Temperature dependence of current perpendicular-to-plane giant magnetoresistance using the interface tailored Heulser alloy electrodes

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Half-metallic Heusler alloy based current perpendicular-to-plane giant magnetoresistance (CPP-GMR) junctions are promising for realizing high GMR ratio[1]. One of interesting features is large temperature dependence of MR for the Heusler based junctions: MR ratios at low temperature are more than three times larger than those at room temperature[2–4], which is an important issue to be improved for enhancing the room temperature CPP-GMR. In this study, we investigated the temperature dependence of CPP-GMR for the interface tailored junctions which show relatively large output voltage at large bias current[5]. The temperature dependence is expected to be changed drastically, because the spacer/Heusler alloy interfaces are crucial points for the CPP-GMR.

Epitaxially grown layered films were prepared onto MgO single crystal substrates. The core structure for the CPP-GMR is $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) (20)|Fe or Mg ($t_{Fe\ or\ Mg}$)|Ag_3Mg (5)|Fe or Mg ($t_{Fe\ or\ Mg}$)|CFMS (7), (nm). The Fe or Mg layers are the interface tailoring layers. The thicknesses of the inserts, $t_{Fe\ or\ Mg}$, were changed from 0 to 0.6 nm in 0.15 nm increments. Post-annealing was done after the deposition of the upper CFMS layer at 550°C. CPP-GMR was measured at the temperature in the range of 10–300 K.

MR ratio increases with decreasing temperature for no-insert and Mg-insert (t_{Mg}: 0.3 nm) junctions. The ratios of the MR ratios at 10 K to 300 K are 3.4 and 2.9 for the no-insert and the Mg-insert junctions, respectively. On the other hand, for the Fe-insert (t_{Fe}: 0.3 nm), MR ratio shows maximum around 250 K and decreases with decreasing temperature. The Mg-inserts improved the temperature dependence probably because of the change of interface electronic structure. The degrade of low-temperature MR for Fe-inserts is possibly because of alloying between the Fe and CFMS around the interface: e.g. Fe-Mn alloy with low Curie temperature was formed locally, or reduced Curie temperature for the ultra-thin Fe-insert[6]. Systematic results including other inserts thicknesses will be shown at the presentation.

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