati H.M. Design of Highly Efficient Load Modulation Transmitter for Wideband Cellular Applications. / Nemati H.M., Cao H., Almgren B., Eriksson T., Fager C. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 11. - P. 2820-2828.

J102. Guerra D. Comparison of N- and Ga-Face GaN HEMTs Through Cellular Monte Carlo Simulations. / Guerra D., Saraniti M., Faralli N., Ferry D.K., Goodnick S.M., Marino F.A. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 12. - P. 3348-3354.

J103. Li Yanbo. Self-consistent analysis of AlSb/InAs high electron mobility transistor structures. / Li Yanbo, Zhang Yang, Zeng Yiping. // Journal of Applied Physics. - 2010. - Vol. 108, No. 4. - P. 044504-044504-7.

J104. Wang L. The role of ultrathin AlN barrier in the reduction in the hot electron and self-heating effects for GaN-based double-heterojunction high electron mobility transistors. / Wang L., Hu W. D., Chen X. S., Lu W. // Journal of Applied Physics. - 2010. - Vol. 108, No. 5. - P. 054501-054501-8.

J105. Meneghini M. Extensive analysis of the luminescence properties of AlGaN/GaN high electron mobility transistors. / Meneghini M., Stocco A., Ronchi N., Rossi F., Salviati G., Meneghesso G., Zanoni E. // Applied Physics Letters. - 2010. - Vol. 97, No. 6. - P. 063508-063508-3.

J106. Lo C. F. Proton irradiation effects on AlN/GaN high electron mobility transistors. / Lo C. F., Chang C. Y., Chu B. H., Kim H.-Y., Kim J., Cullen David A., Zhou Lin, Smith David. J., Pearton S. J., Dabiran Amir, Cui B., Chow P. P., Jang S., Ren F. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2010. - Vol. 28, No. 5. - P. L47-L51.

J107. Ching-Ting Lee. AlGaN/GaN MOS-HEMTs With Gate ZnO Dielectric Layer. / Ching-Ting Lee, Ya-Lan Chiou, Chi-Sen Lee. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 11. - P. 1220-1223.

J108. Guerra D. Aspect Ratio Impact on RF and DC Performance of State-of-the-Art Short-Channel GaN and InGaAs HEMTs. / Guerra D., Akis R., Marino F.A., Ferry D.K., Goodnick S.M., Saraniti M. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 11. - P. 1217-1219.

J109. Ciccognani W. MMIC LNAs for Radioastronomy Applications Using Advanced Industrial 70 nm Metamorphic Technology. / Ciccognani W., Limiti E., Longhi P.E., Renvoise M. // IEEE Journal of Solid-State Circuits. - 2010. - Vol. 45, No. 10. - P. 2008-2015.

J110. McMorrow D. Novel Energy-Dependent Effects Revealed in GeV Heavy-Ion-Induced Transient Measurements of Antimony-Based III-V HEMTs. / McMorrow D., Warner J., DasGupta S., Ramachandran V., Boos J.B., Reed R., Schrimpf R., Paillet P., Ferlet-Cavrois V., Baggio J., Buchner S., El-Mamouni F., Raine M., Duhamel O. // IEEE Transactions on Nuclear Science. - 2010. - Vol. 57, No. 6. - P. 3358-3365.

J111. Yoon S.-W. Linearity enhanced 2.4 GHz WLAN HBT power amplifier using digitally-controlled tunable output matching network with pHEMT switch in GaAs BiFET technology. / Yoon S.-W., Kim S.-I. // Electronics Letters. - 2010. - Vol. 46, No. 23. - P. 1573-1574.

J112. Roberg M. GaN HEMT PA with over 84% power added efficiency. / Roberg M., Hoversten J., Popovic, Z. // Electronics Letters. - 2010. - Vol. 46, No. 23. - P. 1553-1554.

J113. Chen W. High-current-density high-voltage normally-off AlGaN/GaN hybrid-gate HEMT with low on-resistance. / Chen W., Zhou C., Chen K.J. // Electronics Letters. - 2010. - Vol. 46, No. 24. - P. 1626-1627.

J114. Jahanbakht S. Computation of the phase and amplitude noise in microwave oscillators and a simplified calculation method for far enough from the carrier offsets. / Jahanbakht S., Farzaneh F. // IET Microwaves, Antennas & Propagation. - 2010. - Vol. 4, No. 12. - P. 2031-2041.

J115. Ostinelli O. Growth and characterization of iron-doped semi-insulating InP buffer layers for Al-free GaInP/GaInAs high electron mobility transistors. / Ostinelli O., Alt A. R., Lovblom R., Bolognesi C. R. // Journal of Applied Physics. - 2010. - Vol. 108, No. 11. - P. 114502-114502-6.

J116. Yeo S.K. X-band high-power HEMT SPDT switch with selectively anodised aluminium substrate. / Yeo S.K., Kwon Y.S. // Electronics Letters. - 2010. - Vol. 46, No. 24. - P. 1627-1629.

J117. Junghwan Moon. Investigation of a Class-J Power Amplifier With a Nonlinear for Optimized Operation. / Junghwan Moon, Jungjoon Kim, Bumman Kim. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 11. - P. 2800-2811.

J118. Kuroda K. Parasitic Compensation Design Technique for a C-Band GaN HEMT Class-F Amplifier. / Kuroda K., Ishikawa R., Honjo K. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 11. - P. 2741-2750.

J119. Khmyrova Irina. Analysis of terahertz plasma resonances in structures with two-dimensional electron systems periodically modulated by interdigitated gate. / Khmyrova Irina, Yamase Ryosuke, Fukuda Makoto, Watanabe Norikazu. // Journal of Applied Physics. - 2010. - Vol. 108, No. 7. - P. 074511-074511-6.

J120. Manoi A. Benchmarking of Thermal Boundary Resistance in AlGaN/GaN HEMTs on SiC Substrates: Implications of the Nucleation Layer Microstructure. / Manoi A., Pomeroy J.W., Killat N., Kuball M. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 12. - P. 1395-1397.

J121. Takahashi H. 10-Gbit/s Quadrature Phase-Shift-Keying Modulator and Demodulator for 120-GHz-Band Wireless Links. / Takahashi H., Kosugi T., Hirata A., Murata K., Kukutsu N. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 12. - P. 4072-4078.

J122. Roy T. Process Dependence of Proton-Induced Degradation in GaN HEMTs. / Roy T., En Xia Zhang, Puzyrev Y.S., Fleetwood D.M., Schrimpf R.D., Choi B.K., Hmelo A.B., Pantelides S.T. // IEEE Transactions on Nuclear Science. - 2010. - Vol. 57, No. 6. - P. 3060-3065.

J123. Nidhi. N-Polar GaN/AlN MIS-HEMT for Ka-Band Power Applications. / Nidhi, Dasgupta S., Yi Pei, Swenson B.L., Keller S., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 12. - P. 1437-1439.

J124. Maier D. Testing the Temperature Limits of GaN-Based HEMT Devices. / Maier D., Alomari M., Grandjean N., Carlin J.-F., Diforte-Poisson M.-A., Dua C., Chuvilin A., Troadec D., Gaquie,re C., Kaiser U., Delage S.L., Kohn E. // IEEE Transactions on Device and Materials Reliability. - 2010. - Vol. 10, No. 4. - P. 427-436.

J125. Zhi Hong Liu. Study on the Temperature Dependence of the Microwave-Noise Characteristics in AlGaN/GaN HEMTs. / Zhi Hong Liu, Geok Ing Ng, Arulkumaran S. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 9. - P. 2353-2357.

J126. Tapajna M. Importance of impurity diffusion for early stage degradation in AlGaN/GaN high electron mobility transistors upon electrical stress. / Tapajna M., Mishra U. K., Kuball M. // Applied Physics Letters. - 2010. - Vol. 97, No. 2. - P. 023503-023503-3.

J127. Bin Lu. High Breakdown ( ) AlGaN/GaN HEMTs by Substrate-Transfer Technology. / Bin Lu, Palacios T. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 9. - P. 951-953.

J128. Haifeng Sun. Low-Noise Microwave Performance of 0.1 m Gate AlInN/GaN HEMTs on SiC. / Haifeng Sun, Alt A.R., Benedickter H., Feltin E., Carlin J., Gonschorek M., Grandjean N., Bolognesi C.R. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 8. - P. 453-455.

J129. Bin Lu. High-Performance Integrated Dual-Gate AlGaN/GaN Enhancement-Mode Transistor. / Bin Lu, Saadat O.I., Palacios T. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 9. - P. 990-992.

J130. Haifeng Sun. 205-GHz (Al,In)N/GaN HEMTs. / Haifeng Sun, Alt A.R., Benedickter H., Feltin E., Carlin J.-F., Gonschorek M., Grandjean N.R., Bolognesi C.R. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 9. - P. 957-959.

J131. Wang Yu-Lin. Oxygen gas sensing at low temperature using indium zinc oxide-gated AlGaN/GaN high electron mobility transistors. / Wang Yu-Lin, Chang C. Y., Lim Wantae, Pearton S. J., Norton D. P., Chu B. H., Lo C. F., Ren F., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2010. - Vol. 28, No. 2. - P. 376-379.

J132. Dae-Hyun Kim. 30-nm InAs PHEMTs With and. / Dae-Hyun Kim, del Alamo J.A. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 8. - P. 806-808.

J133. Park J. Thermal instability of copper gate AlGaN/GaN HEMT on Si substrate. / Park J., Lee K., Cha H.-Y., Seo K. // Electronics Letters. - 2010. - Vol. 46, No. 14. - P. 1011-1012.

J134. King-Yuen Wong. Characterization and Analysis of the Temperature-Dependent on -Resistance in AlGaN/GaN Lateral Field-Effect Rectifiers. / King-Yuen Wong, Wanjun Chen, Chen K.J. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 8. - P. 1924-1929.

J135. Guowang Li. Threshold Voltage Control in HEMTs by Work-Function Engineering. / Guowang Li, Zimmermann T., Yu Cao, Chuanxin Lian, Xiu Xing, Ronghua Wang, Fay P., Xing H.G., Jena D. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 9. - P. 954-956.

J136. Kuzmik J. Proposal and Performance Analysis of Normally Off GaN/InAlN/AlN/GaN HEMTs With 1-nm-Thick InAlN Barrier. / Kuzmik J., Ostermaier C., Pozzovivo G., Basnar B., Schrenk W., Carlin J.-F., Gonschorek M., Feltin E., Grandjean N., Douvry Y., Gaquie,re C., De Jaeger J.-C., C,ic,o K., Frojhlich K., S,kriniarova, J., Kova,c, J., Strasser G., Pogany D., Gornik E. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 9. - P. 2144-2154.

J137. Liu Z.H. Improved Linearity for Low-Noise Applications in 0.25- GaN MISHEMTs Using ALD as Gate Dielectric. / Liu Z.H., Ng G.I., Arulkumaran S., Maung Y.K.T., Teo K.L., Foo S.C., Sahmuganathan V. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 8. - P. 803-805.

J138. Bo Wang. Integrated Circuit Implementation for a GaN HFET Driver Circuit. / Bo Wang, Riva M., Bakos J.D., Monti A. // IEEE Transactions on Industry Applications. - 2010. - Vol. 46, No. 5. - P. 2056-2067.

J139. Sahoo K.C. Novel Metamorphic HEMTs With Highly Doped InGaAs Source/Drain Regions for High Frequency Applications. / Sahoo K.C., Chien-I Kuo, Yiming Li, Chang E.Y. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 10. - P. 2594-2598.

J140. Danneville F. Microwave Noise and FET Devices. IEEE Microwave Magazine. - 2010. - Vol. 11, No. 6. - P. 53-60.

J141. Ildu Kim. Optimized Design of a Highly Efficient Three-Stage Doherty PA Using Gate Adaptation. / Ildu Kim, Junghwan Moon, Seunghoon Jee, Bumman Kim. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 10. - P. 2562-2574.

J142. Koch S. A 120-145 GHz Heterodyne Receiver Chipset Utilizing the 140 GHz Atmospheric Window for Passive Millimeter-Wave Imaging Applications. / Koch S., Guthoerl M., Kallfass I., Leuther A., Saito S. // IEEE Journal of Solid-State Circuits. - 2010. - Vol. 45, No. 10. - P. 1961-1967.

J143. Shu-Hsien Liao. High Efficiency WCDMA Power Amplifier With Pulsed Load Modulation (PLM). / Shu-Hsien Liao, Wang Y.E. // IEEE Journal of Solid-State Circuits. - 2010. - Vol. 45, No. 10. - P. 2030-2037.

J144. Chang C.-T. Normally-off operation AlGaN/GaN MOS-HEMT with high threshold voltage. / Chang C.-T., Hsu T.-H., Chang E.Y., Chen Y.-C., Trinh H.-D., Chen K.J. // Electronics Letters. - 2010. - Vol. 46, No. 18. - P. 1280-1281.

J145. Dunleavy L. Modeling GaN: Powerful but Challenging. / Dunleavy L., Baylis C., Curtice W., Connick R. //

IEEE Microwave Magazine. - 2010. - Vol. 11, No. 6. - P. 82-96.

J146. Vassilev V. MMIC-Based Components for MM-Wave Instrumentation. / Vassilev V., Wadefalk N., Kozhuharov R., Abbasi M., Gunnarsson S.E., Zirath H., Pellikka T., Emrich A., Pantaleev M., Kallfass I., Leuther A. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 10. - P. 578-580.

J147. DasGupta S. Gate Bias Dependence of Single Event Charge Collection in AlSb/InAs HEMTs. / DasGupta S., McMorrow D., Reed R.A., Schrimpf R.D., Boos J.B. // IEEE Transactions on Nuclear Science. - 2010. - Vol. 57, No. 4. - P. 1856-1860.

J148. Vasallo B.G. Monte Carlo Study of the Dynamic Performance of a 100-nm-Gate InAlAs/InGaAs Velocity Modulation Transistor. / Vasallo B.G., Wichmann N., Bollaert S., Roelens Y., Cappy A., Gonza,lez T., Pardo D., Mateos J. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 10. - P. 2572-2578.

J149. Raffo A. Characterization of GaN HEMT Low-Frequency Dispersion Through a Multiharmonic Measurement System. / Raffo A., Di Falco S., Vadala V., Vannini G. // IEEE Transactions on Microwave Theory and Techniques. - 2010. - Vol. 58, No. 9. - P. 2490-2496.

J150. Marino F.A. Emerging N-Face GaN HEMT Technology: A Cellular Monte Carlo Study. / Marino F.A., Saraniti M., Faralli N., Ferry D.K., Goodnick S.M., Guerra D. // IEEE Transactions on Electron Devices. - 2010. - Vol. 57, No. 10. - P. 2579-2586.

J151. Mingqi Chen. A 1-25 GHz GaN HEMT MMIC Low-Noise Amplifier. / Mingqi Chen, Sutton W., Smorchkova I., Heying B., Wen-Ben Luo, Gambin V., Oshita F., Tsai R., Wojtowicz M., Kagiwada R., Oki A., Jenshan Lin. // IEEE Microwave and Wireless Components Letters. - 2010. - Vol. 20, No. 10. - P. 563-565.

J152. Corrion A.L. Enhancement-Mode AlN/GaN/AlGaN DHFET With 700-mS/mm and 112-GHz. / Corrion A.L., Shinohara K., Regan D., Milosavljevic I., Hashimoto P., Willadsen P.J., Schmitz A., Wheeler D.C., Butler C.M., Brown D., Burnham S.D., Micovic M. // IEEE Electron Device Letters. - 2010. - Vol. 31, No. 10. - P. 1116-1118.

J153. Selvaraj S.L. Breakdown Enhancement of AlGaN/GaN HEMTs on 4-in Silicon by Improving the GaN Quality on Thick Buffer Layers. / Selvaraj S.L., Suzue T., Egawa T. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 6. - P. 587-589.

J154. Hirata A. 10-Gbit/s Wireless Link Using InP HEMT MMICs for Generating 120-GHz-Band Millimeter-Wave Signal. / Hirata A., Yamaguchi R., Kosugi T., Takahashi H., Murata K., Nagatsuma T., Kukutsu N., Kado Y., Iai N., Okabe S., Kimura S., Ikegawa H., Nishikawa H., Nakayama T., Inada T. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 5. - P. 1102-1109.

J155. Nidhi. and of 47 and 81 GHz, Respectively, on N-Polar GaN/AlN MIS-HEMT. / Nidhi, Dasgupta S., Yi Pei, Swenson B.L., Brown D.F., Keller S., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 6. - P. 599-601.

J156. Defrance N. AlGaN/GaN HEMT High Power Densities on /poly-SiC Substrates. / Defrance N., Thorpe J., Douvry Y., Hoel V., De Jaeger J.C., Gaquiere C., Xiao Tang, di Forte-Poisson M.A., Langer R., Rousseau M., Lahreche H. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 6. - P. 596-598.

J157. Jung-Hun Oh. Effects of Multigate-Feeding Structure on the Gate Resistance and RF Characteristics of 0.1- Metamorphic High Electron-Mobility Transistors. / Jung-Hun Oh, Min Han, Sang-Jin Lee, Byoung-Chul Jun, Sung-Woon Moon, Jae-Seo Lee, Jin-Koo Rhee, Sam-Dong Kim. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 6. - P. 1487-1493.

J158. Hung S. C. Minipressure sensor using AlGaN/GaN high electron mobility transistors. / Hung S. C., Chou B. H., Chang C. Y., Lo C. F., Chen K. H., Wang Y. L., Pearton S. J., Dabiran Amir, Chow P. P., Chi G. C., Ren F. // Applied Physics Letters. - 2009. - Vol. 94, No. 4. - P. 043903-043903-3.

J159. Jen-Yi Su. -Band pHEMT Gilbert Mixers With Polyphase and Coupled-Line Quadrature Generators. / Jen-Yi Su, Sheng-Che Tseng, Chinchun Meng, Po-Yi Wu, Yueh-Ting Lee, Guo-Wei Huang. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 5. - P. 1063-1073.

J160. Zanoni E. Localized Damage in AlGaN/GaN HEMTs Induced by Reverse-Bias Testing. / Zanoni E.,

Danesin F., Meneghini M., Cetronio A., Lanzieri C., Peroni M., Meneghesso G. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 5. - P. 427-429.

J161. Chini A. Evaluation of GaN HEMT degradation by means of pulsed I-V, leakage and DLTS measurements. / Chini A., Esposto M., Meneghesso G., Zanoni E. // Electronics Letters. - 2009. - Vol. 45, No. 8. - P. 426-427.

J162. Kolluri S. RF Performance of N-Polar AlGaN/GaN MIS-HEMTs Grown by MOCVD on Sapphire Substrate. / Kolluri S., Yi Pei, Keller S., Denbaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 6. - P. 584-586.

J163. Khalil I. A Novel Self-Pinching Gate Biasing Scheme for Safe Operation and Characterization of GaN HEMTs. / Khalil I., Kuhn S., Liero A., Gesche R. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 5. - P. 302-304.

J164. Kallfass I. A 200 GHz Monolithic Integrated Power Amplifier in Metamorphic HEMT Technology. / Kallfass I., Pahl P., Massler H., Leuther A., Tessmann A., Koch S., Zwick T. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 6. - P. 410-412.

J165. Wang Yu-Lin. Fast detection of a protozoan pathogen, Perkinsus marinus, using AlGaN/GaN high electron mobility transistors. / Wang Yu-Lin, Chu B. H., Chen K. H., Chang C. Y., Lele T. P., Papadi G., Coleman J. K., Sheppard B. J., Dungen C. F., Pearton S. J., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J., Ren F. // Applied Physics Letters. - 2009. - Vol. 94, No. 24. - P. 243901-243901-3.

J166. Wong Man Hoi. High power N-face GaN high electron mobility transistors grown by molecular beam epitaxy with optimization of AlN nucleation. / Wong Man Hoi, Pei Yi, Speck James S., Mishra Umesh K. // Applied Physics Letters. - 2009. - Vol. 94, No. 18. - P. 182103-182103-3.

J167. Cico K. In Al N /Ga N metal-oxide-semiconductor high electron mobility transistor with Al 2 O 3 insulating films grown by metal organic chemical vapor deposition using Ar and N H 3 carrier gases. / Cico K., Kuzmik J., Liday J., Husekova K., Pozzovivo G., Carlin J.-F., Grandjean N., Pogany D., Vogrincic P., Frohlich K. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2009. - Vol. 27, No. 1. - P. 218-222.

J168. Akram R. Imaging capability of pseudomorphic high electron mobility transistors, Al Ga N /Ga N, and Si micro-Hall probes for scanning Hall probe microscopy between 25 and 125 °C. / Akram R., Dede M., Oral A. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2009. - Vol. 27, No. 2. - P. 1006-1010.

J169. Lin Yu-Shyan. Al Ga As /Ga As high-electron mobility transistor with In 0.1 Ga 0.9 As /In 0.22 Ga 0.78 As /In 0.1 Ga 0.9 As channel grown by metal-organic chemical vapor deposition. / Lin Yu-Shyan, Chen Bo-Yuan. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2009. - Vol. 27, No. 2. - P. 606-611.

J170. Neophytou N. Performance Analysis of 60-nm Gate-Length III-V InGaAs HEMTs: Simulations Versus Experiments. / Neophytou N., Rakshit T., Lundstrom M.S. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 7. - P. 1377-1387.

J171. Abermann S. Current collapse reduction in InAlM/GaN MOS hemtHEMTs by in situ surface pre-treatment and atomic layer deposition of ZrO2 high-k gate dielectrics. / Abermann S., Pozzovivo G., Kuzmik J., Ostermaier C., Henkel C., Bethge O., Strasser G., Pogany D., Carlin J.-F., Grandjean N., Bertagnolli E. // Electronics Letters. - 2009. - Vol. 45, No. 11. - P. 570-572.

J172. Liu Z.H. Improved Microwave Noise Performance by SiN Passivation in AlGaN/GaN HEMTs on Si. / Liu Z.H., Arulkumaran S., Ng G.I. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 6. - P. 383-385.

J173. Kamitsuna H. DC to 50 GHz single-pole four-throw InP-HEMT switch IC with highly uniform performance. / Kamitsuna H., Onodera K., Sugitani S., Nishimura K., Murata K., Enoki T. // Electronics Letters. - 2009. - Vol. 45, No. 12. - P. 626-627.

J174. Saito W. Effect of Buffer Layer Structure on Drain Leakage Current and Current Collapse Phenomena in

High-Voltage GaN-HEMTs. / Saito W., Noda T., Kuraguchi M., Takada Y., Tsuda K., Saito Y., Omura I., Yamaguchi M. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 7. - P. 1371-1376.

J175. Lin S. Development of ultra wideband, high efficiency, distributed power amplifiers using discrete GaN HEMTs. / Lin S., Eron M., Fathy A.E. // IET Circuits, Devices & Systems. - 2009. - Vol. 3, No. 3. - P. 135-142.

J176. Nanjo T. Comparison of characteristics of AlGaN channel HEMTs formed on SiC and sapphire substrates. / Nanjo T., Suita M., Oishi T., Abe Y., Yagyu E., Yoshiara K., Tokuda Y. // Electronics Letters. - 2009. - Vol. 45, No. 8. - P. 424-426.

J177. Cuerdo R. The Kink Effect at Cryogenic Temperatures in Deep Submicron AlGaN/GaN HEMTs. / Cuerdo R., Pei Y., Chen Z., Keller S., DenBaars S.P., Calle F., Mishra U.K. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 3. - P. 209-212.

J178. Kyu-Heon Cho. Increase of Breakdown Voltage on AlGaN/GaN HEMTs by Employing Proton Implantation. / Kyu-Heon Cho, Young-Hwan Choi, Jiyong Lim, Min-Koo Han. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 3. - P. 365-369.

J179. Chia-Ta Chang. Changes of Electrical Characteristics for AlGaN/GaN HEMTs Under Uniaxial Tensile Strain. / Chia-Ta Chang, Shih-Kuang Hsiao, Chang E.Y., Chung-Yu Lu, Jui-Chien Huang, Ching-Ting Lee. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 3. - P. 213-215.

J180. Garven M. Simulation and Optimization of Gate Temperatures in GaN-on-SiC Monolithic Microwave Integrated Circuits. / Garven M., Calame J.P. // IEEE Transactions on Components and Packaging Technologies. - 2009. - Vol. 32, No. 1. - P. 63-72.

J181. Khalil I. Improving the Linearity of GaN HEMTs by Optimizing Epitaxial Structure. / Khalil I., Bahat-Treidel E., Schnieder F., Wurfl J. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 3. - P. 361-364.

J182. Ortlepp T. Superconductor-to-Semiconductor Interface Circuit for High Data Rates. / Ortlepp T., Wuensch S., Schubert M., Febvre P., Ebert B., Kunert J., Crocoll E., Meyer H.-G., Siegel M., Uhlmann F.H. // IEEE Transactions on Applied Superconductivity. - 2009. - Vol. 19, No. 1. - P. 28-34.

J183. Thorsell M. Thermal Study of the High-Frequency Noise in GaN HEMTs. / Thorsell M., Andersson K., Fagerlind M., Sudow M., Nilsson P.-A., Rorsman N. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 1. - P. 19-26.

J184. Malmkvist M. Epitaxial Optimization of 130-nm Gate-Length InGaAs/InAlAs/InP HEMTs for Low-Noise Applications. / Malmkvist M., Shumin Wang, Grahn J. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 1. - P. 126-131.

J185. Haifeng Sun. High-Performance 0.1- Gate AlGaN/GaN HEMTs on Silicon With Low-Noise Figure at 20 GHz. / Haifeng Sun, Alt A.R., Benedickter H., Bolognesi C.R. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 2. - P. 107-109.

J186. Meneghesso G. Anomalous Kink Effect in GaN High Electron Mobility Transistors. / Meneghesso G., Zanon F., Uren M.J., Zanoni E. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 2. - P. 100-102.

J187. Chung J.W. N-Face GaN/AlGaN HEMTs Fabricated Through Layer Transfer Technology. / Chung J.W., Piner E.L., Palacios T. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 2. - P. 113-116.

J188. Hsien-Chin Chiu. A High-Linearity Single-Pole-Double-Throw Pseudomorphic HEMT Switch Based on Tunable Field-Plate Voltage Technology. / Hsien-Chin Chiu, Chia-Shih Cheng, Shao-Wei Lin, Chien-Cheng Wei. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 4. - P. 541-545.

J189. Wanjun Chen. Single-Chip Boost Converter Using Monolithically Integrated AlGaN/GaN Lateral Field-Effect Rectifier and Normally Off HEMT. / Wanjun Chen, King-Yuen Wong, Chen K.J. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 5. - P. 430-432.

J190. Sun H.F. 100 nm gate AlGaN/GaN HEMTs on silicon with fT = 90 GHz. / Sun H.F., Alt A.R., Benedickter H., Bolognesi C.R. // Electronics Letters. - 2009. - Vol. 45, No. 7. - P. 376-377.

J191. Brannick A. Influence of Field Plate on the Transient Operation of the AlGaN/GaN HEMT. / Brannick A., Zakhleniuk N.A., Ridley B.K., Shealy J.R., Schaff W.J., Eastman L.F. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 5. - P. 436-438.

J192. Deen D.A. AlN/GaN insulated gate HEMTs with HfO2 gate dielectric. / Deen D.A., Binari S.C., Storm D.F., Katzer D.S., Roussos J.A., Hackley J.C., Gougousi T. // Electronics Letters. - 2009. - Vol. 45, No. 8. - P. 423-424.

J193. Yi Pei. AlGaN/GaN HEMT With a Transparent Gate Electrode. / Yi Pei, Vampola K.J., Zhen Chen, Rongming Chu, DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 5. - P. 439-441.

J194. Oh S. Effect of Parasitic Resistance and Capacitance on Performance of InGaAs HEMT Digital Logic Circuits. / Oh S., Wong H.-S.P. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 5. - P. 1161-1164.

J195. Seok Joo Doo. Pulsed Active Load-Pull Measurements for the Design of High-Efficiency Class-B RF Power Amplifiers With GaN HEMTs. / Seok Joo Doo, Roblin P., Balasubramanian V., Taylor R., Dandu K., Strahler J., Jessen G.H., Teyssier J.-P. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 4. - P. 881-889.

J196. Yi Pei. Effect of Dielectric Thickness on Power Performance of AlGaN/GaN HEMTs. / Yi Pei, Rajan S., Higashiwaki M., Zhen Chen, DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 4. - P. 313-315.

J197. Yu-Ann Lai. A MMIC Doubler Based on Novel Open/Short Stub Hybrids. / Yu-Ann Lai, Chih-Ming Lin, Chun-Chi Su, Chieh-Pin Chang, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 4. - P. 242-244.

J198. Ashok A. Importance of the Gate-Dependent Polarization Charge on the Operation of GaN HEMTs. / Ashok A., Vasileska D., Goodnick S.M., Hartin O.L. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 5. - P. 998-1006.

J199. Jin-Cheol Jeong. An Active IF Balun for a Doubly Balanced Resistive Mixer. / Jin-Cheol Jeong, In-Bok Yom, Kyung-Whan Yeom. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 4. - P. 224-226.

J200. Saxena H. Tunable two-dimensional plasmon resonances in an InGaAs/InP high electron mobility transistor. / Saxena H., Peale R. E., Buchwald W. R. // Journal of Applied Physics. - 2009. - Vol. 105, No. 11. - P. 113101-113101-6.

J201. Bertoluzza F. Hybrid Large-Signal/Lumped-Element Electro-Thermal Modeling of GaN-HEMTs. / Bertoluzza F., Sozzi G., Delmonte N., Menozzi R. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 12. - P. 3163-3170.

J202. Nakasha Y. -band Transmitter and Receiver for 10-Gb/s Impulse Radio With an Optical-Fiber Interface. / Nakasha Y., Sato M., Tajima T., Kawano Y., Suzuki T., Takahashi T., Makiyama K., Ohki T., Hara N. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 12. - P. 3171-3180.

J203. Yu-Syuan Lin. Square-Gate AlGaN/GaN HEMTs With Improved Trap-Related Characteristics. / Yu-Syuan Lin, Jia-Yi Wu, Chih-Yuan Chan, Shawn Hsu, Chih-Fang Huang, Ting-Chi Lee. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 12. - P. 3207-3211.

J204. Jungwoo Joh. Measurement of Channel Temperature in GaN High-Electron Mobility Transistors. / Jungwoo Joh, del Alamo J.A., Chowdhury U., Tso-Min Chou, Hua-Quen Tserng, Jimenez J.L. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 12. - P. 2895-2901.

J205. Akis R. Ballistic Transport in InP-Based HEMTs. / Akis R., Faralli N., Ferry D.K., Goodnick S.M., Phatak K.A., Saraniti M. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 12. - P. 2935-2944.

J206. Xiaoxu Cheng. Physics-Based Compact Model for AlGaN/GaN MODFETs With Close-Formed-and-Characteristics. / Xiaoxu Cheng, Miao Li, Yan Wang. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56,

No. 12. - P. 2881-2887.

J207. Liu Z.H. Mechanism of Increased High-Frequency Channel Noise With PECVD SiN Passivation in AlGaN/GaN HEMTs. / Liu Z.H., Ng G.I., Arulkumaran S. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 11. - P. 1122-1124.

J208. Endoh A. Low-Voltage and High-Speed Operations of 30-nm-Gate Pseudomorphic HEMTs Under Cryogenic Conditions. / Endoh A., Shinohara K., Watanabe I., Mimura T., Matsui T. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 10. - P. 1024-1026.

J209. Chini A. Evaluation and Numerical Simulations of GaN HEMTs Electrical Degradation. / Chini A., Di Lecce V., Esposto M., Meneghesso G., Zanoni E. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 10. - P. 1021-1023.

J210. Rebeiz G. Tuning in to RF MEMS. / Rebeiz G., Entesari K., Reines I., Park S.-j., El-tanani M., Grichener A., Brown A. // IEEE Microwave Magazine. - 2009. - Vol. 10, No. 6. - P. 55-72.

J211. Aflaki P. Dedicated Large-Signal GaN HEMT Model for Switching-Mode Circuit Analysis and Design. / Aflaki P., Negra R., Ghannouchi F.M. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 11. - P. 740-742.

J212. Campbell C. A Wideband Power Amplifier MMIC Utilizing GaN on SiC HEMT Technology. / Campbell C., Lee C., Williams V., Ming-Yih Kao, Hua-Quen Tserng, Saunier P., Balisteri T. // IEEE Journal of Solid-State Circuits. - 2009. - Vol. 44, No. 10. - P. 2640-2647.

J213. Kobayashi K.W. A Cool, Sub-0.2 dB Noise Figure GaN HEMT Power Amplifier With 2-Watt Output Power. / Kobayashi K.W., Yao-Chung Chen, Smorchkova I., Heying B., Luo W.-B., Sutton W., Wojtowicz M., Oki A. // IEEE Journal of Solid-State Circuits. - 2009. - Vol. 44, No. 10. - P. 2648-2654.

J214. Anderson T.J. An AlN/Ultrathin AlGaN/GaN HEMT Structure for Enhancement-Mode Operation Using Selective Etching. / Anderson T.J., Tadjer M.J., Mastro M.A., Hite J.K., Hobart K.D., Eddy C.R., Kub F.J. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 12. - P. 1251-1253.

J215. Nanjo T. AlGaN channel HEMTs on AlN buffer layer with sufficiently low off-state drain leakage current. / Nanjo T., Takeuchi M., Imai A., Suita M., Oishi T., Abe Y., Yagyu E., Kurata T., Tokuda Y., Aoyagi Y. // Electronics Letters. - 2009. - Vol. 45, No. 25. - P. 1346-1348.

J216. Kalavagunta A. Impact of Proton Irradiation-Induced Bulk Defects on Gate-Lag in GaN HEMTs. / Kalavagunta A., Silvestri M., Beck M.J., Dixit S.K., Schrimpf R.D., Reed R.A., Fleetwood D.M., Shen L., Mishra U.K. // IEEE Transactions on Nuclear Science. - 2009. - Vol. 56, No. 6. - P. 3192-3195.

J217. Yuk K.S. A Wideband Multiharmonic Empirical Large-Signal Model for High-Power GaN HEMTs With Self-Heating and Charge-Trapping Effects. / Yuk K.S., Branner G.R., McQuate D.J. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 12. - P. 3322-3332.

J218. Kuzmik J. Analysis of degradation mechanisms in lattice-matched InAlN/GaN high-electron-mobility transistors. / Kuzmik J., Pozzovivo G., Ostermaier C., Strasser G., Pogany D., Gornik E., Carlin J.-F., Gonschorek M., Feltin E., Grandjean N. // Journal of Applied Physics. - 2009. - Vol. 106, No. 12. - P. 124503-124503-7.

J219. Xia Ling. Impact of uniaxial strain on n-channel In 0.15 Ga 0.85 As high electron mobility transistors. / Xia Ling, del Alamo Jesus A. // Applied Physics Letters. - 2009. - Vol. 95, No. 24. - P. 243504-243504-3.

J220. Lu C.-Y. Stable AlGaN/GaN high electron mobility transistors with tungsten nitride gate metallisation. / Lu C.-Y., Chang E.Y., Huang J.-C., Chang C.-T., Lee C.-T. // Electronics Letters. - 2009. - Vol. 45, No. 25. - P. 1348-1349.

J221. Darwish A.M. Dependence of GaN HEMT Millimeter-Wave Performance on Temperature. / Darwish A.M., Huebschman B.D., Viveiros E., Hung H.A. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 12. - P. 3205-3211.

J222. Xu Y. Source access impedance model for AlGaN/ GaN HEMTs. / Xu Y., Guo Y., Wu Y., Xu R., Yan B.,

Lin W. // Electronics Letters. - 2009. - Vol. 45, No. 23. - P. 1193-1194.

J223. Choonghee Lee. A 18 GHz Broadband Stacked FET Power Amplifier Using 130 nm Metamorphic HEMTs. / Choonghee Lee, Youngmin Kim, Yumin Koh, Jihoon Kim, Kwangseok Seo, Jinho Jeong, Youngwoo Kwon. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 12. - P. 828-830.

J224. Saadat O.I. Gate-First AlGaN/GaN HEMT Technology for High-Frequency Applications. / Saadat O.I., Chung J.W., Piner E.L., Palacios T. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 12. - P. 1254-1256.

J225. Batten T. Simultaneous measurement of temperature and thermal stress in AlGaN/GaN high electron mobility transistors using Raman scattering spectroscopy. / Batten T., Pomeroy J. W., Uren M. J., Martin T., Kuball M. // Journal of Applied Physics. - 2009. - Vol. 106, No. 9. - P. 094509-094509-4.

J226. Lin-Sheng Liu. Electrothermal Large-Signal Model of III-V FETs Including Frequency Dispersion and Charge Conservation. / Lin-Sheng Liu, Jian-Guo Ma, Geok-Ing Ng. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 12. - P. 3106-3117.

J227. Shih-En Shih. Design and Analysis of Ultra Wideband GaN Dual-Gate HEMT Low-Noise Amplifiers. / Shih-En Shih, Deal W.R., Yamauchi D.M., Sutton W.E., Wen-Ben Luo, Yaochung Chen, Smorchkova I.P., Heying B., Wojtowicz M., Siddiqui M. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 12. - P. 3270-3277.

J228. Chung J.W. Gate-Recessed InAlN/GaN HEMTs on SiC Substrate With Passivation. / Chung J.W., Saadat O.I., Tirado J.M., Xiang Gao, Guo S., Palacios T. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 9. - P. 904-906.

J229. Rongming Chu. MOCVD-Grown AlGaN Buffer GaN HEMTs With V-Gates for Microwave Power Applications. / Rongming Chu, Zhen Chen, Yi Pei, Newman S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 9. - P. 910-912.

J230. Khalil I. Influence of Dynamic Access Resistances on the Linearity of Large GaN HEMT Powerbars. / Khalil I., Heinrich W. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 8. - P. 527-529.

J231. Ihlefeld J.F. Adsorption-Controlled Growth of BiFeO3 by MBE and Integration with Wide Band Gap Semiconductors. / Ihlefeld J.F., Wei Tian, Zi-Kui Liu, Doolittle W.A., Bernhagen M., Reiche P., Uecker R., Ramesh R., Schlom D.G. // IEEE Transactions on Ultrasonics, Ferroelectrics and Frequency Control. - 2009. - Vol. 56, No. 8. - P. 1528-1533.

J232. Lefebvre E. Gate-Recess Technology for InAs/AlSb HEMTs. / Lefebvre E., Malmkvist M., Borg M., Desplanque L., Wallart X., Dambrine G., Bollaert S., Grahn J. // IEEE Transactions on Electron Devices. - 2009. - Vol. 56, No. 9. - P. 1904-1911.

J233. Mohamed C. A 1-20-GHz Broadband MMIC Demodulator for Low IF Receivers in Multistandard Applications. / Mohamed C., Khy A., Huyart B. // IEEE Transactions on Microwave Theory and Techniques. - 2009. - Vol. 57, No. 10. - P. 2318-2328.

J234. Bahat-Treidel E. AlGaN/GaN HEMT With Integrated Recessed Schottky-Drain Protection Diode. / Bahat-Treidel E., Lossy R., Wurfl J., Trankle G. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 9. - P. 901-903.

J235. Yong-Sub Lee. A High-Efficiency GaN-Based Power Amplifier Employing Inverse Class-E Topology. / Yong-Sub Lee, Mun-Woo Lee, Sang-Ho Kam, Yoon-Ha Jeong. // IEEE Microwave and Wireless Components Letters. - 2009. - Vol. 19, No. 9. - P. 593-595.

J236. Chang C. Y. Development of enhancement mode AlN/GaN high electron mobility transistors. / Chang C. Y., Pearton S. J., Lo C. F., Ren F., Kravchenko I. I., Dabiran A. M., Wowchak A. M., Cui B., Chow P. P. // Applied Physics Letters. - 2009. - Vol. 94, No. 26. - P. 263505-263505-3.

J237. Diduck Q. Frequency performance enhancement of AlGaN/GaN HEMTs on diamond. / Diduck Q., Felbinger J., Eastman L.F., Francis D., Wasserbauer J., Faili F., Babic D.I., Ejeckam F. // Electronics Letters. - 2009. - Vol. 45, No. 14. - P. 758-759.

J238. Kitaygorsky J. HEMT-Based Readout Technique for Dark- and Photon-Count Studies in NbN Superconducting Single-Photon Detectors. / Kitaygorsky J., Dorenbos S., Reiger E., Schouten R., Zwiller V., Sobolewski R. // IEEE Transactions on Applied Superconductivity. - 2009. - Vol. 19, No. 3. - P. 346-349.

J239. Wuensch S. Cryogenic Semiconductor Amplifier for RSFQ-Circuits With High Data Rates at 4.2 K. / Wuensch S., Ortlepp T., Crocoll E., Uhlmann F.H., Siegel M. // IEEE Transactions on Applied Superconductivity. - 2009. - Vol. 19, No. 3. - P. 574-579.

J240. Man Hoi Wong. High-Performance N-Face GaN Microwave MIS-HEMTs With >70% Power-Added Efficiency. / Man Hoi Wong, Yi Pei, Brown D.F., Keller S., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 8. - P. 802-804.

J241. Noh Y.S. Ku-band high-power amplifier MMIC with on-chip gate biasing circuit. / Noh Y.S., Chang D.P., Yom I.B. // Electronics Letters. - 2009. - Vol. 45, No. 15. - P. 794-795.

J242. Haifeng Sun. 102-GHz AlInN/GaN HEMTs on Silicon With 2.5-W/mm Output Power at 10 GHz. / Haifeng Sun, Alt A.R., Benedickter H., Bolognesi C.R., Feltin E., Carlin J.-F., Gonschorek M., Grandjean N., Maier T., Quay R. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 8. - P. 796-798.

J243. Cuerdo R. High-Temperature Microwave Performance of Submicron AlGaN/GaN HEMTs on SiC. / Cuerdo R., Sillero E., Romero M.F., Uren M.J., di Forte Poisson M.-A., Munoz E., Calle F. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 8. - P. 808-810.

J244. Chung J.W. Seamless On-Wafer Integration of Si(100) MOSFETs and GaN HEMTs. / Chung J.W., Jae-kyu Lee, Piner E.L., Palacios T. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 10. - P. 1015-1017.

J245. Xiaobin Xin. Demonstration of Low-Leakage-Current Low-On-Resistance 600-V 5.5-A GaN/AlGaN HEMT. / Xiaobin Xin, Junxia Shi, Linlin Liu, Edwards J., Swaminathan K., Pabisz M., Murphy M., Eastman L.F., Pophristic M. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 10. - P. 1027-1029.

J246. Lee Ching-Sung. SiN-passivated Gamma -gate Al 0.27 Ga 0.73 N /GaN high electron mobility transistors by using a shifted exposure method. / Lee Ching-Sung, Kao An-Yung. // Applied Physics Letters. - 2009. - Vol. 95, No. 9. - P. 093505-093505-3.

J247. Ostermaier C. Ultrathin InAlN/AlN Barrier HEMT With High Performance in Normally Off Operation. / Ostermaier C., Pozzovivo G., Carlin J.-F., Basnar B., Schrenk W., Douvry Y., Gaquiere C., DeJaeger J.-C., Cico K., Frohlich K., Gonschorek M., Grandjean N., Strasser G., Pogany D., Kuzmik J. // IEEE Electron Device Letters. - 2009. - Vol. 30, No. 10. - P. 1030-1032.

J248. Urata R. An Optically Clocked Transistor Array for High-Speed Asynchronous Label Swapping: 40 Gb/s and Beyond. / Urata R., Takahashi R., Suemitsu T., Nakahara T., Suzuki H. // Journal of Lightwave Technology. - 2008. - Vol. 26, No. 6. - P. 692-703.

J249. Medjdoub F. Barrier-Layer Scaling of InAlN/GaN HEMTs. / Medjdoub F., Alomari M., Carlin J.-F., Gonschorek M., Feltin E., Py M.A., Grandjean N., Kohn E. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 5. - P. 422-425.

J250. Torres J. Plasma Waves Subterahertz Optical Beating Detection and Enhancement in Long-Channel High-Electron-Mobility Transistors: Experiments and Modeling. / Torres J., Marinchio H., Nouvel P., Sabatini G., Palermo C., Varani L., Chusseau L., Shiktorov P., Starikov E., Gruzinskis V. // IEEE Journal of Selected Topics in Quantum Electronics. - 2008. - Vol. 14, No. 2. - P. 491-497.

J251. Hsien-Chin Chiu. Phase-Noise Improvement of GaAs pHEMT K-Band Voltage-Controlled Oscillator Using Tunable Field-Plate Voltage Technology. / Hsien-Chin Chiu, Chien-Cheng Wei, Chia-Shih Cheng, Yu-Fei Wu. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 5. - P. 426-429.

J252. Meneghesso G. Reliability of GaN High-Electron-Mobility Transistors: State of the Art and Perspectives. / Meneghesso G., Verzellesi G., Danesin F., Rampazzo F., Zanon F., Tazzoli A., Meneghini M., Zanoni E. // IEEE Transactions on Device and Materials Reliability. - 2008. - Vol. 8, No. 2. - P. 332-343.

J253. Pei Y. X- and Ka-band power performance of AlGaN/GaN HEMTs grown by ammonia-MBE. / Pei Y., Poblenz C., Cordon A.L., Chu R., Shen L., Speck J.S., Mishra U.K. // Electronics Letters. - 2008. - Vol. 44, No.

9. - P. 598.

J254. Wonill Ha. Enhancement-Mode Metamorphic HEMT on GaAs Substrate With 2 S/mm and 490 GHz. / Wonill Ha, Shinohara K., Brar B. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 5. - P. 419-421.

J255. Che-Chung Kuo. Novel Miniature and Broadband Millimeter-Wave Monolithic Star Mixers. / Che-Chung Kuo, Chun-Lin Kuo, Che-Jia Kuo, Maas S.A., Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 4. - P. 793-802.

J256. Jungwoo Joh. Critical Voltage for Electrical Degradation of GaN High-Electron Mobility Transistors. / Jungwoo Joh, del Alamo J.A. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 4. - P. 287-289.

J257. Xian Cui. High Efficiency RF Power Amplifier Designed With Harmonic Real-Time Active Load-Pull. / Xian Cui, Seok Joo Doo, Roblin P., Strahler J., Rojas-Teran R.G. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 4. - P. 266-268.

J258. Villanueva A.A. Degradation Uniformity of RF-Power GaAs PHEMTs Under Electrical Stress. / Villanueva A.A., del Alamo J.A., Hisaka T., Hayashi K., Somerville M. // IEEE Transactions on Device and Materials Reliability. - 2008. - Vol. 8, No. 2. - P. 283-288.

J259. Li-Hsien Huang. AlGaN/GaN Metal-Oxide-Semiconductor High-Electron Mobility Transistors Using Oxide Insulator Grown by Photoelectrochemical Oxidation Method. / Li-Hsien Huang, Shu-Hao Yeh, Ching-Ting Lee, Haipeng Tang, Bardwell J., Webb J.B. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 4. - P. 284-286.

J260. Lisauskas A. Terahertz imaging with GaAS field-effect transistors. / Lisauskas A., von Spiegel W., Boubanga-Tombet S., El Fatimy A., Coquillat D., Teppe F., Dyakonova N., Knap W., Roskos H.G. // Electronics Letters. - 2008. - Vol. 44, No. 6. - P. 408-409.

J261. Boers M. A GaN HEMT amplifier with 6-W output power and >85% power-added efficiency [Student Designs]. / Boers M., Parker A., Weste N. // IEEE Microwave Magazine. - 2008. - Vol. 9, No. 2. - P. 106-110.

J262. Tae-Woo Kim. A Two-Step-Recess Process Based on Atomic-Layer Etching for High-Performance p-HEMTs. / Tae-Woo Kim, Dae-Hyun Kim, Sang-Duk Park, Seung Heon Shin, Seong June Jo, Ho-Jin Song, Young Min Park, Jeoun-Oun Bae, Young-Woon Kim, Geun-Young Yeom, Jae-Hyung Jang, Jong-In Song. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 7. - P. 1577-1584.

J263. Faqir M. Investigation of High-Electric-Field Degradation Effects in AlGaN/GaN HEMTs. / Faqir M., Verzellesi G., Meneghesso G., Zanoni E., Fantini F. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 7. - P. 1592-1602.

J264. Brady R.G. An Improved Small-Signal Parameter-Extraction Algorithm for GaN HEMT Devices. / Brady R.G., Oxley C.H., Brazil T.J. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 7. - P. 1535-1544.

J265. Shealy J.R. Methodology for Small-Signal Model Extraction of AlGaN HEMTs. / Shealy J.R., Jiali Wang, Brown R. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 7. - P. 1603-1613.

J266. Joh J. A Simple Current Collapse Measurement Technique for GaN High-Electron Mobility Transistors. / Joh J., del Alamo J.A., Jimenez J. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 7. - P. 665-667.

J267. Moon J.S. 55% PAE and High Power Ka-Band GaN HEMTs With Linearized Transconductance via GaN Source Contact Ledge. / Moon J.S., Wong D., Hu M., Hashimoto P., Antcliffe M., McGuire C., Micovic M., Willadson P. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 8. - P. 834-837.

J268. Shigekawa N. Surface Acoustic Waves in Reverse-Biased AlGaN/GaN Heterostructures. / Shigekawa N., Nishimura K., Yokoyama H., Hohkawa K. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 7. - P. 1585-1591.

J269. Vasallo B.G. Comparison Between the Noise Performance of Double- and Single-Gate InP-Based HEMTs. / Vasallo B.G., Wichmann N., Bollaert S., Roelens Y., Cappy A., Gonzalez T., Pardo D., Mateos J. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 6. - P. 1535-1540.

J270. Haiou Li. Metamorphic AlInAs/GaInAs HEMTs on GaAs Substrates by MOCVD. / Haiou Li, Chak Wah Tang, Kei May Lau. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 6. - P. 561-564.

J271. Samoska L. A Submillimeter-Wave HEMT Amplifier Module With Integrated Waveguide Transitions Operating Above 300 GHz. / Samoska L., Deal W.R., Chattopadhyay G., Pukala D., Fung A., Gaier T., Soria M., Radisic V., Mei X., Lai R. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 6. - P. 1380-1388.

J272. Jian-An Hou. A Ka Band Balanced Third LO-Harmonic Mixer Using a Lumped-Elements Quadrature Hybrid. / Jian-An Hou, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 6. - P. 404-406.

J273. Medjdoub F. Effect of fluoride plasma treatment on InAlN/GaN HEMTs. / Medjdoub F., Alomari M., Carlin J.-F., Gonschorek M., Feltin E., Py M.A., Gaquiere C., Grandjean N., Kohn E. // Electronics Letters. - 2008. - Vol. 44, No. 11. - P. 696-698.

J274. Ruei Bin Lai. Topology Analysis and Design of Passive HEMT Millimeter-Wave Multiple-Port Switches. / Ruei Bin Lai, Shih Fong Chao, Zuo Min Tsai, Lee J., Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 7. - P. 1545-1554.

J275. Fung A.K. First On-Wafer Power Characterization of MMIC Amplifiers at Sub-Millimeter Wave Frequencies. / Fung A.K., Gaier T., Samoska L., Deal W.R., Radisic V., Mei X.B., Yoshida W., Liu P.S., Uyeda J., Barsky M., Lai R. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 6. - P. 419-421.

J276. Hoel V. First microwave power performance of AlGaN/GaN HEMTs on SopSiC composite substrate. / Hoel V., Defrance N., De Jaeger J.C., Gerard H., Gaquiere C., Lahreche H., Langer R., Wilk A., Lijadi M., Delage S. // Electronics Letters. - 2008. - Vol. 44, No. 3. - P. 238-239.

J277. Endoh A. AlGaN/GaN MIS-HEMTs with fT of 194 GHz at 16 K. / Endoh A., Watanabe I., Yamashita Y., Mimura T., Matsui T. // Electronics Letters. - 2008. - Vol. 44, No. 4. - P. 319-320.

J278. Yong-Sub Lee. High-Efficiency Class-F GaN HEMT Amplifier With Simple Parasitic-Compensation Circuit. / Yong-Sub Lee, Mun-Woo Lee, Yoon-Ha Jeong. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 1. - P. 55-57.

J279. Romero M.F. Effects of Plasma Pretreatment on the SiN Passivation of AlGaN/GaN HEMT. / Romero M.F., Jimenez A., Miguel-Sanchez J., Brana A.F., Gonzalez-Posada F., Cuerdo R., Calle F., Munoz E. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 3. - P. 209-211.

J280. Sathaiya D.M. A Closed-Form Model for Thermionic Trap-Assisted Tunneling. / Sathaiya D.M., Karmalkar S. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 2. - P. 557-564.

J281. Martin A. Balanced AlGaN/GaN HEMT cascode cells: design method for wideband distributed amplifiers. / Martin A., Reveyrand T., Campovecchio M., Aubry R., Piotrowicz S., Floriot D., Quere R. // Electronics Letters. - 2008. - Vol. 44, No. 2. - P. 116-117.

J282. Colantonio P. High-efficiency ultra-wideband power amplifier in GaN technology. / Colantonio P., Giannini F., Giofre R., Piazzon L. // Electronics Letters. - 2008. - Vol. 44, No. 2. - P. 130-131.

J283. Tao Chuan Lim. MOSFETs RF Noise Optimization via Channel Engineering. / Tao Chuan Lim, Valentin R., Dambrine G., Danneville F. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 1. - P. 118-121.

J284. Saito W. A 120-W Boost Converter Operation Using a High-Voltage GaN-HEMT. / Saito W., Nitta T., Kakiuchi Y., Saito Y., Tsuda K., Omura I., Yamaguchi M. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 1. - P. 8-10.

J285. Srinidhi E.R. Volterra-Series-Based Distortion Analysis for Optimization of Out-of-Band Terminations in GaN HEMT Devices. / Srinidhi E.R., Ma R., Kompa G. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 1. - P. 24-27.

J286. Kumar V. 0.25 μm Self-Aligned AlGaN/GaN High Electron Mobility Transistors. / Kumar V., Kim D.H.,

Basu A., Adesida I. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 1. - P. 18-20.

J287. Hsien-Chin Chiu. Electrical Characteristics of Passivated Pseudomorphic HEMTs With Pretreatment. / Hsien-Chin Chiu, Yuan-Chang Huang, Chung-Wen Chen, Liann-Be Chang. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 3. - P. 721-726.

J288. Dong Xu. Asymmetrically Recessed 50-nm Gate-Length Metamorphic High Electron-Mobility Transistor With Enhanced Gain Performance. / Dong Xu, Kong W.M.T., Xiaoping Yang, Smith P.M., Dugas D., Chao P.C., Cueva G., Mohnkern L., Seekell P., Pleasant L.Mt., Schmanski B., Duh K.H.G., Karimy H., Immorlica A., Komiak J.J. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 1. - P. 4-7.

J289. Pukala D. Submillimeter-Wave InP MMIC Amplifiers From 300-345 GHz. / Pukala D., Samoska L., Gaier T., Fung A., Mei X.B., Yoshida W., Lee J., Uyeda J., Liu P.H., Deal W.R., Radisic V., Lai R. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 1. - P. 61-63.

J290. Menozzi R. Temperature-Dependent Characterization of AlGaN/GaN HEMTs: Thermal and Source/Drain Resistances. / Menozzi R., Umana-Membreno G.A., Nener B.D., Parish G., Sozzi G., Faraone L., Mishra U.K. // IEEE Transactions on Device and Materials Reliability. - 2008. - Vol. 8, No. 2. - P. 255-264.

J291. Gunnarsson S.E. A 220 GHz (G-Band) Microstrip MMIC Single-Ended Resistive Mixer. / Gunnarsson S.E., Wadefalk N., Angelov I., Zirath H., Kallfass I., Leuther A. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 3. - P. 215-217.

J292. Chien-I Kuo. RF and Logic Performance Improvement of Composite-Channel HEMT Using Gate-Sinking Technology. / Chien-I Kuo, Heng-Tung Hsu, Chang E.Y., Chia-Yuan Chang, Miyamoto Y., Datta S., Radosavljevic M., Guo-Wei Huang, Ching-Ting Lee. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 4. - P. 290-293.

J293. Gunnarsson S.E. Analysis and Design of a Novel 4 Subharmonically Pumped Resistive HEMT Mixer. IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 4. - P. 809-816.

J294. Resca D. Scalable Nonlinear FET Model Based on a Distributed Parasitic Network Description. / Resca D., Santarelli A., Raffo A., Cignani R., Vannini G., Filicori F., Schreurs D.M.M.-R. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 4. - P. 755-766.

J295. Crupi G. A New Millimeter-Wave Small-Signal Modeling Approach for pHEMTs Accounting for the Output Conductance Time Delay. / Crupi G., Schreurs D.M.M.-P., Raffo A., Caddemi A., Vannini G. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 4. - P. 741-746.

J296. Pei Y. Effect of Al Composition and Gate Recess on Power Performance of AlGaN/GaN High-Electron Mobility Transistors. / Pei Y., Chu R., Shen L., Fichtenbaum N.A., Chen Z., Brown D., Keller S., Denbaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 4. - P. 300-302.

J297. Koudymov A. Analytical HFET-Model in Presence of Current Collapse. / Koudymov A., Shur M.S., Simin G., Kanin Chu, Chao P.C., Lee C., Jimenez J., Balistreri A. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 3. - P. 712-720.

J298. Simms R.J.T. Channel Temperature Determination in High-Power AlGaN/GaN HFETs Using Electrical Methods and Raman Spectroscopy. / Simms R.J.T., Pomeroy J.W., Uren M.J., Martin T., Kuball M. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 2. - P. 478-482.

J299. Jangheon Kim. Analysis of a Fully Matched Saturated Doherty Amplifier With Excellent Efficiency. / Jangheon Kim, Junghwan Moon, Young Yun Woo, Sungchul Hong, Ildu Kim, Jungjoon Kim, Bumman Kim. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 2. - P. 328-338.

J300. Mishra U.K. GaN-Based RF Power Devices and Amplifiers. / Mishra U.K., Shen Likun, Kazior T.E., Yi-Feng Wu. // Proceedings of the IEEE. - 2008. - Vol. 96, No. 2. - P. 287-305.

J301. Hopper R.H. Micro-Raman/Infrared Temperature Monitoring of Gunn Diodes. / Hopper R.H., Oxley C.H., Pomeroy J.W., Kuball M. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 4. - P. 1090-1093.

J302. Kuzmik J. Technology and Performance of InAlN/AlN/GaN HEMTs With Gate Insulation and Current

Collapse Suppression Using Zr or Hf. / Kuzmik J., Pozzovivo G., Abermann S., Carlin J.-F., Gonschorek M., Feltin E., Grandjean N., Bertagnolli E., Strasser G., Pogany D. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 3. - P. 937-941.

J303. Malmkvist M. Epitaxial Optimization of 130-nm Gate-Length InGaAs/InAlAs/InP HEMTs for High-Frequency Applications. / Malmkvist M., Shumin Wang, Grahn J.V. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 1. - P. 268-275.

J304. Pullia A. An SiC/GaN Detector/Front-End Detection System for High-Resolution Alpha-Particle Spectroscopy. / Pullia A., Bertuccio G., Maiocchi D., Caccia S., Zocca F. // IEEE Transactions on Nuclear Science. - 2008. - Vol. 55, No. 6. - P. 3736-3740.

J305. Darwish A.M. Utilizing Diode Characteristics for GaN HEMT Channel Temperature Prediction. / Darwish A.M., Bayba A.J., Hung H.A. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 12. - P. 3188-3192.

J306. Lee J. Low Insertion-Loss Single-Pole-Double-Throw Reduced-Size Quarter-Wavelength HEMT Bandpass Filter Integrated Switches. / Lee J., Ruei-Bin Lai, Chung-Chun Chen, Chin-Shen Lin, Kun-You Lin, Chau-Ching Chiong, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 12. - P. 3028-3038.

J307. Liang C.-T. Huge positive magnetoresistance in a gated Al Ga As /Ga As high electron mobility transistor structure at high temperatures. / Liang C.-T., Tseng Yen Shung, Wu Jau-Yang, Lin Sheng-Di, Yang Chun-Kai, Li Yu-Ru, Chen Kuang Yao, Lin Po-Tsun, Lin Li-Hung. // Applied Physics Letters. - 2008. - Vol. 92, No. 13. - P. 132111-132111-3.

J308. Hung S. C. Detection of chloride ions using an integrated Ag /Ag Cl electrode with Al Ga N /Ga N high electron mobility transistors. / Hung S. C., Wang Y. L., Hicks B., Pearton S. J., Dennis D. M., Ren F., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J., Chi G. C. // Applied Physics Letters. - 2008. - Vol. 92, No. 19. - P. 193903-193903-3.

J309. Chen K. H. c-erbB-2 sensing using Al Ga N /Ga N high electron mobility transistors for breast cancer detection. / Chen K. H., Kang B. S., Wang H. T., Lele T. P., Ren F., Wang Y. L., Chang C. Y., Pearton S. J., Dennis D. M., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2008. - Vol. 92, No. 19. - P. 192103-192103-3.

J310. Liang C.-T. Electron heating and huge positive magnetoresistance in an Al Ga As /Ga As high electron mobility transistor structure at high temperatures. / Liang C.-T., Li Yu-Ru, Lin Li-Hung, Lin Po-Tsun, Yang Chun-Kai, Tseng Yen Shung, Chen Kuang Yao, Cooper N. R., Simmons M. Y., Ritchie D. A. // Applied Physics Letters. - 2008. - Vol. 92, No. 15. - P. 152117-152117-3.

J311. Abe Y. Inverse Class-F AlGaN/GaN HEMT Microwave Amplifier Based on Lumped Element Circuit Synthesis Method. / Abe Y., Ishikawa R., Honjo K. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 12. - P. 2748-2753.

J312. Kumar V. Self-aligned AlGaN/GaN high electron mobility transistors with 0.18 μm gate-length. / Kumar V., Basu A., Kim D.-H., Adesida I. // Electronics Letters. - 2008. - Vol. 44, No. 22. - P. 1323-1324.

J313. Cordier Y. Demonstration of AlGaN/GaN High-Electron-Mobility Transistors Grown by Molecular Beam Epitaxy on Si(110). / Cordier Y., Moreno J.-C., Baron N., Frayssinet E., Chenot S., Damilano B., Semond F. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 11. - P. 1187-1189.

J314. Li-Yang Chen. On an InGaP/InGaAs Double Channel Pseudomorphic High Electron Mobility Transistor With Graded Triple -Doped Sheets. / Li-Yang Chen, Shiou-Ying Cheng, Tzu-Pin Chen, Kuei-Yi Chu, Tsung-Han Tsai, Yi-Chun Liu, Xin-Da Liao, Wen-Chau Liu. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 11. - P. 3310-3313.

J315. Yang Hou. An Efficient Technique for Designing High-Performance Millimeter-Wave Vector Modulators With Low Temperature Drift. / Yang Hou, Lingyun Li, Rong Qian, Xiaowei Sun. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 12. - P. 3100-3107.

J316. Malmkvist M. Electrical Characterization and Small-Signal Modeling of InAs/AlSb HEMTs for Low-Noise

and High-Frequency Applications. / Malmkvist M., Lefebvre E., Borg M., Desplanque L., Wallart X., Dambrine G., Bollaert S., Grahn J. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 12. - P. 2685-2691.

J317. Bahat-Treidel E. Punchthrough-Voltage Enhancement of AlGaN/GaN HEMTs Using AlGaN Double-Heterojunction Confinement. / Bahat-Treidel E., Hilt O., Brunner F., Wurfl J., Trankle G. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 12. - P. 3354-3359.

J318. Cullen David A. Assessment of surface damage and sidewall implantation in AlGaN-based high electron mobility transistor devices caused during focused-ion-beam milling. / Cullen David A., Smith David J. // Journal of Applied Physics. - 2008. - Vol. 104, No. 9. - P. 094304-094304-7.

J319. Popov V. V. Suppression of the intermode plasmon scattering due to total internal reflection of oblique plasmons in a multichannel high-electron-mobility transistor. Applied Physics Letters. - 2008. - Vol. 93, No. 8. - P. 083501-083501-3.

J320. Dabiran A. M. Very high channel conductivity in low-defect AlN/GaN high electron mobility transistor structures. / Dabiran A. M., Wowchak A. M., Osinsky A., Xie J., Hertog B., Cui B., Look D. C., Chow P. P. // Applied Physics Letters. - 2008. - Vol. 93, No. 8. - P. 082111-082111-3.

J321. Leiman V. G. Analysis of resonant detection of terahertz radiation in high-electron mobility transistor with a nanostring/carbon nanotube as the mechanically floating gate. / Leiman V. G., Ryzhii M., Satou A., Ryabova N., Ryzhii V., Otsuji T., Shur M. S. // Journal of Applied Physics. - 2008. - Vol. 104, No. 2. - P. 024514-024514-7.

J322. Lubyshev D. Molecular beam epitaxy growth of metamorphic high electron mobility transistors and metamorphic heterojunction bipolar transistors on Ge and Ge-on-insulator/Si substrates. / Lubyshev D., Fastenau J. M., Wu Y., Liu W. K., Bulsara M. T., Fitzgerald E. A., Hoke W. E. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2008. - Vol. 26, No. 3. - P. 1115-1119.

J323. Nidhi. Study of interface barrier of SiN x /GaN interface for nitrogen-polar GaN based high electron mobility transistors. / Nidhi, Rajan Siddharth, Keller Stacia, Wu Feng, DenBaars Steven P., Speck James S., Mishra Umesh K. // Journal of Applied Physics. - 2008. - Vol. 103, No. 12. - P. 124508-124508-4.

J324. Kang B. S. Electrical detection of biomaterials using AlGaN/GaN high electron mobility transistors. / Kang B. S., Wang H. T., Ren F., Pearton S. J. // Journal of Applied Physics. - 2008. - Vol. 104, No. 3. - P. 031101-031101-11.

J325. Chung J. W. Effect of image charges in the drain delay of Al Ga N /Ga N high electron mobility transistors. / Chung J. W., Zhao X., Wu Y.-R., Singh J., Palacios T. // Applied Physics Letters. - 2008. - Vol. 92, No. 9. - P. 093502-093502-3.

J326. Nanjo Takuma. Remarkable breakdown voltage enhancement in AlGaN channel high electron mobility transistors. / Nanjo Takuma, Takeuchi Misaichi, Suita Muneyoshi, Oishi Toshiyuki, Abe Yuji, Tokuda Yasunori, Aoyagi Yoshinobu. // Applied Physics Letters. - 2008. - Vol. 92, No. 26. - P. 263502-263502-3.

J327. Chen Wanjun. High-performance Al Ga N /Ga N lateral field-effect rectifiers compatible with high electron mobility transistors. / Chen Wanjun, Wong King-Yuen, Huang Wei, Chen Kevin J. // Applied Physics Letters. - 2008. - Vol. 92, No. 25. - P. 253501-253501-3.

