A-1

한국과학기술원 스핀정보물질연구단 및 물리학과
김상국,* 이정원, 정종률, 김종걸, 신성철

Magnetic anisotropy engineering via magnetoelastic coupling in ultrathin Co_xPd_{1-x} alloy films

Korea Advanced Institute of Science and Technology
Sang-Koog Kim,* Jeong-Won Lee, Jong-Ryul Jeong, Jonggeol Kim, and Sung-Chul Shin

1. INTRODUCTION

Spin-reorientation transition (SRT) in ultrathin magnetic films, driven by the thickness of magnetic layers, has attracted much attention over the past decade. It has been well known that the SRT behavior is associated with the energy balance between magnetocrystalline anisotropy modified at the interfaces and/or magnetoelastic anisotropy (MEA), and its competing shape anisotropy. The novel phenomenon has also drawn technological interests because it is applicable to ultrahigh-density information storage. However, controllability and reversibility of the spin switching have not been studied although they are of great importance in magnetic memory devices from a technological point of view.

In the present work, we report smoothly continuous SRT's from the in-plane to perpendicular orientation with increasing the thickness of Pd overlayer directly deposited on ultrathin Co_xPd_{1-x} alloy films. We also report on repeatable transitions in reversible ways between in-plane and perpendicular directions in compositionally modulated films. Oscillatory changes in the easy magnetization axis are clearly confirmed by *in situ* surface magneto-optical Kerr effects (MOKE) measurements during alternate depositions of the individual Co_xPd_{1-x} and Pd layers.

2. EXPERIMENT

The samples studied here are Si(111)/Pd(5 nm)/Co_xPd_{1-x}(3 nm)/Pd (t_{Pd}) and Si(111)/Pd(5 nm)/[Co_xPd_{1-x}(1.5 nm)/Pd(1.0 nm)]$_3$. The individual Co and Pd layers were grown with separate *e*-beam evaporators, while the alloy layers were prepared by co-deposition of Co and Pd. X-ray diffraction study confirmed a highly (111)-oriented polycrystalline structure. The p-polarization MOKE signals were *in situ* measured upon individual depositions of the alternate layers at the deposition position in the same growth chamber. The MOKE measurement system was specially designed to simultaneously measure both the Kerr rotation and ellipticity signals for a magnetic field *H* applied along the film plane (*y*-axis) and normal (*z*-axis), where the laser light was incident at 45° from the film plane. Details of the MOKE setup were described elsewhere[1].

3. RESULTS AND DISCUSSION

Smooth SRT's from the in-plane to normal-to-plane direction in Co_xPd_{1-x} alloy films with increasing Pd overlayer thickness, t_{Pd}, are observed as seen in Fig. 1. These results show that the SRT is a second-order transition (SOT) in spin reorientation. Magnetoelastic coupling term Γ plays a crucial role in such behavior via its contribution to the 4th- as well as 2nd-order anisotropy constants [2]. The nature of SOT is determined by $-\Gamma_4/\Gamma_2$ in conjunction with lattice-misfit strains. It is also found that reversibly oscillatory switches between in-plane and out-of-plane directions can be driven by a deliberate strain modulation [3].

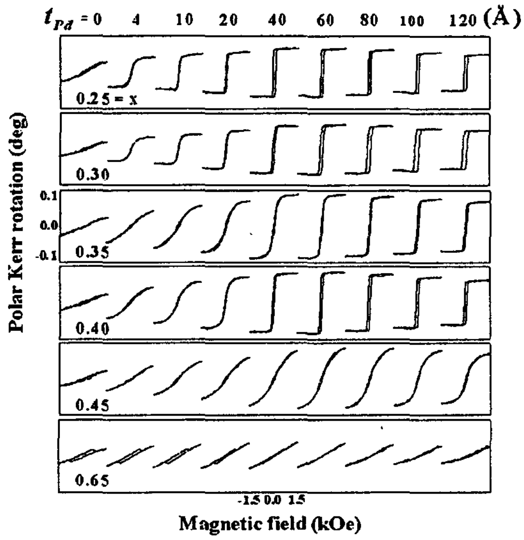

FIG. 1. Polar Kerr rotation loops versus the thickness of Pd overlayer for each x as noted. Polarity of the loops is reproduced to make the rotation angle positive (negative) at +(-) magnetic field H.

4. CONCLUSIONS

Spin engineering established in the present work provides the ability to readily engineer spin orientation in reversible ways from the in-plane to perpendicular direction and vice versa. The observed SRT behavior is likely to originate from the dependence of the misfit strains of magnetic layers on the individual layer thickness through the magnetoelastic origin.

*This work was supported by the Korean Ministry of Science and Technology through the Creative Research Initiatives Project.

5. REFERENCES

[1] J.-W. Lee, J.-R. Jeong, D.-H. Kim, J.-S. Ahn, J. Kim, and S.-C. Shin, Rev. Sci. and Inst. **71** (2000)

[2] S.-K. Kim, J. Kim, and S.-C. Shin, Phys. Rev. B (2001), (to be published).

[3] S.-K. Kim, J.-W. Lee, J.-R. Jeong, J. Kim, S.-C. Shin, Appl. Phys. Lett. 79, 1652 (2001).