Current-perpendicular-to-plane giant magnetoresistance effect in Co_2(Fe-Mn)Si/Ag-Mg/Co_2(Fe-Mn)Si junctions

Hiroyuki Narisawa[1], ○Takahide Kubota[1], and Koki Takanashi[1] (1.IMR, Tohoku Univ.)

E-mail: tkubota@imr.tohoku.ac.jp

Introduction: Development of hard disk drives (HDDs) with a recording density over several tera-bit per square inches is required for the present information society. Current-perpendicular-to-plane giant magnetoresistance effect (CPP-GMR) is expected as a key technology for the reading head element of HDDs, and it is necessary to increase the output ($\propto \Delta R \times A$ which means resistance (R) and area (A) product) of a CPP-GMR junction. From a view point of the material investigation, half-metallic Heusler alloys, such as Co_2(Fe-Mn)Si (CFMS) [1, 2], are promising for achieving high-output-CPP-GMR junctions. However, it is still necessary to increase the output for the application of HDD's reading head. In this work, we investigated CPP-GMR junctions using Ag-Mg spacer layer. The Ag-Mg alloys have several solid solution phases for the Mg-composition ranging 0 – 50 at.%, and lattice mismatch between CFMS and Ag-Mg alloys are less than 3%, typically [3]. Thus it is also expected that the Ag-Mg alloys can be good material candidates for the CPP-GMR junctions.

Experimental: All films were deposited by using an ulgra-high vacuum magnetron sputtering machine (base pressure $< 1 \times 10^{-7}$ Pa). Stacking structure of the samples was: MgO (100) sub. / Cr (20 nm) / Ag (40 nm) / CFMS (20 nm) /Ag-Mg (5 nm)/CFMS (7 nm) / Ag (2 nm) / Au (5 nm). All the layers were deposited at an ambient temperature, and *in situ* post-annealing were performed at 650°C and 500°C, after the depositions of Cr and CFMS layers, respectively. Compositions of CFMS and Ag-Mg were $Co_{48}Fe_{13}Mn_{15}Si_{25}$ (at.%) (~ $Co_{1.9}Fe_{0.5}Mn_{0.6}Si_{1.0}$) and $Ag_{83}Mg_{17}$ (at.%), respectively. The samples were patterned into pillar structures by using an electron-beam lithography and an Ar-ion dry-etching technique. Transport properties were measured by direct current four-probe method at room temperature. In the following part we describe *observed* values of MR ratio which includes parasitic resistance of the junction.

Results: Epitaxial growth and the $L2_1$ ordering of CFMS layer were confirmed by a reflection high energy electron diffraction at the surface of the top CFMS layer. An MR ratio of a junction using the Ag-Mg spacer was 40% which is comparable to that using Ag spacer layer (38%). However, the value of $\Delta R \times A$ of the Ag-Mg-spacer junction was 22 m$\Omega\mu$m^2 which is higher than that of the junction using Ag spacer (10 m$\Omega\mu$m^2). These results imply that the combination of the Ag-Mg spacer and the CFMS Heusler alloy is promising for realizing CPP-GMR junctions applied to the next-generation HDDs' reading head elements.

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References:

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