# 負の超磁歪を有する垂直磁化アモルファス $SmFe_2$ 薄膜

## Amorphous $SmFe_2$ thin films with giant negative magnetostriction and perpendicular magnetic anisotropy

東工大工学院 (M2)冨田 誠人, (B)石山 栞, 石谷 優剛, ○高村 陽太, 中川 茂樹

Tokyo Tech, Masato Tomita, Shiori Ishiyama, Yugo Ishitani, °Yota Takamura, Shigeki Nakagawa

E-mail: takamura@ee.e.titech.ac.jp

Strain-assisted magnetization reversal (SAMR) using inverse magnetostriction (IMS) magnetic tunnel junctions (MTJs) has possibility to reduce energy consumption during the magnetization switching [1]. The magnetostrictive free layer of our proposed IMS-MTJs needs to have perpendicular magnetic anisotropy (PMA) and large, negative magnetostrictive constant $\lambda$. $SmFe_2$ is promising as such a material since $SmFe_2$ is well-known materials with large, negative magnetostriction constant $\lambda$. In addition, some amorphous rare earth transition metal (RE-TM) alloys have been reported to show PMA [2]. In this paper, we systematically investigated magnetic anisotropy and magnetostriction of sputtered $SmFe_2$ films.

All the films were prepared with a facing targets sputtering system. The stack structure was quartz-substrate/W (20 nm)/$Sm_{1.05}Fe_2$ (100 nm)/W (10 nm). The substrate temperature $T_S$ during sputtering varied from RT to 400˚C and post annealing temperature $T_A$ also varied from 300˚C to 600˚C. X-ray diffraction analysis showed that all of $Sm_{1.05}Fe_2$ films had amorphous structure.

Figure 1 shows *M-H* curves for a typical $Sm_{1.05}Fe_2$ thin film exhibiting PMA. The difference between perpendicular and in-plane magnetic anisotropy energy density, $\Delta K$, of the sample was determined to be 0.17 Merg/cc. We have found that $Sm_{1.05}Fe_2$ thin films formed at $T_S$ below 200˚C and annealed at $T_A$ above 500˚C showed clear PMA as indicated in Fig.1.

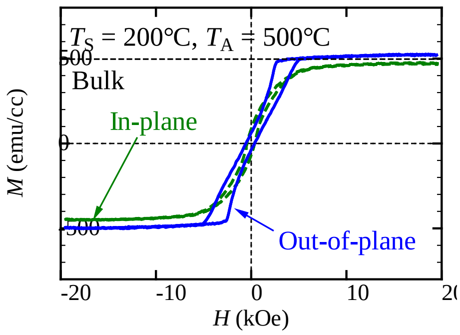

Fig. 1. M-H loops of a $Sm_{1.05}Fe_2$ thin film with $T_S$ = 200˚C and $T_A$ = 500˚C

Demagnetization curves in the first quadrant under various applied pressures was shown in Fig. 2. The sample exhibited the inverse magnetostrictive effect with negative $\lambda$ as magnetization energy reduced by compressive stress and increased by tensile stress. $\lambda$ was estimated to be −920 ppm.

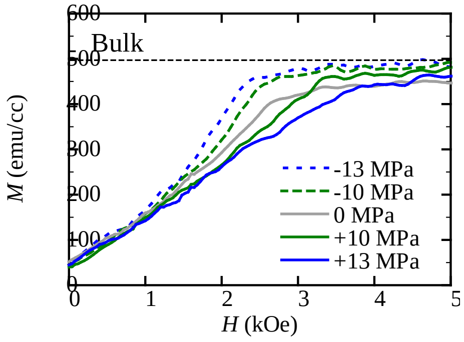

Fig. 2. Demagnetization curves with various applied pressures for the $Sm_{1.05}Fe_2$ thin film with $T_S$ = 200˚C and $T_A$ = 500˚C

From these results, amorphous $Sm_{1.05}Fe_2$ thin films exhibited both of large, negative $\lambda$ and PMA, and are promising as the free layer of IMS-MTJs for ultra-low power STT-MRAM.

[1] Y. Takamura, *et al.*, *Sol. St. Elec.*, **128**, 376 (2017).

[2] V. G. Harris, *et al.*, *Phys. Rev. Lett.*, **69**, 1939 (1992).