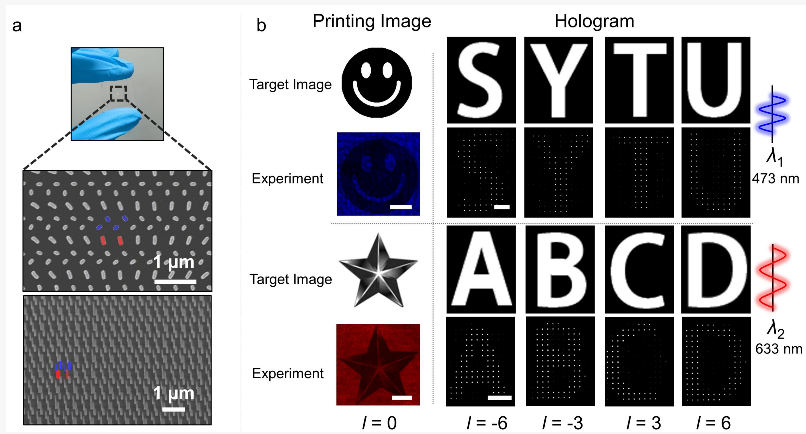
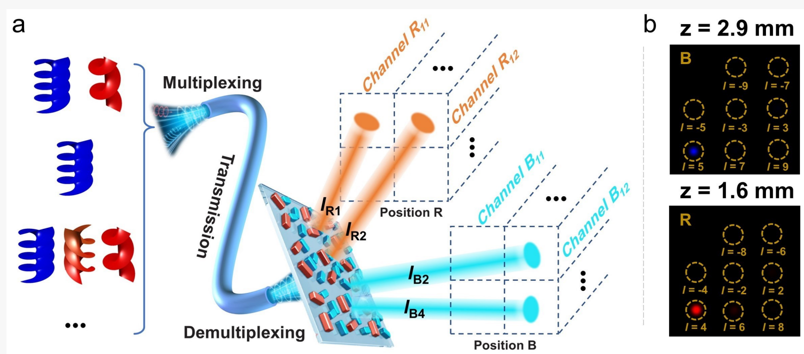
Metasurfaces Manipulate OAM and Wavelength with Complex-Amplitude Control

USA, August 31, 2024 /EINPresswire.com/ -- Realizing the multiplexed manipulation of orbital angular momentum (OAM) and other degree of freedoms (DoFs) of photons in subwavelength scale is a highly desired goal in fields of photonics, integrated optics, and optical engineering. Towards this goal, Scientist in China proposed the idea of multiplexed coherent pixel (MCP) for metasurfaces, which enable the multiplexed manipulation of OAM and wavelength, leading to the high-security and high-capacity metasurfaces, shedding light on multifunctional nanophotonic devices in the future.



Experimental demonstration of the MCP metasurfaces for the multiplexed manipulation of OAM and wavelength.



a. Illustration of the OAM demultiplexer working in two wavelengths. b. Experimental results of OAM demultiplexing with wavelengths of 473 and 633 nm based on the MCP metasurfaces.

The orbital angular momentum (OAM) is a special optical degree of freedom (DoFs), which enables the generation a physically unbounded set of orthogonal modes that can be widely applied for optical communication and information processing with ultra-high capacity and speed. Although the control of OAM has brought about great achievements, the manipulation of OAM currently remains at single-DoF level in integrated systems, which means the multiplexed manipulation of OAM with other optical DoFs in subwavelength scale is still challenging, greatly limiting further applications of OAM in the fields of nanophotonics, integrated optics, and optical engineering, etc.

In order to address this challenge, in a new paper (https://doi.org/10.1038/s41377-024-01420-6) published in Light Science & Applications, a team of scientists, led by Professor Zhang-Kai Zhou from Sun Yat-sen University, China have proposed the idea of multiplexed coherent pixel (MCP) for metasurfaces, which not only realize the full control of amplitude and phase with the incident lights of plane and OAM waves, but also achieve the multiplexed manipulation of OAM and wavelength.

The researchers complete the design of MCP metasurfaces by three steps which are summarized as:

“1. Identifying the optimized geometric parameters of nanopillars, so as to ensure the ability of efficiently responding to multiple independent wavelengths without crosstalk. 2. Establishing the relationship between the rotation angle of nanopillars and the complex amplitude of transmitted wave, enabling the decoupling and independently controlling the phase and amplitude. 3. By employing relevant algorithms, the complex-amplitude components of the reconstructed signals are determined, and the specific arrangement of the nanopillars are confirmed”.

With the ability of manipulating OAM and wavelength in the multiplexed way, novel functions and applications can be invented by the MCP metasurfaces. The researchers declare that:

“Firstly, the MCP metasurface can achieve arbitrary complex-amplitude control of transmitted lights, and it also expands the type of incident light which metasurface can simultaneously respond to from OAM or plane wave to both of them. Secondly, with the ability of realizing multiplexed manipulation of OAM and wavelength, we achieve 10 information recording channels for a single layer metasurface. When these channels are used to integrate printing and hologram images, we can reduce the ratio of basic pixel size to channel number to be as small as 0.064 μm2/channel, which is a new record for the integration of printing and hologram images by a single-layer metasurface with arbitrary complex-amplitude control.”

Furthermore, they demonstrate that the MCP metasurfaces can spatially separate OAM lights of different topological charges and wavelengths, i.e., serving as the nanophotonic device of OAM demultiplexer with different wavelengths. This function is seldom reported in the fields of metasurfaces, and is believed to have great potentials for future optical communications.

In summary, this work not only enriches the means of light manipulation by raising the OAM manipulation from single-DoF level to multiple-DoF level, but also provides valuable insights for the future design of advanced photonic devices. Moreover, through additional structural designs and algorithm optimization, the MCP metasurfaces are believed to hold the capability of manipulating more optical DoFs simultaneously, offering promising chances for creating novel multifunctional nanophotonic devices in the future.

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