Growth of $Mn_{4-x}In_xN$ epitaxial films and analysis of their magnetic structure by X-ray magnetic circular dichroism

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[Introduction] Antiperovskite ferrimagnetic Mn_4N film is a candidate for the domain wall (DW) motion devices thanks to its perpendicular magnetic anisotropy and small spontaneous magnetization (M_S ~ 80 kA/m)[1]. Our group achieved v_{DW}~ 900 m/s at j= 1.2×10^{12}A/m^2 (driven) only by the spin transfer torque at room temperature (RT)[1]. In addition, magnetic compensation of $Mn_{4-x}Ni_xN$[2] and $Mn_{4-x}Co_xN$[3] films was revealed at RT by X-ray absorption spectroscopy (XAS) and X-ray magnetic circular dichroism (XMCD) measurements. More efficient DW motion will be achieved at angular momentum compensation point, which is expected to be found close to the magnetic compensation point. In this work, we focused on $Mn_{4-x}In_xN$ epitaxial films as another candidate because compensation of $Mn_{4-x}In_xN$ bulk was reported[4]. We succeeded in the epitaxial growth of $Mn_{4-x}In_xN$ films for the first time and performed XAS and XMCD measurements to reveal their magnetic structures and magnetic compensation point.

[Experiment] We grew 25-nm-thick $Mn_{4-x}In_xN$ (x= 0.1 and 0.3) films on $SrTiO_3$(001) substrates by molecular beam epitaxy. XAS and XMCD measurements were performed at the twin APPLE-II undulator beam line BL-16A of KEK-PF in Japan. The magnetic field of ±5 T was applied perpendicular to the film plane and circularly polarized X-rays were entered at an incident angle of 54.7° (magic angle).

[Results and Discussion] Figure 1 shows XAS and XMCD spectra of Mn-$L_{2,3}$ absorption edges in $Mn_{3.9}In_{0.1}N$ (a) and $Mn_{3.7}In_{0.3}N$ (b). Distinct shoulders appeared in XAS spectra of both samples at about 2 eV higher photon energy than L_3 edges (640 eV). We attribute this to Mn at the face-centered (II) sites [4]. In XMCD spectra, the sign reversal which suggests the magnetic compensation point was not observed. However, the intensity of β-peak of $Mn_{3.7}In_{0.3}N$ was lower than that of $Mn_{3.9}In_{0.1}N$. Although it is not easy to fully separate the contribution of Mn atoms at corner (I) sites to the spectra from that of Mn(II) atoms, sharp α-peak mainly derives from Mn(I) and broad β-peak does from Mn(II)[2]. From this result, we concluded that In atoms preferentially replaced Mn(II) atoms at x= 0.1 and 0.3. We plan to conduct experiments further on samples with x > 0.3.

[Acknowledgment] The XMCD experiment was performed with the approval of the Photon Factory Program Advisory Committee (Proposal No. 20G537).

[Reference]

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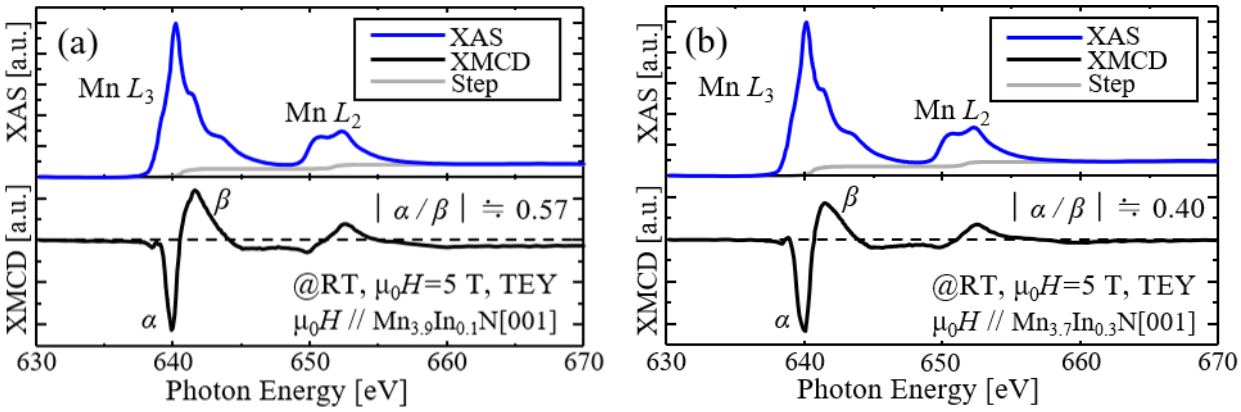

Fig. 1 XAS and XMCD spectra in (a) $Mn_{3.9}In_{0.1}N$ and (b) $Mn_{3.7}In_{0.3}N$ films at Mn-$L_{2,3}$ edges