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Fe $L_{2,3}$ MCD spectra from Fe/Si multilayers

Masaki SUGAWARA, Kosuke SATO, Tadashi HATANO, Mitsunori TOYODA
and Mihiro YANAGIHARA*
Institute of Multidisciplinary Research for Advanced Materials, Tohoku University
2-1-1 Katahira, Aoba-ku, Sendai 980-8577, Japan

Introduction

Fe/Si multilayers are widely studied from the aspect of the strong antiferromagnetic interlayer coupling. We have found for antiferromagnetically-coupled Fe/Si multilayers using soft-X-ray fluorescence (SXF) spectroscopy that no Si layer remains at all during the interdiffusion and that an amorphous (a-) $FeSi_2$ layer of 0.7 nm thick is sandwiched with a-Fe_3Si layers [1]. We have thus assigned the mediating layer for the interlayer coupling to be the a-$FeSi_2$ layer. It is quite interesting that the Fe/Si multilayer exhibits strong interlayer coupling regardless of the interdiffused layer of about 1 nm thick. Magnetic state of the interdiffused layer should be investigated as the next step. To examine the buried layers in multilayers magnetically, X-ray magnetic circular dichroism (MCD) combined with soft-X-ray standing waves might be a useful tool. In this study, we measured MCD spectra at the Fe $L_{2,3}$ thresholds and obtained a preliminary result using the escape depth of photoelectrons.

Experimental

Fe(3.0nm)/Si(t) (t = 0.5, 1.3, 1.7, 2.0 nm) multilayers were prepared on Si wafers using a magnetron sputter system. The topmost Fe layer was designed as thin as 1.0 or 2.0 nm due to the escape depth of the photoelectrons. It was confirmed that the sample of 1.3-nm thick Si layer was antiferromagnetic, while those of 0.5 and 1.7 nm thick were ferromagnetic. The MCD experiment was carried out at AR-NE1B using an absorption MCXD apparatus equipped with a permanent magnet unit of about 1.0 T. Prior to the experiments sample holder and its attachment were thoroughly renewed because the soft X-ray beam should be incident at oblique angles to meet the in-plane magnetization in Fe/Si multilayers.

Results

Figure 1(a) shows Fe $L_{2,3}$ absorption spectra measured using photocurrent from an Fe/Si(1.3nm) multilayer for two circular polarization modes at an oblique angle of 15°. An MCD spectrum obtained from Fig. 1(a) is shown in Fig. 1(b). Spin and orbital magnetic moments calculated from the obtained spectra using the sum rules are plotted as a function of Si layer thickness of the samples in Fig. 2, where solid and open circles stand for the moments of the samples with the topmost Fe layer of 1.0 nm and 2.0 nm thick, respectively. Our moments are small as compared with those of the bulk, which may come from oxidation of the surface Fe layer. It is remarkable in Fig. 2 that the spin moment is enhanced for the sample of 1.3-nm Si layer rather than those of 0.5 and 1.7-nm Si layer. It seems contradictory that the antiferromagnetic sample has a little bit enhanced moment. However, taking account of the escape depth of photoelectrons, it could be interpreted that the spin moment of the topmost Fe layer and the related interdiffused layer is enhanced for the antiferromagnetically-coupled Fe/Si multilayer rather than for the ferromagnetically-coupled ones. This result should be confirmed for oxidation-free samples.

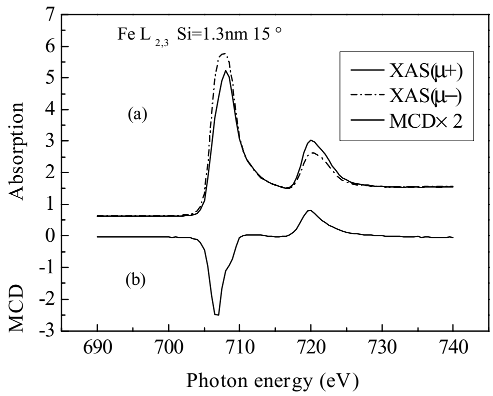

Fig. 1. (a) Fe $L_{2,3}$ absorption spectra of an Fe/Si(1.3nm) multilayer for two polarization modes and (b) an MCD spectrum obtained from (a).

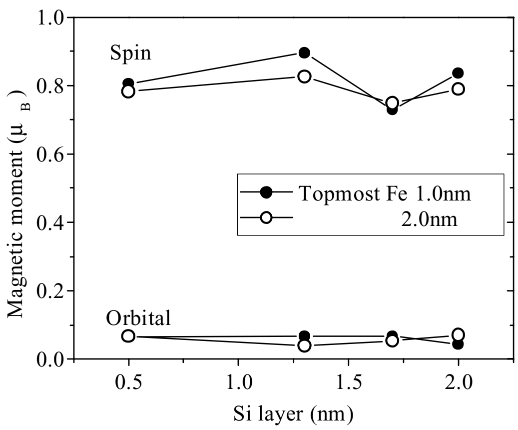

Fig. 2. Spin and orbital moments plotted as a function of Si layer thickness.

References

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* m.yanagi@tagen.tohoku.ac.jp