## Magnetic Interfaces and Nanostructures
## Room 204 - Session MI-WeM

### Magnetic Imaging and Spectroscopies
**Moderator:** M.E. Hawley, Los Alamos National Laboratory

9:00am **MI-WeM3 Development of Spin Resolved Photoemission Facility at the LLNL for the Electronic Structure Study of Actinides**, ***J.G. Tobin***, *S.-W. Yu,* Lawrence Livermore National Laboratory

We have developed a spin-resolved photoemission facility at the Lawrence Livermore National Laboratory (LLNL) to study the electronic structures of Actinides. Although great progress in the determination of the electronic structures of low-Z materials has been achieved through the use of angle-resolved photoemission in combination with synchrotron radiation, the electronic structures of Actinides are less easily accessible with this technique because the electronic structures are modified strongly by spin-orbit interaction. In addition, the radioactivity of Actinides prevents them from easy access for experiments. In this talk, we will address how such problems can be removed in the new facility and present preliminary data.

9:20am **MI-WeM4 A Comparative Study of the Magnetic Domain Structure of Mn Doped ITO Thin Films by Magnetic Force Microscopy**, ***B.I. Kim***, Boise State University, United Sates; *J.O. Holmes, M.R. Kongara, A. Punnoose,* Boise State University

Semiconducting Mn doped ITO thin films have been studied with different Mn doping levels using high resolution magnetic force microscopy (MFM) to understand the magnetic microstructure and uniformity of this room temperature ferromagnet. The film was prepared by sol-gel mediated spin coat technique, and the Co-coated tip (radius < 10 nm) was magnetized vertically using strong external magnetic field before the experiment. We collected four different MFM images (topographic image, magnetic force image, amplitude image and phase image) at the same time to obtain complementary information using ac mode MFM technique. Stable imaging condition could be achieved at distance 50 -100 nm between tip and sample. The magnetic domain structures observed in the ambient condition show thin labyrinthine features with 1-2 µm width for all Mn : ITO thin films regardless of the Mn doping level. MFM images also show that magnetic structures are connected differently depending on the Mn concentration. We could observe a reproducible image with small fine magnetic features with 10nm size for the repeated images, indicating the fine features comes from 8 nm ferromagnetic nanoparticles confirmed from TEM. The sectional profiles across magnetic domains indicate that the variation between positive and negative orientation for the 6% Mn doped samples is twice bigger than those at 9% and 3% doped magnetic films, consistent with an independent magnetization measurement. Comparison of magnetic phase images with those of longitudinal medium suggests that the magnetic moments of Mn : ITO orient vertically on the plane of film surfaces. The study indicates the amount of Mn doping influences the individual magnetic fine features as well as the connectivity of magnetic domains. These observed domain features suggest that magnetic structures on nano- and- macro- scale of Mn : ITO films are closely related to the amount of Mn doping and preparation condition.

9:40am **MI-WeM5 Spin Polarized Scanning Tunneling Spectroscopy of Nano-Scale Co Islands on Cu(111)**, ***O. Pietzsch***, University of Hamburg, Germany **INVITED**

At room temperature, triangular Co islands can be grown on Cu(111), protruding two atomic layers high above the Cu surface. Two different orientations of the triangles are observed, indicating a stacking fault with respect to the fcc stacking of the Cu substrate in one case. We have studied the structural, electronic, and magnetic properties of these islands with spin-averaged and spin-resolved scanning tunneling spectroscopy at low temperatures. Using a non-magnetic tunneling tip, we found the electronic properties of the differently oriented islands to be clearly inequivalent. In differential conductance (dI/dV) maps this leads to strong contrasts at the appropriate energies with signal asymmetries as high as 50 percent. Applying a magnetic tip, another source of contrast with similar strength becomes accessible, originating from the perpendicular magnetization of the islands.@footnote 1@ We discuss the Co spin polarization which is strongly energy dependent and repeatedly changes sign. Quite similar to the Cu substrate surface, the Co islands exhibit a standing wave pattern in the local density of states. In the case of Co, however, the responsible dispersive state is spin-polarized. This spin imbalance modifies the oscillation amplitude. A comparison of the Cu and Co patterns as a function of energy reveals yet another difference: while the Cu patterns indicate two-dimensional free-electron gas behavior, the Co patterns are affected by lateral electron confinement. We compare our observations with models based on an exact solution of the particle-in-a-triangular-box problem@footnote 2@ and a multiple scattering approach.@footnote 3@ @FootnoteText@ @footnote 1@ O. Pietzsch, A. Kubetzka, M. Bode, and R. Wiesendanger, Phys. Rev. Lett. 92, 057202 (2004).@footnote 2@ H.R. Krishnamurthy, H.S. Mani, and H.C. Verma, J. Phys. A: Math. Gen. 15, 2131 (1982).@footnote 3@ E.J. Heller, M.F. Crommie, C.P. Lutz, and D.M. Eigler, Nature 369, 464 (1994).

