Chemical Concentration Dependence of $MoCl_5$ Intercalation to Bilayer Graphene

○(D)Ekkaphop Ketsombun[1], (D)Xiangyu Wu[3,4], Inge Asselberghs[4], (D)Swati Achra[3,4],
Cedric Huyghebaert[4], Dennis Lin[4], Zsolt Tokei[4], and Kazuyoshi Ueno[1,2]
Shibaura Institute of Tech.[1], SIT-RCGI [2], KU Leuven[3], imec[4]
E-mail: ueno@shibaura-it.ac.jp

Introduction: Improved electrical properties of multilayer graphene (MLG) and bilayer graphene (BLG) by $MoCl_5$ intercalation have been expected for a low-resistance narrow interconnect [1, 2]. In our previous study, the temperature of $MoCl_5$ intercalation into BLG can be reduced down to 150°C by using the higher chemical concentration than previous reports, and the electrical properties was significantly improved after intercalation[2-4]. However, the nano-patterned interconnects were damaged from the intercalation process. To reduce the damage, we have reduced the chemical concentration for the low-temperature $MoCl_5$ intercalation and analyzed the doping efficiency and damage on the BLG area.

Experiment: The BLG was grown by CVD on Pt film and subsequently transferred to SiO_2/Si substrate. The sample was set in a glass capsule with high concentration ($MoCl_5$ 0.3412 g and MoO_3 0.0665 g) or 1/2 reduced chemicals. Before the intercalation reaction, the capsule was pre-annealed at 110 ºC for 120 min. The reaction temperature was varied as 150ºC and 175 ºC for 60 min. After the intercalation process, the sample was analyzed by Raman spectroscopy and optical microscope observation.

Results and Discussion: Fig. 1 shows the G-band spectra of the BLG area by Raman after the intercalation process for 60 min. At 150ºC, BLG was intercalated using the high concentration chemicals, but was not intercalated using the 1/2 reduced chemicals. With the reduced chemicals, BLG was intercalated by raising the temperature to 175ºC as shown in Fig. 1. Fig. 2 shows the comparison of intercalation uniformity in BLG between the high and reduced concentration at 150ºC, showing that the uniformity was degraded by reducing the concentration. The higher temperature or longer reaction time may be required to improve the doping performance with the reduced chemicals. Fig. 3 shows the optical images after intercalation for 60 min. Although serious damage was observed with the high concentration, the damage was suppressed with the reduced chemicals both at 150 and 175ºC. From the results, the optimized condition (reduced chemicals at 175ºC) is considered as more appropriate for doping narrow graphene interconnects.

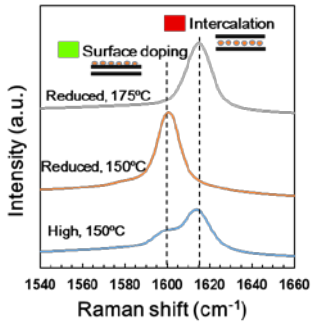

Fig. 1. G-band of BLG after intercalation.

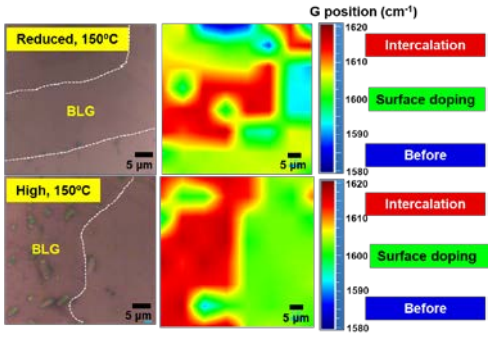

Fig. 2. Raman mapping of G peak position after intercalation.

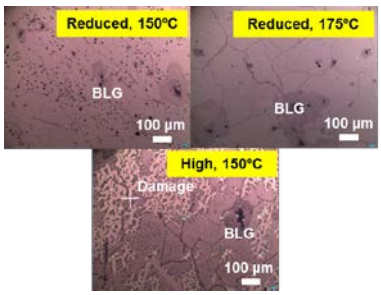

Fig. 3. Optical images after intercalation.

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