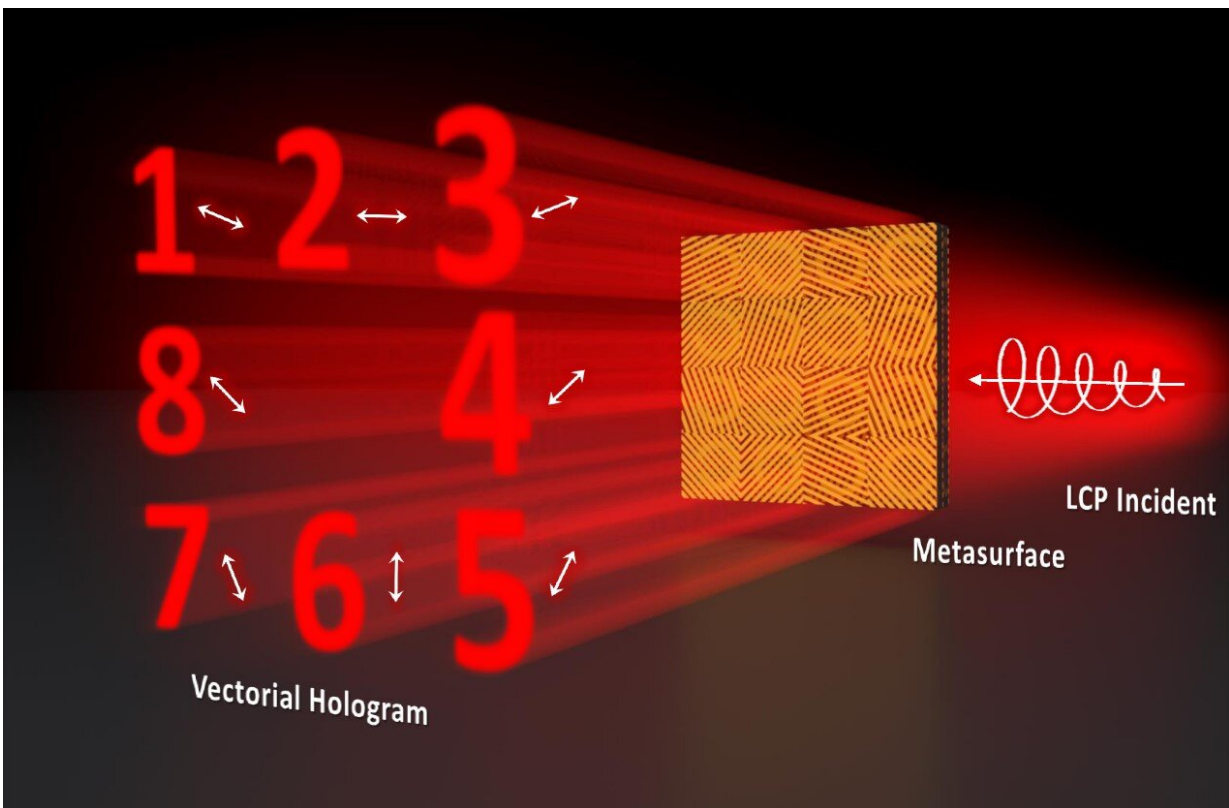


Highly efficient vectorial field manipulation using a transmitted tri-layer metasurface

November 8 2022



Schematic of the designed vectorial hologram metasurface device. Different holograms in eight polarization channels can be generated when the circularly polarized THz wave impinges on the metasurface, because the phase and polarization of the transmitted THz wave can be individually modulated. The hologram in a channel can be hidden by choosing the corresponding detected polarization state. Credit: OEA

A new publication from *Opto-Electronic Advances* discusses highly efficient vectorial field manipulation using a transmitted tri-layer metasurface.

