Optimization of Oxygen Plasma based Etching of Single Layered Graphene through Raman and FESEM Characterization

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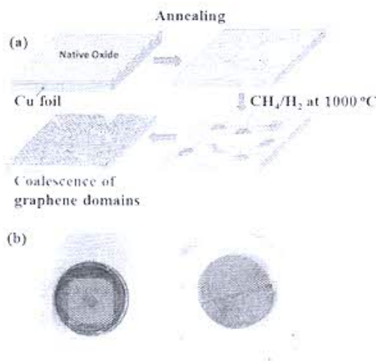
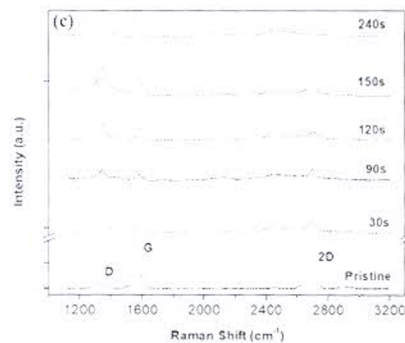
Post-synthesis patterning of single layered graphene (SLG) is essential to realize graphene based novel devices and sensors in practical applications [1]. In this paper, oxygen plasma etching experiments over as grown SLG were carried out, which confirmed the complete etching of SLG layer in 240 s. SLG was grown over copper (Cu) foil by chemical vapor deposition (CVD) technique using methane (CH_4) as precursor gas and hydrogen (H_2) as carrier gas in a furnace heated to 1000 °C as shown in Fig. 1 (a). To transfer SLG on SiO_2/Si substrate, PMMA was spin coated over the Cu-SLG film at 4000 rpm for 60 s, followed by etching of underlying Cu layer by dissolving it into $FeCl_3$ solution. The SiO_2/Si wafer was used to fish out the free flowing PMMA coated SLG from the $FeCl_3$ solution, followed by thorough washing with DI water and ethanol. Acetone was used to remove the PMMA completely from the top; resulting in transferred SLG over SiO_2 surface as shown in Fig. 1 (b). Etching experiments of SLG were carried out using oxygen plasma for 30 s, 90 s, 120 s, 150 s, and 240 s at 200 W RF (13.56 MHz) power, 0.8 torr pressure, and with 2-3 sccm oxygen flow. Raman spectra at different etching times confirm that the 2D peak almost disappear after 240 s of etching as depicted in Fig 1(c).





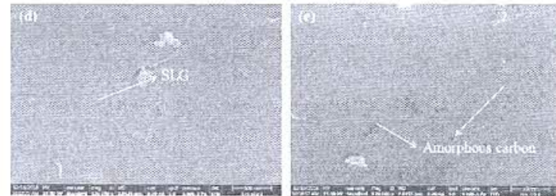


Figure 1. (a) Schematic diagram of SLG synthesis over Cu foil, (b) its transfer over SiO_2/Si wafer, (c) continuous increase in I_D/I_G ratio with etching time and finally disappearance of 2D peak after 240 s etching confirm complete etching of SLG, and FESEM images (d) before and (e) after 240 s plasma etching.

In addition, I_D/I_G ratio increases from 0.17 (pristine) to 1.33 (150 s) with etching time, which indicates the breaking of the C-C bonds and finally leaving only amorphous carbon with residual C=C bond peaks in Raman spectra. FESEM in Fig. 1(d), shows images of pristine graphene (before etch) and (e) is after 240 s of plasma etching, which shows complete etching.

References

[1] M.C. Prado, D. Jariwala, T.J. Marks, and M.C. Hersam, Appl. Phys. Lett. 102, 1 (2013).

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