Liquid Crystal Based Terahertz Metamaterial Absorbers

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Abstract

Metamaterial-based absorbers play a significant role in applications ranging from energy harvesting and thermal emitters to sensors and imaging devices. The middle dielectric layer of conventional metamaterial absorbers has always been solid. Researchers could not detect the near field distribution in this layer or utilize it effectively. Here, we use anisotropic liquid crystal as the dielectric layer to realize electrically fast tunable terahertz metamaterial absorbers. We demonstrate strong, position-dependent terahertz near-field enhancement with sub-wavelength resolution inside the metamaterial absorber. We measure the terahertz far-field absorption as the driving voltage increases. By combining experimental results with liquid crystal simulations, we verify the near-field distribution in the middle layer indirectly and bridge the nearfield and far-field observations. Our work opens new opportunities for creating high-performance, fast, tunable, terahertz metamaterial devices that can be applied in biological imaging and sensing.

We use the COMSOL software to simulate the tunable range of the far field resonant characteristic and the near field enhancement inside TMA. The simulations are performed by a frequency domain solver with periodic boundary conditions. The Au is modeled as a Drude metal with a plasma frequency of 2p*2181 THz and a collision frequency of 2p*6.5 THz. The LC is an anisotropic material with no = 1.5+ j0.05 and ne = 1.8+ j0.03. We choose two cases to simulate. One case is for the initial LC director (the optical axis) parallel to the x axis, i.e., the unbiased state (0 V), with nx = ne , ny = no, nz = no; the other is the extreme situation where all the LC directors are in a vertical orientation with nx = no, ny = no, nz = ne. The linearly polarized THz wave is normally incident into the TMA with the electric field E0 in the x direction.

Reference

[1] Wang, L., et al. Large birefringence liquid crystal material in terahertz range. Opt. Mater. Express 2, 1314-1319 (2012).
[2] Wang, L., et al. Broadband tunable liquid crystal terahertz waveplates driven with porous graphene electrodes. Light Sci. Appl. 4, e253 (2015).
[3] Wang, L., et al. Bridging the terahertz near-field and far-field observations of liquid crystal based metamaterial absorbers. Chin. Phys. B Vol. 25, No 9, 09422(2016).

Figures used in the abstract

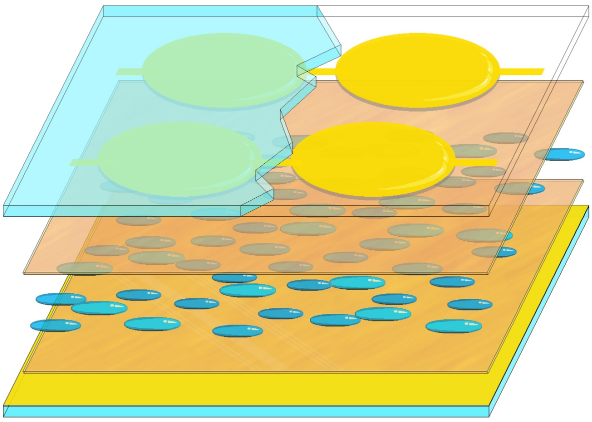

Figure 1: Schematic of an LC-based fast tunable TMA

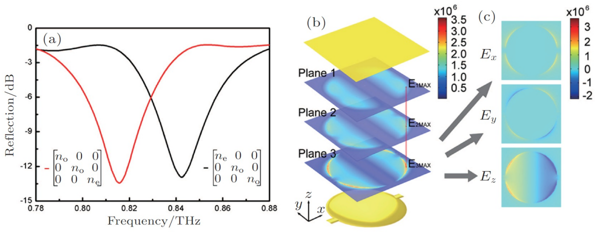

Figure 2: The tunable range of the far field resonant characteristic and the near field enhancement inside TMA