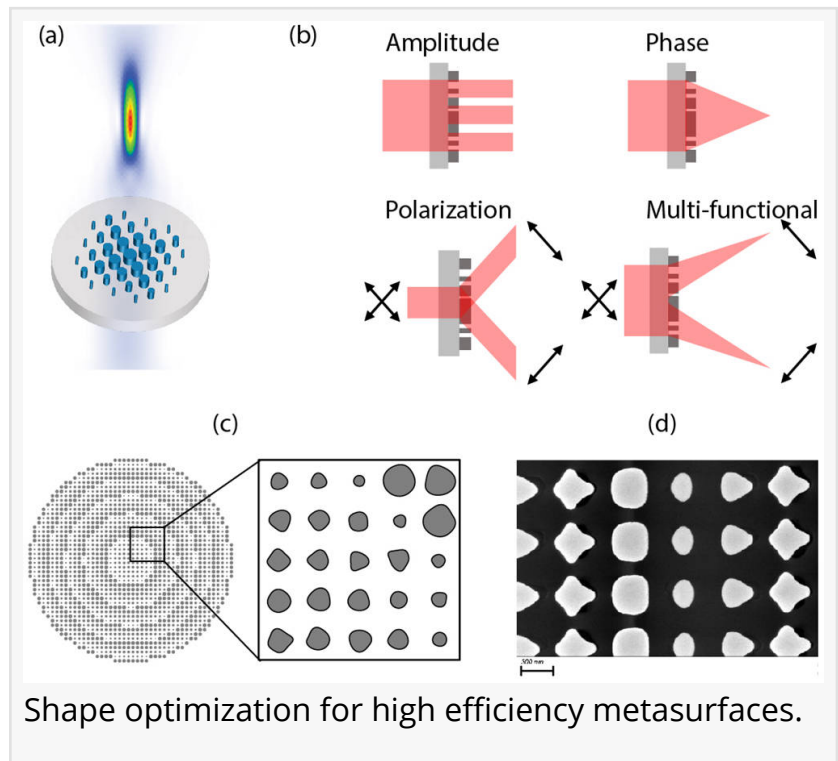


Shape optimization for high efficiency metasurfaces: theory and implementation

GA, UNITED STATES, November 6, 2024 /EINPresswire.com/ -- Metasurfaces are formed by engineering a glass surface with an array of microscopic features, or meta-atoms. Although different optical functionalities can be obtained by changing only the pattern, the resulting metasurfaces often lack the necessary efficiency for many applications. In this report, scientists from Corning and Harvard University collaborate to demonstrate an inverse-design method that optimizes efficiency while respecting fabrication constraints. These results represent a step forward in making practical metasurfaces for broader applications.



Optical systems are critical in various technologies, such as imaging, microscopy, communications, sensing, augmented reality systems and others. Despite its ubiquity, optics lacks a universal platform analogous to the integration of chips in electronic systems. Basic functionalities such as focusing, beam deflection, [polarization](#) rotation or splitting, and color filtering still require different discrete components that are based on different technologies and manufacturing processes. The lack of a universal platform creates significant challenges in scalability, costs, and often leads to bulky systems.

In recent years, metasurfaces have attracted significant attention due to their ability to control many degrees of freedom of an incoming beam, including phase, amplitude, polarization, and dispersion. Many device demonstrations followed, opening opportunities in a wide range of applications such as imaging, polarization optics, sensing, augmented and virtual reality systems, and telecommunications. Despite such broad interest, transitioning from proof-of-principle demonstrations to high-efficiency, practical devices has been extraordinarily challenging in many areas, especially those involving complex functions such as polarization insensitivity, dealing with

complex input and output wavefronts in high-numerical-aperture systems, manipulating multiple wavelengths, etc.

This challenge is rooted in the fundamental physics governing the interaction of light and structured surfaces. It has become clear that engineering complex nonlocal coupling between neighboring meta-atoms is key to achieving high efficiencies. A succession of inverse-designed metasurfaces based on topology optimization has opened a route to deal with the physics but unfortunately, this approach leads to complex, difficult to manufacture structures.

The collaboration between Corning and Harvard proposes an alternative inverse design method that simultaneously deals with nonlocal behavior and rigorously controls the complexity of the structure. While maintaining the generality of the input-output field manipulations, this method allows only smooth boundary deformations of meta-atoms, avoiding appearances of sharp features, holes, small gaps or small features, ensuring compatibility with the fabrication process. The paper includes the theoretical formulation and various numerical and experimental demonstrations of meta-gratings and meta-lenses. The results provide a path towards practical and high-efficiency metasurfaces, representing a step forward in making practical devices for a broader range of applications.

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