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Depth-resolved estimation of MAEs of 2 ML Fe on Ni/Cu(001) films

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Introduction

It has been reported that the Ni films on Cu(001) exhibit an in-plane magnetization below 8 ML, and a perpendicular one between 9-37 ML [1]. It has been also revealed [2] that upon Fe deposition, in-plane magnetized Ni films (≤ 9 ML) undergo the SRT twice; a small deposition (< 1 ML) of Fe causes a transition to perpendicular magnetization, and further Fe deposition (1–2 ML in total) causes a return to in-plane. Perpendicularly magnetized Ni films (≥ 10 ML) also exhibit a transition to in-plane. The magnetic anisotropy energies (MAEs) of Fe in the system have been estimated to be 140 (< 1 ML) and 9 μeV/atom (2 ML). The single layer iron favours perpendicular magnetization strongly, while the 2 ML-thick Fe does not.

In the present study, 2 ML Fe deposited on Ni/Cu(001) films was investigated to clarify the MAEs of the top (K_{top}) and bottom (K_{bot}) layers by using the depth-resolved XMCD technique [3].

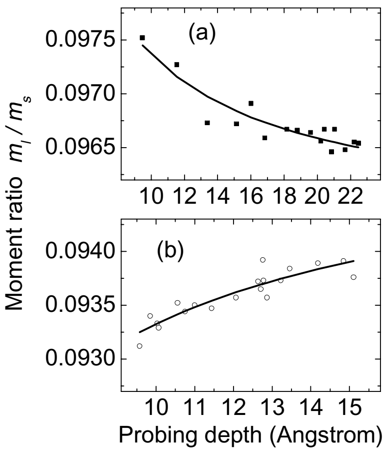
Experiment

XMCD experiments were performed at BL-7A. Fe and Ni films were deposited on a cleaned Cu(001) by an electron-beam evaporation. The thickness was monitored by a RHEED observation. Perpendicularly magnetized Fe(2 ML)/Ni(22 ML)/Cu(001) and in-plane magnetized Fe(2 ML)/Ni(8 ML/Cu(001) films were prepared in order to reveal the MAEs of 2 ML iron on Ni films.

The sample was magnetized by a pulsed current through a coil. Circularly polarized (~80%) x-rays were obtained by using the light emitted downwards from the electron orbit of the storage ring. In order to reveal the depth profiles of the Fe orbital to spin magnetic moment ratios, depth-resolved XMCD experiment [3] was performed in the partial electron yield mode by using a microchannel plate detector. 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.

Results and discussion

Obtained depth–resolved XMCD spectra were analyzed to estimate orbital to spin magnetic moment ratios of iron with the sum rules [4,5]. Figure 1a shows probing depth dependences of iron orbital to spin magnetic mo ratios of the Fe(2 ML)/Ni(22 ML)/Cu(001) film, w was magnetized perpendicular to the sample plane measured in NI geometry. The moment ratios of ML)/ ML)/Cu(001) are shown in Fig where the film magnetized in-p and measured in geometry.



The plot in Fi increases but th Fig. 1b decre with decreasing probing depths. moment ratio o top layer was l than the bottom when the film perpendi magnetization, smaller with in-p magnetization. Fitting the plots with a simple model moment ratios of the top and bottom layers were obta These moment ratios were 0.114 and 0.077 perpendicularly magnetized 2 ML Fe (Fig. 1a), and 0 and 0.116 for in-plane magnetized one (Fig. 1b).

These values give us the results of K_{top} = 174 and K -168 μeV/atom according to Bruno's model [6]. T values mean that the top layer has a large perpendi anisotropy and the bottom layer a large in-plane one. sum of these two is 6 μeV/atom, indicating anisotropy as a whole film, which is in good agree with the MAE of 9 μeV/atom obtained from total ele yield measurements.

References

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