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

1. Univ. of Tsukuba, 2. KEK

Aoi Hatate[1], T. Komori[1], T. Yasuda[1], T. Horiuchi[1], K. Amemiya[2], K. Toko[1], and T. Suemasu[1]

E-mail: blueno.spin@gmail.com

[Introduction] We have focused on compensated ferrimagnetic $Mn_{4-x}Z_xN$ films (Z is a metal element), which are candidates for future domain wall motion (DWM) device materials. For instance, $Mn_{4-x}Ni_xN$ has a magnetic compensation composition at RT[1], which is confirmed by X-ray absorption spectroscopy (XAS) and X-ray magnetic circular dichroism (XMCD) measurements. Remarkably, in $Mn_{3.85}Ni_{0.15}N$, the DWM velocity reached 3,000 m/s at RT[2] thanks to the angular momentum compensation. We expect that $Mn_{4-x}Ga_xN$ epitaxial films can be another candidate. R. Zhang *et al.* reported that bulk $Mn_{4-x}Ga_xN$ has a magnetic compensation composition[3]. However, there have been no reports about the magnetic compensation of $Mn_{4-x}Ga_xN$ films. This time, we report results about XAS and XMCD measurements on $Mn_{4-x}Ga_xN$ epitaxial films.

[Experiment] First we grew 23-nm-thick $Mn_{4-x}Ga_xN$ (x = 0.1 and 0.3) epitaxial films on $SrTiO_3$(001) substrates by molecular beam epitaxy. We performed XAS and XMCD measurements at the twin APPLE-II undulator beamline BL-16A of KEK-PF in Japan. The ±5 T magnetic field and circularly polarized X-rays were applied at the magic angle ($\theta \sim 55^\circ$).

[Result] Figure 1 shows XAS and XMCD spectra on Mn-$L_{2,3}$ absorption edges in (a) $Mn_{3.9}Ga_{0.1}N$ and (b) $Mn_{3.7}Ga_{0.3}N$ at RT. XAS spectra seem to have no difference, suggesting that the valency number of Mn atoms was almost the same. In the XMCD spectra of Fig.1(a), the Mn-L_3 absorption edge contains negative α-peak and positive β-peak. According to K. Ito *et al.*[4] Mn atoms at corner and face-centered sites mainly contribute to α and β peaks, respectively, in Mn_4N. In the XMCD spectra of Fig.1(b), the sign of β-peak is negative, although it is positive in Fig.1(a). It indicates that the direction of the magnetic moment of face-centered Mn reversed, and the magnetic moments of Mn atoms at both sites became parallel in $Mn_{4-x}Ga_xN$ films with increasing the amount of Ga.

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[Reference]

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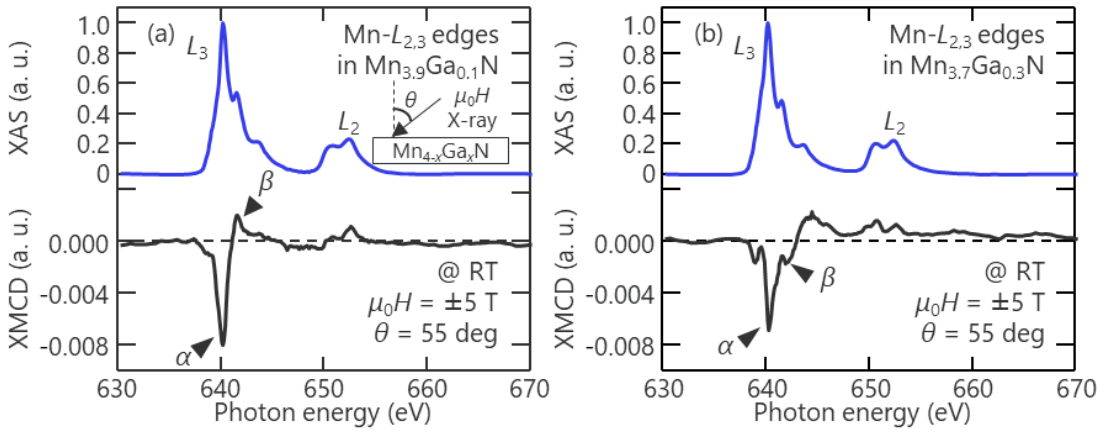

Fig. 1 XAS and XMCD spectra in (a) $Mn_{3.9}Ga_{0.1}N$ and (b) $Mn_{3.7}Ga_{0.3}N$ films at Mn-$L_{2,3}$ edges