Perpendicular magnetic anisotropy of $Co_2Fe_xMn_{1-x}Si$ Heusler alloy ultrathin-films

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Introduction

For the development of MRAM devices with a giga-bit class memory capacity, it is required to reduce critical current density J_{c0} and to get high thermal stability factor over 60. To fulfill these requirements, magnetic thin films with high perpendicular magnetic anisotropy (PMA) are essentially required for the magnetic electrodes of the MTJs.

There are many researches about perpendicular magnetized thin films for magnetic tunnel junctions (MTJs). Among the PMA materials, Heusler alloys with an interfacial PMA are attractive because they are half-metallic and can exhibit high output power when being used in MTJs. There have been reported several previous works on PMA-Heusler alloys[1, 2]. However, systematic investigations such as on material compositions are still needed. In this research, we investigated the Fe composition and the layer thickness dependence of the PMA in $Co_2Fe_xMn_{1-x}Si$ (CFMS) Heusler alloy ultrathin films.

Experimental Procedures

Stacking structure of the samples were MgO (100) substrate/Cr (40 nm)/Pd (10 nm)/$Co_2Fe_xMn_{1-x}Si$ (t_{CFMS})/MgO (2 nm)/Ta (5 nm). The $Co_2Fe_xMn_{1-x}Si$ (CFMS) layer was deposited at room temperature and *in situ* annealing was performed at 400ºC. Fe compositions of the CFMS layer, x were 0, 0.5, and 1. And the thicknesses of the CFMS layer, t_{CFMS} were 0.6, 0.8, 1.0, 1.2, and 1.4 nm. Fabricated films including the ultrathin CFMS layer were measured by a polar magneto optical Kerr effect (p-MOKE) and a superconducting quantum interface device (SQUID).

Results and Discussion

Perpendicularly magnetized film was achieved when the thickness was 0.6 and 0.8 nm for the Co_2MnSi and the $Co_2Fe_{0.5}Mn_{0.5}Si$ samples; and for a case of the Co_2FeSi, the film exhibited perpendicular magnetization only when the thickness was 0.6 nm. Figure 1 shows the product of uniaxial anisotropy energy (K_u) and thickness of the CFMS film (t) for the $Co_2Fe_{0.5}Mn_{0.5}Si$ samples. The results can be fit by a linear function as shown in the figure. From the interception of the linear dependence, the value of interface anisotropy (K_s) is deduced. It is about 1.3 ± 0.8 erg/cm^2 which is comparable to the reported value of the Co_2FeAl films[1]. The value of K_s for other compositions will be shown and will be discussed at the presentation.

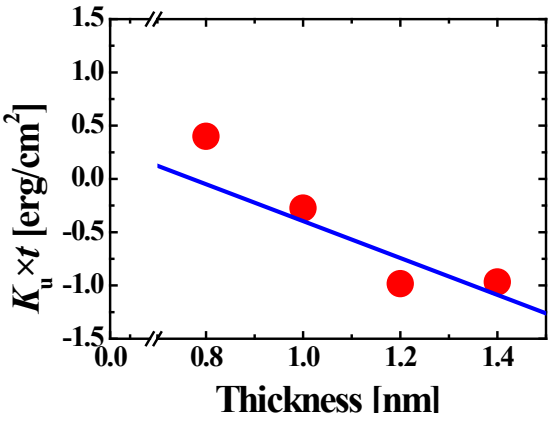

Figure 1. Thickness (t) dependence of the product of $K_u \times t$.

Reference

1) Z. Wen *et al*., Appl. Phys. Lett. **98**, 242507 (2011).
2) Y. Cui *et al*., Appl. Phys. Lett. **102**, 162403 (2013).