Advances in Characterization of Graphene-related Nanomaterials Using Atomic Force Microscopy

By
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Host: Prof. Shen Ze Xiang

Abstract
Current state of atomic force microscopy (AFM) imaging of graphene and its derivatives will be reviewed. The emphasis will be made on exploring their exotic electric properties. For example, potential applications of graphene as ultrathin transistors, sensors and other nanoelectronic devices require them supported on an insulating substrate. Therefore, a quantitative understanding of charge exchange at the interface and spatial distribution of the charge carriers is critical for the device design. Here, we demonstrate that AFM-based technique Kelvin force microscopy (KFM) can be applied as an experimental means to quantitatively investigate the local electrical properties of both single-layer and few-layer graphene films on silicon dioxide. The effect of film thickness on the surface potential is observed. Our measurements indicate that a 66 mV increase in the surface potential is detected for an eleven-layered film with respect to a nine-layer film. Furthermore, with the introduction of multiple lock-in amplifiers (LIAs) in the electronics for scanning probe microscopes, single-pass kelvin force microscopy and probing of the other electric property such as local dielectric permittivity via the capacitance gradient dC/dZ measurements are allowed by the simultaneous use of the probe flexural resonance frequency \( \omega_{\text{mech}} \) in the first LIA targeting the mechanical tip-sample interactions for surface profiling, and a much lower frequency \( \omega_{\text{elec}} \) (both in the second LIA and its second harmonic in the third LIA) for sample surface potential and dC/dZ measurements, respectively. In contrast to surface potentials, the dC/dZ measurements show that local dielectric permittivity of few-layer graphene films maintains at the same level regardless of the film thickness. Such simultaneous monitoring of multiple electronic properties that exhibit different behaviors in response to the graphene layers provides us a technique to achieve both a comprehensive characterization and a better understanding of graphene materials. In addition, new results on investigations of other graphene-related systems such as white graphene (Boron Nitride) and graphene oxide (GO) will be presented.

Short Biography
Jing-jiang Yu received his Ph.D. degree in chemistry from the University of California, Davis in 2006. Under the supervision of Professor Gang-yu Liu, his doctoral thesis focused on using scanning probe lithography to study the size-dependent surface chemistry and biochemistry. He is currently an applications scientist in Nanotechnology Measurements Division at Agilent Technologies. His present research at Agilent includes development of new AFM-based nanofabrication techniques, characterization of self-assembled monolayers and organic thin films, and investigation of surface-initiated biorecognition such as protein immobilization using AFM.

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