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X-ray magnetic circular dichroism study on spin reorientation transitions of Ni/Cu(001) induced by the Fe deposition

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Introduction

It has been reported that the Ni film on Cu(001) exhibit an in-plane magnetization below 8 ML, and a perpendicular one between 9-37 ML[1]. It is also known that the magnetic anisotropy is sensitive to surface or interface structures. For instance, H or CO adsorption stabilizes the perpendicular magnetic anisotropy[2].

In the present study, we investigated Fe/Ni/Cu(001) magnetic films from the viewpoint of spin reorientation transition caused by a magnetic metal (Fe) deposition.

Experiments

A Cu(001) single crystal was cleaned by repeated cycles of Ar^+ sputtering and annealing to 900 K. Fe and Ni films were deposited by an electron-beam evaporation, and the film thickness was monitored by an in situ RHEED observation. The sample was magnetized by a pulsed current through a coil.

XMCD measurement was performed in an UHV chamber at BL-7A. Circularly polarized x-rays were obtained by using the light emitted downwards from the electron orbit of the storage ring by 0.4mrad. The circular polarization factor was about 80%. The total electron yield mode was adopted to determine the total magnetization, while depth-resolved measurements were performed in the partial electron yield mode with a retarding voltage of 500 V, by using an imaging type microchannel plate detector. XMCD spectra were obtained by reversing the film magnetization and subtracting one from another. The direction of the magnetization was examined by measuring XMCD spectra at normal (90º) and grazing (30º) x-ray incidence, which are referred to "NI" and "GI".

Results and discussion

Fig. 1 shows a series of XMCD spectra taken during a stepwise Fe deposition on a Ni(7.5 ML)/Cu(001) film. The spectra show in-plane, perpendicular, and in-plane magnetization as the Fe thickness increases. From a series of XMCD measurements, we obtained a magnetic anisotropy phase diagram of Fe/Ni/Cu(001) (see Fig. 2).

Note here that in-plane magnetized Ni films (7.5, 8 ML) undergo a spin reorientation transition (SRT) to perpendicular magnetization even with a small amount (<0.5 ML) of Fe deposition. Since it has been believed that the magnetization of thin Fe films on Ni follows that of the Ni films, this SRT is very interesting. We suppose that this SRT might be interpreted by large value of M_l/M_s of the Fe film of submonolayer thickness (marked by a red circle in Fig. 3), where M_l and M_s represent the orbital and spin magnetic moments, respectively.

Deposition of 2-3 ML Fe turned magnetization from perpendicular to in-plane, except on the 15 ML Ni film. This is also unexpected, because it is known that magnetization of Fe films is perpendicular on Cu(001). This SRT is possibly due to the structural relaxation of the films. The data analyses of the depth-resolved XMCD are now underway in order to further clarify the mechanism of the SRT.

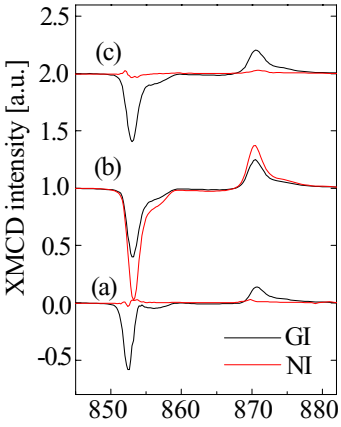

Fig. 1. Ni *L*-edge XMCD spectra from (a) Ni(7.5 ML)/Cu(001), (b) Fe(0.7 ML)/Ni/Cu(001), and (c) Fe(4 ML)/Ni/Cu(001).

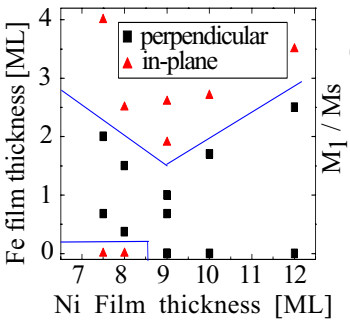

Fig. 2. Magnetic anisotropy phase diagram of Fe/Ni/Cu(001).

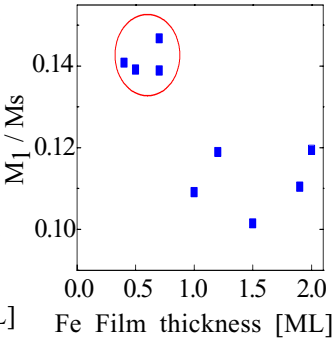

Fig. 3. M_l/M_s of Fe deposited on Ni/Cu(001) films.

References

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