Ag-Mg spacer composition dependence of current perpendicular to plane type giant magnetoresistance effect in Co_2(Fe-Mn)Si/Ag-Mg/Co_2(Fe-Mn)Si junctions

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Introduction: Current perpendicular to film plane giant magnetoresistance (CPP-GMR) effect is recognized as a suitable phenomenon for the application of the reading head elements of hard disc drives (HDDs) with an areal density more than 1 Tbit/inch^2[1]. It is necessary to realize the change of junction resistance area products (ΔRA) value on the order of several-tenth m$\Omega\mu$m^2 with the RA value less than 100 m$\Omega\mu$m^2 for the HDDs application. One promising material combination is half-metallic Heusler alloys and Ag-spacer layer, however ΔRA value was not enough, which was because of the small RA values (~ 20 m$\Omega\mu$m^2) [2, 3] We have reported that the CPP-GMR junctions using $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) electrodes and $Ag_{83}Mg_{17}$ spacer layer exhibit ΔRA value more than 20 m$\Omega\mu$m^2 which is much larger than those using Ag spacer layer[4]. The enhancement of the ΔRA value is attractive for the application point of view, however, transport properties of the CPP-GMR junctions using Ag-Mg alloy have not been understood, yet. Thus, in this work we investigated the Ag-Mg composition dependence of the CPP-GMR effect for the CFMS/Ag-Mg/CFMS junctions.

Experimental: Stacking structure of the samples was; MgO (100) sub./Cr (20 nm)/Ag (40 nm)/CFMS (20 nm)/Ag-Mg (5 nm)/CFMS (7 nm)/Ag (2 nm)/Au (5 nm). All layers were deposited at an ambient temperature, and *in situ* post-annealings were performed at 650°C and 500°C, after the depositions of Cr and CFMS layers, respectively. The Mg compositions of the Ag-Mg layer were 0 (Ag), 4, 12, and 17 at%. The CPP-GMR effects were measured by direct current four probe technique at room temperature.

Results: RA values of the junctions were determined by the plots of junction resistance at parallel magnetization configuration (R_p) as a function of the inverse junction area ($1/A$). The estimated RA values were 27, 41, 46, and 52 m$\Omega\mu$m^2 for the Mg compositions of 0, 4, 12, and 17 at.%, respectively. In contrast to the monotonic increase of the RA values, the values of MR ratios less depend on the Mg composition, which were on the order of 40 to 50%. As a result, the estimated ΔRA values were 13, 15, 20, and 23 m$\Omega\mu$m^2 for the Mg compositions of 0, 4, 12, and 17 at.%, respectively. These results indicate that the Ag-Mg alloy is good for tuning RA value of CPP-GMR junctions, which provides large ΔRA value being suitable for HDDs applications.

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References:

[1] M. Takagishi, *et al*., IEEE Trans. Magn. **46**, 2086 (2010).

[2] Y. Sakuraba, *et al*., Appl. Phys. Lett. **101**, 252408 (2012).

[3] S. Li, *et al*., Appl. Phys. Lett. **103**, 042405 (2013).

[4] H. Narisawa, *et al*., Appl. Phys. Express **8** 063008 (2015).