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# X-ray Absorption and X-ray Magnetic Circular Dichroism Studies of a Monatomic bcc-Co(001) Layer Facing an Amorphous Al-O Tunnel Barrier

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## Introduction

The magnetic tunnel junctions (MTJs) with an amorphous Al-O tunnel barrier show a large tunnel magnetoresistance (TMR) ratio up to 70%, and the MTJs with crystalline MgO(001) tunnel barrier show up to 230% at room temperature [1], which attracts much attention because they are applicable to magnetoresistive random-access-memory and reading heads for magnetic recording. Experimental results of TMR have been usually interpreted by Julliere's expression with spin polarization of the density of states at the Fermi level of both ferromagnetic electrodes. However, the amplitude of TMR and even its sign cannot be fully explained by the theory. Oxidization of the ferromagnetic electrode at the interface could be an origin of the problem. In order to examine the oxidization state of the interface, we evaluated magnetic moments of the one monolayer (1-ML) Co(001) facing Al-O barrier by using x-ray magnetic circular dichroism (XMCD) measurements.

## Experimental

1-ML Co was fabricated on the Fe(001)(6 ML) with a buffer layer of MgO(001)/Cr(001)/Au(001) by using molecular beam epitaxy (MBE) method. After the growth of Co, Al (1 nm) was deposited only on half of the Co surface. Then, the whole surface was naturally oxidized (20 min, *in situ*) in $O_2$ atmosphere (100 Torr) in order to prepare Al-O and CoO layers. Finally, Al-O (3.5 nm) was deposited by using a reactive deposition in $O_2$ atmosphere of $5\times10^{-6}$ Torr. Thus, two samples with interfaces of (a) Co/Al-O and (b) $CoO_x$/Al-O (intentionally oxidized Co) were prepared. XAS and XMCD of these samples were measured from 635 to 855 eV at the KEK Photon Factory (BL11A). A magnetic field (***B***) of ±3T was applied for XMCD measurement using an ultrahigh vacuum superconducting magnet.

## Results and Discussion

Extra shoulders of Co $L_{2,3}$ in XAS due to multiplet effects are not observed [2] for Fe(001)/Co(1 ML)/Al-O contrasting with Fe(001)/CoO*x*(1 ML)/Al-O as shown in Figs.1(a) and (b), indicating that the 1 ML-Co is not oxidized. XMCD at Co $L_{2,3}$ for the samples (a) and (b) are also shown in the figure (XMCD were normalized by the peak height of Co $L_3$ XAS). We evaluated the magnetic moments of the 1-ML Co by using the sum rules from the energy integration of the XAS and XMCD spectra; spin magnetic moment is 1.58 ± 0.2 $\mu_B$; orbital moment is 0.18 ± 0.2 $\mu_B$ and the total magnetic moment of 1-ML Co is 1.76 ± 0.2 $\mu_B$ which is almost the same value as bulk hcp-Co (1.774 $\mu_B$). On the other hand, the total magnetic moment 0.51± 0.1$\mu_B$ is obtained for Co-O/Al-O. It also clearly indicates that the 1 ML-Co adjacent to Al-O barrier is not oxidized.

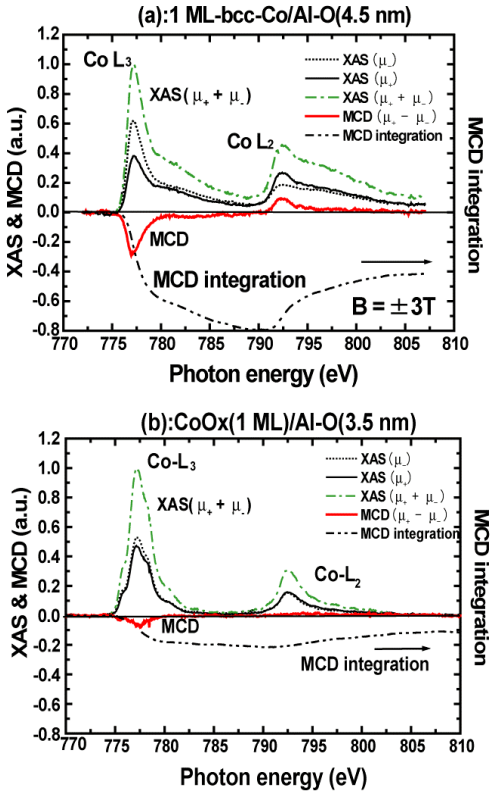


Fig. 1 XAS, XMCD and XMCD integration for samples with interfaces of (a) 1ML-Co/Al-O and (b) $CoO_x$/Al-O.

## References

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