

## XPS and XMCD studies on spin reorientation transition of Co/Pd(111) induced by surface CO chemisorption

Daiju MATSUMURA<sup>1</sup>, Toshihiko YOKOYAMA<sup>2</sup>, Kenta AMEMIYA<sup>1</sup>, Soichiro KITAGAWA<sup>1</sup>,  
Toshiaki OHTA\*<sup>1</sup>

<sup>1</sup>The University of Tokyo, 7-3-1 Hongo, Bunkyo-ku, Tokyo 113-0033, Japan

<sup>2</sup>Institute for Molecular Science, Myodaiji-cho, Okazaki, Aichi 444-8585, Japan

### Introduction

Perpendicular magnetic anisotropy (PMA) is one of the most interesting features of the magnetic thin films. If one considers only electromagnetic effects, surface parallel magnetic easy axis is always stable in the case of thin film. However, some magnetic thin films have a perpendicular magnetic easy axis as a result of the competition among many effects which originate in surface, interface, and so on. Recent XMCD experiments revealed that the adsorption of CO, NO, and O<sub>2</sub> on Co/Pd(111) stabilizes the PMA of the film and extends the thickness region of PMA by about 3 ML [1]. Magnetic sum rule analysis indicated that CO adsorption reduces only surface parallel orbital magnetic moment, keeping the surface normal one. This anisotropic effect of CO on Co thin film is observed only below around 200 K. In order to examine the correlation between the surface adsorption structure and the magnetic anisotropy of the thin film, we have observed the spin reorientation transition of Co/Pd(111) induced by CO adsorption by means of XPS and XMCD on the same system.

### Experiments

The C 1s photoelectron and Co *L*-edge XMCD spectra were taken at the bending-magnet soft x-ray station BL-7A. A single crystal of Pd(111) was cleaned by the repeated cycles of Ar<sup>+</sup> sputtering (2 kV) and annealing at 1000 K. The Co thin films were deposited on Pd(111) at room temperature with the electron-bombardment method. The thickness of each film was estimated by Auger intensity ratio between Co LMM and Pd MNN. XPS measurements were performed with a hemispherical electrostatic analyzer (SES-2002) with the incident energy of 430 eV. For XMCD measurement, we used elliptically polarized x rays emitting downwards from the electron orbital plane by  $-0.4 \pm 0.1$  mrad. The absorption spectra were recorded with the partial-electron-yield mode using a microchannel plate with retarding voltage of 500 V. Each sample was magnetized by a current pulse. The XMCD spectra were obtained by reversing the magnetization of the films. Remanent magnetization was examined.

### Results and discussion

Figure 1 shows the relationship between C 1s photoelectron and Co *L*-edge XMCD spectra from 4.5 ML Co film during CO exposure at the temperature of

200 K. At this thickness, the Co thin film undergoes the spin reorientation transition from surface parallel to perpendicular magnetization induced by CO chemisorption. Because x-ray incident angle in normal in this case, no XMCD signal during the low CO coverage does not indicate that the Co thin film is not magnetized, but is fully magnetized in parallel direction, as confirmed by the XMCD observation at grazing incidence. The growth manner of XPS peak at 285.8 eV suggests that CO first occupies the atop sites. At around 1 L CO exposure, the shoulder peak at 285.3 eV, which is assigned to bridge or hollow sites, gradually grew. At the same time, Co XMCD gradually appeared, which means that the easy axis of Co has just begun to rotate the orientation of spin from surface parallel to perpendicular direction. We have observed same correlation between CO adsorption on bridge or hollow sites and Co perpendicular magnetization by heating desorption experiment. These results clearly indicate that the spin reorientation transition of Co/Pd(111) does not occur by the atop CO adsorption, but is induced exclusively by the CO adsorption on bridge or hollow sites.

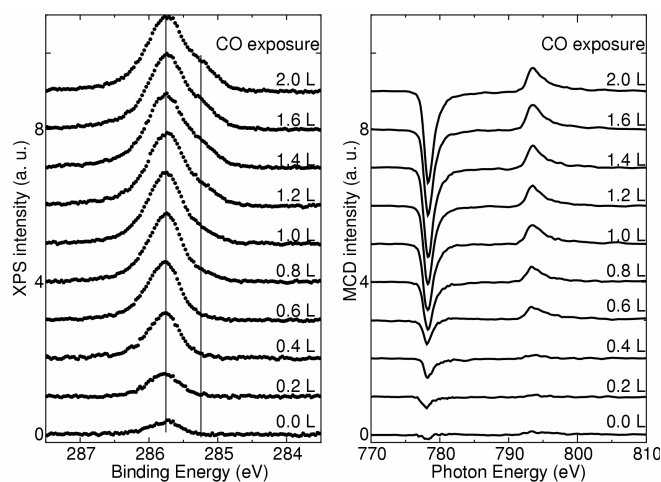


Fig. 1 C 1s photoelectron and normal incident Co *L*-edge XMCD spectra from 4.5 ML Co film on Pd(111) during step by step CO adsorption at 200 K.

### Reference

[1] D. Matsumura et al., Phys. Rev. B, **66**, 024402 (2002)

\* ohta@chem.s.u-tokyo.ac.jp