8-inch Wafer-Scale Synthesis and Tailoring of Graphene by Extension of the Segregation Methods to Metals of Low Carbon Solubility

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Recent advances in graphene synthesis have taken graphene from the table-lab experiments and upstream devices prototyping towards larger scale synthesis. Among these considerable efforts to extend the size of graphene, the chemical vapor deposition (CVD) approach showed the best scalability and transferability and stimulated various prototype applications[1]. In most cases, graphene growth is based on the exposure of carbon species to a heated metal surface that catalyses the carbon species to form, depending on their solubility and diffusivity, mono to few layers of graphene. Up to now, the number of graphene layers was closely dependent on the carbon solubility in the metal. In this work we present very original results in graphene synthesis using solid sources of carbon and metal catalysts (with both high (Nickel) and low (Platinum) carbon solubility). Only a few minutes of processing were required to obtain highly homogeneous graphene fully covering 8 inch. wafers. Using a solid carbon source, a reliable and facile route for growing graphene in an industrial fashion has been demonstrated[2], so-called segregation method.

First, by using Ni thin film as a metal, we have synthesized via the segregation method large area graphene fully covering 8-inch wafers (> 98% coverage). A control from mono to multi-layers graphene has been achieved (Fig. 1). The technique is not limited by the size and it can be easily scaled up to 12-inch wafers or more. The graphene obtained has a high transmittance (92%) and a good conductivity (~600Ω/□). It is thus a good candidate for the ITO replacement in solar cells or any device with a transparent conductive electrode.

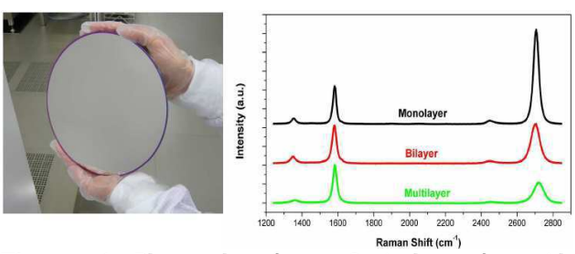

Figure. 1 Photograh of an 8 inch wafer with graphene/Pt/SiO_2/Si stack and Raman spectra of the synthesized graphene.

Second, we have shown for the first time that graphene could be successfully synthesized by segregation method on large wafer scale onto polycrystalline platinum thin film, thus extending this technique to the metals with very low carbon solubility. The formation of graphene is predominately occurring via carbon diffusion through the grain boundaries of the polycrystalline metallic thin film. These boundaries play the role of channels for the diffusion of the carbon species (even when carbon dissolution in the metal is negligible). The proposed mechanism for graphene synthesis would not be restricted only to the platinum metal; it opens a new room for graphene growth using embedded solid carbon sources for a much larger catalogue of metals than initially expected. In addition, we have shown that the shape of graphene could be tailored by appropriate selection of the solid carbon-based source[3] (Fig. 2). Indeed, the silicides, when their formation is favored, are thermodynamically less stable than the metal itself, which lead to surface nanostructuring (by metallic clusters formation) and consequently to graphene suspension. This technique can, therefore, pave the way to new perspectives for the graphene synthesis and the tailoring of its shape on large wafer scale, opening the opportunity for real-life applications.

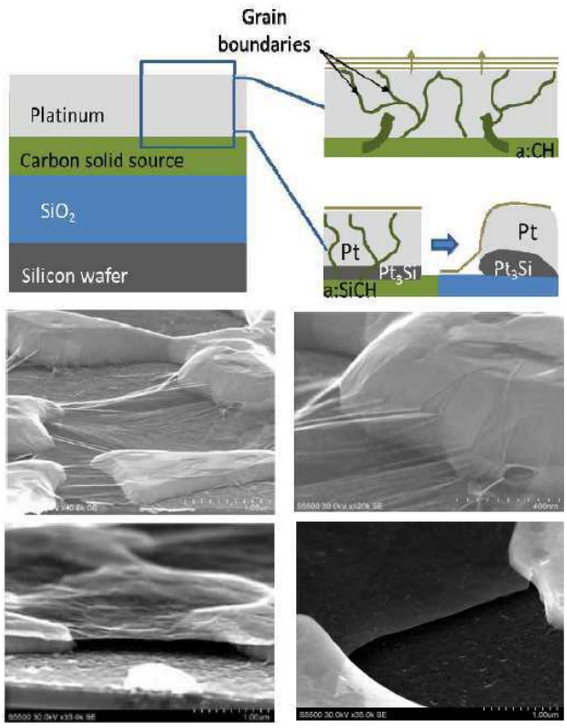

Figure 2. Schematics of the dewetting process and scanning electron microscopy images of platinum silicide clusters fully covered and interconnected by suspended transparent multilayer graphene.

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