Terahertz High-efficiency Multi-functional Devices with Transmissive Dielectric Metasurface

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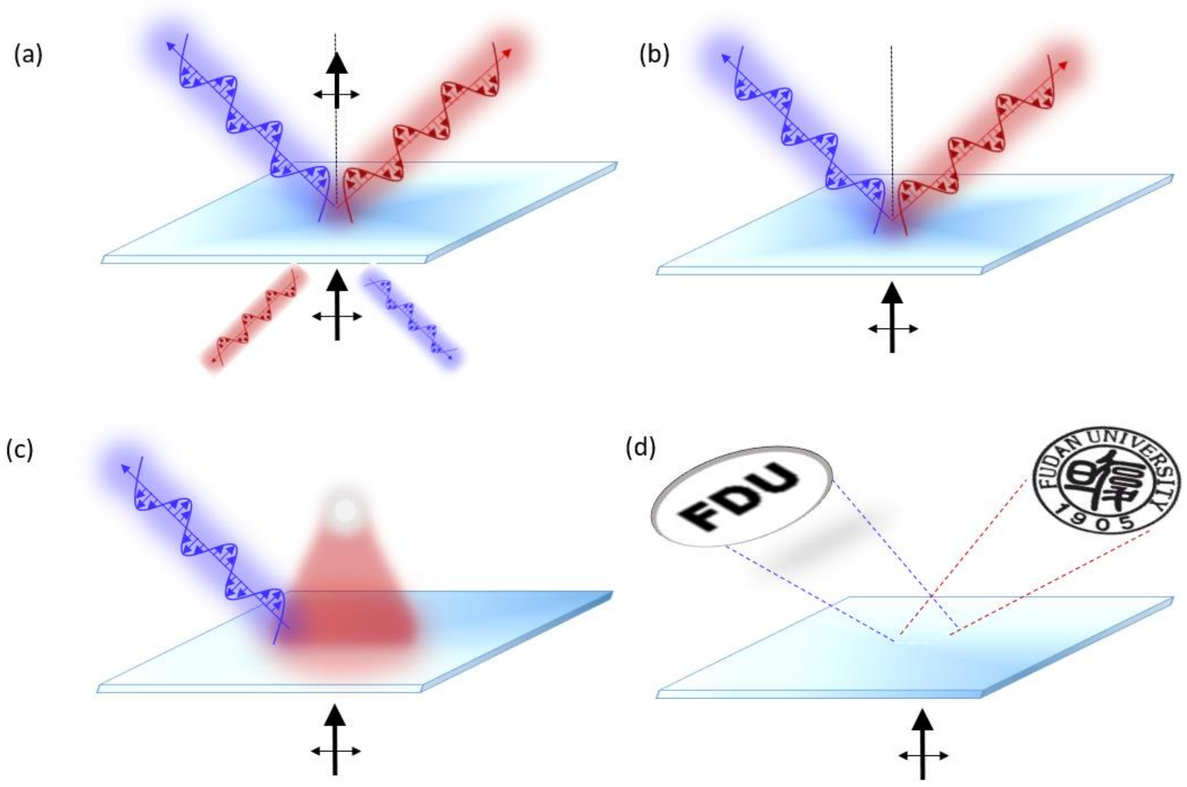
Abstract

The manipulation of circularly polarized (CP) terahertz(THz) waves is very important for fundamental research and highly desired due to the wide demands in applications.

However, conventional terahertz devices are suffering from bulky and low efficiency. Recently, the ultralthin metasurfaces have been employed to control terahertz light. But their absolute efficiency is still very low. In addition, most devices can only work under a single polarized incident light, which is un-convenient for device integration in the future.

Here we have realized the photon spin Hall effect in the terahertz band with 100% efficiency. Besides A efficient multifunctional device be designed and fabricated.

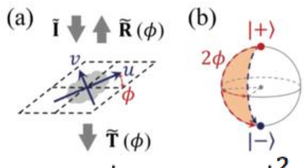


Introduction

The terahertz frequency band (0.1-10THz) is between the microwave and optical frequency bands, and the research and devices on this band is very lack because it has been studied at the latest. But it has a wide range of applications in our lives, especially circularly polarized terahertz waves(or Chiral terahertz light). For example, the vibration and rotation responses of many chiral molecules are in the band. Therefore, it is very important to efficiently control chiral terahertz light. However, the current conventional optical devices are very bulky and low in efficiency. Although the metasurface can be controlled in a very thin system, its absolute efficiency is still very low. In addition, the fixed function greatly limits its application prospects.

