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Magnetic and Electronic States of a Monatomic Fe(001) Layer Facing an Epitaxial MgO(001) Tunnel Barrier Studied by Using XAS and XMCD Measurements

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Introduction

Magnetic tunnel junctions (MTJs) consisting of two ferromagnetic layers separated by an insulating layer (tunnel barrier) exhibit the tunnel magnetoresistance (TMR) effect, which has application to magnetoresistive random-access-memory (MRAM) and magnetic sensors. Fully epitaxial Fe(001)/MgO(001)/Fe(001) is one of promising candidates for novel high-MR MTJs because an extremely high MR ratio has been predicted by *abinitio* calculations [1]. In fact, in our study [2], a large MR ratio over 180% at RT (250% at 20K) was experimentally achieved. On the other hand, there has also been pointed out that partially oxidized FeO_x could be formed at the Fe(001)/MgO(001) interface, which considerably reduces the MR ratio. In this report, we presented the electronic and magnetic states of 1ML-Fe layer adjacent to MgO(001) single crystalline layer by using x-ray absorption spectra (XAS) and x-ray magnetic circular dichroism (XMCD) at the Fe $L_{2,3}$ edges [3].

Experimental

We prepared fully epitaxial multilayer with structure of sample (a) bcc-Co(001) (6ML) / bcc-Fe(001) (1ML) /MgO(001)(20Å)/Al-O(11 Å) with a buffer layer of MgO(001)substrate/MgO(001)(200Å)/Fe(001)(500Å)/Cr (001) (500 Å) by using molecular beam epitaxy (MBE). The single crystalline MgO(20 Å) layer was grown at RT using electron beam evaporation of MgO source material. For a reference of Fe oxide, sample (b) Co(001) (6ML) /FeOx(1ML)/a-Al-O(25Å) with a buffer layer of MgO(001)/Cr(001)(500 Å)/Au(001)(2000 Å) was also prepared. The XAS and XMCD measurements were performed at KEK Photon Factory BL11A. The XAS of FeO_x was measured at the KEK PF-AR NE1B.

Results and Discussion

XAS and XMCD spectra of Co(001)(6 ML)/Fe(001)(1 ML)/MgO(001) at the Fe $L_{2,3}$ edges are shown in Fig.1. The XAS of FeO_x(1 ML) is shown in Fig.2, in which extra shoulders (denoted by arrows) due to the multiplet effect typical to FeO_x are observed. In contrast, such shoulders are not seen in Fig.1. This result indicates that the Fe 1 ML facing the MgO(001) layer is not oxidized. We evaluated the magnetic moments of the Fe 1 ML by using the sum rules from the energy integration of the XAS and XMCD spectra; spin magnetic moment is 2.41 ± 0.1 μ_B; orbital moment is 0.13 ± 0.1 μ_B and the total magnetic moment of Fe 1 ML is 2.54 ± 0.1 μ_B which is considerably higher than that of bulk Fe (2.07 μ_B). We also obtained almost the same value for Fe 2ML sample [3]. On the other hand, the magnetic moment of FeO_x (0.27 ± 0.1μ_B) is an order of magnitude smaller than the Fe moments. These results also suggest no oxidation of the Fe layer facing a single crystalline MgO(001).

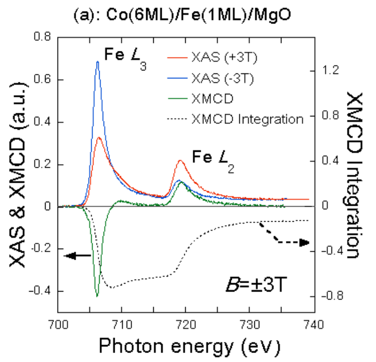

Fig. 1 XAS, XMCD and XMCD integration for samples with interfaces of 1ML-Fe/MgO

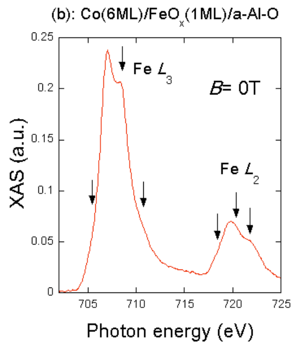

Fig. 2 XAS spectra at Fe $L_{2,3}$ edges for FeO_x/a-Al-O.

References

[1] W. H. Butler *et al.*, Phys. Rev. B 63, 54416 (2001).
[2] S.Yuasa, et al., Nature Materials 3, 968 (2004).
[3] K. Miyokawa et al., Jpn. J. Appl. Phys. 44, L9 (2005).

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