Reliable transfer of large-area single crystal CVD graphene for field effect transistor

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Graphene is a prominent material for the channel of field effect transistors (FET) due to its outstanding carrier mobility [1]. Chemical vapor deposition (CVD) is a promising scalable method to obtain graphene. To achieve practical graphene FET (GFET), reliable transfer process of CVD graphene is necessary. Previous studies reported that the transfer process strongly affects carrier mobilities and Fermi level of graphene [2, 3]. In this research, the effect of substrate treatments, which is a main issue of the transfer, has been investigated. Large-size single-crystal CVD graphene and a resist-less GFET fabrication process have been used to extract the intrinsic effect.

Fig. 1(a) shows the fabrication process of GFET. Graphene was grown by CVD on copper foils. Polymethyl methacrylate (PMMA) was spin-coated as a supporting layer. The Cu was then etched by ammonium persulfate solution. The PMMA/graphene was transferred onto SiO_2 substrates. The SiO_2 substrates were cleaned by three different treatments: (i) sonication in organic solvents (acetone, ethanol, and IPA) for 5 min for each (chemical cleaning); (ii) oxygen plasma 10 min; (iii) UV/Ozone irradiation for 30 min. The PMMA was then dissolved by acetone. Finally, electrodes were deposited on the graphene by vacuum evaporation.

The geometric structure and the chemical state of the SiO_2 surface were examined by atomic force microscope (AFM), and contact angle measurement and Fourier transform infrared spectroscopy (FTIR), respectively. Raman spectroscopy was used to characterize graphene properties [4]. The carrier mobility and charge neutral point (Dirac voltage) of the graphene were obtained by electrical measurements of GFET in vacuum. Fig. 1 (b) shows the relationship between the doping level and Dirac voltage of graphene. Fig. 2 (c) reveals the relationship between the quality and mobility of graphene. It was found the samples treated by the oxygen plasma provide the highest mobility and p-doping of graphene among three treatments. Although high quality is expected to provide high mobility, Fig. 1 (c) does not show such straightforward relationship. It was also found treatment provides different chemical bonds state on the surface from FTIR measurement. Silanol groups and Organic impurity play an important role on graphene properties.

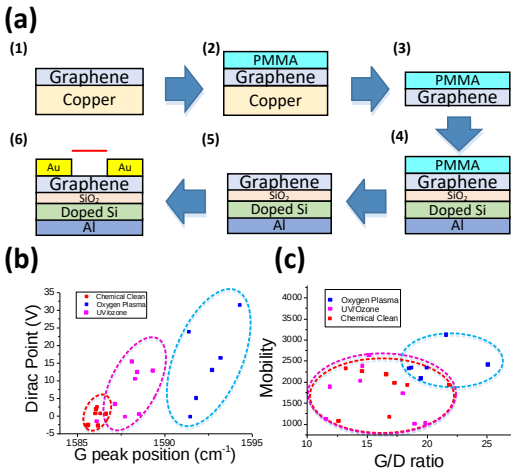

Figure 1 (a) The fabrication process of GFET. (b) The relationship between G peak position (from Raman spectra, related to doping level) and Dirac voltage (c) The relationship between G/D ratio (related to quality) and mobility.

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