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Controlling reflection and absorption of antennae array in THz using liquid crystals and a liquid crystal elastomers

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In this study we explore the possibilities of tuning dipole and Yagi-Uda antennae arrays operating at terahertz frequencies (THz). In the case of dipole antenna array, we use a liquid crystal elastomer to reversibly change the reflection and absorption of the array by applying a strain to the elastomer filled with metallic dipoles. The stretching of the liquid crystal elastomer induces changes in the periodicity and thickness of the system, ultimately modifying the reflectance and absorbance. A linearly polarized wave is either normally or obliquely incident onto the antennae array. In the case of the Yagi-Uda antennae array the structure under investigation comprises a 2D array of metallic Yagi-Uda antennae on a dielectric substrate with a continuous metallic film below and a vacuum layer further beneath. Above the antennae array, there is a layer of nematic liquid crystal (LC) with the initial pi/2 twist of the LC director. Under the Mauguin regime the light polarization rotates following the LC director rotation. The application of an external electric field perpendicular to the substrates reorients the liquid crystal director from its initial twisted state to a homeotropic state, resulting in a change in the light's polarization upon reaching the antennae array.
Our investigation revealed that varying the strain applied to the LC elastomer or voltage applied to initially pi/2 twisted nematic allows for the tunability of plasmonic resonances within the antennae array in the mentioned metamaterial structures. The tunability covers a frequency interval of approximately 7–12 THz. The incident intensity reflectance and absorbance tuning range reaches 90% at some frequencies. By utilizing the electro-optic properties of nematic liquid crystals and elastic properties of LC elastomers, this study introduces a method for tuning the antennae array in THz applications.