Spacer layer thickness dependence of CPP-GMR effects in Co$_2$(Fe-Mn)Si/L1$_2$-Ag-Mg/Co$_2$(Fe-Mn)Si devices

Yusuke Ina$^1$, Takahide Kubota$^1$, and Koki Takanashi$^1$

(1. IMR, Tohoku Univ.)

E-mail: ina@imr.tohoku.ac.jp

Introduction: Current perpendicular-to-plane giant magnetoresistance (CPP-GMR) devices are of interests for applying reading head of hard disk drives (HDDs). CPP-GMR devices with low resistance-area product (RA) and high magnetoresistance (MR) ratio are required for the future HDD applications [1]. We previously reported $\Delta RA$ value of 17 m$\Omega$μm$^2$ in the CPP-GMR devices using a Ag$_{83}$Mg$_{17}$ spacer layer with partial L1$_2$-ordering and Co$_2$Fe$_{0.4}$Mn$_{0.6}$Si (CFMS) electrodes, which was larger than that of the conventional devices with a Ag spacer layer [2]. In this work, we prepared a well ordered L1$_2$ Ag$_{78}$Mg$_{22}$ spacer layer for the CFMS/Ag-Mg/CFMS devices and investigated the spacer layer thickness dependence of CPP-GMR effects.

Experimental: A stacking structure of the samples was; MgO (100)/Cr (20 nm)/Ag (40 nm)/CFMS (20 nm)/Ag$_{78}$Mg$_{22}$ (t nm)/CFMS (7 nm)/Ag (2 nm)/Au (5 nm). All layers were deposited at room temperature, and in situ post-annealing was performed at 650°C and 500°C, after the depositions of Cr and the upper CFMS layers, respectively. The thicknesses of the Ag$_{78}$Mg$_{22}$ spacer layer, $t$, were 2, 3, and 5 nm. The crystal structure was characterized using reflection high energy electron diffraction (RHEED) technique. MR effects were measured by direct current four-terminal method at room temperature.

Results: In situ RHEED observation was performed for the top CFMS surface, and the epitaxial growth and the L2$_1$-ordering of the CFMS were confirmed regardless of the spacer layer thickness. RA values of the CPP-devices were determined from the plots of the junction resistances at the parallel magnetization configuration ($R_p$) as a function of the inverse junction area (1/A). RA values and MR ratios increased with the spacer layer thickness. The maximum values of MR ratio and $\Delta RA$ were 56% and 20 m$\Omega$μm$^2$ for $t$ = 5 nm. CPP-GMR effects of the devices with thicker spacer layer are to be discussed at the presentation.

Acknowledgements: 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.

References: