Monday Morning, October 2, 2000

Magnetic Interfaces and Nanostructures
Room 206 - Session MI-MoM

Magnetic Spectroscopies

Moderator: S.D. Bader, Argonne National Laboratory

8:20am **MI-MoM1 Spin Polarized Photoemission Study of Magnetite Films: Extraction of the Bulk Polarization via a Substrate Overlayer Model***, **S.A. Morton**, G.D. Waddill,* University of Missouri, Rolla*; J.G. Tobin,* Lawrence Livermore National Laboratory*; S. Kim, I.K. Schuller,* University of California, San Diego*; S.A. Chambers,* Pacific Northwest National Laboratory

Many materials have been predicted to be half metallic, yet to date remarkably little truly compelling evidence for this behavior has emerged. One technique that can potentially yield a definitive result is spin polarized photoemission and it is from this technique that the most compelling evidence yet has emerged.@footnote 1@ However such experiments are hampered by the difficulty in producing clean stoichiometric surfaces with a polarisiation that is truly representative of that of the bulk. We have used the spin-resolved photoemission facility at the Advanced Light Source,@footnote 2@ to study the half-metallic candidate Fe@sub 3@O@sub 4@, which holds out the possibility of use in spintronic devices as a pure spin source. The epitaxial films were grown on MgO by UCD and PNNL and were characterized by RHEED, LEED, XRD, and magneto-transport measurements. We have demonstrated that cleaning the samples results in the loss of their polarization. However, our ability to perform spin resolved experiments at higher photon energies, (as a direct result of the high brightness of the 3rd generation source), has enabled us to study the near Fermi edge polarization of the samples "as received", without having to resort further to potentially destructive cleaning techniques. By measuring the polarization as a function of emission angle and photon energy, and combining these measurements with a substrate overlayer model, we have been able to extract the underlying polarization of the bulk material and have demonstrated that it is significantly higher than the 30% initially observed in the "as-received" samples, and may indeed be up to 100%. Furthermore, our spin resolved spectra demonstrate close agreement with simulated spectra derived from theoretical calculations.@footnote 3@ @FootnoteText@ @footnote 1@Park et al, Nature 392 794 (1998); Phys. Rev. Lett. 81 1953 (1998)@footnote 2@Tobin et al, MRS Symp. Proc. 524 185 (1998)@footnote 3@Zhang and Satpathy, Phys. Rev. B. 44 13319 (1991).

8:40am **MI-MoM2 Magnetic Dichroism in the Soft X ray Absorption Region of NiMnSb Ferromagnetic Alloy***, **C.N. Borca**,* University of Nebraska, Lincoln*; S. Stadler,* Naval Research Laboratory*; D. Ristoiu,* CNRS Laboratoire Louis Neel, France*; P.A. Dowben,* University of Nebraska, Lincoln*; Y.U. Idzerda,* Naval Research Laboratory*; J.P. Nozieres,* CNRS Laboratoire Louis Neel, France

We have investigated the magnetic and electronic structure of NiMnSb alloy by soft-X-ray absorption spectroscopy (XAS) and magnetic circular dichroism (MCD) measurements in the Mn 2p and Ni 2p core absorption regions. We have studied the unoccupied orbital symmetry of NiMnSb. The spectra display strong polarization dependence, especially at the Mn 2p threshold. The unoccupied orbital assignment will be presented as a function of temperature and light polarization. The apparent multiplet structures found in the Mn 2p XAS spectra corresponds to a tetragonal crystal field symmetry and is the origin of most of the moment in this Heusler alloy. The XAS spectrum in the Ni 2p core shows a doublet feature in both 2p3/2 and 2p1/2, resulting from the octahedral crystal field.

9:00am **MI-MoM3 Cu Metallic Quantum Well State Dispersions in the Cu/fccFe/Cu(100) System***, **A. Danese**, R.A. Bartynski,* Rutgers University

Multilayers of alternating ultrathin non-magnetic/ferromagnetic (NM/FM) films often exhibit oscillatory magnetic coupling between sequential FM layers. This phenomenon has great technological importance and is associated with the presence of metallic quantum well (MQW) states in the NM layer. To understand the influence of the FM substrate on the electronic states of the NM layer, we have performed an inverse photoemission (IPE) study of the Cu/fccFe/Cu(100) system along the @Gamma@X direction of the surface Brillouin zone (SBZ). We have also modeled this system using a phase accumulation approach. The model predicts that a subset of these states disperse slowly as a function of parallel momentum in the region of the projected spin polarized band gap of the FM layer, which for fccFe lies a few eV above the Fermi energy. We will discuss IPE results for Cu/fccFe/Cu(100) system in this region of the SBZ, both above and below the Curie temperature of the Fe layer. We have also investigated thermal desorption of CO from this system as a function of Cu film thickness to determine how the presence of MQW states influences the chemisorption bond.@footnote 1@ @FootnoteText@ @footnote 1@Supported by NSF-DMR #98-01681 and ACS-PRF #33750-AC6,5.

