Spacer layer thickness dependence of CPP-GMR effects in Co_2(Fe-Mn)Si/$L1_2$-Ag-Mg/Co_2(Fe-Mn)Si devices

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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 ΔRA value of 17 mΩμm^2 in the CPP-GMR devices using a $Ag_{83}Mg_{17}$ spacer layer with partial $L1_2$-ordering and $Co_2Fe_{0.4}Mn_{0.6}Si$ (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) sub./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 650ºC and 500ºC, 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 ΔRA were 56% and 20 mΩμm^2 for t = 5 nm. CPP-GMR effects of the devices with thicker spacer layer are to be discussed at the presentation.

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