J328. Seo Hui-Chan. Ti-based nonalloyed Ohmic contacts for Al 0.15 Ga 0.85 N /Ga N high electron mobility transistors using regrown n+ -Ga N by plasma assisted molecular beam epitaxy. / Seo Hui-Chan, Chapman Patrick, Cho Hyun-Ick, Lee Jung-Hee, Kim Kyekyoon (Kevin). // Applied Physics Letters. - 2008. - Vol. 93, No. 10. - P. 102102-102102-3.

J329. Chu B. H. Enzyme-based lactic acid detection using Al Ga N /Ga N high electron mobility transistors with ZnO nanorods grown on the gate region. / Chu B. H., Kang B. S., Ren F., Chang C. Y., Wang Y. L., Pearton S. J., Glushakov A. V., Dennis D. M., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2008. - Vol. 93, No. 4. - P. 042114-042114-3.

J330. Wang Yu-Lin. Botulinum toxin detection using Al Ga N /Ga N high electron mobility transistors. / Wang Yu-Lin, Chu B. H., Chen K. H., Chang C. Y., Lele T. P., Tseng Y., Pearton S. J., Ramage J., Hooten D., Dabiran

A., Chow P. P., Ren F. // Applied Physics Letters. - 2008. - Vol. 93, No. 26. - P. 262101-262101-3.

J331. Mahadik Nadeemullah A. Surface strain and its impact on the electrical resistivity of GaN channel in AlGaN/GaN high electron mobility transistor. / Mahadik Nadeemullah A., Qadri Syed B., Rao Mulpuri V. // Applied Physics Letters. - 2008. - Vol. 93, No. 22. - P. 222106-222106-3.

J332. Moon J. Highly Efficient Three-Way Saturated Doherty Amplifier With Digital Feedback Predistortion. / Moon J., Kim J., Kim I., Kim B. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 8. - P. 539-541.

J333. Yong-Sub Lee. Unequal-Cells-Based GaN HEMT Doherty Amplifier With an Extended Efficiency Range. / Yong-Sub Lee, Mun-Woo Lee, Yoon-Ha Jeong. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 8. - P. 536-538.

J334. Yuanzheng Yue. AlGaN/GaN MOS-HEMT With Dielectric and Interfacial Passivation Layer Grown by Atomic Layer Deposition. / Yuanzheng Yue, Yue Hao, Jincheng Zhang, Jinyu Ni, Wei Mao, Qian Feng, Linjie Liu. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 8. - P. 838-840.

J335. Deal W.R. A New Sub-Millimeter Wave Power Amplifier Topology Using Large Transistors. / Deal W.R., Mei X.B., Radisic V., Bayuk B., Fung A., Yoshida W., Liu P.H., Uyeda J., Samoska L., Gaier T., Lai R. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 8. - P. 542-544.

J336. Bonani F. When self-consistency makes a difference. / Bonani F., Camarchia V., Cappelluti F., Guerrieri S., Ghione G., Pirola M. // IEEE Microwave Magazine. - 2008. - Vol. 9, No. 5. - P. 81-89.

J337. Hong S.K. Reduced gate leakage current in AlGaN/GaN HEMT by oxygen passivation of AlGaN surface. / Hong S.K., Shim K.H., Yang J.W. // Electronics Letters. - 2008. - Vol. 44, No. 18. - P. 1091-1092.

J338. Rongming Chu. V-Gate GaN HEMTs for X-Band Power Applications. / Rongming Chu, Likun Shen, Fichtenbaum N., Brown D., Zhen Chen, Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 9. - P. 974-976.

J339. Sudow M. An AlGaN/GaN HEMT-Based Microstrip MMIC Process for Advanced Transceiver Design. / Sudow M., Fagerlind M., Thorsell M., Andersson K., Billstrom N., Nilsson P.-A., Rorsman N. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 8. - P. 1827-1833.

J340. Limiti E. Alternative approach to dynamic I/V characterisation of microwave FETs. / Limiti E., Nanni A., Serino A., Giannini F. // Electronics Letters. - 2008. - Vol. 44, No. 14. - P. 852-853.

J341. Zimmermann T. AlN/GaN Insulated-Gate HEMTs With 2.3 A/mm Output Current and 480 mS/mm Transconductance. / Zimmermann T., Deen D., Yu Cao, Simon J., Fay P., Jena D., Xing H.G. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 7. - P. 661-664.

J342. Ciccognani W. High-power monolithic AlGaN/GaN HEMT switch for X-band applications. / Ciccognani W., De Dominicis M., Ferrari M., Limiti E., Peroni M., Romanini P. // Electronics Letters. - 2008. - Vol. 44, No. 15. - P. 911-912.

J343. Dae-Hyun Kim. 30-nm InAs Pseudomorphic HEMTs on an InP Substrate With a Current-Gain Cutoff Frequency of 628 GHz. / Dae-Hyun Kim, del Alamo J.A. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 8. - P. 830-833.

J344. Nakajima M. Low-Frequency Noise Characteristics in Ion-Implanted GaN-Based HEMTs. / Nakajima M., Ohsawa T., Nomoto K., Nakamura T. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 8. - P. 827-829.

J345. Yifeng Wu. A 97.8% Efficient GaN HEMT Boost Converter With 300-W Output Power at 1 MHz. / Yifeng Wu, Jacob-Mitos M., Moore M.L., Heikman S. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 8. - P. 824-826.

J346. Rongming Chu. V-Gate GaN HEMTs With Engineered Buffer for Normally Off Operation. / Rongming Chu, Zhen Chen, DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 11. - P. 1184-1186.

J347. Sudow M. A Single-Ended Resistive -Band AlGaN/GaN HEMT MMIC Mixer. / Sudow M., Andersson K., Fagerlind M., Thorsell M., Nilsson P.-A., Rorsman N. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 10. - P. 2201-2206.

J348. Heller E.R. Simulation of Life Testing Procedures for Estimating Long-Term Degradation and Lifetime of AlGaN/GaN HEMTs. IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 10. - P. 2554-2560.

J349. Chung J.W. Effect of Gate Leakage in the Subthreshold Characteristics of AlGaN/GaN HEMTs. / Chung J.W., Roberts J.C., Piner E.L., Palacios T. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 11. - P. 1196-1198.

J350. Colantonio P. A Design Technique for Concurrent Dual-Band Harmonic Tuned Power Amplifier. / Colantonio P., Giannini F., Giofre R., Piazzon L. // IEEE Transactions on Microwave Theory and Techniques. - 2008. - Vol. 56, No. 11. - P. 2545-2555.

J351. Tessmann A. Metamorphic HEMT MMICs and Modules for Use in a High-Bandwidth 210 GHz Radar. / Tessmann A., Kallfass I., Leuther A., Massler H., Kuri M., Riessle M., Zink M., Sommer R., Wahlen A., Essen H., Hurm V., Schlechtweg M., Ambacher O. // IEEE Journal of Solid-State Circuits. - 2008. - Vol. 43, No. 10. - P. 2194-2205.

J352. Kalavagunta A. Electrostatic Mechanisms Responsible for Device Degradation in Proton Irradiated AlGaN/AlN/GaN HEMTs. / Kalavagunta A., Touboul A., Shen L., Schrimpf R.D., Reed R.A., Fleetwood D.M., Jain R.K., Mishra U.K. // IEEE Transactions on Nuclear Science. - 2008. - Vol. 55, No. 4. - P. 2106-2112.

J353. Khalil I. GaN HEMT Potential for Low-Noise Highly Linear RF Applications. / Khalil I., Liero A., Rudolph M., Lossy R., Heinrich W. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 9. - P. 605-607.

J354. Man Hoi Wong. N-Face Metal-Insulator-Semiconductor High-Electron-Mobility Transistors With AlN Back-Barrier. / Man Hoi Wong, Yi Pei, Rongming Chu, Rajan S., Swenson B.L., Brown D.F., Keller S., DenBaars S.P., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 10. - P. 1101-1104.

J355. Chowdhury U. TEM Observation of Crack- and Pit-Shaped Defects in Electrically Degraded GaN HEMTs. / Chowdhury U., Jimenez J.L., Lee C., Beam E., Saunier P., Balistreri T., Seong-Yong Park, Taehun Lee, Wang J., Kim M.J., Jungwoo Joh, del Alamo J.A. // IEEE Electron Device Letters. - 2008. - Vol. 29, No. 10. - P. 1098-1100.

J356. Yong-Sub Lee. Highly Efficient Doherty Amplifier Based on Class-E Topology for WCDMA Applications. / Yong-Sub Lee, Mun-Woo Lee, Yoon-Ha Jeong. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 9. - P. 608-610.

J357. Dae-Hyun Kim. Lateral and Vertical Scaling of HEMTs for Post-Si-CMOS Logic Applications. / Dae-Hyun Kim, del Alamo J.A. // IEEE Transactions on Electron Devices. - 2008. - Vol. 55, No. 10. - P. 2546-2553.

J358. Yu Liu. A 3-50 GHz Ultra-Wideband PHEMT MMIC Balanced Frequency Doubler. / Yu Liu, Tao Yang, Ziqiang Yang, Jia Chen. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 9. - P. 629-631.

J359. Che-Hung Lin. A 26-38 GHz Monolithic Doubly Balanced Mixer. / Che-Hung Lin, Chih-Ming Lin, Yu-Ann Lai, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2008. - Vol. 18, No. 9. - P. 623-625.

J360. Schmelzer D. A GaN HEMT Class F Amplifier at 2 GHz With > 80% PAE. / Schmelzer D., Long S.I. // IEEE Journal of Solid-State Circuits. - 2007. - Vol. 42, No. 10. - P. 2130-2136.

J361. Kobayashi K.W. Linearized Darlington Cascode Amplifier Employing GaAs PHEMT and GaN HEMT Technologies. IEEE Journal of Solid-State Circuits. - 2007. - Vol. 42, No. 10. - P. 2116-2122.

J362. Dae-Hyun Kim. Logic Suitability of 50-nm In0.7 Ga0.3 As HEMTs for Beyond-CMOS Applications. / Dae-Hyun Kim, del Alamo J.A., Jae-Hak Lee, Kwang-Seok Seo. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 10. - P. 2606-2613.

J363. Jessen G.H. Short-Channel Effect Limitations on High-Frequency Operation of AlGaN/GaN HEMTs for T-Gate Devices. / Jessen G.H., Fitch R.C., Gillespie J.K., Via G., Crespo A., Langley D., Denninghoff D.J., Trejo M., Heller E.R. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 10. - P. 2589-2597.

J364. Deal W.R. Design and Analysis of Broadband Dual-Gate Balanced Low-Noise Amplifiers. / Deal W.R., Biedenbender M., Po-hsin Liu, Uyeda J., Siddiqui M., Lai R. // IEEE Journal of Solid-State Circuits. - 2007. - Vol. 42, No. 10. - P. 2107-2115.

J365. Che-Hung Lin. A 23-37 GHz Miniature MMIC Subharmonic Mixer. / Che-Hung Lin, Yu-Ann Lai, Jui-Chieh Chiu, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 9. - P. 679-681.

J366. Ayubi-Moak J.S. Simulation of Ultrasubmicrometer-Gate Pseudomorphic HEMTs Using a Full-Band Monte Carlo Simulator. / Ayubi-Moak J.S., Ferry D.K., Goodnick S.M., Akis R., Saraniti M. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 9. - P. 2327-2338.

J367. Chia-Yuan Chang. Investigation of Impact Ionization in InAs-Channel HEMT for High-Speed and Low-Power Applications. / Chia-Yuan Chang, Heng-Tung Hsu, Chang E.Y., Chien-I Kuo, Datta S., Radosavljevic M., Miyamoto Y., Guo-Wei Huang. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 10. - P. 856-858.

J368. Camarchia V. Self-Consistent Electrothermal Modeling of Class A, AB, and B Power GaN HEMTs Under Modulated RF Excitation. / Camarchia V., Cappelluti F., Pirola M., Guerrieri S.D., Ghione G. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 9. - P. 1824-1831.

J369. Hong-Yeh Chang. A 30-130 GHz Ultra Broadband Direct-Conversion BPSK Modulator Using a 0.5- m E/D-PHEMT Process. / Hong-Yeh Chang, Cheng-Kuo Lin, Yu-Chi Wang. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 11. - P. 805-807.

J370. Che-Hung Lin. A Variable Conversion Gain Star Mixer for Ka-Band Applications. / Che-Hung Lin, Jui-Chieh Chiu, Chih-Ming Lin, Yu-Ann Lai, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 11. - P. 802-804.

J371. Felbinger J.G. Comparison of GaN HEMTs on Diamond and SiC Substrates. / Felbinger J.G., Chandra M.V.S., Yunju Sun, Eastman L.F., Wasserbauer J., Faili F., Babic D., Francis D., Ejeckam F. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 11. - P. 948-950.

J372. Weinreb S. Design of Cryogenic SiGe Low-Noise Amplifiers. / Weinreb S., Bardin J.C., Mani H. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 11. - P. 2306-2312.

J373. Chen Y.-J.E. An Integrated Wideband Power Amplifier for Cognitive Radio. / Chen Y.-J.E., Li-Yuan Yang, Wei-Chin Yeh. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 10. - P. 2053-2058.

J374. Gunnarsson S.E. Analysis and Design of Millimeter-Wave FET-Based Image Reject Mixers. / Gunnarsson S.E., Kuylenstierna D., Zirath H. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 10. - P. 2065-2074.

J375. Sathaiya D.M. Edge Effects on Gate Tunneling Current in HEMTs. / Sathaiya D.M., Karmalkar S. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 10. - P. 2614-2622.

J376. Raffo A. Electron Device Model Parameter Identification Through Large-Signal-Predictive Small-Signal-Based Error Functions. / Raffo A., Santarelli A., Traverso P.A., Vannini G., Filicori F. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 10. - P. 1997-2005.

J377. Heshmati Z. Microwave Parametric Frequency Dividers With Conversion Gain. / Heshmati Z., Hunter I.C., Pollard R.D. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 10. - P. 2059-2064.

J378. Saito W. Suppression of Dynamic On-Resistance Increase and Gate Charge Measurements in High-Voltage GaN-HEMTs With Optimized Field-Plate Structure. / Saito W., Nitta T., Kakiuchi Y., Saito Y., Tsuda K., Omura I., Yamaguchi M. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 8. - P. 1825-1830.

J379. Dong-Ming Lin. Dual-Gate E/E- and E/D-Mode AlGaAs/InGaAs pHEMTs for Microwave Circuit Applications. / Dong-Ming Lin, Cheng-Kuo Lin, Fan-Hsiu Huang, Jia-Shyan Wu, Wen-Kai Wang, Yu-Yi Tsai, Yi-Jen Chan, Yu-Chi Wang. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 8. - P. 1818-1824.

J380. Datta S. Ultrahigh-Speed 0.5 V Supply Voltage In0.7 Ga0.3 As Quantum-Well Transistors on Silicon Substrate. / Datta S., Dewey G., Fastenau J.M., Hudait M.K., Loubychev D., Liu W.K., Radosavljevic M., Rachmady W., Chau R. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 8. - P. 685-687.

J381. Sarua A. High-Resolution Raman Temperature Measurements in GaAs p-HEMT Multifinger Devices. / Sarua A., Bullen A., Haynes M.., Kuball M.. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 8. - P. 1838-1842.

J382. Khudchenko A.V. Cryogenic Phase Detector for Superconducting Integrated Receiver. / Khudchenko A.V., Koshelets V.P., Dmitriev P.N., Ermakov A.B., Yagoubov P.A., Pylypenko O.M. // IEEE Transactions on Applied Superconductivity. - 2007. - Vol. 17, No. 2. - P. 605-608.

J383. Chaibi M. Accurate large-signal single current source thermal model for GaAs MESFET/HEMT. / Chaibi M., Fernandez T., Rodriguez-Tellez J., Cano J.L., Aghoutane M. // Electronics Letters. - 2007. - Vol. 43, No. 14. - {no data available}.

J384. Cappelluti F. On the Substrate Thermal Optimization in SiC-Based Backside-Mounted High-Power GaN FETs. / Cappelluti F., Furno M., Angelini A., Bonani F., Pirola M., Ghione G. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 7. - P. 1744-1752.

J385. Introzzi R. Characterization of a Cryogenic RF-Preamplifier for Superconducting Photodetector Readout. / Introzzi R., Rajteri M., Brida G. // IEEE Transactions on Applied Superconductivity. - 2007. - Vol. 17, No. 2. - P. 383-386.

J386. Heying B. In situ SiN passivation of AlGaN/GaN HEMTs by molecular beam epitaxy. / Heying B., Smorchkova I.P., Coffie R., Gambin V., Chen Y.C., Sutton W., Lam T., Kahr M.S., Sikorski K.S., Wojtowicz M. // Electronics Letters. - 2007. - Vol. 43, No. 14. - {no data available}.

J387. McMorrow D. Transient Response of Semiconductor Electronics to Ionizing Radiation. Recent Developments in Charge-Collection Measurement. / McMorrow D., Ferlet-Cavrois V., Paillet P., Duhamel O., Baggio J., Boos J.B., Melinger J.S. // IEEE Transactions on Nuclear Science. - 2007. - Vol. 54, No. 4. - P. 1010-1017.

J388. Zuo-Min Tsai. Analysis and Design of Bandpass Single-Pole-Double-Throw FET Filter-Integrated Switches. / Zuo-Min Tsai, Yu-Sian Jiang, Lee J., Kun-You Lin, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 8. - P. 1601-1610.

J389. Tipirneni N.. Silicon Dioxide-Encapsulated High-Voltage AlGaN/GaN HFETs for Power-Switching Applications. / Tipirneni N.., Adivarahan V.., Simin G.., Khan A.. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 9. - P. 784-786.

J390. Sadi T. Hot-Phonon Effect on the Electrothermal Behavior of Submicrometer III-V HEMTs. / Sadi T., Kelsall R.W. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 9. - P. 787-789.

J391. Kim S. 50nm In0.8 GaP/In/ sub 0.4/AlAs/In0.35 GaAs metamorphic HEMTs with ZEP=UV5 bilayer T-gate. / Kim S., Koh Y., Seo K. // Electronics Letters. - 2007. - Vol. 43, No. 16. - P. 895-897.

J392. Saito W. On -Resistance Modulation of High Voltage GaN HEMT on Sapphire Substrate Under High Applied Voltage. / Saito W., Nitta T., Kakiuchi Y., Saito Y., Tsuda K., Omura I., Yamaguchi M. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 8. - P. 676-678.

J393. Kang-Sung Lee. 35-nm Zigzag T-Gate Metamorphic GaAs HEMTs With an Ultrahigh of 520 GHz. / Kang-Sung Lee, Young-Su Kim, Yun-Ki Hong, Yoon-Ha Jeong. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 8. - P. 672-675.

J394. Yong-Sub Lee. A High-Efficiency Class-E GaN HEMT Power Amplifier for WCDMA Applications. / Yong-Sub Lee, Yoon-Ha Jeong. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 8. - P. 622-624.

J395. Suemitsu T. Enhanced Gate Swing in InP HEMTs With High Threshold Voltage by Means of InAlAsSb Barrier. / Suemitsu T., Yokoyama H., Sugiyama H., Tokumitsu M. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 8. - P. 669-671.

J396. Wang Chien-Chung. Huge positive magnetoresistance of Ga As /Al Ga As high electron mobility transistor structures at high temperatures. / Wang Chien-Chung, Liang C.-T., Jiang Yu-Ting, Chen Y. F., Cooper N. R., Simmons M. Y., Ritchie D. A. // Applied Physics Letters. - 2007. - Vol. 90, No. 25. - P. 252106-252106-3.

J397. Lin Y. C. Growth of very-high-mobility Al Ga Sb /In As high-electron-mobility transistor structure on si substrate for high speed electronic applications. / Lin Y. C., Yamaguchi H., Chang E. Y., Hsieh Y. C., Ueki M., Hirayama Y., Chang C. Y. // Applied Physics Letters. - 2007. - Vol. 90, No. 2. - P. 023509-023509-3.

J398. Kang B. S. Prostate specific antigen detection using Al Ga N /Ga N high electron mobility transistors. / Kang B. S., Wang H. T., Lele T. P., Tseng Y., Ren F., Pearton S. J., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2007. - Vol. 91, No. 11. - P. 112106-112106-3.

J399. Kang B. S. pH sensor using Al Ga N /Ga N high electron mobility transistors with Sc 2 O 3 in the gate region. / Kang B. S., Wang H. T., Ren F., Gila B. P., Abernathy C. R., Pearton S. J., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2007. - Vol. 91, No. 1. - P. 012110-012110-3.

J400. Liang C.-T. Electron-electron interactions in Al 0.15 Ga 0.85 N /Ga N high electron mobility transistor structures grown on Si substrates. / Liang C.-T., Lin Li-Hung, Huang J. Z., Zhang Zhi-Yao, Sun Zhe-Hau, Chen Kuang Yao, Chen N. C., Chang P. H., Chang Chin-An. // Applied Physics Letters. - 2007. - Vol. 90, No. 2. - P. 022107-022107-3.

J401. Mohammed Fitih M. First-layer Si metallizations for thermally stable and smooth Ohmic contacts for Al Ga N /Ga N high electron mobility transistors. / Mohammed Fitih M., Wang Liang, Adesida Ilesanmi. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2007. - Vol. 25, No. 2. - P. 324-333.

J402. Choi Y. C. C-doped semi-insulating GaN HFETs on sapphire substrates with a high breakdown voltage and low specific on-resistance. / Choi Y. C., Shi J., Pophristic M., Spencer M. G., Eastman L. F. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2007. - Vol. 25, No. 6. - P. 1836-1841.

J403. Selvaraj S. Lawrence. Al N /Al Ga N /Ga N metal-insulator-semiconductor high-electron-mobility transistor on 4 in. silicon substrate for high breakdown characteristics. / Selvaraj S. Lawrence, Ito Tsuneo, Terada Yutaka, Egawa Takashi. // Applied Physics Letters. - 2007. - Vol. 90, No. 17. - P. 173506-173506-3.

J404. Wang Chih-Cheng. Reactive ion etching technique for via-hole applications in thick GaAs wafers. / Wang Chih-Cheng, Lin Yu-Lu, Lin Shun-Kuan, Li Chun-Sheng, Huang Hou-Kuei, Wu Chang-Luen, Chang Chian-Sern, Wang Yeong-Her. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2007. - Vol. 25, No. 2. - P. 312-317.

J405. Wang Hung-Ta. Fast electrical detection of Hg(II) ions with Al Ga N /Ga N high electron mobility transistors. / Wang Hung-Ta, Kang B. S., Chancellor T. F., Lele T. P., Tseng Y., Ren F., Pearton S. J., Johnson W. J., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2007. - Vol. 91, No. 4. - P. 042114-042114-3.

J406. Kang B. S. Enzymatic glucose detection using ZnO nanorods on the gate region of Al Ga N /Ga N high electron mobility transistors. / Kang B. S., Wang H. T., Ren F., Pearton S. J., Morey T. E., Dennis D. M., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2007. - Vol. 91, No. 25. - P. 252103-252103-3.

J407. Arulkumaran S. High temperature power performance of Al Ga N /Ga N high-electron-mobility transistors on high-resistivity silicon. / Arulkumaran S., Ng G. I., Liu Z. H., Lee C. H. // Applied Physics Letters. - 2007. - Vol. 91, No. 8. - P. 083516-083516-3.

J408. Pozzovivo G. Gate insulation and drain current saturation mechanism in In Al N /Ga N metal-oxide-semiconductor high-electron-mobility transistors. / Pozzovivo G., Kuzmik J., Golka S., Schrenk W., Strasser G.,

Pogany D., Cico K., Tapajna M., Frohlich K., Carlin J.-F., Gonschorek M., Feltin E., Grandjean N. // Applied Physics Letters. - 2007. - Vol. 91, No. 4. - P. 043509-043509-3.

J409. Wong Man Hoi. Low nonalloyed Ohmic contact resistance to nitride high electron mobility transistors using N-face growth. / Wong Man Hoi, Pei Yi, Palacios Tomas, Shen Likun, Chakraborty Arpan, McCarthy Lee S., Keller Stacia, DenBaars Steven P., Speck James S., Mishra Umesh K. // Applied Physics Letters. - 2007. - Vol. 91, No. 23. - P. 232103-232103-3.

J410. Khmyrova I. Analysis of plasma oscillations in high-electron mobility transistorlike structures: Distributed circuit approach. / Khmyrova I., Seijyou Yu. // Applied Physics Letters. - 2007. - Vol. 91, No. 14. - P. 143515-143515-3.

J411. Vink I. T. Cryogenic amplifier for fast real-time detection of single-electron tunneling. / Vink I. T., Nooitgedagt T., Schouten R. N., Vandersypen L. M. K., Wegscheider W. // Applied Physics Letters. - 2007. - Vol. 91, No. 12. - P. 123512-123512-3.

J412. Wang H. T. Electrical detection of kidney injury molecule-1 with Al Ga N /Ga N high electron mobility transistors. / Wang H. T., Kang B. S., Ren F., Pearton S. J., Johnson J. W., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2007. - Vol. 91, No. 22. - P. 222101-222101-3.

J413. Lin H. C. Enhancement-mode GaAs metal-oxide-semiconductor high-electron-mobility transistors with atomic layer deposited Al 2 O 3 as gate dielectric. / Lin H. C., Yang T., Sharifi H., Kim S. K., Xuan Y., Shen T., Mohammadi S., Ye P. D. // Applied Physics Letters. - 2007. - Vol. 91, No. 21. - P. 212101-212101-3.

J414. Jardel O. An Electrothermal Model for AlGaN/GaN Power HEMTs Including Trapping Effects to Improve Large-Signal Simulation Results on High VSWR. / Jardel O., De Groote F., Reveyrand T., Jacquet J.-C., Charbonniaud C., Teyssier J.-P., Floriot D., Quere R. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 12. - P. 2660-2669.

J415. Shih-Fong Chao. 40-GHz MMIC SPDT and Multiple-Port Bandpass Filter-Integrated Switches. / Shih-Fong Chao, Che-Chung Kuo, Zou-Min Tsai, Kun-You Lin, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 12. - P. 2691-2699.

J416. Tae-Woo Kim. Effect of a Two-Step Recess Process Using Atomic Layer Etching on the Performance of In0.52 Al0.48 As/In0.53 Ga0.47 As p-HEMTs. / Tae-Woo Kim, Dae-Hyun Kim, Sang Park Duk, Geun Yeom Young, Byeong Lim Ok, Jin-Koo Rhee, Jae-Hyung Jang, Jong-In Song. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 12. - P. 1086-1088.

J417. Deal W.R. Development of Sub-Millimeter-Wave Power Amplifiers. / Deal W.R., Mei X.B., Radisic V., Lange M.D., Yoshida W., Liu Po-hsin, Uyeda J., Barsky M.E., Fung A., Gaier T., Lai R. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 12. - P. 2719-2726.

J418. Vasallo B.G. Comparison Between the Dynamic Performance of Double- and Single-Gate AlInAs/InGaAs HEMTs. / Vasallo B.G., Wichmann N., Bollaert S., Roelens Y., Cappy A., Gonzalez T., Pardo D., Mateos J. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 11. - P. 2815-2822.

J419. Poblenz C. Power Performance of AlGaN/GaN HEMTs Grown on SiC by Ammonia-MBE at 4 and 10 GHz. / Poblenz C., Corrion A.L., Recht F., Chang Soo Suh, Chu R., Shen L., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 11. - P. 945-947.

J420. Nomoto K. Remarkable Reduction of On-Resistance by Ion Implantation in GaN/AlGaN/GaN HEMTs With Low Gate Leakage Current. / Nomoto K., Tajima T., Mishima T., Satoh M., Nakamura T. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 11. - P. 939-941.

J421. Jarndal A. Large-Signal Model for AlGaN/GaN HEMTs Accurately Predicts Trapping- and Self-Heating-Induced Dispersion and Intermodulation Distortion. / Jarndal A., Kompa G. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 11. - P. 2830-2836.

J422. Boulay S. AlGaN/GaN HEMTs on a (001)-Oriented Silicon Substrate Based on 100-nm SiN Recessed Gate Technology for Microwave Power Amplification. / Boulay S., Touati S., Sar A.A., Hoel V., Gaquiere C., De Jaeger J.-C., Joblot S., Cordier Y., Semond F., Massies J. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 11. - P. 2843-2848.

J423. Pei Y. Deep submicron AlGaN/GaN HEMTs with ion implanted source/drain regions and non-alloyed ohmic contacts. / Pei Y., Recht F., Fichtenbaum N., Keller S., DenBaars S.P., Mishra U.K. // Electronics Letters. - 2007. - Vol. 43, No. 25. - P. 1466-1467.

J424. McClory J.W. Temperature Dependent Electrical Characteristics of Neutron Irradiated AlGaN/GaN HFETs. / McClory J.W., Petrosky J.C. // IEEE Transactions on Nuclear Science. - 2007. - Vol. 54, No. 6. - P. 1969-1974.

J425. Schuette Michael L. Highly selective zero-bias plasma etching of GaN over AlGaN. / Schuette Michael L., Lu Wu. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2007. - Vol. 25, No. 6. - P. 1870-1874.

J426. Trivedi A.R. Switching voltage, dynamic power dissipation and on-to-off conductance ratio of a spin field effect transistor. / Trivedi A.R., Bandyopadhyay S., Cahay M. // IET Circuits, Devices & Systems. - 2007. - Vol. 1, No. 6. - P. 395-400.

J427. Fan-Hsiu Huang. A W-band Injection-Locked Frequency Divider Using GaAs pHEMTs and Cascode Circuit Topology. / Fan-Hsiu Huang, Cheng-Kuo Lin, Yen-Shiang Wu, Yu-Chi Wang, Yi-Jen Chan. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 12. - P. 885-887.

J428. Sarazin N. X-band power characterisation of AlInN/AlN/GaN HEMT grown on SiC substrate. / Sarazin N., Jardel O., Morvan E., Aubry R., Laurent M., Magis M., Tordjman M., Alloui M., Drisse O., Di Persio J., di Poisson M.A., Delage S.L., Vellas N., Gaquiere C., Theron D. // Electronics Letters. - 2007. - Vol. 43, No. 23. - {no data available}.

J429. Sun H.F. Impact of selective Al2 O3 passivation on current collapse in AlGaN/GaN HEMTs. / Sun H.F., Bolognesi C.R. // Electronics Letters. - 2007. - Vol. 43, No. 23. - {no data available}.

J430. Yu-Ann Lai. A Compact Ka-Band Planar Three-Way Power Divider. / Yu-Ann Lai, Chi-Ming Lin, Jui-Chieh Chiu, Che-Hung Lin, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 12. - P. 840-842.

J431. Erickson N.R. A Low-Loss 74-110-GHz Faraday Polarization Rotator. / Erickson N.R., Grosslein R.M. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 12. - P. 2495-2501.

J432. Mizutani T. AlGaN/GaN HEMTs With Thin InGaN Cap Layer for Normally Off Operation. / Mizutani T., Ito M., Kishimoto S., Nakamura F. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 7. - P. 549-551.

J433. Seelmann-Eggebert M. A Systematic State–Space Approach to Large-Signal Transistor Modeling. / Seelmann-Eggebert M., Merkle T., van Raay F., Quay R., Schlechtweg M. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 2. - P. 195-206.

J434. Adivarahan V. Selectively Doped High-Power AlGaN/InGaN/GaN MOS-DHFET. / Adivarahan V., Gaevski M., Koudymov A., Yang J., Simin G., Khan M.A. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 3. - P. 192-194.

J435. Lin C.-H. A Compact 6.5-W PHEMT MMIC Power Amplifier for Ku-Band Applications. / Lin C.-H., Liu H.-Z., Chu C.-K., Huang H.-K., Liu C.-C., Chang C.-H., Wu C.-L., Chang C.-S., Wang Y.-H. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 2. - P. 154-156.

J436. Wu Y. C. SPDT GaAs Switches With Copper Metallized Interconnects. / Wu Y. C., Chang E. Y., Lin Y. C., Hsu H. T., Chen S. H., Wu W. C., Chu L. H., Chang C. Y. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 2. - P. 133-135.

J437. Di Song. Normally Off AlGaN/GaN Low-Density Drain HEMT (LDD-HEMT) With Enhanced Breakdown Voltage and Reduced Current Collapse. / Di Song, Jie Liu, Zhiqun Cheng, Tang W.C.W., Lau K.M., Chen K.J. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 3. - P. 189-191.

J438. Kuan-Wei Lee. Improvement of Impact Ionization Effect and Subthreshold Current in InAlAs/InGaAs Metal–Oxide–Semiconductor Metamorphic HEMT With a Liquid-Phase Oxidized InAlAs as Gate Insulator. / Kuan-Wei Lee, Kai-Lin Lee, Xian-Zheng Lin, Chao-Hsien Tu, Yeong-Her Wang. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 3. - P. 418-424.

J439. Hideaki Matsuzaki. Lateral Scale Down of InGaAs/InAs Composite-Channel HEMTs With Tungsten-Based Tiered Ohmic Structure for 2-S/mm gm and 500-GHz fT. / Hideaki Matsuzaki, Takashi Maruyama, Toshihiko Koasugi, Hiroyuki Takahashi, Masami Tokumitsu, Takatomo Enoki. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 3. - P. 378-384.

J440. Suzuki T. A 50-Gbit/s 450-mW Full-Rate 4:1 Multiplexer With Multiphase Clock Architecture in 0.13- InP HEMT Technology. / Suzuki T., Kawano Y., Nakasha Y., Yamaura S., Takahashi T., Makiyama K., Hirose T. // IEEE Journal of Solid-State Circuits. - 2007. - Vol. 42, No. 3. - P. 637-646.

