Spontaneous Magnetic Moment of Pt in Perpendicular Magnetic Recording Media

The hard disk drive (HDD) that stores a large amount of information for computers and networks is becoming a crucial device for information technology. The essential figure of merit for the HDD is the areal density of the recorded bits on a disk, which contributes to large capacity, small size, and low cost simultaneously. At present, the areal density exceed 100 Gbits per square inch. This density corresponds to a bit area of only 80×80 nm^2. However, the areal density increase is approaching saturation due to the physical limitation of the thermal decay of recorded bits. As element permanent magnets that represent recorded bits become smaller and smaller with the areal density increase, thermal energy overwhelms the anisotropy energy that maintains the direction of recorded magnetization.

Perpendicular magnetic recording [1] is the key technology to overcome this limit. The Co/Pt multilayer film described here is one of the most promising candidate disk material for perpendicular recording, which was originally developed for magneto-optical recording [2]. It has a layered structure consisting of alternative deposited Co and Pt layers whose thicknesses are both on the subnanometer scale. The film exhibits a strong perpendicular magnetic anisotropy caused by interfacial anisotropy between the Co and Pt layers. This high anisotropy is advantageous for high-density recording disks to ensure a good thermal stability of the recorded bits. In this experiment, the study of the magnetic behavior of Pt was carried out. The Co/Pt multilayer exhibits a very high anisotropy. In particular, the magnetism of Pt at the interface of Co was studied.

The addition of Pt to Co based alloy enhances magnetic anisotropy. Therefore, Pt is widely used for disks. On the other hand, Pt addition sometimes increases media noise. Since media noise depends on film microstructure, Pt atoms may modify the magnetic grain structure. The atomic magnetic behavior of Pt is interesting from this viewpoint, as well.

Samples are prepared by sputtering deposition. The film structure is shown in Fig 1. The number of Co/Pt deposition pairs is usually more than ten; however in this experiment, one Pt film and Co film were layered. Co 15 nm in thickness was deposited without any additive elements on the Ti seed layer, followed by the deposition of Pt films of various thicknesses. The Pt thicknesses were 0.2, 0.5, 1 and 2 nm. No passivation layer was deposited on it.

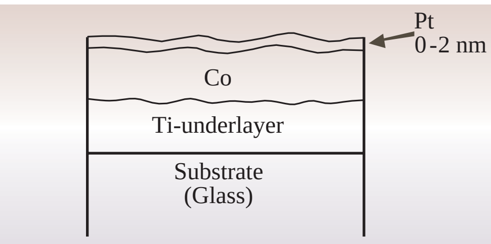

Fig. 1. Schematic of layer structure of prepared samples of Co/Pt layered disk.

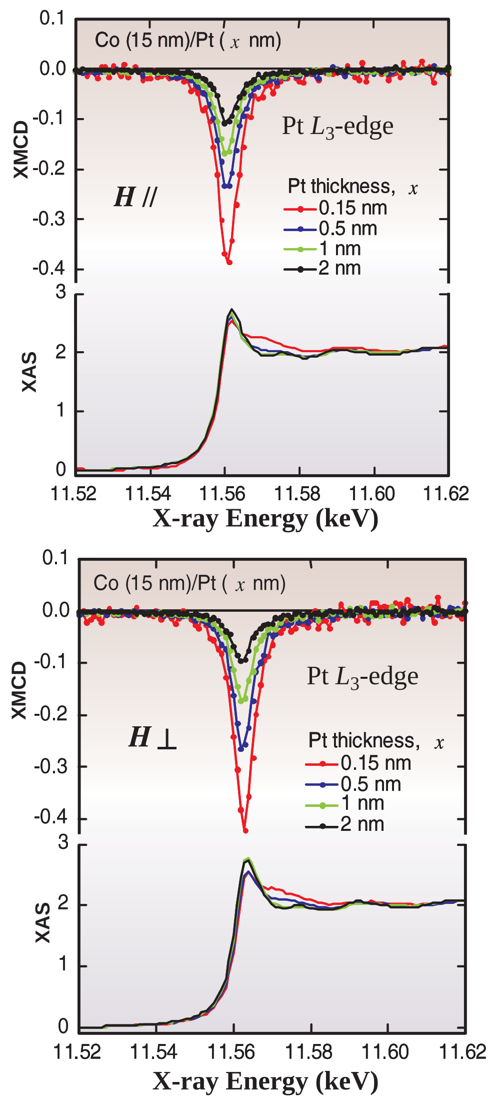

Fig. 2. XMCD spectra at the Pt L_3 edge of Pt in Co/Pt films of different Pt thicknesses, compared with spin-averaged XAS spectra. Applied fields are in-plane (upper) and perpendicular (lower).

