Modulation of plasmons in graphene by substrate modification

Makoto Takamura
Norio Kumada, Shengnan Wang and Kazuhide Kumakura
NTT Basic Research Laboratories, NTT Corporation, 3-1 Morinosato Wakamiya, Atsugi, Kanagawa 243-0198, Japan
takamura.makoto@lab.ntt.co.jp

Graphene plasmons offer unique possibilities for controlling light in nano-devices and for optoelectronics. Plasmonic properties can be widely controlled by tuning carrier density, *n*. Electrical carrier doping to control plasmon has been intensively studied [1]. Chemical doping is another promising approach, which will be applicable to plasmon waveguides [2]; however, only few experiments have been reported so far.

In this study, we investigate plasmons behaviour in graphene modified by chemical doping caused by a substrate modification with a self-assembled monolayer (SAM) of organic compounds. We used 3-amino-propyltriethoxysilane to form an SAM at the interface between a SiO_2 substrate and graphene, which modifies the *n* of graphene. Graphene grown by a chemical vaper deposition method was transferred onto the SAM. As a reference, we also prepared samples with graphene directly on a substrate. Propagating plasmons were imaged with a scattering-type scanning near-field optical microscope (s-SNOM) [1, 3].

In Fig. 1, near-field amplitude obtained with the s-SNOM is plotted as a function of position across domain boundaries (DBs) in the two types of samples. It shows the profile of interference patterns with different peak distances corresponding to the half of plasmon wavelengths, $\lambda_p/2$. The λ_p in the samples with the SAM is smaller than that in the samples without the SAM. The carrier densities estimated from the dependence of λ_p on the incident beam wavelength are n ~3.6×10^{12} cm^{-2} and ~1×10^{13} cm^{-2} in the samples with and without the SAM, respectively (Fig. 2). These values are consistent with those measured by the van der Pauw method. Our results demonstrate that plasmon properties in graphene can be modulated by the chemical doping from the SAM. Patterning of the SAM would be useful to fabricate plasmonic devices, such as waveguides.

References

[1] J. Chen et al., Nature, 487 (2012) 77
[2] A. Vakil and N. Engheta, Science, 332 (2011) 1291
[3] Z. Fei et al., Nat. Nanotechnol., 8 (2013) 821

Figures

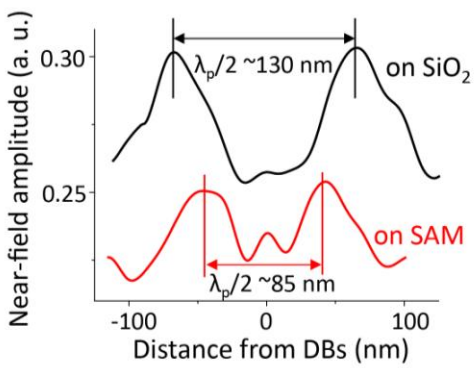

Figure 1: Near-field amplitude profiles across DBs of graphene with an incident beam at 10.7 μm.

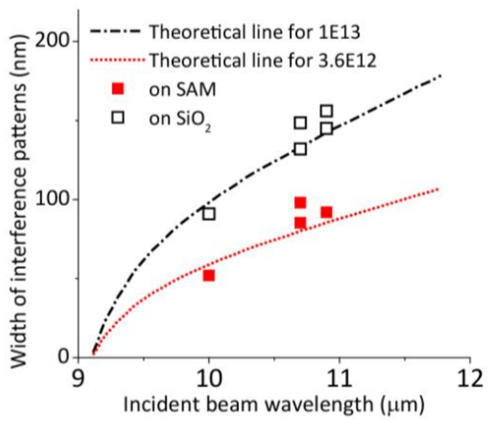

Figure 2: Distance between interference peaks as a function of incident beam wavelength.