MAGNETISM AT THE NANOSCALE: A VOYEUR'S TALE

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There has been a renaissance in magnetism in the last decade or so. In the area of micromagnetics (although in the modern context it should be nanomagnetics), major breakthroughs have resulted from the development of new magnetic imaging techniques [1]. A powerful magnetic microscope is the magnetic force microscope (MFM), a variant of the atomic force microscope.

One of the frontiers in magnetism being pushed back is to understand the domain structure and the magnetization reversal in nanometer sized particles. We have utilized the high resolution MFM (30nm) we developed [2] to increase our fundamental understanding of magnetism on this length scale. First I will present a very elementary introduction to micromagnetics research and a description of MFM with a hands on demonstration of the basic principle. I will then present our recent investigations of the magnetic domain structure in Ni dots with diameters ranging from 40nm to 1700nm [3]. The dots and unpatterned witness films possess a substantial perpendicular-to-the-plane anisotropy which results in the witness films having stripe domains with a period on the order of 200nm for the magnetization perpendicular to the film plane. In the dots, the magnetic domain states fall into two general magnetic domain classifications: stripe domains, and ring domains. The specific stripe and ring structures differ for the different dot diameters. In both the experiments and the simulations, a convenient dimensionless parameter for predicting which of the specific magnetic states will occur is the ratio of the dot diameter to the stripe period. The abundances of each specific domain structure as a function of the dot diameter to stripe width ratio has been experimentally determined. Given the consistency between the experiments and the simulations, one can be confident the simulations accurately provide information on the magnetization well below the HRMFM resolution.

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[3] G. D. Skidmore, A. Kunz, C. E. Campbell, and E. Dan. Dahlberg, Phys. Rev. B 70, 012410 (2004).

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