Meta-atoms

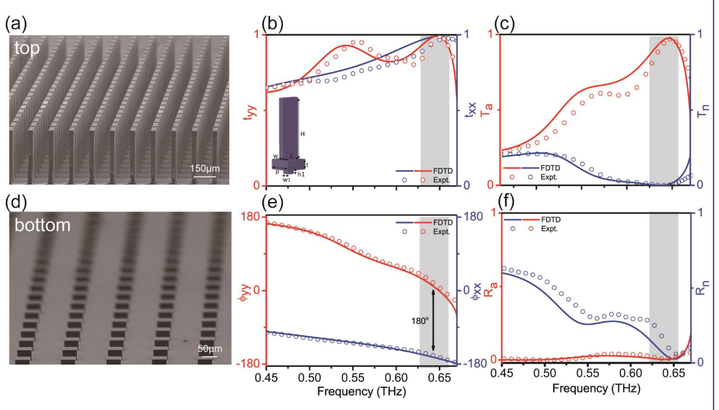
High Efficiency Criterion



$$T_a = \left|t_{xx} - t_{yy}\right|^2/4, \quad R_a = \left|r_{xx} - r_{yy}\right|^2/4$$

$$T_n = \left|t_{xx} + t_{yy}\right|^2/4, \quad R_n = \left|r_{xx} + r_{yy}\right|^2/4$$

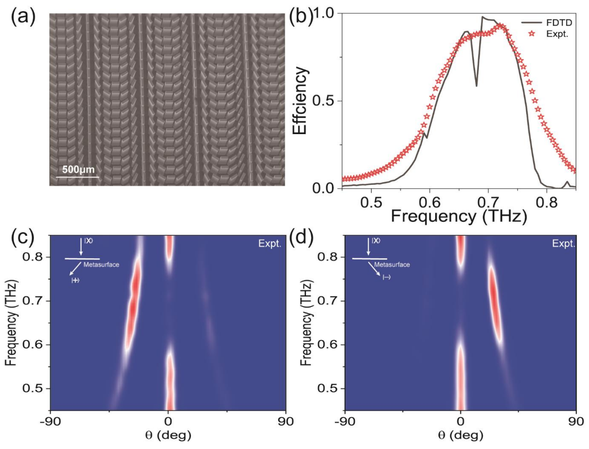
➢ $|t_{xx}| = |t_{yy}| = 1, \arg(t_{xx}) - \arg(t_{xx}) = \pi$



- The 100% efficiency of polarization conversion
- High aspect ratio(about 12.12 times)
- Freestanding sample

