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# Spin transfer torque switching in nano-pillars with SAF reference layer

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Spin transfer torque is mostly studied in nanopillars that consist of two ferromagnetic (FM) layers (reference and free, respectively), separated by a thin non-magnetic spacer. Spin polarized current is used to switch the magnetization of the free FM layer. The main challenge for implementing the spin transfer torque-random access memory (STT-RAM) devices is the reduction of the critical current (IC) required for switching, while maintaining a suitable thermal stability. To minimize IC, we propose a unique design of nanopillars for STT-RAM devices, consisting solely of Co/Ni multilayers (MLs) with the total magnetic anisotropy perpendicular to the film surface. A synthetic anti-ferromagnet (SAF), consisting of two Co/Ni MLs coupled anti-ferromagnetically through a Ru layer, is used as a reference layer in order to minimize the dipolar field on the free layer, FL. FL is a single 4x[Co/Ni] multilayer separated from SAF by a thin Cu layer. The Co/Ni thickness ratio is optimized to have low damping. Adding Pt and Pd was avoided in order to lower the spin orbit scattering in magnetic layers and intrinsic damping in the FL [1]. The intrinsic Gilbert damping of a continuous 4x[Co/Ni] multilayer film was measured by FMR to be $\alpha = 0.022$, which is significantly lower than in Pt and Pd based magnetic MLs with perpendicular anisotropy. Resistance versus current at fixed applied fields and magnetoresistance curves for different applied currents of circularly shaped 200nm diameter nanopillars were measured at room temperature. The minor loops for the FL exhibit an average offset of 0.038 T, reflecting a small dipolar interaction between the SAF and the FL. We also characterized STT-driven switching in our nanopillars. The critical current, IC, required to reverse the magnetization of the FL from parallel (P) to anti-parallel (AP) alignment is 6.1 mA (1.94×10ˆ11 Am−2) and from AP to P is 4.3 mA (1.37×10ˆ11 Am−2) in zero magnetic field. With volume of the FL, VFL = 1x10-22 m3, we find that Ic/(VFLHc) is 6.25x 1020 A/Tm3. This indicates that our device is almost twice as efficient as any previously reported device with SAF as a reference layer [2].

[1] S. Mangin, D. Ravelosona, J. A. Katine, M. J. Carey, B. D. Terris, and E. E. Fullerton, Nature Materials, 5, 210 (2006).
[2] I. Tudosa, J. A. Katine, S. Mangin, E. E. Fullerton, Applied Physics Letters, 96, 212504 (2010).

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