MICROMAGNETIC MODELING OF HIGH RESISTANCE MAGNETIC TUNNEL JUNCTIONS INCLUDING THE EFFECT OF NON-UNIFORM CURRENT DISTRIBUTION

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Nanoscale time resolved images of magnetization dynamics induced by spin torque have shown inhomogeneous magnetization spatial configurations even for nanostructures with elliptical section as small as 150 nm x 100 nm [1]. This fact points out the necessity of using full micromagnetic modeling to describe accurately the magnetization reversal mechanisms. One of the aspects to include in the model is the possibility of non-uniform spatial current distribution. The current distribution should be computed dynamically because during the spin-torque-driven processes the resistance of the nanostructure changes according to the magnetization spatial configuration. In this work computations including this effect will be presented.

Nanopillars of CoFe (8nm, exchange biased fixed layer) / MgO (0.8nm) / Py (4nm, free layer) with elliptical cross section (90nm x 35nm) have been analyzed. MgO high resistance magnetic tunnel junctions have been chosen due to their potential for device applications in magnetic storage [2] and also because the high resistance changes could give rise to a more non-uniform current distributions [3,4].

A simple model for computing dynamically the non-uniform current distribution is proposed. The free layer is modeled as an array of parallel resistors in which each computational cell corresponds to a resistor. The resistance value for each cell is computed from the local magnetization at every time step. This model lies on the assumption that the current is fully perpendicular when crossing the free layer. This fact is validated by means of 3D simulations performed with a commercial finite element electromagnetic software. In the situations considered, it is demonstrated that the tangential component of the current density is, at most, 2% of the total current.

Preliminary results on the effect of non-uniform current distribution on critical switching currents for both parallel-antiparallel and antiparallel-parallel transitions will be presented.

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