CPP-GMR devices using $Co_2Fe(Ga_{0.5}Ge_{0.5})$ full Heusler alloy and a AgZn alloy spacer

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The current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) devices with a metallic spacer layer have been considered to be promising for read sensors of ultrahigh density hard disk drives (HDDs). Using a Ag spacer layer, the MR ratios have reached over 50% with the resistance-change area product (ΔRA) reaching 9-12 mΩ μm^2. However, a room-temperature ΔRA of at least 15 mΩ μm^2 is required to use CPP-GMR as a read sensor for the areal density of over 2 Tbit/in^2. In this work, we report a very large MR output obtained from the CPP-GMR devices that use CFGG Heusler alloy as ferromagnetic layers combined with an Ag-Zn alloy spacer.

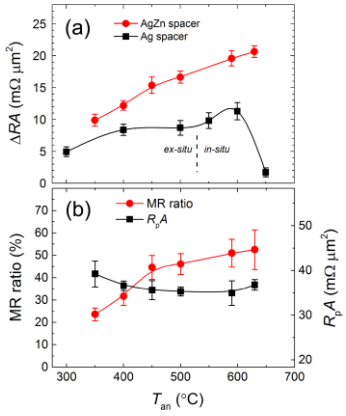

Fig. 1 Annealing temperature dependence of (a) ΔRA for AgZn, Ag spacer and (b) MR ratio and intrinsic R_pA for AgZn spacer.

Fully epitaxial multi-layer stacks of Cr(10)/Ag(100)/CFGG(10) /AgZn(5)/CFGG(10)/Ag(5)/Ru(8) (thickness in nm) were deposited onto (001) MgO single-crystalline substrates at room temperature (RT) by ultrahigh vacuum magnetron sputtering with a base pressure lower than 4×10^{-7} Pa. The CFGG and AgZn layers were deposited from alloy targets. The compositions of the deposited films examined by the induced coupled plasma analysis were $Co_{47.2}Fe_{25.9}Ga_{13.5}Ge_{13.4}$ and $Ag_{50.2}Zn_{49.8}$ (at%). The top CFGG layer was annealed right after deposition with annealing temperature (T_{an}) ranging from 350ºC to 630ºC. The samples were fabricated into CPP-GMR devices using electron beam lithography and Ar milling. The area of the pillar was measured by scanning electron microscopy. The microstructure was characterized by transmission electron microscopy (TEM).

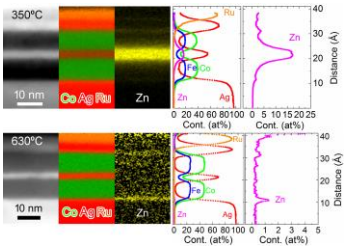

Fig. 2 HAADF-STEM images and EDS mappings for thin film stack of MgO//Cr(10)/Ag(100)/CFGG(10)/AgZn (5)/CFGG(10)/Ag(5)/Ru(8) annealed at 350ºC and 630ºC.

Intrinsic MR ratio of 25.6% with ΔRA of 10.9 mΩ μm^2 was obtained in the sample annealed at 350ºC and MR ratio of 59.6% with ΔRA of 21.5 mΩ μm^2 in the sample annealed at 630ºC (Fig. 1). The structure of AgZn was found to be B2 in the as-deposited state; however, it changes to fcc after annealing at 350ºC. At 630ºC, Zn diffuses out of the spacer region (Fig. 2). The diffusion of Zn at 630ºC improves the degree of ordering in CFGG, thereby enhancing the MR output. This work shows that the CPP-GMR devices with the AgZn spacer layer are promising for readers for high-density HDDs. The method for obtaining high spin polarization by utilizing the diffusion of Zn would be useful not only for CPP-GMR but also for other spintronic applications.