Historical Review of the Printed Reflectarray Antenna*

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A reflectarray is an array antenna similar to a parabolic reflector, but with its elements designed to allow its flat or slightly curved aperture surface to achieve conformal mounting with significantly reduced mass and volume. The main beam of the antenna can be designed to tilt or actively scan to large angles from the broadside direction by using low-loss phase shifters. For large deployable apertures, the antenna's reflecting surface, being flat, can be more easily and reliably deployed than a curved parabolic reflector. This article gives a brief review of the development history and key design methodologies for the reflectarray antenna.

The reflectarray antenna concept was first demonstrated during the early 1960s [Berry]. Large open-ended waveguide elements were used at relatively low microwave frequencies, which resulted in very bulky and heavy structures. In addition, the efficiencies of these reflectarrays were not studied and optimized. More than ten years later (in the mid 1970's), the very clever concept of the spiraphase reflectarray was developed [Phelan], where switching diodes were used in an 8-arm spiral or crossed dipoles of a circularly polarized reflectarray to electronically scan the main beam to large angles. Due to the thick spiral cavity and large electronic components, the overall spiraphase reflectarray was still relatively bulky and heavy, and was not pursued further. The antenna's efficiency also remains to be improved.

Due to the invention of the low-profile microstrip antenna, various printed microstrip reflectarrays were developed in the late 80's and early 90's. They came in various forms, but all with flat low-profile and low-mass reflecting surfaces. One method used identical patch elements with different-length phase delay lines [Munson; Huang]. The other used variable dipole or patch sizes [Kelkar; Pozar]. Printed annular rings of variable sizes arranged in Fresnel zone configuration were used to focus the beam [Guo and Barton]. Circularly polarized microstrip patches with identical size but variable angular rotations were designed to form a highly-efficient high-performance reflectarray [Huang]. Pozar was the first to use the infinite array approach to calibrate the element phase versus element change, as well as to employ the reflectarray for contour beam applications. In the early 2000's, the development of the reflectarray has mushroomed and several performance improvement techniques are worth mentioning here. One used multi-layer stacked patches to improve the reflectarray bandwidth [Encinar]. An amplifying reflectarray was developed [Bialkowski]. The element performance was optimized by using the Genetic algorithm [Zich]. The reflectarray using a sub-reflector and array feed configuration was also studied [Rahmat-Samii]. The dual-band reflectarray is another area being studied [Chang; Zawadzki and Huang]. In addition to these various techniques and improvements, the reflectarray design approach and several recent developments will be presented in the symposium.

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