7A, 11A/2003G014

Direct observation of surface magnetic anisotropy and effects of CO adsorption

Kenta AMEMIYA*[1], Enju SAKAI[1], Daiju MATSUMURA[1], Hitoshi ABE[1], Toshihiko YOKOYAMA[2], and Toshiaki OHTA[1]
[1]Graduate School of Science, The University of Tokyo, Hongo, Bunkyo-ku, Tokyo 113-0033, Japan
[2]Institute for Molecular Science, Myodaiji-cho, Okazaki, Aichi 444-8585, Japan

Introduction

Manipulation of surface magnetic anisotropy of ultrathin films has attracted much interest in this decade, since the magnetic property is strongly affected by the surface environment. Vollmer et al., reported that CO adsorption on a Ni/Cu(100) film enhances perpendicular magnetic anisotropy of the film, which originally exhibits the in-plane and perpendicular magnetization below and above 7-10 ML, respectively [1]. No direct observation of surface magnetic anisotropy has been achieved, however, which is inevitable to understand the mechanism of the CO-induced change in the magnetic property of the film. In the present study, we have separately extracted surface and inner layer components of the XMCD spectra for Ni films, by using the depth-resolved XMCD technique [2].

Experiments

All the experiments were carried out at BL-7A and 11A in an ultra-high vacuum chamber. Ni films were grown on a clean and ordered Cu(100) single crystal at room temperature. The XMCD spectra were recorded in a partial electron yield mode with a retarding voltage of 500 V. The emitted electrons were collected with an imaging type microchannel plate detector at different detection angles, which correspond to the probing depths. The normal and grazing X-ray incidence configurations were adopted for the perpendicular and in-plane magnetization, respectively.

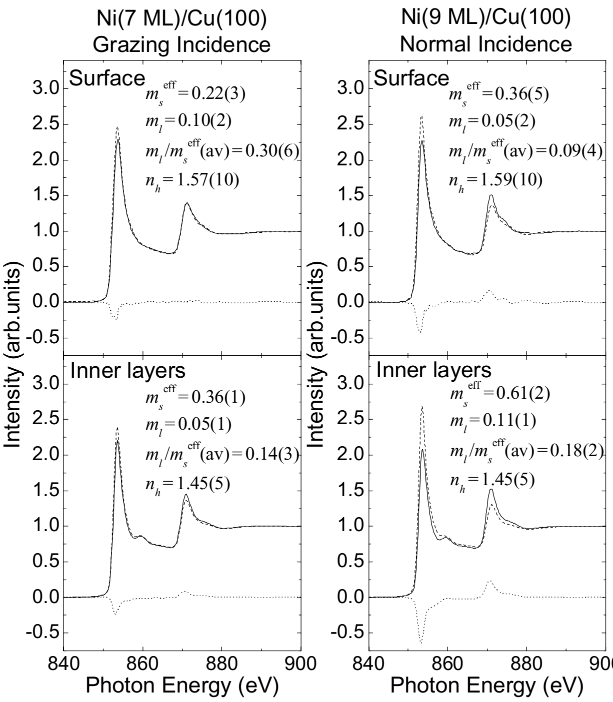

Fig. 1. Extracted surface and inner layer components of the circularly polarized (solid and dashed lines) and difference (dotted line) spectra for bare Ni films.

Results and discussion

The surface and inner layer components of the XMCD spectra were extracted from a set of the absorption spectra with different probing depths. The extracted spectra are depicted in Fig. 1, together with the effective spin ($m_s^{eff} = m_s + m_T$) and orbital (m_l) magnetic moments estimated by using the sum rules. The ratio between m_l and m_s^{eff}(av) (averaged m_s^{eff} over the whole film) is also shown, to consider the thickness dependence of Curie temperature.

It is recognized from Fig. 1 that the surface orbital moment is much larger in the in-plane direction, while the inner layer one is larger in the perpendicular direction. This directly indicates that the surface and inner layers have tendencies toward in-plane and perpendicular magnetization, respectively, which explains the thickness dependence of the magnetic easy axis of the Ni films.

Upon CO adsorption, the surface magnetization is drastically reduced as clearly seen in Fig. 2. Therefore, the CO-induced enhancement of the perpendicular magnetization is interpreted as the reduction of surface magnetic anisotropy, which originally has a strong tendency toward the in-plane magnetization.

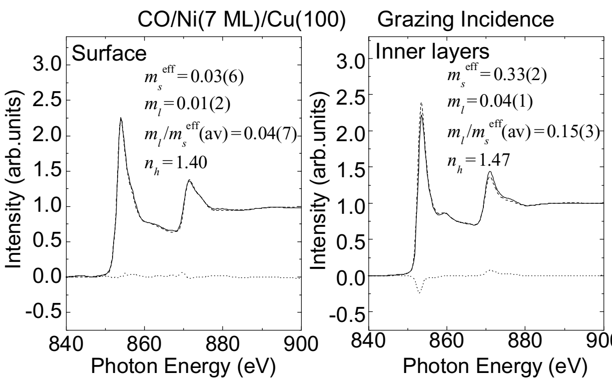

Fig. 2. Extracted spectra for CO/Ni(7 ML)/Cu(100).

References

[1] S. van Dijiken et al., J. Magn. Mag. Mater. 210, 316 (2000).
[2] K. Amemiya et al., Appl. Phys. Lett. 84, 936 (2004).

* amemiya@chem.s.u-tokyo.ac.jp