About the switching process in magnetic tunnel junctions with two fixed layers and one soft magnetic layer

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The theoretical predictions [1, 2] and the experiments [3] on spin transfer switching demonstrated that the spin transfer torque random access memory (STTRAM) is one of the promising candidates for future universal memory. The reduction of the current density required for switching and the increase of the switching speed are among the most important challenges in this area. In this work we investigate the dynamics of the switching process in a magnetic tunnel junction (MTJ) composed of five layers with the magnetization of the two side layers fixed. The spin torque enhancement in penta-layer structures was recently predicted [4] to result in a significantly lower critical switching voltage at a switching delay comparable to that in tri-layer structures. We performed extensive micromagnetic modeling of the tri-layer and the penta-layer structures. In contrast to [4] we employ the Slonczewski model [1, 2] for the spin torque. The use of this model is justified in structures with a free ferromagnetic layer thickness of a few nanometers. Based on this model we optimized the penta-layer MTJ from [3] by investigating the influence of the thicknesses of the fixed layers on the magnetostatic exchange magnetic field in the plane of the free magnetic layer. The corresponding dependence is shown in Fig.1. Each point is a result of statistical averaging with respect to 10 different realizations of the switching process. The fastest and the most symmetric switching is achieved, when the fixed layer thickness is around 9nm. The reason for this result is revealed in Fig.2: the in-plane component of the magnetostatic exchange field is best compensated for a thickness of the fixed layer around 9nm.

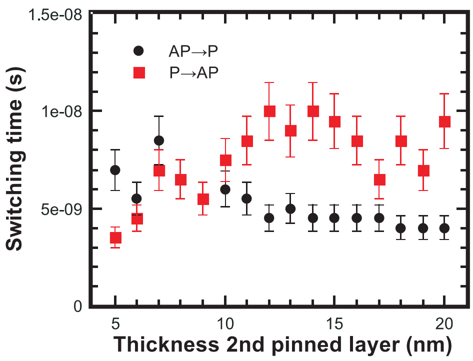
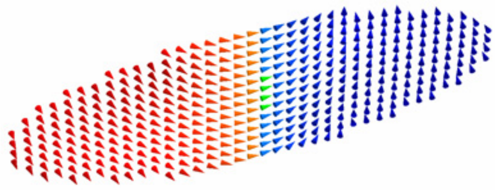
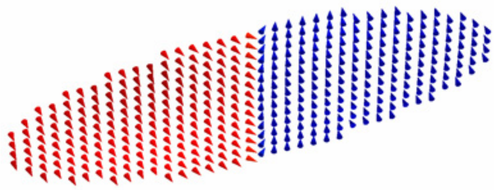


Figure 1: Dependence of the switching times between the two stable configurations on the thickness of the second fixed magnetic layer. The thickness of the first magnetic layer is 8nm.



(a)



(b)

Figure 2: Snapshots of the magnetostatic exchange magnetic field between the fixed layers and the free magnetic layer at the plane of the free layer:
(a) the thickness of the second fixed layer is 5nm; (b) 9nm.

[1] J. Slonczewski, J. Magn. Magn. Mater., **159** (1996), L1-L7.

[2] J. Slonczewski, Phys. Rev. B, **71** (2005), 024411.

[3] G. D. Fuchs et al., Appl. Phys. Lett., **86** (2005), 152509.

[4] N.N. Mojumdar et al., J. Appl. Phys., **108** (2010), 104306.