J441. Raphal Aubry. SThM Temperature Mapping and Nonlinear Thermal Resistance Evolution With Bias on AlGaN/GaN HEMT Devices. / Raphal Aubry, Jean-Claude Jacquet, J. Weaver, Olivier Durand, P. Dobson, G. Mills, Marie-Antoinette di Forte-Poisson, Simone Cassette, Sylvain-Laurent Delage. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 3. - P. 385-390.

J442. Chu C.-K. A 9.1–10.7 GHz 10-W, 40-dB Gain Four-Stage PHEMT MMIC Power Amplifier. / Chu C.-K., Huang H.-K., Liu H.-Z., Lin C.-H., Chang C.-H., Wu C.-L., Chang C.-S., Wang Y.-H. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 2. - P. 151-153.

J443. Liu J. DC and RF Characteristics of AlGaN/GaN/InGaN/GaN Double-Heterojunction HEMTs. / Liu J., Zhou Y., Zhu J., Cai Y., Lau K. M., Chen K. J. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 1. - P. 2-10.

J444. Xu J. Transient Thermal Analysis of GaN Heterojunction Transistors (HFETs) for High-Power Applications. / Xu J., Yin W.-Y., Mao J. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 1. - P. 55-57.

J445. Koudymov A. Power Stability of AlGaN/GaN HFETs at 20 W/mm in the Pinched-Off Operation Mode. / Koudymov A., Wang C. X., Adivarahan V., Yang J., Simin G., Khan M. A. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 1. - P. 5-7.

J446. Simin G. RF-Enhanced Contacts to Wide-Bandgap Devices. / Simin G., Yang Z.-J. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 1. - P. 2-4.

J447. Cheng Z.Q. A Low Phase-Noise -Band MMIC VCO Using High-Linearity and Low-Noise Composite-Channel HEMTs. / Cheng Z.Q., Yong Cai, Jie Liu, Yugang Zhou, Lau K.M., Chen K.J. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 1. - P. 23-29.

J448. Su K.-H. A Novel Dilute Antimony Channel In0.2 Ga0.8 AsSb/GaAs HEMT. / Su K.-H., Hsu W.-C., Lee C.-S., Wu T.-Y., Wu Y.-H., Chang L., Hsiao R.-S., Chen J.-F., Chi T.-W. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 2. - P. 96-99.

J449. Chang F.-C. A 4–41 GHz Singly Balanced Distributed Mixer Using GaAs pHEMT Technology. / Chang F.-C., Wu P.-S., Lei M.-F., Wang H. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 2. - P. 136-138.

J450. Toufik Sadi. Electrothermal Monte Carlo Simulation of Submicrometer Si/SiGe MODFETs. / Toufik Sadi, Robert W. Kelsall, Neil J. Pilgrim. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 2. - P. 332-339.

J451. Deparis N. Monolithic 10 GHz TDR/TDT analyser with novel architecture. / Deparis N., Rolland N., Rolland P.A. // Electronics Letters. - 2007. - Vol. 43, No. 1. - P. 38-39.

J452. Jeng-Han Tsai. A 38–46 GHz MMIC Doherty Power Amplifier Using Post-Distortion Linearization. / Jeng-Han Tsai, Tian-Wei Huang. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 5. - P. 388-390.

J453. Rodenbeck C.T. Accurate prediction of large-signal harmonic distortion in gallium nitride HEMTs. / Rodenbeck C.T., Follmann R. // Electronics Letters. - 2007. - Vol. 43, No. 10. - P. 590-591.

J454. Russo S. Influence of the Source–Gate Distance on the AlGaN/GaN HEMT Performance. / Russo S., Di Carlo A. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 5. - P. 1071-1075.

J455. Deal W.R. Demonstration of a 270-GHz MMIC Amplifier Using 35-nm InP HEMT Technology. / Deal W.R., Mei X.B., Radisic V., Yoshida W., Liu P.H., Uyeda J., Barsky M., Gaier T., Fung A., Samoska L., Lai R. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 5. - P. 391-393.

J456. Mei X.B. 35-nm InP HEMT SMMIC Amplifier With 4.4-dB Gain at 308 GHz. / Mei X.B., Yoshida W., Deal W.R., Liu P.H., Lee J., Uyeda J., Dang L., Wang J., Liu W., Li D., Barsky M., Kim Y.M., Lange M., Chin T.P., Radisic V., Gaier T., Fung A., Samoska L., Lai R. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 6. - P. 470-472.

J457. Medjdoub F. Characteristics of Al2 O3 /AlInN /GaN MOSHEMT. / Medjdoub F., Sarazin N., Tordjman M., Magis M., di Forte-Poisson M.A., Knez M., Delos E., Gaquiere C., Delage S.L., Kohn E. // Electronics Letters. - 2007. - Vol. 43, No. 12. - P. 691-692.

J458. Byeong Ok Lim. 50-nm T-Gate InAlAs/InGaAs Metamorphic HEMTs With Low Noise and High fT Characteristics. / Byeong Ok Lim, Mun Kyo Lee, Tae Jong Baek, Min Han, Sung Chan Kim, Jin-Koo Rhee. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 7. - P. 546-548.

J459. Jin-Yu Shiu. Oxygen Ion Implantation Isolation Planar Process for AlGaN/GaN HEMTs. / Jin-Yu Shiu, Jui-Chien Huang, Desmaris V., Chia-Ta Chang, Chung-Yu Lu, Kumakura K., Makimoto T., Zirath H., Rorsman N., Chang E.Y. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 6. - P. 476-478.

J460. Leuzzi G. Global Modeling Analysis of HEMTs by the Spectral Balance Technique. / Leuzzi G., Stornelli V. // IEEE Transactions on Microwave Theory and Techniques. - 2007. - Vol. 55, No. 6. - P. 1405-1412.

J461. Kruppa W. Low-Frequency Noise in AlSb/InAs and Related HEMTs. / Kruppa W., Boos J.B., Bennett B.R., Papanicolaou N.A., Park D., Bass R. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 5. - P. 1193-1202.

J462. F. Medjdoub. Evaluation of AlInN=GaN HEMTs on sapphire substrate in microwave, time and temperature domains. / F. Medjdoub, D. Ducatteau, C. Gaquiere, J.-F. Carlin, M. Gonschorek, E. Feltin, M.A. Py, N. Grandjean, E. Kohn. // Electronics Letters. - 2007. - Vol. 43, No. 5. - P. 71-72.

J463. Reale A. Thermal Maps of GaAs P-HEMT: A Novel System Based on the Photocurrent Spectral Analysis. / Reale A., Di Carlo A., Peroni M., Lanzieri C., Lavagna S. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 4. - P. 879-882.

J464. Jos Mara Tirado. Trapping Effects in the Transient Response of AlGaN/GaN HEMT Devices. / Jos Mara Tirado, Jos Luis Sanchez-Rojas, Jos Ignacio Izpura. // IEEE Transactions on Electron Devices. - 2007. - Vol. 54, No. 3. - P. 410-417.

J465. Radisic V. Demonstration of Sub-Millimeter Wave Fundamental Oscillators Using 35-nm InP HEMT Technology. / Radisic V., Mei X.B., Deal W.R., Yoshida W., Liu P.H., Uyeda J., Barsky M., Samoska L., Fung A., Gaier T., Lai R. // IEEE Microwave and Wireless Components Letters. - 2007. - Vol. 17, No. 3. - P. 223-225.

J466. Yong Cai. High-Temperature Operation of AlGaN/GaN HEMTs Direct-Coupled FET Logic (DCFL) Integrated Circuits. / Yong Cai, Zhiqun Cheng, Zhenchuan Yang, Chak Wah Tang, Lau K.M., Chen K.J. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 5. - P. 328-331.

J467. Srinidhi E.R. A New Method for Identification and Minimization of Distortion Sources in GaN HEMT Devices Based on Volterra Series Analysis. / Srinidhi E.R., Jarndal A., Kompa G. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 5. - P. 343-345.

J468. Gunnarsson S.E. 60 GHz Single-Chip Front-End MMICs and Systems for Multi-Gb/s Wireless Communication. / Gunnarsson S.E., Karnfelt C., Zirath H., Kozhuharov R., Kuylenstierna D., Fager C., Ferndahl M., Hansson B., Alping A., Hallbjorner P. // IEEE Journal of Solid-State Circuits. - 2007. - Vol. 42, No. 5. - P. 1143-1157.

J469. Koudymov A. Compact Model of Current Collapse in Heterostructure Field-Effect Transistors. / Koudymov A., Shur M.S., Simin G. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 5. - P. 332-335.

J470. Jessen G.H. RF Power Measurements of InAlN/GaN Unstrained HEMTs on SiC Substrates at 10 GHz. / Jessen G.H., Gillespie J.K., Via G.D., Crespo A., Langley D., Aumer M.E., Ward C.S., Henry H.G., Thomson

D.B., Partlow D.P. // IEEE Electron Device Letters. - 2007. - Vol. 28, No. 5. - P. 354-356.

J471. Hongtao Xu. A high-efficiency class-E GaN HEMT power amplifier at 1.9 GHz. / Hongtao Xu, Gao S., Heikman S., Long S.I., Mishra U.K., York R.A. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 1. - P. 22-24.

J472. R. Urata. An optically clocked transistor array with dual serial-to-parallel and parallel-to-serial conversion capability for optical label swapping. / R. Urata, R. Takahashi, T. Nakahara, K. Takahata, H. Suzuki. // IEEE Photonics Technology Letters. - 2006. - Vol. 18, No. 1. - P. 67-69.

J473. Das J. Improved Thermal Performance of AlGaN/GaN HEMTs by an Optimized Flip-Chip Design. / Das J., Oprins H., Hangfeng Ji, Sarua A., Ruythooren W., Derluyn J., Kuball M., Germain M., Borghs G. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 11. - P. 2696-2702.

J474. Gao S. Two-stage quasi-class-E power amplifier in GaN HEMT technology. / Gao S., Hongtao Xu, Heikman S., Mishra U.K., York R.A. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 1. - P. 28-30.

J475. Ducatteau D. Output power density of 5.1/mm at 18 GHz with an AlGaN/GaN HEMT on Si substrate. / Ducatteau D., Minko A., Hoel V., Morvan E., Delos E., Grimbert B., Lahreche H., Bove P., Gaquiere C., De Jaeger J.C., Delage S. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 1. - P. 7-9.

J476. Weifeng Zhao. Thermally stable Ge/Ag/Ni Ohmic contact for InAlAs/InGaAs/InP HEMTs. / Weifeng Zhao, Seiyon Kim, Jian Zhang, Adesida I. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 1. - P. 4-6.

J477. Riemer P.J. Low-power W-band CPWG InAs/AlSb HEMT low-noise amplifier. / Riemer P.J., Buhrow B.R., Hacker J.B., Bergman J., Brar B., Gilbert B.K., Daniel E.S. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 1. - P. 40-42.

J478. Tanaka Y. 700-V 1.0- Buried Gate SiC-SIT (SiC-BGSIT). / Tanaka Y., Okamoto M., Takatsuka A., Arai K., Yatsuo T., Yano K., Kasuga M. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 11. - P. 908-910.

J479. Kokawa Takuya. Liquid-phase sensors using open-gate Al Ga N /Ga N high electron mobility transistor structure. / Kokawa Takuya, Sato Taketomo, Hasegawa Hideki, Hashizume Tamotsu. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2006. - Vol. 24, No. 4. - P. 1972-1976.

J480. Liu Yuwei. Influence of silicon nitride passivation on transport properties in In Al As /In Ga As /In P composite channel high electron mobility transistor structures. / Liu Yuwei, Wang Hong. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2006. - Vol. 24, No. 4. - P. 1711-1715.

J481. Hoke W. E. Reaction of molecular beam epitaxial grown AlN nucleation layers with SiC substrates. / Hoke W. E., Torabi A., Hallock R. B., Mosca J. J., Kennedy T. D. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2006. - Vol. 24, No. 3. - P. 1500-1504.

J482. Anderson Travis. Laser ablation of via holes in GaN and Al Ga N /Ga N high electron mobility transistor structures. / Anderson Travis, Ren Fan, Pearton Stephen J., Mastro Michael A., Holm Ron T., Henry Rich L., Eddy Charles R., Lee Joon Yeob, Lee Kwan-Young, Kim Jihyun. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2006. - Vol. 24, No. 5. - P. 2246-2249.

J483. Nidhi. Study of Impact of Access Resistance on High-Frequency Performance of AlGaN/GaN HEMTs by Measurements at Low Temperatures. / Nidhi, Palacios T., Chakraborty A., Keller S., Mishra U.K. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 11. - P. 877-880.

J484. Seiyon Kim. 0.15- -Gate InAlAs/InGaAs/InP E-HEMTs Utilizing Ir/Ti/Pt/Au Gate Structure. / Seiyon Kim, Adesida I. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 11. - P. 873-876.

J485. Sagisaka H. Suppression of surface segregation of silicon dopants during molecular beam epitaxy of (411)A In 0.75 Ga 0.25 As /In 0.52 Al 0.48 As pseudomorphic high electron mobility transistor structures. / Sagisaka H., Kitada T., Shimomura S., Hiyamizu S., Watanabe I., Matsui T., Mimura T. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2006. - Vol. 24, No. 6. - P. 2668-2671.

J486. Jie Liu. AlGaN/GaN/InGaN/GaN DH-HEMTs with an InGaN notch for enhanced carrier confinement. / Jie Liu, Yugang Zhou, Jia Zhu, Lau K.M., Chen K.J. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 1. - P. 10-12.

J487. Gao S. High-efficiency power amplifier design including input harmonic termination. / Gao S., Butterworth P., Ooi S., Sambell A. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 2. - P. 81-83.

J488. Kamitsuna H. Low-power InP-HEMT switch ICs integrating miniaturized 2Ч2 switches for 10-Gb/s systems. / Kamitsuna H., Yamane Y., Tokumitsu M., Sugahara H., Muraguchi M. // IEEE Journal of Solid-State Circuits. - 2006. - Vol. 41, No. 2. - P. 452-460.

J489. Joblot S. AlGaN/GaN HEMTs on [001] silicon substrates. / Joblot S., Cordier Y., Semond F., Lorenzini P., Chenot S., Massies J. // Electronics Letters. - 2006. - Vol. 42, No. 2. - P. 117-118.

J490. Wei-Chou Hsu. Performance improvement in tensile-strained In0.5 Al0.5 As/Inx Ga1-x As/In0.5 Al0.5 As metamorphic HEMT. / Wei-Chou Hsu, Dong-Hai Huang, Yu-Shyan Lin, Yeong-Jia Chen, Jun-Chin Huang, Chang-Luen Wu. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 3. - P. 406-412.

J491. Oxley C.H. On the temperature and carrier density dependence of electron saturation velocity in an AlGaN/GaN HEMT. / Oxley C.H., Uren M.J., Coates A., Hayes D.G. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 3. - P. 565-567.

J492. Palacios T. Use of double-channel heterostructures to improve the access resistance and linearity in GaN-based HEMTs. / Palacios T., Chini A., Buttari D., Heikman S., Chakraborty A., Keller S., DenBaars S.P., Mishra U.K. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 3. - P. 562-565.

J493. Kuzmik J. InAlN/GaN HEMTs: a first insight into technological optimization. / Kuzmik J., Kostopoulos A., Konstantinidis G., Carlin J.-F., Georgakilas A., Pogany D. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 3. - P. 422-426.

J494. Uren M.J. Punch-through in short-channel AlGaN/GaN HFETs. / Uren M.J., Nash K.J., Balmer R.S., Martin T., Morvan E., Caillas N., Delage S.L., Ducatteau D., Grimbert B., De Jaeger J.C. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 2. - P. 395-398.

J495. Sung Chan Kim. High-performance 94-GHz single balanced mixer using 70-nm MHEMTs and surface micromachined technology. / Sung Chan Kim, An D., Byeong Ok Lim, Tae Jong Baek, Dong Hoon Shin, Jin Koo Rhee. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 1. - P. 28-30.

J496. Sanabria C. The effect of gate leakage on the noise figure of AlGaN/GaN HEMTs. / Sanabria C., Chakraborty A., Hongtao Xu, Rodwell M.J., Mishra U.K., York R.A. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 1. - P. 19-21.

J497. Palacios T. AlGaN/GaN high electron mobility transistors with InGaN back-barriers. / Palacios T., Chakraborty A., Heikman S., Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 1. - P. 13-15.

J498. Zbitou J. Hybrid rectenna and monolithic integrated zero-bias microwave rectifier. / Zbitou J., Latrach M., Toutain S. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 1. - P. 147-152.

J499. Saito W. Recessed-gate structure approach toward normally off high-Voltage AlGaN/GaN HEMT for power electronics applications. / Saito W., Takada Y., Kuraguchi M., Tsuda K., Omura I. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 2. - P. 356-362.

J500. Karmalkar S. On the resolution of the mechanism for reverse gate leakage in AlGaN/GaN HEMTs. / Karmalkar S., Satyan N., Sathaiya D.M. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 2. - P. 87-89.

J501. Crespo-Cadenas C. Evaluation of ACPR in mixers based on a parametric harmonic-balance approach. / Crespo-Cadenas C., Reina-Tosina J., Madero-Ayora M.J. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 1. - P. 445-450.

J502. Aust M.V. A 2.8-W Q-Band High-Efficiency Power Amplifier. / Aust M.V., Sharma A.K., Fordham O.,

Grundbacher R., To R., Tsai R.S., Lai R. // IEEE Journal of Solid-State Circuits. - 2006. - Vol. 41, No. 10. - P. 2241-2247.

J503. Tae-Woo Kim. A Capless p-HEMT Having a Self-Aligned Gate Structure. / Tae-Woo Kim, Seong June Jo, Jong-In Song. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 9. - P. 722-724.

J504. Tipirneni N. The 1.6-kV AlGaN/GaN HFETs. / Tipirneni N., Koudymov A., Adivarahan V., Yang J., Simin G., Khan M.A. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 9. - P. 716-718.

J505. Karmalkar S. A closed-form model of the drain-voltage dependence of the off-state channel electric field in a HEMT with a field plate. / Karmalkar S., Soudabi N. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 10. - P. 2430-2437.

J506. Kim T.-W. Characteristics of 0.2 μm depletion and quasi-enhancement mode self-aligned gate capless p-HEMTs. / Kim T.-W., Kim D.-H., Shin S.-H., Jo S.-J., Jang J.H., Song J.-I. // Electronics Letters. - 2006. - Vol. 42, No. 20. - P. 1178-1179.

J507. Crupi G. Accurate Multibias Equivalent-Circuit Extraction for GaN HEMTs. / Crupi G., Dongping Xiao, Schreurs D.M.M.-P., Limiti E., Caddemi A., De Raedt W., Germain M. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 10. - P. 3616-3622.

J508. Passlack M. Implant-free high-mobility flatband MOSFET: principles of operation. / Passlack M., Rajagopalan K., Abrokwah J., Droopad R. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 10. - P. 2454-2459.

J509. Dora Y. High Breakdown Voltage Achieved on AlGaN/GaN HEMTs With Integrated Slant Field Plates. / Dora Y., Chakraborty A., McCarthy L., Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 9. - P. 713-715.

J510. Yong Cai. Control of Threshold Voltage of AlGaN/GaN HEMTs by Fluoride-Based Plasma Treatment: From Depletion Mode to Enhancement Mode. / Yong Cai, Yugang Zhou, Lau K.M., Chen K.J. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 9. - P. 2207-2215.

J511. Jindal R.P. Compact Noise Models for MOSFETs. IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 9. - P. 2051-2061.

J512. Sadi T. Simulation of Electron Transport in InGaAs/AlGaAs HEMTs Using an Electrothermal Monte Carlo Method. / Sadi T., Kelsall R., Pilgrim N. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 8. - P. 1768-1774.

J513. Yong Cai. Monolithically Integrated Enhancement/Depletion-Mode AlGaN/GaN HEMT Inverters and Ring Oscillators Using Plasma Treatment. / Yong Cai, Zhiqun Cheng, Tang W.C.W., Lau K.M., Chen K.J. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 9. - P. 2223-2230.

J514. Liu Y. Enhancement-mode quaternary AlInGaN/GaN HEMT with non-recessed-gate on sapphire substrate. / Liu Y., Egawa T., Jiang H. // Electronics Letters. - 2006. - Vol. 42, No. 15. - P. 884-886.

J515. Matsuzaki H. 3 S/mm extrinsic transconductance of InP-based high electron mobility transistor by vertical and lateral scale-down. / Matsuzaki H., Maruyama T., Enoki T., Tokumitsu M. // Electronics Letters. - 2006. - Vol. 42, No. 15. - P. 883-884.

J516. Desmaris V. Comparison of the DC and Microwave Performance of AlGaN/GaN HEMTs Grown on SiC by MOCVD With Fe-Doped or Unintentionally Doped GaN Buffer Layers. / Desmaris V., Rudzinski M., Rorsman N., Hageman P.R., Larsen P.K., Zirath H., Rodle T.C., Jos H.F.F. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 9. - P. 2413-2417.

J517. Wang Hung-Ta. Robust detection of hydrogen using differential Al Ga N /Ga N high electron mobility transistor sensing diodes. / Wang Hung-Ta, Anderson T. J., Ren F., Li Changzhi, Low Zhen-Ning, Lin Jenshan, Gila B. P., Pearton S. J., Osinsky A., Dabiran Amir. // Applied Physics Letters. - 2006. - Vol. 89, No. 24. - P. 242111-242111-3.

J518. Chang Yuancheng. A thermal model for static current characteristics of Al Ga N /Ga N high electron

mobility transistors including self-heating effect. / Chang Yuancheng, Zhang Yimen, Zhang Yuming, Tong K. Y. // Journal of Applied Physics. - 2006. - Vol. 99, No. 4. - P. 044501-044501-5.

J519. Liu Yuwei. Experimental evidence for dislocation-related gettering in metamorphic InP /InGaAs high electron mobility transistor (HEMT) structures on GaAs substrate. / Liu Yuwei, Wang Hong. // Journal of Applied Physics. - 2006. - Vol. 100, No. 3. - P. 034505-034505-5.

J520. Cui L. J. Correlation between optical and electrical properties in In 0.52 Al 0.48 As /In x Ga 1-x As metamorphic high-electron-mobility-transistor structures on GaAs substrates. / Cui L. J., Zeng Y. P., Wang B. Q., Zhu Z. P., Guo S. L., Chu J. H. // Journal of Applied Physics. - 2006. - Vol. 100, No. 3. - P. 033705-033705-4.

J521. Tan S. G. Utilization of magnetoelectric potential in ballistic nanodevices. / Tan S. G., Jalil M. B. A., Bala Kumar S., Teo K. L., Liew Thomas. // Journal of Applied Physics. - 2006. - Vol. 99, No. 8. - P. 084305-084305-6.

J522. Dora Yuvaraj. ZrO 2 gate dielectrics produced by ultraviolet ozone oxidation for GaN and AlGaN /GaN transistors. / Dora Yuvaraj, Han Sooyeon, Klenov Dmitri, Hansen Peter J., No Kwang-soo, Mishra Umesh K., Stemmer Susanne, Speck James S. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2006. - Vol. 24, No. 2. - P. 575-581.

J523. Liu Yuwei. Effect of rapid thermal annealing on the optical and electrical properties of metamorphic high electron mobility transistor structures with composite In Ga As /In P channel. / Liu Yuwei, Wang Hong. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2006. - Vol. 24, No. 1. - P. 292-297.

J524. Ryzhii V. Plasma oscillations in high-electron-mobility transistors with recessed gate. / Ryzhii V., Satou A., Knap W., Shur M. S. // Journal of Applied Physics. - 2006. - Vol. 99, No. 8. - P. 084507-084507-5.

J525. Yu Hongbo. Growth of high crystalline quality semi-insulating GaN layers for high electron mobility transistor applications. / Yu Hongbo, Caliskan Deniz, Ozbay Ekmel. // Journal of Applied Physics. - 2006. - Vol. 100, No. 3. - P. 033501-033501-4.

J526. Selvaraj S. Lawrence. Enhancement of drain current density by inserting 3 nm Al layer in the gate of Al Ga N /Ga N high-electron-mobility transistors on 4 in. silicon. / Selvaraj S. Lawrence, Egawa Takashi. // Applied Physics Letters. - 2006. - Vol. 89, No. 19. - P. 193508-193508-3.

J527. Wang Liang. Correlating the Schottky barrier height with the interfacial reactions of Ir gates for In Al As /In Ga As high electron mobility transistors. / Wang Liang, Zhao Weifeng, Adesida Ilesanmi. // Applied Physics Letters. - 2006. - Vol. 89, No. 21. - P. 211910-211910-3.

J528. Meyer David J. S F 6 /O 2 plasma effects on silicon nitride passivation of Al Ga N /Ga N high electron mobility transistors. / Meyer David J., Flemish Joseph R., Redwing Joan M. // Applied Physics Letters. - 2006. - Vol. 89, No. 22. - P. 223523-223523-3.

J529. Liang C.-T. Al 0.15 Ga 0.85 N /Ga N high electron mobility transistor structures grown on p -type Si substrates. / Liang C.-T., Chen Kuang Yao, Chen N. C., Chang P. H., Chang Chin-An. // Applied Physics Letters. - 2006. - Vol. 89, No. 13. - P. 132107-132107-3.

J530. Lee Keon Jae. Bendable GaN high electron mobility transistors on plastic substrates. / Lee Keon Jae, Meitl Matthew A., Ahn Jong-Hyun, Rogers John A., Nuzzo Ralph G., Kumar Vipan, Adesida Ilesanmi. // Journal of Applied Physics. - 2006. - Vol. 100, No. 12. - P. 124507-124507-4.

J531. McAlister S. P. Self-heating and the temperature dependence of the dc characteristics of GaN heterostructure field effect transistors. / McAlister S. P., Bardwell J. A., Haffouz S., Tang H. // and Films Journal of Vacuum Science & Technology A: Vacuum, Surfaces. - 2006. - Vol. 24, No. 3. - P. 624-628.

J532. Kang B. S. Electrical detection of deoxyribonucleic acid hybridization with Al Ga N /Ga N high electron mobility transistors. / Kang B. S., Pearton S. J., Chen J. J., Ren F., Johnson J. W., Therrien R. J., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J. // Applied Physics Letters. - 2006. - Vol. 89, No. 12. - P. 122102-122102-3.

J533. Manan V. A low power and low noise p-HEMT ku band VCO. / Manan V., Long S.I. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 3. - P. 131-133.

J534. Lan X. A Q-band low phase noise monolithic AlGaN/GaN HEMT VCO. / Lan X., Wojtowicz M., Smorchkova I., Coffie R., Tsai R., Heying B., Truong M., Fong F., Kintis M., Namba C., Oki A., Wong T. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 7. - P. 425-427.

J535. Dora Y. Effect of ohmic contacts on buffer leakage of GaN transistors. / Dora Y., Chakraborty A., Heikman S., McCarthy L., Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 7. - P. 529-531.

J536. Masud M.A. A 45-dB variable-gain low-noise MMIC amplifier. / Masud M.A., Zirath H., Kelly M. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 6. - P. 2848-2855.

J537. Karnfelt C. High-purity 60-GHz-band single-chip /spl times/8 multipliers in pHEMT and mHEMT technology. / Karnfelt C., Kozhuharov R., Zirath H., Angelov I. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 6. - P. 2887-2898.

J538. Medjdoub F. Small-signal characteristics of AlInN/GaN HEMTs. / Medjdoub F., Carlin J.-F., Gonschorek M., Py M.A., Grandjean N., Vandenbrouck S., Gaquiere C., Dejaeger J.C., Kohn E. // Electronics Letters. - 2006. - Vol. 42, No. 13. - P. 779-780.

J539. Campos-Roca Y. G-band metamorphic HEMT-based frequency multipliers. / Campos-Roca Y., Schworer C., Leuther A., Seelmann-Eggebert M. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 7. - P. 2983-2992.

J540. Mury T. Analysis and synthesis of pHEMT class-E amplifiers with shunt inductor including ON-state active-device resistance effects. / Mury T., Fusco V.F. // IEEE Transactions on Circuits and Systems I: Regular Papers. - 2006. - Vol. 53, No. 7. - P. 1556-1564.

J541. Storm D.F. Microwave power performance of MBE-grown AlGaN/GaN HEMTs on HVPE GaN substrates. / Storm D.F., Roussos J.A., Katzer D.S., Mittereder J.A., Bass R., Binari S.C., Hanser D., Preble E.A., Evans K. // Electronics Letters. - 2006. - Vol. 42, No. 11. - P. 663-665.

J542. Guang Chen. A low gate bias model extraction technique for AlGaN/GaN HEMTs. / Guang Chen, Kumar V., Schwindt R.S., Adesida I. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 7. - P. 2949-2953.

J543. Kumar V. Field-plated 0.25-μm gate-length AlGaN/GaN HEMTs with varying field-plate length. / Kumar V., Guang Chen, Shiping Guo, Adesida I. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 6. - P. 1477-1480.

J544. Kruppa W. InAs HEMT narrowband amplifier with ultra-low power dissipation. / Kruppa W., Boos J.B., Bennett B.R., Papanicolaou N.A., Park D., Bass R. // Electronics Letters. - 2006. - Vol. 42, No. 12. - P. 688-690.

J545. Blanchard R.R. Stress-related hydrogen degradation of 0.1-μm InP HEMTs and GaAs PHEMTs. / Blanchard R.R., del Alamo J.A. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 6. - P. 1289-1293.

J546. Shuo Jia. Enhancement-mode AlGaN/GaN HEMTs on silicon substrate. / Shuo Jia, Yong Cai, Deliang Wang, Baoshun Zhang, Lau K.M., Chen K.J. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 6. - P. 1474-1477.

J547. Cho K.J. Gallium-nitride microwave Doherty power amplifier with 40 W PEP and 68% PAE. / Cho K.J., Kim W.J., Stapleton S.P., Kim J.H., Lee B., Choi J.J., Kim J.Y. // Electronics Letters. - 2006. - Vol. 42, No. 12. - P. 704-705.

J548. Watanabe I. Velocity Enhancement in Cryogenically Cooled InP-Based HEMTs on (411)A-Oriented Substrates. / Watanabe I., Shinohara K., Kitada T., Shimomura S., Yamashita Y., Endoh A., Mimura T., Hiyamizu S., Matsui T. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 11. - P. 2842-2846.

J549. Daoud S.M. A novel wideband MMIC voltage controlled attenuator with a bandpass filter topology. /

Daoud S.M., Shastry P.N. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 6. - P. 2576-2583.

J550. Denis D. Coupled electrothermal, electromagnetic, and physical modeling of microwave power FETs. / Denis D., Snowden C.M., Hunter I.C. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 6. - P. 2465-2470.

J551. Jeng-Han Tsai. Design and analysis of a 44-GHz MMIC low-loss built-in linearizer for high-linearity medium power amplifiers. / Jeng-Han Tsai, Hong-Yeh Chang, Pei-Si Wu, Yi-Lin Lee, Tian-Wei Huang, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 6. - P. 2487-2496.

J552. Kallfass I. A Unified Approach to Charge-Conservative Capacitance Modelling in HEMTs. / Kallfass I., Schumacher H., Brazil T.J. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 12. - P. 678-680.

J553. Darwish A.M. AlGaN/GaN -Band 5-W MMIC Amplifier. / Darwish A.M., Boutros K., Luo B., Huebschman B.D., Viveiros E., Hung H.A. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 12. - P. 4456-4463.

J554. Toufik Sadi. Investigation of Self-Heating Effects in Submicrometer GaN/AlGaN HEMTs Using an Electrothermal Monte Carlo Method. / Toufik Sadi, Robert W. Kelsall, Neil J. Pilgrim. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 12. - P. 2892-2900.

J555. Seok Joo Doo. Effective Suppression of IV Knee Walk-Out in AlGaN/GaN HEMTs for Pulsed-IV Pulsed-RF With a Large Signal Network Analyzer. / Seok Joo Doo, Roblin P., Jessen G.H., Fitch R.C., Gillespie J.K., Moser N.A., Crespo A., Simpson G., Jon King. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 12. - P. 681-683.

J556. Kawano Y. RF Chipset for Impulse UWB Radar Using 0.13- InP-HEMT Technology. / Kawano Y., Nakasha Y., Yokoo K., Masuda S., Takahashi T., Hirose T., Oishi Y., Hamaguchi K. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 12. - P. 4489-4497.

J557. Gunnarsson S.E. 60 GHz MMIC double balanced Gilbert mixer in mHEMT technology with integrated RF, LO and IF baluns. / Gunnarsson S.E., Gavell M., Kuylenstierna D., Zirath H. // Electronics Letters. - 2006. - Vol. 42, No. 24. - P. 1402-1403.

J558. Andrenko A.S. Active Broad X-Band Circular Patch Antenna. / Andrenko A.S., Ivanchenko I.V., Ivanchenko D.I., Karelin S.Y., Korolev A.M., Laz'Ko E.P., Popenko N.A. // IEEE Antennas and Wireless Propagation Letters. - 2006. - Vol. 5, No. 1. - P. 529-533.

J559. Ma B.Y. InAs/AlSb HEMT and Its Application to Ultra-Low-Power Wideband High-Gain Low-Noise Amplifiers. / Ma B.Y., Bergman J., Chen P., Hacker J.B., Sullivan G., Nagy G., Brar B. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 12. - P. 4448-4455.

J560. Masuda S. Very Compact High-Gain Broadband Low-Noise Amplifier in InP HEMT Technology. / Masuda S., Ohki T., Hirose T. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 12. - P. 4565-4571.

