Molding the Optical Transmission with a Meta-Transmitarray

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Here, we propose a new route to locally manipulate the optical transmission amplitude and phase with unprecedented flexibility and efficiency. To achieve this aim, we extend the idea of radio-frequency transmitarrays (D. M. Pozar, Electronics Letters 32, 2109-2111, 1996) and transplant some relevant concepts to optical frequencies using plasmonics. This novel concept of optical "meta-transmitarray" opens new exciting routes to control the nanoscale optical transmission, overcoming many limitations of existing solutions.

We show that it is possible to locally tailor the transmission coefficient of planarized multilayered structures composed of parallel metasurfaces by modeling them as transmission-line segments and loads. This theoretical framework provides useful physical insight and opens several exciting possibilities compared to other recent solutions. A single metasurface [as proposed by N. Yu, et al., Science 333, 333 (2011)] does not allow arbitrary control of the transmission amplitude and phase, causing severe constraints on the allowed wave manipulation and drastically limiting the maximum throughput and their practical applications. Instead, we show that by using a simple symmetric stack of three metasurfaces, we can provide a general solution, valid in any frequency regime, to have full control of the local transmission phase, while keeping unitary transmission amplitude and zero reflection, if desired. In this way, we offer a realistic scenario to fully control the impinging beam and tailor it at will for various applications.

By exploiting the concept of optical nanocircuits enabled by plasmonic materials (N. Engheta, A. Salandrino, and A. Alù, Phys. Rev. Lett. 95, 095504, 2005), we also propose a realistic implementation of these concepts at optical frequencies. Our designed meta-transmitarray is made of only two materials, silicon and aluminum-doped zinc oxide, and provides deflection and focusing of the impinging light with ideal efficiency. More in general, any phase pattern can be imprinted to the impinging beam, without losing any energy in reflection. This capability is extremely beneficial for many applications, including concentrating solar cells, nanoscale signal processing and holography. We believe that our findings represent an important step forward in the quest for manipulating the nanoscale optical transmission. Thanks to the independent control of transmission amplitude and phase, our concept of meta-transmitarray may provide crucial benefits for many practical micro- and nano-scale applications, opening new doors for processing and manipulation of optical signals at the nanoscale.