First Direct Synthesis of Graphene/Half-metallic Heusler Alloy Heterostructure for Spintronic Device Applications

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The low spin signal and tiny magneto-resistance is becoming a central issue in graphene-spintronic devices [1] in which conventional ferromagnets (FMs) such as Ni, Co, Fe of low spin polarization were used. Adopting highly spin-polarized material such as half-metal into graphene/FM heterostructure can be the most effective way to enhance the performance of graphene-spintronics device, experimental demonstration, however, is still lacking. This study, for the first time, reports a new heterostructure consisting of a single layer graphene (SLG) synthesized by high-vacuum chemical vapor deposition (CVD) on $Co_2FeGe_{0.5}Ga_{0.5}$ (CFGG) Heusler alloy whose half-metallicity has been confirmed experimentally [2].

CFGG layer with a thickness of 50 nm was epitaxially grown on a MgO(001) single-crystal substrate by magnetron sputtering at room temperature. The CFGG/MgO sample was then transferred into a CVD chamber for graphene synthesis. SLG was successfully synthesized on CFGG by optimizing the CVD process. **Fig. 1** shows the STM image taken from the synthesized SLG/CFGG heterostructure, which reveals an epitaxial growth of SLG on CFGG. Due the large lattice-mismatch between CFGG and graphene, moiré pattern of graphene is observed. **Fig. 2** shows the C *K*-edge XAS spectra of the SLG/CFGG heterostructure obtained by changing the incidence angle of a linearly polarized x-ray beam. The peak intensity from the π* and σ* state of graphene shows an opposite behavior of incidence-angle dependence, convincing the formation of a graphitic structure. Strikingly, the peak from the π* state of grapene observed here is very sharp, indicating a weak chemical bonding between graphene and CFGG. It makes the SLG/CFGG heterostructure unique from other graphene/FM systems such as SLG/Ni, Co, Fe which have received intensive studies so far. The quasi-freestanding nature of graphene on CFGG makes the SLG/CFGG heterostructure extremely promising for high-performance spintronic devices.

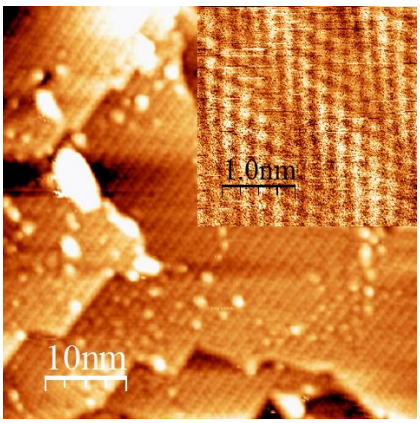

Fig. 1 Large-area and atomic resolution STM image of the SLG/CFGG heterostructure.

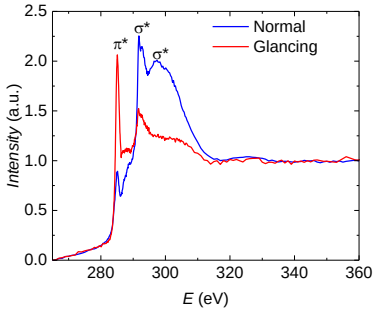

Fig. 2 C *K*-edge XAS spectra of the SLG/CFGG heterostructure.

[1] Han *et al*. Nat. Nanotechnol. **9**, 794-807 (2014); [2] Li *et al*. Appl. Phys. Lett. **103**, 042405 (2013).