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Systematic investigation of MR properties in CPP-GMR devices using $Co_2Fe_xMn_{1-x}Si$ electrodes

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Current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) devices are promising as a magnetic read sensor for next generation HDD. However, larger MR ratio is required for applying CPP-GMR devices to practical read sensors. Co-based full-Heusler compounds such as Co_2MnSi (CMS) are promising spintronics materials because of their half-metallic electronic structure. Previously, a large MR ratio around 36% at RT has been observed in CPP-GMR devices with CMS electrodes[1]. Recently, it was reported that the largest MR ratio of 75% at RT in CPP-GMR devices with $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) electrodes[2]. However, the systematic investigation in CFMS-based CPP-GMR devices had been not reported. Therefore, we reported systematic investigation in CFMS-based CPP-GMR devices such as composition and measurement temperature dependences[3]. In this study, we investigate the annealing temperature dependence of CFMS or CMS-based CPP-GMR devices in addition to our previous study.

The CPP-GMR devices of MgO(001)-sub.//Cr(20)/Ag(40)/CFMS(20)/Ag(5)/CFMS(3)/Ag(2)/Au(5) and MgO(001)-sub.//Cr(20)/Ag(40)/CMS(9)/Ag(5)/CMS(9)/Ag(2)/Au(5) (in nm) were prepared by an ultra vacuum compatible magnetron sputtering system (P_{base} < 3×10^{-8} Pa). The composition of CFMS was $Co_2Fe_{0.5}Mn_{0.5}Si$ analyzed by EPMA. The annealing temperatures of each CFMS or CMS layers after the deposition were 350 to 625˚C. The actual pillar sizes of the CPP-GMR devices of 0.010 to 0.366 μm^2 were strictly estimated.

Figure 1 shows the annealing temperature dependence of MR ratio in CFMS or CMS-based CPP-GMR devices. The MR ratio shown in Fig.1 is the maximum MR ratio including parasitic resistance arising from the electrode resistance. It is found that the MR ratio about 0% in the CMS-based CPP-GMR devices annealed at 600˚C. We consider that it might be caused by the interdiffusion of Mn in CMS layers into/to the interface region of Ag spacer. On the other hand, the CFMS-based CPP-GMR devices still keep large MR ratio above 600˚C. The reason may be the suppression of the interdiffusion by substituting Fe for Mn in CMS.

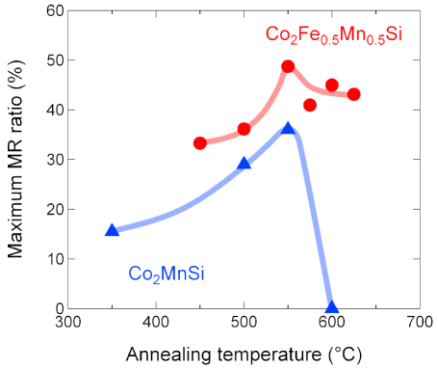

Fig.1 The annealing temperature dependence of MR ratio in CFMS or CMS-based CPP-GMR devices

Reference

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2) J. Sato, *et al*, Appl. Phys. Express **4**, 113005 (2011).
3) Y. Sakuraba, *et al*, Appl. Phys. lett. **101**, 252408 (2012).