J561. Ruonan Wang. Planar integration of E/D-mode AlGaN/GaN HEMTs using fluoride-based plasma treatment. / Ruonan Wang, Yong Cai, Tang W., Lau K.M., Chen K.J. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 8. - P. 633-635.

J562. Cheng-Shih Lee. Copper-Airbridged Low-Noise GaAs PHEMT With Diffusion Barrier for High-Frequency Applications. / Cheng-Shih Lee, Yi-Chung Lien, Chang E.Y., Huang-Choung Chang, Szu-Houng Chen, Ching-Ting Lee, Li-Hsin Chu, Shang-Wen Chang, Yen-Chang Hsieh. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 8. - P. 1753-1758.

J563. An D. A Novel 94-GHz MHEMT Resistive Mixer Using a Micromachined Ring Coupler. / An D., Sung-Chan Kim, Jung-Dong Park, Mun-Kyo Lee, Hyun-Chang Park, Kim S.-D., Wan-Joo Kim, Jin-Koo Rhee. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 8. - P. 467-469.

J564. Fan-Hsiu Huang. V-Band GaAs pHEMT Cross-Coupled Sub-Harmonic Oscillator. / Fan-Hsiu Huang,

Cheng-Kuo Lin, Yi-Jen Chan. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 8. - P. 473-475.

J565. Che-Hung Lin. A Single Supply, High Linearity 2-W PA MMIC for WLAN Applications Using Quasi-Enhancement Mode PHEMTs. / Che-Hung Lin, Hong-Zhi Liu, Chen-Kuo Chu, Hou-Kuei Huang, Chi-Chuan Liu, Ching-Hsueh Chang, Chang-Luen Wu, Chian-Sern Chang, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 11. - P. 618-620.

J566. Gaudenzio Meneghesso. Current Collapse and High-Electric-Field Reliability of Unpassivated GaN/AlGaN/GaN HEMTs. / Gaudenzio Meneghesso, Fabiana Rampazzo, Peter Kordos, Giovanni Verzellesi, Enrico Zanoni. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 12. - P. 2932-2941.

J567. David A. J. Moran. 50-nm Self-Aligned and “Standard” T-gate InP pHEMT Comparison: The Influence of Parasitics on Performance at the 50-nm Node. / David A. J. Moran, Helen McLelland, Khaled Elgaid, Griogair Whyte, Colin R. Stanley, Iain Thayne. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 12. - P. 2920-2925.

J568. Young Chul Choi. The Effect of an Fe-doped GaN Buffer on off -State Breakdown Characteristics in AlGaN/GaN HEMTs on Si Substrate. / Young Chul Choi, Milan Pophristic, Ho-Young Cha, Boris Peres, Michael G. Spencer, Lester F. Eastman. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 12. - P. 2926-2931.

J569. David W. DiSanto. At-Bias Extraction of Access Parasitic Resistances in AlGaN/GaN HEMTs: Impact on Device Linearity and Channel Electron Velocity. / David W. DiSanto, C. R. Bolognesi. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 12. - P. 2914-2919.

J570. Palacios T. High-performance E-mode AlGaN/GaN HEMTs. / Palacios T., Suh C.-S., Chakraborty A., Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 6. - P. 428-430.

J571. Jinho Jeong. A fully integrated V-band PLL MMIC using 0.15-μm GaAs pHEMT technology. / Jinho Jeong, Youngwoo Kwon. // IEEE Journal of Solid-State Circuits. - 2006. - Vol. 41, No. 5. - P. 1042-1050.

J572. Krishnamohan T. High-mobility ultrathin strained Ge MOSFETs on bulk and SOI with low band-to-band tunneling leakage: experiments. / Krishnamohan T., Krivokapic Z., Uchida K., Nishi Y., Saraswat K.C. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 5. - P. 990-999.

J573. Muller C.R. Self-gating controlled pronounced threshold hysteresis in electron Y-branch switch with quantum dots. / Muller C.R., Worschech L., Forchel A. // Electronics Letters. - 2006. - Vol. 42, No. 10. - P. 603-604.

J574. Bosch W. Low cost X-band power amplifier MMIC. / Bosch W., Mayock J.G.E., O'Keefe M.F., McMonagle J. // IEEE Aerospace and Electronic Systems Magazine. - 2006. - Vol. 21, No. 3. - P. 21-25.

J575. Yuan H.-C. High-gain multi-finger power n-MODFET on Si substrate. / Yuan H.-C., Jiang N., Ma Z., Croke E.T. // Electronics Letters. - 2006. - Vol. 42, No. 6. - P. 375-377.

J576. Shen L. Unpassivated high power deeply recessed GaN HEMTs with fluorine-plasma surface treatment. / Shen L., Palacios T., Poblenz C., Corrion A., Chakraborty A., Fichtenbaum N., Keller S., Denbaars S.P., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 4. - P. 214-216.

J577. Medjdoub F. Power measurement setup for large signal microwave characterization at 94 GHz. / Medjdoub F., Vandenbrouck S., Gaquiere C., Delos E., Zaknoune M., Theron D. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 4. - P. 218-220.

J578. Hung C.-W. Three-terminal-controlled resistor-type hydrogen sensor. / Hung C.-W., Lin H.-L., Tsai Y.-Y., Lai P.-H., Fu S.-I., Chen H.-I., Liu W.-C. // Electronics Letters. - 2006. - Vol. 42, No. 10. - P. 578-580.

J579. Saito W. Demonstration of 13.56-MHz class-E amplifier using a high-Voltage GaN power-HEMT. / Saito W., Domon T., Omura I., Kuraguchi M., Takada Y., Tsuda K., Yamaguchi M. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 5. - P. 326-328.

J580. Shen L. High performance deeply-recessed GaN power HEMTs without surface passivation. / Shen L.,

Chakraborty A., McCarthy L., Fichtenbaum N., Keller S., DenBaars S.P., Mishra U.K. // Electronics Letters. - 2006. - Vol. 42, No. 9. - P. 555-556.

J581. Zuo-Min Tsai. FET-integrated CPW and the application in filter synthesis design method on traveling-wave switch above 100 GHz. / Zuo-Min Tsai, Mei-Chao Yeh, Hong-Yeh Chang, Ming-Fong Lei, Lin K.-Y., Chin-Shen Lin, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2006. - Vol. 54, No. 5. - P. 2090-2097.

J582. Zimmermann T. Piezoelectric GaN sensor structures. / Zimmermann T., Neuburger M., Benkart P., Hernandez-Guillen F.J., Pietzka C., Kunze M., Daumiller I., Dadgar A., Krost A., Kohn E. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 5. - P. 309-312.

J583. Krishnamohan T. High-mobility low band-to-band-tunneling strained-Germanium double-gate heterostructure FETs: Simulations. / Krishnamohan T., Donghyun Kim, Chi Dong Nguyen, Jungemann C., Nishi Y., Saraswat K.C. // IEEE Transactions on Electron Devices. - 2006. - Vol. 53, No. 5. - P. 1000-1009.

J584. Ciccognani W. GaAs cryo-cooled LNA for C-band radioastronomy applications. / Ciccognani W., Di Paolo F., Giannini F., Limiti E., Longhi P.E., Serino A. // Electronics Letters. - 2006. - Vol. 42, No. 8. - P. 471-472.

J585. Endoh A. Threshold voltage shifts in decananometre-gate AlGaN/GaN HEMTs. / Endoh A., Yamashita Y., Hikosaka K., Matsui T., Hiyamizu S., Mimura T. // Electronics Letters. - 2006. - Vol. 42, No. 8. - P. 490-492.

J586. Younkyu Chung. W-band waveguide-packaged InP HEMT reflection grid amplifier. / Younkyu Chung, Chun-Tung Cheung, DeLisio M.P., Rutledge D.B. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 6. - P. 324-326.

J587. Okamoto Y. 100 W C-band single-chip GaN FET power amplifier. / Okamoto Y., Wakejima A., Ando Y., Nakayama T., Matsunaga K., Miyamoto H. // Electronics Letters. - 2006. - Vol. 42, No. 5. - P. 283-285.

J588. Hong-Zhi Liu. A single-supply Ku-band 1-W power amplifier MMIC with compact self-bias PHEMTs. / Hong-Zhi Liu, Che-Hung Lin, Chen-Kuo Chu, Hou-Kuei Huang, Mau-Phon Houng, Ching-Hsueh Chang, Chang-Luen Wu, Chian-Sern Chang, Yeong-Her Wang. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 6. - P. 330-332.

J589. Kruger O. Laser-assisted processing of VIAs for AlGaN/GaN HEMTs on SiC substrates. / Kruger O., Schone G., Wernicke T., Lossy R., Liero A., Schnieder F., Wurfl J., Trankle G. // IEEE Electron Device Letters. - 2006. - Vol. 27, No. 6. - P. 425-427.

J590. Jarndal A. An accurate small-signal model for AlGaN-GaNHEMT suitable for scalable large-signal model construction. / Jarndal A., Kompa G. // IEEE Microwave and Wireless Components Letters. - 2006. - Vol. 16, No. 6. - P. 333-335.

J591. Caddemi A. Microwave characterization and modeling of packaged HEMTs by a direct extraction procedure down to 30 K. / Caddemi A., Crupi G., Donato N. // IEEE Transactions on Instrumentation and Measurement. - 2006. - Vol. 55, No. 2. - P. 465-470.

J592. Jang K.C. Offset wide-recessed In0.49 GaP/Al0.45 GaAs barrier E-pHEMT with high current density. / Jang K.C., Kim S.W., Lee J.H., Seo K.S. // Electronics Letters. - 2006. - Vol. 42, No. 5. - P. 309-310.

J593. R. Urata. A compact low-power label swapper for asynchronous burst optical packets based on an optically clocked transistor array. / R. Urata, R. Takahashi, T. Nakahara, H. Suzuki. // IEEE Photonics Technology Letters. - 2006. - Vol. 18, No. 7. - P. 871-873.

J594. Liu D. In0.53 Ga0.47 As/InAs0.3 P0.7 composite channel high electron mobility transistors. / Liu D., Hudait M., Lin Y., Kim H., Ringel S.A., Lu W. // Electronics Letters. - 2006. - Vol. 42, No. 5. - P. 307-309.

J595. Chin-Chuan Cheng. Pd-oxide- Al0.24 Ga0.76 As (MOS) high electron mobility transistor (HEMT)-based hydrogen sensor. / Chin-Chuan Cheng, Yan-Ying Tsai, Kun-Wei Lin, Huey-Ing Chen, Wei-Hsi Hsu, Ching-Wen Hung, Rong-Chau Liu, Wen-Chau Liu. // IEEE Sensors Journal. - 2006. - Vol. 6, No. 2. - P. 287-292.

J596. Curras-Francos M.C. Table-based nonlinear HEMT model extracted from time-domain large-signal

measurements. IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 5. - P. 1593-1600.

J597. Haijiang Yu. Ion implanted AlGaN-GaN HEMTs with nonalloyed Ohmic contacts. / Haijiang Yu, McCarthy L., Rajan S., Keller S., Denbaars S., Speck J., Mishra U. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 5. - P. 283-285.

J598. Mekonnen G.G. 80-Gb/s InP-based waveguide-integrated photoreceiver. / Mekonnen G.G., Bach H.-G., Beling A., Kunkel R., Schmidt D., Schlaak W. // IEEE Journal of Selected Topics in Quantum Electronics. - 2005. - Vol. 11, No. 2. - P. 356-360.

J599. Yanagawa S. Analytical approach to evaluate thermal reduction effects of peripheral structures on microwave power GaAs device chips. IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 5. - P. 324-326.

J600. Kamitsuna H. 40 Gbit/s/ch 2Ч2 switch IC using InP HEMTs. / Kamitsuna H., Yamane Y., Tokumitsu M., Sugahara H., Muraguchi M. // Electronics Letters. - 2005. - Vol. 41, No. 9. - P. 532-534.

J601. Moon J.S. Gate-recessed AlGaN-GaN HEMTs for high-performance millimeter-wave applications. / Moon J.S., Shihchang Wu, Wong D., Milosavljevic I., Conway A., Hashimoto P., Hu M., Antcliffe M., Micovic M. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 6. - P. 348-350.

J602. Wren M. Experimental class-F power amplifier design using computationally efficient and accurate large-signal pHEMT model. / Wren M., Brazil T.J. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 5. - P. 1723-1731.

J603. Wen-Kai Wang. Performance enhancement by using the n+ -GaN cap layer and gate recess technology on the AlGaN-GaN HEMT fabrication. / Wen-Kai Wang, Po-Chen Lin, Ching-Huao Lin, Cheng-Kuo Lin, Yi-Jen Chan, Guan-Ting Chen, Chyi J.-I. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 1. - P. 5-7.

J604. Saito W. Design optimization of high breakdown voltage AlGaN-GaN power HEMT on an insulating substrate for RON A-VB tradeoff characteristics. / Saito W., Kuraguchi M., Takada Y., Tsuda K., Omura I., Ogura T. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 1. - P. 106-111.

J605. Kettle D. A Ka-band InP MMIC 180° phase switch. / Kettle D., Roddis N., Sloan R. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 6. - P. 425-427.

J606. Wei-Chou Hsu. Characteristics of In0.425 Al0.575 As-InxGa1-x As metamorphic HEMTs with pseudomorphic and symmetrically graded channels. / Wei-Chou Hsu, Yeong-Jia Chen, Ching-Sung Lee, Tzong-Bin Wang, Jun-Chin Huang, Dong-Hai Huang, Ke-Hua Su, Yu-Shyan Lin, Chang-Luen Wu. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 6. - P. 1079-1086.

J607. Yuh-Renn Wu. Sources of transconductance collapse in III-V nitrides-consequences of velocity-field relations and source/gate design. / Yuh-Renn Wu, Singh M., Singh J. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 6. - P. 1048-1054.

J608. Shuo Jia. AlGaN-GaN HEMTs on patterned silicon (111) substrate. / Shuo Jia, Dikme Y., Deliang Wang, Chen K.J., Lau K.M., Heuken M. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 3. - P. 130-132.

J609. Lee C. Effects of AlGaN/GaN HEMT structure on RF reliability. / Lee C., Witkowski L., Tserng H.-Q., Saunier P., Birkhahn R., Olson D., Munns G., Guo S., Albert B. // Electronics Letters. - 2005. - Vol. 41, No. 3. - P. 155-157.

J610. Storm D. F. Growth and characterization of plasma-assisted molecular beam epitaxial-grown AlGaN/GaN heterostructures on free-standing hydride vapor phase epitaxy GaN substrates. / Storm D. F., Katzer D. S., Mittereder J. A., Binari S. C., Shanabrook B. V., Zhou Lin, Smith David J., Xu X., McVey D., Vaudo R. P., Brandes G. R. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2005. - Vol. 23, No. 3. - P. 1190-1193.

J611. Saito W. Influence of surface defect charge at AlGaN-GaN-HEMT upon Schottky gate leakage current and breakdown voltage. / Saito W., Kuraguchi M., Takada Y., Tsuda K., Omura I., Ogura T. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 2. - P. 159-164.

J612. Jie Liu. Highly linear Al0.3 Ga0.7 N-Al0.05 Ga0.95 N-GaN composite-channel HEMTs. / Jie Liu, Yugang Zhou, Rongming Chu, Yong Cai, Chen K.J., Lau K.M. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 3. - P. 145-147.

J613. Chu L.H. 2 V-operated InGaP-AlGaAs-InGaAs enhancement-mode pseudomorphic HEMT. / Chu L.H., Chang E.Y., Chen S.H., Lien Y.C., Chang C.Y. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 2. - P. 53-55.

J614. Wei-Chou Hsu. High-temperature thermal stability performance in δ-doped In0.425 Al0.575 As--In0.65 Ga0.35 As metamorphic HEMT. / Wei-Chou Hsu, Yeong-Jia Chen, Ching-Sung Lee, Tzong-Bin Wang, Yu-Shyan Lin, Chang-Luen Wu. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 2. - P. 59-61.

J615. Torabi A. Influence of AlN nucleation layer on the epitaxy of GaN/AlGaN high electron mobility transistor structure and wafer curvature. / Torabi A., Hoke W. E., Mosca J. J., Siddiqui J. J., Hallock R. B., Kennedy T. D. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2005. - Vol. 23, No. 3. - P. 1194-1198.

J616. Oxley C.H. Measurements of unity gain cutoff frequency and saturation velocity of a GaN HEMT transistor. / Oxley C.H., Uren M.J. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 2. - P. 165-169.

J617. Werquin M. High power and linearity performances of gallium nitride HEMT devices on sapphire substrate. / Werquin M., Gaquiere C., Guhel Y., Vellas N., Theron D., Boudart B., Hoel V., Germain M., De Jaeger J.C., Delage S. // Electronics Letters. - 2005. - Vol. 41, No. 1. - P. 46-47.

J618. Sanabria C. Influence of epitaxial structure in the noise figure of AlGaN/GaN HEMTs. / Sanabria C., Hongtao Xu, Palacios T., Chakraborty A., Heikman S., Mishra U.K., York R.A. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 2. - P. 762-769.

J619. Cheng Chin-Chuan. Study of hydrogen-sensing characteristics of a Pt-oxide-AlGaAs metal-oxide-semiconductor high electron mobility transistor. / Cheng Chin-Chuan, Tsai Yan-Ying, Lin Kun-Wei, Chen Huey-Ing, Hsu Wei-Hsi, Hong Ching-Wen, Lin Han-Lien, Liu Wen-Chau. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2005. - Vol. 23, No. 5. - P. 1943-1947.

J620. Katzer D. S. Molecular beam epitaxy of In Al N /Ga N heterostructures for high electron mobility transistors. / Katzer D. S., Storm D. F., Binari S. C., Shanabrook B. V., Torabi A., Zhou Lin, Smith David J. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2005. - Vol. 23, No. 3. - P. 1204-1208.

J621. Tinkham B. P. Growth of InAsSb-channel high electron mobility transistor structures. / Tinkham B. P., Bennett B. R., Magno R., Shanabrook B. V., Boos J. B. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2005. - Vol. 23, No. 4. - P. 1441-1444.

J622. Yamashita Yoshimi. 120-nm -T-shaped-Mo /Pt /Au -gate Al Ga N /Ga N high electron mobility transistors. / Yamashita Yoshimi, Endoh Akira, Ikeda Keiji, Hikosaka Kohki, Mimura Takashi, Higashiwaki Masataka, Matsui Toshiaki, Hiyamizu Satoshi. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2005. - Vol. 23, No. 5. - P. L13-L15.

J623. Chang-Soon Choi. Phototransistors based on InP HEMTs and their applications to millimeter-wave radio-on-fiber systems. / Chang-Soon Choi, Hyo-Soon Kang, Woo-Young Choi, Dae-Hyun Kim, Kwang-Seok Seo. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 1. - P. 256-263.

J624. Ye P. D. GaN metal-oxide-semiconductor high-electron-mobility-transistor with atomic layer deposited Al 2 O 3 as gate dielectric. / Ye P. D., Yang B., Ng K. K., Bude J., Wilk G. D., Halder S., Hwang J. C. M. // Applied Physics Letters. - 2005. - Vol. 86, No. 6. - P. 063501-063501-3.

J625. Lanford W.B. Recessed-gate enhancement-mode GaN HEMT with high threshold voltage. / Lanford W.B., Tanaka T., Otoki Y., Adesida I. // Electronics Letters. - 2005. - Vol. 41, No. 7. - P. 449-450.

J626. Varonen M. Resistive HEMT mixers for 60-GHz broad-band telecommunication. / Varonen M., Karkkainen M., Riska J., Kangaslahti P., Halonen K.A.I. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 4. - P. 1322-1330.

J627. Kang B. S. Capacitance pressure sensor based on GaN high-electron-mobility transistor-on-Si membrane. / Kang B. S., Kim J., Jang S., Ren F., Johnson J. W., Therrien R. J., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J., Chu S. N. G., Baik K., Gila B. P., Abernathy C. R., Pearton S. J. // Applied Physics Letters. - 2005. - Vol. 86, No. 25. - P. 253502-253502-3.

J628. Cheng Chin-Chuan. Hydrogen sensing properties of a Pt -oxide -Al 0.24 Ga 0.76 As high-electron-mobility transistor. / Cheng Chin-Chuan, Tsai Yan-Ying, Lin Kun-Wei, Chen Huey-Ing, Liu Wen-Chau. // Applied Physics Letters. - 2005. - Vol. 86, No. 11. - P. 112103-112103-3.

J629. Fareed R. S. Qhalid. High-power AlGaN /InGaN /AlGaN /GaN recessed gate heterostructure field-effect transistors. / Fareed R. S. Qhalid, Hu X., Tarakji A., Deng J., Gaska R., Shur M., Khan M. A. // Applied Physics Letters. - 2005. - Vol. 86, No. 14. - P. 143512-143512-3.

J630. Kang B. S. Detection of halide ions with Al Ga N /Ga N high electron mobility transistors. / Kang B. S., Ren F., Kang M. C., Lofton C., Tan Weihong, Pearton S. J., Dabiran A., Osinsky A., Chow P. P. // Applied Physics Letters. - 2005. - Vol. 86, No. 17. - P. 173502-173502-3.

J631. Deal W.R. A W-band InAs/AlSb low-noise/low-power amplifier. / Deal W.R., Tsai R., Lange M.D., Boos J.B., Bennett B.R., Gutierrez A. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 4. - P. 208-210.

J632. Mertens S.D. Hydrogen sensitivity of InP HEMTs with WSiN-based gate stack. / Mertens S.D., del Alamo J.A., Suemitsu T., Enoki T. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 3. - P. 305-310.

J633. Kang-Wei Fan. K-band MMIC active band-pass filters. / Kang-Wei Fan, Ching-Chih Weng, Zou-Min Tsai, Huei Wang, Shyh-Kang Jeng. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 1. - P. 19-21.

J634. Kaper V.S. Signal generation, control, and frequency conversion AlGaN/GaN HEMT MMICs. / Kaper V.S., Thompson R.M., Prunty T.R., Shealy J.R. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 1. - P. 55-65.

J635. Jalil M.B.A. Modeling of a ferromagnetic two-dimensional electron gas device. / Jalil M.B.A., Yong Jiang, Goh G.K.L. // IEEE Transactions on Magnetics. - 2005. - Vol. 41, No. 3. - P. 1118-1125.

J636. Scotti G. MMIC yield optimisation by design centring and off-chip controllers [centring read as centering]. / Scotti G., Tommasino P., Trifiletti A. // IEE Proceedings - Circuits, Devices and Systems. - 2005. - Vol. 152, No. 1. - P. 54-60.

J637. Rongming Chu. AlGaN-GaN double-channel HEMTs. / Rongming Chu, Yugang Zhou, Jie Liu, Deliang Wang, Chen K.J., Lau K.M. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 4. - P. 438-446.

J638. Edwards A.P. Improved reliability of AlGaN-GaN HEMTs using an NH3 plasma treatment prior to SiN passivation. / Edwards A.P., Mittereder J.A., Binari S.C., Katzer D.S., Storm D.F., Roussos J.A. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 4. - P. 225-227.

J639. Kim S. Iridium Schottky contact on In0.52 Al0.48 As. / Kim S., Cueva G., Adesida I. // Electronics Letters. - 2005. - Vol. 41, No. 11. - P. 665-667.

J640. Jianjun Gao. Relationships between common source, common gate, and common drain FETs. / Jianjun Gao, Boeck G. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 12. - P. 3825-3831.

J641. Shohat J. Investigation of drain-line loss and the S22 kink effect in capacitively coupled distributed amplifiers. / Shohat J., Robertson I.D., Nightingale S.J. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 12. - P. 3767-3773.

J642. Uchiyama H. Strained epilayers effectively reduce plasma-induced fluorine damage in P-HEMTs. / Uchiyama H., Taniguchi T., Kudo M. // IEEE Transactions on Device and Materials Reliability. - 2005. - Vol. 5, No. 4. - P. 706-712.

J643. Medjdoub F. High performances of InP channel power HEMT at 94 GHz. / Medjdoub F., Zaknoune M.,

Wallart X., Gaquiere C., Theron D. // Electronics Letters. - 2005. - Vol. 41, No. 25. - P. 1406-1408.

J644. Dawson D. Beyond G-band: a 235 GHz InP MMIC amplifier. / Dawson D., Samoska L., Fung A.K., Lee K., Lai R., Grundbacher R., Po-Hsin Liu, Raja R. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 12. - P. 874-876.

J645. Hsien-Chin Chiu. High breakdown voltage (Al0.3 Ga0.7)0.5 In0.5 P/InGaAs quasi-enhancement-mode pHEMT with field-plate technology. / Hsien-Chin Chiu, Yi-Chyun Chiang, Chan-Shin Wu. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 10. - P. 701-703.

J646. Koudymov A. Mechanism of current collapse removal in field-plated nitride HFETs. / Koudymov A., Adivarahan V., Yang J., Simin G., Khan M.A. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 10. - P. 704-706.

J647. Inoue Y. A 90-GHz InP-HEMT lossy match amplifier with a 20-dB gain using a broadband matching technique. / Inoue Y., Sato M., Ohki T., Makiyama K., Takahashi T., Shigematsu H., Hirose T. // IEEE Journal of Solid-State Circuits. - 2005. - Vol. 40, No. 10. - P. 2098-2103.

J648. Jeong J. W-band divide-by-3 frequency divider using 0.1 μm InAlAs/InGaAs metamorphic HEMT technology. / Jeong J., Kim S., Choi W., Noh H., Lee K., Seo K.-S., Kwon Y. // Electronics Letters. - 2005. - Vol. 41, No. 18. - P. 1005-1006.

J649. Seo S. Wideband balanced AiGaN/GaN HEMT MMIC low noise amplifier. / Seo S., Pavlidis D., Moon J.S. // Electronics Letters. - 2005. - Vol. 41, No. 16. - P. 37-38.

J650. Sozza A. Thermal stability of mo-based schottky contact for AiGaN/GaN HEMT. / Sozza A., Dua C., Morvan E., Grimbert B., di Forte-Poisson M.A., Delage S.L., Zanoni E. // Electronics Letters. - 2005. - Vol. 41, No. 16. - P. 61-62.

J651. Kim S. Enhancement-mode In0.52 Al0.48 As/In0.53 Ga0.47 As/InP HEMT utilising Ir/Ti/Pt/Au gate. / Kim S., Adesida I., Jang J.-H. // Electronics Letters. - 2005. - Vol. 41, No. 15. - P. 871-872.

J652. Hong-Zhi Liu. Simple, low-cost, subsystem fabrication. / Hong-Zhi Liu, Hou-Kuei Huang, Chih-Cheng Wang, Ray-Jay Chiu, Che-Hung Lin, Chen-Kuo Chu, Mau-Phon Houng, Yeong-Her Wang. // IEEE Circuits and Devices Magazine. - 2005. - Vol. 21, No. 4. - P. 12-17.

J653. Wichmann N. Fabrication and characterization of 100-nm In0.53 Ga0.47 As-In0.52 Al0.48 As double-gate HEMTs with two separate gate controls. / Wichmann N., Duszynski I., Wallart X., Bollaert S., Cappy A. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 9. - P. 601-603.

J654. Lei Zhang. Efficient analytical formulation and sensitivity analysis of neuro-space mapping for nonlinear microwave device modeling. / Lei Zhang, Jianjun Xu, Yagoub M.C.E., Runtao Ding, Qi-Jun Zhang. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 9. - P. 2752-2767.

J655. Tessmann A. 220-GHz metamorphic HEMT amplifier MMICs for high-resolution imaging applications. IEEE Journal of Solid-State Circuits. - 2005. - Vol. 40, No. 10. - P. 2070-2076.

J656. Kang I.H. Improved low-frequency-noise characteristic of selectively hydrogen-pretreated quasi-enhancement HEMTs. / Kang I.H., Kim S.C., Bahng W., Kim N.K., Song J.-I. // Electronics Letters. - 2005. - Vol. 41, No. 17. - P. 981-982.

J657. Mohammed F.M. Si-induced enhancement of ohmic performance of Ti/Al/Mo/Au metallisation for AlGaN/GaN HEMTs. / Mohammed F.M., Wang L., Koo H.J., Adesida I. // Electronics Letters. - 2005. - Vol. 41, No. 17. - P. 984-985.

J658. An D. High switching performance 0.1-μm metamorphic HEMTs for low conversion loss 94-GHz resistive mixers. / An D., Bok-Hyung Lee, Byeong-Ok Lim, Mun-Kyo Lee, Sung-Chan Kim, Jung-Hun Oh, Kim S.-D., Hyung-Moo Park, Dong-Hoon Shin, Jin-Koo Rhee. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 10. - P. 707-709.

J659. Sung-Won Kim. High-performance 0.1-μm In0.4 AlAs/In0.35 GaAs MHEMTs with Ar plasma treatment. / Sung-Won Kim, Kang-Min Lee, Jae-Hak Lee, Kwang-Seok Seo. // IEEE Electron Device Letters. - 2005. - Vol.

26, No. 11. - P. 787-789.

J660. Gunnarsson S.E. Highly integrated 60 GHz transmitter and receiver MMICs in a GaAs pHEMT technology. / Gunnarsson S.E., Karnfelt C., Zirath H., Kozhuharov R., Kuylenstierna D., Alping A., Fager C. // IEEE Journal of Solid-State Circuits. - 2005. - Vol. 40, No. 11. - P. 2174-2186.

J661. Palacios T. High-power AlGaN/GaN HEMTs for Ka-band applications. / Palacios T., Chakraborty A., Rajan S., Poblenz C., Keller S., DenBaars S.P., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 11. - P. 781-783.

J662. Elgaid K. 50-nm T-gate metamorphic GaAs HEMTs with fT of 440 GHz and noise figure of 0.7 dB at 26 GHz. / Elgaid K., McLelland H., Holland M., Moran D.A.J., Stanley C.R., Thayne I.G. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 11. - P. 784-786.

J663. Jarndal A. A new small-signal modeling approach applied to GaN devices. / Jarndal A., Kompa G. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 11. - P. 3440-3448.

J664. Feng Z.H. Enhanced-performance of AlGaN-GaN HEMTs grown on grooved sapphire substrates. / Feng Z.H., Cai S.J., Chen K.J., Lau K.M. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 12. - P. 870-872.

J665. Soga I. Direct integration of GaAs HEMTs on AlN ceramic substrates using fluidic self-assembly. / Soga I., Hayashi S., Ohno Y., Kishimoto S., Maezawa K., Mizutani T. // Electronics Letters. - 2005. - Vol. 41, No. 23. - P. 1275-1276.

J666. Yang Z. High-power operation of III-N MOSHFET RF switches. / Yang Z., Koudymov A., Adivarahan V., Yang J., Simin G., Khan M.A. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 12. - P. 850-852.

J667. Calame J.P. Simulations of direct-die-attached microchannel coolers for the thermal management of GaN-on-SiC microwave amplifiers. / Calame J.P., Myers R.E., Wood F.N., Binari S.C. // IEEE Transactions on Components and Packaging Technologies. - 2005. - Vol. 28, No. 4. - P. 797-809.

J668. Medjdoub F. InP HEMT downscaling for power applications at W band. / Medjdoub F., Zaknoune M., Wallart X., Gaquiere C., Dessenne F., Thobel J.-L., Theron D. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 10. - P. 2136-2143.

J669. Chen-Kuo Chu. A fully matched high linearity 2-W PHEMT MMIC power amplifier for 3.5 GHz applications. / Chen-Kuo Chu, Hou-Kuei Huang, Hong-Zhi Liu, Chiu R.-J., Che-Hung Lin, Chih-Cheng Wang, Mau-Phon Houng, Yeong-Her Wang, Chuan-Chien Hsu, Wang Wu, Chang-Luen Wu, Chian-Sern Chang. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 10. - P. 667-669.

J670. Ching-Hui Lin. Transient pulsed analysis on GaN HEMTs at cryogenic temperatures. / Ching-Hui Lin, Wen-Kai Wang, Po-Chen Lin, Cheng-Kuo Lin, Yu-Jung Chang, Yi-Jen Chan. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 10. - P. 710-712.

J671. Palacios T. Influence of the dynamic access resistance in the gm and fT linearity of AlGaN/GaN HEMTs. / Palacios T., Rajan S., Chakraborty A., Heikman S., Keller S., DenBaars S.P., Mishra U.K. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 10. - P. 2117-2123.

J672. Kumar V. Field-plated 0.25 μm gate-length AlGaN/GaN HEMTs on 6H-SiC with power density of 9.1 W/mm at 18 GHz. / Kumar V., Chen G., Guo S., Peres B., Eliasevich I., Adesida I. // Electronics Letters. - 2005. - Vol. 41, No. 19. - P. 1080-1081.

J673. Brabetz T. Voltage-driven class E amplifier and applications. / Brabetz T., Fusco V.F. // IEE Proceedings - Microwaves, Antennas and Propagation. - 2005. - Vol. 152, No. 5. - P. 373-377.

J674. Vijayakrishna V.J. Unified analytical model of HEMTs for analogue and digital applications. / Vijayakrishna V.J., Vaishnav S., DasGupta N., DasGupta A. // IEE Proceedings - Circuits, Devices and Systems. - 2005. - Vol. 152, No. 5. - P. 425-432.

J675. Papanicolaou N.A. Sb-based HEMTs with InAlSb/InAs heterojunction. / Papanicolaou N.A., Bennett B.R., Boos J.B., Park D., Bass R. // Electronics Letters. - 2005. - Vol. 41, No. 19. - P. 1088-1089.

J676. Shohat J. 10-Gb/s driver amplifier using a tapered gate line for improved input matching. / Shohat J., Robertson I.D., Nightingale S.J. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 10. - P. 3115-3120.

