Evaluating a Crystallographically Heterogeneous Graphene/L1₀⁻FePd Interface with a Perpendicular Orbital Moment by Depth-Resolved X-Ray Magnetic Circular Dichroism

A heterogeneous interface was fabricated by growing graphene (Gr) using chemical vapor deposition on an L1₀⁻FePd epitaxial film grown by sputtering. The depth-resolved X-ray magnetic circular dichroism (XMCD) analyses revealed that the perpendicular magnetized orbital magnetic moment was excited at the Gr/L1₀⁻FePd interface. The perpendicular orbital moment is owing to the shortening of the interatomic distance between Gr and L1₀⁻FePd, which produces a robust high electron density at the interface, resulting in a chemisorption-type vdW force having strong orbital hybridization.

Van der Waals (vdW) force is a type of intramolecular force that acts between atoms, ions, and molecules, and has a weaker bond force than covalent bonds, ionic bonds, and metal bonds; so-called vdW is the flexible bonding. Graphene (Gr) is a carbon consisting of a single layer of atoms arranged in a two-dimensional honeycomb lattice (hexagonal crystal symmetry). An L1₀⁻FePd has tetragonal crystal symmetry, which possesses a high uniaxial magnetocrystalline anisotropy (UMA) constant together with a low magnetic damping constant [1], which are attractive magnetic properties for the recording layer in a high-density nonvolatile magnetic random-access memory (MRAM). The hexagonal Gr and the tetragonal L1₀⁻FePd are crystallographically heterogeneous. However, the first-principles calculations predicted that the Gr/L1₀⁻FePd heterogeneous crystal interface exists with an energetically stable crystal orientation that is Gr armchair axis was parallel to FePd [100]₀, then it is possible to experimentally fabricate the Gr/L1₀⁻FePd heterogeneous interface. (Fig. 1) We are interested in exploring a new heterointerface to find new interfacial physics. This study aims to explore new interfacial physics in a crystallographical heterointerface of Gr/L1₀⁻FePd bilayer. To understand the crystallographically heterogeneous interface at the atomic resolution level for explaining the novel physical properties, a cross-sectional scanning transmission electron microscope (STEM) observation was carried. Furthermore, in order to investigate spin magnetic moments and orbital magnetic moments individually, and also to investigate these depth profiles, the depth-resolved X-ray magnetic circular dichroism (XMCD) measurement was carried out [2].

The heterogeneous interface was fabricated by growing Gr using chemical vapor deposition on the L1₀⁻FePd epitaxial film grown by sputtering [3]. The Gr/L1₀⁻FePd was fabricated by a chemical vapor deposition (CVD) method for the hexagonal Gr on the L1₀⁻FePd epitaxial film, which was grown by r.f. magnetron sputtering. The L1₀⁻FePd surface was cleaned by heating and pressurized under a reducing hydrogen atmosphere before growing the Gr by the CVD [3].

First principal calculation

van der Waals force (vdW force)

\[ \text{Physisorption vDW force} \]  
\[ \text{Chemisorption vDW force} \]

\[ 0.32 \text{nm} \]

\[ 0.20 \text{nm} \]

\[ \text{Graphene} \]

\[ \text{L1₀⁻FePd} \]

Figure 1: Calculated crystal structure of graphene/L1₀⁻FePd heterointerface. The interlayer distance between graphene was 0.32 nm which is physisorption vDW force, and the shorter interlayer distance between graphene and L1₀⁻FePd was chemisorption vDW force [2].


REFERENCES

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