A Dual-band Orbital Angular Momentum Beam Generator Based on High Efficiency Metasurfaces

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In this paper, a high efficiency dual-band metasurface is presented for generating a vortex beam. As the basic pattern of the unit cell rotating, the cross-polarization abrupt phase shifts cover a 2π range and all of the transmission amplitudes are more than 0.7 under a circular polarization incidence. The orbital angular momentum (OAM) beam generator is designed based on the dual-band metasurface, which is composed of 21×21 unit cells with spatially varying orientation. The performance of the designed device shows excellent agreement between the computation results and simulation results.

The demand of data capacity and spectral efficiency is more than ever before, as they are rapidly reaching the limit in communication systems. The vortex beam carries the OAM comprising tremendously additional message. The topological charge of vortex beam is theoretically unbounded, meaning the potential of achieving tremendously extra data capacity. Traditional methods for OAM beam generation, which were generated using spiral phase or space light modulators, may cause the difficulty of being integrated with other components because of their bulky structures. The metasurface, a class of two-dimensional artificial materials, is implemented in our design for its ability to control polarization and phase distribution, which can overcome the structural limitation. By employing the high efficiency metasurface unit cell as phase shifters, the OAM beam generator based on metasurface can be conveniently realized. In this paper, we demonstrate a high efficiency dual-band two-layer metasurface unit cell, where transmission P-B (Pancharatnam-Berry) phases can be manipulated independently at two gigahertz (GHz) frequencies, respectively. The basic structure consists of a complementary split-ring resonator (CSRR), a circular hole and an electric-field-couple (ECL) resonator: the CSRR and the circular hole are perforated on an aluminum layer, and the ECL resonator is situated in the middle of the hole. The two identical aluminum layers are fabricated on both sides of a substrate. The transmission of the metasurface unit cell is more than 0.7 when illuminated by a circularly polarized wave. A dual-band OAM beam generator based on the high efficiency metasurface is studied. The thickness of this planar metasurface is truly subwavelength (about 0.1λ), thus has the potential to achieve compact integrated devices. With proper scaling, the designed meta-atoms can be extended to millimeter wave and low terahertz frequency ranges.