MAR05-2004-005304

Abstract for an Invited Paper
for the MAR05 Meeting of
the American Physical Society

Time-Domain Measurements of Nanomagnet Dynamics Driven by Spin-Polarized Current

ILYA KRIVOROTOV, Cornell University

The transfer of spin angular momentum from a spin-polarized current to a nanomagnet exerts torque, and can cause the magnet's moment either to reverse its direction or to enter a state of steady precession. Exploiting a new nanoscale spin valve design, we make first time-resolved measurements of these dynamics. These measurements are made in Py(4 nm)/Cu(8 nm)/Py(4 nm)/IrMn(8 nm) nanopillar spin valves in which exchange bias is used to create a non-zero equilibrium angle between the magnetic moments of the free and fixed permalloy (Py) nanomagnets. In the regime of steady-state precession, the current-driven dynamics exhibit a high degree of coherence, as evidenced by long dephasing times ($\sim 10^2$ ns). Measurements of the onset of the persistent precession in response to a current step demonstrate a fast ($\sim$ 1 ns) response of the nanomagnet to variations of the current. In the switching regime, time-resolved measurements demonstrate that spin-transfer-driven magnetization reversal in our samples is accomplished via a process of coherent precession. We also make time-resolved measurements of magnetic relaxation of the free Py nanomagnet excited by a short current pulse. These measurements, made as a function of spin-polarized current bias, demonstrate that the effective Gilbert damping parameter can be tuned by the spin-transfer torque. The value of the damping parameter in the limit of no current bias significantly exceeds the damping of an extended 4 nm thick Py film – which is attributable to substantial spin pumping in the nanopillar structure. Our results demonstrate that coherent nanomagnet dynamics can be generated by spin-transfer torques in properly designed magnetic nanostructure devices and directly measured in both the time and frequency domains. This opens a wide range of opportunities for new types of fundamental studies of nanomagnet dynamics and for novel technological applications in the areas of high frequency communications and signal processing.