Magnetic Interfaces and Nanostructures
Room 2006 - Session MI-WeM

Magnetic Imaging
Moderator: D.P. Pappas, NIST

8:00am **MI-WeM1 Imaging Magnetic Nanostructures via Resonant Soft X-Ray Spectro Holography**, ***O. Hellwig***, Hitachi Global Storage Technologies **INVITED**

I will present how to exploit the coherence and tunable polarization of soft X-ray synchrotron radiation for imaging magnetic nanostructures via Fourier Transform Holography. This new lensless imaging technique is based on the direct Fourier inversion of a holographically formed soft x-ray interference pattern. Our implementation is particularly simple and is based on placing the sample behind a lithographically manufactured mask with a micron-sized sample aperture and a nano-sized reference hole. The technique avoids costly zone plate X-ray lenses as used in conventional X-ray microscopy. By exploiting the magnetic dichroism in resonance at the L3 edges of the magnetic transition metals (wavelength ~ 1-2 nm (700-900 eV), images of magnetic nanostructures have been obtained with a spatial resolution below 50 nm. Different examples will be presented. The technique is transferable to a wide variety of specimen, appears scalable to diffraction-limited resolution (about 2 nm), and is well suited for ultra-fast single-shot imaging with future X-ray free electron laser sources. @FootnoteText@Experiments have been performed at BESSY in Berlin in collaboration with Stefan Eisebitt and Wolfgang Eberhardt, BESSY GmbH, Albert-Einstein-Str.15, 12489 Berlin, Germany and Jan Luening, William F. Schlotter and Joachim Stoehr SSRL, Stanford Linear Accelerator Center, 2575 Sand Hill Road, Menlo Park CA 94025, USA and Department of Applied Physics, 316 Via Pueblo Mall, Stanford University, Stanford, CA 94305-4090 .

8:40am **MI-WeM3 Magnetic Moment Measurements Using Anisotropic Magnetoresistance**, ***F.C.S. da Silva***, University of Colorado at Denver and Health Science Center; *S.T. Halloran, R.R. Owings, A.B. Kos, W.C. Uhlig, J. Unguris, D.P. Pappas,* National Institute of Standards and Technology

The Anisotropic Magnetoresistive (AMR) effect is used to estimate the magnetic moment of thin-film Permalloy discs. The method uses the angular dependence of the AMR to measure the shape anisotropy field of a high aspect ratio (100:1) needle positioned near the disc. The measurement is directly related to the product (saturation magnetization)x(thickness) of the sample via the demagnetizing factor. Uncertainties in the absolute value of the magnetic moment are mainly due to sistematic deviations of magnetization from the single domain state. The AMR results are supported by scanning electron microscopy with polarization analysis, conventional magnetometry measurements, and micromagnetic simulations.

9:00am **MI-WeM4 Measuring Spin Dependant Hot Electron Transport using Spin-Polarized Ballistic Electron Emission Microscopy**, ***A.J. Stollenwerk***, University at Albany, SUNY; *M.R. Krause,* Thompson, Germany; *D.H. Idell, V.P. LaBella,* University at Albany, SUNY

Devices that utilize the spin degree of freedom rely on transport of electron spin through materials and material interfaces. Further knowledge of spin-polarized electron transport can aid in the development of these and other spintronic devices. To this end, we developed spin polarized ballistic electron emission microscopy (SP-BEEM), where a ferromagnetic STM tip is utilized to inject spin-polarized electrons into a ferromagnetic metal semiconductor Schottky diode. This technique allows measurement of spin polarized hot electron transport as a function of angle between the magnetic field of the tip and the magnetic field of the sample. This provides a powerful instrument to study spin dependant transport due to the full 2Ï? rotational capability and the nanoscale positioning of the STM tip. The talk will discuss this technique and how to use it to extract spin dependent attenuation lengths of ferromagnetic metals.

9:20am **MI-WeM5 Spin-polarized STM as a Tool to Study Non-Periodic Magnetic Structures**, ***W. Wulfhekel***, Universitaet Karlsruhe, Germany; *U. Schlickum,* EPFL, Switzerland; *C.L. Gao, J. Kirschner,* Max-Planck Institut fur Mikrostrukturphysik, Germany **INVITED**

The high lateral resolution of spin-polarized scanning tunneling microscopy (Sp-STM) offers the possibility to study the influence of crystal defects on ferromagnetic and antiferromagnetic structures as well as combined systems. Atomic substrate steps in W(100) were found to influence the domain walls of thin Fe films leading to a reduced wall width and pinning. This is explained by the atomic arrangement at the step edges reducing ferromagnetic exchange and enhancing magnetic anisotropy. Further, steps in ferromagnetic substrates induce frustrations in thin antiferromagnetic films via the exchange interaction. The behavior of these topological frustrations in Mn films on Fe(100) was studied and linked with atomic exchange parameters in the film and across the ferromagnet-antiferromagnet interface. Similarly, in ferromagetic films grown on stepped antiferromagnets frustrations may arise due to the exchange across the interface as will be shown on the example of Co grown on NiMn(001). Finally, the use of Sp-STM to resolve the complex and non-collinear spin structure of reconstructed @alpha@-Mn films is demonstrated.

