ELASTIC PROPERTIES OF GRAPHENE SUSPENDED ON A POLYMER SUBSTRATE

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Graphene, a recently isolated [1] one-atom-thick crystal of carbon atoms arranged in a honeycomb lattice, has attracted great interest during the past few years due to its remarkable electronic [2] and mechanical [3] properties. The unique combination of very high carrier mobility [4], high intrinsic strength [3], and very low mass of suspended graphene sheets make graphene ideal as a main building block of advanced nanoelectromechanical systems [5]. Previously proposed methods for fabrication of suspended graphene structures on non-patterned substrates involved the selective suspension of graphene sheets through a chemical etching by buffered hydrofluoric acid [6]. However, wet etching is an isotropic process and the shape of the underetched area cannot be controlled. In addition, the surface tension associated with this process leads to the collapse of suspended sheets if the samples have not been critical-point dried [4,6]. Here we report on an alternative method for fabricating multiple free-standing structures on the same sheet of graphene. Micromechanically exfoliated mono and bilayer graphene sheets were sandwiched between two layers of polymethyl-methacrylate, in which suspended areas were defined by e-beam lithography (Fig.1). The method does not require critical-point drying and provides full control over the shape and position of the suspended areas. Mechanical characterization of suspended graphene sheets was performed by nanoindentation with an atomic force microscopy tip (Fig.2). The obtained built-in tension of 12 nN is significantly lower compared to suspended graphene exfoliated on a SiO_2 substrate [7], allowing access to the intrinsic properties of suspended graphene. Fabricated devices exhibit high stiffness and tensile strength as evidenced from the large elastic modulus of 0.4 TPa, which is in agreement with the values previously reported for graphene [3,8].

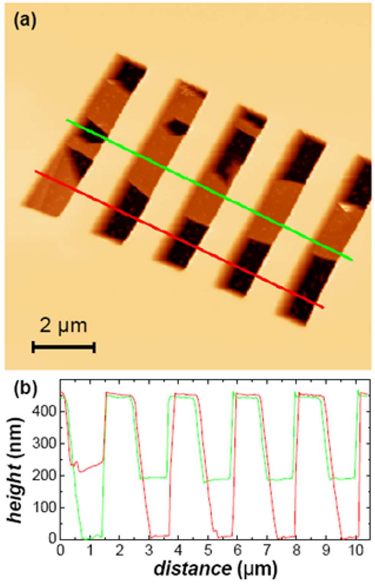

Figure 1: A graphene sheet suspended over 5 PMMA windows. (a) AFM image of the device. (b) Height profiles of the device along green and red sections in (a). The thicknesses of the bottom and top layers are 200 and 250 nm.

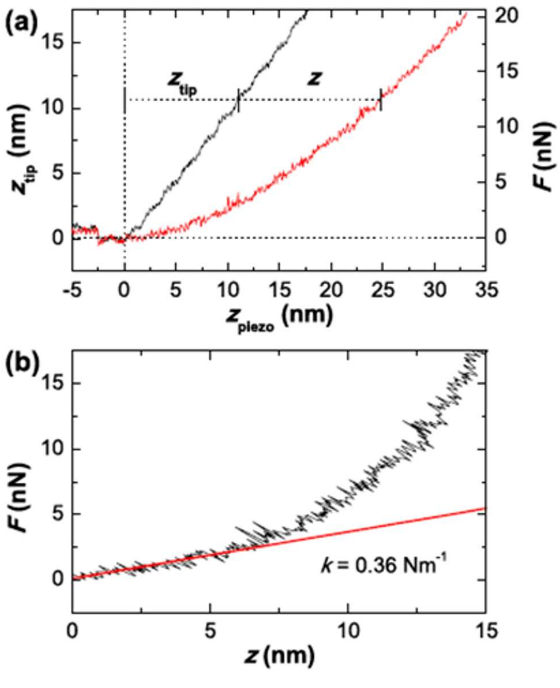

Figure 2: The force-distance curves measured by the nanointentation method. (a) A curve measured on a hard substrate (black) and suspended graphene sheet (red). The difference in z_{piezo} of the curves at a fixed force F is equal to the displacement z of the sheet. (b) Force exerted on the sheet as a function of the displacement of the sheet. The elastic constant k of the sheet is calculated as the slope of the force-displacement curve in the linear regime.

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