Graphene Charge Transfer in Plasmonic Materials

Min-Wen Yu [1,2], Satoshi Ishii [2], Tadaaki Nagao[2], Kuo-Ping Chen [3]

[1] Institute of Lighting and Energy Photonics, College of Photonics, National Chiao Tung University, 301 Gaofa 3rd Road, Tainan 711, Taiwan

[2] International Center for Materials Nanoarchitectonics (MANA), National Institute for Materials Science (NIMS), 1-1 Namiki, Tsukuba, Ibaraki 305-0044, Japan

[3] Institute of Imaging and Biomedical Photonics, College of Photonics, National Chiao Tung University, 301 Gaofa 3rd Road, Tainan 711, Taiwan

E-mail: kpchen@nctu.edu.tw ; NAGAO.Tadaaki@nims.go.jp

1. Introduction

While graphene (G) is atomically thin, it has a strong influence on the surface potential when it is transferred on a metal film [1][2].

In this study, we investigated the charge transfer between the noble metal and the transition metal nitride (Au and ZrN) by the kelvin probe force microscopy (KPFM) and the spectroscopic ellipsometry. This work can be developed in graphene-plasmonics hybrid structures.

2. Results and discussion

CVD-grown graphene sheets were transferred onto Au and ZrN thin films having the thicknesses of 50 nm. KPFM scanning was performed around the boundary of metal (Au or ZrN) to obtain the surface potential (SP) difference (Fig.1a). The scanning results for the Au and ZrN with and without graphene on the top surface are shown in Fig. 1b and Fig. 1c, respectively. Fig. 1d and 1e show the SP profiles extracted from Figs. 1b and 1c. The lowering/rising of SP corresponds to electron/hole accumulation. The results in Fig. 1 (d) and 1(e) show the changes in charge transfer from Au and ZrN are different, which shows that the two materials have opposite effects on charge transfer.

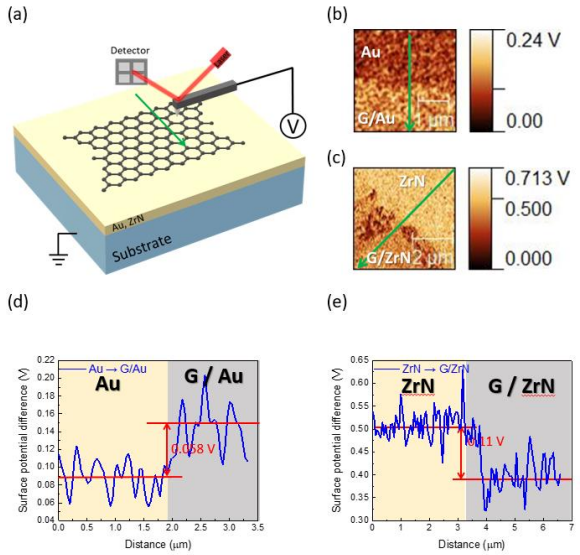

Fig. 1 (a) Schematic of KPFM scanning (b) KPFM scanning images for (b) Au and G / Au, and (c) ZrN and G / ZrN. Surface potential profiles on (d) Au and (e) ZrN.

In addition, the charge transfer phenomenon is also investigated by the ellipsometry measurement. The plasma frequency (ω_p) is proportional to the square root of electron concentration (n_e) shown as,

$$\omega_p = \sqrt{\frac{n_e e^2}{m_e \epsilon_0}}$$

where e is electron charge, m_e is electron effective mass and ϵ_0 is the permittivity of vacuum. Fig. 2 shows the dielectric function of graphene modified Au and ZrN. In the ellipsometry modeling, we added a few layers of graphene in fitting model and the results are similar as without graphene layers. The decrease in $|\varepsilon_{real}|$ after graphene transfer to the Au film indicates the decrease of ω_p, in turn shows the decrease of electron concentration (Au). In contrast, increase in $|\varepsilon_{real}|$ indicates the increase of electron concentration (ZrN) due to the graphene transfer. These finds are consistent with the KPFM studies in Fig. 1.

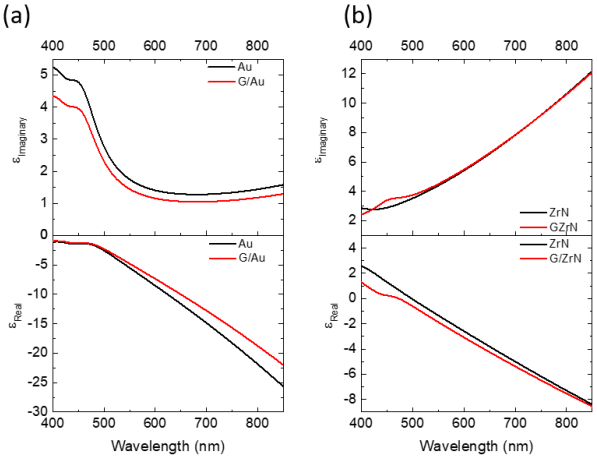

Fig. 2 Fitted ϵ_{real} and $\epsilon_{imaginary}$ of (a) Au and G / Au (b) ZrN and G /ZrN from the ellipsometry measurements.

3. Conclusions

In summary, we have investigated the charge transfer between the metals (Au and ZrN) and graphene. Our studies demonstrate that graphene transfer can result in either increase or decrease of the surface charges depending on the bottom metal.

References

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