Magnetic compensation of $Mn_{4-x}Ni_xN$ confirmed by X-ray magnetic circular dichroism and analysis on its structure

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[Introduction]

Antiperovskite ferrimagnetic Mn_4N film is a candidate of the future domain wall (DW) motion devices, with which we achieved v_{DW} ~ 900 m/s at j = 1.2×10^{12} A/m^2 only by the effect of spin transfer torque at room temperature[1]. We also focus on $Mn_{4-x}Ni_xN$ film as another candidate. In our previous report, we found out the sign of anomalous Hall resistivity and Kerr rotation angle change between 0.1 < x < 0.25 and attributed them to the magnetic compensation[2]. It leads to more efficient DW motion at angular momentum compensation point, which is expected to be found close to the magnetic compensation point. However, a replacement site for Ni and a magnetic structure of $Mn_{4-x}Ni_xN$ have not been studied yet. In this work, we performed X-ray absorption spectroscopy (XAS) and X-ray magnetic circular dichroism (XMCD) measurements to make them clear and prove its magnetic compensation.

[Experiment]

10-nm-thick $Mn_{4-x}Ni_xN$ (x = 0.1 and 0.25) epitaxial films were grown on $SrTiO_3$(001) substrates. XAS and XMCD measurements were performed at the twin APPLE-II undulator beam line BL-16A of KEK in Japan. Both the magnetic field of ± 3 T and circularly polarized X-ray were applied perpendicular to the film plane.

[Results and Discussion]

Figures 1(a) and 1(b) show XAS and XMCD spectra of Mn-$L_{2,3}$ edges in $Mn_{3.9}Ni_{0.1}N$ and $Mn_{3.75}Ni_{0.25}N$, respectively. Distinct shoulders appear in the XAS spectra of both samples at about 2 eV higher photon energy than those of the L_3 (640 eV) and L_2 (650.5 eV) edges. We attribute this to the electric dipole transition from a metal 2p core level to a hybridization state generated between the orbitals of N 2p and metal 3d at face-centered (II) sites, which doesn't happen for ones at corner (I) sites[3]. In XMCD spectra, one has the shape of the other with its sign reversed. From this result, we found out the magnetizations of Mn(I) and Mn(II) reverse along the magnetic field between 0.1 < x < 0.25, which is caused by the magnetic compensation. Spectra of Ni-$L_{2,3}$ edges will be discussed in the presentation.

[Reference]

[1] T. Gushi *et al*., arXiv:1901. 06868.

[2] T. Komori *et al*., J. Appl. Phys. **125**, 213902 (2019).

[3] F. Takata *et al*., Phys. Rev. Mater. **2**, 024407 (2018).

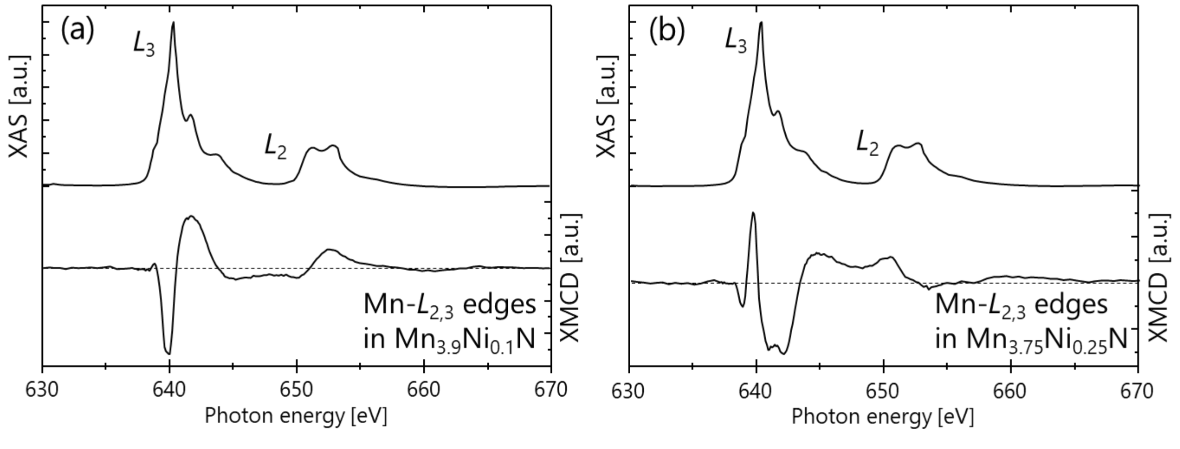

FIG. 1. XAS and XMCD spectra in (a) $Mn_{3.9}Ni_{0.1}N$ and (b) $Mn_{3.75}Ni_{0.25}N$ films at Mn-$L_{2,3}$ edges.