$L1_2$ Ag-Mg ordered alloy spacer layer for Heusler alloy based current perpendicular-to-plane giant magnetoresistance devices

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The current perpendicular-to-plane (CPP) giant magnetoresistive devices are attracting great interests for applying reading head elements for hard disk drives (HDDs) [1]. It was reported that the CPP giant magnetoresistive (GMR) devices using cobalt (Co) based Heusler alloy films and a silver (Ag) spacer layer exhibited larger change of the resistance area product (ΔRA) compared with that using the conventional $3d$ transition metal thin films [2, 3]. However, it is still necessary to increase ΔRA values of CPP-GMR devices for the future HDD applications.

In this study, we have investigated Ag-Mg alloys for the spacer layer of the Heusler based CPP-GMR devices [4]. Tha stacking structure of the devices was as follow: MgO (100) substrate / Cr (20 nm) /Ag (40 nm) / $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS, 20 nm) / $Ag_{100-x}Mg_x$ (5 nm) / CFMS (7 nm) / Ag (2 nm) / Au (5 nm). The Mg compositions, x of the Ag-Mg spacer layer were 0, 4, 8, 12, 17, 22, and 26 at.%. An epitaxial growth was confirmed for all the samples except for the one with $x = 26$ at.%. The $L1_2$ ordering of the Ag-Mg layer was also confirmed locally and widely for $x = 17$ and 22 at.%, respectively. MR ratio of the devices less depends on the Mg compositions. Maximum value of the MR ratio was 58% at room temperature for $x = 22$%. Here, MR ratio was defined as follows; MR ratio = $(R_{\rm AP} - R_{\rm P})/(R_{\rm P} - R_{\rm para})$, where $R_{\rm P(AP)}$, and $R_{\rm para}$ represent resistances at the parallel (anti-parallel) magnetization configuration and the parasitic resistance of the device electrodes. On the other hand, ΔRA increased with the Mg composition, up to $x = 22$at.%. The values of ΔRA were 17 and 20 m$\Omega \cdot \mu$m^2 for $x = 17$ and 22 at.%, respectively, which were larger than that of the Ag spacer layer devices (13 m$\Omega \cdot \mu$m^2). These results indicate that the Ag-Mg alloy is good for enhancing the ΔRA value of the CPP-GMR devices at the low RA region, which is suitable for HDDs applications.

Acknowledgments: This work was supported by the Hattori Hokokai Foundation, ImPACT program of the Council for Science, Technology and Innovation, and a KAKENHI (No. 25220910) from JSPS.

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