Magnetic compensations in $Mn_{4-x}Co_xN$ epitaxial films proved by X-ray magnetic circular dichroism

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[Introduction]

Mn_4N film is an antiperovskite ferrimagnet without rare-earth which is advantageous in fast magnetization reversal due to its perpendicular magnetic anisotropy ($K_u \sim 1.1 \times 10^5$ J/m^3) and a small saturation magnetization (M_S = 71 kA/m)[1]. Previous study on 1–2μm-wide Mn_4N strips showed the fastest spin-transfer-torque-driven domain wall motion ($v_{DW} \simeq$ 900 m/s at 1.3×10^{12} A/m^2) at room temperature (RT)[1]. To achieve faster v_{DW}, Mn_4N based mixed crystals have been studied in pursuit of compensation. Recently, $Mn_{4-x}Ni_xN$ films have been suggested to have a magnetic compensation (MC) point between x = 0.1 and 0.25 at RT[2]. We found that $Mn_{4-x}Co_xN$ films have a compensation point between x = 0 and 0.8 from the result of x-ray magnetic circular dichroism (XMCD) measurements[3]. However, there is a lack of information about the magnetic behavior of $Mn_{4-x}Co_xN$ at values x much smaller or larger than 0.8. In this work, we performed XMCD measurements on $Mn_{4-x}Co_xN$ epitaxial films at x = 0.2 and 1.3 and investigated the change in magnetic structures by composition ratio to verify MC at RT in this material.

[Experiment]

20–30 nm-thick $Mn_{4-x}Co_xN$ films with x = 0–1.3 were epitaxially grown on $SrTiO_3$(001) substrates by molecular beam epitaxy. SiO_2 or Ta capping layers were sputtered *in-situ* on the surface to prevent oxidation. X-ray absorption spectroscopy (XAS) and XMCD measurements were performed at BL-16A of Photon Factory.

[Result and discussion]

Figures 1(a)-1(c) show the XAS and XMCD spectra of Mn in $Mn_{4-x}Co_xN$ at x = 0.2, 0.8[3], and 1.3, respectively. In these figures, the sharp peak near 640 eV comes from Mn atoms at corner sites, and the broad peak near 643 eV originates from those at face-centered sites [3]. We observed the sign reversals of XMCD signals between x = 0.2 and 0.8, and also between x = 0.8 and 1.3. Similar sign reversals were also observed in the XMCD signals of Co atoms. These results indicate that MC occurs twice in the range of x = 0–1.3 in $Mn_{4-x}Co_xN$.

Acknowledgment

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[References]

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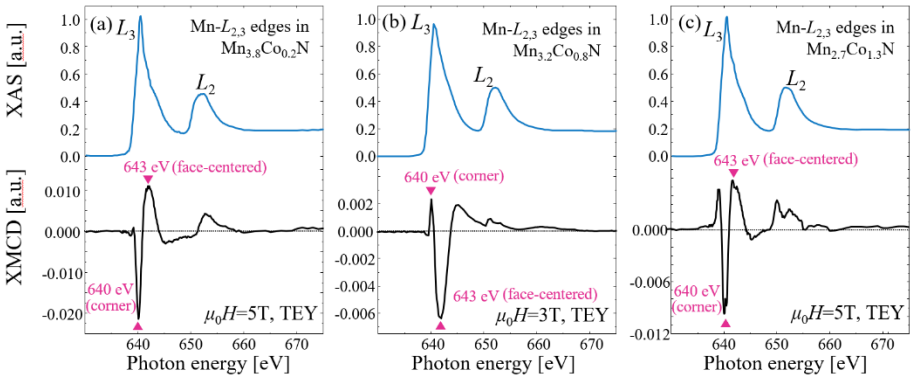

Fig. 1 XAS (blue) and XMCD (black) spectra in (a) $Mn_{3.8}Co_{0.2}N$, (b) $Mn_{3.2}Co_{0.8}N$[3], and (c) $Mn_{2.7}Co_{1.3}N$ films at the Mn $L_{2,3}$ absorption edges.