Energy Landscape for Thermally Activated Switching of Perpendicular Magnetic Nanopillars in a Transverse field

Gabriel D. Chaves-O'Flynn,[1] Corrado C. M. Capriata,[2,3] B. Gunnar Malm,[3] and Andrew D. Kent[2]

[1] *Institute of Molecular Physics, Polish Academy of Sciences*
[2] *Center for Quantum Phenomena, Department of Physics, New York University*
[3] *Division of Electronics and Embedded Systems, KTH - Royal Institute of Technology, Stockholm, Sweden*

Generating bitstreams that are truly random is a necessary requirement for many applications in stochastic computing. A promising solution to this problem is based in thermally activated switching between metastable magnetic states of the the free layer of perpendicularly magnetized circular magnetic tunnel junctions (pMTJ) in which an applied in-plane field can modify the ground state and lower the energy barrier (E_b). Estimates of thermal stability of magnetic states require the identification of configurations that are either minima or saddle configurations of the energy density functional. In this work, we identify states involved in thermally activated switching for various device diameters and applied fields. The simplest model [1] assumes a coherent magnetization reversal (macrospin) for which the transition state is uniformly magnetized parallel to the applied field. This model can be verified using overdamped micromagnetic simulations after introducing a shape dependent magnetostic correction. For large size devices, the transition state is no longer uniform but has a sigmoidal magnetization profile. We provide analytical solutions for 1D magnetization profiles involved in thermally activated magnetization reversals and compare them with numerical results using the String Method for the Study of Rare Events [2]. Our result provides a useful framework to quickly estimate the most likely transition state and energy barrier of pMTJs under transverse fields.

References:

[1] Garanin et al., "Thermally activated escape rates of uniaxial spin systems with transverse field: Uniaxial crossovers," PRE 60, 6499 (1999).
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