Flat Polarizing Lenses: Design, Synthesis and Applications

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Abstract: The concept of "polarizing lens" is presented and its generalization to design novel lenses is examined. After exploring the general theoretical formulations, optimal designs to realize polarizing lenses at infrared frequencies are presented. An efficient phase-amplitude synthesis method is also employed in the design of polarizing lenses. The proposed method provides the phase and amplitude distribution of the reflected field on each element that best suits the required focusing and polarization specifications. Here, we first demonstrate a novel single layer metalens design that can have both light focusing and polarization manipulation capability simultaneously. The designed metalens enables us to integrate two important categories of optical components, i.e., circular polarizer and lens, into a thin plasmonic metasurface. This will significantly reduce the cost, volume, loss, and complexity of optical systems. Second, the methods here developed also allow to design a flat lens with a needle-like focus beam with a small spot size, close to the Abbe's diffraction limit, and an extended depth of focus. The idea of extending the depth of focus while keeping the focal spot small increases the interaction of the source field with the object as well as simplifies the alignment procedures for many optical systems. A two-dimensional array of newly-shaped optical antennas with polarization dependent and spatially varying phase response can imprint such unique compact polarizing lenses. The idea of polarizing lens is expected to lead to the further development of optical components, due to its groundbreaking implications in integrated optics, most notably the possibility of having focused beam with an extended depth of focus and metalenses with birefringent behaviors.

Keywords: polarizing lens; metalens; plasmonic metasurfaces; spot size; depth of focus.

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