Fabrication of MTJ array for bio-magnetic field sensor

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Tunnel magneto resistive (TMR) sensors are promising candidates to replace SQUID with their recent development. They may work with low energy consumption and at room temperature environment with desired magnetic field sensitivity. In order to detect a smaller magnetic field, such as a bio-magnetic field of 10^{-8}–10^{-10} Oe, we have to develop magnetic tunneling junctions (MTJs) with higher sensitivity (over 100%/Oe). In recent studies, we achieved 40%/Oe in MTJs with amorphous CoFeSiB ferromagnetic electrodes [1]. However, MTJ arrays are needed to reduce 1/f noise and obtain enough signal-to-noise ratio [2]. In this study, we fabricated 10x10 arrays of MTJs with amorphous CoFeSiB and investigated their TMR effect.

Film deposition was performed in multi target Ultra high vacuum (UHV) system with P< $3x10^{-6}$ Pa. The thin film stacking was deposited on Si/SiO2 wafer as Ta(5)/Ru(10)/Ta(5)/CoFeSiB(30) /Ru(0.4)/$Co_{40}Fe_{40}B_{20}$(3)/MgO(3)/$Co_{40}Fe_{40}B_{20}$(3)/Ru(0.9)/$Co_{75}Fe_{25}$(5)/$Ir_{22}Mn_{78}$(10)/Ta(5)/Ru(8) (in nm). MTJs were fabricated with conventional micro-processes such as photo lithography and Ar ion milling. Junction area of every MTJ was 31x31um. MTJs were annealed in vacuum furnace under 1T magnetic field to observe annealing effect on TMR character. TMR effect was measured with PC controlled 4 probe system.

Figures 1 and 2 show annealing temperature dependence of TMR ratio and coercive field (H_c) respectively compared with single MTJs. For as deposited MTJs, TMR ratio was comparable to that in single MTJ. However, increase of TMR ratio by annealing process was small compared with single MTJs and a maximum TMR ratio was only 130% at 325°C. The reduction of TMR in MTJ arrays is due to the distribution of the TMR ratio and the resistance in each MTJ after annealing. On the hand, H_c was comparable to that in single MTJs. This result indicates that distribution of magnetic properties in the free layer was small in MTJ arrays. This work was supported by S-Innovation program, Japan Science and Technology Agency (JST). [1].D. Kato *et al.*, *Appl. Phys. Express* **6,** 103004 (2013), [2] M. Tondra et al. J. Appl. Phys. 83, 6688 (1998).

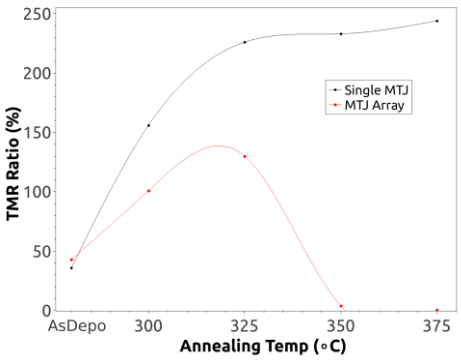

Fig 1: Annealing temperature dependence of TMR

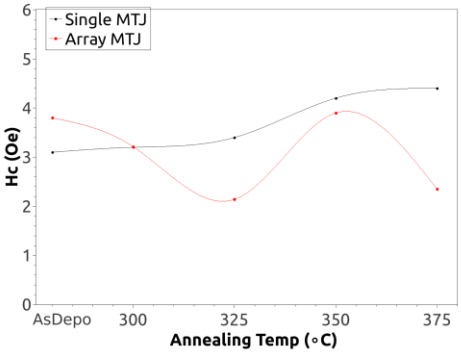

Fig 2: Annealing Temperature dependence of H_c