Recent Research Progress in Microwave Metasurfaced Antenna

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***Abstract* – This paper briefs the recent research activities in microwave antenna applications that make use of metasurfaces. The interesting design initiatives including the grating lobes and sidelobes suppression of circularly-polarized patch subarray, and beam-steering control using active metasurface are presented.**

***Index Terms* — Metasurfaced antenna, sidelobe level (SLL) suppression, grating lobes, active metasurface; reconfigurable.**

1. Introduction

Metasurfaces (MTS) are the two-dimensional (2-D) equivalents of the 3-D metamaterials, which are artificially made materials exhibiting extraordinary electromagnetic properties. Due to the planar nature, metasurface offers many advantages over the 3-D counterparts, such as low loss and low cost, and requires only simple fabrication of milling or etching technique. These meaningfully benefit the realization of performance enhancement of small printed antennas in a cost-effective way. Moreover, metasurfaces have the ability to be easier electromagnetically coupled, in the upright near-field region, with the printed source antennas, like patch antennas [1]-[2], slot antennas [3]-[4] and loop antennas [5]. As a result, metasurfaced planar antennas owns a low profile (smaller height) yet simultaneous wideband and high-gain radiation characteristics, which are different to the conventional half-wavelength-height superstrate covered antennas or resonant cavity antennas, e.g. Fabry-Perot cavity antennas. Therefore, these features and advantages attract a great deal of research effort on the metasurface applications in the antenna society. Over the past few years, we witnessed the growth of metasurface applications in the areas of microwave antennas applications [3]-[10]. Numerous teams describe performance enhancement of microwave antennas using: *metasurface-loaded* [3]-[4], *metasurface-enabled* [6]-[7], and *metasurface-based* [8], however, a generic term of "*metasurfaced*" [1]-[2], [9]-[10] is more straightforward in describing the extraordinary functions with simple structures, where a planar source antenna is surfaced (and enhanced) by using a metasurface in the near-field region.

In this paper, we report our recent progress in design of metasurfaced antennas at the Qingdao Technological University, China. A number of interesting antenna designs are exposed for the first time. They include the anisotropic-metasurfaced circularly polarized (CP) 2-by-2 array for sidelobes and grating lobes suppression; beam-steering of microstrip patch antenna coupled with active metasurface.

2. Sidelobe Levels Suppression of CP Subarray

It is known that CP subarrays having element spacing above 0.7 wavelengths exhibit very high (about -5dB with reference to main-lobe) cross-polar lobes in the diagonal plane (*phi* = 45º), whilst high (in the order of -10dB) co-polar sidelobe levels appear in the principal planes. This has long been the design hardship of CP array and has not been solved [11]. As such, the 3-dB gain-reduction bandwidth of CP arrays becomes very narrow although high directivity can be obtained. Fig. 1 illustrates a method that makes use of anisotropic metasurface to overcome the problem whilst enhancing radiation performance.

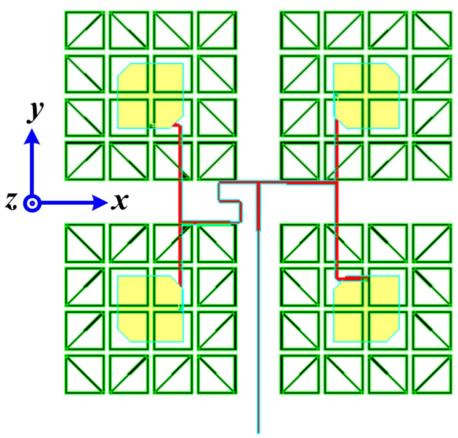
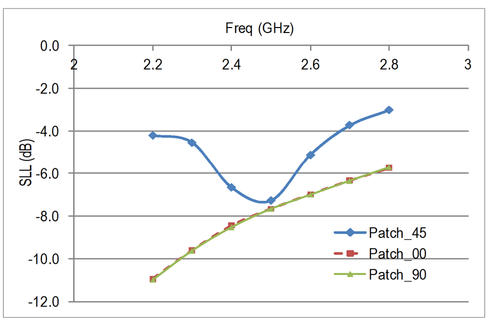
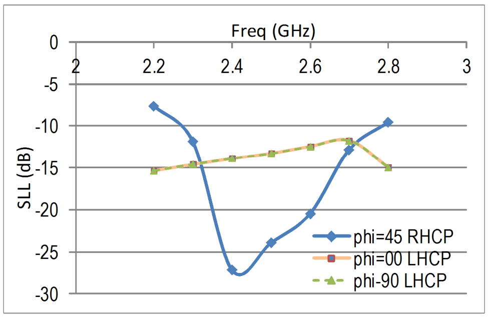


Fig. 1. SLL suppression using anisotropic MTS



(a)



(b)

Fig. 2: SLL performance of CP array having an element spacing of 0.83λ_o (a) before and (b) after adding AMTS.

3. Beam Steering of Microstrip Patch Antenna

Simple structure for the beam-steering function of microstrip patch antenna in a reconfigurable manner is highly desired. For example, titled beams required from the mobile base-station antennas and WiFi base-station antenna. Fig. 3 demonstrates a cost-effective solution on the 2-dimensional beam steering over the azimuth plane. The 16 square unit-cells cover the ordinary probe-fed patch antenna at 2.4 GHz. Unit-cells with square split-rings represent associated switches (e.g. PIN-diode) are OFF whereas the closed rings indicate the ON-state. The 16 unit-cells are divided into 4 quadrants with each quadrant having 4 cells. The 4 square rings in the third quadrant results for a max beam deflection away from the boresight in both the principal planes as shown in Fig. 4. It has been noted that 1-dimensional fixed beam deflection was proposed in [12].

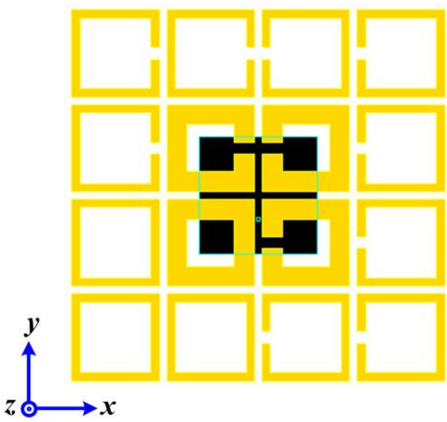
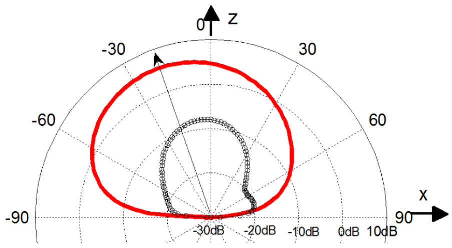
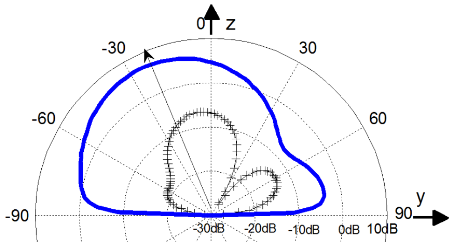


Fig. 3. Beam steering control using active metasurface.



(a)



(b)

Fig. 4. Max beam angle deflected to –20º and –26º directions in (a) xz-plane and (b) yz-plane, respectively.

4. Conclusion

This conference paper reports the recent research progress in metasurfaced antennas, wherein simple structure yet cost-effectiveness are the main themes. The metasurfaced antennas are currently being optimized and fabricated. Thereby, only the design initiatives and primary results are presented. The detailed analysis, optimizations and results will be presented in future journal articles.

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