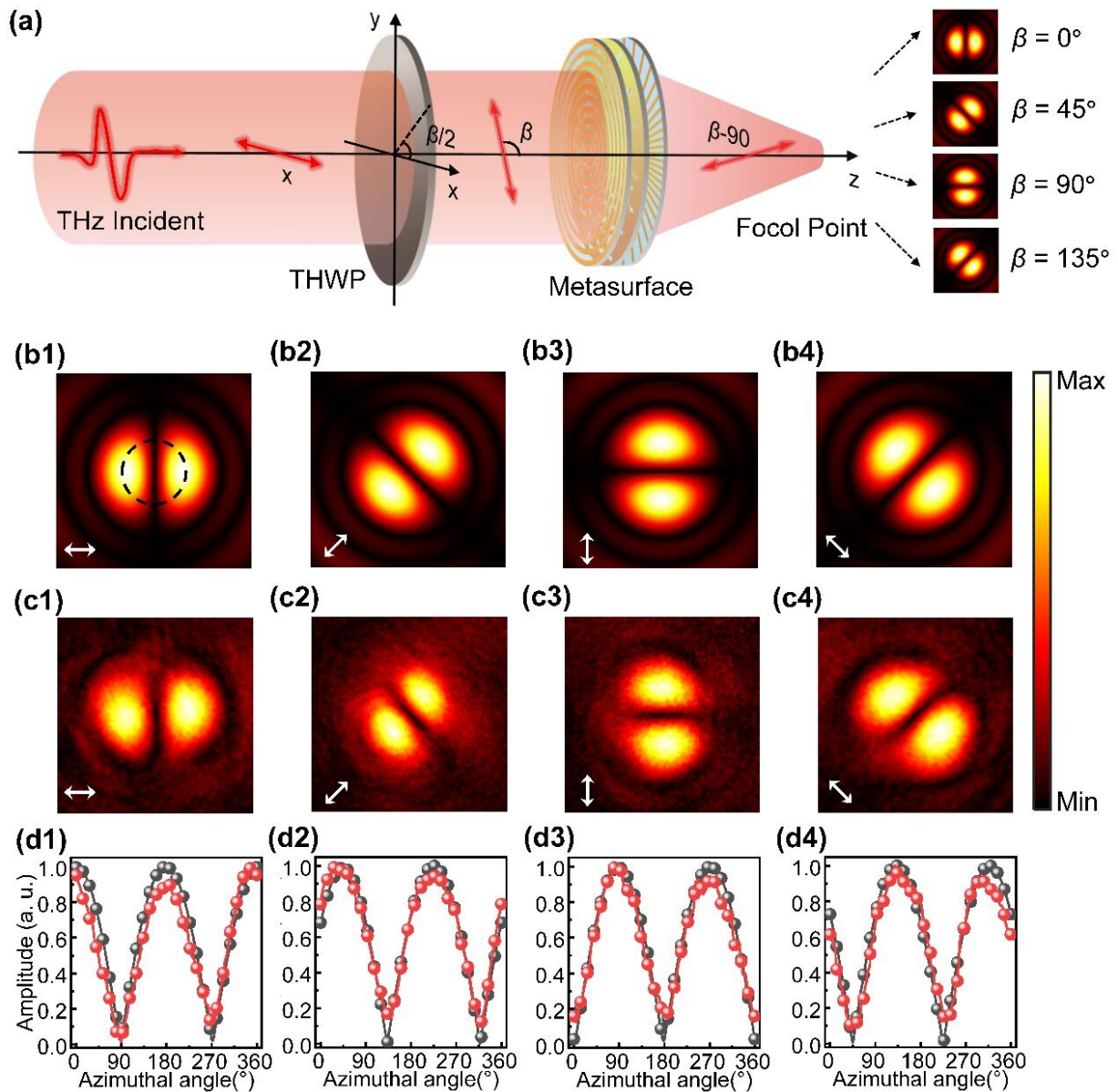
As one of the inherent properties of light, polarization carries a large amount of information and has important applications in [information security](#), optical communications, and image encryption. Light fields with both complex amplitude distribution and polarization distribution are called vector fields. The spatial polarization distribution increases the information capacity of the light field.

