

Anomalous surface magnetism and structure of CO/Fe/Cu(001), NO/Fe/Cu(001) observed by depth-resolved XMCD and EXAFS

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Magnetic thin films show a great variety of phenomena, and attract much interest fundamentally and technologically. Fe films on Cu(001) are typical magnetic thin films, and Fe(<4 ML)/Cu(001) films exhibit a perpendicular ferromagnetic coupling among a whole film. We have studied the effects of CO adsorption [1] and NO adsorption on the magnetic properties. The structures of the CO/Fe/Cu(001) films have been also examined.

X-ray magnetic circular dichroism (XMCD) gives us magnetic properties, and extended x-ray absorption fine structure (EXAFS) is a powerful method to study local structures. Conventional and depth-resolved XMCD experiments were carried out at remanent condition at BL-7A of Photon Factory. EXAFS was measured at BL-7C. All the measurements were carried out at 120 K.

XMCD measurements were carried out for Fe(2 and 4 ML)/Cu(001) before and after CO adsorption. The bare films were magnetized perpendicularly, and the spin magnetic moment, m_s^{eff} , was $\sim 2.4 \mu_B$. The 2 ML film was not affected by CO adsorption, while CO adsorption changed the magnetic properties of the 4 ML film drastically. The direction of magnetization rotated from perpendicular to in plane, and m_s^{eff} was reduced to $\sim 1.1 \mu_B$. The anomalous magnetic structure was revealed by the depth-resolved XMCD analysis. The surface two layers of CO/Fe(4 ML)/Cu(001) lost the spin magnetic moment upon CO adsorption, and only the bottom two layers had magnetization (Figure 1). The film structure was studied by EXAFS, and we suggest that the surface structure of the Fe(4 ML)/Cu(001) film was changed upon CO adsorption, but that of the 2 ML film was not affected by CO adsorption. The changed structure should be the origin of the disappearance of surface magnetization.

Also, NO adsorption induced striking magnetic structures in the NO/Fe/Cu(001) films. The apparent fifty percent reduced magnetization compared to the bare film was obtained for the NO/Fe(4 ML)/Cu(001) film. The magnetization direction was in plane. Detailed depth-resolved XMCD analyses have given us the conclusion that an antiferromagnetic coupling between the surface layer and the other layers is induced in the films.

[1] H. Abe *et al.* PRB **77**, 054409 (2008).

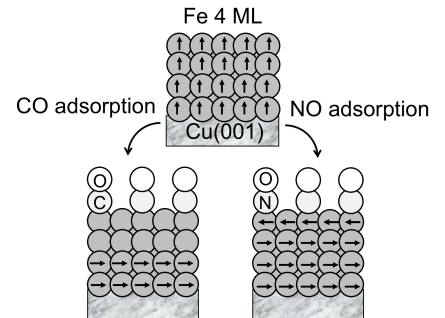


Figure 1: Schematic images of the magnetic structures of the CO/Fe/Cu(001) and NO/Fe/Cu(001).