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Tunable mid-infrared plasmons supported by graphene nanomesh structures

Abstract. The mid-infrared (MIR) spectral regime plays a very important role in the fields of materials analysis, imaging and spectroscopy, due to its ability to detect a molecule's spectral fingerprint, or the strong IR signatures of some greenhouse gases[1]. However, infrared light interacts poorly with molecules and this requires cooling system to be integrated with the existing MIR photodetectors in most applications. On the other hand, graphene, a hexagonal lattice of carbon atoms, has attracted a huge attention due to its remarkable electronic and optical properties since it was successfully exfoliated with the tape method a decade ago[2]. However, the gapless nature of graphene's band structure and the low absorption of graphene at the MIR[3] wavelengths restrict its application at this spectra range. Therefore, increasing light absorption and introducing a bandgap benefit the MIR graphene optoelectronics[4]. In this paper, we investigate the graphene nanomesh platform which possesses a size-dependent band gap[5] and can also support the MIR graphene plasmons. As shown in figure 1, the graphene nanomesh platform comprises an array of nano scale circular holes. The absorption of the graphene nanomesh platform with MIR plasmons with different Fermi level has been simulated by using finite-element method (CST Microwave Studio) and it has been found that after optimizing the size of the nanoholes there is an order of magnitude improvement in absorption compared with a pure graphene layer with the same parameters, as shown in the inset of figure 1. The working wavelength and polarization sensitivity of the plasmon resonance can also be engineered with the size and shape of nanoholes. The graphene nanomesh structure can be used in a wide range of optoelectronic systems, such as high-sensitivity and frequency-selective photodetectors and sensors.

References

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Figure

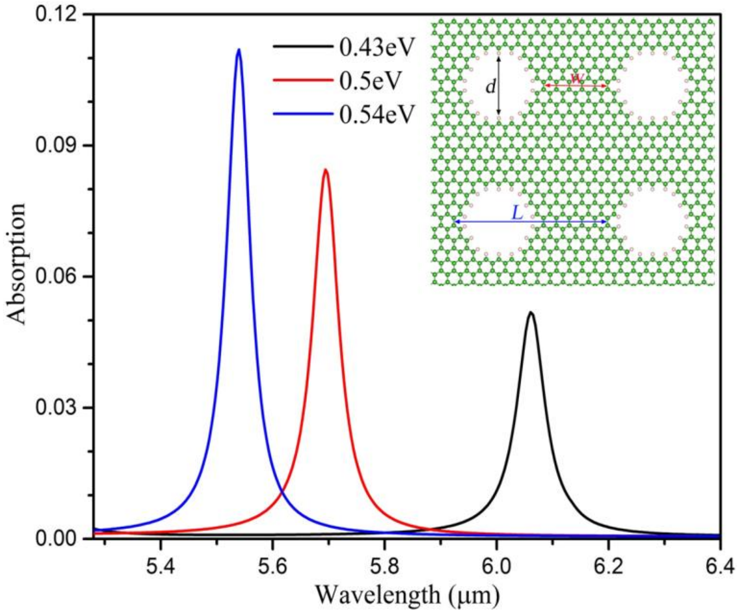

Figure 1: The absorption spectra of graphene nanomesh structure at different Fermi level with unit length (L) of 100 nm, diameter (d) of 60 nm and mobility of 6000 cm^2/Vs, the inset is the schematic of graphene nanomesh platform.