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Annealing temperature dependence of properties of magnetic tunnel junction with perpendicular easy axis using MgO/CoFeB/Ta/CoFeB/MgO recording structure

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Magnetic tunnel junctions with perpendicular easy axis (p-MTJs) are attracting attention as a promising building block for next-generation nonvolatile spintronics-based VLSIs.[1] It was reported that CoFeB-MgO p-MTJs with double-interface have a high potential to satisfy both low intrinsic critical current I_{C0} and high thermal stability factor Δ at reduced dimensions while maintaining high tunnel magnetoresistance (TMR) ratio.[2] For integration of p-MTJs with CMOS, MTJ needs to have the capability to withstand annealing to at least 350^{o}C for back-end-of-process compatibility. In this work, we study annealing temperature (T_a) dependence of properties of p-MTJ with MgO/CoFeB/Ta/CoFeB/MgO recording structure.

Stack structure composed of Ta(5)/Pt(5)/synthetic ferrimagnetic (SyF) reference layer/MgO/CoFeB(1.6)/Ta(0.45)/CoFeB(1)/MgO/Ta(5)/Ru(5) is deposited on thermally oxidized Si substrate by dc/rf magnetron sputtering. Numbers in parentheses are nominal thicknesses in nm. The SyF reference layer structure is the same as used in Ref. [2]. Circular p-MTJs with diameter D varied from 40 to 90 nm in diameter are fabricated by electron beam lithography, reactive ion etching, and Ar ion milling. After the p-MTJs fabrication, annealing is done for 1 hour under 0.4 T perpendicular magnetic field.

Figure 1 summarizes T_a dependence of TMR ratio where the TMR ratio is averaged over MTJs with D ranging from 40 to 90 nm. TMR ratio monotonically increases over 100% with increasing annealing temperature up to 320^{o}C, which agrees with previous work [3]. However, the TMR ratio drops to about 70% at T_a = 350^{o}C. The reason for the reduction of TMR ratio could be attributed to the tilting of magnetization of CoFeB layer in SyF reference layer at antiparallel magnetization configuration verified by measurement of major resistance versus magnetic field (R-H) curve.

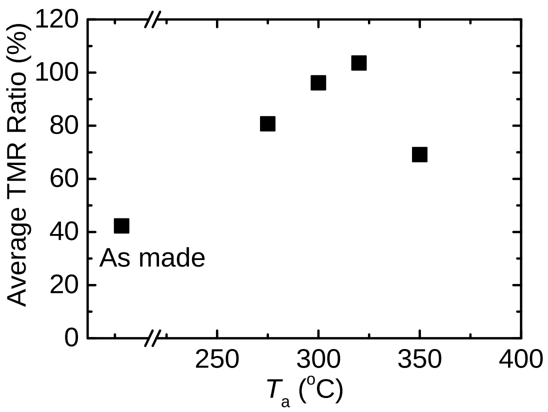

Fig. 1 Annealing temperature dependence of tunnel magnetoresistance ratio for magnetic tunnel junctions with synthetic ferrimagnetic reference layer and MgO/CoFeB/Ta/CoFeB/MgO recording structure.

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