

Fast Switching STT-MRAM Cells for Future Universal Memory

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Magnetoresistive random access memory with spin transfer torque (STT-MRAM) is a promising candidate for future universal memory because of small area demand, unlimited endurance, non-volatility, and long retention. However, improvement regarding the essential parameters including reduction of the switching current density is still needed. Finding alternative architectures for magnetic tunnel junction (MTJ) structures is of considerable importance for the success of STT-MRAM. A MTJ with a composite free layer (C-MTJ) shown in Fig.1a was proposed in our recent work. The free magnetic layer of such a structure consists of two equivalent parts of half-elliptic form separated by a narrow non-magnetic spacer. C-MTJs demonstrate a substantial decrease of the switching time and switching current as compared to standard MTJs with a monolithic free layer.

We performed further structural optimizations of C-MTJs by means of extensive micromagnetic simulations and propose a new structure of the composite free layer, C2-MTJ (Fig.1b). In a C2-MTJ the free layer consists of two ellipses with the major axes $a/2$ and b ($a > 2b$) inscribed into a rectangle $a \times b$. This structure is easier to fabricate as compared to the previous generation of C-MTJs. We investigated the switching characteristics depending on the geometry. We find that the new C2-MTJ switches as fast as the C-MTJ (Fig.2), without substantial loss of thermal stability (Fig.3). The narrow switching time distribution characteristic to C-MTJs is also preserved in C2-MTJs. The proposed C2-MTJ offers great potential for further performance optimization of STT-MRAM cells for future universal memory.

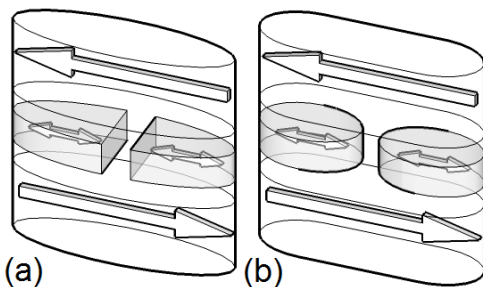


Fig.1 Schematic illustration of penta-layer MTJs with composite free layer C-MTJ (a) and C2-MTJ (b).

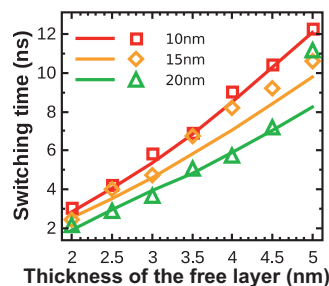


Fig.2 Switching time of C-MTJs (symbols) and C2-MTJs (lines) as function of the thickness of the free layer.

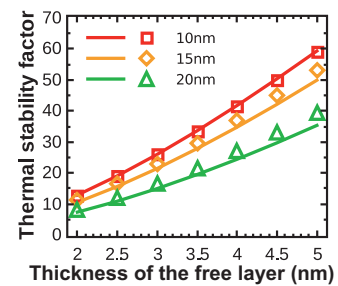


Fig.3 Thermal stability factor for C-MTJ (symbols) and C2-MTJ (lines) as function of the thickness of the free layer.

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