Control of second annealing temperature in magnetic tunnel junction based sensors by IrMn thickness

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Magnetic tunnel junctions (MTJs) are promising candidate to replace SQUID senseor, because MTJs have features of small size, low power consumption and room temperature operation. High signal (≅ sensitivity: TMR/2H_k, H_k is magnetic anisotropy field)/noise ratio and linear resistance response are required in MTJ sensors. In previous work, double annealing process was carried out to obtain both high sensitivity and linear response. However, second annealing process need to optimize because magnetic anisotropy of free layer seemed to be dispersed at high second annealing temperature [1]. In this study, we investigated the magneto-resistance properties in MTJs with different IrMn thickness in order to control second annealing temperature.

The films were deposited onto thermally oxidized Si wafers using magnetron sputtering system and the stacking structures of the MTJ films were Subs./Ta (5)/$Ni_{80}Fe_{20}$ (70)/Ru (0.8)/$Co_{40}Fe_{40}B_{20}$ (3)/MgO (2.5)/$Co_{40}Fe_{40}B_{20}$ (3)/Ru (0.8)/$Co_{75}Fe_{25}$ (5)/$Ir_{22}Mn_{78}$ (6,10)/Ta (5)/Ru (8 nm). The magneto-resistance properties were measured by the DC four-probe method at RT. After micro-fabrication, the MTJs were annealed at 350°C for 1 h in a vacuum furnace. The MTJs were annealed again (second annealing process) for 15 min in the atmosphere to obtain orthogonal magnetic easy axis of free and pinned layers.

Figs. 1 (a) and (b) show TMR curves in MTJs with 10 and 6 nm thick IrMn antiferromagnetic layers. For the MTJ with 10 nm thick IrMn, TMR ratio was small at second annealing temperature ($T_{a\text{-}2nd}$) = 220°C and increased with increasing $T_{a\text{-}2nd}$. A small TMR at low $T_{a\text{-}2nd}$ was attributed to imperfect anti-parallel configuration of free and pinned layer magnetizations, because easy axis of pinned layer did not change the direction to applied magnetic field during second annealing. On the other hand, for the MTJ with 6 nm thick IrMn, both large TMR and linear response were observed even at $T_{a\text{-}2nd}$ = 220°C, because the second annealing temperature that magnetic anisotropy of pinned layer was induced decreased by thin IrMn layer. From those results, we found that second annealing temperature can be controlled by IrMn thickness. In presentation, we will discuss the signal/noise ratio at small and low frequency AC magnetic field.

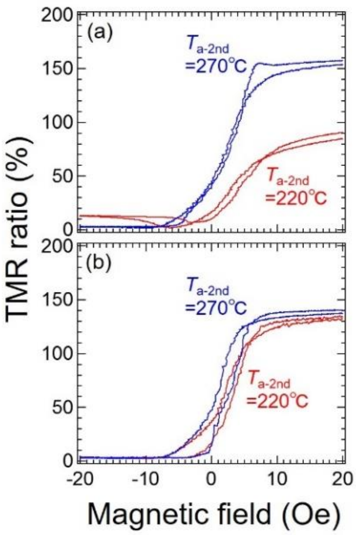

Fig. 1 TMR curves in MTJ with t_{IrMn} = (a)10nm, (b)6 nm

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