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N-type conduction of K-doped stacked graphene layers

Control of n- and p-type of graphene is one of the most important techniques to utilize graphene as electric applications. It was reported in our previous study that potassium (K)-doped bilayer graphene was fabricated by dipping in potassium hydroxide (KOH) and that K-doped bilayer graphene showed stable n-type conduction due to potassium intercalation between graphene sheets [1]. However, deposition processes of bilayer graphene are not simple and easy [2, 3].
It was reported that stacked graphene layers, obtained by repeating transfer process using CVD single layer graphene, showed high transparent conductive properties [4] and high carrier mobilities [5]. Thus, it is expected that the stacked graphene layers is one of the most appropriate structures for the graphene electronic devices. In this paper, we report about K-doped stacked graphene layers by transfer process and by dipping the sample in KOH solution [6].

Single layer CVD graphene was deposited on Cu foils by thermal CVD. PMMA was coated on as-grown graphene surface and then Cu foils were etched by $FeCl_3$ solution. PMMA/graphene was transferred onto the other single layer CVD graphene on Cu. PMMA/graphene/graphene structures were obtained by etching of Cu. Next, PMMA/graphene/graphene was dipped in KOH solution to dope with K. After rinse of samples in DI water, PMMA/graphene/graphene was transferred onto SiO_2/Si substrate. Finally, K-doped stacked graphene layers were obtained by removing PMMA in acetone. Non-doped stacked graphene layers were also fabricated as references.
The obtained K-doped stacked graphene layers were characterized by X-ray photoelectron spectroscopy (XPS) and Raman spectroscopy. FET structures were fabricated by photolithography and e-beam deposition in order to measure the electrical properties. The electrical properties were measured in vacuum at room temperature. Before measurements, thermal treatments at 300ºC was carried out to remove the residue on the graphene surface.

Typical XP spectra of K-doped and non-doped samples are shown in Fig. 1. The C1s main peaks at are confirmed for both spectra. Peaks of $K2p_{3/2}$ and $K2p_{1/2}$ at 294 and 297 eV are observed. It is considered that potassium is intercalated between graphene layers. This is similar to XPS results of K-doped bilayer graphene [1]. It was confirmed that no major difference in Raman spectra between K-doped and non-doped stacked graphene layers.

Conductivity vs gate-source voltage characteristics of K-doped and non-doped stacked graphene layers are shown in Fig. 2. Dirac points of K-doped and non-doped stacked graphene layers are -2.2 and +9.2 V, respectively. These results suggest that K-doped and non-doped stacked graphene layers are n- and p-type conduction. The obtained results are consistent with the previous reports about bilayer graphene [1]. It was reported that the CVD graphene transferred to SiO_2/Si substrate usually shows p-type conduction [7]. Therefore, electron transfer from potassium to carbon was taken place and n-type conduction was obtained.

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References

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Figures

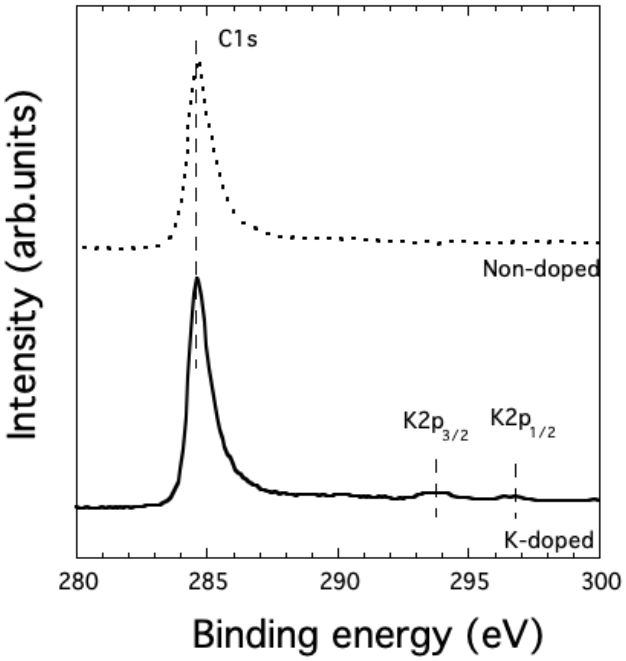

Figure 1: XP spectra of K-doped and non-doped stacked graphene layers

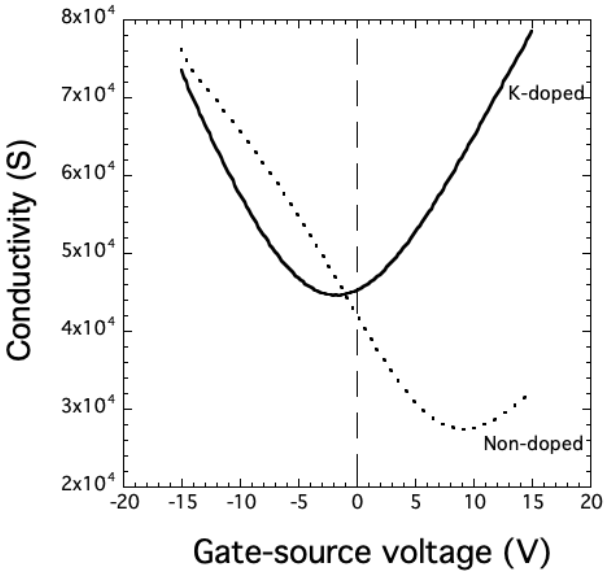

Figure 2: Conductivity vs source-gate voltage characteristics of K-doped and non-doped stacked graphene layers