Ultra-Thin Metamaterial-Enhanced Liquid-Crystal Terahertz Spatial Phase Modulator

O. Buchnev, N. Podoliak, K. Kaltenecker, M. Walther, M. Kaczmarek and V. A. Fedotov

Abstract (250 words)

Efficient spatial control of terahertz radiation is one of the main challenges of the THz technology. Spatial light modulators (SLMs) based on LCs are established technology in photonics. LCs have been also identified as promising materials for THz applications due to their wide transmittance window. However, effective THz phase control requires the thickness of an LC cell to be greater than several hundred micrometers due to relatively low LC birefringence in the THz domain, and high driving voltage, often in excess of 100V.
An intriguing way of improving the performance and characteristics of LC-based THz devices has emerged recently with the advent of metamaterials, artificially structured electromagnetic materials that are designed to manipulate light in ways no natural materials can. We already demonstrated an efficient electrically-driven mechanism of controlling THz radiation by combining optical anisotropy of a thin low-voltage LC cell (which was too thin to produce any noticeable transmission effect alone) with resonant response of a THz planar metamaterial.
Here we take the above concept one step further and experimentally realize an optically thin large-area spatial phase modulator. It consists of two layers of THz planar metamaterials separated by a 12 μm thick LC layer. Besides enhancing optical anisotropy of the LC layer, the metamaterials also act as spatially addressable electrodes, which transform the resulting structure into an array of sub-wavelength pixels with independently controlled electromagnetic phase.
Our approach enables a new family of LC-enabled compact THz devices for efficient control and manipulation of THz wavefronts.

100-word abstract:

We demonstrate experimentally a very thin THz spatial phase modulator based on planar metamaterials hybridysed with a liquid-crystal (LC) cell. It consists of two layers of THz planar metamaterials separated by a 12 μm thick LC layer. Besides enhancing optical anisotropy of the LC layer, the metamaterials also act as spatially addressable electrodes, which transform the resulting structure into an array of sub-wavelength pixels with independently controlled electromagnetic phase. Our approach brings about a new family of LC-enabled but optically thin THz devices for efficient control and manipulation of THz wavefronts.