Metasurfaces, which are a two-dimensional form, have the advantage of small size and low loss. Although the efficient vector field modulation can be easily achieved using dielectric metasurfaces, the thickness of dielectric metasurface devices in the terahertz (THz) band is quite large, which results in a low yield of processing.

Highly efficient modulation performance can also be achieved using a multilayer metallic metasurface. The innovative construction of a tri-layer metasurface consisting of two metallic gratings and a metallic split-ring antenna enables independent modulation of the phase and polarization state of transmitted THz waves. The tri-layer metallic metasurface can be easily processed using conventional UV lithography and lift-off techniques, which can reach a theoretical efficiency up to 90%.

A vectorial hologram with eight channels with different linear polarization states is demonstrated experimentally. The information in different holograms can be hidden by choosing the polarization channel for detection. Moreover, an azimuthally polarized THz vectorial beam generator is realized and characterized for use as a THz polarization analyzer. The incident polarization angle can be observed graphically with high accuracy. This work contributes to achieving multi-functional

metasurface in the THz band and can benefit THz communication and optical information security.



Schematic and characteristics of the designed THz metasurface polarization analyzer. (a) Schematic of the working process of the THz metasurface polarization analyzer. An x-polarized THz wave is incident onto a THz half-wave plate (THWP), and the fast axis of the THWP is along the $\beta/2$ direction. The output THz wave is β -polarized and then incident on the metasurface device. The

transmitted wave is transferred to the cross-polarization state, which is along the $\beta-90^\circ$ direction and focused on the focal plane. The amplitude distribution of the focal spot is along the θ direction. (b1–b4) Simulated amplitude distributions on the focal plane for $\beta = 0, 45^\circ, 90^\circ,$ and $135^\circ,$ respectively. Each white arrow represents the incident polarization state. (c1–c4) Experimental amplitude distributions on the focal plane for $\beta = 0, 45^\circ, 90^\circ,$ and $135^\circ,$ respectively. (d1)–(d2) Amplitude distribution curves extracted from the amplitude distributions along the black dashed circle in Fig. 3(b1) for $\beta = 0, 45^\circ, 90^\circ,$ and $135^\circ,$ where the gray and red curves represent the simulated and experimental results, respectively. Credit: OEA

The authors of this article propose an efficient tri-layer metallic metasurface vectorial holographic device. This innovative device uses a tri-layer metallic metasurface to achieve independent modulation of the phase and polarization state of transmitted THz waves. The work designs two efficient vector devices, the first being a polarization-controlled image hiding device, which can generate hologram images 1 to 8 with different polarizations state in eight different channels under the incidence of circularly polarized THz waves. Different image in a specific channel can be hidden by selecting the detected polarization state.

A THz polarization analyzer was designed and fabricated using the proposed metasurface. When a THz wave polarized with angle β is incident from the top layer, the designed device can generate a TEM₁₀-mode spot with a rotation angle of β on the focal plane. Thus, the polarization direction of the input wave can be distinguished by the distribution of the light pattern on the focal plane. In contrast to a conventional polarizer, the advantage of the proposed [metasurface](#) polarization analyzer is that it can work in single-shot detection.

As it is well known, one must rotate the polarizer for at least 180 degrees

to obtain the polarization angle when using a traditional polarization analyzer, which is inconvenient for the measurement of the single pulse or transient fields. This device can be used to characterize the incident [polarization](#) angle through a single-shot image with high accuracy.

More information: Huan Zhao et al, Highly efficient vectorial field manipulation using a transmitted tri-layer metasurface in the terahertz band, *Opto-Electronic Advances* (2022). [DOI: 10.29026/oea.2023.220012](#)

Provided by Compuscript Ltd

Citation: Highly efficient vectorial field manipulation using a transmitted tri-layer metasurface (2022, November 8) retrieved 21 June 2024 from <https://phys.org/news/2022-11-highly-efficient-vectorial-field-transmitted.html>

<p>This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.</p>
--