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CO adsorption effects on magnetism of Fe(2,4 ML)/Cu(001)

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Introduction

Atomic and Magnetic properties of Fe ultrathin films on Cu(001) have been extensively studied. In the film thickness less than 4 ML (Regime I), the film exhibit a distorted fcc structure and a ferromagnetic coupling among a whole film with perpendicular magnetization. Between 5 and 11 ML (Regime II), the film shows fcc structure, and the top two layers couple ferromagnetically to each other, while the inner layers are either anti-ferromagnetic, or in a spin-density wave state.

In this report, we present the effects of CO adsorption on the magnetic properties of Fe/Cu(001) thin films as a function of film thickness. An Fe film of 2 ML is not affected by CO adsorption, while a 4 ML film changes the magnetic properties drastically. The direction of magnetization rotates from perpendicular to in-plane, and the surface layers lose the spin magnetic moment. Consequently, only the two layers, which are located at the interface to the Cu(001) substrate, keep magnetization. These magnetic phases are interpreted by assuming that CO adsorption kills ferromagnetic coupling of surface layers, while the magnetic structure of two layers adjacent to the Cu(001) substrate is unaffected by CO adsorption.

Experiment

XMCD experiments were performed at BL-7A and BL-11A. Fe films were deposited on a cleaned Cu(001) by an electron-beam evaporation. The thickness was monitored by RHEED observations, and 2 and 4 ML Fe films were prepared.

The sample was magnetized by a pulsed current through a coil. Circularly polarized (~80%) x-rays were obtained by using the light emitted upwards or downwards from the electron orbit of the storage ring. Depth-resolved XMCD experiment [3] was performed in the partial electron yield mode by using a microchannel plate detector in order to reveal the depth profiles of the Fe spin magnetic moments at 100 K. XMCD spectra were obtained by reversing the film magnetization. The direction of the magnetization was examined by measuring XMCD spectra at normal (90º) and grazing (30º) x-ray incidences, which are referred to "NI" and "GI", respectively. After each clean film measurement, the film was dosed with CO 5 L (1.3×10^{-5} Pa, 50 s), and the CO adsorbed films were studied in the same way as mentioned above.

Results and discussion

Fe *L*-edge XMCD spectra of Fe(2 and 4 ML)/Cu(001) before and after CO adsorption are shown in Fig. 1. The spectra were analyzed to obtain a spin magnetic moment (m_s) by applying the sum rules[2,3], leading to $m_s \sim 2.4\ \mu_B$ for bare Fe films. After CO adsorption, $m_s = 2.3\ \mu_B$ for CO/Fe(2 ML)/Cu(001) and $m_s = 1.1\ \mu_B$ for CO/Fe(4 ML)/Cu(001). The spin magnetic moment of CO/Fe(4 ML)/Cu(001) is about half of that of CO/Fe(2 ML)/Cu(001). The depth-resolved XMCD spectra (not shown here) of CO/Fe(4ML)/Cu(001) were analyzed, and a good fitting result was obtained for a simple model, which is composed of the magnetically dead top two layers and magnetically alive bottom two layers. The result was that the top two layers have 0.17 μ_B and bottom two layers 2.31 μ_B.

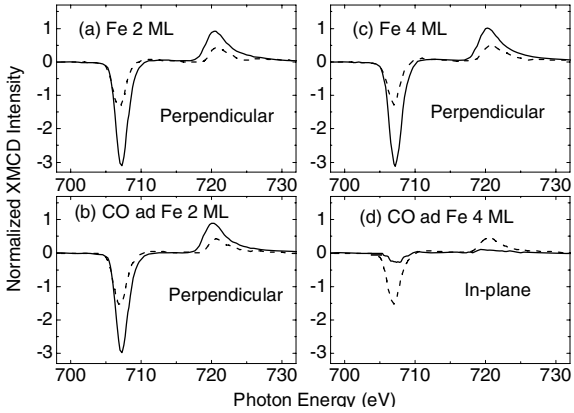

Fig. 1. Fe *L*-edge XMCD spectra. The magnetization direction of the 4 ML Fe film rotates from perpendicular to in-plane after CO adsorption. Solid line spectra correspond to NI, dashed ones to GI.

A possible explanation for these phenomena is that CO adsorption kills ferromagnetic coupling of surface layer(s), while the Cu(001) substrate keeps the magnetic structure of adjacent two layers.

References

[1] K. Amemiya et al., Appl. Phys. Lett. **84**, 936 (2004).
[2] B. T. Thole et al., Phys. Rev. Lett. **68**, 1943 (1992).
[3] P. Carra et al., Phys. Rev. Lett. **70**, 694 (1993).

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