**Presentation Title**

**Spin-dependent transport in current-perpendicular-to-plane/current-in-plane devices with highly spin-polarized Heusler compounds**

**Abstract**

Half-metallic ferromagnets (HMFs), which possess perfectly spin-polarized conduction electrons due to the semiconducting gap in either the up- or down-spin channel at the Fermi level, are attracting much interest in spintronics because they are expected to enhance and elicit various spin-dependent phenomena and improve the performance of applications. Recently, several Co-based full-Heusler compounds, a class of HMFs, such as Co₂MnSi (CMS), Co₂MnGe, and Co₂FeAl₀.₅Si₀.₅, have been applied as ferromagnetic electrodes in magnetic tunnel junctions and large MR ratios due to high spin-polarization have been reported at low temperature (LT) successfully[1,2]. However, MR ratio drastically decreases with temperature due to the thermal fluctuation of magnetic moments and/or the impurities and dislocations at the barrier/Heusler electrode interfaces. Thus, it is one of the most challenging works to realize high spin-polarization reflecting a half-metallicity not only at LT but also room temperature (RT) for future spintronics. The final goal of our research in this project is to realize nearly ideal half-metallicity at RT in the current-perpendicular-to-plane/current-in-plane type devices.

One of the most promising next application of half-metallic Heusler compounds is the electrode for CPP-GMR devices which have a structure of ferromagnetic electrode/nonmagnetic spacer/ferromagnetic electrode. Because the spin-dependent electron scatterings not only at the interface but also inside the bulk region can contribute to the MR effect. In this study, we have fabricated the CPP-GMR devices with the (001)-oriented fully-epitaxial CMS/Ag/CMS structures and successfully observed large MR ratio over 30% at RT as shown in Fig.1[3-5]. This MR ratio was one order of magnitude larger than that reported in the CPP-GMR devices with convention transition metals such as Fe or Co. We also analyzed the spin-asymmetry of electric resistivity at the interface and in the bulk region (represented by the coefficients $\gamma$ and $\beta$, respectively) on the basis of the two-current model proposed by Valet and Fert. The result showed that the interface spin-asymmetry $\gamma$ was quite large and predominantly contributes to observed large MR ratio.[4] We successfully clarified by the theoretical support from Prof. Shirai’s group that the origin of large $\gamma$ is the good Fermi surface
matching of majority spin electron band between (001)-CMS and (001)-Ag.[4] Not only MR effect but also spin-transfer-torque (STT) induced phenomena such as STT-induced magnetization switching (SIMS) and oscillation (STO) are also interesting topic since large STT effect can be expected by using highly-spin-polarized Heusler compounds. Very recently, we successfully observed large output power of STO (~ 3nW) in the CMS/Ag/CMS device due to large MR effect and STT effect as shown in Fig.2.[6] Because the precession angle of STT we observed was still very low (just 12°), we expect to enhance output power drastically by inducing the large magnetization precession mode in the CMS layer in near future.

In addition to the CPP-type device, current-in-plane type (lateral type) devices using half-metallic Heusler compounds are also interesting to study because multi-termination can be realized easily in a lateral device. We fabricated the lateral type spin valve device with consists of two CMS wires (one is spin-injector and the other one is detector) and a nonmagnetic Ag channel wire. It is still preliminary result but we observed large spin-accumulation signal $\Delta R_s$ of 7.2 mΩ at RT in the Ag wire. To inject highly spin-polarized current or pure spin current from half-metals to semiconductors in the lateral device is an important subject for realizing new spintronic applications such as spintransistor.