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Interface perpendicular magnetic anisotropy between ultrathin Fe film and MgO studied by x-ray magnetic circular dichroism

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MgO-based magnetic tunnel junctions have been developed by exploiting the strong perpendicular magnetic anisotropy (PMA) of 2.1×10^5 J/m^3 at the interfaces between MgO and CoFeB transition metal alloys [1]. As a fundamental understanding of PMA induced at the interface between ferromagnetic layer and MgO barrier layer, the electronic and magnetic structures of the interfaces between ultrathin Fe layer and MgO have to be clarified explicitly [2]. It brings the understanding for the origin of the PMA in Heusler alloys Co_2FeAl facing on MgO [3]. In order to investigate the PMA energy, it is necessary to evaluate the orbital magnetic moments along parallel and perpendicular directions to the surface. Here, we report the anisotropic orbital moments of Fe/MgO by using angular dependent x-ray magnetic circular dichroism (XMCD).

Samples were grown by electron-beam evaporation methods on MgO substrates. The 0.7-nm-thick Fe layer was deposited on Cr buffer layer and MgO layer was also grown on thin Fe layer. Post annealing at 450 °C was performed to enhance PMA, which was estimated to be 1.4 MJ/m^3 by SQUID-VSM at room temperature [2]. In-plane saturation field of 0.7 nm Fe layer on MgO was estimated to be 2 T. XMCD measurements were performed at UVSOR BL-4B under the conditions of 5 K and ±5 T.

Figure 1 shows Fe *L*-edge x-ray absorption spectra taken by circular polarized x-rays and XMCD. Clear metallic peaks in absorption spectra reveal no mixing with oxygen atoms. The XMCD spectra depending on the geometries (normal or grazing incidence) reveal the difference in L_3 edges, resulting in the large orbital magnetic moments at the normal incidence geometry. The large PMA in Fe/MgO interface is derived from the anisotropic orbital magnetic moments of Fe. In the presentation, we discuss and compare the PMA amplitudes deduced from XMCD, magnetization measurements, and the first-principles band structure calculations.

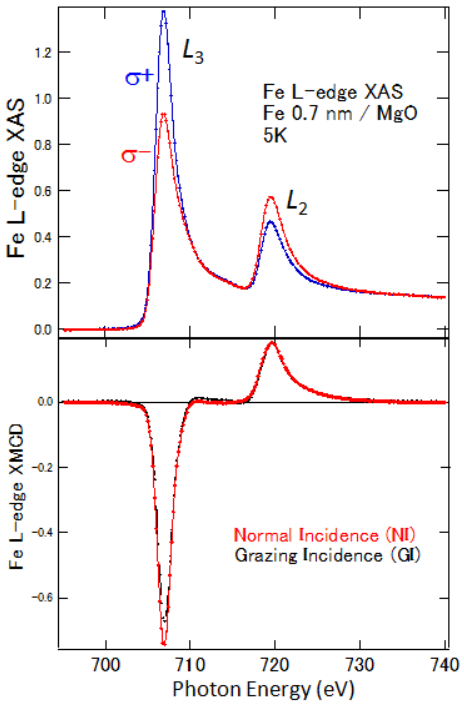

Fig. 1: Fe *L*-edge x-ray absorption spectra with polarized x-rays at normal incidence setup and angular-dependent XMCD of Fe/MgO.

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