19a-S2-10

Fabrication of Magnetic Tunnel Junctions with $Co_2Fe_{0.4}Mn_{0.6}Si$ Heusler Alloy for Magnetic Field Sensor Devices

Department of Applied Physics, Tohoku Univ. [1]

°**Atsuo Ono**[1]**, Mikihiko Oogane**[1]**, Hiroshi Naganuma**[1]**, and Yasuo Ando**[1]

E-mail: atsuo@mlab.apph.tohoku.ac.jp

The discovery of the large tunnel magnetoresisitance (TMR) effect in magnetic tunnel junctions (MTJs) enables us to design highly sensitive magnetic field sensors. In such applications, MTJs with a large sensitivity and a linear resistance response are needed. In our previous study, MTJs using amorphous CoFeSiB free layer exhibited a large sensitivity of 40%/Oe (sensitivity = TMR ratio/2H_k, H_k : anisotropy field) [1]. However, improvement of sensitivity was required to detect a very small magnetic field such as brain field (ca. 10^{-8} Oe). To improve the sensitivity, $Co_2Fe_{0.4}Mn_{0.6}Si$ (CFMS) Heusler alloy is useful for free layer because CFMS is a good candidate for high-spin polarization and a good soft magnetism [2]. In this study, we fabricated MTJs with CFMS Heusler alloy electrode to confirm that the MTJs showed a linear resistance response.

The stacking structure of MTJs was Si/SiO_2/MgO (20)/CFMS (50)/MgO (2.0)/$Co_{50}Fe_{50}$ (5)/$Ir_{22}Mn_{78}$ (10) /Ta (5) (in nm). All the films were prepared by an ultra-high vacuum magnetron sputtering system. The MTJs were fabricated using photolithography and Ar ion milling. After micro-fabrication, the MTJs were annealed at 200 to 350℃ with a magnetic field of 1T for 1h in a high-vacuum furnace, in order to induce magnetic anisotropy and estimate high TMR ratio (1st annealing). After the first annealing, the MTJs were annealed again at 160 to 200℃ in air with in-plane 90° rotated magnetic field, in order to achieve hysteresis-free linear resistance response (2nd annealing). Magneto-resistance properties were measured at room temperature by using the DC four–probe method.

Figure 1 shows the 1st annealing temperature dependence of TMR curves. Direction of magnetic field was easy axis of the free layer. TMR ratio was 72% at 200°C and decreased by increasing annealing temperature. In addition, TMR curves showed a hysteresis as shown in Fig. 1. This result indicates that both magnetic easy axes of free and pinned layers were parallel. Figure 2 shows the 2nd annealing temperature dependence of TMR curves. Direction of magnetic field was hard axis of the free layer. TMR curve showed a linear resistance response in the MTJ annealed at 200°C. We found that the MTJs with CFMS Heusler alloy electrode was useful for the sensor applications. This work was supported by the S-Innovation program, Japan Science and Technology Agency (JST).

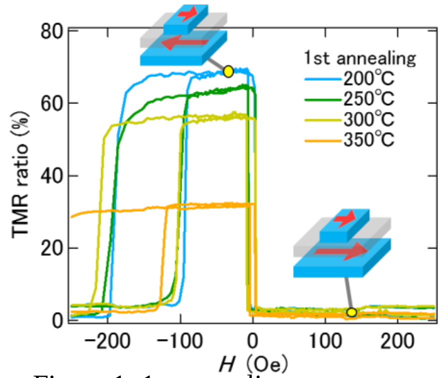

Figure 1: 1st annealing temperature dependence of MR curves.

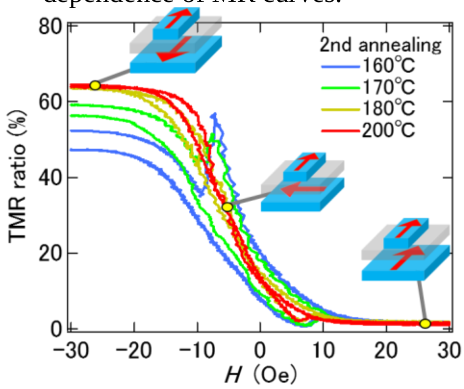

Figure 2: 2nd annealing temperature dependence of MR curves.

[1]D. Kato, *et al.*, Appl. Phys. Express **6**, 103004 (2013)

[2]T. Kubota, *et al.*, Appl. Phys. Lett. **94**, 122504 (2009)