Plasmonic Response in Graphene under Periodic Carrier Density Modulation

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Graphene plasmons are attracting much attention for plasmonic device applications owing to their tunability by electrical means. The tunability of plasmon frequency has been demonstrated in a variety of graphene micro/nano-cavities defined by etching. It has been theoretically proposed that the electrical tuning of the plasmon frequency can be utilized for developing transformation optics devices [1]: by tailoring the spatial distribution of the carrier density in a continuous graphene, it is possible to send plasmons to a desired point. However, plasmon response in graphene under carrier density modulation has been poorly explored experimentally because of difficulty of inducing it without affecting the electro-magnetic environment.

In this work, we spatially modulate the carrier density using chemical doping from self-assembled monolayer (SAM) of organosilane, which is thin enough not to affect the effective dielectric constant. Graphene grown by CVD method has transferred on the SAM patterned into 1.7-μm-wide ribbons separated by 6.3 μm on a Si/SiO_2 substrate (Fig. 1). Fourier transform infrared spectroscopy shows two absorption peaks in THz range (Fig. 2, top). From the dependence of the peak positions on the electrostatic doping from the Si back gate, the two peaks are identified as plasmon modes mostly localized in the graphene/SAM and graphene/SiO_2 micro-ribbon arrays. We demonstrate that it is possible to select a micro-ribbon array for the plasmon excitation by setting the Fermi energy of the other array to the charge neutrality point (Fig. 2, bottom). These results are important step towards realization of graphene-based transformation optics devices.

References

[1] A. Vakil and N. Engheta, Science 332 (2011) 1291

[2] N.-H. Tu *et al*. Jpn. J. Appl. Phys. 57 (2018) 110307

Figures

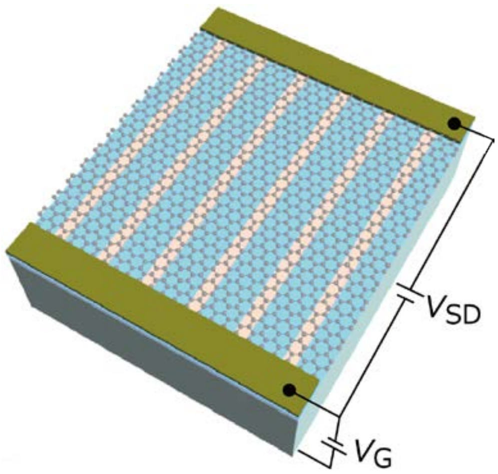

Figure 1: Schematic illustration of a sample. Continuous graphene is transferred on a SiO_2 substrate (light blue) with patterned SAM (orange).

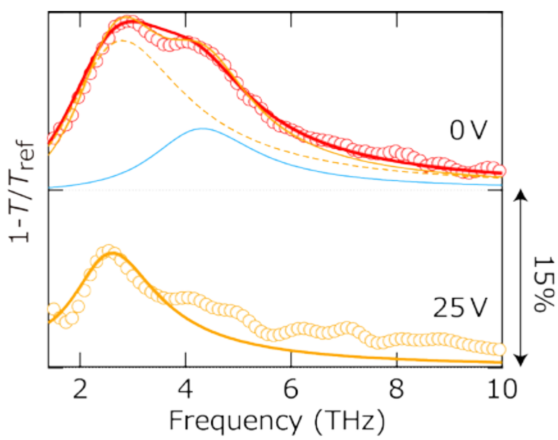

Figure 2: Extinction spectra (circles) for two values of the Si back gate bias. At the gate bias of 25 V, the Fermi energy of graphene on SAM is at the CNP, and plasmons are excited only in graphene/SiO_2 micro-ribbons.