Low-Mass Low-Profile Metasurface Antennas Based on Anisotropic Surface Impedance

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Leaky-wave antennas are a class of antennas that use a non-completely confined traveling wave as the main radiating mechanism The possibility of transforming a surface wave into a leaky wave by using a periodically varying isotropic impedance plane has been demonstrated by Oliner and Hessel [1]. An example of antenna designed by using this concept is reported in [2]. In the last years, metasurfaces (MTS) have revealed to be a powerful tools to realize a variable impedance sheet. In the microwave range, impenetrable MTS are obtained by printing a periodic arrangement of electrically small elements on a grounded slab; due to the small periodicity compared with the wavelength, MTS can be characterized in terms of a surface impedance which imposes boundary conditions on the ratio between the average tangential components of the electric and magnetic fields A modulation of the MTS equivalent surface impedance may be obtained by gradually varying the geometry of the elements in contiguous cells [3]. The effective impedance is obtained by considering each constituent element of the metasurface as embedded in a locally uniform periodic structure and identifying the local value of reactance with that of a periodic texture which matches the local geometry.

The opportunity to employ MTS to realize planar antennas assumes considerable importance for space applications. In fact, in such environment it is crucial to reduce as much as possible the radiator's profile and mass as well as the feeding network complexity while maintaining high performances in terms of gain and side lobe level. In this framework, MTS antennas are excellent candidates. Indeed, they consist of thin slabs, they can be manufactured by means of low-cost technologies, and they exhibit extremely low mass and extreme flatness. Furthermore, they can be excited by simple embedded feeding points. All of these characteristics match very well the usual requirements for space antennas, where reflectors are the most employed devices. In this regard, metasurface radiators' main challenge now moves to the direction of realizing more compact structures, improving the aperture efficiency and reaching gains comparable with the ones of reflectors of the same size. Often, the capability to operate in circular polarization is also a design constraint.

An additional degree of freedom for the control of polarization is offered by the use of *anisotropic* impedance surfaces. These latter may be implemented by using MTS with asymmetric unit cells. An effective synthesis method of this type of MTS antennas has been reported in [4,5]. The approach has been recently extended also to slot-type MTS [6]. In these works, however, the polarization properties of the radiated field are estimated by making some simplifying assumptions on the current distribution. A different approach is instead followed in this work, by rigorously extending the Oliner procedure to the case of a periodically modulated *anisotropic* impedance. This approach provides, for any given periodic impedance profile, the polarization and the propagation constant of the supported leaky wave. This information is used to shape the radiation pattern by synthesizing a prescribed aperture field distribution.

References

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