Gap plasmon-based metasurfaces for control of light

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Plasmonic metasurfaces, i.e., nanometer-thin surface metal nanostructures with subwavelength-sized lattice units, have recently attracted considerable attention due to their abilities to efficiently control both phase and amplitude of transmitted and reflected radiation. In this work, we show how metal-insulator-metal configurations in which the upper metal layer is periodically structured, thus supporting gap surface plasmon (GSP) resonances, allow for efficient control of the phase of the reflected light [1]. This fact is illustrated by the 1D-periodic GSP-based metasurface in Fig. 1(a) and the associated reflection coefficient [Fig. 1(b)], demonstrating a strong variation in the reflection phase (~275°) as a function of strip width w with only a modest dip in reflection at the GSP resonance (w = 115nm).

The understanding of light reflection by arrays of GSP resonators has led us to further develop the concept of GSP-based metasurfaces, including the design of efficient, compact (i.e., subwavelength thick) and background-free (i.e., no diffraction and no scattering into other polarizations) wave plates in reflection and flat focusing mirrors - the latter functionality is obtained by gradient (i.e., inhomogeneous) metasurfaces. Moreover, we have demonstrated how 2D-periodic gradient metasurfaces, in which the top metal layer comprises a periodic arrangement of metal nanobricks, facilitate the independent control of reflection phases of orthogonal light polarizations [2]. As an example, Fig. 1(c) shows a top-view image of a unit cell functioning as a polarization beam splitter by employing opposite phase gradients for orthogonal polarizations. Finally, one should note that gradient birefringent metasurfaces enable the design of efficient unidirectional polarization-controlled surface plasmon polariton couplers.

We believe that the presented work establishes a new class of compact optical components, viz., plasmonic GSP-based metasurfaces with controlled gradient birefringence, which may find applications in nanophotonic systems and plasmonic circuitry.

Figure 1. (a) Sketch of 1D-periodic GSP-based metasurface. The incident field is TM-polarized and propagates normal to the surface. (b) Amplitude and phase of reflected light from metasurface in a) as a function of strip width w when λ = 800nm, Λ = 260nm, d = 50nm, and t = 30nm. (c) Representative SEM image of fabricated unit cell functioning as a polarization beam splitter at λ = 800nm. Here, Λ = 240nm.