Coarsely discretized printed circuit metasurfaces for mm-wave applications

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Metasurfaces and other planar composite materials for wavefront manipulation are often designed using deeply subwavelength resonators [1]. This includes transmit- and reflect-arrays [1], and modulated reactance surface antennas [2]. These planar devices are widely explored in the microwave range, and they appear appealing for applications in communication and radar sensing.

At higher frequencies of operation, such as millimeter waves (mm-waves) and terahertz, fabrication constraints make many common designs unfeasible, and the use of coarse array structures is required. Using larger metallic resonators with lateral dimensions on the order of $\lambda/3$ facilitates the fabrication, but it requires significant additional effort with regards to synthesis. Many conventional design methods which are based on continuous surface impedance or analytical equations may render inaccurate when being used in the context of coarse arrays. Additionally, near-field coupling effects from adjacent resonators are often more severe.

Recently, we demonstrated a design framework for transmissive Huygens-type metasurfaces with which the influence of near-field coupling is compensated [3,4]. Additionally, other effects of performance degradation such as losses on copper roughness and fabrications tolerances typical for mm-wave devices are effectively reduced [4]. Similarly, in the case of modulated reactance leaky-wave antennas, coarse discretization can lead to relaxed fabrication requirements, but it requires numerical methods e.g. for the determination of the band structure [5]. For emerging applications, reconfigurable apertures are increasingly demanded. Metasurface based switched beam antennas represent a promising alternative to other approaches for reconfigurable apertures, such as those requiring bias networks, or discrete elements like PIN diodes [6,7].

In this contribution, we concentrate on antenna systems incorporating static metasurfaces with coarse discretization and we review our recent progress on corresponding design methods. We present switched beam antennas based on transmissive metasurfaces as well as modulated reactance leaky-wave antennas operating at 80 GHz. Experimental results which include high resolution near-field and far-field scanning are shown.

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