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Supplementary information

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Generation of structured light beams with polarization variation along arbitrary spatial trajectories using tri-layer metasurfaces

Tong Nan[1,2], Huan Zhao[3], Jinying Guo[4,5], Xinke Wang[2], Hao Tian[1] and Yan Zhang[2]*

[1]School of Physics, Harbin Institute of Technology, Harbin 150001, China; [2]Beijing Key Laboratory of Metamaterials and Devices, Key Laboratory of Terahertz Optoelectronics, Ministry of Education, Beijing Advanced Innovation Center for Imaging Theory and Technology, Department of Physics, Capital Normal University, Beijing 100048, China; [3]Institute of Microelectronics Chinese Academy of Sciences, Beijing 100029, China; [4]Shanghai Institute of Optics and Fine Mechanics, Chinese Academy of Sciences, Shanghai 201800, China; [5]Center of Materials Science and Optoelectronics Engineering, University of Chinese Academy of Sciences, Beijing 100049, China.

*Correspondence: Y Zhang, E-mail: yzhang@cnu.edu.cn

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Section 1: Amplitude transmittance of the designed tri-layer metasurface

Figure S1 shows the transmission spectrum of the metasurface structure with θ = 90°. The incident wave is x-polarized and the transmitted light is y-polarized. It can be seen from the figure that in the range of 0.4~1.1 THz, the amplitude transmittance is higher than 75%.

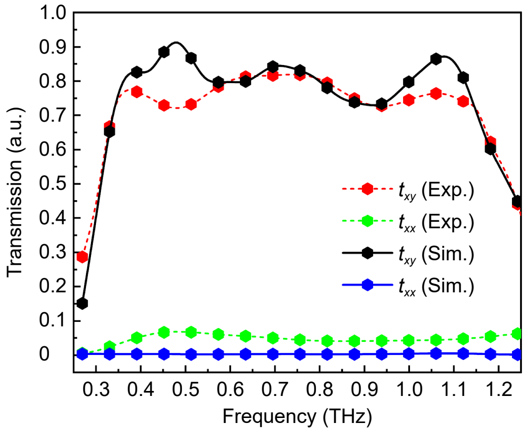

Fig. 1 | Transmitted spectrum of the metasurface cell with θ = 90°. The incident wave is x-polarized and the transmitted light is y-polarized.

Section 2: Evaluation of working efficiency

In the simulation, the field monitors were set to record the electric fields E_x and E_y in the frequency range from 0.1 to 1.5 THz. The working efficiency is defined as:

$$\eta = \sqrt{\frac{I_{\text{out}}}{I_{\text{in}}}}$$

where I_{out} and I_{in} are the integrated total intensities of the transmitted and incident waves respectively, at one specific frequency. The working efficiency is 0.384 in the experiment when the incident light is RCP THz wave. It can be found that the working efficiency is almost half of that of the three-layer metasurface unit, which is attributed to the underlying meta-grating reflecting half of the electric field of the RCP incident THz wave.

Section 3: Fabrication process of samples

We fabricated the samples through conventional UV lithography, thermal evaporation, and lift-off techniques. Initially, we performed standard lithography and subsequent lift-off processes to acquire the bottom metal metagrating layer on a 500 μm-thick high-resistance silicon substrate. Subsequently, we applied four layers of polyimide (PI) through spin coating on the bottom metagrating layer. After each spin coating, we gradientally baked the sample to transform the PI into a solid state and achieving an exact 10 μm-thick PI layer. Following four cycles of coating and baking, we obtained a 40 μm-thick PI spacer. Next, we repeated the standard lithography and subsequent lift-off steps to obtain the middle layer, consisting of a metal C-shaped split-ring antenna array meticulously aligned with the bottom metagrating layer. The coating and baking cycles were then repeated to add another 40 μm-thick PI spacer layer atop the metal C-shaped split-ring antenna array. Finally, we underwent another round of regular lithography and subsequent lift-off to secure the top metal metagrating layer.