Stacking structure optimization of MTJ sensor array with CoFeSiB free layer

°S. Cakir[1], M. Oogane[1], D. Kato[1], K. Fujiwara[1], J. Jono[2] and Y. Ando[1]

[1] Department of Applied Physics, Tohoku University

[2] Konica Minolta Corporation

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

Magnetic tunnel junction (MTJ) sensors become popular on various sensing application with their recent development [1]. Highly sensitive MTJs (over 100%/Oe) are needed to detect small field such as bio-magnetic fields. In recent studies, our group reported sensitivity of 40%/Oe in MTJs with amorphous CoFeSiB ferromagnetic electrodes [2]. However, MTJ arrays are needed to obtain enough signal-to-noise ratios [3]. In this study, we investigated sensor properties in series connected arrays of 100 MTJs with soft CoFeSiB electrodes and different thickness of IrMn and CoFeB layers.

Film deposition was performed in multi target ultra-high-vacuum (UHV) system with $P < 3\text{x}10^{-6}$ Pa base pressure. The thin film stacking was deposited on Si/SiO_2 wafer with magnetic field assistance as Ta(5)/Ru(10)/Ta(5)/CoFeSiB(100)/Ru(0.4)/$Co_{40}Fe_{40}B_{20}$(3)/MgO(RA)/$Co_{40}Fe_{40}B_{20}$(A)/Ru(0.9)/$Co_{75}Fe_{25}$(5)/ $Ir_{22}Mn_{78}$(B)/Ta(5)/Ru(8) (nm) where MgO RA value is $3\text{x}10^4 \Omega\mu m^2$, A is 2.0,2.5,3.0 and B is 6-10. MTJ arrays were fabricated with conventional micro-processes such as photo lithography and Ar ion milling. MTJs were annealed two times in vacuum furnace under 1T magnetic field on easy axis and orthogonal to easy axis for hysteresis free TMR response. First annealing temperature was 350°C and second annealing temperature was 270°C. Magnetoresistance was measured with PC controlled 4 probe system.

Figure 1 is Comparison of NiFe and CoFeSiB Series connected array MTJs. Although TMR sensitivity was higher for MTJs with CoFeSiB, the loop shift was large. Figure 2 shows transfer curves for various thicknesses of pinned CoFeB layer contained stacking. As Pinned CoFeB increased, transfer curve shifted to origin and sensitivity at zero field was improved.

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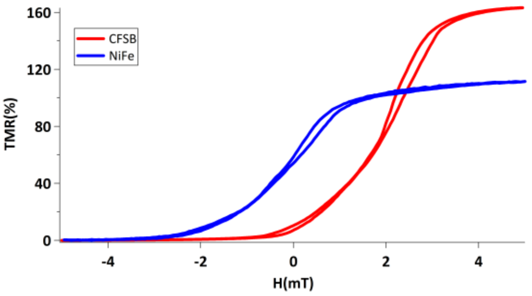

Fig. 1 Transfer curves for NiFe and CFSB MTJs array.

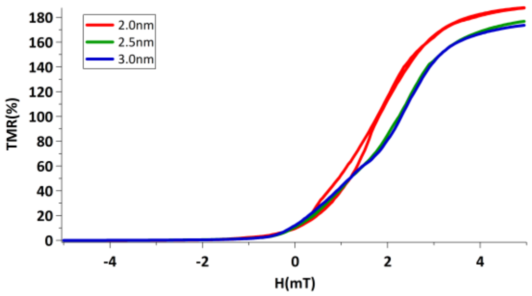

Fig. 2 Transfer curves of various thickness pinned CoFeB.