X-ray magnetic circular dichroism study on spin reorientation transitions of Co/Pd(111) induced by surface chemisorption

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Introduction

The perpendicular magnetic anisotropy (PMA) of ultrathin films has been investigated widely because PMA is energetically unstable if one considers only classical magnetic dipole-dipole interaction. Recently, it is reported that H or CO surface chemisorption stabilizes PMA of Ni/Cu(001) by using Kerr effect [1]. We have revealed that H and CO adsorption stabilize PMA of Ni/Cu(001) in different mechanism that depends on surface adsorption fashion by using x-ray magnetic circular dichroism (XMCD). And we have investigated surface adsorption effects of Co/Pd(111) by means of XMCD and discovered that CO or NO surface chemisorption stabilizes PMA [2]. In the case of CO adsorption, from the viewpoint of surface orbital magnetic moment, it is revealed that anisotropic change of surface orbital moment induced by CO chemisorption is the key of stabilization of PMA and the anisotropic change is attributed to the surface chemisorption fashion.

Experiments

XMCD study was taken at the bending-magnet station Beamline BL-7A. All the experiments were performed in a UHV atmosphere. A single crystal of Pd(111) was cleaned by the cycles of Ar^+ sputtering (2 kV) and subsequent annealing at 1070 K. Co was evaporated by electron-bean evaporation method. The thickness of films was calibrated by Auger intensity ratio between Co and Pd.

Circularly polarized x rays were obtained by using upper or lower ($\pm$0.4 mrad) part from the storage ring. The circular polarization factor is about 80 %. All the spectra were recorded in a partial-electron-yield mode by using microchannel plate with retarding voltage of -500 V. The films were magnetized by a current pulse. The XMCD spectra were obtained by reversing the magnetization of films. The remanent magnetization was examined.

Results

We performed normal (90 deg.) and grazing (30 deg.) incidence study to know the easy axis of the films. The critical thickness is about 3.5 ML in the case of surface clean films. Below the critical thickness, films have perpendicular magnetization and above that films have parallel one. On the other hand, CO-covered films have larger perpendicular magnetization region. CO adsorption spread the perpendicular magnetization region about 3 ML.

Fig. 1 shows orbital magnetic moment before and after CO adsorption. From the viewpoint of magnetic easy axis, we classify Co thickness into three regions. In region I, the films have always perpendicular magnetic moment even before CO adsorption and perpendicular orbital moment is almost conserved. In region III, the films have always parallel magnetic moment even after CO adsorption and parallel orbital moment is quenched by CO adsorption. In region II, spin reorientation transition from parallel to perpendicular occurs and perpendicular orbital moment (after CO adsorption) is larger than parallel (before CO adsorption) one. The anisotropic change of the surface orbital moment is the main issue of PMA stabilization by surface chemisorption.

Different type in changing of orbital moment is attributed to CO adsorption fashion. CO adsorbs on surface with keeping molecular axis almost perpendicular and only parallel orbital moment is quenched.

References

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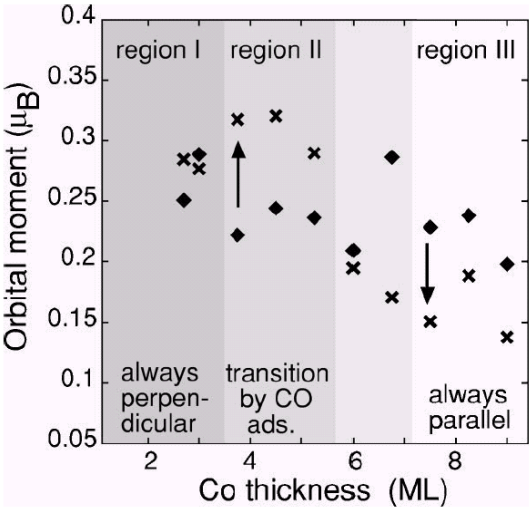

Fig. 1. Orbital magnetic moments of the Co films on Pd(111) at 200 K as a function of Co thickness. Diamonds and crosses denote clean and CO-adsorbed Co, respectively.