Magnetic tunnel junctions with an equiatomic CoFeMnSi Heusler alloy electrode

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Highly spin-polarized current sources are an essential requirement for spintronic devices, which are expected to provide non-volatile, reconfigurable logic functions and ultralow power consumption. Due to the existence of an energy gap for one spin band, half-metallic ferromagnets feature complete spin polarization P at the Fermi level E_F and are suitable candidates for spin-polarized current sources. Among the various half-metallic materials, Co_2-based ternary Co_2YZ and pseudo-quaternary $Co_2Y_{1-x}Y'_xZ$ full Heusler alloys have a special place due to their tunable electronic structure, a Curie temperature T_C that is well above room temperature, and P that is close to unity.

As a different class of materials, there is increasing interest in equiatomic quaternary XX'YZ Heusler alloys since these materials can exhibit various functional properties resulting from their crystal structures differing in symmetry from the original Heusler $L2_1$ structure [1]. Here, we focus on CoFeMnSi (CFMS) from among the numerous elemental combinations suggested. Quite recently, we succeeded in growing single-crystalline CFMS films that have full $B2$ and partial $L2_1$ ordering, which were still expected to show a half-metallicity even though the pseudo gap in the majority spin band could be lost due to the non-ideal Y-type structure [2].

In this work, we study on TMR for CFMS/MgO/CoFe MTJs to gain an insight into the half-metallicity of CFMS. A relatively high TMR ratio of about 521% and 101% were observed at 10 and 300 K, respectively, as shown in Fig. 1 [3]. This suggested the high spin polarization of CFMS with a full $B2$ and partial $L2_1$ ordered structure even though the obtained TMR ratio was smaller than the past record in the MgO-MTJs with CoFe and Mn-enriched Co_2MnSi Heusler alloy electrodes [4]. The large bias voltage dependence of the TMR ratio was also observed at low temperature, as similarly observed in Co_2MnSi Heusler alloys-based MTJs in the past. The physical origin of this TMR ratio is discussed in terms of the half-metallicity of CFMS.

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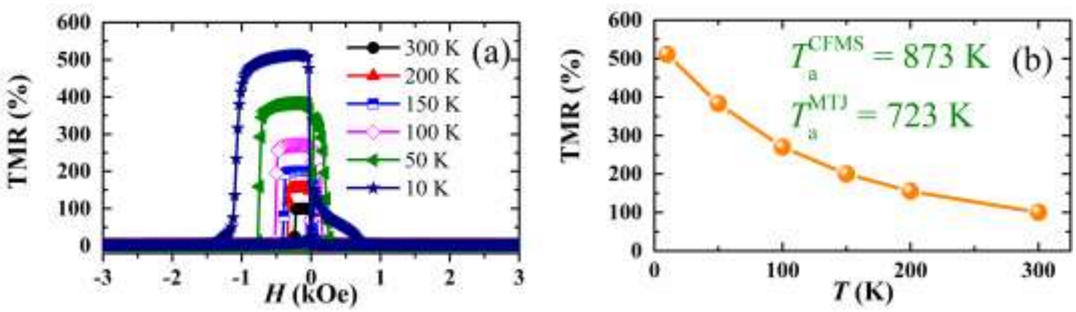

Figure 1. (a) The TMR curves for the MTJs with T_a^{CFMS} = 873 K and T_a^{MTJ} = 723 K with different measurement temperatures T. (b) The TMR values as a function of T. Here, T_a^{CFMS} and T_a^{MTJ} are the CFMS post annealing and MTJ *ex-situ* annealing temperatures.