Loading direction dependence of graphene thickness measured using atomic force microscope

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Abstract

After discovery of graphene using micromechanical cleavage technique[1], extremely many researches have been carried out so far due to its outstanding material characteristics such as electrical[2,3], mechanical[4,5] properties and so on. However, thickness of monolayer graphene, i.e. distance between surfaces of monolayer grapheme and substrate, has been experimentally determined in a wide range of 0.3 nm to 1.5 nm using scanning tunneling microscope (STM) or atomic force microscope (AFM) with atomic-scale resolution while it is theoretically predicted as 0.34 nm. Identification of exact thickness of monolayer grapheme is very important issue for application of grapheme to nano-devices whose performance strongly depends on dimensions of constituent materials, however, it has been rarely performed so far. We investigated AFM topographic images of graphene, of which thickness was determined by AFM tapping and contact mode. Thickness of graphene was observed as almost constant using AFM tapping mode, however, that identified using AFM contact mode showed strong dependence on sample rotation angle with certain periodicity. From analysis of torsion images and topographies, we suggest that the variation originates from effect of intrinsic ripple of graphene.

References

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Figures

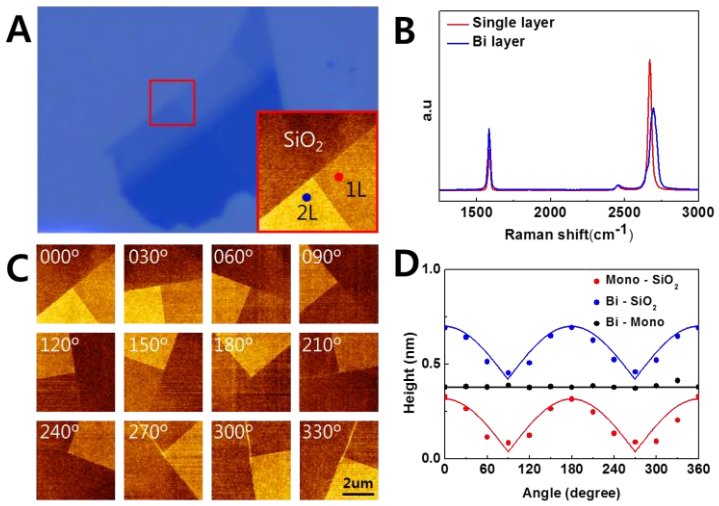

Figure 1. (A) optical image of graphene smaple.(inset : AFM image in red square sector), (B) (A) raman spectra of each red and blue spot on opical image. (C) \AFM image altered variously through loading direction in red square sector.(0degree to 330degree respectively 30 degree step), (D) Height graph of sample altered through loading direction.(red sircle : monolayer graphene height, blue sircle : bilayer graphene height, black sircle : differnece between bilayer and monolayer graphene)