Systematical investigation of two orthogonal plasmonic modes of graphene ellipse array

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Graphene nanostructures can support localized plasmonic resonances from terahertz to infrared ranges, showing many unique characteristics such as subwavelength confinement, strong field localization and tunability [1]. Localize plasmonic resonances have been extensively studied in various structures such as graphene nanoribbons and nanodisks [2], possessing potential applications in photonics and optoelectronics [3].

The graphene ellipses support two orthogonal plasmonic modes along major and minor axis, showing polarization-dependent resonances [4]. This provides another degree of freedom, compared to graphene ribbons and disks, in manipulation of the interaction between mater with light, which deserves further investigation both theoretically and experimentally.

In this paper, we develop a theoretical model to describe the plasmonic resonances of graphene ellipse array on an isotropic substrate (Figure 1(a)). The extinction spectra for two orthogonal modes, namely the high-frequency mode along the minor axis and the low-frequency mode along the major axis, calculated by theoretical model agree well with the experiment results. The polarization dependence of the two orthogonal modes are fully studied as shown in Figure 1(b) and 1(c). By experimentally controlling the parameters including ellipticity of the structure, fermi energy of graphene and the substrate material, the resonance modes can be dynamically tuned.

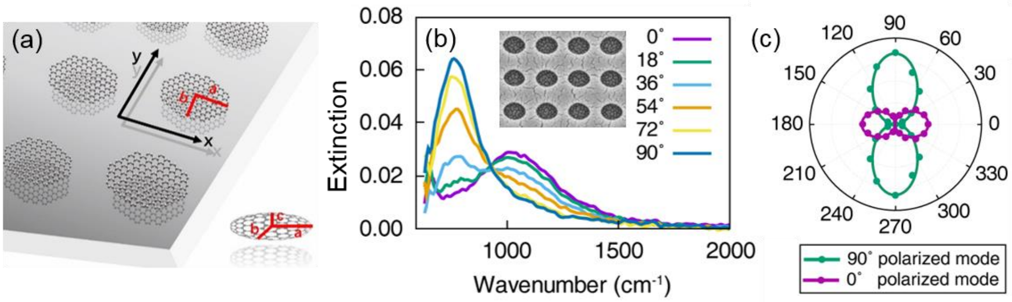

Fig. 1(a) Schematic diagram of the graphene ellipse array on a substrate. (b) The extinction spectra of two orthogonal plasmonic modes of graphene ellipses at different polarization angles. (c) The polarization-dependence of the two plasmonic modes.

In conclusion, we investigate both the theory and experiments of the plasmonic modes supported by graphene ellipse array, which provides valuable insight into the properties of plasmonic resonators. The two polarization-dependent modes show red shift with increasing length of the axis and decreasing fermi level of graphene, respectively. Furthermore, with a polar substrate, the interaction of graphene plasmons with substrate phonons brings hybridization of the two modes in each direction of the ellipse. Therefore, the graphene ellipses have potential applications as detectors, filters and sensors in infrared range with the guidance of the theoretical model and experiment results.

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