Fabrication of highly (001)-oriented $Co_2Fe_{0.4}Mn_{0.6}Si$ Heusler alloy thin films deposited on thermally oxidized Si substrate

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Magnetic tunnel junctions (MTJs) with polycrystalline $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) full Heusler alloy is a promising device for highly sensitive magnetic field sensor application, because polycrystalline CFMS films are expected to possess both high spin polarization and low magnetic anisotropy. However, tunnel magneto-resistance (TMR) ratio of 72 % in MTJs with polycrystalline CFMS electrodes was slightly lower than that of 103% in MTJs with epitaxial CFMS electrodes [1]. Low (001)-orientation in polycrystalline CFMS films is a possible reason for the observed small TMR ratio. In this study, we have fabricated highly (001)-oriented polycrystalline CFMS films by optimization of MgO buffered layers.

The stacking structures of buffer layer were $Si/SiO_2/MgO(20)$, $Si/SiO_2/Ta(5)/Co_{40}Fe_{40}B_{20}(5)/MgO(20)$, and $Si/SiO_2/Ta(5)/Co_{40}Fe_{40}B_{20}(5)/Mg$ (0.2 - 1.2)/MgO(20) (unit in nm). All films were prepared by ultra-high vacuum magnetron sputtering system. The Ar sputtering gas pressure for MgO layer preparation was varied from 0.05 to 0.36 Pa. The CFMS (50 nm) films were prepared on the MgO buffer layers above mentioned and the films were annealed at 700℃. The structural and magnetic properties of prepared films were measured by XRD and VSM. The surface morphology was investigated by AFM.

We confirmed from XRD measurements that MgO buffer layers had (001)-orientation in all the stacking structures, however, FWHM of rocking-curves for the (001)-peak were significantly different depending on the stacking structures. The MgO layers prepared on the Ta/CoFeB/Mg layers showed the highest (001)-orientation, and a minimum FWHM of the (001)-peak was 2.8° . The Ta/CoFeB is well known as buffer layer to grow (001)-oriented MgO layer [2]. In addition, very thin Mg layer inserted into the CoFeB/MgO interface prevented oxidation of the surface of the CoFeB layer. As a result, highly (001)-oriented MgO buffer layers on Ta/CoFeB/Mg were obtained. Figure 1 shows the FWHM of rocking curves for the CFMS films grown on the MgO buffer layers showing various FWHM of rocking curve. We have successfully fabricated highly (001)-oriented CFMS films on the highly oriented Ta/CoFeB/Mg/MgO buffer layers. This work was supported by the S-Innovation program, Japan Science and Technology Agency (JST).

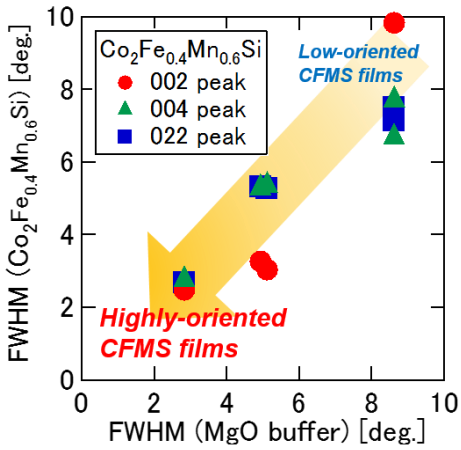

Fig. 1 FWHM of rocking curves for MgO buffer layers and CFMS layers

[1] 第 75 回応用物理学会秋季学術講演会 19a-S2-10
[2] S. Ikeda, *et al.*, Appl. Phys. Lett. **93**, 082508 (2008)