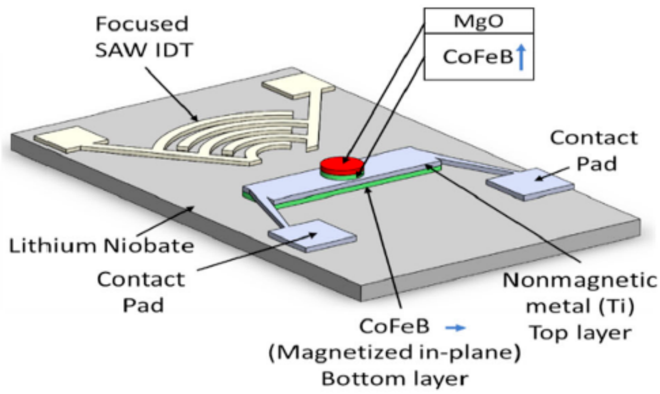
Energy Efficient Switching of Spin-Orbit Torque Memory Devices

Magnetic Random Access Memory based upon nanoscale Magnetic Tunnel Junctions (MTJs) has been proposed as an alternative to CMOS-based memory devices such as DRAM. Within the MTJ, the magnetization of a soft magnetic layer is switched by Spin-Orbit Torque (SOT). However, switching a “bit” stored in MRAM currently requires ~1000 times more energy than a bit stored in a CMOS device. In this project we will use Surface Acoustic Wave (SAW)-induced Ferromagnetic Resonance (FMR) in conjunction with SOT to reduce the switching energy of MRAM. A schematic representation of a test geometry is shown within the figure. An interdigitated transducer (IDT) defined on a piezoelectric substrate generates a SAW that propagates towards and strains the soft CoFeB magnetic layer of the MTJ. Due to magnetoelastic coupling, a few tens of cycles of SAW at the FMR frequency (~10 GHz) will cause the magnetization to precess at large amplitude so that a much reduced SOT is needed for the magnetization to switch. Test devices will be fabricated at Virginia Commonwealth University and the Massachusetts Institute of Technology before the time dependent magnetization dynamics are studied in Exeter by means of time resolved scanning Kerr microscopy.



Schematic representation of the test geometry. A CoFeB/MgO pillar is formed on a heavy metal/CoFeB bilayer through which a current is passed to generate a spin-orbit torque (SOT). Simultaneous excitation by a surface acoustic wave (SAW) from an interdigitated antenna leads to a reduction of the SOT needed to induce switching. The fixed magnetic layer of the MTJ pillar is omitted so that the dynamics of the CoFeB free layer can be probed with a focused laser beam.