ND*nano* Undergraduate Research Fellowship (NURF)
2013 Project Summary

1) Student name: Robert L. Frame III

2) Faculty mentor name: Prof. Gyorgy Csaba and Prof. Wolfgang Porod

3) Project title: Building a Kerr Effect Device for Nanomagnet Measurements

4) Briefly describe any new skills you acquired during your summer research:

The newest skills I acquired where in the field of optics and precision measurement techniques. I possessed no prior experience with optical components such as polarizers, analyzers, etc. This project was also the first experience using a lock-in amplifier. Together with a photo-elastic modulator, the lock-in amplifier is tuned to a specific ac frequency to disregard noise in the form of ambient light, and measure a small signal modulated by a reference that is desired, eventually resulting in a proportional mean dc value. The use of reflected light microscopy and its principles to develop a MOKE microscope was also an acquired skill relating to optics. I also developed a differential amplifier for a Hall-effect sensor, which was my first experience using a sensor to measure magnetic fields. For mounting the laser needed in the MOKE, a coupling part was designed by myself and then machined. This was my first experience with creating a 3d model in software and having a physical part made.

5) Please briefly share a practical application/end use of your research:

This MOKE device will be used to analyze magnetic properties of nanomagnets. The hysteresis curve of magnetic structures can be plotted by measuring the intensity of a laser, vs. a changing magnetic field strength. This shows what strength of field causes the nanomagnets to switch polarity. Understanding how these nanomagnets behave under changing magnetic fields is the key to their use in storing information in the form of logic.

Project summary:

The goal of this project was to develop a Kerr-effect microscope to study the behavior of nanoscale magnets – the ones used in Nanomagnetic Logic devices. Nanomagnetic logic is a new technology that has the potential to change the way computers as we know them store information. Computer memory is volatile, meaning it loses information once power is removed. The application of nanomagnetic technology to computer memory could enable computers to essentially boot instantaneously as the nanomagnets would retain their stored information even once power is removed. One way to analyze the magnetic properties of nanofilms is with the Kerr effect. A MOKE system is advantageous in categorizing magnetic characteristics of nanomagnetic films, by measuring the change in polarization of a laser beam as it reflects off a sample of nanofilm. A hysteresis curve is then created by plotting the laser light intensity vs. the change in magnetic field that the sample experiences.

The first half of my research was spent modifying a previously built MOKE setup consisting of a modified ellipsometer. A differential amplifier was built to interface a Hall-effect sensor with a new lock-in amplifier/software setup than that used previously. The laser used previously was replaced with a more stable model, and a modified mounting piece was designed and built. The system is used to create hysteresis graphs automated by software for various nanofilms. The second half of my research consisted of building a similar setup using a modified reflected light microscope. The microscope setup will be more beneficial for measurements on the nanoscale, with more precise alignment options. As my research finished this device was still in the experimental phase.

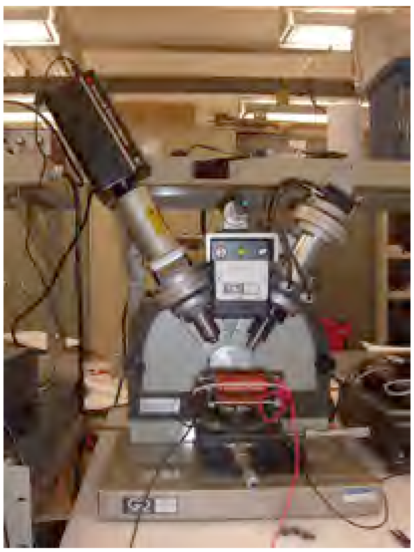

Figure 1: Modified Ellipsometer MOKE

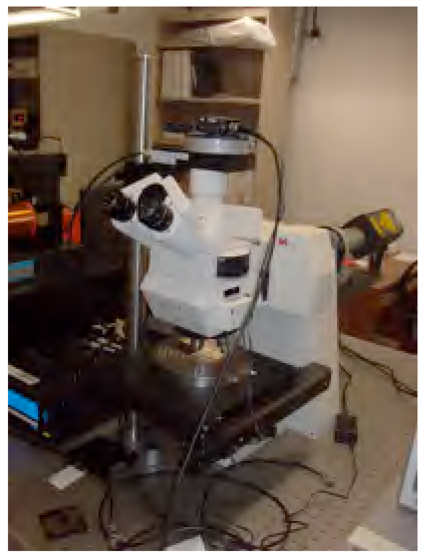

Figure 2: Modified Microscope MOKE

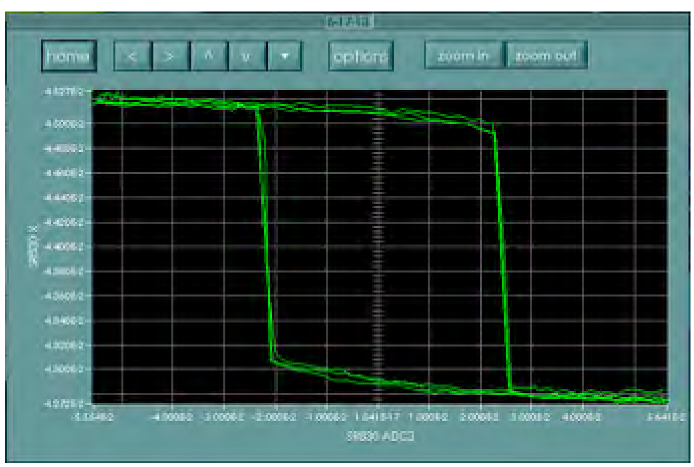

Figure 3: Hysteresis Plot of Laser Magnitude vs. Magnetic Field Strength

Publications (papers/posters/presentations):
MOKE manual (users guide)