J677. Kuzmik J. Transient thermal characterization of AlGaN/GaN HEMTs grown on silicon. / Kuzmik J., Bychikhin S., Neuburger M., Dadgar A., Krost A., Kohn E., Pogany D. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 8. - P. 1698-1705.

J678. Blanchard R.R. Hydrogen-induced changes in the breakdown voltage of InP HEMTs. / Blanchard R.R., del Alamo J.A., Calveras A.C. // IEEE Transactions on Device and Materials Reliability. - 2005. - Vol. 5, No. 2. - P. 231-234.

J679. van Raay F. A coplanar X-band AlGaN/GaN power amplifier MMIC on s.i. SiC substrate. / van Raay F., Quay R., Kiefer R., Benkhelifa F., Raynor B., Pletschen W., Kuri M., Massler H., Muller S., Dammann M., Mikulla M., Schlechtweg M., Weimann G. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 7. - P. 460-462.

J680. Weaver B. D. High radiation tolerance of In As /Al Sb high-electron-mobility transistors. / Weaver B. D., Boos J. B., Papanicolaou N. A., Bennett B. R., Park D., Bass R. // Applied Physics Letters. - 2005. - Vol. 87, No. 17. - P. 173501-173501-3.

J681. Gila B. P. Improved oxide passivation of Al Ga N /Ga N high electron mobility transistors. / Gila B. P., Hlad M., Onstine A. H., Frazier R., Thaler G. T., Herrero A., Lambers E., Abernathy C. R., Pearton S. J., Anderson T., Jang S., Ren F., Moser N., Fitch R. C., Freund M. // Applied Physics Letters. - 2005. - Vol. 87, No. 16. - P. 163503-163503-3.

J682. Watanabe I. High transconductance of 2.25 S/mm observed at 16 K for 195-nm-gate In0.75 Ga0.25 As/In0.52 Al0.48 As HEMT fabricated on [411]A-oriented InP substrate. / Watanabe I., Shinohara K., Kitada T., Shimomura S., Yamashita Y., Endoh A., Mimura T., Matsui T., Hiyamizu S. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 7. - P. 425-428.

J683. Chun San Chu. Q-factor characterization of RF GaN-based metal-semiconductor-metal planar interdigitated varactor. / Chun San Chu, Yugang Zhou, Chen K.J., Lau K.M. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 7. - P. 432-434.

J684. Sanabria C. A GaN differential oscillator with improved harmonic performance. / Sanabria C., Hongtao Xu, Heikman S., Mishra U.K., York R.A. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 7. - P. 463-465.

J685. Campos-Roca Y. A D-band frequency doubler MMIC based on a 100-nm metamorphic HEMT technology. / Campos-Roca Y., Schworer C., Leuther A., Seelmann-Eggebert M., Massler H. // IEEE Microwave and Wireless Components Letters. - 2005. - Vol. 15, No. 7. - P. 466-468.

J686. Moon Jeong S. Room-temperature InAlAs /InGaAs /InP planar resonant tunneling-coupled transistor. / Moon Jeong S., Rajavel Rajesh, Bui Steven, Wong Danny, Chow David H. // Applied Physics Letters. - 2005. - Vol. 87, No. 18. - P. 183110-183110-3.

J687. Kerherve E. 40-Gb/s wide-band MMIC pHEMT modulator driver amplifiers designed with the real frequency technique. / Kerherve E., Moreira C.P., Jarry P., Courcelle L. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 6. - P. 2145-2152.

J688. Clifton J.C. Novel multimode J-pHEMT front-end architecture with power-control scheme for maximum efficiency. / Clifton J.C., Albasha L., Lawrenson A., Eaton A.M. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 6. - P. 2251-2258.

J689. Dow-Chih Niu. An X-band front-end module using HTS technique for a commercial dual mode radar. / Dow-Chih Niu, Tung-Wuu Huang, Hao-Jung Lee, Chi-Yang Chang. // IEEE Transactions on Applied Superconductivity. - 2005. - Vol. 15, No. 2. - P. 1008-1011.

J690. Jinho Jeong. V-band high-order harmonic injection-locked frequency-divider MMICs with wide bandwidth and low-power dissipation. / Jinho Jeong, Youngwoo Kwon. // IEEE Transactions on Microwave Theory and Techniques. - 2005. - Vol. 53, No. 6. - P. 1891-1898.

J691. Kang B. S. Electrical detection of immobilized proteins with ungated AlGaN /GaN high-electron-mobility Transistors. / Kang B. S., Ren F., Wang L., Lofton C., Tan Weihong W., Pearton S. J., Dabiran A., Osinsky A., Chow P. P. // Applied Physics Letters. - 2005. - Vol. 87, No. 2. - P. 023508-023508-3.

J692. Vitusevich S. A. Dynamic redistribution of the electric field of the channel in Al Ga N /Ga N high electron mobility transistor with nanometer-scale gate length. / Vitusevich S. A., Danylyuk S. V., Kurakin A. M., Klein N., Luth H., Petrychuk M. V., Belyaev A. E. // Applied Physics Letters. - 2005. - Vol. 87, No. 19. - P. 192110-192110-3.

J693. Dammann M. Reliability of 50 nm low-noise metamorphic HEMTs and LNAs. / Dammann M., Leuther A., Tessmann A., Massler H., Mikulla M., Weimann G. // Electronics Letters. - 2005. - Vol. 41, No. 12. - P. 699-701.

J694. Kim Seiyon. Measurements of thermally induced nanometer-scale diffusion depth of Pt /Ti /Pt /Au gate metallization on InAlAs /InGaAs high-electron-mobility transistors. / Kim Seiyon, Adesida Ilesanmi, Hwang Heedon. // Applied Physics Letters. - 2005. - Vol. 87, No. 23. - P. 232102-232102-3.

J695. Kang B.S. AlGaN/GaN-based diodes and gateless HEMTs for gas and chemical sensing. / Kang B.S., Suku Kim, Ren F., Gila B.P., Abernathy C.R., Pearton S.J. // IEEE Sensors Journal. - 2005. - Vol. 5, No. 4. - P. 677-680.

J696. Zhiqun Cheng. Broadband microwave noise characteristics of high-linearity composite-channel Al0.3 Ga0.7 N/Al0.05 Ga0.95 N/GaN HEMTs. / Zhiqun Cheng, Jie Liu, Yugang Zhou, Yong Cai, Chen K.J., Lau K.M. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 8. - P. 521-523.

J697. Yong Cai. High-performance enhancement-mode AlGaN/GaN HEMTs using fluoride-based plasma treatment. / Yong Cai, Yugang Zhou, Chen K.J., Lau K.M. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 7. - P. 435-437.

J698. Medjdoub F. 94 GHz high power performances of InAs0.4 P0.6 channel HEMTs on InP. / Medjdoub F., Zaknoune M., Wallart X., Gaquiere C., Theron D. // Electronics Letters. - 2005. - Vol. 41, No. 13. - P. 769-771.

J699. Gaquiere C. A high-power W-band pseudomorphic InGaAs channel PHEMT. / Gaquiere C., Grunenputt J., Jambon D., Delos E., Ducatteau D., Werquin M., Theron D., Fellon P. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 8. - P. 533-534.

J700. Yunju Sun. Large-signal performance of deep submicrometer AlGaN/AlN/GaNHEMTs with a field-modulating plate. / Yunju Sun, Eastman L.F. // IEEE Transactions on Electron Devices. - 2005. - Vol. 52, No. 8. - P. 1689-1692.

J701. Adivarahan V. Stable CW operation of field-plated GaN-AlGaN MOSHFETs at 19 W/mm. / Adivarahan V., Yang J., Koudymov A., Simin G., Khan M.A. // IEEE Electron Device Letters. - 2005. - Vol. 26, No. 8. - P. 535-537.

J702. Dumka D.C. AlGaN/GaN HEMTs on Si substrate with 7 W/mm output power density at 10 GHz. / Dumka D.C., Lee C., Tserng H.Q., Saunier P., Kumar M. // Electronics Letters. - 2004. - Vol. 40, No. 16. - P. 1023-1024.

J703. Juncu V.D. Behaviour of logic gates fabricated on Si/SiGe MODFET technology. / Juncu V.D., Kallfass I., Sloan R., Hatfield J.V. // Electronics Letters. - 2004. - Vol. 40, No. 12. - P. 772-774.

J704. Umeda Y. 10 Gbit/s series-connected voltage-balancing pulse driver with high-speed input buffer. / Umeda Y., Kanda A., Sano K., Murata K., Sugahara H. // Electronics Letters. - 2004. - Vol. 40, No. 15. - P. 934-935.

J705. Smerzi S.A. A Ku-band monolithic receiver for DVB-S applications. / Smerzi S.A., Girlando G., Copani T., Palmisano G. // IEEE Communications Magazine. - 2004. - Vol. 42, No. 8. - P. 132-139.

J706. Wichmann N. InAlAs-InGaAs double-gate HEMTs on transferred substrate. / Wichmann N., Duszynski I., Wallart X., Bollaert S., Cappy A. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 6. - P. 354-356.

J707. Rafael G. High-order derivatives in measurement of mobility in HEMT devices. / Rafael G., Fernandez T., Rodriguez-Tellez J., Tazon A., Mediavilla A. // Electronics Letters. - 2004. - Vol. 40, No. 11. - P. 700-702.

J708. Minko A. AlGaN-GaN HEMTs on Si with power density performance of 1.9 W/mm at 10 GHz. / Minko A., Hoel V., Morvan E., Grimbert B., Soltani A., Delos E., Ducatteau D., Gaquiere C., Theron D., De Jaeger J.C., Lahreche H., Wedzikowski L., Langer R., Bove P. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 7. - P. 453-455.

J709. Shiojima K. High-power AlGaN/GaN dual-gate high electron mobility transistor mixers on SiC substrates. / Shiojima K., Makimura T., Kosugi T., Sugitani S., Shigekawa N., Ishikawa H., Egawa T. // Electronics Letters. - 2004. - Vol. 40, No. 12. - P. 775-776.

J710. Doo-Hyeb Youn. The effects of isoelectronic Al doping and process optimization for the fabrication of high-power AlGaN-GaN HEMTs. / Doo-Hyeb Youn, Jae-Hoon Lee, Kumar V., Kyu-Seok Lee, Jung-Hee Lee, Adesida I. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 5. - P. 785-789.

J711. Kushwaha M.S. Resonant response of a FET to an AC signal: influence of magnetic field, device length, and temperature. / Kushwaha M.S., Vasilopoulos P. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 5. - P. 803-813.

J712. Vilches A. SiGe HMODFET "KAIST" micropower model and amplifier realization. / Vilches A., Fobelets K., Michelakis K., Despotopoulos S., Papavassiliou C., Hackbarth T., Konig U. // IEEE Transactions on Circuits and Systems I: Regular Papers. - 2004. - Vol. 51, No. 6. - P. 1100-1105.

J713. Hontschel J. Simulation of quantum transport in monolithic ICs based on In0.53 Ga0.47 As-In0.52 Al0.48 As RTDs and HEMTs with a quantum hydrodynamic transport model. / Hontschel J., Stenzel R., Klix W. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 5. - P. 684-692.

J714. Johnson J.W. 12 W/mm AlGaN-GaN HFETs on silicon substrates. / Johnson J.W., Piner E.L., Vescan A., Therrien R., Rajagopal P., Roberts J.C., Brown J.D., Singhal S., Linthicum K.J. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 7. - P. 459-461.

J715. Lee J.-W. Microwave noise characteristics of AlGaN/GaN HEMTs on SiC substrates for broad-band low-noise amplifiers. / Lee J.-W., Kuliev A., Kumar V., Schwindt R., Adesida I. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 6. - P. 259-261.

J716. Hongtao Xu. A C-band high-dynamic range GaN HEMT low-noise amplifier. / Hongtao Xu, Sanabria C., Chini A., Keller S., Mishra U.K., York R.A. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 6. - P. 262-264.

J717. Lanford W. AlGaN/InGaN HEMTs for RF current collapse suppression. / Lanford W., Kumar V., Schwindt R., Kuliev A., Adesida I., Dabiran A.M., Wowchak A.M., Chow P.P., Lee J.-W. // Electronics Letters. - 2004. - Vol. 40, No. 12. - P. 771-772.

J718. Mateos J. Design optimization of AlInAs-GaInAs HEMTs for low-noise applications. / Mateos J., Gonzalez T., Pardo D., Bollaert S., Parenty T., Cappy A. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 8. - P. 1228-1233.

J719. Lin K.-Y. Millimeter-wave MMIC passive HEMT switches using traveling-wave concept. / Lin K.-Y., Wen-Hua Tu, Ping-Yu Chen, Hong-Yeh Chang, Huei Wang, Ruey-Beei Wu. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 8. - P. 1798-1808.

J720. Hirata A. High-directivity photonic emitter using photodiode module integrated with HEMT amplifier for 10-Gbit/s wireless link. / Hirata A., Kosugi T., Meisl N., Shibata T., Nagatsuma T. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 8. - P. 1843-1850.

J721. Okino T. Drain current DLTS of AlGaN-GaN MIS-HEMTs. / Okino T., Ochiai M., Ohno Y., Kishimoto S., Maezawa K., Mizutani T. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 8. - P. 523-525.

J722. Yuh-Jing Hwang. A W-band subharmonically pumped monolithic GaAs-based HEMT gate mixer. / Yuh-Jing Hwang, Huei Wang, Tah-Hsiung Chu. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 7. - P. 313-315.

J723. Parkinson G. MMIC implementation of non-reciprocal couplers using pHEMT devices. / Parkinson G., Paul D.K. // Electronics Letters. - 2004. - Vol. 40, No. 13. - P. 810-811.

J724. Margraf M. Analysis and modeling of low-frequency noise in resistive FET mixers. / Margraf M., Boeck G. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 7. - P. 1709-1718.

J725. Forestier S. A new nonlinear capacitance model of millimeter wave power PHEMT for accurate AM/AM-AM/PM simulations. / Forestier S., Gasseling T., Bouysse Ph., Quere R., Nebus J.M. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 1. - P. 43-45.

J726. Shen L. High-power polarization-engineered GaN/AlGaN/GaN HEMTs without surface passivation. / Shen L., Coffie R., Buttari D., Heikman S., Chakraborty A., Chini A., Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 1. - P. 7-9.

J727. Hongtao Xu. Integration of Bax Sr1-x TiO3 thin films with AlGaN/GaN HEMT circuits. / Hongtao Xu, Pervez N.K., Hansen P.J., Shen L., Keller S., Mishra U.K., York R.A. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 2. - P. 49-51.

J728. Wen-Kai Wang. Low damage, Cl2 -based gate recess etching for 0.3-μm gate-length AlGaN/GaN HEMT fabrication. / Wen-Kai Wang, Yu-Jen Li, Cheng-Kuo Lin, Yi-Jen Chan, Guan-Ting Chen, Jen-Inn Chyi. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 2. - P. 52-54.

J729. Oxley C.H. Method for measuring source resistance Rs in saturation region of GaN HEMT device over bias conditions (Vgs ,Vds). Electronics Letters. - 2004. - Vol. 40, No. 5. - P. 344-346.

J730. Huili Xing. High breakdown voltage AlGaN-GaN HEMTs achieved by multiple field plates. / Huili Xing, Dora Y., Chini A., Heikman S., Keller S., Mishra U.K. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 4. - P. 161-163.

J731. Samoska L. A 20 mW, 150 GHz InP HEMT MMIC power amplifier module. / Samoska L., Peralta A., Ming Hu, Micovic M., Schmitz A. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 2. - P. 56-58.

J732. Wu Y.-F. 30-W/mm GaN HEMTs by field plate optimization. / Wu Y.-F., Saxler A., Moore M., Smith R.P., Sheppard S., Chavarkar P.M., Wisleder T., Mishra U.K., Parikh P. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 3. - P. 117-119.

J733. Bernat J. Impact of layer structure on performance of unpassivated AlGaN/GaN/SiC HEMTs. / Bernat J., Wolter M., Fox A., Marso M., Flynn J., Brandes G., Kordos P. // Electronics Letters. - 2004. - Vol. 40, No. 1. - P. 78-80.

J734. Lee J.-W. Microwave noise performances of AlGaN/GaN HEMTs on semi-insulating 6H-SiC substrates. / Lee J.-W., Kumar V., Schwindt R., Kuliev A., Birkhahn R., Gotthold D., Guo S., Albert B., Adesida I. // Electronics Letters. - 2004. - Vol. 40, No. 1. - P. 80-81.

J735. Valdivia G.R. Measurement of mobility in HEMT devices using high-order derivatives. / Valdivia G.R., Ibanez T.F., Rodriguez-Tellez J., Puente A.T., Sanchez A.M. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 1. - P. 1-7.

J736. Chini A. 12 W/mm power density AlGaN/GaN HEMTs on sapphire substrate. / Chini A., Buttari D., Coffie R., Heikman S., Keller S., Mishra U.K. // Electronics Letters. - 2004. - Vol. 40, No. 1. - P. 73-74.

J737. Jong-Wook Lee. A temperature-dependent nonlinear analytic model for AlGaN-GaN HEMTs on SiC. / Jong-Wook Lee, Webb K.J. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 1. - P. 2-9.

J738. Lynch J. W-band multiplier chipset. / Lynch J., Lyons B., Entchev E., Tessmann A., Massler H., Leuther A., Schlechtweg M. // Electronics Letters. - 2004. - Vol. 40, No. 2. - P. 130-132.

J739. Murata K. 100-Gb/s multiplexing and demultiplexing IC operations in InP HEMT technology. / Murata K., Sano K., Kitabayashi H., Sugitani S., Sugahara H., Enoki T. // IEEE Journal of Solid-State Circuits. - 2004. - Vol. 39, No. 1. - P. 207-213.

J740. Thompson R. Performance of the AlGaN HEMT structure with a gate extension. / Thompson R., Prunty T., Kaper V., Shealy J.R. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 2. - P. 292-295.

J741. Neuburger M. Analysis of surface charging effects in passivated AlGaN-GaN FETs using a MOS test electrode. / Neuburger M., Allgaier J., Zimmermann T., Daumiller I., Kunze M., Birkhahn R., Gotthold D.W., Kohn E. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 5. - P. 256-258.

J742. Po-Yu Chen. K-band HBT and HEMT monolithic active phase shifters using vector sum method. / Po-Yu Chen, Tian-Wei Huang, Huei Wang, Yu-Chi Wang, Chung-Hsu Chen, Pane-Chane Chao. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 5. - P. 1414-1424.

J743. Chini A. Power and linearity characteristics of field-plated recessed-gate AlGaN-GaN HEMTs. / Chini A., Buttari D., Coffie R., Shen L., Heikman S., Chakraborty A., Keller S., Mishra U.K. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 5. - P. 229-231.

J744. Rajan S. Power performance of AlGaN-GaN HEMTs grown on SiC by plasma-assisted MBE. / Rajan S., Waltereit P., Poblenz C., Heikman S.J., Green D.S., Speck J.S., Mishra U.K. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 5. - P. 247-249.

J745. Lien Y.C. Low-noise metamorphic HEMTs with reflowed 0.1-μm T-gate. / Lien Y.C., Chang E.Y., Chang H.C., Chu L.H., Huang G.W., Lee H.M., Lee C.S., Chen S.H., Shen P.T., Chang C.Y. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 6. - P. 348-350.

J746. Chou Y.C. The effect of gate metal interdiffusion on reliability performance in GaAs PHEMTs. / Chou Y.C., Leung D., Grundbacher R., Lai R., Liu P.H., Kan Q., Biedenbender M., Eng D., Oki A. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 6. - P. 351-353.

J747. Yu Lung Tang. A broadband PHEMT MMIC distributed doubler using high-pass drain line topology. / Yu Lung Tang, Po-Yo Chen, Huei Wang. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 5. - P. 201-203.

J748. Behtash R. MMIC power amplifier based on AlGaN/GaN HEMTs at 10 GHz. / Behtash R., Tobler H., Berlec F.-J., Ziegler V., Leier H., Balmer R.S., Martin T., Neuburger M., Schumacher H. // Electronics Letters. - 2004. - Vol. 40, No. 9. - P. 564-566.

J749. Xinwen Hu. The energy dependence of proton-induced degradation in AlGaN/GaN high electron mobility transistors. / Xinwen Hu, Choi B.K., Barnaby H.J., Fleetwood D.M., Schrimpf R.D., Sungchul Lee, Shojah-Ardalan S., Wilkins R., Mishra U.K., Dettmer R.W. // IEEE Transactions on Nuclear Science. - 2004. - Vol. 51, No. 2. - P. 293-297.

J750. Jinho Jeong. Monolithic distributed amplifier with active control schemes for optimum gain and group-delay flatness, bandwidth, and stability. / Jinho Jeong, Youngwoo Kwon. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 4. - P. 1101-1110.

J751. Minko A. High microwave and noise performance of 0.17-μm AlGaN-GaN HEMTs on high-resistivity silicon substrates. / Minko A., Hoel V., Lepilliet S., Dambrine G., De Jaeger J.C., Cordier Y., Semond F., Natali F., Massies J. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 4. - P. 167-169.

J752. Menozzi R. Off-state breakdown of GaAs PHEMTs: review and new data. IEEE Transactions on Device and Materials Reliability. - 2004. - Vol. 4, No. 1. - P. 54-62.

J753. Hacker J.B. An ultra-low power InAs/AlSb HEMT Ka-band low-noise amplifier. / Hacker J.B., Bergman J., Nagy G., Sullivan G., Kadow C., Heng-Kuang Lin, Gossard A.C., Rodwell M., Brar B. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 4. - P. 156-158.

J754. O'Droma M. New percentage linearization measures of the degree of linearization of HPA nonlinearity. / O'Droma M., Mgebrishvili N., Goacher A. // IEEE Communications Letters. - 2004. - Vol. 8, No. 4. - P. 214-216.

J755. Forestier S. Joint optimization of the power-added efficiency and the error-vector measurement of 20-GHz pHEMT amplifier through a new dynamic bias-control method. / Forestier S., Bouysse P., Quere R., Mallet A., Nebus J.-M., Lapierre L. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No.

4. - P. 1132-1141.

J756. Tessmann A. A flip-chip packaged coplanar 94 GHz amplifier module with efficient suppression of parasitic substrate effects. / Tessmann A., Riessle M., Kudszus S., Massler H. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 4. - P. 145-147.

J757. Chu K.K. 9.4-W/mm power density AlGaN-GaN HEMTs on free-standing GaN substrates. / Chu K.K., Chao P.C., Pizzella M.T., Actis R., Meharry D.E., Nichols K.B., Vaudo R.P., Xu X., Flynn J.S., Dion J., Brandes G.R. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 9. - P. 596-598.

J758. Schneider D. Tuned transition from a quantum well to a quantum wire investigated by magnetophonon resonance. / Schneider D., Brink C., Schlachetzki A., Ploner G., Strasser G., Gornik E. // Journal of Applied Physics. - 2004. - Vol. 95, No. 5. - P. 2509-2517.

J759. Cabria L. A PHEMT frequency doubling active antenna with BPSK modulation capability. / Cabria L., Garcia J.A., Malaver E., Tazon A. // IEEE Antennas and Wireless Propagation Letters. - 2004. - Vol. 3, No. 1. - P. 310-313.

J760. Roschier Leif. Noise performance of the radio-frequency single-electron transistor. / Roschier Leif, Hakonen P., Bladh K., Delsing P., Lehnert K. W., Spietz Lafe, Schoelkopf R. J. // Journal of Applied Physics. - 2004. - Vol. 95, No. 3. - P. 1274-1286.

J761. Satou A. Characteristics of a terahertz photomixer based on a high-electron mobility transistor structure with optical input through the ungated regions. / Satou A., Ryzhii V., Khmyrova I., Ryzhii M., Shur M. S. // Journal of Applied Physics. - 2004. - Vol. 95, No. 4. - P. 2084-2089.

J762. Pronic O. Procedure for accurate noise modelling of microwave FETs against temperature. / Pronic O., Mitic G., Randelovic J., Markovic V. // Electronics Letters. - 2004. - Vol. 40, No. 24. - P. 1551-1553.

J763. Lee C. Effects of RF stress on power and pulsed IV characteristics of AlGaN/GaN HEMTs with field-plate gates. / Lee C., Tserng H., Witkowski L., Saunier P., Guo S., Albert B., Birkhahn R., Munns G. // Electronics Letters. - 2004. - Vol. 40, No. 24. - P. 1547-1548.

J764. McMorrow D. Transient response of III-V field-effect transistors to heavy-ion irradiation. / McMorrow D., Boos J.B., Knudson A.R., Lotshaw W.T., Doe Park, Melinger J.S., Bennett B.R., Torres A., Ferlet-Cavrois V., Sauvestre J.-E., D'Hose C., Flament O. // IEEE Transactions on Nuclear Science. - 2004. - Vol. 51, No. 6. - P. 3324-3331.

J765. Dumka D.C. RF reliability performance of AlGaN/GaN HEMTs on Si substrate at 10 GHz. / Dumka D.C., Lee C., Tserng H.Q., Saunier P. // Electronics Letters. - 2004. - Vol. 40, No. 24. - P. 1554-1556.

J766. Bennett Brian R. Materials growth for InAs high electron mobility transistors and circuits. / Bennett Brian R., Tinkham Brad P., Boos J. Brad, Lange Michael D., Tsai Roger. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2004. - Vol. 22, No. 2. - P. 688-694.

J767. Chen Yen-Wei. Enhancement-mode In 0.52 Al 0.48 As/In 0.6 Ga 0.4 As tunneling real space transfer high electron mobility transistor. / Chen Yen-Wei, Chen Yeong-Jia, Hsu Wei-Chou, Hsu Rong-Tay, Wu Yue-Huei, Lin Yu-Shyan. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2004. - Vol. 22, No. 3. - P. 974-976.

J768. Kang B. S. Pressure-induced changes in the conductivity of AlGaN /GaN high-electron mobility-transistor membranes. / Kang B. S., Kim S., Ren F., Johnson J. W., Therrien R. J., Rajagopal P., Roberts J. C., Piner E. L., Linthicum K. J., Chu S. N.G., Baik K., Gila B. P., Abernathy C. R., Pearton S. J. // Applied Physics Letters. - 2004. - Vol. 85, No. 14. - P. 2962-2964.

J769. Irwin K. D. Microwave SQUID multiplexer. / Irwin K. D., Lehnert K. W. // Applied Physics Letters. - 2004. - Vol. 85, No. 11. - P. 2107-2109.

J770. Solodky S. Surface photovoltage spectroscopy of metamorphic high electron mobility transistor structures. / Solodky S., Baksht T., Khramtsov A., Leibovitch M., Hava S., Shapira Yoram. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2004. - Vol. 22, No. 5. - P. 2434-2438.

J771. Kang B. S. Annealing temperature stability of Ir and Ni-based Ohmic contacts on Al Ga N /Ga N high electron mobility transistors. / Kang B. S., Kim S., La Roche J. R., Ren F., Fitch R. C., Gillespie J. K., Moser N., Jenkins T., Sewell J., Via D., Crespo A., Dabiran A. M., Chow P. P., Osinsky A., Pearton S. J. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2004. - Vol. 22, No. 6. - P. 2635-2639.

J772. Hoke W. E. Material properties and performance of metamorphic optoelectronic integrated circuits grown by molecular beam epitaxy on GaAs substrates. / Hoke W. E., Leoni R. E., Whelan C. S., Kennedy T. D., Torabi A., Marsh P. F., Zhang Y., Xu C., Hsieh K. C. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2004. - Vol. 22, No. 3. - P. 1554-1557.

J773. Lubyshev D. Comparison of As- and P-based metamorphic buffers for high performance InP heterojunction bipolar transistor and high electron mobility transistor applications. / Lubyshev D., Fastenau J. M., Fang X.-M., Wu Y., Doss C., Snyder A., Liu W. K., Lamb M. S. M., Bals S., Song C. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2004. - Vol. 22, No. 3. - P. 1565-1569.

J774. Suzuki T. A 80-gbit/s D-type flip-flop circuit using InP HEMT technology. / Suzuki T., Takahashi T., Hirose T., Takikawa M. // IEEE Journal of Solid-State Circuits. - 2004. - Vol. 39, No. 10. - P. 1706-1711.

J775. Fukuyama H. Photoreceiver module using an InP HEMT transimpedance amplifier for over 40 gb/s. / Fukuyama H., Sano K., Murata K., Kitabayashi H., Yamane Y., Enoki T., Sugahara H. // IEEE Journal of Solid-State Circuits. - 2004. - Vol. 39, No. 10. - P. 1690-1696.

J776. M. Marso. A novel two-color photodetector based on an InAlAs-InGaAs HEMT Layer structure. / M. Marso, M. Wolter, P. Kordos. // IEEE Photonics Technology Letters. - 2004. - Vol. 16, No. 11. - P. 2541-2543.

J777. Meneghesso G. Surface-related drain current dispersion effects in AlGaN-GaN HEMTs. / Meneghesso G., Verzellesi G., Pierobon R., Rampazzo F., Chini A., Mishra U.K., Canali C., Zanoni E. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 10. - P. 1554-1561.

J778. Zhang A.P. Stability of AlGaN/GaN high-power HEMTs under DC and RF stresses. / Zhang A.P., Kaminsky E.B., Allen A.F., Hedrick J.W., Vertiatchikh A., Eastman L.F. // Electronics Letters. - 2004. - Vol. 40, No. 19. - P. 1229-1230.

J779. Storm D.F. Room temperature Hall mobilities above 1900 cm2 /V s in MBE-grown AlGaN/GaN HEMT structures. / Storm D.F., Katzer D.S., Binari S.C., Shanabrook B.V., Xu X., McVey D.S., Vaudo R.P., Brandes G.R. // Electronics Letters. - 2004. - Vol. 40, No. 19. - P. 1226-1227.

J780. Zirath H. Development of 60-GHz front-end circuits for a high-data-rate communication system. / Zirath H., Masuda T., Kozhuharov R., Ferndahl M. // IEEE Journal of Solid-State Circuits. - 2004. - Vol. 39, No. 10. - P. 1640-1649.

J781. Suemitsu T. An intrinsic delay extraction method for Schottky gate field effect transistors. IEEE Electron Device Letters. - 2004. - Vol. 25, No. 10. - P. 669-671.

J782. Darwish A.M. Thermal resistance calculation of AlGaN-GaN devices. / Darwish A.M., Bayba A.J., Hung H.A. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 11. - P. 2611-2620.

J783. Cabral P.M. Nonlinear device model of microwave power GaN HEMTs for high power-amplifier design. / Cabral P.M., Pedro J.C., Carvalho N.B. // IEEE Transactions on Microwave Theory and Techniques. - 2004. - Vol. 52, No. 11. - P. 2585-2592.

J784. Saito W. High breakdown Voltage undoped AlGaN-GaN power HEMT on sapphire substrate and its demonstration for DC-DC converter application. / Saito W., Kuraguchi M., Takada Y., Tsuda K., Omura I., Ogura T. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 11. - P. 1913-1917.

J785. Bok-Hyung Lee. Two-stage broadband high-gain W-band amplifier using 0.1-μm metamorphic HEMT technology. / Bok-Hyung Lee, An D., Mun-Kyo Lee, Byeong-Ok Lim, Kim S.-D., Jin-Koo Rhee. // IEEE Electron Device Letters. - 2004. - Vol. 25, No. 12. - P. 766-768.

J786. Wen-Kai Wang. Low-κ BCB passivation on AlGaN-GaN HEMT fabrication. / Wen-Kai Wang, Ching-Huao Lin, Po-Chen Lin, Cheng-Kuo Lin, Fan-Hsiu Huang, Yi-Jen Chan, Guan-Ting Chen, Jen-Inn Chyi. // IEEE

Electron Device Letters. - 2004. - Vol. 25, No. 12. - P. 763-765.

J787. Koudymov A. Monolithically integrated high-power broad-band RF switch based on III-N insulated gate transistors. / Koudymov A., Rai S., Adivarahan V., Gaevski M., Yang J., Simin G., Khan M.A. // IEEE Microwave and Wireless Components Letters. - 2004. - Vol. 14, No. 12. - P. 560-562.

J788. Jeong Park. Thermal modeling and measurement of AlGaN-GaN HFETs built on sapphire and SiC substrates. / Jeong Park, Moo Whan Shin, Lee C.C. // IEEE Transactions on Electron Devices. - 2004. - Vol. 51, No. 11. - P. 1753-1759.

J789. McMorrow D. Ionization-induced carrier transport in InAlAs/InGaAs high electron mobility transistors. / McMorrow D., Knudson A.R., Boos J.B., Doe Park, Melinger J.S. // IEEE Transactions on Nuclear Science. - 2004. - Vol. 51, No. 5. - P. 2857-2864.

J790. Behtash R. AlGaN/GaN HEMTs on Si(111) with 6.6 W/mm output power density. / Behtash R., Tobler H., Neuburger M., Schurr A., Leier H., Cordier Y., Semond F., Natali F., Massies J. // Electronics Letters. - 2003. - Vol. 39, No. 7. - P. 626-627.

J791. Di Martino A. Statistical nonlinear model of MESFET and HEMT devices. / Di Martino A., Marietti P., Olivieri M., Tommasino P., Trifiletti A. // IEE Proceedings - Circuits, Devices and Systems. - 2003. - Vol. 150, No. 2. - P. 95-103.

J792. Chini A. 2.1 A/mm current density AlGaN/GaN HEMT. / Chini A., Coffie R., Meneghesso G., Zanoni E., Buttari D., Heikman S., Keller S., Mishra U.K. // Electronics Letters. - 2003. - Vol. 39, No. 7. - P. 625-626.

J793. Vaha-Heikkila T. On-wafer noise-parameter measurements at W-band. / Vaha-Heikkila T., Lahdes M., Kantanen M., Tuovinen J. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 6. - P. 1621-1628.