XMCD experiments on the Pt $L_{2,3}$ edges were carried out in the fluorescence mode at beamline **BL39XU**. Monochromatic X-rays were incident on a Co/Pt sample perpendicularly to the film plane. A magnetic field was applied in the perpendicular direction to the sample plane so as to measure the perpendicular 'hysteresis loop'. The maximum field was 20 kOe to attain saturation magnetization. The M_s of Co is approximately 1420 emu/cm^3, therefore the field of 20 kOe is greater than the demagnetization field, $4\pi M_s$, that was sufficient to magnetically saturate the sample. Applied in-plane field was also measured to compare the two hysteresis loops, and to observe magnetic anisotropy. The intensities of fluorescent X-rays were detected using a silicon drift chamber, which confirms that total count rates as high as 105 cps and the efficient separation of Pt $L_{\alpha1}$ and $L_{\alpha2}$ lines from the elastic scattering mainly originate from the substrate.

Figure 2 shows the observed XMCD spectra of Co/Pt films of different Pt thicknesses for in-plane (upper) and perpendicular (lower) applied fields. The spin-averaged XAS spectra of the samples are compared in the bottom of each figure. The XMCD and XAS amplitudes were scaled per unit Pt thickness. The two sets of spectra are almost identical, which means no magnetic anisotropy of the magnetism of Pt is present. The Pt sample of 0.2 nm thickness shows the largest XMCD amplitude, which is 20% of that in the case of the XAS edge jump. XMCD amplitude decreases with increasing Pt thickness, indicating that Pt magnetization decreases with the distance from the interface with Co.

With the help of the magneto-optical sum rules, we estimated the magnetic moment of the Pt 5*d* electrons as a function of distance from the Co/Pt interface as shown in Fig. 3. The amount of magnetic moment per hole exhibits an almost exponential decay, in which the maximum number is 0.4 μ_B / hole for a Pt atom in contact with Co atoms at the interface. This spontaneous moment is close to that of Ni. The change in Pt moment m(x) with Pt thickness x was well reproduced by an exponential function, $m(x) = m_0 * \exp(-x/d)$, with a characteristic thickness d = 0.4 nm, which characterizes the effective range of hybridization between Co and Pt. The relatively large magnetic moment of Pt will affect the macroscopic magnetic characteristics such as saturation magnetization, M_s, of the Co/Pt multi-layered film.

From the viewpoint of the nanostructure of CoCrPt alloy films, the moment of Pt can adversely affect the magnetic isolation of CoCr gains. Since the Pt atoms in CoCr are not localized in grains, the polarized Pt atoms at grain boundaries magnetically connect the grains. The XMCD measurement contributes to the nanotechnology of magnetic disks.

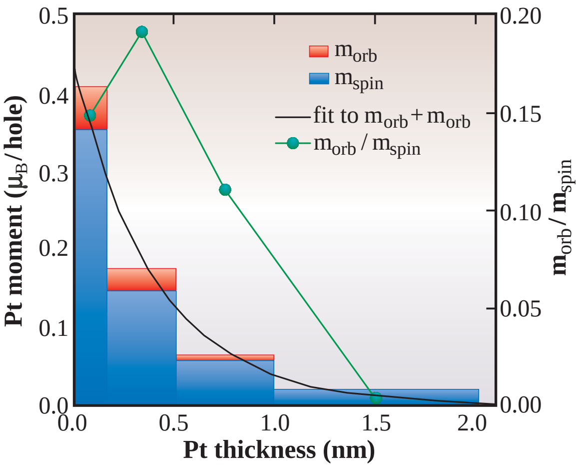

Fig. 3. Spontaneous magnetic moment of Pt atoms as a function of thickness of the Co interface. Morb (top of the bars) and Mspin (bottom of the bars) are orbit and spin moments, respectively. The black exponential decay line is the fit curve to the measurement.

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References

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