Multilayer Active Metasurface for Beam Scanning Antenna Applications

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Metasurfaces are layered microwave structures allowing unconventional manipulation of wave propagation in free space. A considerably portion of the metasurface research is inspired by the idea of generalized Snell's Law (N. Yu *et al*., *Science* 334, 2011), which utilizes the gradient of the abrupt phase shift along the metasurface to control the beam propagation. Works have been conducted in both microwave and optics regime (S. Sun *et al*., *Nature Mat*. 3292, 2012, Z. Wei *et al*., *Opt. Exp*. 21, 2013), and an application outlook of the methodology on beam scanning antenna is expected. However, these proposed structures mostly implemented fixed element arrays along the metasurface. To realize an actively tunable beam scanning antenna, active elements must be used to control the phase gradient, thus the scanning angle, and the scanning range is largely limited by the tunable range of the elements. In common designs, the scanning range is limited to a few to ten degrees.

To account for this problem, this work proposes a possible solution. Several layers of the metasurface are stacked, with spacers in between. The metasurface consists of an array of identical elements with embedded varactors, which offers active tenability. Each layer of the metasurface is designed to provide a beam scanning range of about ten degrees. With several layers functioning collectively, the structure is able to provide a large beam scanning range.

Figure 1 shows the unit cell of the metasurface. The substrate used is ROGERS 4350 with 0.83 mm thickness. The varactors diode used is a commercially available one with the tuning range of 0.8-5 pF. The gradient is along the *y*-direction. Figure 2 shows the far field radiation when each layer reaches its maximum gradient. It is validated that the proposed structure can achieve a 30 degree beam scanning angle along one direction, or 60 degrees in total.

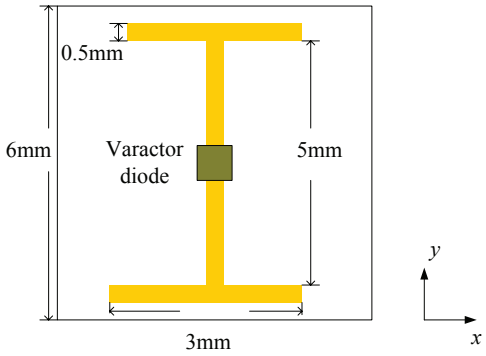

Fig. 1. Unit cell of the gradient surface.

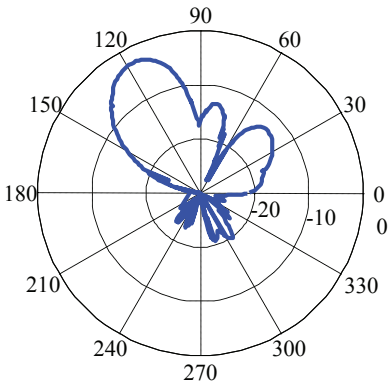

Fig. 2. Gradient of the abrupt phase change with .respect to the varactor value.