Wide tunability in plasmon reflection by carrier density pattern in graphene

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Controlling the propagation of surface plasmon polaritons (SPP) is the key for realizing plasmonic circuits. Graphene plasmon allows for controlling SPP to reflect and refract by spatially varying charge-carrier concentration (*n*) [1]. Plasmon reflection and refraction have been reported at grain boundaries [2] and bilayer-/monolayer-graphene interface [3]. However, at these interfaces, the *n* is naturally randomly determined and such randomness limits the controllability of the plasmons. Here, we demonstrate plasmon control in graphene utilizing artificial interfaces between areas with different *n* [4].

We fabricated the artificial interfaces in graphene using chemical doping from patterned self-assembled monolayer (SAM) of 3-amino-propyltriethoxysilane. The SAM was formed on the SiO_2 surface and patterned into stripes. Graphene was transferred onto it (Fig. 1). The plasmonic response was monitored by a scattering-type scanning near-field optical microscope (s-SNOM) [2, 3].

Near-field amplitude image measured by s-SNOM is shown in Fig. 2a. At the center of the image, the amplitude is modulated due to the reflection of the plasmons, which is caused by the difference in *n* at the interface between graphene/SiO_2 and graphene/SAM. Here, *n* was independently estimated by Raman scattering: $n_1 \sim 1\times10^{13}$ cm^{-2} for graphene/SiO_2 and $n_2 \sim 4\times10^{12}$ cm^{-2} for graphene/SAM. We obtained the consistent values from the plasmon wavelength, which was determined from the distance between the constructive interference at grain boundaries [2] (λ_{p1} and λ_{p2} in Fig. 2a). The reflection coefficient (r_p) was estimated to be ~0.2 with this condition. r_p can be further tuned by electrical gating. We found that r_p depends on the difference in *n* (Δn) (Fig. 2b). We numerically calculated the near-field amplitude profiles across the interface and estimated r_p from the profiles. The calculations reproduce the experiments and indicate that r_p can be tuned from 0 to 1 (Fig. 2b). This controllable r_p achieved by artificial design of the interface allows us to make plasmonic lenses.

Figures

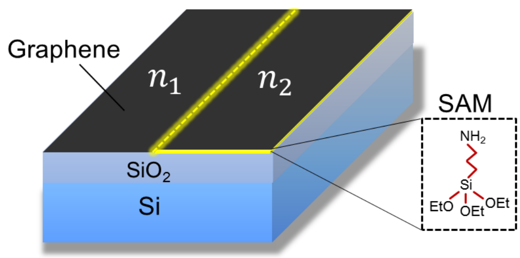

Figure 1: Graphene on SiO_2/Si, where the SiO_2 surface is partially covered with the SAM [4].

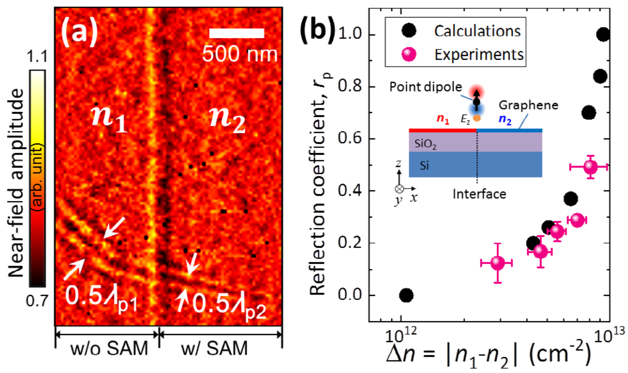

Figure 2: (a) Near-field amplitude image around the interface with an incident beam at λ_0=10.7 μm, and (b) plasmon reflection coefficient as a function of Δn [4]. Inset is a calculation model.

References

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