Magnetic Tunnel Junction with Amorphous NiFeSiB Electrode for Highly Sensitive Magnetic Field Sensor

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Magnetic tunnel junctions (MTJs) based magnetic field sensors are promising candidate to replace SQUID, because of small size, low power consumption, and room temperature operation. A high sensitivity (=TMR ratio/2H_k, H_k is magnetic anisotropy field) is required to detect a very small magnetic field such as bio-magnetic field (10^{-8} – 10^{-10} Oe). In addition, we need to reduce noise of the MTJ sensors at low-frequency, because typical bio-magnetic field is below several hundred Hz. In previous work, we achieved the detectivity of 4 x 10^{-4} Oe in a single MTJ with amorphous CoFeSiB electrode [1]. However, higher detecticvity is necessary for detection of bio-magnetic field. In low frequency, the 1/*f* noise is dominant and the noise can be reduced by using the soft magnetic materials with high saturation magnetization (M_s) [2]. In this study, we investigated the TMR properties in MTJs with amorphous NiFeSiB electrode with a higher M_s than CoFeSiB.

The films were deposited onto thermally oxidized Si wafers using an ultra-high-vacuum magnetron sputtering system (P_{base} < 3.0 x 10^{-6} Pa). The stacking structures of the MTJ films were $Si/SiO_2/Ta(5)/Ru(10)/Ta(5)/Ni_{16}Fe_{62}Si_8B_{14}(30)/Ru(t_{Ru})/Co_{40}Fe_{40}B_{20}(3)/MgO(2.5)/Co_{40}Fe_{40}B_{20}(3)/Ru(0.9)/Co_{75}Fe_{25}(5)/Ir_{22}Mn_{78}(10)/Ta(5)$ (in nm). The magneto-resistance properties were measured by the DC four-probe method at RT in magnetic shield room.

The measured M_s of NiFeSiB was 1200 emu/cc (cf. 650 emu/cc in CoFeSiB). Fig. 1 shows Ru thickness dependence of TMR for various annealing temperature (T_a) of MTJs. TMR ratio increased with annealing temperature. The maximum TMR ratio of 215% was observed at t_{Ru} = 0.7 nm and the TMR ratio was higher than those in MTJs with NiFe and CoFeSiB electrodes. We will show the magnetic sensor performance in the MTJs with NiFeSiB electrode.

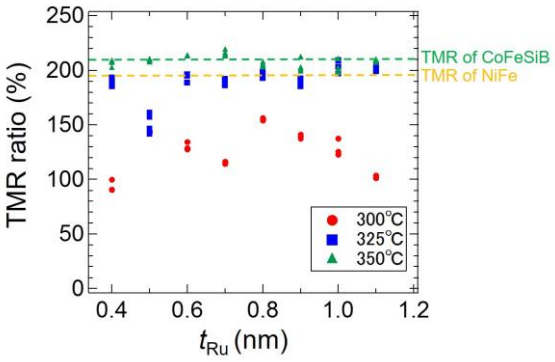

Fig. 1 Ru thickness (t_{Ru}) dependence of TMR ratio in MTJs with NiFeSiB electrode

This work was supported by the S-Innovation program, Japan Science and Technology Agency (JST), Center of Innovative Integrated Electronic Systems, and Grant-in-Aid for JSPS Fellows 15J02067

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[2] W. F. Egelhoff Jr. *et al*., Sensors and Actuators A **155** (2009) 217 - 225