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X-ray magnetic diffraction experiments of a Pd/Co multilayer film

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Introduction

Multilayer films of Pd/Co exhibit perpendicular magnetic anisotropy (PMA) [1]. We have performed X-ray magnetic diffraction (XMD) experiments, and have tried to observe spin and orbital magnetic factors of Pd/Co multilayer films. We aim to contribute to elucidate the origin of the PMA of the multilayer films.

Experiment

A Pd/Co multilayer film of a composition Pd(3.2 nm)/Co(0.8 nm) was sputtered on a glass substrate (0.15 mm thickness). The total thickness of the multilayer film was about 3 μm. The XMD experiment has been performed on BL3C where the dedicated XMD experimental system including a four-circle diffractometer, an electromagnet and a pure-Ge solid state detector (SSD) is installed. We have adopted a monochromatic X-ray method using a double crystal Si(111) monochromator, which was presented previously [2], in order to reduce fluorescent X-rays from the sample. We have measured flipping ratios of Pd/Co (222) diffraction intensities by reversing the magnetic field direction in the spin configuration (α=135°) shown in Fig. 1 and in the orbital configuration (α=0°).

Results and discussion

The observed intensity profile of the diffracted X-rays is shown in Fig. 2 as red solid circles. Here, we have chosen the X-ray energy, 7.791 keV, so as that the scattering angle for the Pd/Co (222) diffraction is 90°. This incident X-ray energy is above the Co-K absorption edge energy 7.709 keV, and considerable amounts of fluorescent X-rays, CoK_α and CoK_β, have been observed as shown in Fig. 1. Therefore, we have measured fluorescent X-rays only in the vicinity of the diffraction spots by moving the SSD slightly. The observed fluorescent X-ray profile is shown in Fig. 2 as blue open circles. Then the Pd/Co (222) diffraction profile has been obtained by subtracting the fluorescence profile from the raw profile including both diffraction and fluorescence. We have obtained the Pd/Co (222) diffraction profile as shown in Fig. 2 as green solid circles.

By using the Pd/Co (222) integrated intensity, we have obtained the flipping ratio in the spin configuration, R_S = $(0.99\pm0.49)\times10^{-3}$ for measuring time of 60 hours. Then the electromagnet has been rotated to the orbital configuration, and we have obtained the flipping ratio, R_L= $(0.85\pm0.84)\times10^{-3}$ for measuring time of 20 hours. These flipping ratios are the first XMD result of a multilayer films, and will be analysed further for the spin and orbital magnetic form factors.

A more effective method that will enable us to measure the flipping ratios more precisely in much shorter time is planned and will be performed in the near future.

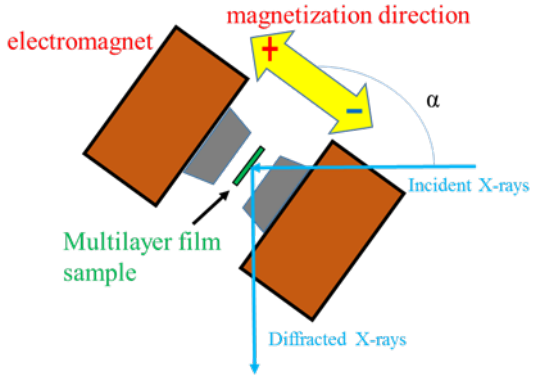

Fig. 1 XMD experimental configuration.

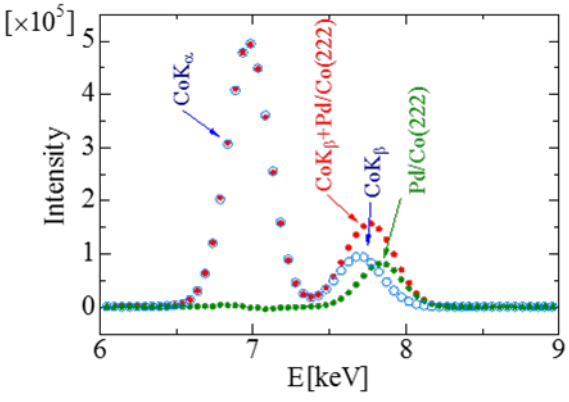

Fig. 2 Observed X-ray intensity profiles.

References

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[2] H. Shimoyama et al., Photon Factory. Activity. Report. #30 (2013) 209.
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