9:20am **MI-MoM4 On the Evolution of Magnetic Moments of Fe in FeCo(100) & FeNi(100) Alloy Films***, **N.A.R. Gilman**, R. Zhang, R.F. Willis,* Pennsylvania State University*; M. Hochstrasser, J.G. Tobin,* Lawrence Livermore National Laboratory

We report on the variation of the local magnetic moments with changing composition in Fe@sub x@Co@sub 1-x@ and Fe@sub x@Ni@sub 1-x@ alloy films grown epitaxially on fcc Cu(100). The elemental magnetic moments were determined from magnetic-field-induced intensity asymmetry observed in angle-dependent photoelectron spectroscopy of the 3p core-levels of the constituent atoms - "x-ray magnetic dichroism.@footnote 1@ Both the Fe and the Ni moments change in magnitude with changing composition of FeNi alloys.@footnote 2@ The 'stoichiometrically averaged moment' follows the Slater-Pauling curve up to a critical filling of the 3d bands (corresponding to ~2.5 holes in the minority-spin d-band) at which point it collapses to a lower spin-state ('Invar' effect). This is caused by a sudden change in the Fe local moment. This magnetic instability is predicted theoretically independent of what element the Fe is alloyed with ie, a similar collapse is expected for FeCo alloys at the same critical filling of the d-bands.@footnote 3@ However, to date, no such collapse of the Fe moment has been observed in similarly grown FeCo alloy films with fcc-like pseudomorphic structure. In this paper, we present new results comparing the evolution of the Fe moments in FeNi and FeCo fcc pseudomorphic films grown on Cu(100). Simultaneously, we monitor the distribution of states in momentum space at the Fermi energy. The Fermi surface topology confirms that the films are of fcc symmetry, although tetragonal distortion occurs with increasing Fe moment. The dichotomy in the magnetic behavior is discussed in the light of these, and other recent results. @FootnoteText@ @footnote 1@ C. Roth et al., Phys. Rev. Lett. 70, 3479 (1993). @footnote 2@ R.F. Willis et al., Phys. Rev. B, in press (2000) @footnote 3@ P. James et al., Phys. Rev. B 59, 419 (1999).

9:40am **MI-MoM5 X-Ray and Neutron Scattering Studies of Magnetic Roughness in Thin Magnetic Films***, **S.K. Sinha**,* Argonne National Laboratory*; S.A. Stepanov,* Illinois Institute of Technology & Argonne National Laboratory*; R.M. Osgood,* Argonne National Laboratory **INVITED**

It has become apparent that magnetic roughness at interfaces plays an important role in, for instance, the magnetic and transport behavior of thin film magnetic devices. Reflectivity and diffuse scattering studies of thin films using neutrons or X-rays can be used to distinguish between chemical and magnetic roughness at interfaces and to determine the parameters characterizing the latter, such as the correlation length. We discuss the theory of magnetic scattering of neutrons and resonant X-rays by rough interfaces within the Born and Distorted Wave Born Approximations and illustrate how it has been used to analyze experimental results attained on several systems so far.

10:20am **MI-MoM7 Diffuse X-Ray Resonant Magnetic Scattering (DXRMS) of Thin Magnetic Films on Anisotropic Substrates***, **J.J. Kelly IV**, D.E. Savage, F. Liu, F. Flack, M.G. Lagally,* University of Wisconsin, Madison

Recent applications of very thin magnetic films and magnetic multilayers, such as in magneto-electronics or magnetic data storage, have emphasized the necessity of understanding the nature of magnetism at surfaces and interfaces. For example, the effect of surface and interface morphology, both chemical and magnetic, on spin dependent electron scattering, and thus spintronics devices, is a critical question. Diffuse x-ray resonant magnetic scattering (DXRMS), a unique element-specific technique, provides information on both the chemical and magnetic morphology at surfaces and interfaces by looking at the diffuse and specular components of resonant magnetic x-ray scattering. Using DXRMS and the magneto-optical Kerr effect (MOKE), we have investigated the influence of deliberately induced anisotropic morphology on the magnetic properties of thin magnetic films and multilayers. Changes in x-ray scattering and coercivity are observed as the sample is rotated relative to the incident x-ray beam, and correlated with morphology. The results are discussed in light of previous results using DXRMS and theory. @FootnoteText@ Research supported by NSF and Seagate.

10:40am **MI-MoM8 Control of Surface Roughness during Nanoscale Multilayer Deposition by Adding Surfactants***, X.W. Zhou,* The University of Virginia*; W. Zou, H.N.G. Wadley,* The University of Virginia, usa

Nanoscale multilayers often exhibit special properties not possessed by their bulk constituents. For instance, multilayers composed of a thin (~20 Å) conductive layer (such as Cu) sandwiched between thin (~50 Å) ferromagnetic layers (e.g., Co) undergo a larger drop in electrical resistance under an external magnetic field. This property, called magnetoresistance, has been utilized in hard drive read heads to allow a significant increase in hard drive storage capacity, and are being explored for nonvolatile random access memories. The performance of these devices can be improved when the interfacial roughness and interlayer mixing of the multilayers can be reduced. While hyperthermal energy deposition techniques have been used to grow the nonequilibrium flat interfaces in the nanoscale multilayers, considerable interests are also growing in searching new multilayer material systems that intrinsically generate low interfacial roughness and interlayer mixing. Traditional material search criteria primarily based upon lattice-match, magnetic saturation, and thermal immiscibility resulted in high quality NiCo/Cu/NiCo multilayers. Better multilayers are likely to be formulated among more complex multilayer structures involving more elements. However, the tremendous possibilities of complex multilayer systems preclude a mere experimental trial and error search for the multilayer systems. Using an atomistic simulation approach, the effects of adding Ag and Au in the NiCo/Cu/NiCo multilayers have been explored. Remarkable Ag surface segregation and surface flattening effects were observed. These surfactant effects were found to be much less for Au. Analyses indicated that such effects can be attributed to the larger size (compared to Cu, Ni, and Co) and lower cohesive energy (compared to Cu, Ni, Co, and Au) of Ag atoms. This finding suggested a new set of materials that should be explored in experiments.

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