How flat can graphene be?

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Graphene is known to display roughness as a result of conforming to surface – e.g. silicon dioxide (SiO_2), and intrinsic roughness in the absence of a substrate [1]. Roughness is a suspected key source of scattering and a limiter of the carrier mobility in clean graphene samples [2]. Suspending graphene flakes has proven to increase the electron mobility drastically compared to graphene supported on SiO_2 [3], as adverse effects on the mobility from the SiO_2 are eliminated. Similar improvements in mobility are obtained by encapsulating the graphene in hexagonal boron nitride (hBN) [4]. In this study we have fabricated graphene samples encapsulated by hBN that are suspended over apertures in a substrate and used electron diffraction in a transmission electron microscope to measure the roughness [5] (Fig. 1). For this sample type we find a strong suppression in the measured RMS roughness down to 12 pm. We furthermore compare the roughness of these samples to suspended bare graphene and graphene on suspended hBN, and find the roughness of graphene on suspended hBN to be < 25 pm; similar to that measured for previous work for graphene on mica, and less than that typically observed for graphene on hBN supported by SiO_2 [4]. Our first-principles calculations of the phonon bands in graphene/hBN heterostructures show that the flexural acoustic phonon mode is localized predominantly in the hBN layers upon hBN encapsulation. These results may lead to new fabrication strategies for obtaining high electron mobility graphene devices.

References

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Figures

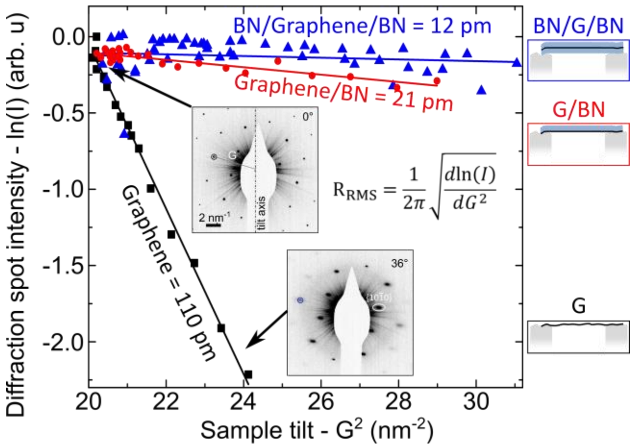

Figure 1: The intensity of {10-10} diffraction spots [ln(I)] as a function of the square of the distance from the diffraction spot to the center of the diffraction pattern [G^2]. Insets show diffraction patterns for suspended graphene at zero tilt and large tilt and schematics of the different sample types.