BL-16A/2012G667,2013S2-004

Fe $L_{2,3}$-edge x-ray magnetic circular dichroism of FePt thin films with controlled $L1_0$ order

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1 Introduction

There has been increasing demand to decrease the size of and to increase the capacity for magnetic recording media. For this purpose, perpendicular magnetic anisotropy is necessary to increase the recording density. FePt with the $L1_0$ structure shows particularly strong perpendicular magneto-crystalline anisotropy and is a promising candidate material for high-density magnetic recording media because the magnetic anisotropy constant K_u of the $L1_0$–ordered FePt reaches as large as $5x10^7$ erg/cc. The degree of $L1_0$ order S in the FePt thin films can be controlled by changing the annealing temperature and time [1].

As a general property of magneto-crystalline anisotropy, Bruno [2] has proposed that K_u is proportional to the difference in the orbital magnetic moment between the in-plane and out-of-plane magnetic field directions. If $L1_0$ ordered FePt thin films follow the Bruno formula, the anisotropy of the orbital moment of Fe 3*d* electrons plays a key role in their magneto-crystalline anisotropy.

In this work, we have measured x-ray magnetic circular dichroism (XMCD) of FePt films at the Fe $L_{2,3}$ edge in order to obtain the orbital and spin magnetic moments for various directions of magnetic field from in-plane to out-of-plane.

2 Experiment

FePt thin films were fabricated on MgO (100) single crystal substrates using an ultrahigh vacuum magnetron sputtering. The stacked structure is MgO subs./Fe (1nm)/Au (30nm)/FePt (20nm)/Au(2nm). The deposition and annealing temperature (T_S and T_A) was varied in the range from room temperature to 600 °C. The composition of the FePt layer was $Fe_{43}Pt_{57}$ as determined by electron probe x-ray microanalysis. The degree of $L1_0$ order was examined by 2θ-θ scans of x-raydiffraction (XRD) with Cu-Kα radiation. The crystal orientation was also monitored by reflection high energy electron diffraction (RHEED) during the film growth.

Fe $L_{2,3}$-edge XMCD spectra were taken in the total electron yield mode at room temperature under a magnetic field of 1.0 T with changing the field direction from in-plane to out-of-plane of the film surface.

3 Results and Discussion

Figure 1 shows the XMCD intensities as functions of magnetic field direction for the FePt thin films annealed at 600 °C (S = 0.7), 500 °C (S = 0.5), 300 °C (S = 0.4), and un-annealed one (S = 0.0). The angular dependence is seen to strongly depend on the degree of $L1_0$ order S. The larger S is, the weaker the angular dependence becomes, reflecting the stronger magnetic anisotropy with the perpendicular easy magnetization axis.

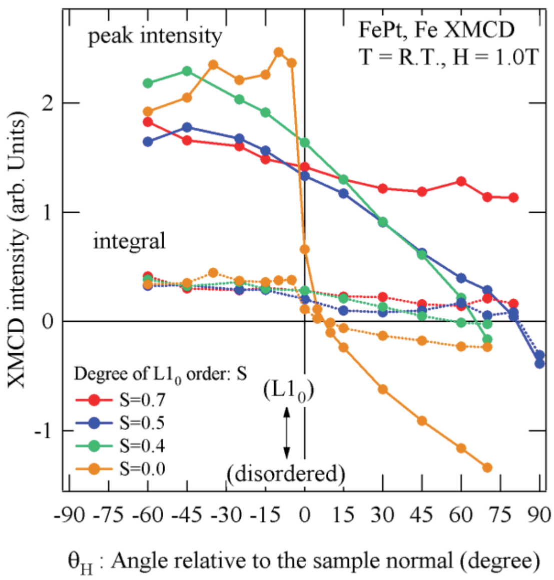

Fig. 1: Magnetic-field-direction dependence of the XMCD intensities for the FePt thin films with different degrees of $L1_0$ order. The peak intensity and the integral of XMCD are proportional to the spin magnetic moments and orbital magnetic moments, respectively, projected on the light-propagation direction.

References
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