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Co/Pd 다층박막에 있어서 수직자기 이방성의 원인

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Source of Perpendicular Magnetic Anisotropy in Co/Pd Multilayer Thin Films

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I. INTRODUCTION

There has been much effort made toward a scientific goal to find source of the intrinsic uniaxial perpendicular anisotropy in Co/Pd and Co/Pt multilayers having large perpendicular magnetic anisotropy used as magneto-optical recording media[1-3]. Properties such as magnetic anisotropy have been shown to depend remarkably on both the layer thickness and the interface structure.

Since the interesting discovery of Co/Pd multilayer system with the perpendicular anisotropy in 1985[4], the large perpendicular anisotropy has been explained by the interfacial anisotropy in terms of Neel's type-surface anisotropy[5] in the early period. Later, Co/Pd and Co/Pt multilayers having different principle crystallographic orientation have been epitaxially grown[2,3] by Molecular Beam Epitaxy method to find that the orientation of multilayers effectively contributes the perpendicular anisotropy. In addition, magnetoelastic coupling term has been believed as an alternative source in various systems with a large lattice mismatch[6].

However, to obtain direct evidence for the sources of perpendicular anisotropy, the detailed structural information such as static strain and interface structure should be extracted depending on the Co layer thickness prior to other magnetic properties. Therefore, in the present study, polarization-dependent Extended X-ray Absorption Fine Structure (EXAFS), which is an excellent tool to study a locally anisotropic environment of an absorbing atom, is employed to investigate an average number of different surrounding atoms (N), their distance (R) to the absorbing atoms, the spatial fluctuation (σ^2) of distances in both directions, parallel and perpendicular to the film plane. The purpose of this study is to investigate the distances and coordination numbers of nearest neighbors in both directions, especially for Co/Pd multilayer systems with Co layer thickness of less than ~ 6 Å.

II. EXPERIMENTS

Co/Pd multilayer films were prepared by alternating the deposition in high vacuum chamber (base pressure of 2×10^{-7} mbar). The deposition rate was held at < 0.3 Å /sec to eliminate fluctuation in the layer thicknesses. 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. The x-ray scattering was carried out to confirm the multilayer structure and to determine the layer thickness in low- and high-angle regions.

III. RESULTS AND DISCUSSION

Figure 1 shows a series of hysteresis loops of multilayer films measured under a magnetic field perpendicular to the film surface. For ~3 Å-thick Co layer, the squareness of hysteresis loop is almost perfect.

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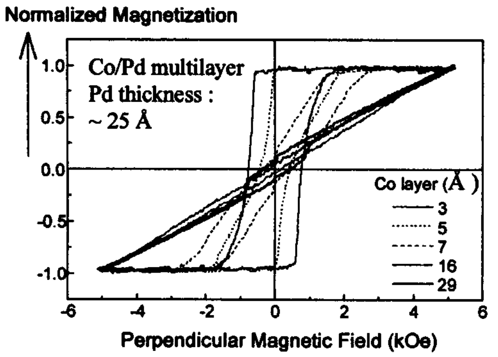

Fig. 1. Magnetic hysteresis loops for Co/Pd multilayers under an applied field perpendicular to the film plane.

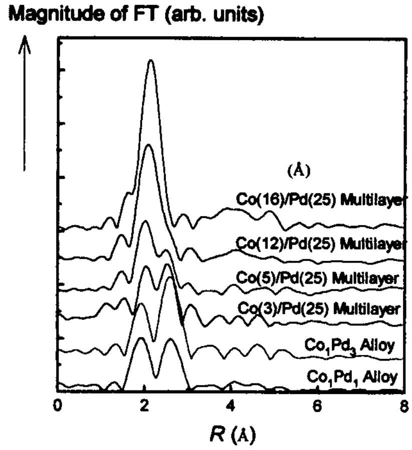

Fig. 2. RDFs of Co/Pd multilayers and Co_xPd_y alloy films. The radial distances are not corrected for phase shifts.

Figure 2 shows the radial distribution functions (RDFs) extracted from EXAFS's of multilayers, compared with those of Co_xPd_y alloy films. In a direct comparison, the shape of RDF for ~3 Å-thick Co layer is very similar to that of Co_1Pd_1 alloy film. It is believed that there are intermixing regions between Co and Pd layers corresponding to alloy phase. In addition, in-plane Co atoms expand under tensile strain to large extent whereas out-of-plane Co ones are under compressive strain by Poisson response. The dependence of the strain and coordination number on the Co layer thickness will be discussed from the fitting results later.

Figure 3 show the magnetostriction coefficient vs. bilayer thickness of sputtered [111]-textured Co/Pd multilayer films. As the bilayer thickness decreases, the magnetostriction constant becomes close to an alloy film with corresponding concentration. Thus, the effective perpendicular anisotropy of multilayers is believed to be contributed by two phases : intermixing region (alloy phase) and Co layer (similar with bulk phase). Finally, Co/Pd multilayer with an extremely small thickness of Co layer (less than ~4 Å) has a large perpendicular anisotropy due to the magnetoelastic anisotropy employed from interface region (alloy phase), which may profoundly influence the entire film. This contribution also arises from large tensile strain in the film plane

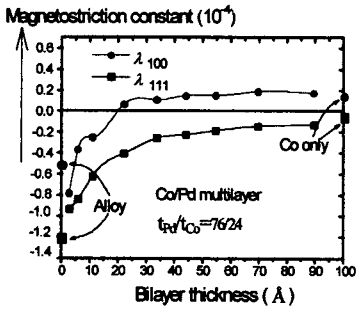

Fig. 3. Magnetostriction coefficients as a function of bilayer thickness for Co/Pd multilayers (Redrawn from reference [7])

IV. CONCLUSIONS

The multilayer system is made up of repetition of interfaces and individual layers. In particular, as the layer thickness decreases, the properties are dominated by interface structure. Thus, the perpendicular anisotropy is dominated by the magnetoelastic anisotropy of Co atoms caused by tensile strain within interface region in which Co atoms are embedded into Pd matrix.

V. REFERENCES

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