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Ga^+-induced changes in magnetic anisotropy of Pt/Co/Pt thin films studied by X-ray magnetic circular dichroism

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1 Introduction

Plenty of efforts have been made to realize perpendicular magnetic anisotropy (PMA) in thin films and multilayers, in view of the application to high-density magnetic recording media. Among them, the control of magnetic anisotropy by ion irradiation has attracted much interest in this decade, due to a possibility of nanostructure patterning by using a focused ion beam. In fact, a Ga^+-induced spin reorientation transition to perpendicular magnetization from an in-plane magnetized Pt/Co/Pt thin film has been reported at medium ion fluences in the 10^{14} ions/cm^2 region [1]. Although the film exhibits in-plane magnetization at higher doses, it has very recently revealed that PMA appears again at much higher ion fluences in the 10^{15} ions/cm^2 regions [2].

In the present study, we performed X-ray magnetic circular dichroism (XMCD) experiments to clarify the origin of the Ga^+ irradiation-induced changes in magnetic anisotropy of a Pt/Co/Pt thin film in a wide range of the ion fluence.

2 Experiment

Co L-edge XMCD spectra were taken at room temperature in the total-electron-yield mode at the soft X-ray undulator beamline, BL-16A. The XMCD measurements were performed in an applied magnetic field of 1.2 T in the normal and grazing incidence configurations, in which the angle between the X-ray beam and sample normal is 0 and 55°, respectively.

3 Results and Discussion

The XMCD spectra are shown in Fig. 1, and the magnetic moments are estimated by the sum-rule analysis, which are summarized in Fig. 2. A larger orbital magnetic moment of Co in the out-of-plane direction compared with that in the in-plane direction is observed at the first PMA region with medium ion fluences. This is consistent with the recent study, in which the appearance of PMA is accompanied with larger out-of-plane orbital moment and a large lattice distortion as revealed by extended X-ray absorption fine structure (EXAFS) measurements [3]. On the other hand, no significant difference in the orbital moments is found in the second PMA region with higher ion fluences, suggesting a different origin for the appearance of PMA. An EXAFS experiment at the high Ga^+ fluence region is being planned in order to clarify the lattice distortion and the degree of Co-Pt mixing, and to understand the origin of PMA.

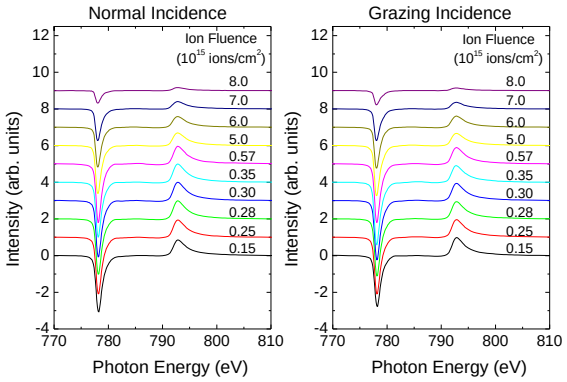

Fig. 1: Co L-edge XMCD spectra for a Pt/Co/Pt film with different ion influences.

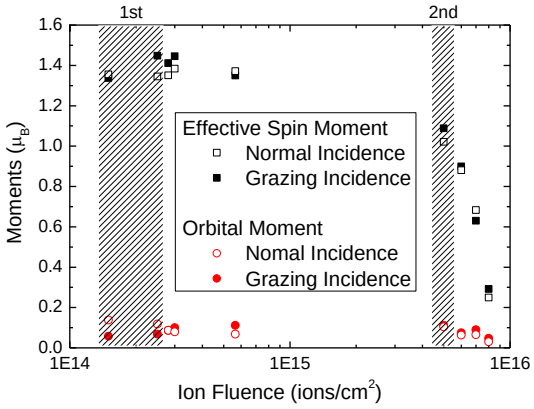

Fig. 2: Effective spin and orbital moments. Shaded areas correspond to the PMA regions.

References

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