XMCD study on spin reorientation transition of nickel thin films induced by adsorption of H_2 and CO

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Introduction

It is well known that magnetic thin films show unique properties such as perpendicular magnetic anisotropy (PMA), which is energetically unstable when one takes only classical magnetic dipole-dipole interaction into consideration. Among magnetic films that show PMA, Ni thin films on Cu(100) have extensively been investigated because Ni films exhibit PMA in the wide thickness range of 10-50 monolayer (ML).

Recent experiments have shown that H_2 or CO adsorption on Ni surface stabilizes PMA [1]. The stabilization was attributed to a decrease in the surface anisotropy energy that favours parallel magnetization. In this report we discuss the results of experiments by Ni *L*-edge x-ray magnetic circular dichroism (XMCD) of Ni/Cu(100) before and after H_2 or CO adsorption in order to more fully understand adsorption effects on surface magnetic anisotropy.

Experiments

The XMCD spectra were performed at Beamline 7A. A Cu(100) single crystal was cleaned by cycles of Ar^+ sputtering and heating at 900 K. Ni was evaporated by resistively heated wires. Film thickness was controlled with *in-situ* monitoring oscillation of reflection high-energy electron beams. The samples were magnetized by Helmholtz coil with a pulse current. All the measurements were made with remanent magnetization. In the adsorption experiments, the samples were kept at 200 K for H_2 exposure and at 300 K for CO. Both exposures satisfied the condition of saturation.

Results and discussion

Because of low Curie temperatures of Ni thin films, no XMCD spectra were taken less than 6 ML in our experiments. We observed perpendicular magnetization over 9 ML for clean films. In a range of film thickness of 7-9 ML, the easy axis of films rotates from parallel to perpendicular when covered with H_2 or CO. These results qualitatively agree with the literature [1].

Figure 1 shows the ratio of magnetic orbital and spin moments (M_l/M_s) in the vicinity of the spin reorientation transition. Below 9 ML, the relative value of orbital moments of films covered with CO is enhanced as compared to that of the H_2–covered ones. The origin of difference values could be understood from adsorption behavior.

H_2 adsorbs dissociatively in a four-fold hollow site and forms a covalent-metallic surface bond. The H overlayer on Ni shows marked reduction of the absolute values of surface orbital moments. On the contrary, CO adsorbs on a top site with the molecular axis perpendicular, leading to only small quenching of the moment. Therefore, the H-covered films have small orbital moments, while the CO-covered ones have nearly the same moments as those of the uncovered ones. Small parallel and perpendicular orbital moments induced by H adsorption stabilize PMA, while relatively larger perpendicular moments compared to parallel ones for the CO-covered films also stabilize PMA. We have shown that PMA is stabilized on adsorption of H_2 and CO in a different fashion although the spin reorientation transition is caused similarly.

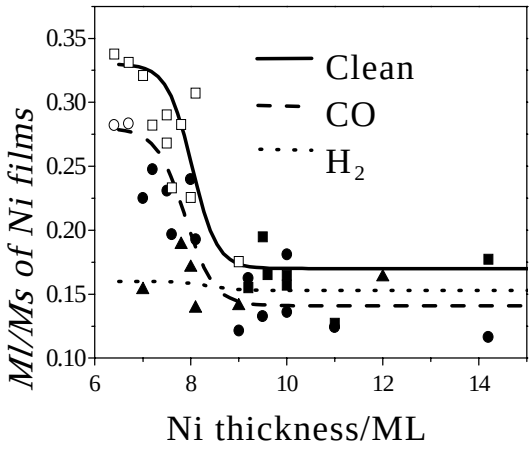

Fig. 1. The ratio of magnetic orbital and spin moments, M_l/M_s, before and after adsorption of H_2 or CO. The square data points indicate the value for the clean films. The circle and triangular points correspond to the value for the films covered with CO and H_2, respectively. Closed and open symbols represent perpendicular and parallel moments, respectively.

Reference

[1] S. van Dijken *et al.*, J. Magn. Magn. Mater. **210** (2000) 316.

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