Reduction of the switching current in spin transfer torque random access memory

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The spin transfer torque random access memory (STT-RAM) is one of the promising candidates for future universal memory [1]. The reduction of the current required for switching and the increase of the switching speed are the most important challenges in STT-RAM research [2]. Perpendicular MTJs with interface-induced anisotropy [3] show potential, but still require reduced damping and increased thermal stability [4]. In [5] we proposed the CoFe/spacer (1 nm)/ $Ni_{81}Fe_{19}$ (4 nm)/spacer (1 nm)/ CoFe structure with an elliptical cross-section and a composite free layer obtained by removing a central stripe of 5 nm width from the monolithic free layer. We found a decrease in the switching time compared to the five-layer structure of same dimensions with a monolithic free layer. The non-zero angle between the fixed magnetization and the magnetization in the free layer results in enhanced STT when the current starts flowing. In the case of the monolithic structure, however, the torque remains marginal in the central region: as the amplitude of the end domains precession increases, the central region experiences almost no spin torque and preserves its initial orientation. As a physical explanation we have found that the switching barrier becomes equal to the shape anisotropy barrier responsible for thermal stability, which results in a switching current density reduction.

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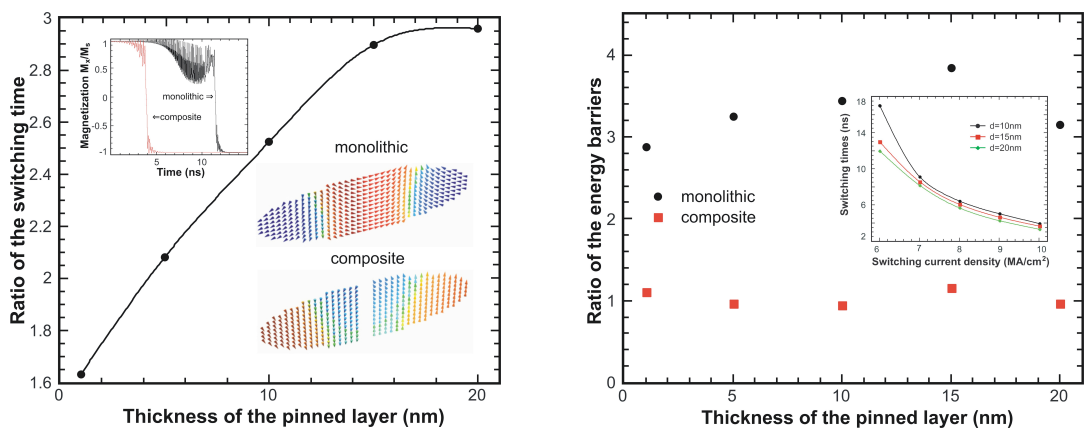

Fig. 1. (left) Ratio of the switching time in the monolithic structure compared to the structure with composite layer *vs.* thickness of the pinned layer. Inset shows the evolution of the average magnetization of the free layer during the switching process for a pinned layer thickness of 10 nm (top) and snapshots of the switching process for the monolithic and the composite free layer structure (bottom). (right) Ratio of the switching energy barrier and the shape anisotropy energy in the monolithic structure (circles) and in the composite structure (squares) *vs.* thickness of the pinned layer. The inset shows the dependence of the switching times as function of the current density for 10–20 nm pinned layer thicknesses.

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