Significant modification of magneto-transport properties of Mn$_4$N thin films by Ni substitution

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[Introduction]

Mn$_4$N thin film is a possible candidate for the future DW motion devices due to its small saturation magnetization ($M_S$) of 80 emu/cm$^3$ and perpendicular magnetic anisotropy (PMA) of $\sim$1 Merg/cm$^3$. We had successfully grown Mn$_{4-x}$Ni$_x$N thin films on MgO(001) substrates by MBE and investigated their magnetic properties, finding out that $M_S$ drastically decreased by a small amount of Ni substitution. PMA was observed when $x \leq 0.25$. We therefore speculate that Mn$_{4-x}$Ni$_x$N is more suitable for faster DW motion than Mn$_4$N with smaller current. In this work, we grew Mn$_{4-x}$Ni$_x$N thin films on SrTiO$_3$ (STO)(001) substrates, which matches the Mn$_4$N lattice better than MgO(001), and investigated their transport and magnetic properties.

[Experiment]

10-nm-thick Mn$_4$N film and 30-nm-thick Mn$_{4-x}$Ni$_x$N ($x = 0.1, 0.25, 0.5$) films were grown on STO(001) and MgO(001) substrates by MBE. The magnetic properties were measured by vibrating sample magnetometer (VSM). Anomalous Hall Effect (AHE) was measured by physical properties measurement system (PPMS). Both measurements were performed at room temperature.

[Results and discussion]

PMA was observed in Mn$_{4-x}$Ni$_x$N on STO when $x \leq 0.5$ and $M_S$ decreased with the increase of $x$; $M_S$ of Mn$_{3.9}$Ni$_{0.1}$N was 47.4 emu/cm$^3$. Figures 1 and 2 show the anomalous Hall resistivity ($\rho_{\text{AH}}$) of Mn$_{4-x}$Ni$_x$N thin films on STO(001) and MgO(001) with the magnetic field perpendicular to plane. Although the $\rho_{\text{AH}}$ of Mn$_4$N thin film was negative, this value became positive when $x = 0.25$ and 0.5. We consider that Ni substitution drastically modified the spin-dependent conduction properties of Mn$_4$N. We plan to measure AMR to investigate magneto-transport properties.

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2) T. Komori et al., the 65th JASP spring meeting, 19p-D104-20 (2018).