Thermal stability and underlayer effect on synthetic ferrimagnet free layer of magnetic tunnel junctions

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The increase of demagnetizing field causes the increase of switching fields of free magnetic layers when bit size of MRAM becomes smaller than several hundred nanometer. To suppress the increase of the switching fields, synthetic ferrimagnet (SynF) structure for the free magnetic layer has been proposed. By adopting SynF, effective magnetizations of the free layers can be decreased while keeping sufficient physical layer thickness. However, interlayer mixing of SynF can reduce the antiferromagnetic coupling strength significantly. In this article, we studied the effect of underlayer surface roughness and annealing on the coupling strength of SynF to evaluate feasibility of practical application. Samples with stacking structures of Ta(50)/NiFe(30)/Cu(200)/NiFe(30)/IrMn(30)/CoFe(40)/Al(10)-O/SynF[NiFe(69)/Ru(dRu)/NiFe(45)]/Ta(50) (Sample A), Ta(50)/SynF/Ta(50) (Sample B) and Al(10)-O/SynF/Ta(50) (S-ample C) (units in braces are A) were fabricated using ICP assisted rf magnetron sputter. VSM was used to measure magnetic hysteresis loops of the samples before and after annealing at temperature of between 150 and 250 °C. Surface roughness was measured using atomic force microscopy. Fig. 1. shows saturation field (H_s) of SynFs with various underlayers. The value of H_s is proportional to coupling strength of SynF. The coupling in Sample A (SynF in MTJ) was much smaller than that in Sample A (SynF on Ta underlayer). H_s of Sample C showed a minimum at Al thickness of 30 Å. However, further increase of Al thickness gave rise to reinforcement of the coupling strength. Surface area ratio (real surface area / scan area) obtained from surface topography for Sample C showed a maximum at at Al thickness of 30 Å. Therefore, the lower coupling strength would be attributed to unerlayer roughness with short lateral periods. The coupling in Sample A with Ru thickness of 9 Å showed better duration against annealing than that of 4.5 Å. Positive formation enthalpy of NiRu alloy would suggest that thermal stability of the thicker Ru layer is higher than the thinner one.

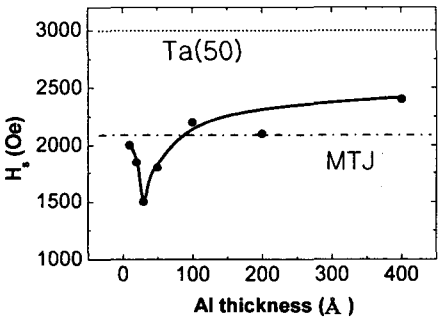

Fig.1. Hs of SynF on various underlayers; (•) Al(10~400 Å), (·····) Ta(50 Å) and (- · -) MTJ. Solid line is guide for eyes.

References

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