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DEVELOPING LOW-COST GRAPHENE DEVICES

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In spite of numerous efforts for developing the applications of graphene, it remains difficult to put the remarkable physical properties of this material into devices. This is mainly due to the fact that large-area (industrial) graphene includes in its structure and on its surfaces a significant density of defects that make as many traps and scattering centres for charge carriers. The idea of the present work, contrary to diminishing the defect density, is to **use the defects** and the very large surface to volume ratio of that 2D material, to transform it into high sensitivity sensors.

When defects are useful, low-temperature growth becomes the method that best satisfies both physical and financial demands. Here, we further decrease preparation costs by performing growth not only at low temperature directly on the final insulating substrate (glass), but also by printing the device contacts by ink-jet printing. Graphene layers actually develop at the interface between a metallic catalytic film and the insulating substrate during plasma-enhanced chemical vapour deposition (PE-CVD).[1,2]

Resistivity of the graphene foils was measured by the four-point methods using ink-jet printed electrods, and a resistivity as low as 820 ohms/sq were obtained. Moreover, the sensitivity of such graphene foils to water vapour was evaluated, with the prospect to use them in humidity sensors for civil engineering.

In this presentation, we explain how graphite may precipitate at the interface in addition to the surface.[2,3] Then we show examples of graphene obtained at temperatures in between 450 and 550°C, on glass (Fig.), fused silica, alumina and SiO_2//Si. Transmission electron microscopy indicates that the structure is nanocrystalline. We finally show the humidity response of the fabricated device. Results seem to indicate that high-defect density, thin deposits are more sensitive to water vapour than thicker ones. .

References

[1] L. Baraton, C. S. Cojocaru, D. Pribat, "Process for controlled growth of graphene films", French Patent 0805769- 2008.
[2] C. S. Lee, L. Baraton, Z. He, J.-L. Maurice, M. Chaigneau, D. Pribat and C. S. Cojocaru, *SPIE proceedings*, 7761 (2010), 77610P.
[3] L. Baraton, Z. B. He, C. S. Lee, C. S. Cojocaru, M. Châtelet, J. L. Maurice, Y. H. Lee, D. Pribat, EPL (Europhys. Lett.) 2011, 96, 46003.

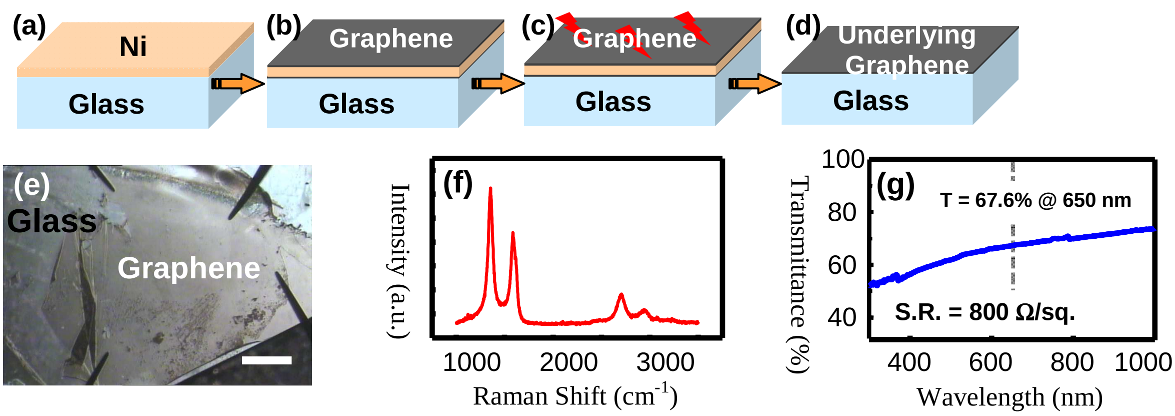

Figure: Example of graphene-on-glass obtained by PE-CVD. Top: process for obtaining graphene directly on the insulating substrate. (a) Deposition of Ni film by evaporation; (b) PECVD: graphene layers develop at the surface of the Ni film, and at the interface with the insulating substrate. (c) To uncover interfacial graphene, top layer graphene is first etched off *in situ* by strong water vapour plasma; Ni is then etched using standard wet process, leaving graphene laying directly on a functional substrate (d, e). Bottom: graphene-on-glass obtained after 12-mn PE-CVD at 450 °C. (e) Optical image (scale bar is 0.1 mm) after removal of the nickel film and top-surface graphene, the electrical probes are visible; (f) typical Raman spectrum; (g) transmittance. The resistance per square measured on patterned device is 800 Ω.

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