

## Structural study of Co ultrathin films on Pd(111) by Surface EXAFS

Jun MIYAWAKI<sup>1</sup>, Daiju MATSUMURA<sup>1</sup>, Akihiro NOJIMA<sup>1</sup>, Toshihiko YOKOYAMA<sup>2</sup>,  
Toshiaki OHTA<sup>\*1</sup>

<sup>1</sup>Department of Chemistry, Graduate School of Science, 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

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. It is reported that the property of magnetism is determined by the magnetic anisotropy energy (MAE), which is influenced by small displacements from the bulk structure [1]. Co ultrathin films on Pd(111) is one of the systems showing large PMA, but the structure of the Co ultrathin films is not revealed because of its island growth mode and alloy-like environment at interfaces. The structural studies of the Co films have exclusively been done for the multilayers [2], but not for the ultrathin films yet. Thus, we performed surface EXAFS study on the Co ultrathin films on Pd(111).

### Experimental

All the experiments were performed in a UHV condition. A single crystal of Pd(111) was cleaned by the cycles of Ar<sup>+</sup> sputtering (2 kV) and subsequent annealing at 1100K. Co was evaporated by the electron-beam evaporation method. Thickness of the films was calibrated by Auger intensity ratio, Co LMM/ Pd MNN.

EXAFS spectra were taken at BL-7C with a double-crystal Si(111) monochromator detuned by ~40% at normal(90°) and grazing(30°) x-ray incidence. The incident x-rays were detected by an ionization chamber filled with N<sub>2</sub> and fluorescent x-rays by a single element SSD.

### Results

Fig. 1 shows Fourier transforms of the Co-K EXAFS spectra for 2ML and 4ML Co films on Pd(111) measured at 110K and the curve fitting results of the first-neighbor shell are listed in Table 1. Basically we can get in-plane information from the normal incidence EXAFS spectra and out-of-plane information from the grazing incidence ones.

Fig. 1 indicates that the in-plane Co-Co interatomic distance (2.50 Å) is almost same as the bulk value (2.51 Å) and out-of-plane one (2.48 Å) is a little smaller than that. These results should be compared with those from multilayers[2], where the out-of-plane Co-Co distance is compressed, but the in-plane one is expanded, compared with the bulk ones.

As for the Co-Pd interatomic distance, it is found that in case of 2ML Co ultrathin films, both in-plane and out-of-plane Co-Pd interatomic distance is 2.67 Å and in case

4ML one, out-of-plane interatomic distance is 2.66 Å and in-plane Pd atoms were not detected.

The atomic radii of Co and Pd are 1.25 Å and 1.38 Å, respectively and the expected Co-Pd interatomic distance is 2.63 Å, which is in reasonable agreement with the obtained Co-Pd interatomic distances.

Although we have not determined the absolute value of coordination number yet and we cannot directly compare 2ML Co films with 4ML ones, the ratio of the estimated coordination number between Co and Pd shows that the number of Pd atoms in 2ML Co films is larger than that in 4ML ones. This suggests that the interface is alloy-like, which is also in good agreement with the result from multilayers.

The fcc or hcp/Co structure should be discriminated by the difference in higher shells. However, for these films higher shells were not clearly seen and it was difficult to distinguish between hcp and fcc structures.

### References

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

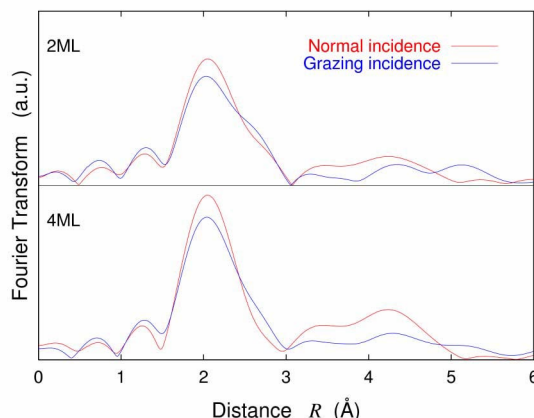


Fig. 1. Fourier transforms of the Co-K EXAFS spectra for the Co films on Pd(111) at 110 K.

Table 1. Curve fitting results of the first-neighbor shell. Values in parentheses are estimated errors for the last digit.

	$R_{\text{Co-Pd}}$ (Å)	$R_{\text{Co-Co}}$ (Å)
4ML normal incidence	---	2.50(2)
4ML grazing incidence	2.66(2)	2.48(2)
2ML normal incidence	2.67(2)	2.50(2)
2ML grazing incidence	2.67(2)	2.48(2)