Half-metallic Heusler compounds: Spin-dependent transport properties in thin films and magnetoresistive devices

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History of half-metallic materials started more than 30 years ago from the first prediction of half-metallicity in NiMnSb by Groot et al.[1] Although nearly 100% spin-polarization at room temperature (RT) has never been observed so far in magnetoresistive devices via spin-dependent transport measurements, there is still large expectation in various spintronic applications with half-metals because large spin-polarization without using tunnelling spin-filter effect is beneficial to realize high performance spintronic devices with very low device resistance. Recent extensive studies on current-perpendicular-to-plane giant magnetoresistive (CPP-GMR) devices using half-metallic Co-based full Heusler compounds successfully demonstrated large enhancement of magnetoresistance at RT with small RA below 0.1Ωμm^2 due to high spin-polarization of Co-based full Heusler compounds. Large MR ratio over 30% at RT has been reported in fully-epitaxial CPP-GMR devices with Co-based Heusler such as Co_2MnSi, $Co_2FeGa_{0.5}Ge_{0.5}$(CFGG) and $Co_2Fe_{0.4}Mn_{0.6}Si$[2-4], which is one order of magnitude larger than CPP-GMR with general 3*d* transition metals (Figure 1). We have recently fabricated fully-epitaxial CPP-GMR devices CFGG/Ag/CFGG with very thin NiAl insertion to CFGG/Ag interfaces and observed surprisingly large MR ratios of 82% at RT and 285% at 10 K[5]. This enhancement by inserting thin NiAl seems to be related with good electronic band matching between NiAl and CFGG electrode, but careful analysis beyond the framework of diffusive transport model is necessary because the thickness of inserted NiAl is just 0.21 nm which is shorter than mean free path. On the other hand, the effect of chemical disordering of Heusler on spin-polarization of conduction electron have been carefully analysed in our recent study via AMR effect and anomalous XRD measurement in SPring-8.[6,7] Our studies clearly confirmed the importance to suppress Co antisite by optimizing the composition ratio in Heusler film/electrode for obtaining large spin-polarization. The progress of recent study and future prospect of half-metallic Heusler compounds will be presented.

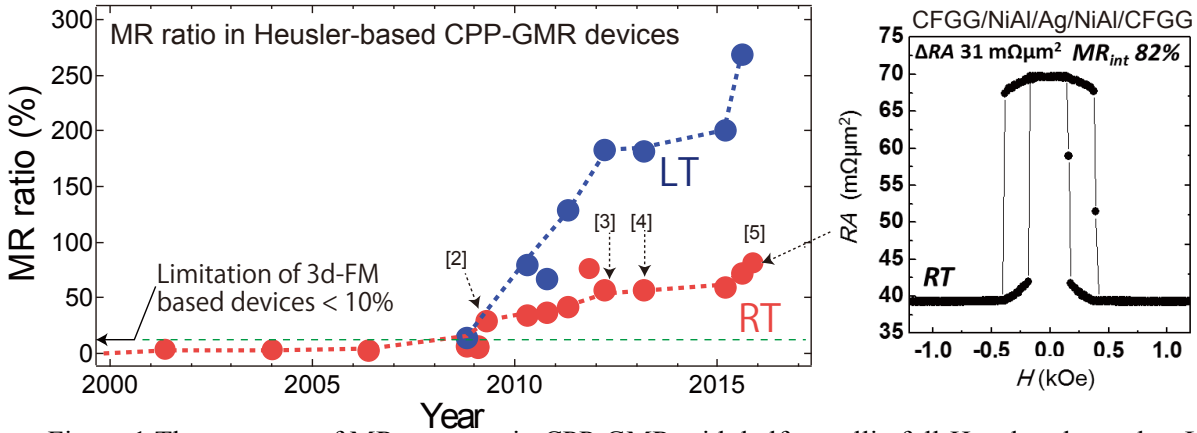

Figure 1.The progress of MR property in CPP-GMR with half-metallic full-Heusler electrodes. Left figure shows MR curve at RT in CFGG/NiAl/Ag/NiAl/CFGG CPP-GMR device[5].

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