Spin Transfer Torque and Dynamics in Magnetic Nanopillars

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Giant Magnetoresistance (GMR) is a change in the resistance or a change in the current flowing through a Ferromagnet/Normal (F/N) metallic multilayer due to a change in the magnetic order. There is now a great interest in the inverse phenomenon of GMR, Spin Transfer Torque (STT), where a large applied current density causes the magnetization to switch direction or to precess producing GHz radiation. STT can be demonstrated in a magnetic nanopillar, a nanopatterned (area~100nm^2) F1/N/F2 structure where a current flowing through F1 becomes spin-polarized and exerts a torque on the magnetization of F2.

We test whether the transport in the N layer affects the switching characteristics when the transport is changed from 'ballistic (much less than 1 scattering event per transit of the 10nm thick N layer) to 'diffusive' (few scattering events per transit). Surprisingly, the most sophisticated model that treats the transport as diffusive predicts too large of an effect compared to the experimental results.

Additionally, I will present measurements of STT driven magnetization dynamics of a magnetic nanopillar where the GMR effect is utilized to measure the resistance in the frequency domain. Among the more interesting results are sharp peaks in zero applied magnetic field when a large enough, negative direct current is applied. These low frequency, current hysteretic, narrow-bandwidth oscillations are consistent with the dynamics of a non-uniform magnetic state such as a vortex state.

A complimentary approach towards spin manipulation is through semiconductor spintronics. Magnetic semiconductors, semiconductors that are doped with magnetic elements, are a new class of materials. I will present evidence that ZnO doped with Mn because of its high ferromagnetic transition temperature and its strong carrier polarization is a promising magnetic semiconductor and could be potentially used in spin based electronic applications of the future.