Dependence of thermal stability on magnetic coupling in magnetic tunnel junction

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Thermal stability of magnetic tunnel junction (MTJ) is an important factor for the application of MTJ in connection with a semiconductor transistor. Recently, the study on the thermal stability in MTJ revealed that the thermal degradation of MTJ is closely associated with an interfacial mixing effect at ferromagnetic/AlOx interface [1,2]. In this work, we have investigated the change of magnetic coupling strength in MTJ with a structure of hard and soft magnetic layers as a function of barrier thickness and its thermal annealing and also studied the correlation between the magnetic coupling and thermal stability. The MTJs were prepared by a DC magnetron sputtering and consisted of Ta(10)/CoFe(12)/AlO_X/NiFe(20)/Ta(5) deposited on SiO_2/Si substrate, where the number of in parenthesis is a nominal thickness of each layer in the unit of nm. The nominal thickness of Al layer (t_{Al}) was varied from 1.0 nm to 2.0 nm. We have measured isothermal magnetization at room temperature before and after thermal annealing at 225^{O}C for the junctions with t_{Al} = 1.0 nm and 2.0 nm. The VSM data indicates that the magnetic coupling strength becomes higher with lower t_{Al} in the range of 1.0 ~ 2.0 nm, archetypical thickness Al in MTJ for practical use. In addition, thermal annealing works to reduce (and increase) the magnetic coupling for the junctions with $t_{Al} \geq 1.7$ nm (and $t_{Al} \leq$ 1.6nm), respectively. This observation can be utilized to understand consistently the change of the measured magneto-resistance ratio and its shape of the junctions depending upon the structures and thermal annealing. Our study demonstrates that the thermal stability of MTJ depends substantially not only the interface quality but also the magnetic properties of MTJ intimately associated with the insulating barrier structure.

References

[1] Minn-Tsong Lin, C. H. Ho, Y. D. Yao, R. T. Huang, C. C. Liao, F. R. Chen, and J. J. Kai, J. Appl. Phys. **91**, 7475 (2002)

[2] S. Cardoso, P. P. Freitas, Z. G. Zhang, P. Wei, N. Barradas, and J. C. Soares, J. Appl. Phys. **89**, 6650 (2001)