Growth of Au-doped Mn_4N epitaxial films: substrate dependence

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[Introduction] An antiperovskite ferrimagnetic Mn_4N film is a notable candidate for the domain wall motion devices thanks to its perpendicular magnetic anisotropy[1] and small spontaneous magnetization (M_S ~ 100 kA/m)[2]. In addition, we can control the properties of Mn_4N by replacing Mn atoms by another element such as Ni[3].

This time, we focus on $Mn_{4-x}Au_xN$ epitaxial films. Li *et al*. previously reported that the epitaxial growth of $Mn_{3.5}Au_{0.5}N$ film on MgO(001) substrates and the sign reversal of anomalous Hall effect (AHE)[4]. In this work, we grew $Mn_{4-x}Au_xN$ films on $SrTiO_3$[STO](001) and MgO(001) and researched their substrate dependences. The lattice mismatches between Mn_4N and these substrates are approximately −0.1% and −6%, respectively.

[Experiment] We fabricated 23-nm-thick $Mn_{4-x}Au_xN$ (x = 0.4 and 0.8) films onto STO(001) and MgO(001) substrates by molecular beam epitaxy. Crystalline quality was evaluated by ω–2θ X-ray diffraction (XRD) and reflection high-energy electron diffraction (RHEED). The Hall effect measurements were conducted at room temperature with a physical properties measurement system (PPMS).

[Result] Figure 1 shows the XRD profiles and RHEED patterns of $Mn_{4-x}Au_xN$ on (a) STO(001) and (b) MgO(001) substrates. Except $Mn_{3.2}Au_{0.8}N$ on STO, we only observed peaks derived from $Mn_{4-x}Au_xN$ and substrates in the XRD profiles, and sharp streaks were observed in the RHEED patterns. The peak shift in XRD indicates that the lattice constant of $Mn_{4-x}Au_xN$ increased by Au doping. The crystalline orientation of $Mn_{3.2}Au_{0.8}N$ on STO is degraded compared to that of $Mn_{3.6}Au_{0.4}N$ due to the lattice mismatch between $Mn_{3.2}Au_{0.8}N$ and the substrate.

Figure 2 shows the anomalous Hall resistivity ρ_{AHE} of $Mn_{4-x}Au_xN$ on MgO(001). We observed the sign reversal of AHE resistivity at x = 0.4 and 0.8. The results of X-ray circular magnetic dichroism will be discussed in talk to show the cause of this sign reversal.

[Acknowledgment] The measurements with PPMS were performed with the help of Associate Prof. T. Koyano of Cryogenics Division of Univ. Tsukuba.

[Reference]

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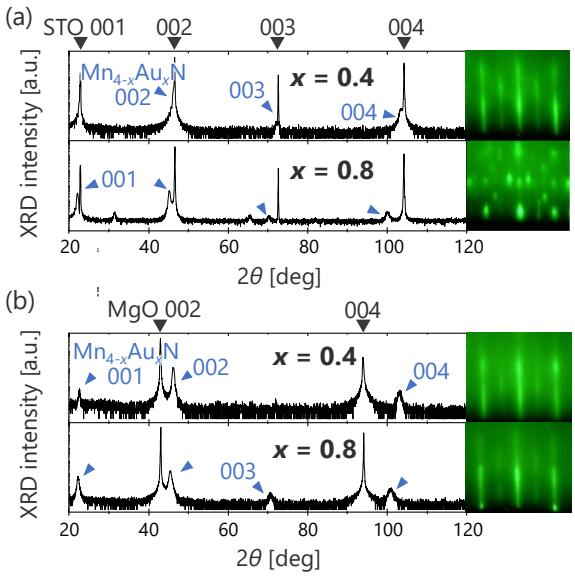

Fig. 2 ω–2θ XRD profiles and RHEED patterns along [100] azimuth of $Mn_{4-x}Au_xN$ on (a) STO(001) and (b) MgO(001)

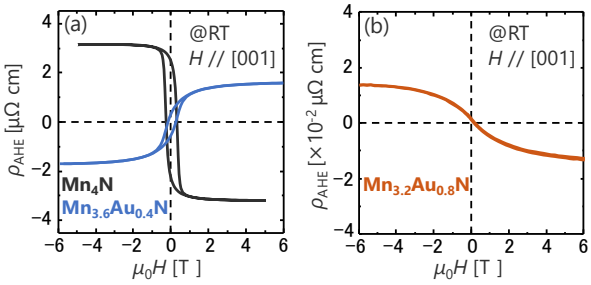

Fig. 1 ρ_{AHE} of (a) Mn_4N, $Mn_{3.6}Au_{0.4}N$ and (b) $Mn_{3.2}Au_{0.8}N$ on MgO(001)