Magnetic Interfaces and Nanostructures
Room 316 - Session MI-ThA

Magnetization Dynamics

Moderator: W.H. Rippard, National Institute of Standards and Technology

2:00pm **MI-ThA1 Ultrafast MOKE Study of Magnetization Dynamics in Exchange-Biased FeMn/Co and IrMn/Co Thin Films***, **K. Seu**, H. Huang, A.C. Reilly,* College of William and Mary*; W.F. Egelhoff, L Gan,* National Institute of Standards and Technology

We have observed coherent magnetization rotation in exchange-biased Co systems by ultrafast laser pump-probe magnetooptical Kerr effect (MOKE). This technique, first introduced by Ju et al. in the study of NiO/NiFe, uses ultrafast photoexcitation to spontaneously decouple the antiferromagnetic/ferromagnetic system.@footnote 1@ The magnetization undergoes coherent precession as described by the Landau-Lifshitz-Gilbert equations of motion.@footnote 1@ Such ultrafast measurements provide opportunity to study the ultimate time scale for these processes as well as determination of fundamental parameters such as anisotropy and damping.@footnote 2@ This is in analogy with FMR, but with the benefit of direct access to the time domain, sub-micron spatial resolution and straightforward in-situ application. Co exchange-biased systems such as FeMn/Co and IrMn/Co, besides being technologically important, offer an interesting comparison to the NiFe systems. It has been observed that magnetization reversal takes place via more complicated processes in Co, involving nucleation of many small domains.@footnote 3@ Also, recent FMR experiments suggest that the damping in IrMn/Co films is not strongly dependent on exchange bias field strength, unlike the NiO/NiFe system.@footnote 4@ We will present measurements of anisotropy and damping parameters in FeMn/Co and IrMn/Co as a function of Co thickness and exchange bias field strength. These will be used to further explore the nature of exchange biasing in these systems as well as investigate the wider applicability of ultrafast optical techniques. @FootnoteText@ @footnote 1@Ganping Ju et al., Phys Rev Lett 82, 3705 (1999), Phys Rev. B., 62, 1171 (2000)@footnote 2@ M. van Kampen et al., Phys. Rev. Lett. 88, 227201 (2002)@footnote 3@ Chan-Gyu Lee et al., J. Appl. Phys. 91, 8566 (2002)@footnote 4@ R.D. McMichael et al., J. Appl. Phys. 83, 7037 (1998).

2:40pm **MI-ThA3 Spatial and Temporal Control of Magnetization Dynamics in Lithographic Elements and Nanocrystalline Composites***, **M.R. Freeman**, M. Belov, K. Buchanan, A. Krichevsky, A. Meldrum,* University of Alberta, Canada **INVITED**

Time-resolved optical microscopy is a versatile tool for investigations of dynamic phenomena in magnetic thin films, including resonance, reversal, and relaxation.@footnote 1@ Broadband pulsed ferromagnetic resonance studies of square NiFe elements were performed to investigate the control of modal oscillations in inhomogeneously magnetized structures. The spatiotemporal evolution of the magnetization, as excited by a small out-of-plane transient magnetic field, was imaged in the presence of a weak in-plane static bias. In a uniform platelet the spatial response is governed by the nonuniform static magnetization distribution associated with closure domains across the bias field direction. A circular pinhole was patterned in the center of a square platelet to show that the spatial pattern of FMR response also sensitively depends on weak variations of the static magnetization. Comparison to numerical modeling confirms that the experimental observation of spatially-nonuniform damping is a result of the evolution of energy into shorter wavelength modes. The magnetic switching behavior of mesoscopic structures continues to arouse interest for technological applications. Magnetization reversal of mesoscopic structures driven in a crossed-excitation wire (prototype MRAM) geometry will be described. The magnetic and magneto-optical properties of nanocomposite materials created using ion implantation and subsequent thermal processing are also being investigated. Implanting iron ions into a SiO2 host results in a collection of randomly oriented crystalline Fe nanoparticles, the magnetic and microstructual properties of which depend on both the implantation and annealing conditions. Iron implanted SiO2 samples subject to a particular treatment exhibit large Faraday rotation and an extremely fast and tunable response to out-of-plane excitation. @FootnoteText@ @footnote 1@ B.C. Choi, A. Krichevsky, and M.R. Freeman, to be published in Proceedings of the IEEE, June 2003.

