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X-ray absorption and magnetic circular dichroism study of single-layer and bilayer graphene on Ni(111) surface

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Introduction

Spintronics is an emerging technology taking advantage of the dual freedom of both charge and spin degrees. Recent studies have started to shed light on the spintronic application of conjugated organic molecules and nanocarbons, in which the spins of conduction electrons can be preserved for a long time and distance. In this emerging field (so-called molecular spintronics), the control of the electronic and magnetic structures at the interfacial region between molecules / nanocarbons and ferromagnetic magnetic metals are considered to be of special importance for the functionalization as spintronic devices [1]. In these years, special attention is given to the graphene spin-valves in which graphene is used as spin transport media. Contrary to the expectations that the extremely long spin-diffusion length and high spin-injection efficiency would be realized in such graphene-based devices, the reported values are disappointing: less than several nm and a few percent, respectively. These results imply that the electronic interactions via the interfaces with magnetic electrodes and/or substrates have predominant influences to the spin-related properties of graphene in the devices.

In this study [2], as a model system to study the interfacial electronic interactions with magnetic electrodes, electronic and spin states of the single-layer and bilayer graphene on the Ni(111) surface were investigated using X-ray absorption and magnetic circular dichroism (XAS and XMCD) spectroscopies.

Experimental results

The growth of graphene was performed by exposing a Ni(111) thin film to benzene in an ultra-high vacuum (UHV) growth chamber with a base pressure of 3×10^{-7} Pa. The Ni(111) thin film was epitaxially grown on an α-Al_2O_3(0001) substrate with atomically flat surface, which was prepared by annealing the substrate at 1173 K in an open air. Recently, it was successfully demonstrated that the precise control of the graphene layer number (single-layer and bilayer) can be realized according to the optimization of the benzene dosage by the in-situ analysis of the reflection high energy electron diffraction (RHEED) profiles and Auger electron spectroscopy, which reflect the crystallinity and carbon amount change during the graphene growth, respectively [3]. Based on this study, the samples of single-layer and bilayer graphene (SLG and BLG) on Ni(111) were obtained at the benzene doses of 100 L and 1.8×10^{5} L (1 L = 1.33×10^{-4} Pa·s) at the substrate temperature of 800K. These samples prepared in the UHV chamber were transferred into the analysis chamber without breaking UHV.

The XAS and XMCD spectra at the C *K*-edge and Ni *L*-edge were obtained in the partial-electron-yield mode with the circularly polarized X-ray beam with a circular polarization factor 0.8, using BL7A of Photon Factory (KEK). The measurements were performed at ambient temperature and at the X-ray incident angles of 20° and 90°. The XMCD spectra were measured under the condition of the in-plane magnetization reversal of Ni.

Fig. 1 shows the C *K*-edge XAS and XMCD spectra of the SLG/Ni(111) and BLG/Ni(111) samples. Spectral features in the regions around 285 and 288 eV and in the region above 290 eV are attributed to the C 1s → π* and C 1s → σ* transitions in graphene. It is found that the XMCD signals from the graphene on the Ni surface change dramatically between SLG and BLG: negligible intensity for SLG and a clear peak component in the π* region for BLG. The present results revealed a strong quenching of the orbital moment in SLG/Ni(111) and a relax of the quenching in BLG/Ni(111).

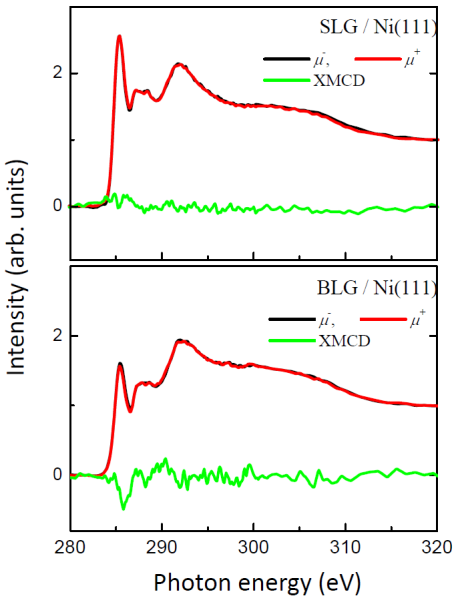

Fig. 1. C *K*-edge XAS and XMCD spectra measured for the SLG/Ni and BLG/Ni(111) samples. The X-ray incident angel was set at 20°.

References

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