Alterations of magnetic and magneto-transport properties of Mn_4N thin films by Co substitution

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[Introduction]

Mn_4N thin film is a notable rare-earth free material which has the advantage of sharp magnetization reversal because of its PMA ($K_u \sim 1.1 \times 10^5$ J/m^3) and a small M_S ($= 7.1 \times 10^4$ A/m).[1] Previous study on 1–2 μm wide Mn_4N strips showed the fastest spin transfer torque-driven domain wall motion ($v_{DW} \simeq 900$ m/s at 1.2×10^{12} A/m^2 at RT.[1] In order to achieve faster v_{DW}, Mn_4N based mixed crystal nitrides have been studied in pursuit of a compensation point. Recently, $Mn_{4-x}Ni_xN$ thin films have been suggested to have a magnetic compensation point between x = 0.1 and 0.25 at RT.[2] $Mn_{4-x}Co_xN$ thin films are also considered to have a compensation point;[3] however, their magneto-transport properties and magnetic structure have yet to be made clear. In this work, we formed $Mn_{4-x}Co_xN$ epitaxial films to investigate them for various Co compositions x.

[Experiment]

20–30 nm-thick $Mn_{4-x}Co_xN$ films with x = 0–1.2 were epitaxially grown on $SrTiO_3$(001) substrate by molecular beam epitaxy. SiO_2 or Ta capping layers were sputtered *in-situ* on the surface to prevent oxidation. Co composition x dependence of M_S was evaluated by a vibrating sample magnetometer. Anomalous Hall effect (AHE) measurement was performed to obtain ρ_{AHE} curves for various Co compositions.

[Result and discussion]

Figure 1 shows the x dependences of M_S in $Mn_{4-x}Co_xN$ films. The M_S decreased almost linearly with x and reached a minimum M_S of 13.7 kA/m at x = 1.0. Even at this point, PMA was observable although Co_4N is known as an in-plane magnetic anisotropy material. For x > 1.0, the M_S started to increase.

Figure 2 exhibits the AHE hysteresis loops acquired for various x under the magnetic field applied normal to sample surface. We observed the sign reversal between x = 1.1 and 1.2. These results suggest that the magnetic compensation point is between these points. In the presentation, we'd like to also discuss their magnetic structures based on the results obtained from XMCD measurements.

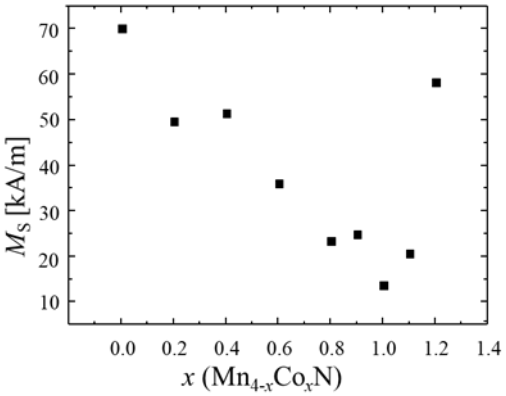

Fig. 1 Co composition x dependence of M_S in $Mn_{4-x}Co_xN$ films at RT.

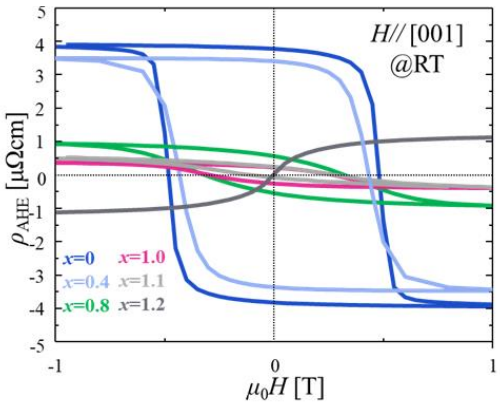

Fig. 2 AHE hysteresis loops of $Mn_{4-x}Co_xN$ films at RT.

[References]

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[3] K. Ito *et al.*, AIP Adv., **6**, 056201 (2016).