Inverse Designed Volumetric Metaoptics for Sorting Light by Color, Polarization, and Spatial Mode

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Metaoptics leverages electromagnetic phenomena and the advanced abilities of modern nanofabrication to replicate traditional optical devices in a fraction of the thickness and to realize novel, compact, multifunctional devices with no known bulk equivalent. Motivated by the expanding role of optics in modern technologies, this field has seen a rise in design techniques for realizing increasingly powerful photonic structures. Three-dimensional devices, with refractive index distributions patterned at subwavelength scales, represent an enormous design space capable of achieving highly efficient, free space, multifunctional structures. By utilizing a gradient-based, iterative optimization algorithm, a technique for nanophotonic inverse design, we demonstrate scattering structures with unique responses to all the fundamental properties of light. The algorithm is constrained such that resulting devices can be made with realistic multilayer fabrication processes. We present dielectric structures that can be placed directly on top of image sensor arrays and sort light to different pixels based on its wavelength, polarization, incident angle, and angular momentum, thus enabling efficient and exotic camera technologies. The color and polarization devices, consisting of six patterned layers, are fabricated using two-photon lithography and measured in the mid-infrared spectral region where there are several spectroscopic and imaging applications.