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Observation of High Coercivity in Co/Pt Multilayers

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Co/Pt 다층박막의 고 보자력화를 위한 연구

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1. Introduction

Co/Pt multilayers have been attracting wide attention because of their novel properties and potential technical applications. In Co/Pt multilayers, it was confirmed that the magnetic anisotropy energy and the Kerr rotation angle are large enough to obtain a square hysteresis loop and a good signal to noise ratio at short wavelengths (400-500 nm). However, Co/Pt multilayers have a drawback to show a small coercivity, which might yield unstability of a written domain. It is known that the coercivity in Co/Pt multilayers are sensitive to the preparation methods and parameters. In the sputtering deposition, the coercivity is strongly dependent on the preparation conditions such as the species of sputtering gas and underlayer materials[1]. In this paper, we report an enhancement of the coercivity in Co/Pt multilayer prepared on the transparent Si_3N_4 dielectric underlayer prepared onto the rotating substrate.

2. Experiment

Co/Pt multilayers were prepared by dc magnetron sputtering from 2-in-diameter Co and Pt targets at 20 mTorr Ar pressure. The individual sublayer thicknesses were 4 Å for Co and 9 Å for Pt with 10 total bilayers. Si_3N_4 dielectric underlayers were prepared by dc reactive magnetron sputtering from 2-in-diameter P-doped Si target with Ar gas including N_2 of 33 mol % at 3 mTorr. Two different conditions for the preparation of the bilayers were chosen to compare the structural and magnetic properties. For the type-I samples, both of Co/Pt multilayers and Si_3N_4 underlayers were prepared onto the rotating substrates without shielding plates and a shutters, which yielded the oblique incidence of sputtered materials. For the type-II samples, both of Co/Pt multilayers and Si_3N_4 dielectric underlayers were prepared onto the stationary substrates. The shielding plates and a stainless shutter with two target-sized holes were placed between the targets and the substrate table to prevent cross contamination and oblique incidence of the sputtered materials. The polar Kerr hysteresis loops were measured using a Kerr spectrometer at 532-nm wavelength. Structural analysis was made by x-ray diffractometery. Magnetic anisotropy was measured using a torque magnetometer at an applied field of 15 kOe. The surface morphology was investigated using an atomic force microscope (AFM).

3. Results and Discussion

Fig.1 shows the polar Kerr hysteresis loops for (4 Å-Co/9 Å-Pt)$_{10}$ multilayers on Si_3N_4 underlayers measured from the film side. Figs. 1(a) and 1(b) are the Kerr hysteresis loops for the bilayers prepared onto the rotating and stationary substrates, respectively. No noticeable change in the Kerr rotation angle can be seen in the figure, whereas the sample prepared onto the rotating substrate exhibits a large coercivity than the sample prepared onto the stationary substrate. It can be seen in the figure that the coercivity for the type-I sample is more than two-fold higher than that of the type-II sample. Some of previous works pointed out that the major origins of a high coercivity in Co/Pt multilayers are domain wall pinning effects as well as the high perpendicular anisotropy energy due to the sharp interfaces. To clarify the enhanced coercivity in our study, we have examined the surface morphologies of Si_3N_4 underlayers prepared under two different conditions. It could be seen that the surface of the type-I is generally rougher than the type-II. The enhancement of surface roughness would occur for oblique deposition owing to the shadowing of the neighboring area by the growing microstructures[2]. Since more pinning sites are expected in the sample prepared on the rough underlayer, a higher coercivity in the type-I sample than the type-II sample seems to be caused by enhanced domain wall pinning effects in type-I sample.

4. Conclusion

We have observed a considerably high coercivity in Co/Pt multilayer on Si_3N_4 dielectric underlayer. The coercivity in Co/Pt multilayer on Si_3N_4 underlayer prepared onto the rotating substrate was more than two-fold larger than that of the stationary substrate. It was observed that the surface of Si_3N_4 underlayer prepared onto the rotating substrate was rougher than that of Si_3N_4 underlayer deposited onto the stationary substrate. We believe that an increase of the coercivity in the bilayers prepared onto the rotating substrates is mainly ascribed to the enhancement of domain wall pinning effects due to the surface roughness of Si_3N_4 underlayer.

References

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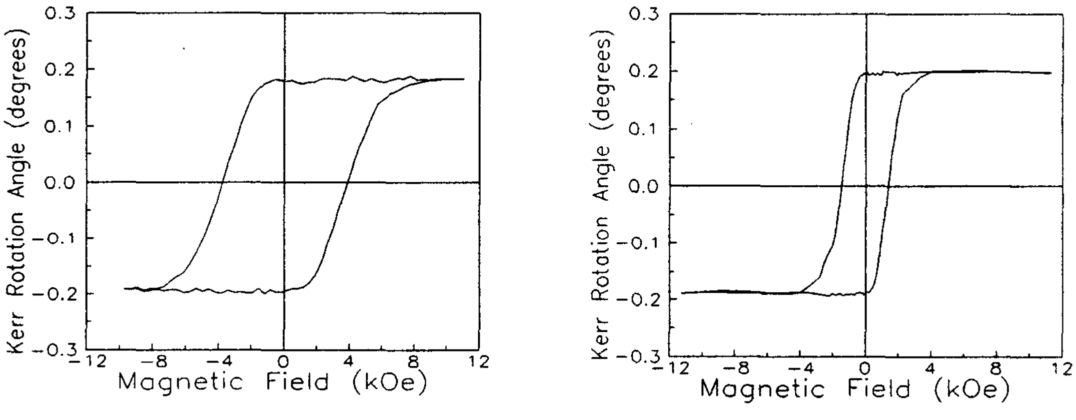

(a) (b)

Fig. 1. Kerr hysteresis loops for the bilayers consisting of (4 Å-Co/9 Å-Pt)$_{10}$ multilayer on Si_3N_4 underlayer prepared onto (a) rotating and (b) stationary substrates.