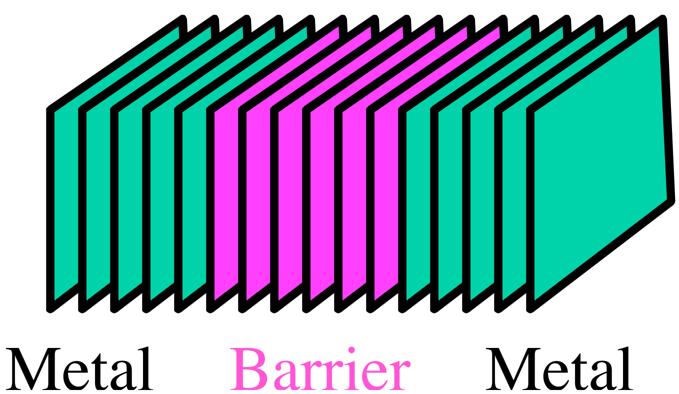
NSF Nanoscale Science and Engineering Grantees Conference, Dec 16-18, 2003
Grant # : 0210717

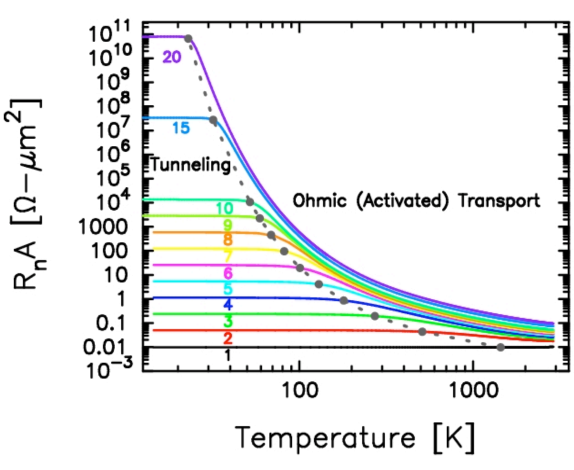
NANO HIGHLIGHT
Computational design and optimization of nanoscale spintronic and thermoelectric devices

NSF NIRT Grant 0210717

PIs: **J. K. Freericks[a], A. Y. Liu[a], and B. A. Jones[b]**
[a]Georgetown University and [b]IBM, Almaden Research Center

Quantum mechanical tunneling--the ability of electrons to connect from one side of a device to the other via the overlap of the electronic waves on each side of the device--is one of the most important processes employed in creating interesting electronic devices [1]. Most commercially used tunneling devices are made from semiconductors, but recent advances in magnetic tunnel junctions will shortly see the introduction of nonvolatile random access memories (MRAM) constructed out of magnetic metal-insulator-magnetic metal tunnel junctions. Even though the use of tunneling is widespread throughout technology, the science behind the process is still not fully understood. We have performed simulations of junctions where the insulating barrier is tuned to lie close to the metal-insulator boundary, and hence has a shallower barrier than in current devices. Due to the lower barrier height, we are able to see the crossover from quantum-mechanical dominated transport of electrons to a classical process (where electrons move across the barrier because their temperature gives them enough energy to "punch through" the barrier). We have discovered a new energy scale associated with the resistance that allows us to predict the crossover from tunneling (where the resistance is essentially a constant with temperature) to the classical regime (where the resistance is reduced rapidly with temperature). The figure shows this behavior, where we plot the resistance versus temperature on a log-log plot for different numbers of atomic planes in the barrier. The dashed line is a prediction of the crossover temperature, determined by this new energy scale. Note how the crossover moves to *lower* temperatures as the barrier becomes *thicker* [2].





References

[1] For further information about this project email **freericks@physics.georgetown.edu**, **liu@physics.georgetown.edu**, **or bajones@almaden.research.ibm.com** .
[2] Submitted to Applied Physics Letters (2003).