Measurement of reduced graphene oxide conductivity using Electrostatic Force Microscopy

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In the route of transferring the extraordinary properties of graphene to real applications one of the most promising means for obtaining graphene in large amounts is the oxidation-reduction process of graphite [1]. The main advantages of this procedure lie in its scalability, cost effective and the high yield of monolayers obtained via this route. Deoxygenation of the initially insulating Graphene Oxide (GO) sheets leads to a partial recovery of the original conductivity of graphene[2]. Due to the different starting materials and procedures used in the preparation of Reduced Graphene Oxide (RGO) layers a large dispersion of conductivity can be found in literature[3]. The standard process to characterize the conductivity of micrometer sized films usually involves tedious lithography procedures that impede a quick estimation making highly desirable to develop a fast and non invasive method for characterizing the conductivity of single layers.

In this work we report experimental results showing that Electrostatic Force Microscopy (EFM) can be used as a contactless method to accurately distinguish between monolayered RGO sheets with different conductivities in the range of 0-3 S/m on an insulating substrate. Comparing EFM and conventional conductivity measurements we find that the electrostatic interaction between RGO sheets and a metalized AFM tip is strongly dependent on the conductivity of the layers. Using the reported method, it is possible to evaluate the conductivity of RG0 sheets in less than 1 hour, without the need of electrical contacts.

We also report theoretical modeling of the EFM signal[4] in our experimental set-up which allows us determining ε_{eff} of the RGO layers from the experimental data. This effective permittivity is found to span from 5, for the oxidized (insulating) case to 2000 for the more conductive layers.

We will also discuss how the sensitivity of EFM to high conductivities is due to the combination of the extreme thinness and high conductivity with low density of charge carriers of RGO layers.

References

[1] Stankovich, S. et al., Journal Of Materials Chemistry, **16** (2006) 155.

[2] Gomez-Navarro, C. et al., Nano Letters, **7** (2007) 3499.

[3] Dai, B. et al., Nano Research, **4** (2011) 434.

[4] Sacha, G. M.,et al., Journal of Applied Physics, **101** (2007) 024310.

Figures

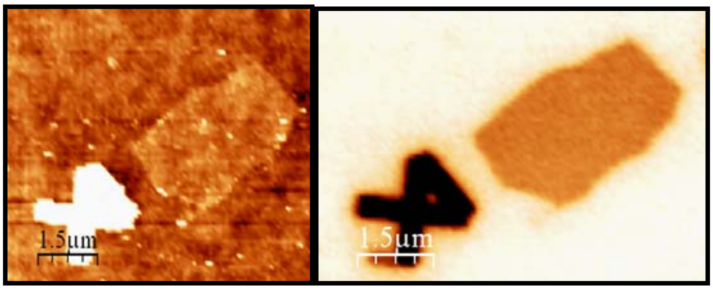

Figure caption: AFM topographic image and electrostatic force image of a region comprising a gold marker (feature on the down-left corner), a reduced graphene oxide layer and a SiO_2/Si substrate.