Yuki Okigawa[1]
Takatoshi Yamada[1], Masataka Hasegawa[1], Kenji Watanabe[2], Takashi Taniguchi[2]
1. National Institute of Advanced Industrial Science and Technology, 1-1-1 Higashi, Tsukuba, Japan
2. National Institute for Materials Science
okigawa.yuki@aist.go.jp

Relationship between mobility and Raman spectra for plasma CVD graphene on HTHP *h*-BN

Extremely high mobility of exfoliated graphene on high-temperature high pressure (HTHP) *h*-BN was reported [1,2]. Although CVD graphene is expected to be an appropriate material for practical applications, the reported carrier mobility of CVD graphene is lower than that of exfoliated graphene. Improvements of the carrier mobility of CVD graphene is one of the remaining issues to utilize CVD graphene as the practical applications. It was reported in our previous study, the mobility could be suppressed by the charged impurities near the interface of graphene and the strain for graphene at the case of thermal CVD graphene on HTHP *h*-BN.

Plasma CVD is high through-put synthesis process for graphene with large-area [5,6]. Therefore, plasma CVD graphene is appropriate to utilize the practical application. In this study, we fabricated the four terminal devices of plasma CVD graphene on exfoliated HTHP *h*-BN and evaluate the relationship between field effect mobility and Raman spectra.

Single layer graphene was synthesized on the Cu foil by plasma CVD. PMMA was coated to the as-grown graphene surface on Cu foil as a support material, and Cu foil was etched using ammonium persulfate. PMMA/CVD graphene was transferred to the HTHP *h*-BN/SiO_2/Si in deionized water. Four terminal devices with back gate were fabricated using electron beam lithography. Electrical properties were measured at room temperature in vacuum (under 10^{-2} Pa) after thermal treatment at 300ºC in vacuum, and field effect mobility was calculated from transconductance (g_m) obtained by sheet resistance vs gate voltage (V_{GS}) characteristics. Raman spectra, in which wave length of laser is 488 nm, was obtained from the graphene channel on HTHP *h*-BN.

Figure 1(a) shows a typical sheet resistance depending on V_{GS} for a plasma CVD graphene on HTHP *h*-BN. The Dirac point is located near V_{GS} = 0 V. The filed effect mobility for hole and electron is 18633 and 14965 cm^2/Vs, respectively. Figure 1 (b) shows the Raman spectrum for graphene channel (sample devices as measured electrical properties). The peaks corresponding to *h*-BN (1365 cm^{-1}) and graphene (1579 and 2691 cm^{-1}) were obtained. High intensity ratios between 2D and G (I_{2D}/I_G) (~8.5) and narrow 2D FWHM (20.4 cm^{-1}) was observed. The Raman results suggest that the high quality plasma CVD graphene on HTHP *h*-BN was obtained.

Figure 2 shows relationship between calculated electron mobility and I_{2D}/I_G. Although small numbers of the charged impurities are expected from high I_{2D}/I_G, scatters in electron mobility is obtained. For thermal CVD graphene, increasing of the electron mobility was obtained with increasing of I_{2D}/I_G. Taking the results of thermal CVD graphene into account, decreasing the amount of charged impurities could not completely suppress the mobility dispersion. To understand these results in details, we are currently investigating the surface morphologies of graphene channels and strain for graphene.

This report is partially founded by the New Energy and Industrial Technology Development Organization (Grant No. P 16010). The four terminal devices were fabricated at the AIST Nano-Processing Facility, which is supported by the IBEC Innovation Platform.

References

[1] C. R. Dean et al. nature nanotechnology 5, (2010) 722.
[2] L. Wang et al. Science 342 (2013) 614.
[3] S. M. Kim et al, Nature communication, 6 (2015) 8662.
[4] Y. Okigawa et al, The 79th JSAP Autumn Meeting 2019,
[5] Y. Okigawa et al, APL, 103 (2013) 153106
[6] T. Yamada et al, Carbon, 50 (2012) 2615.
[7] D. M. Basko et al, PRB 80 (2009) 165413.

Figures

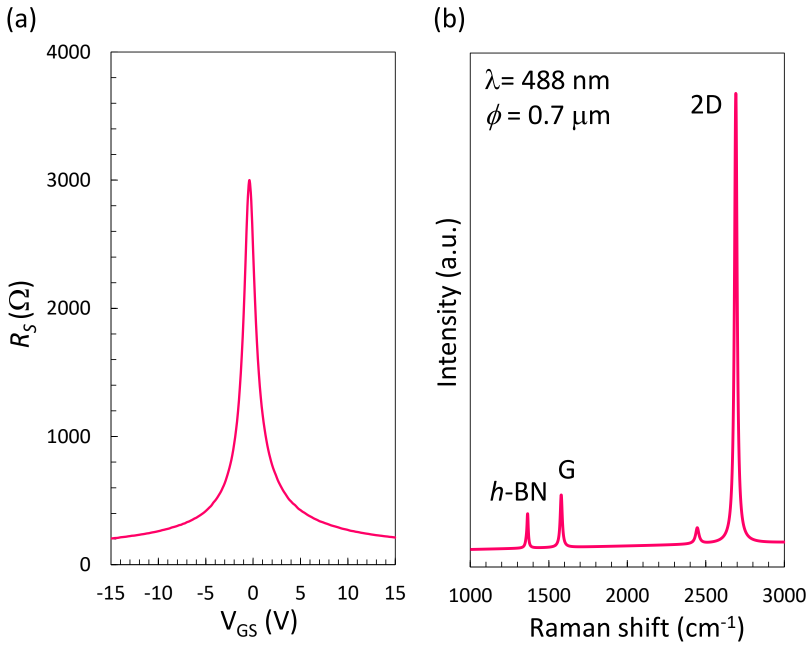

Figure 1: (a) sheet resistance vs V_{GS} characteristics, (b) Raman spectrum for graphene channel on HTHP *h*-BN.

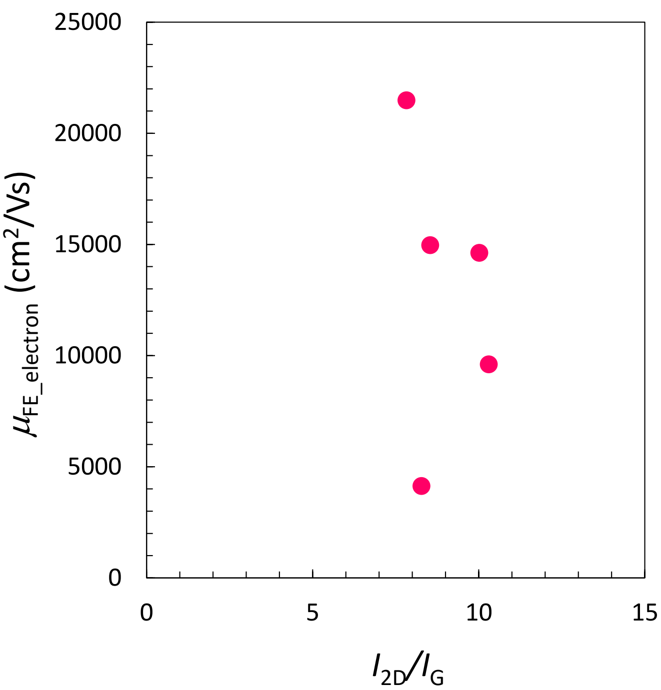

Figure 2: Relationship between filed effect mobility for electron and I_{2D} /I_G