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Bias current density dependence of CPP-GMR ratio in Co_2(Fe, Mn)Si Heusler alloy based junctions

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For the present advanced information society, the importance of storage devices with a high recording density, such as hard disk drives (HDDs), is increasing. It is required to develop a highly sensitive reading head element for HDDs with a recording density over several tela-bit per square inch. The current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) device is one of a candidate of the reading head element for the next generation HDDs. We previously reported large MR ratio of 49% at room temperature for the CPP-GMR devices using half metal Heusler alloy $Co_2(Fe_x, Mn_{1-x})Si$ (CFMS) [1]. The high output of the Heusler alloy based CPP-GMR devices is attractive, although the reported high MR ratio was measured at a small bias current density (~ 0.05×10^8 A/cm^2). Operation at a high current density (1.0×10^8 A/cm^2) is needed for the commercial reading head for assuring high enough signal-to-noise (S/N) ratio. However, it is expected that the MR ratio of the CFMS-based CPP-GMR devices decreases drastically under the operation using high-current density, because fluctuation of magnetization becomes large under the large current flow for its small Gilbert damping constant, α, of the CFMS layer (especially $x \sim 0.4$) [2]. Understanding of the current density dependence of MR ratio in CPP-GMR devices using Heusler alloys can be useful for the development of the device applications. Therefore, in this study, the current density dependence of MR ratio in CPP-GMR devices was investigated using Heusler alloy CFMS electrode with several compositions.

Samples were prepared by an ultrahigh-vacuum (UHV)-compatible magnetron sputtering system. The prepared CPP-GMR devices include CFMS(20 nm)/Ag(5 nm)/CFMS (7 nm) trilayer where the composition of the CFMS layers were; x = 0.3, 0.5, and 1.0. The current density dependence of MR ratio was measured by a direct current four-probe technique. The polarity of the bias current was defined as an electron flows from top to bottom when the positive bias was applied. The current density for the measurement was changed from 0.05×10^8 A/cm^2 to 1×10^8 A/cm^2. Fig. 1 shows the bias current density dependence of the normalized MR ratio for the three CFMS compositions. The MR ratio decreases with increasing the current density for all compositions, which is independent of the compositions. The junction size dependence and the dependence of resistance area product on the bias current density will be also discussed at the presentation.

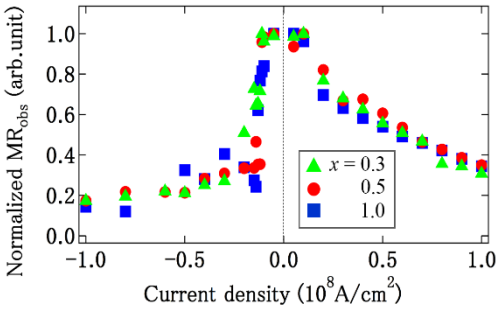

Fig.1 Bias current density dependence of the MR ratio for the CPP-GMR devices using CFMS electrodes.

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