Wetting properties of partially suspended graphene monolayers

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Recently, the wetting properties of supported graphene monolayers has attracted a lot of attention due to the possible applications of graphene as a coating material A fundamental and yet unresolved issue is how the one-atom thick graphene layer influences the wettability of the underlying substrate by screening the liquid-substrate chemical, van der Waals and electrostatic interactions. Rather contradictory results have been reported, suggestive of either the wetting transparency [1] (no effect of graphene on the contact angle) or translucency [2, 3] of graphene (nearly constant contact angle on graphene, irrespective of the underlying substrate). A factor contributing to these controversial results is the adsorption of airborne contaminants that significantly alter the wetting properties of graphene [4].

Here, we present an experimental study of the wetting properties of partially suspended graphene monolayers obtained by transferring graphene monolayers on recently developed nanostructured substrates. These surfaces, textured at the 50nm length scale, can be fabricated in a large range of morphologies including cones, cylindrical pillars, grooves and pits [5]. By transferring graphene on these substrates, we were able to gradually adjust the surface fraction of suspended graphene from a nearly free-standing graphene layer (on sharp cones the estimated graphene-substrate contact is estimated of the order of 5 %) to a fully supported one (on flat silica substrate) and thus assess quantitatively the role of the underlying substrate on the wettability of graphene. We used a new graphene transfer method that obviates the irreversible contamination associated to polymer-assisted transfer. We demonstrate that this technique can be used successfully to deposit graphene monolayers large enough to perform macroscopic contact angle measurements on both (super)-hydrophilic and (super)-hydrophobic substrates. The samples were annealed at high temperature in reductive atmosphere to remove traces of ambient hydrocarbons. Water contact angle measurements were carried out on hydrophobic textures, where the droplet lies partially suspended on air, and on hydrophilic textures, where water was found to wick the texture resulting in graphene supported by both silicon and water. This experiment therefore allows to study the influence of the underlying substrate by allowing to change it gradually from air to silicon dioxide and water. Over this large range of experimental conditions, our results show a limited (< 30°) dependence of the contact angle on the chemical nature of the underlying substrate, suggesting a translucent behavior of graphene.

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