Scientists propose flexible terahertz carrier-envelope phase shifter based on metamaterials

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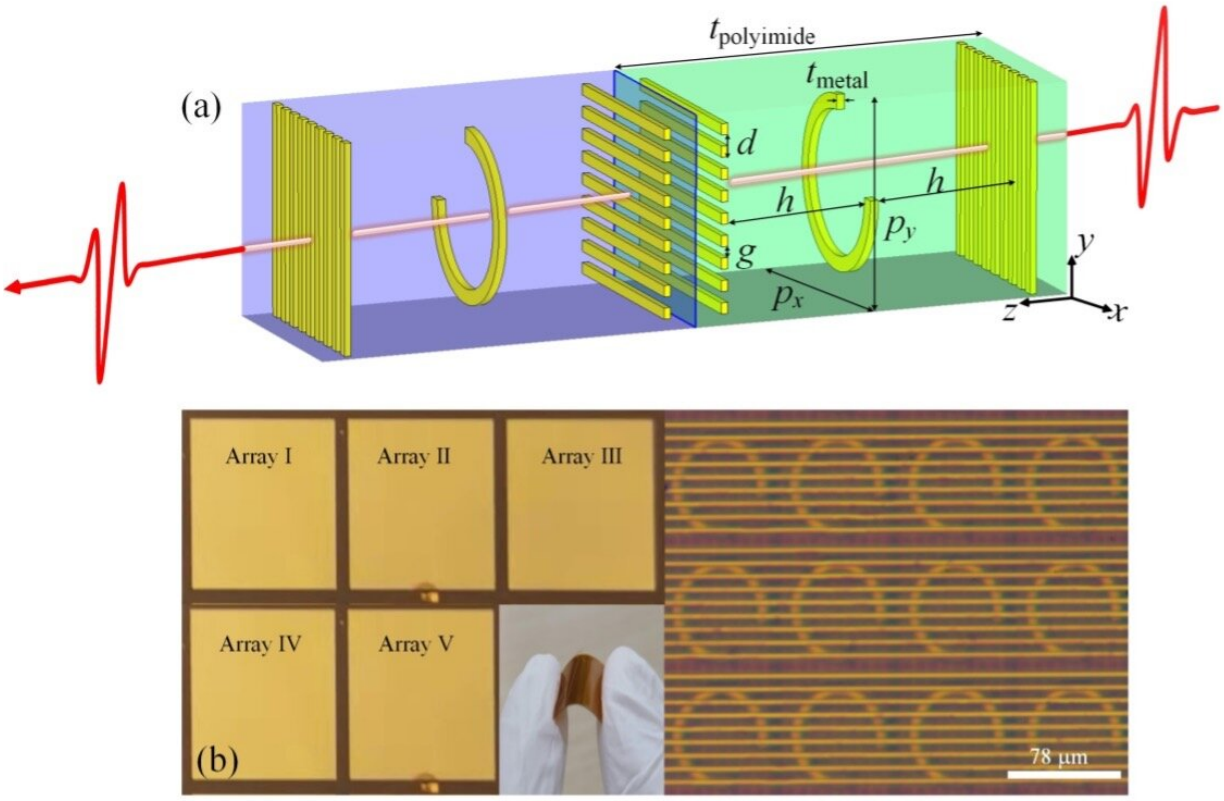

(a) Perspective view of the unit cell of array. (b) Overall and local optical images of the CEP shifter from top view, and flexibility of the CEP shifter demonstrated by manually bending the sample. Credit: AIR

Manipulating terahertz (THz) waveforms is important for its applications. Despite the rapid progress in metamaterials (MMs), the carrier-envelope phase (CEP) control for THz pulse is still challenging due to its broadband feature.

THz scanning tunneling microscope (THz-STM) is an emerging technique combining both high temporal and spatial resolution.

A research team led by Prof. Wang Tianwu from the Aerospace Information Research Institute (AIR), Chinese Academy of Sciences (CAS), proposes an ultra-thin THz CEP shifter composed of different MM arrays, which can modulate the CEP of broadband THz pulses in the sub-wavelength thickness range and maintain the electric field polarization.

The study was published in *Advanced Optical Materials*.

The CEP shifter is based on a specified split-ring resonator (SRR) with a pair of cross-oriented gratings to enhance the transmission efficiency. The CEP shift is realized by resonance phase and Pancharatnam-Berry phase of SRR, which can be shifted as high as 2π.

When the incident pulse is modulated by different MM arrays in turn, the change of temporal waveforms of the THz pulse under different CEP values is clearly observed by THz time domain spectroscopy system (THz-TDS), which correlates with the simulation results.

The research team also verified that the CEP shifter has good robustness under wide-angle incidence and a large deformation of the sample. Compared to the complex THz CEP controller composed of different parts, the proposed CEP shifter is ultra-thin and flexible, with low insertion loss and is easy to install and operate. It is expected to be used as a key component for THz-STM.

The design scheme can also be applied to other frequency bands by appropriately scaling the geometry parameters of the structure. In addition, the proposed CEP shifter will allow investigation of the CEP dependence of THz matter interactions.

More information: Tong Li et al, Flexible THz Carrier-Envelope Phase Shifter Based on Metamaterials, *Advanced Optical Materials* (2022). DOI: 10.1002/adom.202200541

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