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Frictional Characteristics of Mixed-Layer Graphene Fabricated by AFM

Sunghyun Kim, Suenne Kim
Hanyang University, Department of Applied Physics
426-791, Ansan, South Korea
shdak6990@gmail.com; skim446@hanyang.ac.kr

Extended Abstract

Many graphene studies have been focused on unique or preeminent characteristics of the material, such as frictional anisotropy, zero-gap semi-conductivity, extremely high carrier mobility, or superlubricity. Most of the unique aspects of graphene originate from its characteristic lattice structure. For example, a recent study about the frictional properties of bilayer graphene reports anisotropic friction coefficients related to the hexagonal atomic arrangements (Kim et al., 2015). The frictional characteristics of graphene are also found to depend on the number of stacked layers. Lee et al. (2010) reported the decrease of friction with the increase of layer thicknesses in various kinds of 2D materials.

Here, we have fabricated a graphene nanostructure consists of one to four graphene layers by folding 400 x 800 nm^2 monolayer graphene using a commercial AFM (Park Systems, NX-10). To achieve this, firstly, monolayer graphene on a SiO_2 substrate was prepared by mechanical exfoliation method (Novoselov et al., 2005). The weakly adhered graphene was then cut and folded multiple times while scanning using an AFM tip. After the folding processes, the mixed-layer graphene sample was baked at around 130°C for 30 minutes for better attachment to the substrate.

In this work, we have examined frictional characteristics of the mixed-layer graphene with the topmost layers of respective levels oriented in different in-plane crystallographic directions. Experimentally, lateral force microscope (LFM) is often used to examine surface friction force (V_{LFM}) of nanomaterials and atomically thin sheets including graphene.* LFM friction values (V_{LFM}) obtained from the various one to four levels are different from each other. Moreover, these friction values do not follow the decreasing trend (Lee et al., 2010) with increasing thickness. We show here the cutting and folding procedures have introduced mixed crystallographic directions on the respective topmost layers leading unconventional frictional characteristics different from the previous report (Lee et al., 2010).

*Atomic force microscope (AFM) gathers friction data in lateral force microscopy (LFM) mode. LFM signal (V_{LFM}), which reflects the tilted degree of a tip sliding on a surface, is proportional to the friction force between the tip and the sample, thereby the friction coefficient relating the two.

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