META-FLUIDIC-MATERIALS DESIGN, FABRICATION AND EXPERIMENT

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Metasurfaces are subwavelength-thick planar materials artificially designed with distinctive electromagnetic properties. The flexibility of tailoring both the permittivity and permeability of the metasurface enables its extraordinary electromagnetic response that cannot be find in natural materials. The extraordinary electromagnetic properties of metasurface lead to many promising and practical applications. This doctorate thesis focuses on the design, simulation, fabrication and experimental measurement of meta-fluidic-material for tailoring the optical properties of electromagnetic waves. Specifically, three types of meta-fluidic-material are studied and discussed, namely: (1) dispersion-controllable metasurface for tailoring the dispersion property of metasurface; (2) polarization-independent tunable metasurface for polarization-independent beam control, and (3) Tunable birefringent metasurface for the manipulation of birefringence.

The first part of this thesis demonstrates an adaptable metasurface in which the optical response is dynamically controlled according to the incident wavelength for specific functionality. The adaptable metasurface is composed of a periodic array of liquid-metal ring-shaped resonators whereby their geometry can be tuned individually. The adaptable metasurface is designed for dispersion control with applications include deflecting electromagnetic waves of different frequencies into the same directions or focusing them with the same focal length .

The second part of this thesis reports a subwavelength-thick polarization-independent metasurface composed of reconfigurable C-shaped resonators (RCRs). The symmetry of RCRs bestows the scattered electromagnetic waves with equal amplitude and phase modulation under TM-polarized incidence and TE-polarized incidence, which empowers the metasurface with the feature of polarization independence. Spin-conserved retroreflection and polarization-independent beam steering are demonstrated by designing the metasurface with certain phase gradient to introduce an in-plane momentum to the incident EM wave.

The third part of the thesis presents a tunable birefringent metasurface for manipulation of the birefringence of metasurface. The tunable cross resonators serve as the building blocks of the tunable birefringent metasurface. The two orthogonal resonance eigenmodes of the tunable cross resonators can be independently controlled and tuned to tailor the birefringence of the metasurface. The independent control and tailor of two orthogonal resonance modes is enabled by the flexibility of microfluidic system. Applications such as tunable beam splitting, polarization-insensitive beam steering and quarter waveplates are demonstrated through the manipulation of the birefringence of this tunable birefringent metasurface.

In conclusion, dispersion control, polarization independence, and birefringence manipulation are demonstrated using meta-fluidic-material, which paves the way for promising applications in flat optical technologies, communication system and imaging system, to name just a few.

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