Temperature dependence of magneto-transport properties in $Mn_{4-x}Ni_xN$measured by anomalous magnetoresistance important for current induced domain wall motion

Univ. of Tsukuba, °Taro Komori, Haruka Mitarai, Taku Hirose, and Takashi Suemasu

E-mail: s1820324@s.tsukuba.ac.jp

【Introduction】 Mn_4N film is a notable candidate for the fast magnetization switching thanks to its PMA and small M_S ($\simeq$ 80 kA/m) [1]. Our group has recently achieved domain wall motion velocity of 900 m/s at j = 1.2× 10^{12} A/m^2 [1], the fastest and most efficient among the records on spin transfer torque-driven ones. What's more, we found the magnetic compensation in $Mn_{4-x}Ni_xN$ between x = 0.1~0.25 [2], around which we expect more efficient magnetization switching. However, there's a lack of information on the properties at low temperature, from which the compensation by temperature or the spin polarization of the conductive electrons can be found. In this work, we performed anomalous Hall effect (AHE) and anomalous magnetoresistance (AMR) measurements by modulating temperature for the samples with various Ni composition x.

【Experiment】 $Mn_{4-x}Ni_xN$ samples (30 nm) were fabricated onto $SrTiO_3$(001) substrates by molecular beam epitaxy. AHE and AMR measurements were performed by physical properties measurement system (PPMS). Before measurements, film samples were processed into Hall bars with a width of 200 μm and a length of 3500 μm. The angle made by the vectors of current and magnetization was defined as Φ. The magnetic field of 9 T was applied parallel to the plane.

【Results and Discussion】 Fig. 1 shows the AMR curves in Mn_4N/STO(001). The results really corresponded with the report on Mn_4N/MgO(001) [3], which suggests there's no substrate dependence of the *s*-*d* scattering system and DOS of *d* orbitals. Fig. 2 shows the Fourier coefficients in AMR curves in $Mn_{4-x}Ni_xN$ (x = 0, 0.05, 0.15). As we can observe in Fig. 1, cos2θ(C_2) and cos4θ(C_4) components are recognized in $Mn_{4-x}Ni_xN$ systems. It was reported that C_4 components derive from the split in $d\varepsilon$ states (d_{xy}, d_{yz}, d_{xz}) under the tetragonal crystal field below 100 K in antiperovskite nitrides [3,4]. In $Mn_{4-x}Ni_xN$, however, smaller C_4 components were confirmed in larger Ni composition x although there was no significant change in their lattice constants. Therefore, we expect such crystal field was weaken by Ni replacement, and since $d\varepsilon$ states orbitals have significant influence of AHE, this discovery can be the key to the better understanding in the magneto-transport properties of $Mn_{4-x}Ni_xN$.

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【References】

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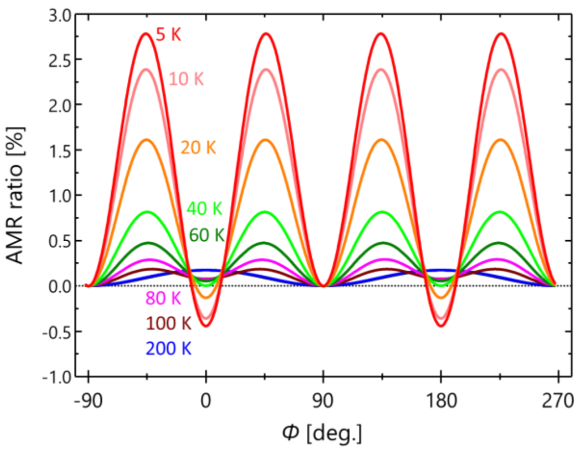

Fig.1 AMR ratio ($\rho(\phi)$-ρ(90°))/ρ(90°)) in Mn_4N/STO(001) at various temperature.

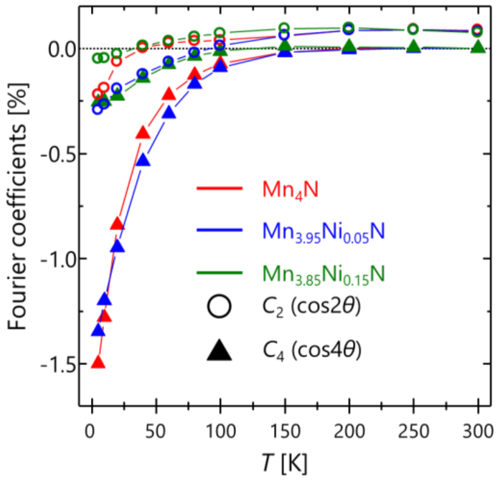

Fig.2 Fourier coefficients C_2 and C_4 in AMR curves of $Mn_{4-x}Ni_xN$.