Holographic imaging of adsorbates on graphene by point projection microscopy and theoretical reconstructions

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Two-dimensional materials such as graphene have been studied intensely recently, because of their promising application in electronics, catalysis and biosensing. Adsorbates on graphene affect the properties of the graphene, but their mass-thickness contrast and diffraction contrast are extremely weak in TEM with the operation voltage of 100 kV or higher. Therefore, we built a low-energy electron point projection microscopy (PPM). The setup of our PPM is shown in Fig. 1, which consists of a single-atom tip (SAT), a suspended graphene sample, and a retractable screen. The sample is illuminated by the electron beam emitted from the SAT, and the electron hologram is projected on the screen. The operation voltage of PPM varies from 20 to 500 V. The much lower operation voltage makes PPM much more sensitive to adsorbates on the 2D materials. In addition, radiation damage can be significantly reduced. These advantages make PPM a suitable tool to investigate adsorbates on graphene [1].

In this work, we used PPM to investigate adsorbates on suspended graphene. In the first part, the dynamics of adsorbates were recorded in time sequences of electron holograms. The evolution of the structures was later reconstructed by a method of conventional digital holography. In one sequence, the adsorbates aggregated over time, and became thicker under the illumination over a duration of one hour. In another sequence, the movement of an adsorbate of 3 nm was recorded. The ideal resolution of the holograms, which is defined by the numerical aperture, should be 3~4 Å. Practically, the resolution was apparently reduced to only few nm because of a well-known twin-image problem. In the second part, another reconstruction method based on transport intensity equation (TIE) is tested by the simulation to solve the twin-image problem. The TIE method can reconstruct the phase on the screen plane by using two or more holograms recorded at slightly different sample-screen distances [2]. The exit wave in the sample plane can then be computed by Fresnel backward propagation. In our simulation, the resolution of the images reconstructed by the TIE method is significantly improved. It demonstrates the possibility to eliminate the twin-image problem by recording holograms at different screen positions.

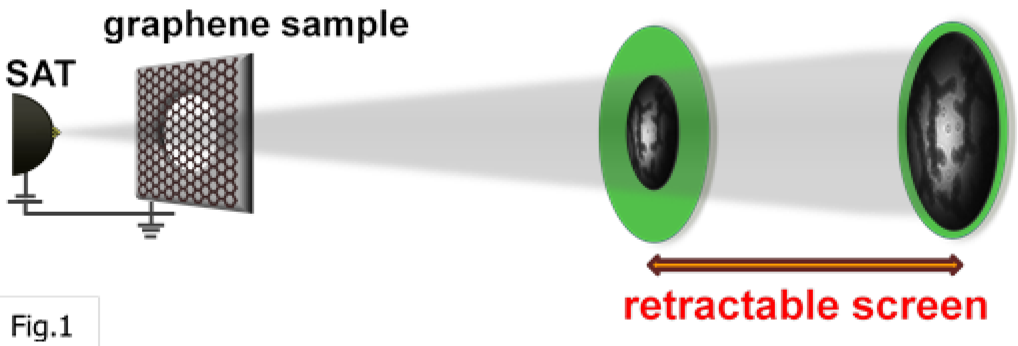

Fig.1

References:

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