Ag/InZnO/Zn スペーサーを用いた CPP-GMR 素子の微細構造

Effects of layer thickness and microstructure of CPP-GMR with Ag/InZnO/Zn spacer

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Transparent conductive oxide-based spacer layers for current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) sensor device have demonstrated significant improvements of MR ratio ($\Delta R/R$) and signal output of the sensors. In the previous work [1] inserting thin (<1 nm) Ag and Zn layers below and above the In-Zn-O (IZO) (~2 nm) spacer, respectively (namely, Ag/IZO/Zn spacer structure) was shown to be essential to obtain the relatively large MR output. Here we report systematic investigations of the dependence of the Ag and Zn thickness on RA and $\Delta R/R$, and the microstructure of the CPP-GMR sensor films with the Ag/IZO/Zn spacer.

Polycrystalline spin-valve devices were fabricated using Ta(2)/Ru(2)/IrMn(6)/CoFe(2.8)/Ru(0.8)/CoFe(0.6)/CoFeBTa(0.8)/CMFG(2.5)/CoFe(0.4)/Ag(0.2 or 0.4)/IZO(1.6)/Zn(0.8)/CoFe(0.4)/CMFG(4)/CoFe(1)/Ru(8) (thickness in nm) films, where CMFG denotes $Co_2(Mn_{0.6}Fe_{0.4})Ge$ Heusler alloy. As shown in Fig. 1, by using Ag/IZO/Zn trilayer spacers the MR ratio ($\Delta R/R$) of the CPP-GMR devices improved up to 22% with increased RA up to ~110 mΩ μm^2 compared to the case with the $Ag_{90}Sn_{10}$ metallic spacer (RA ~65 mΩ μm^2, $\Delta R/R$ ~9%).

The spatial distributions and the depth concentration profiles of In, Zn and Ag by energy dispersive x-ray spectroscopy (EDS) are shown in Fig. 2(a)-(d) for the Ag(0.4)/IZO(1.6)/Zn(0.8) spacer (RA ~75 mΩ μm^2 and $\Delta R/R$ up to 19%). The Ag mapping shows a laterally discontinuous distribution of the Ag concentration in the IZO spacer. The Ag-rich parts may have a higher electric conductivity than that of the IZO matrix, which could be the mechanism of the increased RA and $\Delta R/R$ using the Ag/IZO/Zn spacer. An enrichment of Mn in the position of the spacer layer was also found (Fig. 4(e)), which may be due to the diffusion of Mn during the annealing at 280 °C. Since Mn in spacer layer may cause a considerable spin-flip scattering which degrades the CPP-GMR output, suppressing the Mn diffusion to the spacer layer should be the key for further improvements of CPP-GMR sensor output.

Ref. [1] Nakatani et al. Appl. Phys. Express 8, 093003 (2015).

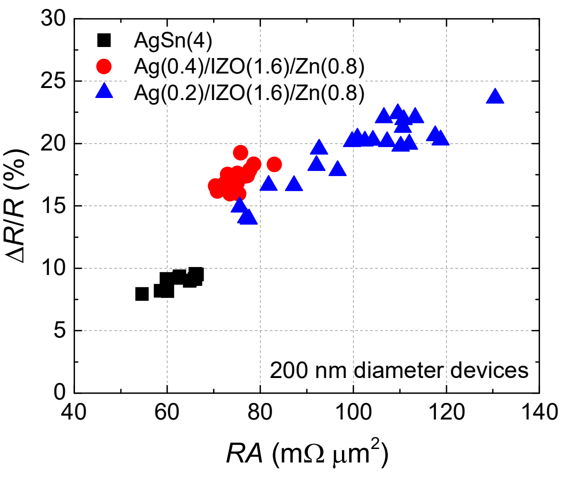

Fig. 1 RA-$\Delta R/R$ of the CPP-GMG sensors with AgSn and Ag/IZO/Zn spacers

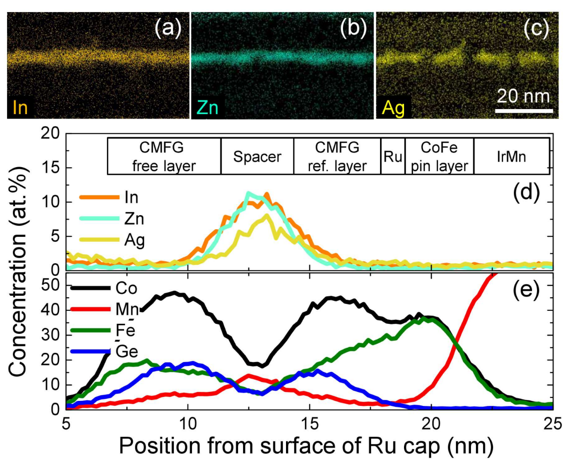

Fig. 2 EDS mapping and depth profile of the CPP-GMR film with Ag(0.4)/IZO(1.6)Zn(0.8) spacer.