Non-Catalytic Growth of Nanographene Films on Silicon Oxide at Low Temperature

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Abstract: Large area high quality, polycrystalline graphene and graphene single crystals can be grown by chemical vapor deposition (CVD) on metals with promising results for many applications.[1,2] At present, this process is expensive owing to large energy consumption at the typical synthesis temperature around 1000ºC and because underlying metal has to be removed. In this scenario, the game changing breakthrough would be the development of processes to rapidly deposit high quality graphene layers on arbitrary substrates, at low temperature.[3]

In this work we have faced this production challenge and we present the synthesis and systematic study on nanographene based films directly grown on silicon oxide by using remote-ECR Plasma Assisted CVD at low temperature (~550ºC).[4] These films have been grown from different carbon sources (C_2H_2, CH_4) and carrier gases (H_2, Ar). Optical Emission Spectroscopy (OES) allows us to inquire into the differences in the composition of the generated plasmas and then to elucidate the main precursor species that contribute to the film growth in each case. The fabrication process is rapid and performed in large area (2 inch) dielectric substrates. TEM and electron diffraction analysis show the formation of layered nanographene material. Raman Spectroscopy and AFM reveal that the film consists of nanocrystals with a domain size between 2-10 nm depending on the synthesis conditions (**figure 1**), usually interconnected by amorphous material. Functional optoelectric characterization of these films confirms the high transparency over 95% and relative high conductivity around 5 kΩ without doping (**figure 2**), exceeding the properties of non-doped nanographene films grown at low temperatures reported by far.[5] This method avoids damaging and expensive transfer processes of nanographene films and improves compatibility with current fabrication technologies. Moreover, tailored graphene based structures and graphene flakes with nanometer-size can be synthesized by this method that open the way for graphene chemistry and functionalization with straight application in several fields.[6] Even carbon and graphene nanodots under 10 nm size have recently attracted wide attention because of their strong photoluminescence.[7] These tiny dots could be attractive candidates for bioimaging and biosensors.

References

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Figure 1. a) AFM image of nanographene film grown from C_2H_2 before full coverage of the substrate. b) Raman spectrum of the film with full coverage.

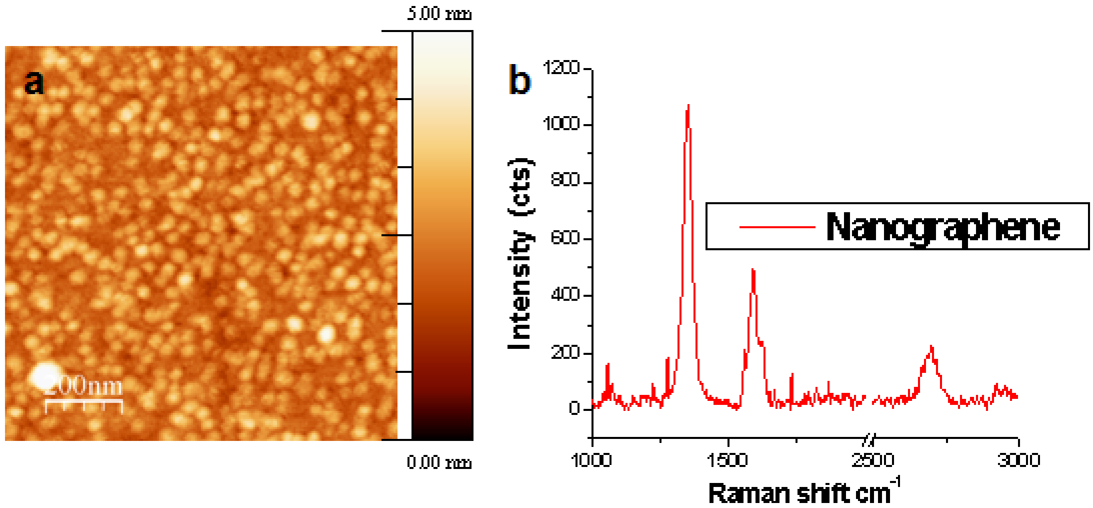

Figure 2. a) Optical transmittance of nanographene films grown from CH_4 (for different deposition times and post annealing treatments). The inset compares the transmittance of the films at 550 nm. b) Sheet resistance of the films.