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Simplified Estimation of Crystallographic Orientation of Strained Graphene by Micro-Raman Spectroscopy

Strain engineering is a promising but unexplored method of modulating electron transport in graphene. Graphene has a peculiar property that lattice strain produces an effective vector potential exerted only on electrons in graphene[1]. The resulting spatially varying pseudo magnetic field can be used, for example, to induce a transport gap in graphene.[2] Here, it is noted that the magnitude of the pseudo magnetic field strongly depends on the crystallographic orientation of the strain. Thus, for the further understanding of the strain related phenomena, determination of the crystallographic orientation of strain is indispensable.

So far, the crystallographic orientation of strain has been estimated by using the polarized Raman spectroscopy.[3] Under uniaxial strain, the Raman G band splits into two sub-bands (G+ and G-), which have different polarization dependence. The polarization dependence of the G+ (G-) amplitude together with the orientation of the polarizer gives the crystallographic orientation of strain. However, it is usually not easy to accurately determine the orientation of the polarizer in a commercial micro-Raman spectroscopy system, the error of which directly causes the error of the strain orientation. Here, we propose a simpler method by which one can determine the strain orientation without determining the polarizer orientation independently.

Our method of estimating the strain orientation is based on a recent theory telling that by uniaxial strain the Raman 2D band splits into three sub-bands with different polarization dependence[4]. From the comparison of the polarization dependence of G and 2D bands, one can derive the strain orientation. An example is shown in Fig. 1. Here, we induced uniaxial strain in exfoliated graphene by placing parallel resist bars between graphene and the substrate. Due to small strain, neither G nor 2D band splits, but the peak frequency of each band exhibits periodic modulation as a function of the rotation angle of the sample, θ_r, from which we estimated the strain orientation with respect to the zigzag direction to be 37.4 degree.

References

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Figures

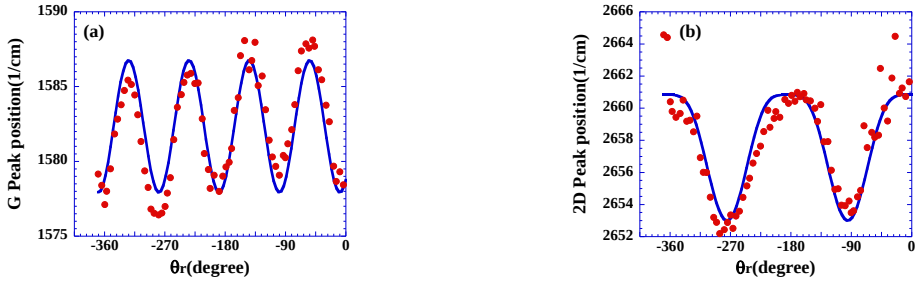

Figure 1: Peak positions of (a) G and (b) 2D bands as a function of the rotation angle of the sample. The lines are results of fitting to theory.