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Graphene transparency to underlying surface potential studied by KPFM

During the last decade, an increasing number of papers indicated that 2D materials are transparent to intermolecular interactions [1,2,3]. This phenomenon leads to the fact that electronic properties of underlying surface can penetrate through 2D materials, and was demonstrated by e.g. substrate-governed epitaxial growth on top of a 2D material interfacial layer [2,3].

The strength of electric fields penetrating through the interfacial layer is given by the material combination and number of layers. As a consequence, for example, homoepitaxial growth of LiF on top of graphene interfacial layer is possible with up to 3 ML graphene, whereas GaAs homoepitaxial growth was possible with only 1 ML interfacial graphene [3]. On the other hand, if hexagonal boron nitride is used as an interfacial layer, the possibilities of substrate-governed epitaxial growth are significantly reduced, since it screens the electric fields better than graphene [3].

The transparency to interactions may also bring significant advantage to applications, where special and unstable surface properties are required. Graphene can protect the substrate from degradation while keeping the surface properties given by the substrate [4]. Additionally, being impenetrable to even small ions, this property offers exciting possibilities in designing membranes [1].

In this study, the transparency of graphene to substrate electric fields was visualized and quantified by KPFM (Kelvin Probe Force Microscopy). KPFM is an AFM-based technique for surface electrical characterization that can be used to probe local surface potentials with standard lateral resolution well under 100 nm.

Graphene flakes with 1-3 ML were grown on a Cu foil by CVD. During cooling, a faceted surface was formed under graphene which has been explained by energy minimization principles? [5]. KPFM imaging revealed that different surface facets exhibit different potentials, in agreement with assumptions based on distinct surface energies of these facets. In case of 2 ML graphene, the potential difference between facets sensed by KPFM was reduced by approx. 58 % with respect to 1 ML graphene. The results were also compared with those for CVD graphene grown on Pt. It has shown similar potential difference changes above graphene with the number of layers, pointing to the reproducibility and universality of KPFM-based quantification.

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