NDnano Undergraduate Research Fellowship (NURF)
2011 Project Summary

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Project title: Micromagnetic Simulations of GaAs/Fe Core-Shell Nanowires

The GaAs/Fe core-shell nanowires are novel nanostructures and the understanding of their magnetic properties can lead to possible new devices. We are interested in how the object oriented micromagnetic framework (OOMMF) program created by ITL/NIST deals with the hexagonal core-shell geometry of the Fe shell. We are also interested in whether the core-shell ratio affects the magnetization reversal behaviors as seen in the simulated hysteresis loops. Further research can be done by comparing the results of simulation with experiment in order to understand the limits of the computational model.

We found that the magnetization reversal behavior of a 10 nm long nanowire with a cubic anisotropy when the applied field is along the wire, (in the z-axis), varies with the core-shell ratio. The z-axis is the hard axis of magnetization when the Fe shell is thick compared to the GaAs core but becomes the easy axis of magnetization when the shell is thin. This variance is lost when the wire becomes very long, (1 micron), where the z-axis remains the easy axis at any core-shell ratio. We also found that the magnetization reversal behaviors along the x and y-axis of the 1 micron long nanowire in cubic anisotropy changes as the core-shell ratio is varied. For cases where the Fe shell is thick, the magnetic hysteresis shows similar results for the x and y direction. However, as the Fe shell becomes thinner, we can see more prominently that the x-axis is the intermediate axis of magnetization and that the y-axis is the hard axis. We conclude that the different magnetic behavior for the thin shell arises from the corner-to-corner alignment in the x-direction having less neighbors when compared to the side-to-side alignment in the y-direction. This "less neighbor" argument also correlates with the results for the thick Fe shell where the number of neighbors becomes the same for the corner-to-corner and the side-to-side alignment and hence results in similar hysteresis loops. In addition, the comparison between simulations for a 1-micron long nanowire with uniaxial anisotropy and with cubic anisotropy, (with the applied magnetic field in the direction perpendicular to the nanowire), show similar magnetization reversal behaviors. However, there are different domain patterns for when the applied field becomes zero and this difference indicates that it is necessary to develop a new procedure which can be used for a material with both types of anisotropies in order to get the full picture of the hysteresis.

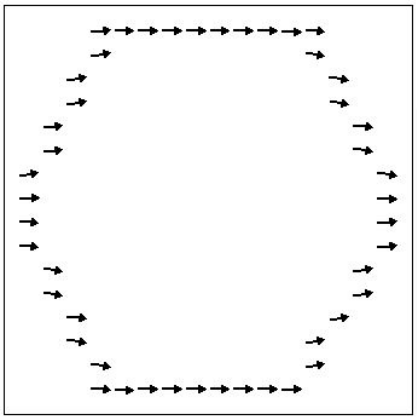

Figure 1

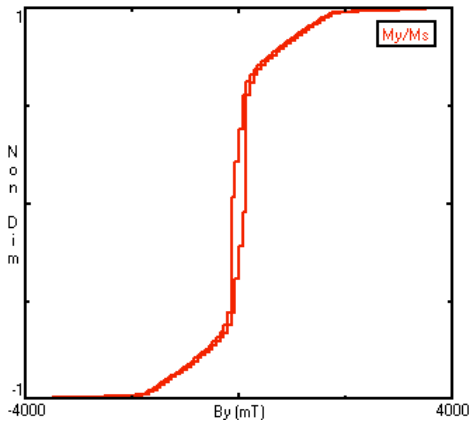

Figure 2

Figure 1: The magnetic moments aligning in the y-direction. Figure 2: The magnetic hysteresis after field reversals.