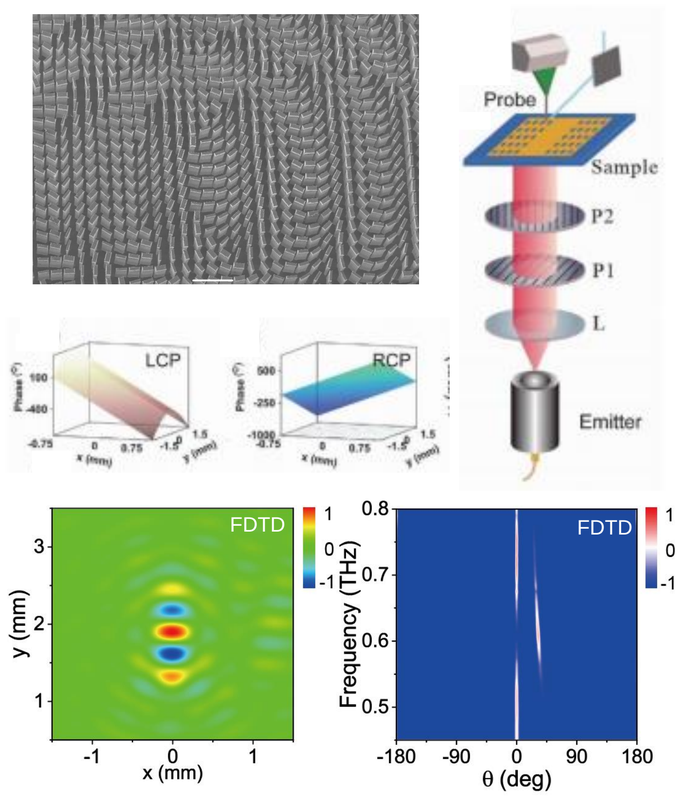
Photon Spin Hall effect

$$\boldsymbol{\Phi_\sigma(x,y) = (\Phi_0 + \xi_\sigma \cdot x) + G_\sigma(y)}$$



- The efficiency of device is nearly about 100%
- Realize the complete separation of left-handed light and right-handed light

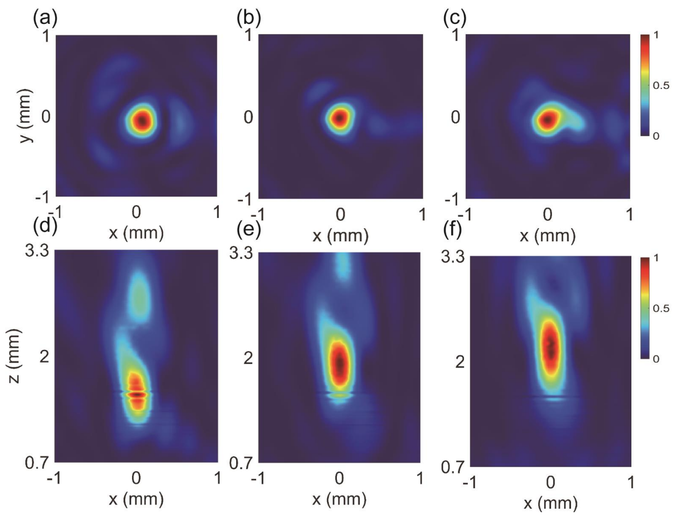
Simulation results

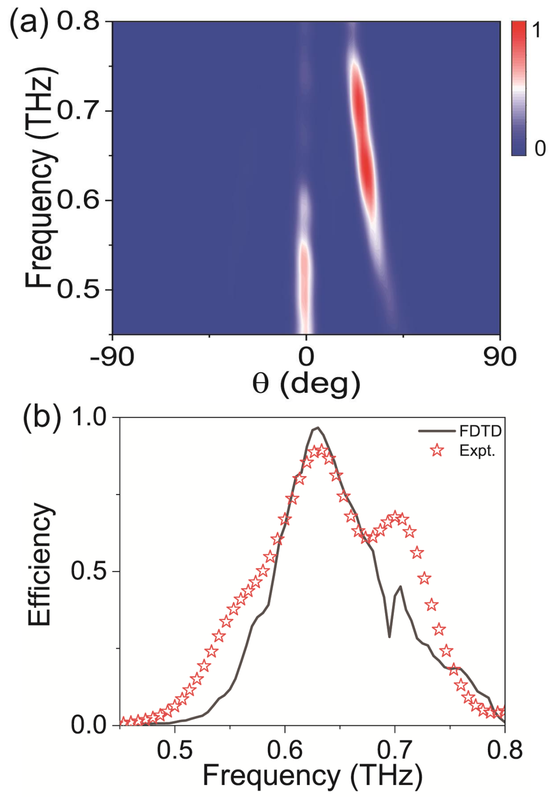


Experimental results

$$G_+(y) = k_0\left(\sqrt{F^2 + y^2} - F\right)$$

$$G_-(y) = A + \xi_y \cdot y$$





- In principle, our device can realize arbitrary manipulation of terahertz light. Here , we demonstrate two different functions through experiments which is focusing and refraction for LCP and RCP incident light respectively.

Conclusions

Based on the all-dielectric metasurface, the photon spin Hall effect with 100% efficiency is realized in the terahertz band. And the function of geometric phase metasurface is unlocked for left and right-handed circularly polarized light. Focusing and refraction are realized when the incident light is LCP and RCP respectively.

References

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