Investigation of composition dependence on the exchange anisotropy in Pt$_x$Mn$_{1-x}$/Co70Fe30 Films

Sina Ranjbar$^1$, Masakiyo Tsunoda$^2$, Mikihiko Oogane$^1$, Yasuo Ando$^{1,3}$

$^1$Ranjbar.sina.t2@dc.tohoku.ac.jp

$^1$Department of Applied Physics, Tohoku University, Sendai 980-8579, Japan

$^2$Department of Electronic Engineering, Tohoku University, Sendai 980-8579, Japan

$^3$Center for Science and Innovation in Spintronics (Core Research Cluster) Organization for Advanced Studies

Exchange bias (EB) can be observed by the exchange coupling between the magnetic moments of an antiferromagnet (AFM) and those of a ferromagnet (FM) at an AFM/FM interface [1,2]. There are many reasons to choose AFM materials for instances: the large exchange-biasing field, the high blocking temperature at which the exchange-biasing disappears, good corrosion resistance, minimal critical thickness, and surface flatness [3,4]. In this study we systematically investigated the exchange anisotropy for ferromagnetic Co$_{70}$Fe$_{30}$ and antiferromagnetic Pt-Mn bilayer films by Co-sputtering method. We focused on the relevance between the exchange bias and the composition of the Pt$_x$Mn$_{1-x}$ (14 < x < 22 and 45 < x < 56 at %) films, and we successfully optimized the composition. The crystal structure of the Pt$_x$Mn$_{1-x}$ films was FCC for 14 < x < 22 at % and FCT for 45 < x < 56 at % after annealing at 370°C for 6 hours. The unidirectional anisotropy constant ($J_k$) for fcc-Pt$_{15}$Mn$_{85}$ (20 nm) and fct-Pt$_{48}$Mn$_{52}$ (20 nm) prepared under optimum conditions in composition were 0.16 and 0.20 erg/cm$^2$, respectively. In addition, to optimize the annealing temperature of the respective optimum compositions (Pt$_{48}$Mn$_{52}$, Pt$_{15}$Mn$_{85}$), we need to investigate the changes of $J_k$ value as a function of annealing temperature. Both Pt$_{15}$Mn$_{85}$ and Pt$_{48}$Mn$_{52}$ films showed a larger unidirectional anisotropy constant ($J_k$) than in other reports for the bilayer system that uses Pt-Mn antiferromagnetic layer. They also showed a flatter surface than that of other antiferromagnetic/ferromagnetic materials, which is suitable to avoid unexpected interlayer coupling in spin-valve structure. The obtained Pt-Mn films with a large exchange anisotropy and slight roughness are useful as an antiferromagnetic layer in spintronic applications.

Key words: antiferromagnetic material, PtMn thin film, exchange anisotropy