J794. Sjoman P. Planck satellite 70 GHz EBB-version back end module. / Sjoman P., Ruokokoski T., Hughes N.J., Jukkala P., Kangaslahti P., Ovaska S., Eskelinen P. // IEEE Aerospace and Electronic Systems Magazine. - 2003. - Vol. 18, No. 5. - P. 22-25.

J795. Manfra M. Unpassivated AlGaN/GaN HEMTs with CW power density of 3.2 W/mm at 25 GHz grown by plasma-assisted MBE. / Manfra M., Weimann N., Baeyens Y., Roux P., Tennant D.M. // Electronics Letters. - 2003. - Vol. 39, No. 8. - P. 694-695.

J796. Sawada K. Elimination of kink phenomena and drain current hysteresis in InP-based HEMTs with a direct ohmic structure. / Sawada K., Arai T., Takahashi T., Hara N. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 2. - P. 310-314.

J797. Tsung-Hsing Yu. Theoretical study of a GaN-AlGaN high electron mobility transistor including a nonlinear polarization model. / Tsung-Hsing Yu, Brennan K.F. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 2. - P. 315-323.

J798. Weimann N.G. Unpassivated AlGaN-GaN HEMTs with minimal RF dispersion grown by plasma-assisted MBE on semi-insulating 6H-SiC substrates. / Weimann N.G., Manfra M.J., Wachtler T. // IEEE Electron Device Letters. - 2003. - Vol. 24, No. 2. - P. 57-59.

J799. Kantanen M. A wide-band on-wafer noise parameter measurement system at 50-75 GHz. / Kantanen M., Lahdes M., Vaha-Heikkila T., Tuovinen J. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 5. - P. 1489-1495.

J800. Baksht T. Impact ionization measurements and modeling for power PHEMT. / Baksht T., Solodky S., Leibovitch M., Bunin G., Shapira Y. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 2. - P. 479-485.

J801. Wadefalk N. Cryogenic wide-band ultra-low-noise IF amplifiers operating at ultra-low DC power. / Wadefalk N., Mellberg A., Angelov I., Barsky M.E., Bui S., Choumas E., Grundbacher R.W., Kollberg E.L., Lai R., Rorsman N., Starski P., Stenarson J., Streit D.C., Zirath H. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 6. - P. 1705-1711.

J802. Kappeler O. 108 GHz dynamic frequency divider in 100 nm metamorphic enhancement HEMT technology. / Kappeler O., Leuther A., Benz W., Schlechtweg M. // Electronics Letters. - 2003. - Vol. 39, No. 13. - P. 989-990.

J803. Shouxuan Xie. High-linearity class B power amplifiers in GaN HEMT technology. / Shouxuan Xie, Paidi V., Coffie R., Keller S., Heikman S., Moran B., Chini A., DenBaars S.P., Mishra U., Long S., Rodwell M.J.W. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 7. - P. 284-286.

J804. Chou Y.C. Reliability investigation of 0.07-μm InGaAs-InAlAs-InP HEMT MMICs with pseudomorphic In0.75 Ga0.25 As channel. / Chou Y.C., Leung D., Lai R., Grundbacher R., Barsky M., Kan Q., Tsai R., Wojtowicz M., Eng D., Tran L., Block T., Liu P.H., Nishimoto M., Oki A. // IEEE Electron Device Letters. - 2003. - Vol. 24, No. 6. - P. 378-380.

J805. Hara N. Highly uniform InAlAs-InGaAs HEMT technology for high-speed optical communication system ICs. / Hara N., Makiyama K., Takahashi T., Sawada K., Arai T., Ohki T., Nihei M., Suzuki T., Nakasha Y., Nishi M. // IEEE Transactions on Semiconductor Manufacturing. - 2003. - Vol. 16, No. 3. - P. 370-375.

J806. Jin-Ping Ao. Copper gate AlGaN/GaN HEMT with low gate leakage current. / Jin-Ping Ao, Kikuta D., Kubota N., Naoi Y., Ohno Y. // IEEE Electron Device Letters. - 2003. - Vol. 24, No. 8. - P. 500-502.

J807. Jing Wang. Ballistic transport in high electron mobility transistors. / Jing Wang, Lundstrom M. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 7. - P. 1604-1609.

J808. Prokopenko G.V. An HTS X-band DC SQUID based amplifier: modeling and development concepts. / Prokopenko G.V., Shitov S.V., Borisenko I.V., Mygind J. // IEEE Transactions on Applied Superconductivity. - 2003. - Vol. 13, No. 2. - P. 1046-1049.

J809. Cheol-Gyu Hwang. Simple K-band MMIC VCO utilizing a miniaturized hairpin resonator and a three-terminal p-HEMT varactor with low phase noise and high output power properties. / Cheol-Gyu Hwang, Jeong-Seon Lee, Jeong-Hoon Kim, Noh-Hoon Myung, Jong-In Song. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 6. - P. 229-231.

J810. Orzati A. A V-band up-converting InP HEMT active mixer with low LO-power requirements. / Orzati A., Robin F., Meier H., Benedikter H., Bachtold W. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 6. - P. 202-204.

J811. Wartenberg S.A. The epHEMT gate at microwave frequencies. / Wartenberg S.A., Hauser J.R. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 6. - P. 1718-1723.

J812. Sahoo D.K. High-field effects in silicon nitride passivated GaN MODFETs. / Sahoo D.K., Lal R.K., Hyungtak Kim, Tilak V., Eastman L.F. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 5. - P. 1163-1170.

J813. Kanda A. 10 Gbit/s series-connected voltage-balancing pulse driver with direct-coupled current switches. / Kanda A., Umeda Y., Enoki T. // Electronics Letters. - 2003. - Vol. 39, No. 12. - P. 908-909.

J814. Vilches A. Monolithic micropower amplifier using SiGe n-MODFET device. / Vilches A., Fobelets K., Michelakis K., Despotopoulos S., Papavassiliou C., Hackbarth T., Konig U. // Electronics Letters. - 2003. - Vol. 39, No. 12. - P. 884-886.

J815. Kuo-Liang Deng. A miniature broad-band pHEMT MMIC balanced distributed doubler. / Kuo-Liang Deng, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 4. - P. 1257-1261.

J816. Yu M. 40 Gbit/s low-voltage distributed limiting drivers for optical modulators. / Yu M., Lao Z., Lee S., Xu A., Ho V., Radisic V., Guinn K., Wang K.C. // Electronics Letters. - 2003. - Vol. 39, No. 3. - P. 301-302.

J817. Parker A.E. Bias and frequency dependence of FET characteristics. / Parker A.E., Rathmell J.G. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 2. - P. 588-592.

J818. Orzati A. A 110-GHz large-signal lookup-table model for InP HEMTs including impact ionization effects. / Orzati A., Schreurs D.M.M.-P., Pergola L., Benedickter H., Robin F., Homan O.J., Bachtold W. // IEEE

Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 2. - P. 468-474.

J819. Kang I.-H. Enhancement-mode p-HEMT using selective hydrogen treatment. / Kang I.-H., Song J.-I. // Electronics Letters. - 2003. - Vol. 39, No. 4. - P. 408-409.

J820. Savian D. Channel temperature measurement of PHEMT by means of optical probes. / Savian D., Di Carlo A., Lugli R., Peroni M., Cetronio C., Lanzieri C., Meneghesso G., Zanoni E. // Electronics Letters. - 2003. - Vol. 39, No. 2. - P. 247-248.

J821. Zhang A.P. 9.2 W/mm (13.8 W) AlGaN/GaN HEMTs at 10 GHz and 55 V drain bias. / Zhang A.P., Rowland L.B., Kaminsky E.B., Tucker J.B., Kretchmer J.W., Allen A.F., Cook J., Edward B.J. // Electronics Letters. - 2003. - Vol. 39, No. 2. - P. 245-247.

J822. Green B.M. Microwave power limits of AlGaN/GaN HEMTs under pulsed-bias conditions. / Green B.M., Tilak V., Kaper V.S., Smart J.A., Shealy J.R., Eastman L.F. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 2. - P. 618-623.

J823. Rashmi. Comprehensive analysis of small-signal parameters of fully strained and partially relaxed high Al-content lattice mismatched Alm Ga1-m N/GaN HEMTs. / Rashmi, Kranti A., Haldar S., Gupta M., Gupta R.S. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 2. - P. 607-617.

J824. Vitusevich S.A. Design and characterization of an all-cryogenic low phase-noise sapphire K-band oscillator for satellite communication. / Vitusevich S.A., Schieber K., Ghosh I.S., Klein N., Spinnler M. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 1. - P. 163-169.

J825. Smorchkova I.P. AlGaN/GaN HEMTs-operation in the K-band and above. / Smorchkova I.P., Wojtowicz M., Sandhu R., Tsai R., Barsky M., Namba C., Liu P.-S., Dia R., MinhDao Truong, Ko D., Wang J., Wang H., Khan A. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 2. - P. 665-668.

J826. Nagy W. Linearity characteristics of microwave-power GaN HEMTs. / Nagy W., Brown J., Borges R., Singhal S. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 2. - P. 660-664.

J827. Paidi V. High linearity and high efficiency of class-B power amplifiers in GaN HEMT technology. / Paidi V., Shouxuan Xie, Coffie R., Moran B., Heikman S., Keller S., Chini A., DenBaars S.P., Mishra U.K., Long S., Rodwell M.J.W. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 2. - P. 643-652.

J828. Jung-Hui Tsai. A novel InGaP/InGaAs/GaAs double δ-doped pHEMT with camel-like gate structure. IEEE Electron Device Letters. - 2003. - Vol. 24, No. 1. - P. 1-3.

J829. Youn D.-H. High power 0.25 μm gate GaN HEMTs on sapphire with power density 4.2 W/mm at 10 GHz. / Youn D.-H., Kumar V., Lee J.-H., Schwindt R., Chang W.-J., Hong J.-Y., Jeon C.-M., Bae S.-B., Park M.-R., Lee K.-S., Lee J.-L., Adesida I. // Electronics Letters. - 2003. - Vol. 39, No. 6. - P. 566-567.

J830. Lao Z. 40 Gbit/s lumped-element modulator driver in GaAs pHEMTs. / Lao Z., Yu M., Guinn K., Lee S., Ho V., Xu M., Radisic V., Wang K.C. // Electronics Letters. - 2003. - Vol. 39, No. 6. - P. 516-517.

J831. Cidronali A. Physical/electromagnetic pHEMT modeling. / Cidronali A., Leuzzi G., Manes G., Giannini F. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 3. - P. 830-838.

J832. Kun-You Lin. Millimeter-wave MMIC single-pole-double-throw passive HEMT switches using impedance-transformation networks. / Kun-You Lin, Yu-Jiu Wang, Dow-Chih Niu, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 4. - P. 1076-1085.

J833. Hong-Yeh Chang. A 77-GHz MMIC power amplifier for automotive radar applications. / Hong-Yeh Chang, Huei Wang, Yu M., Yonghui Shu. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 4. - P. 143-145.

J834. Singh D.V. Static frequency divider circuit using 0.15 μm gate length Si0.2 Ge0.8 /Si0.7 Ge0.3 p-MODFETs. / Singh D.V., Koester S.J., Chu J.O., Jenkins K.A., Mooney P.M., Ouyang Q.C., Ruiz N., Ott J.A., Ralston D., Wetzel M., Asbeck P.M., Saenger K.L., Patel V.V., Grill A. // Electronics Letters. - 2003. - Vol. 39, No. 6. - P. 570-572.

J835. Vellas N. Power results at 4 GHz of AlGaN/GaN HEMTs on high resistive silicon [111] substrate. / Vellas N., Gaquiere C., Minko A., Hoel V., De Jaeger J.C., Cordier Y., Semond F. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 3. - P. 99-101.

J836. Risacher C. GaAs HEMT low-noise cryogenic amplifiers from C-band to X-band with 0.7-K/GHz noise temperature. / Risacher C., Belitsky V. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 3. - P. 96-98.

J837. Schwindt R.S. Millimeter-wave high-power 0.25-μm gate-length AlGaN/GaN HEMTs on SiC substrates. / Schwindt R.S., Kumar V., Kuliev A., Simin G., Yang J.W., Khan M.A., Muir M.E., Adesida I. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 3. - P. 93-95.

J838. Junghyun Kim. High-performance V-band cascode HEMT mixer and downconverter module. / Junghyun Kim, Moon-Suk Jeon, Dongki Kim, Jinho Jeong, Youngwoo Kwon. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 3. - P. 805-810.

J839. Piernas B. A compact and low-phase-noise Ka-band pHEMT-based VCO. / Piernas B., Nishikawa K., Nakagawa T., Araki K. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 3. - P. 778-783.

J840. Bartolucci G. Phase noise characterisation of planar magnetostatic wave oscillators. / Bartolucci G., Marcelli R., Jinsong Chen. // Electronics Letters. - 2003. - Vol. 39, No. 5. - P. 442-444.

J841. Sano K. 50-gbit/s InP HEMT 4: 1 multiplexer/1: 4 demultiplexer chip set with a multiphase clock architecture. / Sano K., Murata K., Kitabayashi H., Sugitani S., Sugahara H., Enoki T. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 12. - P. 2548-2554.

J842. I-Jen Chen. A V-band quasi-optical GaAs HEMT monolithic integrated antenna and receiver front end. / I-Jen Chen, Huei Wang, Powen Hsu. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 12. - P. 2461-2468.

J843. Steinhoff G. pH response of GaN surfaces and its application for pH-sensitive field-effect transistors. / Steinhoff G., Hermann M., Schaff W. J., Eastman L. F., Stutzmann M., Eickhoff M. // Applied Physics Letters. - 2003. - Vol. 83, No. 1. - P. 177-179.

J844. Marso M. Investigation of buffer traps in an AlGaN/GaN/Si high electron mobility transistor by backgating current deep level transient spectroscopy. / Marso M., Wolter M., Javorka P., Kordos P., Luth H. // Applied Physics Letters. - 2003. - Vol. 82, No. 4. - P. 633-635.

J845. Saito W. High breakdown voltage AlGaN-GaN power-HEMT design and high current density switching behavior. / Saito W., Takada Y., Kuraguchi M., Tsuda K., Omura I., Ogura T., Ohashi H. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 12. - P. 2528-2531.

J846. Kumar V. High performance 0.25 μm gate-length AlGaN/GaN HEMTs on 6H-SiC with power density of 6.7 W/mm at 18 GHz. / Kumar V., Lee J.-W., Kuliev A., Aktas O., Schwindt R., Birkhahn R., Gotthold D., Guo S., Albert B., Adesida I. // Electronics Letters. - 2003. - Vol. 39, No. 22. - P. 1609-1611.

J847. Jong-Wook Lee. A gallium-nitride push-pull microwave power amplifier. / Jong-Wook Lee, Eastman L.F., Webb K.J. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 11. - P. 2243-2249.

J848. Kumar V. High transconductance enhancement-mode AlGaN/GaN HEMTs on SiC substrate. / Kumar V., Kuliev A., Tanaka T., Otoki Y., Adesida I. // Electronics Letters. - 2003. - Vol. 39, No. 24. - P. 1758-1760.

J849. Coffie R. Unpassivated p-GaN/AlGaN/GaN HEMTs with 7.1 W/mm at 10 GHz. / Coffie R., Shen L., Parish G., Chini A., Buttari D., Heikman S., Keller S., Mishra U.K. // Electronics Letters. - 2003. - Vol. 39, No. 19. - P. 1419-1420.

J850. Li Yih-Juan. Depletion- and enhancement-mode In 0.49 Ga 0.51 P /InGaAs /AlGaAs high-electron-mobility transistors with high-breakdown voltage. / Li Yih-Juan, Hsu Wei-Chou, Chen Yen-Wei, Shieh Hir-Ming. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2003. - Vol. 21, No. 3. - P. 981-983.

J851. Arulkumaran S. Characterization of different-Al-content Al x Ga 1-x N/GaN heterostructures and high-electron-mobility transistors on sapphire. / Arulkumaran S., Egawa T., Ishikawa H., Jimbo T. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2003. - Vol. 21, No. 2. - P. 888-894.

J852. Sugiyama Hiroki. Thermal stability of InP-based high electron mobility transistor epitaxial wafers. / Sugiyama Hiroki, Watanabe Kazuo, Yokoyama Haruki, Kobayashi Takashi. // Journal of Applied Physics. - 2003. - Vol. 93, No. 7. - P. 4260-4267.

J853. Oukhanski N. Low noise, low power consumption high electron mobility transistors amplifier, for temperatures below 1 K. / Oukhanski N., Grajcar M., Ilichev E., Meyer H.-G. // Review of Scientific Instruments. - 2003. - Vol. 74, No. 2. - P. 1145-1146.

J854. White B.D. Electrical, spectral, and chemical properties of 1.8 MeV proton irradiated AlGaN/GaN HEMT structures as a function of proton fluence. / White B.D., Bataiev M., Goss S.H., Hu X., Karmarkar A., Fleetwood D.M., Schrimpf R.D., Schaff W.J., Brillson L.J. // IEEE Transactions on Nuclear Science. - 2003. - Vol. 50, No. 6. - P. 1934-1941.

J855. Solodky S. Surface photovoltage spectroscopy of epitaxial structures for high electron mobility transistors. / Solodky S., Khramtsov A., Baksht T., Leibovitch M., Hava S., Shapira Yoram. // Applied Physics Letters. - 2003. - Vol. 83, No. 12. - P. 2465-2467.

J856. Junghyun Kim. A high-performance 40-85 GHz MMIC SPDT switch using FET-integrated transmission line structure. / Junghyun Kim, Won Ko, Sung-Ho Kim, Jinho Jeong, Youngwoo Kwon. // IEEE Microwave and Wireless Components Letters. - 2003. - Vol. 13, No. 12. - P. 505-507.

J857. Song Jung-Hoon. Generation of coherent gigahertz acoustic phonons in AlGaN/GaN microwave field-effect transistors. / Song Jung-Hoon, Zhang Qiang, Patterson W., Nurmikko A. V., Uren M. J., Hilton K. P., Balmer R. S., Martin T. // Applied Physics Letters. - 2003. - Vol. 83, No. 5. - P. 1023-1025.

J858. Kuzm . Electrostatic discharge effects in AlGaN/GaN high-electron-mobility transistors. / Kuzm , k J., Pogany D., Gornik E., Javorka P., Kordos P. // Applied Physics Letters. - 2003. - Vol. 83, No. 22. - P. 4655-4657.

J859. Kuo-Liang Deng. Design and analysis of novel high-gain and broad-band GaAs pHEMT MMIC distributed amplifiers with traveling-wave gain stages. / Kuo-Liang Deng, Tian-Wei Huang, Huei Wang. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 11. - P. 2188-2196.

J860. Kaper V.S. High-power monolithic AlGaN/GaN HEMT oscillator. / Kaper V.S., Tilak V., Hyungtak Kim, Vertiatchikh A.V., Thompson R.M., Prunty T.R., Eastman L.F., Shealy J.R. // IEEE Journal of Solid-State Circuits. - 2003. - Vol. 38, No. 9. - P. 1457-1461.

J861. Bessemoulin A. A 4-W X-band compact coplanar high-power amplifier MMIC with 18-dB gain and 25% PAE. / Bessemoulin A., Quay R., Ramberger S., Massler H., Schlechtweg M. // IEEE Journal of Solid-State Circuits. - 2003. - Vol. 38, No. 9. - P. 1433-1437.

J862. Masuda S. An over-110-GHz InP HEMT flip-chip distributed baseband amplifier with inverted microstrip line structure for optical transmission system. / Masuda S., Takahashi T., Joshin K. // IEEE Journal of Solid-State Circuits. - 2003. - Vol. 38, No. 9. - P. 1479-1484.

J863. Koley G. Electrical bias stress related degradation of AlGaN/GaN HEMTs. / Koley G., Kim H., Eastman L.F., Spencer M.G. // Electronics Letters. - 2003. - Vol. 39, No. 16. - P. 1217-1218.

J864. Sano K. 50-Gb/s 4-b multiplexer/demultiplexer chip set using InP HEMTs. / Sano K., Murata K., Sugitani S., Sugahara H., Enoki T. // IEEE Journal of Solid-State Circuits. - 2003. - Vol. 38, No. 9. - P. 1504-1511.

J865. Adams K.M. System control and management for low-cost high-volume GaAs manufacturing. / Adams K.M., Coe M.E., Della-Morrow C.D., Flynn K.P., Hertle J., Klingbeil L.S. Jr., Ploeger J.B., Tebelak D.C. // IEEE Transactions on Semiconductor Manufacturing. - 2003. - Vol. 16, No. 3. - P. 390-398.

J866. O'Keefe M.F. GaAs pHEMT-based technology for microwave applications in a volume MMIC production environment on 150-mm wafers. / O'Keefe M.F., Atherton J.S., Bosch W., Burgess P., Cameron N.I., Snowden

C.M. // IEEE Transactions on Semiconductor Manufacturing. - 2003. - Vol. 16, No. 3. - P. 376-383.

J867. Javorka P. Influence of SiO2 and Si3 N4 passivation on AlGaN/GaN/Si HEMT performance. / Javorka P., Bernat J., Fox A., Marso M., Luth H., Kordos P. // Electronics Letters. - 2003. - Vol. 39, No. 15. - P. 1155-1157.

J868. Vertiatchikh A.V. Effect of the surface and barrier defects on the AlGaN/GaN HEMT low-frequency noise performance. / Vertiatchikh A.V., Eastman L.F. // IEEE Electron Device Letters. - 2003. - Vol. 24, No. 9. - P. 535-537.

J869. Zhang Y. 40-Gbit/s OEIC on GaAs substrate through metamorphic buffer technology. / Zhang Y., Whelan C.S., Leoni R., Marsh P.F., Hoke W.E., Hunt J.B., Laighton C.M., Kazior T.E. // IEEE Electron Device Letters. - 2003. - Vol. 24, No. 9. - P. 529-531.

J870. Sleiman A. Channel thickness dependence of breakdown dynamic in InP-based lattice-matched HEMTs. / Sleiman A., Di Carlo A., Lugli P., Meneghesso G., Zanoni E., Thobel J.L. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 10. - P. 2009-2014.

J871. Lee C. AlGaN-GaN HEMTs on SiC with CW power performance of >4 W/mm and 23% PAE at 35 GHz. / Lee C., Saunier P., Jinwei Yang, Khan M.A. // IEEE Electron Device Letters. - 2003. - Vol. 24, No. 10. - P. 616-618.

J872. Nabet B. Photodetectors based on heterostructures for opto-electronic applications. / Nabet B., Cola A., Cataldo A., Xiying Chen, Quaranta F. // IEEE Transactions on Microwave Theory and Techniques. - 2003. - Vol. 51, No. 10. - P. 2063-2072.

J873. Jessen G.H. High performance 0.14 μm gate-length AlGaN/GaN power HEMTs on SiC. / Jessen G.H., Fitch R.C., Gillespie J.K., Via G.D., Moser N.A., Yannuzzi M.J., Crespo A., Sewell J.S., Dettmer R.W., Jenkins T.J., Davis R.F., Yang J., Khan M.A., Binari S.C. // IEEE Electron Device Letters. - 2003. - Vol. 24, No. 11. - P. 677-679.

J874. Mizutani T. A study on current collapse in AlGaN/GaN HEMTs induced by bias stress. / Mizutani T., Ohno Y., Akita M., Kishimoto S., Maezawa K. // IEEE Transactions on Electron Devices. - 2003. - Vol. 50, No. 10. - P. 2015-2020.

J875. Kawano Y. 88 GHz dynamic 2:1 frequency divider using resonant tunnelling chaos circuit. / Kawano Y., Ohno Y., Kishimoto S., Maezawa K., Mizutani T., Sano K. // Electronics Letters. - 2003. - Vol. 39, No. 21. - P. 1546-1548.

J876. Ellis G.A. Active planar inverted-F antennas for wireless applications. / Ellis G.A., Liw S. // IEEE Transactions on Antennas and Propagation. - 2003. - Vol. 51, No. 10. - P. 2899-2906.

J877. Abele P. 32 GHz MMIC distributed amplifier based on n-channel SiGe MODFETs. / Abele P., Zeuner M., Kallfass I., Muller J., Hiwilepo H.L., Hackbarth T., Chrastina D., von Kanel H., Konig U., Schumacher H. // Electronics Letters. - 2003. - Vol. 39, No. 20. - P. 1448-1449.

J878. Shigematsu H. A 54-GHz distributed amplifier with 6-VPP output for a 40-Gb/s LiNbO3 modulator driver. / Shigematsu H., Sato M., Hirose T., Watanabe Y. // IEEE Journal of Solid-State Circuits. - 2002. - Vol. 37, No. 9. - P. 1100-1105.

J879. Li H.P. An updated temperature-dependent breakdown coupling model including both impact ionization and tunneling mechanisms for AlGaAs/InGaAs HEMTs. / Li H.P., Hartin O.L., Ray M. // IEEE Transactions on Electron Devices. - 2002. - Vol. 49, No. 9. - P. 1675-1678.

J880. Mishra U.K. AlGaN/GaN HEMTs-an overview of device operation and applications. / Mishra U.K., Parikh P., Yi-Feng Wu. // Proceedings of the IEEE. - 2002. - Vol. 90, No. 6. - P. 1022-1031.

J881. Vellas N. High linearity performances of GaN HEMT devices on silicon substrate at 4 GHz. / Vellas N., Gaquiere C., Guhel Y., Werquin M., Bue F., Aubry R., Delage S., Semond F., De Jaeger J.C. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 8. - P. 461-463.

J882. Viveiros D. Jr. A tunable all-pass MMIC active phase shifter. / Viveiros D. Jr., Consonni D., Jastrzebski

A.K. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 8. - P. 1885-1889.

J883. Binari S.C. Trapping effects in GaN and SiC microwave FETs. / Binari S.C., Klein P.B., Kazior T.E. // Proceedings of the IEEE. - 2002. - Vol. 90, No. 6. - P. 1048-1058.

J884. Gillespie J.K. Effects of Sc2 O3 and MgO passivation layers on the output power of AlGaN/GaN HEMTs. / Gillespie J.K., Fitch R.C., Sewell J., Dettmer R., Via G.D., Crespo A., Jenkins T.J., Luo B., Mehandru R., Kim J., Ren F., Gila B.P., Onstine A.H., Abernathy C.R., Pearton S.J. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 9. - P. 505-507.

J885. Coffie R. p-capped GaN-AlGaN-GaN high-electron mobility transistors (HEMTs). / Coffie R., Buttari D., Heikman S., Keller S., Chini A., Shen L., Mishra U.K. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 10. - P. 588-590.

J886. Yamashita Y. Pseudomorphic In0.52 Al0.48 As/In0.7 Ga0.3 As HEMTs with an ultrahigh fT of 562 GHz. / Yamashita Y., Endoh A., Shinohara K., Hikosaka K., Matsui T., Hiyamizu S., Mimura T. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 10. - P. 573-575.

J887. McMorrow D. Charge-collection dynamics of InP-based high electron mobility transistors (HEMTs). / McMorrow D., Boos J.B., Park D., Buchner S., Knudson A.R., Melinger J.S. // IEEE Transactions on Nuclear Science. - 2002. - Vol. 49, No. 3. - P. 1396-1400.

J888. Meliani C. DC-92 GHz ultra-broadband high gain InP HEMT amplifier with 410 GHz gain-bandwidth product. / Meliani C., Post G., Rondeau G., Decobert J., Mouzannar W., Dutisseuil E., Lefevre R. // Electronics Letters. - 2002. - Vol. 38, No. 20. - P. 1175-1177.

J889. Young-Taek Lee. A compact-size microstrip spiral resonator and its application to microwave oscillator. / Young-Taek Lee, Jong-Sik Lim, Chul-Soo Kim, Dal Ahn, Sangwook Nam. // IEEE Microwave and Wireless Components Letters. - 2002. - Vol. 12, No. 10. - P. 375-377.

J890. Santarelli A. Equivalent-voltage approach for modeling low-frequency dispersive effects in microwave FETs. / Santarelli A., Zucchelli G., Paganelli R., Vannini G., Filicori F. // IEEE Microwave and Wireless Components Letters. - 2002. - Vol. 12, No. 9. - P. 339-341.

J891. Shur M.S. Low ballistic mobility in submicron HEMTs. IEEE Electron Device Letters. - 2002. - Vol. 23, No. 9. - P. 511-513.

J892. Chen S.H. High power Al0.3 Ga0.7 As/In0.2 Ga 0.8 As enhancement-mode PHEMT for low-voltage wireless communication systems. / Chen S.H., Li Chang, Chang E.Y., Wu J.W., Chun-Yen Chang. // Electronics Letters. - 2002. - Vol. 38, No. 18. - P. 1063-1064.

J893. Schreurs D.M.M.-P. Straightforward and accurate nonlinear device model parameter-estimation method based on vectorial large-signal measurements. / Schreurs D.M.M.-P., Verspecht J., Vandenberghe S., Vandamme E. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 10. - P. 2315-2319.

J894. Lee C. State-of-art CW power density achieved at 26 GHz by AlGaN/GaN HEMTs. / Lee C., Wang H., Yang J., Witkowski L., Muir M., Khan M.A., Saunier P. // Electronics Letters. - 2002. - Vol. 38, No. 16. - P. 924-925.

J895. Cordier Y. AlGaN/GaN HEMTs on resistive Si(111) substrate grown by gas-source MBE. / Cordier Y., Semond F., Massies J., Dessertene B., Cassette S., Surrugue M., Adam D., Delage S.L. // Electronics Letters. - 2002. - Vol. 38, No. 2. - P. 91-92.

J896. Buttari D. Systematic characterization of Cl2 reactive ion etching for improved ohmics in AlGaN/GaN HEMTs. / Buttari D., Chini A., Meneghesso G., Zanoni E., Moran B., Heikman S., Zhang N.Q., Shen L., Coffie R., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 2. - P. 76-78.

J897. Seong-June Jo. Molecular beam epitaxy growth and characterization of InGaP/InGaAs pseudomorphic high electron mobility transistors (HEMTs) having a channel layer over critical layer thickness. / Seong-June Jo, Jeong Hoon Kim, Jong-In Song. // IEEE Transactions on Electron Devices. - 2002. - Vol. 49, No. 3. - P. 354-360.

J898. Young-Taek Lee. A novel phase noise reduction technique in oscillators using defected ground structure. / Young-Taek Lee, Jong-Sik Lim, Jun-Seok Park, Ahn D., Sangwook Nam. // IEEE Microwave and Wireless Components Letters. - 2002. - Vol. 12, No. 2. - P. 39-41.

J899. Yen-Wei Chen. High breakdown characteristic δ-doped InGaP/InGaAs/AlGaAs tunneling real-space transfer HEMT. / Yen-Wei Chen, Wei-Chou Hsu, Her-Ming Shieh, Yeong-Jia Chen, Yu-Shyan Lin, Yih-Juan Li, Tzong-Bin Wang. // IEEE Transactions on Electron Devices. - 2002. - Vol. 49, No. 2. - P. 221-225.

J900. Drozdovski N.V. GaN-based high electron-mobility transistors for microwave and RF control applications. / Drozdovski N.V., Caverly R.H. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 1. - P. 4-8.

J901. Ce-Jun Wei. A new model for enhancement-mode power pHEMT. / Ce-Jun Wei, Tkachenko Y.A., Bartle D. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 1. - P. 57-61.

J902. Kuwahara S. 43 Gbit/s, 200 km unrepeatered transmission experiment using high-sensitivity digital OEIC receiver module. / Kuwahara S., Yonenaga K., Miyamoto Y., Murata K., Kitabayashi H., Shimizu N., Toba H. // Electronics Letters. - 2002. - Vol. 38, No. 1. - P. 38-40.

J903. Mimura T. The early history of the high electron mobility transistor (HEMT). IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 3. - P. 780-782.

J904. Lang M. 66 GHz 2:1 static frequency divider using 100 nm metamorphic enhancement HEMT technology. / Lang M., Leuther A., Benz W., Nowotny U., Kappeler O., Schlechtweg M. // Electronics Letters. - 2002. - Vol. 38, No. 14. - P. 716-717.

J905. Jong-Sik Lim. Application of defected ground structure in reducing the size of amplifiers. / Jong-Sik Lim, Jun-Seok Park, Young-Taek Lee, Dal Ahn, Sangwook Nam. // IEEE Microwave and Wireless Components Letters. - 2002. - Vol. 12, No. 7. - P. 261-263.

J906. Kuzmik J. Determination of channel temperature in AlGaN/GaN HEMTs grown on sapphire and silicon substrates using DC characterization method. / Kuzmik J., Javorka R., Alam A., Marso M., Heuken M., Kordos P. // IEEE Transactions on Electron Devices. - 2002. - Vol. 49, No. 8. - P. 1496-1498.

J907. Hoel V. High-power AlGaN/GaN HEMTs on resistive silicon substrate. / Hoel V., Vellas N., Gaquiere C., De Jaeger J.C., Cordier Y., Semond F., Natali F., Massies J. // Electronics Letters. - 2002. - Vol. 38, No. 14. - P. 750-752.

J908. Javorka P. AlGaN/GaN HEMTs on silicon substrates with fT of 32/20 GHz and fmax of 27/22 GHz for 0.5/0.7 μm gate length. / Javorka P., Alam A., Fox A., Marso M., Heuken M., Kordos P. // Electronics Letters. - 2002. - Vol. 38, No. 6. - P. 288-289.

J909. Kim N. Cavity coupling structure for planar oscillators showing DR-like reflective characteristics. / Kim N., Kwon Y. // Electronics Letters. - 2002. - Vol. 38, No. 5. - P. 210-211.

