

異方性磁気抵抗効果を用いた $\text{Co}_2\text{FeGa}_{0.5}\text{Ge}_{0.5}$ 薄膜のスピン分極率解析Analysis of bulk spin-polarization in $\text{Co}_2\text{FeGa}_{0.5}\text{Ge}_{0.5}$ thin films

via anisotropic magnetoresistance effect

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Recently giant MR ratios over 50% at room temperature (RT) were reported in CPP-GMR devices using half-metallic Heusler electrodes such as $\text{Co}_2\text{FeGa}_{0.5}\text{Ge}_{0.5}$ (CFGG), suggesting higher spin-polarization at RT in Heusler electrodes than that in general 3d transition ferromagnets. However, surprisingly, MR ratio drastically enhanced with decreasing temperature over 200% at 10 K[1]. Such unexpected large temperature dependence is a common behavior in CPP-GMR devices with various Heusler electrodes but its mechanism has not been clarified so far. In this study, to clarify the temperature dependence of MR ratio, we analyzed temperature dependence of bulk spin-polarization in CFGG thin films having different compositions and chemical orderings via anisotropic magnetoresistance (AMR) effect, which is based on the recent theoretical model of AMR [2].

(001)-oriented epitaxial CFGG thin films having a nearly stoichiometric composition ($\text{Co}_{49}\text{Fe}_{23}\text{Ga}_{14}\text{Ge}_{14}$) and a Co-rich composition ($\text{Co}_{54}\text{Fe}_{26}\text{Ga}_{11}\text{Ge}_9$) were deposited on a (001)-MgO substrate. Deposited films were annealed at different temperature T_{ann} from 300 to 700°C. Our previous study on AMR effect in various Co_2FeZ and Co_2MnZ films showed a positive correlation between the magnitude of negative AMR ratio and spin-polarization in bulk region [3], suggesting that AMR can be a facile way to investigate a bulk spin-polarization in Co-based Heusler. Since the main origin of AMR is *s-d* scattering via impurities [2], the contribution of electron-phonon scattering on resistivity ρ must be excluded from AMR to simply discuss a temperature dependence of bulk spin-polarization. Therefore, we evaluated $\Delta\rho(T)$ by multiplying AMR(T) by $\rho(T)$, and $\Delta\rho$ normalized at 10K is plotted in Fig.1. The temperature dependence of $\Delta\rho$ is the most remarkable in the film annealed at 300°C but gradually becomes small with T_{ann} . Finally, almost no temperature dependence was observed at over 600°C. On the other hand, $\Delta\rho$ in Co-rich CFGG films showed large temperature dependence in all T_{ann} even above 600°C. This analysis indicates that nearly stoichiometric CFGG having a clear half-metallic gap due to less Co antisite shows small temperature dependence of bulk spin-polarization. [1]Jung et al., APL 108, 102408 (2016). [2]Kokado et al., JPSJ 81,024705 (2012). [3] Sakuraba et al., APL 104, 172407 (2014).

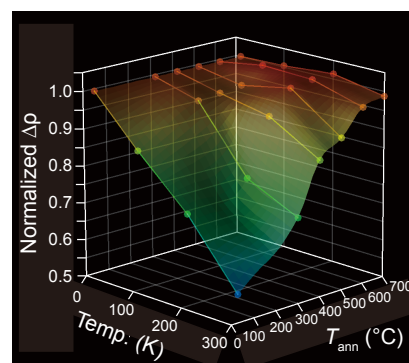


Figure 1 Temperature dependence of $\Delta\rho$ of AMR normalized at 10 K in nearly stoichiometric CFGG films annealed at different temperature.