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Perpendicular Magnetic Anisotropy in $L1_0$-$Mn_{1-x}Co_xAl$ Thin Films

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Magnetic materials with a high perpendicular magnetic anisotropy (K_u), a low magnetic damping and a low saturation magnetization (M_s) are required for Giga-bit STT-MRAM applications. We focus on $L1_0$-ordered MnAl alloy with a high K_u (1.5×10^7 erg/cc) and a relatively small M_s (550 emu/cc) [1]. However, fabrication conditions, such as preparation temperature, pressure of sputtering Ar gas and etc., to obtain $L1_0$-orederd MnAl thin films are tightly restricted. In our previous work, we found that substitution of a small amount of Co for Mn was great useful to obtain $L1_0$-orederd thin films [2]. In this study, we have systematically investigated the crystal and magnetic properties in $Mn_{1-x}Co_xAl$ films with various Co content (x).

All thin films were prepared by UHV-DC/RF magnetron sputtering system. The film structure was MgO (100) sub. / CrRu (40 nm) / $Mn_{1-x}Co_xAl$ (50 nm) / Ta (5 nm). Co content (x) in $Mn_{1-x}Co_xAl$ layers was varied from 0 to 0.08. Substrate temperature (T_s) during deposition of $Mn_{1-x}Co_xAl$ layers was varied as T_s = 200 ~ 400°C. Structural and magnetic properties were respectively measured by XRD and SQUID.

We confirmed from XRD measurements that $Mn_{1-x}Co_xAl$ films with x = 0 - 0.08 showed (001)-orientation and $L1_0$-ordering. Peaks of (001) and (002) for $Mn_{1-x}Co_xAl$ gradually shifted to higher angle with increasing Co content x. $Mn_{1-x}Co_xAl$ films with x = 0 - 0.08 were perpendicularly magnetized at optimized T_s. Fig. 1 shows Co content x dependences of perpendicular magnetic anisotropy energy and saturation magnetization. Although both K_u and M_s were decreased with increasing x, very large K_u of ca. 9 Merg/cc was obtained at x = 0.03. The $Mn_{0.97}Co_{0.03}Al$ films with very large K_u are promising candidate of ferromagnetic electrodes for nano-scaled MTJs.

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References:

[1] M. Hosoda, M. Oogane *et al.*, J. Appl. Phys., 111, 07A324 (2012).

[2] K. Watanabe, M. Oogane *et al*., JSAP spring meeting (2016).

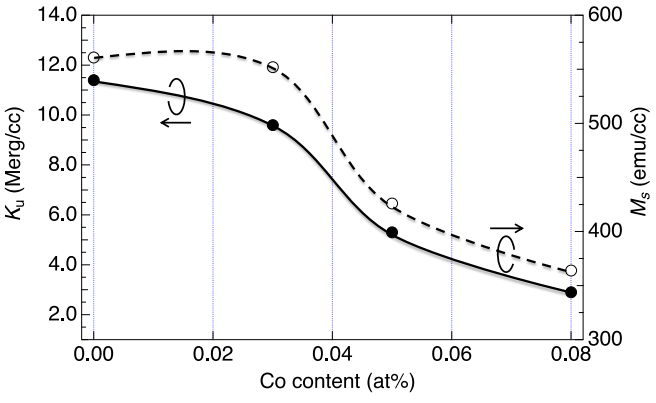

Fig. 1 Co content dependences of K_u and M_s in $L1_0$-ordered $Mn_{1-x}Co_xAl$ films.