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Observation of Fe/$BaTiO_3$ interface magnetic state by x-ray magnetic circular dichroism

Masako Sakamaki[1,*] and Kenta Amemiya[1]
[1]Photon Factory, Tsukuba 305-0801, Japan

Change in the interface magnetic state of Fe thin film grown on $BaTiO_3$ substrate induced by ferroelectric polarization reversal was investigated by means of x-ray magnetic circular dichroism (XMCD). We observed change in the remanent magnetization and slight peak shift at $L_{2,3}$ edges depending on the applied magnetic field. This can be caused by the change in the occupation of Fe *d* orbitals due to the hybridization between Ti 3*d*-O 2*p* and Fe 3*d* orbitals at the interface.

1 Introduction

Electric filed-induced magnetization switching was recently demonstrated[1], which has a great potential to reduce the energy consumption in the magnetization switching process. One idea to control magnetization by an electric field has been proposed as a multiferroic concept[2]. For instance, it is reported that the coercive field of ferromagnetic Fe thin film grown on a ferroelectric $BaTiO_3$ (BTO) substrate changes when a voltage is applied between the Fe film and the bottom of the substrate even at RT[3]. Since the mechanism of the voltage-induced effects on the magnetic properties has not been clearly understood, we have performed the x-ray magnetic circular dichroism (XMCD) measurement for the Fe thin films grown on the BTO substrate, and observed the change in the interface magnetic state induced by polarization reversal of the substrate.

2 Experiment

Fe films were grown by electron bombardment evaporation in a high vacuum chamber, in which the substrate temperature was kept at 373 K. A Au cover layer was deposited on the film to make an electric contact to the film, and the voltage of ±1 kV was applied during the measurement between the film surface and the bottom of the substrate. XMCD were measured at BL-16A and 7A of the Photon Factory. All the measurements were taken at grazing incidence configuration in the Fluorescence yield mode at RT.

3 Results and Discussion

Figure 1(a) shows magnetic hysteresis curve of 1 nm-thick Fe film taken by using Fe L_3 edge XMCD. The remanent magnetization at 0 Oe, M_0, changes slightly depending on the applied magnetic field, as seen in Fig. 1(b). On the other hand, Fig. 2 shows Fe L-edge XMCD spectra taken at different applied voltages. Overall spectral shape seems similar to each other, but the slight peak shift at L_3 and L_2 edges by the ferroelectric polarization reversal is observed. These can be explained by the change in the occupation of Fe *d* orbitals due to the hybridization between Ti 3*d*-O 2*p* and Fe 3*d* orbitals at the interface. Indeed, x-ray absorption spectra show that the component of the oxidation state of Fe increases near the interface, which directly suggests the hybridization between Fe and the BTO substrate.

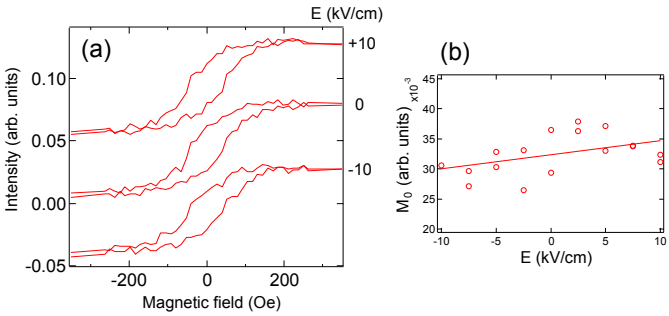

Fig. 1: (a) Magnetic hysteresis curve of 1 nm-thick Fe film grown on BTO substrate taken at Fe L_3 edge. (b) Applied electric field dependence of the remanent magnetization, M_0.

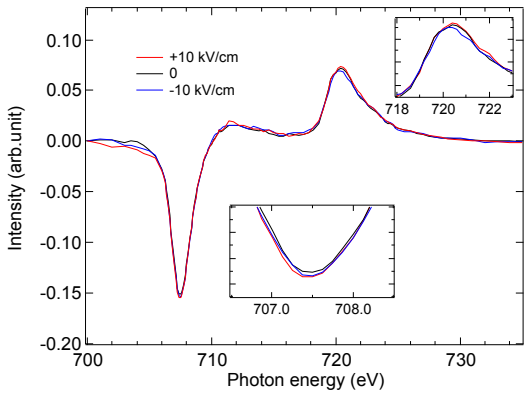

Fig. 2: Fe L-edge XMCD spectra of 1 nm-thick Fe film grown on BTO substrate. Inset figures are the enlargement of L_3 and L_2 –edge regions.

References

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* masako.sakamaki@kek.jp