Magneto-transport Properties of $(Mn_{1-x}Co_x)_2VAl$ Heusler Alloy Films

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A Half-metallic ferrimagnet, $(Mn_{1-x}Co_x)_2VAl$ is an ideal material for spintronic applications because of its high spin polarization and low saturation magnetization M_s, and theoretically becomes a fully compensated ferrimagnet at x = 0.5 [1]. However, the magneto-transport properties of the thin films have never been reported. The anomalous Hall effect (AHE) is largely affected by the electronic structure in the vicinity of the Fermi energy E_F. In this study, the relation between the AHE and the M_s in $(Mn_{1-x}Co_x)_2VAl$ thin films has been systematically investigated to reveal their electronic properties.

50-nm-thick $(Mn_{1-x}Co_x)_2VAl$ thin films were grown on a MgO (001) single-crystal substrates using a magnetron sputtering technique. The structural and magnetic properties of the prepared films were characterized by using XRD and a SQUID, respectively. The AHE was measured in the 10-300 K temperature range using DC four-probe method of a PPMS. The Hall resistivity ρ_{xy} and the longitudinal resistivity ρ_{xx} were simultaneously measured. An external magnetic field H up to 50 kOe was applied perpendicular to (001) film plane, and electric current was flowed along $(Mn_{1-x}Co_x)_2VAl$ [100] direction. The Hall conductivity σ_{xy} is determined using the formula: $\sigma_{xy} = \rho_{xy}/(\rho_{xy}^2 + \rho_{xx}^2)$, and the anomalous Hall conductivity σ_{AH} is obtained by extrapolating the linear part of the σ_{xy} to $H = 0$.

Fig. 1 shows x dependences of the ordered parameters S. The obtained values are more than 60% for $B2$ and 40% for $L2_1$, at each x. These are good evidences that the highly-ordered epitaxial films were prepared. Fig. 2 shows x dependences of the M_s and the σ_{AH}, measured at 50K. We obtained the low σ_{AH} for $x = 0.5$, corresponding to the low M_s. The σ_{AH}/M_s ratio is 0.38, 0.13, and 0.24 ($cm^2/\Omega emu$) for x = 0, 0.5 and 1, respectively. This relatively high σ_{AH}/M_s ratio for $x = 0$ may be caused by its d-orbital band crossing the E_F.

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[1] I. Galanakis *et al.*, Phys. Rev. B **75**, 092407 (2007).

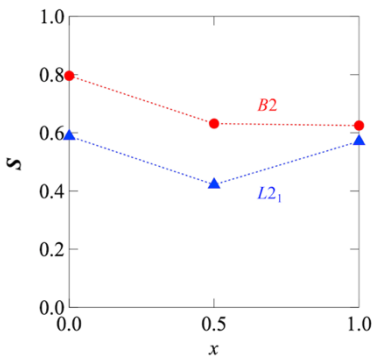

Fig. 1 x dependences of S_{B2} and S_{L21}

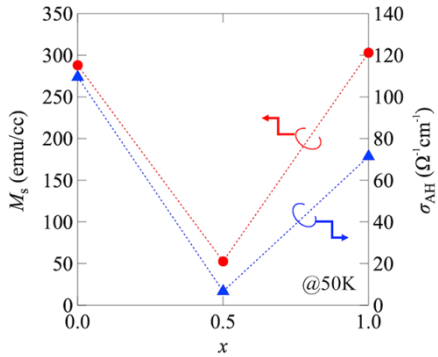

Fig. 2 x dependences of M_s and σ_{AH} at 50K