J910. Yuh-Jing Hwang. A 78-114 GHz monolithic subharmonically pumped GaAs-based HEMT diode mixer. / Yuh-Jing Hwang, Chun-Hsien Lien, Huei Wang, Sinclair M.W., Gough R.G., Kanoniuk H., Tah-Hsiung Chu. // IEEE Microwave and Wireless Components Letters. - 2002. - Vol. 12, No. 6. - P. 209-211.

J911. Junghyun Kim. Intermodulation analysis of dual-gate FET mixers. / Junghyun Kim, Youngwoo Kwon. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 6. - P. 1544-1555.

J912. Mittereder J.A. Quantitative measurement of channel temperature of GaAs devices for reliable life-time prediction. / Mittereder J.A., Roussos J.A., Anderson W.T., Ioannou D.E. // IEEE Transactions on Reliability. - 2002. - Vol. 51, No. 4. - P. 482-485.

J913. Urazhdin S. A simple low-dissipation amplifier for cryogenic STM. / Urazhdin S., Tessmer S. H., Ashoori R. C. // Review of Scientific Instruments. - 2002. - Vol. 73, No. 2. - P. 310-312.

J914. Cui L. J. Rapid thermal annealing effects on step-graded InAlAs buffer layer and In 0.52 Al 0.48 As/In 0.53 Ga 0.47 As metamorphic high electron mobility transistor structures on GaAs substrates. / Cui L. J., Zeng Y. P., Wang B. Q., Wu J., Zhu Z. P., Lin L. Y. // Journal of Applied Physics. - 2002. - Vol. 91, No. 4. - P. 2429-

2432.

J915. Torabi A. Surface and interface characterization of GaN/AlGaN high electron mobility transistor structures by x-ray and atomic force microscopy. / Torabi A., Ericson P., Yarranton E. J., Hoke W. E. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2002. - Vol. 20, No. 3. - P. 1234-1237.

J916. Shinohara Keisuke. Simple and high-precision asymmetric gate-recess process for ultrafast InP-based high electron mobility transistors. / Shinohara Keisuke, Matsui Toshiaki, Yamashita Yoshimi, Endoh Akira, Hikosaka Kohki, Mimura Takashi, Hiyamizu Satoshi. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2002. - Vol. 20, No. 5. - P. 2096-2100.

J917. Long A. Design of an opto-electronic modulator driver amplifier for 40-Gb/s data rate systems. / Long A., Buck J., Powell R. // Journal of Lightwave Technology. - 2002. - Vol. 20, No. 12. - P. 2015-2021.

J918. Weimann N.G. Submicron AlGaN/GaN HEMTs with very high drain current density grown by plasma-assisted MBE on 6H-SiC. / Weimann N.G., Manfra M.J., Chakraborty S., Tennant D.M. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 12. - P. 691-693.

J919. Crowne Frank J. Microwave response of a high electron mobility transistor in the presence of a Dyakonov-Shur instability. Journal of Applied Physics. - 2002. - Vol. 91, No. 8. - P. 5377-5383.

J920. Dutta A.K. 40 Gb/s postamplifier and p-i-n/preamplifier modules for next generation optical front-end systems. / Dutta A.K., Takechi M., Virk R.S., Kobayashi M., Araki K., Sato K., Gentrup M., Ragle R. // Journal of Lightwave Technology. - 2002. - Vol. 20, No. 12. - P. 2229-2238.

J921. Piernas B. Analysis of balanced active doubler for broad-band operation-the frequency-tuning concept. / Piernas B., Nishikawa K., Nagagawa T., Hayashi H., Araki K. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 4. - P. 1120-1126.

J922. Feiginov Michael N. Negative differential conductance in the tunnel Schottky contact with two-dimensional channel. Applied Physics Letters. - 2002. - Vol. 81, No. 5. - P. 930-932.

J923. Vellas N. Load impedance influence on the ID (YDS) characteristics of AlGaN/GaN HEMTs in large signal regime at 4 GHz. / Vellas N., Gaquiere C., Bue F., Guhel Y., Boudart B., de Jaeger J.C., Poisson M.A. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 5. - P. 246-248.

J924. Fang C. Y. A study of subbands in AlGaN/GaN high-electron-mobility transistor structures using low-temperature photoluminescence spectroscopy. / Fang C. Y., Lin C. F., Chang Edward Yi, Feng M. S. // Applied Physics Letters. - 2002. - Vol. 80, No. 24. - P. 4558-4560.

J925. Arulkumaran S. Comparative study of drain-current collapse in AlGaN/GaN high-electron-mobility transistors on sapphire and semi-insulating SiC. / Arulkumaran S., Egawa T., Ishikawa H., Jimbo T. // Applied Physics Letters. - 2002. - Vol. 81, No. 16. - P. 3073-3075.

J926. Lang M. 58-82 GHz 4: 1 dynamic frequency divider using 100 nm metamorphic enhancement HEMT technology. / Lang M., Leuther A., Benz W., Raynor B., Schlechtweg M. // Electronics Letters. - 2002. - Vol. 38, No. 8. - P. 367-368.

J927. Kawano Y. 50 GHz frequency divider using resonant tunnelling chaos circuit. / Kawano Y., Ohno Y., Kishimoto S., Maezawa K., Mizutani T. // Electronics Letters. - 2002. - Vol. 38, No. 7. - P. 305-306.

J928. Hsien-Chin Chin. Enhanced power performance of enhancement-mode Al0.5 Ga 0.5 As/In0.15 Ga0.85 As pHEMTs using a low-k BCB passivation. / Hsien-Chin Chin, Ming-Jyh Hwu, Shih-Cheng Yang, Yi-Jen Chan. // IEEE Electron Device Letters. - 2002. - Vol. 23, No. 5. - P. 243-245.

J929. Bollaert S. fmax of 490 GHz metamorphic In0.52 Al0.48 As/In0.53 Ga0.47 As HEMTs on GaAs substrate. / Bollaert S., Cordier Y., Zaknoune M., Parenty T., Happy H., Lepilliet S., Cappy A. // Electronics Letters. - 2002. - Vol. 38, No. 8. - P. 389-391.

J930. Moon J.S. Linearity of low microwave noise AlGaN/GaN HEMTs. / Moon J.S., Micovic M., Kurdoghlian A., Janke R., Hashimoto P., Wong W.-S., McCray L. // Electronics Letters. - 2002. - Vol. 38, No. 22. - P. 1358-

1359.

J931. Jaechun Lee. A phase noise reduction technique in microwave oscillator using high-Q active filter. / Jaechun Lee, Young-Taek Lee, Sangwook Nam. // IEEE Microwave and Wireless Components Letters. - 2002. - Vol. 12, No. 11. - P. 426-428.

J932. Nakasha Y. A 43-Gb/s full-rate-clock 4:1 multiplexer in InP-based HEMT technology. / Nakasha Y., Suzuki T., Kano H., Tsukashima K., Ohya A., Sawada K., Makiyama K., Takahashi T., Nishi M., Hirose T., Takikawa M., Watanabe Y. // IEEE Journal of Solid-State Circuits. - 2002. - Vol. 37, No. 12. - P. 1703-1709.

J933. Miyake Y. Light-controlled frequency-shift keying modulator using millimetre-wave monolithic integrated circuit oscillator. / Miyake Y., Aoki Y., Okada M., Hoshino K., Harada H., Fujise M. // Electronics Letters. - 2002. - Vol. 38, No. 22. - P. 1371-1373.

J934. Tatu S.O. Ka-band direct digital receiver. / Tatu S.O., Moldovan E., Brehm G., Ke Wu, Bosisio R.G. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 11. - P. 2436-2442.

J935. Miranda J.M. Influence of the calibration kit on the estimation of parasitic effects in HEMT devices at microwave frequencies. / Miranda J.M., Fager C., Zirath H., Sakalas P., Munoz S., Sebastian J.L. // IEEE Transactions on Instrumentation and Measurement. - 2002. - Vol. 51, No. 4. - P. 650-655.

J936. Chung Y. Effects of output harmonic termination on PAE and output power of AlGaN/GaN HEMT power amplifier. / Chung Y., Hang C.Y., Cai S., Chen Y., Lee W., Wen C.P., Wang K.L., Itoh T. // IEEE Microwave and Wireless Components Letters. - 2002. - Vol. 12, No. 11. - P. 421-423.

J937. Junghyun Kim. A new "active" predistorter with high gain and programmable gain and phase characteristics using cascode-FET structures. / Junghyun Kim, Moon-Suk Jeon, Jaehak Lee, Youngwoo Kwon. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 11. - P. 2459-2466.

J938. Batty W. Global coupled EM-electrical-thermal simulation and experimental validation for a spatial power combining MMIC array. / Batty W., Christoffersen C.E., Yakovlev A.B., Whitaker J.F., Mortazawi A., Al-Zayed A., Ozkar M., Ortiz S.C., Reano R.M., Yang K., Katehi L.P.B., Snowden C.M., Steer M.B. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 12. - P. 2820-2833.

J939. White B.D. Characterization of 1.8-MeV proton-irradiated AlGaN/GaN field-effect transistor structures by nanoscale depth-resolved luminescence spectroscopy. / White B.D., Bataiev M., Brillson L.J., Choi B.K., Fleetwood D.M., Schrimpf R.D., Pantelides S.I., Dettmer R.W., Schaff W.J., Champlain J.G., Mishra A.K. // IEEE Transactions on Nuclear Science. - 2002. - Vol. 49, No. 6. - P. 2695-2701.

J940. Hai Xiao. Push-push oscillator with simplified circuit structure. / Hai Xiao, Tanaka T., Aikawa M. // Electronics Letters. - 2002. - Vol. 38, No. 24. - P. 1545-1547.

J941. Bongim Jun. Carrier-removal rate and mobility degradation in heterojunction field-effect transistor structures. / Bongim Jun, Subramanian S. // IEEE Transactions on Nuclear Science. - 2002. - Vol. 49, No. 6. - P. 3222-3229.

J942. Katzer D.S. MBE growth of AlGaN/GaN HEMTs with high power density. / Katzer D.S., Binari S.C., Storm D.F., Roussos J.A., Shanabrook B.V., Glaser E.R. // Electronics Letters. - 2002. - Vol. 38, No. 25. - P. 1740-1741.

J943. Leich A. 65 GHz bandwidth optical receiver combining a flip-chip mounted waveguide photodiode and GaAs-based HEMT distributed amplifier. / Leich A., Hurm V., Sohn J., Feltgen T., Bronner W., Kohler K., Walcher H., Rosenzweig J., Schlechtweg M. // Electronics Letters. - 2002. - Vol. 38, No. 25. - P. 1706-1707.

J944. Cidronali A. Ultralow DC power VCO based on InP-HEMT and heterojunction interband tunnel diode for wireless applications. / Cidronali A., Collodi G., Camprini M., Nair V., Manes G., Lewis J., Goronkin H. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 12. - P. 2938-2946.

J945. Tessmann A. Compact single-chip W-band FMCW radar modules for commercial high-resolution sensor applications. / Tessmann A., Kudszus S., Feltgen T., Riessle M., Sklarczyk C., Haydl W.H. // IEEE Transactions on Microwave Theory and Techniques. - 2002. - Vol. 50, No. 12. - P. 2995-3001.

J946. Murata K. 100 Gbit/s multiplexing and demultiplexing IC operations in InP HEMT technology. / Murata K.,

Sano K., Sugitani S., Sugahara H., Enoki T. // Electronics Letters. - 2002. - Vol. 38, No. 24. - P. 1529-1531.

J947. Leven A. Design of narrow-band photoreceivers by means of the photodiode intrinsic conductance. / Leven A., Hurm V., Reuter R., Rosenzweig J. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 10. - P. 1908-1913.

J948. Shen L. AlGaN/AlN/GaN high-power microwave HEMT. / Shen L., Heikman S., Moran B., Coffie R., Zhang N.-Q., Buttari D., Smorchkova I.P., Keller S., DenBaars S.P., Mishra U.K. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 10. - P. 457-459.

J949. Jong-Wook Lee. Broadband GaN HEMT push-pull microwave power amplifier. / Jong-Wook Lee, Webb K.J. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 9. - P. 367-369.

J950. Chung Y. High power wideband AlGaN/GaN HEMT feedback amplifier module with drain and feedback loop inductances. / Chung Y., Cai S., Lee W., Lin Y., Wen C.P., Wang K.L., Itoh T. // Electronics Letters. - 2001. - Vol. 37, No. 19. - P. 1199-1200.

J951. Takagi T. MMIC development for millimeter-wave space application. / Takagi T., Yamauchi K., Itoh Y., Urasaki S., Komaru M., Mitsui Y., Nakaguro H., Kazekami Y. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 11. - P. 2073-2079.

J952. Kuzmik J. Power electronics on InAlN/(In)GaN: Prospect for a record performance. IEEE Electron Device Letters. - 2001. - Vol. 22, No. 11. - P. 510-512.

J953. Murata K. Fully monolithic integrated 43 Gbit/s clock and data recovery circuit in InP HEMT technology. / Murata K., Sano K., Sano E., Sugitani S., Enoki T. // Electronics Letters. - 2001. - Vol. 37, No. 20. - P. 1235-1237.

J954. Tilak V. Influence of barrier thickness on the high-power performance of AlGaN/GaN HEMTs. / Tilak V., Green B., Kaper V., Kim H., Prunty T., Smart J., Shealy J., Eastman L. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 11. - P. 504-506.

J955. Nam S. RF and microwave phase shifter using complementary bias techniques. / Nam S., Payne A.W., Robertson I.D. // Electronics Letters. - 2001. - Vol. 37, No. 18. - P. 1124-1125.

J956. Arnaboldi C. Integrated HEMT-based charge amplifier-design and experiment. / Arnaboldi C., Guazzoni C., Longoni A., Pessina G., Cetronio A. // IEEE Transactions on Nuclear Science. - 2001. - Vol. 48, No. 3. - P. 473-478.

J957. Radisic V. 80 GHz MMIC HEMT VCO. / Radisic V., Samoska L., Micovic M., Ming Hu, Janke P., Ngo C., Nguyen L. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 8. - P. 325-327.

J958. Farina M. Full-wave modeling of linear FETs for millimeter waves. / Farina M., Rozzi T. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 8. - P. 1443-1450.

J959. McPherson D.S. Vector modulator for W-band software radar techniques. / McPherson D.S., Lucyszyn S. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 8. - P. 1451-1461.

J960. Shigematsu H. A 49-GHz preamplifier with a transimpedance gain of 52 dBΩ using InP HEMTs. / Shigematsu H., Sato M., Suzuki T., Takahashi T., Imanishi K., Hara N., Ohnishi H., Watanabe Y. // IEEE Journal of Solid-State Circuits. - 2001. - Vol. 36, No. 9. - P. 1309-1313.

J961. Ransijn H. A 10-Gb/s laser/modulator driver IC with a dual-mode actively matched output buffer. / Ransijn H., Salvador G., Daugherty D.D., Gaynor K.D. II. // IEEE Journal of Solid-State Circuits. - 2001. - Vol. 36, No. 9. - P. 1314-1320.

J962. Ahmed A. A temperature-dependent nonlinear analysis of GaN/AlGaN HEMTs using Volterra series. / Ahmed A., Islam S.S., Anwar A.F.M. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 9. - P. 1518-1524.

J963. Ikeda H. An auto-gain control transimpedance amplifier with low noise and wide input dynamic range for 10-Gb/s optical communication systems. / Ikeda H., Ohshima T., Tsunotani M., Ichioka T., Kimura T. // IEEE

Journal of Solid-State Circuits. - 2001. - Vol. 36, No. 9. - P. 1303-1308.

J964. Somerville M.H. Determining dominant breakdown mechanisms in InP HEMTs. / Somerville M.H., Putnam C.S., del Alamo J.A. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 12. - P. 565-567.

J965. Webb K.J. Fabrication and operation of a velocity modulation transistor. / Webb K.J., Cohen E.B., Melloch M.R. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 12. - P. 2701-2709.

J966. Klein P.B. Effect of deep traps on sheet charge in AlGaN/GaN high electron mobility transistors. / Klein P.B., Binari S.C., Ikossi K., Wickenden A.E., Koleske D.D., Henry R.L. // Electronics Letters. - 2001. - Vol. 37, No. 25. - P. 1550-1551.

J967. Chien-Jen Wang. A dual-beam asymmetrically scanning leaky-wave antenna by utilizing a HEMT resistive upconverter. / Chien-Jen Wang, Yu-Hau Sheu, Jou C.F. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 12. - P. 492-494.

J968. Lazaro M. Neural networks for large- and small-signal modeling of MESFET/HEMT transistors. / Lazaro M., Santamaria I., Pantaleon C. // IEEE Transactions on Instrumentation and Measurement. - 2001. - Vol. 50, No. 6. - P. 1587-1593.

J969. McMorrow D. Charge-collection dynamics of AlSb-InAs-GaSb resonant interband tunneling diodes (RITDs) [for MOBILE logic circuits]. / McMorrow D., Magno R., Bracker A.S., Bennett B.R., Buchner S., Melinger J.S. // IEEE Transactions on Nuclear Science. - 2001. - Vol. 48, No. 6. - P. 1973-1979.

J970. Shih-Cheng Yang. (Alx Ga1-x)0.5 In0.5 P/In 0.15 Ga0.85 As (x=0, 0. 3, 1. 0) heterostructure doped-channel FETs for microwave power applications. / Shih-Cheng Yang, Hsien-Chin Chiu, Yi-Jen Chan, Hao-Hsiung Lin, Jenn-Ming Kuo. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 12. - P. 2906-2910.

J971. Sjoman P. Planck satellite 70 GHz receiver noise tests. / Sjoman P., Ruokokoski T., Jukkala P., Eskelinen P. // IEEE Aerospace and Electronic Systems Magazine. - 2001. - Vol. 16, No. 12. - P. 19-23.

J972. Duperrier C. New design method of uniform and nonuniform distributed power amplifiers. / Duperrier C., Campovecchio M., Roussel L., Lajugie M., Quere R. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 12. - P. 2494-2500.

J973. Javorka P. AlGaN/GaN Round-HEMTs on (111) silicon substrates. / Javorka P., Alam A., Nastase N., Marso M., Hardtdegen H., Heuken M., Luth H., Kordos P. // Electronics Letters. - 2001. - Vol. 37, No. 22. - P. 1364-1366.

J974. Leich M. 6 Vpp-66 GHz-ultrabroadband amplifier for fibre-optical transmission systems. / Leich M., Ludwig M., Kuri A., Hulsmann A., Schlechtweg M. // Electronics Letters. - 2001. - Vol. 37, No. 23. - P. 1397-1398.

J975. Zirath H. Analog MMICs for millimeter-wave applications based on a commercial 0.14-μm pHEMT technology. / Zirath H., Fager C., Garcia M., Sakalas P., Landen L., Alping A. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 11. - P. 2086-2092.

J976. Parker A.E. Measurement and characterization of HEMT dynamics. / Parker A.E., Rathmell J.G. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 11. - P. 2105-2111.

J977. Matinpour B. K-band receiver front-ends in a GaAs metamorphic HEMT process. / Matinpour B., Lal N., Laskar J., Leoni R.E., Whelan C.S. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 12. - P. 2459-2463.

J978. Green B.M. High-power broad-band AlGaN/GaN HEMT MMICs on SiC substrates. / Green B.M., Tilak V., Lee S., Kim H., Smart J.A., Webb K.J., Shealy J.R., Eastman L.F. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 12. - P. 2486-2493.

J979. Marso M. AlGaN/GaN varactor diode for integration in HEMT circuits. / Marso M., Wolter M., Javorka P., Fox A., Kordos P. // Electronics Letters. - 2001. - Vol. 37, No. 24. - P. 1476-1478.

J980. Nuttinck S. Study of self-heating effects, temperature-dependent modeling, and pulsed load-pull

measurements on GaN HEMTs. / Nuttinck S., Gebara E., Laskar J., Harris H.M. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 12. - P. 2413-2420.

J981. Sacconi F. Spontaneous and piezoelectric polarization effects on the output characteristics of AlGaN/GaN heterojunction modulation doped FETs. / Sacconi F., Di Carlo A., Lugli P., Morkoc H. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 450-457.

J982. Binari S.C. Trapping effects and microwave power performance in AlGaN/GaN HEMTs. / Binari S.C., Ikossi K., Roussos J.A., Kruppa W., Doewon Park, Dietrich H.B., Koleske D.D., Wickenden A.E., Henry R.L. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 465-471.

J983. Eastman L.F. Undoped AlGaN/GaN HEMTs for microwave power amplification. / Eastman L.F., Tilak V., Smart J., Green B.M., Chumbes E.M., Dimitrov R., Hyungtak Kim, Ambacher O.S., Weimann N., Prunty T., Murphy M., Schaff W.J., Shealy J.R. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 479-485.

J984. Furuta H. Optical injection locking of a 38-GHz-band InP-based HEMT oscillator using a 1.55-/spl mu/m DSB-SC modulated lightwave. / Furuta H., Maeda M., Nomoto T., Kobayashi J., Kawasaki S. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 1. - P. 19-21.

J985. Bradley S.T. Influence of AlGaN deep level defects on AlGaN/GaN 2-DEG carrier confinement. / Bradley S.T., Young A.P., Brillson L.J., Murphy M.J., Schaff W.J., Eastman L.E. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 412-415.

J986. Chumbes E.M. AlGaN/GaN high electron mobility transistors on Si(111) substrates. / Chumbes E.M., Schremer A.T., Smart J.A., Wang Y., MacDonald N.C., Hogue D., Komiak J.J., Lichwalla S.J., Leoni R.E. III., Shealy J.R. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 420-426.

J987. Yi-Feng Wu. Very-high power density AlGaN/GaN HEMTs. / Yi-Feng Wu, Kapolnek D., Ibbetson J.P., Parikh P., Keller B.P., Mishra U.K. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 586-590.

J988. Egawa T. Characterizations of recessed gate AlGaN/GaN HEMTs on sapphire. / Egawa T., Guang-Yuan Zhao, Ishikawa H., Umeno H., Jimbo T. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 603-608.

J989. Sironen M. A subharmonic self-oscillating mixer with integrated antenna for 60-GHz wireless applications. / Sironen M., Qian Y., Itoh T. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 3. - P. 442-450.

J990. Sang Yun Lee. An X-band GaN HEMT power amplifier design using an artificial neural network modeling technique. / Sang Yun Lee, Cetiner B.A., Torpi H., Cai S.J., Jiang Li, Alt K., Chen Y.L., Wen C.P., Wang K.L., Itoh T. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 495-501.

J991. Keller S. Gallium nitride based high power heterojunction field effect transistors: process development and present status at UCSB. / Keller S., Yi-Feng Wu, Parish G., Naiqian Ziang, Xu J.J., Keller B.P., DenBaars S.P., Mishra U.K. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 552-559.

J992. Vetury R. The impact of surface states on the DC and RF characteristics of AlGaN/GaN HFETs. / Vetury R., Zhang N.Q., Keller S., Mishra U.K. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 3. - P. 560-566.

J993. McPherson D.S. 110 GHz vector modulator for adaptive software-controlled transmitters. / McPherson D.S., Hwa-Chang Seo, Young-Lae Jing, Lucyszyn S. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 1. - P. 16-18.

J994. Watanabe I. Mobility enhancement by reduced remote impurity scattering in a pseudomorphic In 0.7 Ga 0.3 As/In 0.52 Al 0.48 As quantum well high electron mobility transistor structure with (411)A super-flat interfaces grown by molecular-beam epitaxy. / Watanabe I., Kanzaki K., Aoki T., Kitada T., Shimomura S., Hiyamizu S. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2001. - Vol. 19, No. 4. - P. 1515-1518.

J995. Hoke W. E. Molecular beam epitaxial growth and characterization of strain-compensated Al 0.3 In 0.7 P/InP/Al 0.3 In 0.7 P metamorphic-pseudomorphic high electron mobility transistors on GaAs substrates. / Hoke W. E., Lemonias P. J., Kennedy T. D., Torabi A., Tong E. K., Chang K. L., Hsieh K. C. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2001. - Vol. 19, No. 4. - P. 1519-1523.

J996. Yuan K. Metamorphic In 0.52 Al 0.48 As/In 0.53 Ga 0.47 As high electron mobility transistors on GaAs with In x Ga 1-x P graded buffer. / Yuan K., Radhakrishnan K., Zheng H. Q., Ng G. I. // Journal of Vacuum Science & Technology B: Microelectronics and Nanometer Structures. - 2001. - Vol. 19, No. 6. - P. 2119-2122.

J997. Lu Jian-Qiang. Terahertz detection by high-electron-mobility transistor: Enhancement by drain bias. / Lu Jian-Qiang, Shur Michael S. // Applied Physics Letters. - 2001. - Vol. 78, No. 17. - P. 2587-2588.

J998. Keller S. Effect of growth termination conditions on the performance of AlGaN/GaN high electron mobility transistors. / Keller S., Vetury R., Parish G., DenBaars S. P., Mishra U. K. // Applied Physics Letters. - 2001. - Vol. 78, No. 20. - P. 3088-3090.

J999. Kim D. M. Photovoltaic effects on pinch-off voltage and open-circuit voltage in high-electron-mobility-transistor and Schottky-diode configurations. Applied Physics Letters. - 2001. - Vol. 78, No. 11. - P. 1553-1555.

J1000. Sang-Soon Kim. Highly strained InGaP/InGaAs p-HEMT using reduced area growth. / Sang-Soon Kim, Jong-In Song. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 2. - P. 59-61.

J1001. Lazaro M. Smoothing the canonical piecewise-linear model: an efficient and derivable large-signal model for MESFET/HEMT transistors. / Lazaro M., Santamaria I., Pantaleon C., Sanchez A.M., Puente A.T., Fernandez T. // IEEE Transactions on Circuits and Systems I: Fundamental Theory and Applications. - 2001. - Vol. 48, No. 2. - P. 184-192.

J1002. Archer J.W. An indium phosphide MMIC amplifier for 180-205 GHz. / Archer J.W., Lai R., Grundbacher R., Barsky M., Tsai R., Reid P. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 1. - P. 4-6.

J1003. Jong-Soo Lee. Small signal and power measurements of AlGaN/GaN HEMT with SiN passivation. / Jong-Soo Lee, Vescan A., Wieszt A., Dietrich R., Leier H., Young-Se Kwon. // Electronics Letters. - 2001. - Vol. 37, No. 2. - P. 130-132.

J1004. Huei Wang. Power-amplifier modules covering 70-113 GHz using MMICs. / Huei Wang, Samoska L., Gaier T., Peralta A., Hsin-Hsing Liao, Leong Y.C., Weinreb S., Chen Y.C., Nishimoto M., Lai R. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 1. - P. 9-16.

J1005. Gresham I. A compact manufacturable 76-77-GHz radar module for commercial ACC applications. / Gresham I., Jain N., Budka T., Alexanian A., Kinayman N., Ziegner B., Brown S., Staecker P. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 1. - P. 44-58.

J1006. Sohn J. Enhancement mode Al0.25 Ga0.75 As/In0.2 Ga0.8 As nanowire HEMTs. / Sohn J., Lee B.H., Jeong M.Y., Jeong Y.H. // Electronics Letters. - 2001. - Vol. 37, No. 5. - P. 322-323.

J1007. Yanev A.S. Wide-band balanced active HEMT mixer. / Yanev A.S., Todorov B.N., Ranev V.Z. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 7. - P. 1359-1361.

J1008. Kim M. A monolithic MEMS switched dual-path power amplifier. / Kim M., Hacker J.B., Mihailovich R.E., DeNatale J.F. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 7. - P. 285-286.

J1009. Dumka D.C. High performance 0.35 μm gate-length monolithic enhancement/depletion-mode metamorphic In0.52 Al0.48 As/In0.53 Ga0.47 As HEMTs on GaAs substrates. / Dumka D.C., Hoke W.E., Lemonias P.J., Cueva G., Adesida I. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 8. - P. 364-366.

J1010. Fay P. Digital integrated circuit using integrated InAlAs/InGaAs/InP HEMTs and InAs/AlSb/GaSb RITDs. / Fay P., Lu J., Xu Y., Bernstein G.H., Gonzalez A., Mazumder P., Chow D.H., Schulman J.N. // Electronics Letters. - 2001. - Vol. 37, No. 12. - P. 758-759.

J1011. Yong Gui Xie. A novel InGaAs/InAlAs insulated gate pseudomorphic HEMT with a silicon interface control layer showing high DC- and RF-performance. / Yong Gui Xie, Kasai S., Takahashi H., Chao Jiang, Hasegawa H. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 7. - P. 312-314.

J1012. Mahon S.J. Wide-band MMIC Kowari mixer/phase shifters. / Mahon S.J., Harvey J.T., Young A.C. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 7. - P. 1229-1234.

J1013. Makioka S. Super self-aligned GaAs RF switch IC with 0.25 dB extremely low insertion loss for mobile communication systems. / Makioka S., Anda Y., Miyatsuji K., Ueda D. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 8. - P. 1510-1514.

J1014. Karmalkar S. Enhancement of breakdown voltage in AlGaN/GaN high electron mobility transistors using a field plate. / Karmalkar S., Mishra U.K. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 8. - P. 1515-1521.

J1015. Kim J.H. Improved microwave and noise performances of InGaP/In0.33 Ga0.67 As p-HEMT grown on patterned GaAs substrate. / Kim J.H., Jo S.-J., Song J.-I. // Electronics Letters. - 2001. - Vol. 37, No. 15. - P. 981-983.

J1016. Yamashita Y. Ultra-short 25-nm-gate lattice-matched InAlAs/InGaAs HEMTs within the range of 400 GHz cutoff frequency. / Yamashita Y., Endoh A., Shinohara K., Higashiwaki M., Hikosaka K., Mimura T., Hiyamizu S., Matsui T. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 8. - P. 367-369.

J1017. Karmalkar S. RESURF AlGaN/GaN HEMT for high voltage power switching. / Karmalkar S., Jianyu Deng, Shur M.S. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 8. - P. 373-375.

J1018. Akita M. High-frequency measurements of AlGaN/GaN HEMTs at high temperatures. / Akita M., Kishimoto S., Mizutani T. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 8. - P. 376-377.

J1019. Shealy J.B. Low-phase noise AlGaN/GaN FET-based voltage controlled oscillators (VCOs). / Shealy J.B., Smart J.A., Shealy J.R. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 6. - P. 244-245.

J1020. Moon J.S. GaN/AlGaN HEMTs operating at 20 GHz with continuous-wave power density >6 W/mm. / Moon J.S., Micovic M., Janke P., Hashimoto P., Wong W.-S., Widman R.D., McCray L., Kurdoghlian A., Nguyen C. // Electronics Letters. - 2001. - Vol. 37, No. 8. - P. 528-530.

J1021. Dunn G.M. Gunn instabilities in power HEMTs. / Dunn G.M., Phillips A., Topham P.J. // Electronics Letters. - 2001. - Vol. 37, No. 8. - P. 530-531.

J1022. Thomas D.G. Jr. Single-ended HEMT multiplier design using reflector networks. / Thomas D.G. Jr., Branner G.R. // IEEE Transactions on Microwave Theory and Techniques. - 2001. - Vol. 49, No. 5. - P. 990-993.

J1023. Parker A.E. Intermodulation nulling in HEMT common source amplifiers. / Parker A.E., Guoli Qu. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 3. - P. 109-111.

J1024. Rolfes I. Cryogenic noise parameter measurements of microwave devices. / Rolfes I., Musch T., Schiek B. // IEEE Transactions on Instrumentation and Measurement. - 2001. - Vol. 50, No. 2. - P. 373-376.

J1025. Schulman J.N. InGaAs zero bias backward diodes for millimeter wave direct detection. / Schulman J.N., Chow D.H., Jang D.M. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 5. - P. 200-202.

J1026. Fay P. Fabrication of monolithically-integrated InAlAs/InGaAs/InP HEMTs and InAs/AlSb/GaSb resonant interband tunneling diodes. / Fay P., Lu Jiang, Xu Y., Bernstein G.H., Chow D.H., Schulman J.N., Dunlap H.L., de los Santos H.J. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 6. - P. 1282-1284.

J1027. Chien-Jen Wang. Active dual-beam leaky-wave antenna with asymmetrically scanning capability. Electronics Letters. - 2001. - Vol. 37, No. 11. - P. 672-673.

J1028. Radisic V. 164-GHz MMIC HEMT doubler. / Radisic V., Micovic M., Hu M., Janke P., Ngo C., Nguyen L., Samoska L., Morgan M. // IEEE Microwave and Wireless Components Letters. - 2001. - Vol. 11, No. 6. - P.

241-243.

J1029. Klein P.B. Investigation of traps producing current collapse in AlGaN/GaN high electron mobility transistors. / Klein P.B., Binari S.C., Ikossi-Anastasiou K., Wickenden A.E., Koleske D.D., Henry R.L., Katzer D.S. // Electronics Letters. - 2001. - Vol. 37, No. 10. - P. 661-662.

J1030. Boudrissa M. A 0.15-µm 60-GHz high-power composite channel GaInAs/InP HEMT with low gate current. / Boudrissa M., Delos E., Wallaert X., Theron D., De Jaeger J.C. // IEEE Electron Device Letters. - 2001. - Vol. 22, No. 6. - P. 257-259.

J1031. Boudrissa M. Enhancement-mode Al0.66 In0.34 As/Ga0.67 In0.33 As metamorphic HEMT, modeling and measurements. / Boudrissa M., Delos E., Gaquiere C., Rousseau M., Cordier Y., Theron D., Jaeger J.C. // IEEE Transactions on Electron Devices. - 2001. - Vol. 48, No. 6. - P. 1037-1044.
