A New Strategy to Decouple Epitaxial Graphene from Metals: Potential-Controlled Electrochemical-Oxidation

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The catalytic role of the metallic substrates has been the perfect starting point to grow high quality graphene layers by thermal decomposition of aromatics [1]. However, metallic substrates quench the graphene's outstanding properties that make graphene the most promising material for future applications. Thus, protocols to transfer graphene to different technologically relevant substrates are mandatory. These transfer processes are cost inefficient and some can severely degrade the properties of graphene by introducing structural and chemical defects. As an alternative, we propose a novel approach that is less invasive and easily scalable. We target pristine graphene sheets grown on metals and employ electrochemical oxidation at controlled potentials to introduce a single atom-thick oxide decoupling layer. A multi-technique structural characterization (STM, AFM and Raman) combined with theoretical studies (ab-initio calculations) of the different steps of the process has been carried out to fully understand this decoupling.

Epitaxial graphene has been grown on Pt(111) in UHV by thermal decomposition of aromatics. Fig. 1a shows a representative STM image of a typical Moiré as well as the typical LEED pattern obtained for Gr on Pt(111) [2]. After in-situ characterization the sample was removed from UHV and characterized by AFM, SEM and Raman spectroscopy before and after electrochemical treatments. Fig. 1b shows important changes in the Raman spectra of the graphene layer induced by the electrochemical treatment. The AFM overall topography shows that about 90% of the surface is decoupled, and ab-initio calculations clearly show that intercalation of a single atom-thick oxide layer can induce a structural separation of the graphene with respect to the surface. These results suggest that carefully controlled electrochemical oxidation can provide an alternative and cleaner method to the transfer of graphene.

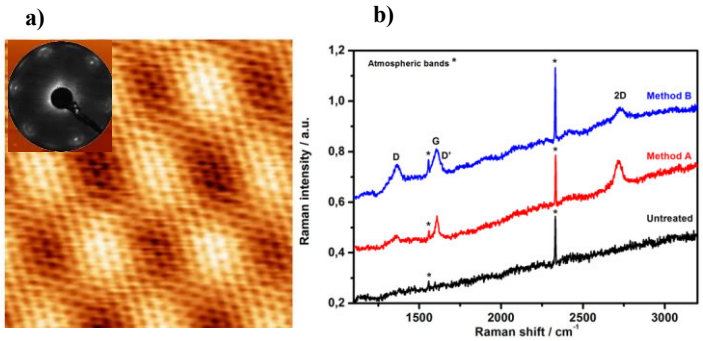

Figure 1: a) STM image of Gr/Pt(111) showing a characteristic Moiré ((4x4)nm^2, I=4nA, V=10mV). The inset shows the LEED pattern. b) Raman spectra of graphene epitaxially grown on Pt(111) before treatment (lower spectrum), and after two different electrochemical treatments (method A: less aggressive, method B: more aggressive).

References

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[2] Merino, P. et al., ACS Nano 5, (2011) 5627.