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 (1.94×10^{11} Am^{-2}) and from AP to P is 4.3 mA (1.37×10^{11} Am^{-2}) in zero magnetic field. With volume of the FL, V_{FL} = $1x10^{-22}$ m^3, we find that $Ic/(V_{FL}H_c)$ is 6.25x 10^{20} A/Tm^3. This indicates that our device is almost twice as efficient as any previously reported device with SAF as a reference layer [2].

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FS-07. All-Spin-Orbit Switching of Perpendicular Magnetization.

M. Kazemi[1], G. Rowlands[2], S. Shi[3], R. Buhrman[3] and E. Friedman[1] *1. Electrical Engineering, University of Rochester, Rochester, NY; 2. Quantum Information Processing, BBN Technologies, Cambridge, MA; 3. School of Applied and Engineering Physics, Cornell University, Ithaca, NY*

Devices with perpendicular magnetization are of great interest due to high miniaturization capability and thermal stability[1], retaining deeply scaled magnetic bits over long periods of time. Fast and energy efficient writing of magnetic bits into these devices remains a challenge[2]. Current-induced spin-orbit torques (SOTs) have a significant potential for fast and energy efficient writing of magnetic bits. However, to deterministically switch the perpendicular magnetization by SOTs, a magnetic field is required, which hampers technological applications[2,3]. Tapered devices[4,5] have recently been proposed to achieve deterministic switching, where the device thickness is reduced toward one end to introduce additional torques or tilt anisotropy from perpendicular direction. A complex process is however required to control varying thickness of tapered devices; also, tilting anisotropy emulates the effect of magnetic fields, restricting thermal stability and device scaling. In this manuscript, a device with perpendicular magnetization is introduced which, without the need for a magnetic field, can be deterministically switched by current-induced SOTs. Magnetic energy landscape of the device is shaped with respect to spin accumulation to ensure that an in-plane current pulse of appropriate amplitude or duration favors a specific stable state of magnetization, allowing SOTs to deterministically switch perpendicular magnetization in the absence of any magnetic field. Device operation is demonstrated through macrospin and micromagnetic simulations at room temperature. The device can be deterministically switched in both toggle and non-toggle modes, by choosing appropriate amplitude or duration of the current pulse. Presented device provides more than two orders of magnitude enhancement in switching time-energy product as compared to state-of-the-art spin-transfer-torque (STT) devices[6].

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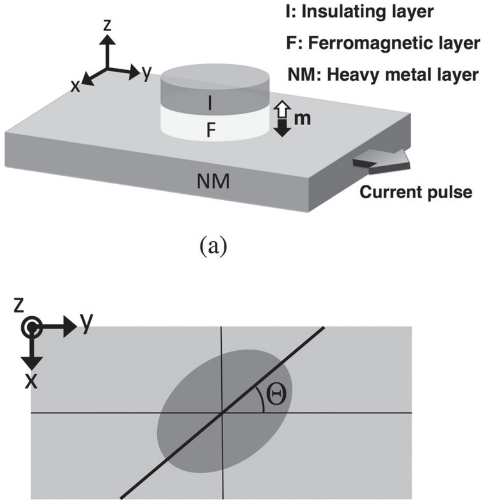
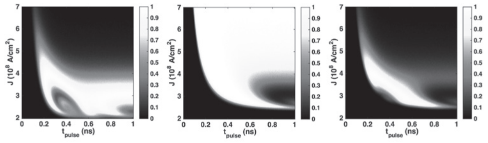


(a)

(b)

Fig. 1 Structure of the all-spin-orbit perpendicularly magnetized device. (a) Geometry and layer architecture, and (b) x-y cross section.



(a) (b) (c)

Fig. 2 Switching probability diagrams as a function of current pulse duration and amplitude for the device with Θ=π/3. Switching events from (a) +z to -z direction, and (b) -z to +z direction. (c) Toggle switching events.

FS-08. Intrinsic spin-orbit torque in a single domain nanomagnet.

A. Kalitsov[1], *S. Nikolaev*[2], J. Velev[3] and M. Chshiev[2] *1. MINT Center, University of Alabama, Tuscaloosa, AL; 2. UMR 8191 CEA/CNRS/UJF, SPINTEC, Grenoble, France; 3. University of Puerto Rico, San Juan, PR*

Magnetization switching in nanoscale devices induced by electric currents has been a subject of intensive studies in recent years. One of the most elaborated approaches is the transfer of spin angular momentum between non-collinear ferromagnetic layers, an effect known as spin transfer torque [1, 2]. An alternative way to produce spin torques is based on spin-orbit coupling (SOC) [3,4]. The presence of spin-orbit torques (SOT) in single nanomagnets has been predicted theoretically with analytical models [5], while in the context of transport calculations the majority of works deal with the quasi-classical Boltzmann approach [6]. Nevertheless, rigorous quantum-mechanical approaches are still lacking. In this work, we focus on the study of intrinsic mechanisms of SOT based on the ballistic transport theory within the Keldysh non-equilibrium Green's function (NEGF) formalism and tight binding Hamiltonian model for a ferromagnetic layer with Rashba spin-orbit coupling [7]. In order to calculate transport properties, we develop our approach in the so-called current-in-plane geometry. In this setup, the system is separated into three regions, a scattering region connected to the left and right semi-infinite leads all made of the same material, where a finite voltage drop is introduced in the leads by maintaining them in local thermodynamic equilibrium with chemical potentials. To gain insights into physical picture, we derive an analytic expression for SOT in the first order of SOC and use it to analyze the SOT dependence on the band structure parameters and applied voltage. We show that the first order in SOC terms leads to the field-like SOT, while its antidamping-like counterpart appears in the second order of the SOC strength. In Fig. 1 SOT dependenies on the band filling and exchange splitting are shown, that might explain opposite signs of SOT in recent experiments [8]. Finally, our results are directly verified