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ORIGINS OF PERPENDICULAR MAGNETIC ANISOTROPY IN Ni/Pd MULTILAYER FILMS

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Ni/Pd 다층박막에서 수직자기이방성의 원인

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I. INTRODUCTION

The magnetic properties of magnetic multilayer films are of great interests both from fundamental and technological applicability purposes. Ni-based multilayers have been reported to show in-plane anisotropy at room temperature and a theoretical investigation by Gay and Richter has also predicted in-plane anisotropy for monolayer Ni. However, very recently Shin *et al.* [1] has observed room-temperature PMA in Ni/Pt multilayers and it was claimed that stress-induced magnetoelastic anisotropy was a major origin for the observed PMA in this system. In this study we report room-temperature PMA in Ni/Pd multilayer films and investigate the contribution of magnetoelastic anisotropy.

II. EXPERIMENT

Ni/Pd multilayer films were prepared on corning glass substrates of 130-㎛ in thickness by sequential dc magnetron sputtering of Ni and Pd at an Ar sputtering pressure of 7 mTorr. Typical deposition rates, obtained under an applied power of 30 W to each target, were 1.0 Å/s and 3 Å/s for Ni and Pd, respectively. Stress and magnetostriction coefficient of Ni/Pd multilayer films were obtained using a optical fiber lever sensor which could detect the displacement caused by a sub-monolayer deposition[2].

III. RESULTS AND DISCUSSION

The torque measurements of Ni/Pd multilayer films revealed that the samples with the Ni sublayer thickness less than about 11 Å had perpendicular magnetic anisotropy. A typical torque curve of $(5.1\text{-Å Ni}/5.7\text{-Å Pd})_{30}$ multilayer having PMA is demonstrated in Fig. 1, together with a torque curve for an in-plane anisotropy sample of $(20.2\text{-Å Ni}/5.7\text{-Å Pd})_{30}$ multilayer.

In situ stress measurements revealed that stress in Ni sublayer was tensile in all samples and inversely proportional to the Ni sublayer thickness. This result indicates the incoherent growth of Ni sublayer on Pd sublayer due to a large misfit of 9.5% in the (111) matching planes of Ni and Pd. The magnetostriction coefficient of the samples was negatively increased from -0.7×10^{-5} to -2.0×10^{-5} with increasing the Ni sublayer thickness.

Using the phenomenological model, we have quantitatively determined K_d, K_λ, and K_s, as shown in Fig.2. Assuming that K_c had a bulk Ni value of 4.5×10^4 erg/cm^3, the surface anisotropy determined from a linear fitting of $K_u t$-t plot was 0.03 erg/cm^2, which was by a factor of 10 smaller than a typical value observed in Co- or Fe-based multilayers. The magnetoelastic anisotropy, determined from the measurements of stress and magnetostriction coefficient was $2.8-4.2\times10^5$ erg/cm^3. It is clearly noticed that the surface anisotropy alone could not overcome a negative contribution of the shape anisotropy to yield PMA in our Ni/Pd multilayer films. Therefore, it could be concluded that the positive magnetoelastic anisotropy play a significant role to have a PMA for Ni/Pd multilayer films in addition to the positive surface anisotropy.

VI. CONCLUSIONS

We have observed the room temperature perpendicular magnetic anisotropy for Ni/Pd multilayer films by suitable choice of the Ni- and Pd-layer thicknesses. Using the phenomenological model magnetic anisotropy was analyzed quantitatively by the measurements of each sources of anisotropy. From this analysis we have found that the perpendicular magnetic anisotropy for Ni/Pd multilayer films were originated from the positive magnetoelastic anisotropy and positive surface anisotropy.

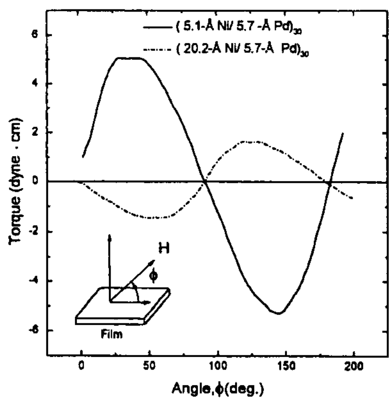

Fig. 1. Torque curves of $(5.1\text{-Å}\ /5.7\text{-Å}\ Pd)_{30}$ and $(20.2\text{-Å}\ /5.7\text{-Å}\ Pd)_{30}$.

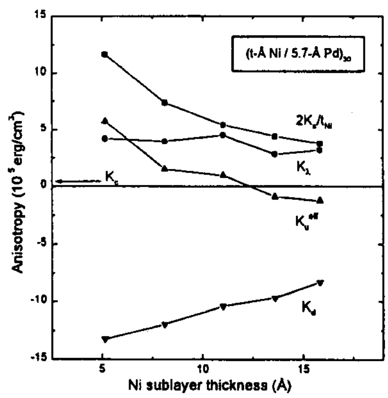

Fig. 2. K_u^{eff}, K_d, K_λ, and $2K_s/t_{Ni}$ as a function of Ni sublayer thickness together With K_c.

V. REFERENCES

[1] S.-C. Shin, G. Srinivas, Y.-S. Kim, and M.-G. Kim, Appl. Phy. Lett. 73, 393 (1998).

[2] Y.-S. Kim and S.-C. Shin, Thin Solid Films **258**, 128 (1995).