Simultaneous and Efficient Spin-State and Wave-Front Manipulation with Meta-surfaces

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Abstract: Arbitrary manipulation on the spin state and wave front of electromagnetic (EM) wave are highly desired due to its importance in science and applications, but conventional devices based on natural materials suffer from low efficiency and bulky size with limited functionalities. Although metasurfaces have demonstrated great capability to manipulate light beams, ultra-thin and highly efficient meta-devices with simultaneous and independent control on wave-front and spin-state (polarization) of light are still rarely seen. Here we propose a general approach to design functional meta-surfaces, achieving efficient and arbitrary wave front manipulation with simultaneous and arbitrary local spin state control. As proof-of-concepts, we designed and characterized two meta-beam-deflectors with controllable spin-state regime based on our generic approach, exhibiting half- and quarter-wave-plate functionalities with high working efficiencies (84% for absolute efficiency and 98% for polarization conversion efficiency) and ultra-broad band properties (relative bandwidth of 45% at 1550 nm) in near infrared. We further experimentally demonstrated, to the best of our knowledge, the first cylindrically polarized Surface Plasmon Polaritons (SPP) coupler with measured working efficiency of 61.4 % at 1064 nm incidence. Our findings open a new avenue to achieve more performant spin-related light manipulation effects by providing an alternative designing strategy, stimulating many high-performance functional meta-devices to satisfy the increasing application demands in modern optical system.

KEYWORDS: Meta-surfaces, local spin-state, wave-front manipulation, Surfaces plasmon polaritons (SPP), vortex beam, high efficiency.

OCIS codes: 260.0260, 260.3060

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