Metamaterial-Liquid Crystal Ultra-Thin Spatial Phase Modulator for THz Applications

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Efficient spatial control of terahertz radiation is one of the main challenges of the THz technology. Spatial light modulators (SLMs) based on liquid crystals (LC) are established technology in photonics. LCs have been also identified as promising materials for terahertz 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 microns due to relatively low LC birefringence in the THz domain, as well as high driving voltage, often in excess of 100 V [1].

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 [2]. We have already experimentally demonstrated a very efficient electrically-driven mechanism of THz radiation control 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 [3].

In the present work 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. This new development brings about a new family of LC-enabled but optically thin THz devices for efficient control and manipulation of THz wavefronts.

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