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Magnetic states of Co and Mn atoms at the Co_2MnGe/MgO interfaces studied by x-ray absorption spectroscopy and soft x-ray magnetic circular dichroism study

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Introduction

Co-based full Heusler alloys, Co_2YZ such as Co_2MnGe (CMG) and Co_2MnSi (CMS) are promising candidates as ferromagnetic electrodes in magnetic tunnel junctions (MTJ), because theories have predicted that they are perfect half-metals [1]. A numerical study in Ref. 2 suggests that lattice distortions and the existence of impurities at the interfaces make the spin polarization small. Hence, the quality of the interface is a key to obtain higher tunnel magnetoresistance (TMR) ratio, and it is highly important to characterize the interfacial magnetic and electronic states of Heusler alloy/MgO MTJs.

In this report, we have studied the magnetic states and the electronic structures of Mn and Co atoms in CMG facing to an MgO barrier by using x-ray absorption spectroscopy (XAS) and soft x-ray magnetic circular dichroism (XMCD). In order to extract the information about the interfacial magnetic and electronic states, we have investigated the film-thickness dependence of XMCD

Experimental

The fabricated sample layer structure (from the substrate side) was as follows: MgO (001) single crystal substrate/MgO buffer layer (10 nm)/CMG (t_{CMG} nm)/MgO barrier (2 nm)/AlO_x (1nm) capping layer.. For XMCD measurements, we used BL-16A and off-plane circularly polarized soft x-rays from the bending magnet beamline BL-11A.

Result and discussion

In Fig. 1(a), Mn $L_{2,3}$ XAS spectra for 53-, 4-, and 2-monolayer (ML) samples, a shoulder-like structure was observed in the higher energy region of the Mn L_3 peak, and the Mn L_2 peak was split into a doublet. These features are characteristic of bulk CMG and CMS [3]. The probing depth of XAS and XMCD around $h\gamma \sim 600$-800 eV is several nm. Therefore, the XAS and XMCD for the 53-ML sample reflects bulk-like feature in addition to interfacial feature. As thickness of CMG films decreases, XAS and XMCD become less interfacial sensitive. As shown in Fig. 1(a) and (b), the XMCD signal is reduced with decreasing thickness.

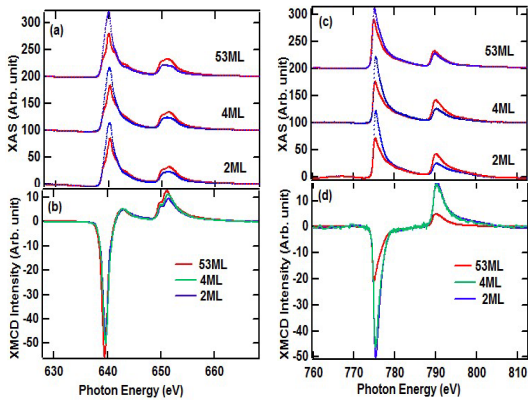

Figure 1: Mn & Co $L_{3,2}$-edges XAS [(a), (c)] and Mn & Co $L_{3,2}$-edges XMCD ($\Delta\mu = \mu_+ - \mu_-$) [(b), (d)]of Mn-rich $Co_2Mn_{1.40}Ge$ samples with various film-thicknesses at 300 K and $B = \pm 3$ T. μ_+ (blue dotted line) and μ_- (red solid line) are the absorption coefficients for photon helicity + and -.

Fig. 1(d) displays the Co $L_{3,2}$-edge XMCD spectra. For all the samples, a shoulder-like structure was observed in the higher energy region of the Co L_3-edge XAS as shown in Fig. 1(c). This feature is common to bulk samples [3]. The XMCD signals were enhanced as the film thickness decreases, implying that the Co atoms in the interfacial region are strongly spin-polarized. We could not find CoO-like multiplet structure [4] for all the samples.

References

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