Estimation of switching energy barrier by String method assuming side-wall damage for mass production of MRAM

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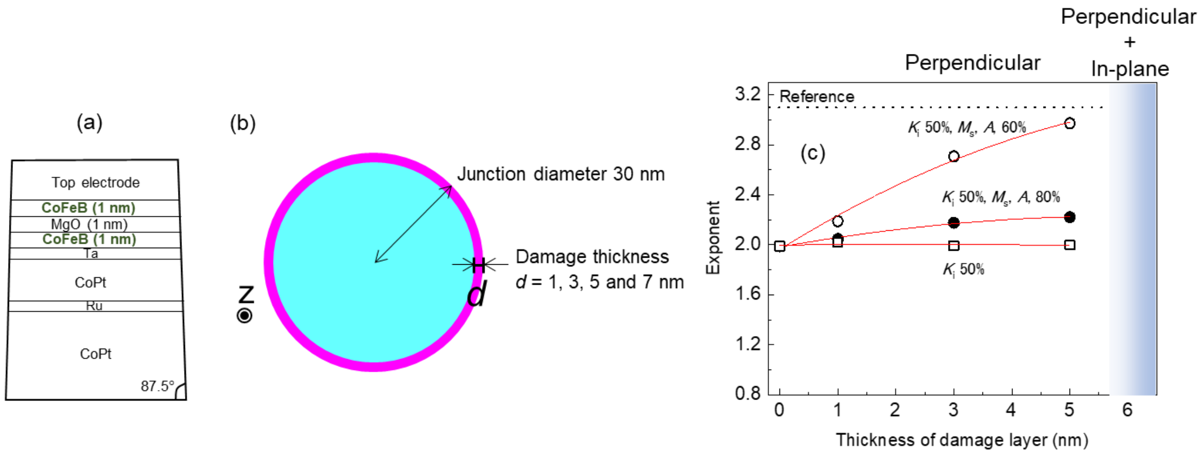
In last decade, much effort has been devoted to develop spintronics-based integrated circuits (ICs) with perpendicular magnetized magnetic tunnel junctions (*p*-MTJs). This is because they offer capability for high performance at low operation voltage and high endurance in addition to low-power consumption owing to non-volatile nature.[1, 2] The spintronics-based ICs using spin-transfer-torque magnetoresistive random access memories (STT-MRAM) are now about to enter into mass production phase.

In the case of mass production, damage control during microfabrication process is very important, *ex*) reactive ion etching, milling, *etc*.. In this study, the influence of magnetic damage at the sidewall of a *p*-MTJs, that are core device of STT-MRAM, was discussed based on thermal stability factor Δ, double-logarithm plot of normalized switching energy barrier E and saturation magnetization M_s, and their exponential slope n. Δ was calculated by String method and the domain wall was formed in all the simulation condition. String method is useful to find the minimum energy path between parallel (P) and antiparallel (AP) states of MTJs. In order to reduce total calculation cost, the magnetization curves (M - H) were simulated before the String method and we only calculate minimum energy path from P to AP state. Naively, n increased with increasing the thickness of damaged layer at the sidewall. It was found that the sidewall damage can be explained by reduction of M_s and exchange stiffness constant A_s rather than the interfacial perpendicular anisotropy.



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