Graphene Metamaterials Supported Tunable Terahertz Fano Resonance

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Abstract : The manipulation of THz waves is still a challenging task due to lack of natural materials interacted with it strongly. Designed by tailoring the characters of unit cells (meta-molecules), the advance of metamaterials (MMs) may solve this problem. However, because of Ohmic and radiation losses, the performance of MMs devices is subjected to the dissipation and low quality factor (Q-factor). This dilemma may be circumvented by Fano resonance, which arises from the destructive interference between a bright continuum mode and dark discrete mode (or a narrow resonance). Different from symmetric Lorentz spectral curve, Fano resonance indicates a distinct asymmetric line-shape, ultrahigh quality factor, steep variations in spectrum curves. Fano resonance is usually realized through symmetry breaking. However, if concentric double rings (DR) are placed closely to each other, the near-field coupling between them gives rise to two hybridized modes (bright and narrowband dark modes) because of the local asymmetry, resulting into the characteristic Fano line shape. Furthermore, from the practical viewpoint, it is highly desirable requirement that to achieve the modulation of Fano spectral curves conveniently, which is an important and interesting research topics. For current Fano systems, the tunable spectral curves can be realized by adjusting the geometrical structural parameters or magnetic fields biased the ferrite-based structure. But due to limited dispersion properties of active materials, it is still a tough work to tailor Fano resonance conveniently with the fixed structural parameters. With the favorable properties of extreme confinement and high tunability, graphene is a strong candidate to achieve this goal. The DR-structure possesses the excitation of so-called “trapped modes,” with the merits of simple structure and high quality of resonances in thin structures. By depositing graphene circular DR on the SiO2/Si/ polymer substrate, the tunable Fano resonance has been theoretically investigated in the terahertz regime, including the effects of graphene Fermi level, structural parameters and operation frequency. The results manifest that the obvious Fano peak can be efficiently modulated because of the strong coupling between incident waves and graphene ribbons. As Fermi level increases, the peak amplitude of Fano curve increases, and the resonant peak position shifts to high frequency. The amplitude modulation depth of Fano curves is about 30% if Fermi level changes in the scope of 0.1-1.0 eV. The optimum gap distance between DR is about 8-12 μm, where the value of figure of merit shows a peak. As the graphene ribbon width increases, the Fano spectral curves become broad, and the resonant peak denotes blue shift. The results are very helpful to develop novel graphene plasmonic devices, e.g. sensors and modulators.

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