10:40am **MI-WeM9 Imaging Electrical Spin Injection in Lateral Ferromagnet/Semiconductor Devices**, ***S. Crooker***, Los Alamos National Laboratory **INVITED**

Using methods for low-temperature scanning magneto-optical Kerr microscopy, we directly image the electrical injection and subsequent transport of spin-polarized electrons in lateral ferromagnet/semiconductor devices.@footnote 1@ These structures have metallic ferromagnetic (Fe) source and drain tunnel-barrier contacts at opposite ends of a lightly-doped n:GaAs semiconductor channel. The images reveal efficient electrical spin injection extending out to 120 microns in the GaAs channel, and accumulation of spin polarized electrons within a diffusion length (10 microns) of the drain contact. Both injected and accumulated electrons have the same spin orientation (antiparallel to the contact magnetization). By controlling, in situ, the uniaxial strain applied to the device substrate, we show that the accumulated spin polarization actually flows away from the drain contact (against the net electron current), indicating that these electrons are polarized by spin-sensitive reflection from the ferromagnetic drain contact. Furthermore, we show that the electrical conductance of these devices is modulated by the spin orientation of electrons flowing through the drain, demonstrating that the Fe/GaAs Schottky tunnel barrier contacts function both as electrical spin injectors as well as detectors. These experiments are conducted in a geometry that is sensitive only to electron spin precession, allowing for detailed modeling of spin transport in the channel. @FootnoteText@ @footnote 1@ S.A. Crooker, M. Furis, X. Lou, C. Adelmann, D.L. Smith, C.J. Palmstrom, and P.A. Crowell, Science v309, p2191 (2005). This work was supported by the DARPA SPINS and Los Alamos LDRD programs, ONR, and the NSF MRSEC program under DMR 02-12032.

11:20am **MI-WeM11 Intrinsic Nanoscale Electronic Phase Separation and Simple Percolation in La1-xSrxCoO3**, ***J. Wu***, *J. Parker, M. Torija, C. Perrey, C.B. Carter,* University of Minnesota; *J. Lynn,* National Institute of Standards and Technology; *H. Zheng, J. Mitchell,* Argonne National Laboratory; *C. Leighton,* University of Minnesota

The doped pervoskite cobaltite La1-xSrxCoO3 has been advanced as a model system for studying magnetoelectronic phase separation. We present here a combination of chemically sensitive high-resolution TEM, SANS, and transport data that reveal interesting new features of this phase separation. The TEM data show that the material is chemically homogenous down to nm length scales, proving that the phase separation is truly intrinsic electronic phase separation. The SANS data, which were performed at several compositions below x = 0.18 (where long-range ferromagnetism (FM) sets in), reveal that the FM clusters have a maximum size of about 2-3 nm, independent of doping. This demonstrates that the percolation transition that occurs at x = 0.18 is due to an increasing density of clusters with increasing x, not an expansion of cluster size. These observations naturally explain the simple percolation observed in single crystal transport, i.e. conductivity exponents close to predicted values and a critical composition (x = 0.18) close to the expected value for the 3-D percolation limit. Comparisons to theoretical work on purely electronic phase separation provide insight into the physical mechanisms controlling the phase separation. Work supported by ACS PRF, NSF and DoE.

11:40am **MI-WeM12 Non-Fermi-Liquid Behavior in Quasi-One-Dimensional Li@sub 0.9@Mo@sub 6@O@sub 17@**, ***E.W. Plummer***, The University of Tennessee, Knoxville and Oak Ridge National Laboratory **INVITED**

Temperature dependent scanning tunneling spectroscopy data of the quasi-one-dimensional conductor Li@sub 0.9@Mo@sub 6@O@sub 17@ will be presented. The differential tunneling current in the low-temperature spectra shows a power-law beefier around the Fermi energy, which is expected for a clean Luttinger liquid. The power-law exponent is

found to be 0.6. Spectra for a temperature range of 5 to 55 K can be fitted fairly well with a model for tunneling into a Luttinger liquid at the appropriate temperature. A fit with a model based on a zero bias anomaly is significantly worse compared to the Luttinger liquid model. No signature of a phase transition at T= 24 K is observed in the data.

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