# Nanoscale Spin Transfer Devices and Materials

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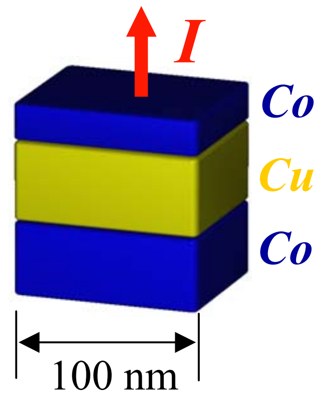
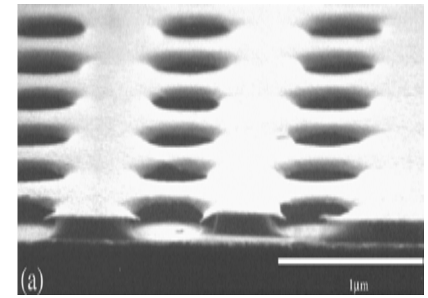
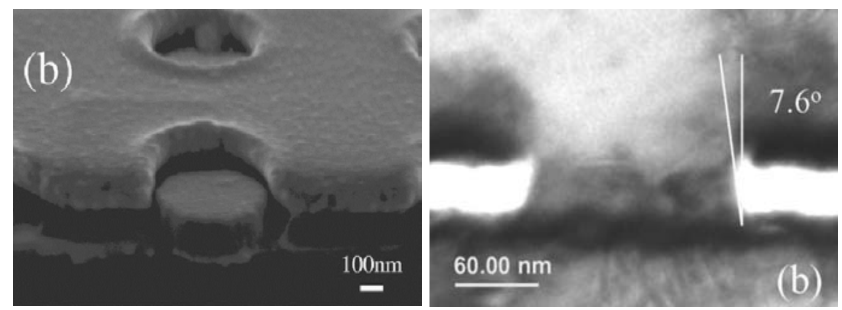
An electric current flow through small magnets can transport spin angular momentum and dramatically affect the magnets, even changing their magnetization direction. As much information is stored in magnetic materials (such as, in hard disk drives) this phenomena once better understood and controlled may lead to ultra-fast and high density memories. A bottleneck to research progress has been the fabrication of magnetic materials which are less than 100 nm in lateral size with electrical contacts. With Dr. Sun at IBM Research, we are developing and using a new nanostencil substrate method that enables the rapid prototyping of devices and materials. A very recent highlight of this research is:

- The first observation of current-induced magnetic excitations in devices that consist of only *one* thin magnetic layer. Up until recently it was thought that two magnetic layers were necessary for spin-current-induced excitations.




First an array of undercut stencils are fabricated.




Left: Then the desired layered structure is grown by evaporation of material onto the stencil.
Right: Cross-sectional transmission electron microscopy image. Sufficient material is added to fill-up the stencil producing electrical contact to the top and bottom of the nanopillar.

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Additional information available at:
http://www.physics.nyu.edu/kentlab/

It is well known that an electric current can affect a magnetic material and vice-versa. This is the basis for electric motors and generators.  A current in a wire produces a magnetic field that can exert a force on a nearby magnet. This magnetic field is associated with the flow of charge, due to electrons moving in the wire. For example, a compass needle (which is nothing more than a magnetic material in the shape of a needle) placed close to the wire can be deflected by the current-induced magnetic field. This was realized over 150 years ago. Very recently it was discovered that a current flow directly through a small magnet can exert a much stronger force on the magnet, even changing its magnetization direction. This force arises because electrons have an intrinsic magnetic moment (a spin) in addition to their electrical charge. In a magnetic conductor (like Iron or Cobalt)  the electrons that move are polarized in one direction. When they flow they can “move” magnetism from one region of the conductor to another--this has been called spin-transfer, as electron spins are moved from one place to other. This new kind of interaction between a magnet and a current is still poorly understood and experiments on very important to establishing the basic physics. For example, up until early this year, it was though that two magnetic layers were necessary in order for there to be spin-transfer effects, one layer to create a spin-polarized current and the other to respond to the polarization. Recent experiments in our group have shown that these effects occur even when only one layer in present, the same layer that creates the spin-polarized current responds to the resulting current. This is observation is very important to our understanding of spin-transfer as well as device concepts that will use this new interaction. There is also great potential for information processing devices based on this interaction with both improved energy efficient and speed.

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Kent group at NYU involved in spin-transfer studies. Pictured above (left-right):
Wenyu Chen, Andrew Kent, Barbaros Ozyilmaz, Jan Larsen, Jean-Marc Beaujour and Mariano Zimmler

- Education

  **Post-doc:** Jean-Marc Beaujour

  **Graduate Students:** Wenyu Chen, Jan Larsen and Barbaros Ozyilmaz (accepted post-doc position, starting 2005).

  **Undergraduates:** Mariano Zimmler (beginning graduate study at Harvard, Fall 2004), Stuart Kirschner, Brian Hayes and Lorraine Robinson

  **High School Student**: Yuriy Kagan, Intel Science Research (beginning at Columbia, Fall 2004)

- Societal Impact

  **Research of fundamental importance and critical to future magnetic information storage technology.**