MAR07-2006-003109

Abstract for an Invited Paper
for the MAR07 Meeting of
the American Physical Society

Spin-torque-induced reversal in nanopillars containing perpendicularly magnetized layers.

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Devices where at least one of the magnetic elements has the anisotropy normal to the film surface are theoretically predicted to increase the efficiency and/or the speed of spin-torque switching. Devices where both the layers have the magnetization normal to the surface increase the efficiency of reversal while devices that combine perpendicular and in-plane magnetized layers are predicted to increase the speed of switching. In this talk we describe recent experimental demonstrations of current-induced magnetic reversal of magnetic elements with perpendicular anisotropy and high coercive fields [1]. The best results are observed for Co/Ni multilayers, which exhibit higher giant magnetoresistance values and spin-torque efficiencies than Co/Pt multilayers. The sample structures are nanopillars with a Co/Pt/Co/Ni composite reference magnetic element and a Co/Ni free layer that responds to the current. The reference layers were designed to have significantly higher anisotropy and coercive allowing a complete current-field phase diagram of the free layer reversal to be explored. The results are compared to micromagnetic modelling that, depending on the bias current and applied field, details regions of irreversible magnetic switching, coherent and incoherent spin waves, or static non-uniform magnetization states. Whereas only the two uniform magnetization states are available under the action of a magnetic field, we observed current induced Bloch domain walls in pillars as small as 100x50 nm2 [2]. This domain wall state can be further controlled by current to restore the uniform states. This ability to manipulate high-anisotropy magnetic elements could prove enabling for a range of spintronic applications. This research is done in collaboration with S. Mangin, D. Ravelsona, Y. Lemaho, Y. Henry, J. Katine, M. Carey, and B. Terris.

[1] S. Mangin et al., Nature Materials **5**, 210 (2006).
[2] D. Ravelosona et al., Phys. Rev. Lett. **96**, 186604 (2006).