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Co_xPd_y 합금박막에 있어서 수직자기이방성의 구조적 원인

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Structural Origin of Perpendicular Magnetic Anisotropy in Evaporated Co_xPd_y Alloy Films

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I. INTRODUCTION

Since the striking experimental discovery of the perpendicular magnetic anisotropy in Co/Pd[1] and Co/Pt[2] multilayer films, there have been extensive studies on application of the multilayers as magneto-optical recording materials. However, the Co layer thickness of Co/Pd and Co/Pt multilayer should be less than several atomic monolayers to have perpendicular magnetic anisotropy. This limits the practical application of multilayer system.

Later, the perpendicular magnetic anisotropy was found in alloy films, CoPd[3] and CoPt[4], as well. CoPt[4] alloy films have large perpendicular magnetic anisotropy and 100% remanence, and high coercivity, comparable to those in Co/Pd and Co/Pt multilayers. Thus, the alloy films are better candidates for magneto-optical recording media than multilayer films. Many researches have been made to setup relationships between film composition, preparation condition, microstructure and magnetic properties. However, the origin of intrinsic perpendicular anisotropy in the alloy has not been understood due to inadequate structural informations, and its origin is still not understood.

The authors have investigated the Co-Co and Co-Pd interatomic distances(R) in both directions, perpendicular and parallel to the film surface, using polarization-dependent Extended X-ray Absorption Fine Structure (EXAFS).

II. EXPERIMENTS

Co_xPd_y alloy films were deposited on silicon substrate by co-evaporation from in high vacuum chamber (base pressure of 2×10^{-7} mbar). The compositions were confirmed to be within 5% by x-ray photoelectron spectroscopy. The deposition rate were held at < 0.1 Å /sec to keep compositional uniformity through total thickness of the films. The hysteresis loops were measured by a vibrating sample magnetometer. X-ray absorption spectra were measured on the EXAFS beam line at the VEPP-3 storage ring (the Siberian Synchrotron Center of the Budker Institute of Nuclear Physics). The data were recorded at room temperature using the Co K_α fluorescence yield as a measure of absorption in a polarization-dependent geometry.

III. RESULTS AND DISCUSSION

Figure 1 shows the hysteresis loops of Co_xPd_y alloy films, measured in the magnetic field perpendicular to the film surface. Figure 2 shows the radial distribution function's (RDF's) extracted from EXAFS's of the alloy films. The fitting results are summarized in Table I.

Table I. Best fit values of Co-Co nearest neighbor obtained from the model standards.

Sample	out-of-plane		In-plane atoms	
	R (Å)	$\Delta\sigma^2$	R (Å)	$\Delta\sigma^2$
Co_1Pd_1	2.53	0.022	2.46	0.019
Co_1Pd_3	2.52	0.026	2.59	0.015
Co_1Pd_5	2.49	0.025	2.62	0.011
Co_1Pd_3 + Pd under.	2.52	0.019	2.68	0.012
(Co_1Pd_3+ Pd)×10	2.43	0.020	2.63	0.012

The Co-Co interatomic distances are very different between in-plane and out-of-plane atoms. The authors believe that the physical-vapor-deposition process induces tensile stress between in-plane Co atoms. As a natural consequence of Poisson response, there should be compressive strain in normal direction.

Figure 3 show the negative large magneto-striction coefficients as a function of Co concentration in [111]-textured Co_xPd_y alloy films. Hence then, the origin of perpendicular magnetic anisotropy in Co_xPd_y is mainly attributed to the magnetoelastic contribution of Co atoms due to the growth-induced tensile strain of Co atoms in the film plane and [111] texture. The [111] texture of samples is confirmed by x-ray diffraction study.

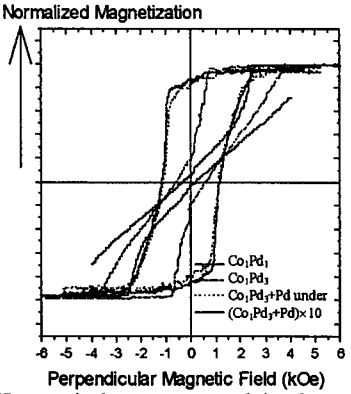

Fig. 1. Hysteresis loops measured in the magnetic filed perpendicular to the film plane for CoPd alloy films.

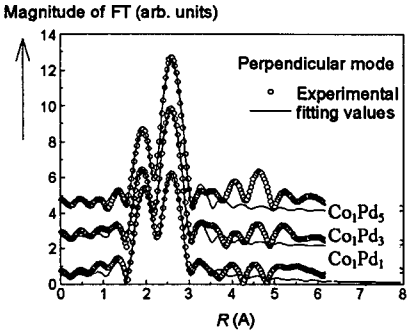

Fig. 2. Examples of RDF's extracted from fluorescence EXAFS.

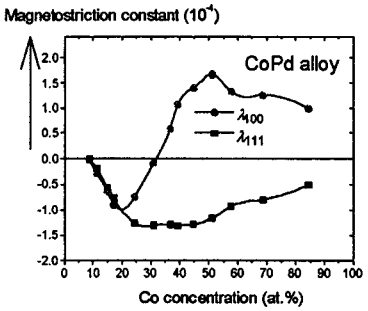

Fig. 3. Magnetostriction coefficients of CoPd alloy films versus Co concentration. (redrawn from reference [5])

IV. CONCLUSIONS

CoPd alloy films show the perpendicular magnetic anisotropy which varies with Co concentration. The large perpendicular anisotropy are mainly attributed by the magnetoelastic contribution, that is, large negative magnetostriction constants λ_{111}, and the growth-induced [111] texture and tensile strain in the film plane.

V. REFERENCES

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