Novel one-step method for the delamination of epitaxial graphene on SiC

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Integration of high quality graphene materials as elements of basic electronic components, such as transistors, antennas, etc., relies on competitive, efficient, scalable and sustainable processing technologies. From an industrial viewpoint, the lack of robust device fabrication processes explains why graphene adoption is limited and development of marketable graphene applications is still immature. A paradigmatic bottleneck is the application of transfer methods.

We present the successful exfoliation of epitaxial graphene (EG) on SiC by the electrochemical delamination method [1], which relies on the force exerted by gas bubbles generated at the graphene-substrate interface. For the first time, EG has been detached from SiC substrate as a cheap, one-step process (Fig. 1), instead of the use of either an expensive stressor layer or an intermediate hydrogenation step [2].

We have applied H_2 bubbling to EG grown on the Si face of off-axis cut 4H-SiC. A key aspect has been the use of highly doped SiC substrates to allow enough current flow at reasonable potentials. Typical voltages for effective EG delamination are 10-13 V. Graphene release can be attained in just few seconds (Fig.1).

An exemplary SEM image and Raman spectrum of single layer EG transferred to SiO_2 substrate is displayed in Figure 2. The preliminary results of electronic testing of transferred large-size single-layer EG also support this new technology.

Summarizing, we have demonstrated that electrochemical cell bubbling can be applied to transfer EG on SiC. Similarly to its use on CVD graphene, the advantages of this process include reduction of time and energy costs, as well as of environmental impact, for it is based on 1) a faster method, 2) cheaper and simpler processing, 3) less amount and hazardousness of generated chemical waste, and 4) potential re-use of substrate material. As the bubbling methodology is scalable, it could be applied to large samples. Additionally, applied to EG, graphene transfer is made compatible with CMOS technology.

References

[1] C.J.L, De La Rosa *et al.*, Appl. Phys. Lett, 102 (2013) 022101
[2] S. Gorantla *et al.*, Nanoscale, 6 (2014) 889

Figures

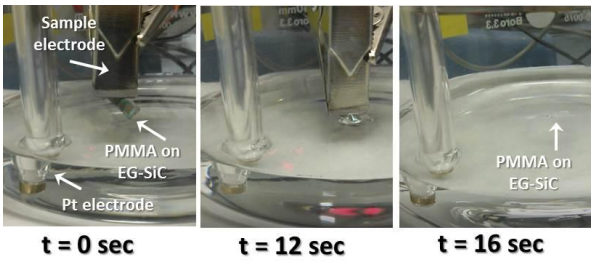

Figure 1: Setup & sequence of electrochemical delamination of EG in NaOH aqueous solution.

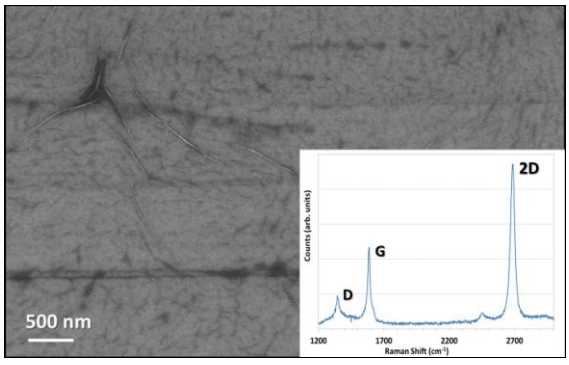

Figure 2: SEM micrograph of EG-SiC transferred to SiO_2. Inset is a Raman spectrum of the same, which corresponds to a monolayer graphene flake (FWHM ~ 37cm^{-1}).