3:20pm **MI-ThA5 Real-Time Imaging of Spin Dynamics in Magnetic Vortex Structures***, **J.P. Park**, P. Eames, D.M. Engebretson, P.A. Crowell,* University of Minnesota **INVITED**

Patterned nanometer-scale magnetic structures have been proposed as media for high-density data storage. A prerequisite for implementing such a technology will be an understanding of the fundamental characteristics of magnetic nanostructures, including switching times, damping constants, and the spatial distribution of collective modes. We use time-resolved Kerr microscopy to study the spin dynamics of individual ferromagnetic disks with thicknesses of 50 nm and aspect ratios @beta@= L/R ~ 0.1 - 0.5, where L is the thickness and R the radius.@footnote 1@ The equilibrium state of each disk in zero field is a vortex with a singularity at the center. As the field is reduced from saturation, the vortex nucleates at one edge of the disk, and it moves across the diameter until it is annihilated at the opposite edge in negative fields. We observe three distinct excitations of this vortex state, in contrast to the simple uniform precession observed in the saturated state. The lowest mode corresponds to the gyrotropic motion of the entire vortex around its equilibrium position.@footnote 2@ The exact nature of the higher modes is being explored through a combination of spatially-resolved spectroscopy and micromagnetic simulations. The frequencies of all three vortex modes are nearly independent of the value of the applied field and hence the position of the vortex inside the disk. This work was supported by NSF DMR 99-83777, the Research Corporation, the Alfred P. Sloan Foundation, the University of Minnesota MRSEC (DMR 02-12032), and the Minnesota Supercomputing Institute. @FootnoteText@ @footnote 1@J. P. Park, P. Eames, D. M. Engebretson, J. Berezovsky, and P. A. Crowell, Phys. Rev. B 67, 020403R (2003). @footnote 2@K. Yu. Guslienko et. al., J. Appl. Phys. 91, 8037 (2002). .

4:00pm **MI-ThA7 High-Frequency Noise and Thermal Fluctuations in GMR Devices***, **S.E. Russek**,* National Institute of Standards and Technology

High-frequency (1 GHz to 8 GHz) magnetic noise has been measured in giant magnetoresistive (GMR) devices with dimensions down to 100 nm. Both commercial recording heads and GMR devices fabricated within microwave circuit structures were measured. The uniform ferromagnetic resonance mode has been measured as a function of applied field, bias current, and temperature. In addition to the uniform mode, other modes have been observed that are due to micromagnetic structure in the devices. The presence of these modes can be correlated with Barkhausen noise in the magnetoresistance data. The data have been fit with simple models based on the fluctuation-dissipation theorem and with numerical models that incorporate more complex dissipation processes.

4:20pm **MI-ThA8 Weak Spin Pumping and Inhomogeneity in Cr/NiFe/Cr Trilayers***, **R.D. McMichael**, A.J. Shapiro, A.P. Chen, W.F. Egelhoff,* National Institute of Standards and Technology

Ferromagnetic resonance linewidth measurements on 10 nm Cr/5 nm Ni@sub 80@Fe@sub 20@/10 nm Cr trilayers show that Cr does not contribute significantly to the damping properties of NiFe. In contrast, measurements in Pt/NiFe/Pt and Pd/NiFe/Pd trilayers have demonstrated strong "spin pumping" enhancements due to the normal metal layers.@footnote 1@ The experiments described here were designed to determine whether similar spin-pump damping effects were likely in CoCr recording media due to the presence of Cr in grain boundaries. We found that the linewidth in Cr/NiFe/Cr trilayers was large relative to Cu/NiFe/Cu trilayers. To discern the origins of the enhanced line width, Cu spacer layers were included between the NiFe layer and either the bottom or top Cr layer and an analysis of the angular dependence of the line width was performed. The results show that the linewidth increase is associated with inhomogeneity at the bottom Cr/NiFe interface. The inhomogenitey at this interface may be a reflection of the growth beginning as bcc-NiFe on bcc-Cr and converting to fcc-NiFe. Growth of Cr on NiFe had an insignificant effect on the linewidth of the NiFe. These conclusions were confirmed by MOIF imaging of the magnetization reversal, which showed nucleation and growth of reversed domains in NiFe on Cr, but which showed low coercivity motion of a single domain wall sweeping out the entire area when the NiFe was deposited on Cu, whether the cap layer was Cu or Cr. @FootnoteText@ @footnote 1@ S. Mizukami, Y. Ando and T. Miyazaki, Jpn. J. Appl. Phys., v. 40, pp. 580-585 (2001).

4:40pm **MI-ThA9 Tunnel Barrier Materials Development for Magnetometer based Josephson Qubits***, **D.P. Pappas**, R. McDermott, D.A. Hte, R.W. Simmonds, K.M. Lang, J.M. Martinis,* National Institute of Standards and Technology

Although Josephson-junction qubits show great promise for quantum computing, the origin of dominant decoherence mechanisms remains unknown. We report Rabi oscillations for a phase qubit, and show that their "coherence amplitude" is significantly degraded by spurious microwave resonances. These resonances appear to arise from changes in the junction critical current, produced by fluctuations in the position of electrons or atoms within the tunnel barrier. We argue this mechanism is a dominant source of decoherence in all present Josephson qubits, and improvements will require materials research directed at the tunnel barriers to remove these spurious resonances. In order to test the influence of the junctions on the cohereance amplitude we have developed tunnel junctions fabricated from both Al/AlO/AL and Al/AlN/Al trilayer structures.

Author Index

Bold page numbers indicate presenter