Improvement of MR output in $Co_2MnGa_{0.25}Ge_{0.75}$ Heusler alloy based CPP-GMR devices through composition tuning

S. Li, Y. K. Takahashi, Y. Sakuraba, T. Furubayashi, and K. Hono

National Institute for Materials Science, Tsukuba 305-0047, Japan

Many recent investigations have shown that the usage of Heusler alloy is an effective way to enhance the MR output in current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) devices due to its half-metallic nature as predicted by band structure calculations. We have developed highly spin polarized $Co_2MnGa_{0.25}Ge_{0.75}$ full Heusler alloy and achieved large MR output by using it as ferromagnetic electrode in CPP-GMR devices [1]. In our previous study, DO_3-disorder was found with annealing temperature (T_a) higher than 450 ^oC in the CoMnGaGe film with the composition of $Co_{52.7}Mn_{25.6}Ga_{6.1}Ge_{16.5}$. The DO_3-disorder (Co antics) is thought to decrease the spin polarization of Co-based Heusler alloy based on the band structure calculations [2]. MR output was thus degraded due to the appearance of Co antics in our previously study using CoMnGaGe film. In this work, we report an improvement of MR output in CPP-GMR device by suppressing the Co antics through the composition tuning in CoMnGaGe Heusler alloy.

Epitaxial CoMnGaGe thin films with the composition of $Co_{46.4}Mn_{28.8}Ga_{7.1}Ge_{17.7}$ (refer to Mn-rich CMGG) or $Co_{52.7}Mn_{25.6}Ga_{6.1}Ge_{16.5}$ (refer to Co-rich CMGG) were prepared by using MgO(100) single crystal substrate in ultra-high vacuum magneto-sputtering system. CPP-GMR devices were fabricate through conventional EB lithography and Ar ion milling process. Anisotropy magneto resistance (AMR) measurement was performed in a physics property measurement system (PPMS) and GMR measurement was performed in the CPP-geometry.

Fig. 1 shows AMR as function of T_a in Mn-rich CMGG film and Co-rich CMGG films with thickness of 50 nm, deposited on MgO substrate. The amplitude of negative AMR reaches maximum at T_a=500 ^oC, and then decreases with further increasing T_a. This can be interpreted by the reduction of spin polarization caused by Co antics at high T_a in Co-rich CMGG film, which has been discussed in our previous work [3]. On the other hand, AMR in Mn-rich CMGG film shows monotonic relation with T_a up to 650 ^oC, which might indicate suppressed Co antics in Mn-rich CMGG film by increasing the concentration of Mn. Fig. 2 shows CPP-GMR output as function of T_a in Mn-rich CMGG film and Co-rich CMGG films based CPP-GMR devices. The Mn-rich CMGG film based CPP-GMR devices show more robust dependence of T_a. It is gives strong evidence of suppressed Co antics in CMGG film thus leading to lager spin polarization. The ΔRA drops at high T_a might be due to the chemical diffusion between Mn and Ag in case of Mn-rich CMGG film based CPP-GMR devices.

[1]Y. K. Takahashi et al, J. Appl. Phys. **113**, 1223901 (2013)　[2]S. Picozzi et al, J. Phys.: Condens. Matter, **19**, 315215 (2007)　[3]Y. Sakuraba et al, Appl. Phys. Lett. **104**, 172407 (2011)

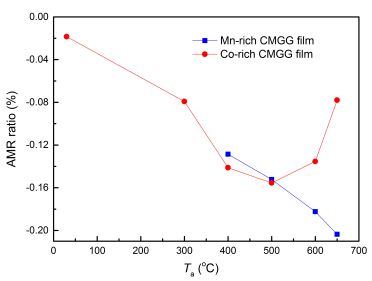

Fig. 1 AMR as function of T_a in Mn-rich (blue square) and Co-rich CMGG (red circle) films.

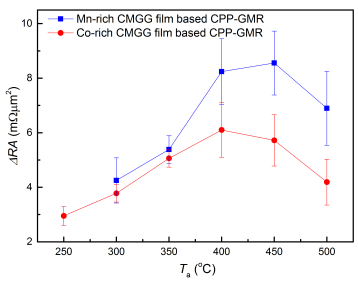

Fig. 2 ΔRA as function of T_a in Mn-rich (blue square) and Co-rich CMGG (red circle) films based CPP-GMR devices.