Effect of oxygen exposure at Co_2FeSi/MgO interfaces on perpendicular magnetic anisotropy of Co_2FeSi layer

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Perpendicular magnetic anisotropy (PMA) induced at MgO/ferromagnetic(FM)-materials-interface[1] has been attracted considerable attention, since they are very useful to apply perpendicular magnetic tunnel junction (MTJ). It is considered that the hybridization between Fe 3d and O 2p orbitals plays an important role to induce PMA at MgO/FM interface.[2,3] Recently, we reported that MgO-induced PMA was obtained in half-metallic ferromagnetic full-Heusler Co_2FeSi (CFS) alloy thin films.[4] In this work, we demonstrated that the PMA induced at the CFS/MgO interface system was changed by exposing the CFS surface to O_2.

Multilayer-stack-structure of Cr(40 nm)/Pd(40 nm)/CFS(1 nm) were prepared on an MgO (100) single crystaline substrate using facing targets sputtering (FTS) system at the base pressure below 5.0×10^{-5} Pa with Ar sputtering gas at room temperature. After the deposition of the CFS layer, oxygen exposure process was carried out in the chamber for 10 min. An oxygen exposure amount was varied from 0 to 9.0 ML (Mega Langmuir). Subsequently, MgO(2 nm) layers were deposited by RF-sputtering from MgO targets. Ta was formed as a capping layer. All the layers without the MgO layers were deposited by DC sputtering.

Figures 1(a)-(c) show magnetization characteristics of the ultrathin CFS/MgO layers with O_2-exposure-amount of (a) 0 ML, (b) 0.9 ML and (c) 9.0 ML, respectively. PMA was obtained above 0.9 ML and was enhanced by increasing O_2-exposure-amount. Roughly estimated PMA energy density (K_u) increased with increasing O_2-exposure-amount. This result suggests that the increments of combination between Fe and O causes enhancement of PMA. We will discuss PMA quantitatively and show analysis of binding state using X-ray photoelectron spectroscopy (XPS).

References

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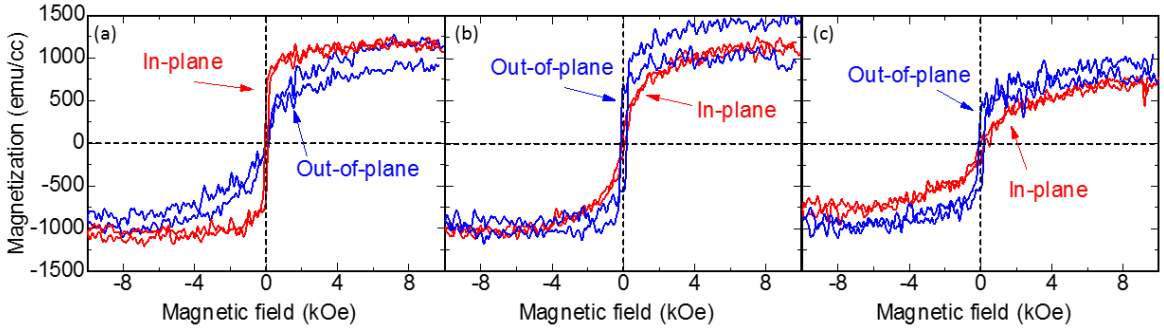

Fig. 1: Magnetic properties of ultrathin CFS/MgO layers for various oxygen exposure amount of (a) 0 ML, (b) 0.9 ML and (c) 9.0 ML.