Loss Mechanisms of Folded Reflectarray Antennas

Wolfgang Menzel[1], Shady Keyrouz[2], Jiang Li[3] Sabine Dieter[4]

Institute of Microwave Techniques, University of Ulm
PO Box, D-89069 Ulm, Germany

{[1] wolfgang.menzel, [2] shady.keyrouz, [3] jiang.li, [4] sabine.dieter}@uni-ulm.de

***Abstract*— Folded reflectarray antennas can provide a good solution for millimeter-wave systems requiring compact, low-cost antennas, e.g. in automotive applications. This contribution investigates different approaches of such antennas with rectangular and composite reflecting elements. Special emphasis is put on gain and antenna loss mechanisms, including increased beamwidth and sidelobe level as well as metallization losses.**

I. INTRODUCTION

Printed planar reflectarrays [1 - 6] have gained increasing interest due to their low weight, design flexibility, or ease of fabrication. A more compact version of such antennas is provided by folded reflectarray antennas [4 - 6] which have already been implemented into an automotive radar.

The cross section and the photograph of part of a typical folded reflectarray antenna are shown in Fig. 1. This antenna consists of a circular waveguide feed horn, a polarizing grid printed on a dielectric substrate, and the specific reflectarray substrate with printed metal elements, for example rectangular patch elements, which, simply by their geometry, both adjust the overall phase angle and twist the polarization of the incoming wave by 90° providing a 180° phase shift between the two polarizations of the reflected wave (Fig. 2). This dual function requires that the reflection phase angle can be adjusted independently for both polarizations.

The array amplitude distribution generally is determined by the feed illumination, and for pencil beam antennas, the phase angle distribution is adjusted to realize an outgoing plane wave. The relation between reflection element phase angle and geometry typically is calculated based on

- an infinite periodic structure of elements (or unit cell approach)
- a plane wave incident from normal (or from a single direction)
- the assumption that the incident power is completely reflected with no amplitude variation over phase angle
- the assumption that all phase angle values can be adjusted
- zero metallization thickness.

For a typical reflectarray design, none of these assumptions holds, leading to a degradation of the antenna performance. Metallization thickness is the less critical item, as it affects only the performance of very narrow elements or large elements coming close together (narrow air gap), but such dimensions can be largely avoided, as the phase angle curve is very flat for these dimensions (see Fig. 3). In principle, metallization thickness can even be included in the unit cell calculation with some additional effort. Consequently, this investigation will deal with the remaining items.

Looking at the photograph in Fig. 1, it becomes immediately clear that the assumption of periodicity is not valid at all. Varying phase angles and, above all, the large change of element geometry in case of phase angle steps of 360° leads to phase errors.

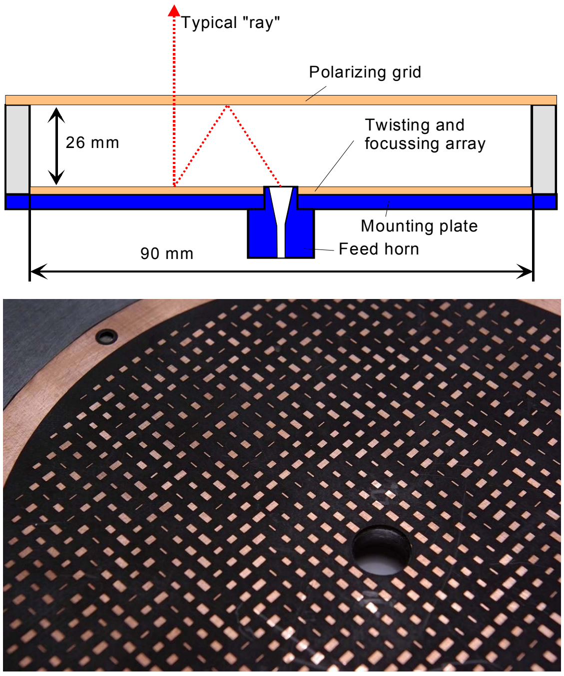

Fig. 1 Cross section of folded reflectarray antenna and photograph of a section of a reflectarray with rectangular elements.

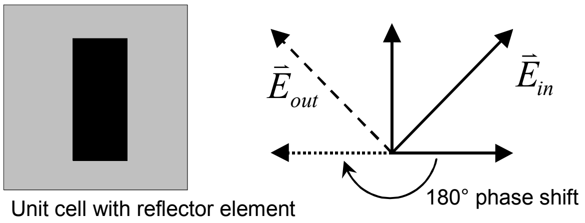

Fig. 2 Principle of polarization twisting.

Fig. 3 shows reflection phase angle and amplitude of rectangular reflector elements as a function of length (parallel to the direction of the electric field) for two different substrate thicknesses. Both metal conductivity as well as loss tangent of

978-2-87487-019-4 © 2010 EuMA