10:20am **MI-WeM7 Evolution of (Surface) Magnetic Moment and Magnetic Ordering Behavior in Epitaxial Transition Metal Films**, ***K.R. Podolak***, The Pennsylvania State University; *N. Janke-Gilman,* Latrobe University, Australia; *R.F. Willis,* The Pennsylvania State University

We report dichroism in angle-resolved x-ray photoemission with linearly polarized synchrotron radiation of the 3p core levels of the ferromagnetic elements Fe, Ni, Co, and their binary alloys.@footnote 1@ A systematic study of the spectral width (W) and the dichroism asymmetry amplitude (A) distinguishes the magnitudes of the elemental moments from the overall saturization magnetization. The Slater-Pauling curve is shown to be a plot of the stoichiometric mean saturization magnetization per atom. The spectral width (W) increases with increasing ferromagnetism. The dichroism asymmetry amplitude (A) senses the onset of disorder, instabilities, and changes in the magnetic anisotropy. These new measurements provide a new insight into the magnetic order in these thin film alloys and surface moment enhancement. @FootnoteText@ @footnote 1@ R.F. Willis and N. Janke-Gilman. Europhys. Lett., 69, 411 (2005).

10:40am **MI-WeM8 Spin-Resolved Core Level Photoemission of the Ni/Co/Cu(001) System Using Circularly Polarized X-Rays**, ***T. Komesu***, *G.D. Waddill,* University of Missouri-Rolla; *M.T. Butterfield, S.-W. Yu, J.G. Tobin,* Lawrence Livermore National Laboratory

We present spin-resolved 2p core level photoemission results for Co/Cu(001) and for Ni/Co/Cu(001). For the former we have collected the core level spectra by reversing the magnetization of the Co film emphasizing exchange effects in the spin-polarization as well as by reversing the helicity of the incident x-rays on an unmagnetized sample which isolates spin-orbit effects in the observed spin-polarization. For the exchange effects we observe strong spin polarization in the main peaks and a weaker spin polarization effect in the controversial satellite peak at ~4 eV higher binding energy than the main peaks. The spin-orbit spectrum shows strong spin-polarization throughout the spectral region that changes sign between the 2p3/2 and 2p1/2 peak consistent with its sensitivity to the core-hole spin-orbit coupling. Finally, we have studied the effects of charge transfer for the Ni/Co/Cu(001) system using spin-resolved photoemission where we see changes in the spin polarization of the main peaks and satellite features of both Ni and Co 2p core levels that can be understood in terms of charge transfer from the Co to the Ni as a function of Ni film thickness. These results establish that spin-resolved core level photoemission is a sensitive probe of electron correlation effects in thin magnetic films and surfaces. This work was performed under the auspices of the U.S. DOE by University of California Lawrence Livermore National Laboratory under contract W-7405-Eng-48.

11:00am **MI-WeM9 Medard Welch Award Lecture: Studies of Magnetic Materials and Nanostructures using Synchrotron Radiation Spectroscopy, Diffraction, and Holography**, ***C. Fadley***[1], University of California, Davis and LBNL, Berkeley **INVITED**

I will discuss several recent developments in studies of magnetic surfaces and magnetic nanostructures using synchrotron radiation, with special emphasis on work in the soft x-ray regime at the Berkeley Advanced Light Source. Instrumentation that has been developed to carry out multiple spectroscopies with varying degrees of surface sensitivity (photoemission, x-ray absorption, and x-ray emission) on a single sample will be introduced, together with future prospects in photoemission based on higher-speed detection.@footnote 1@ Then a new standing wave-plus-wedge method for non-destructively studying buried interfaces in multilayer nanostructures will be considered.@footnote 2@ This method has permitted determining concentration and magnetization profiles through an Fe/Cr giant magnetoresistive interface,@footnote 2a@ as well as layer-specific densities of states in a magnetic tunnel junction consisting of FeCoB/FeCo/Al@sub 2@O@sub 3@.@footnote 2c@ This approach should

[1] **Medard W. Welch Award Winner**

also be useful in a variety of other interface studies,@footnote 2b@ with the use of soft x-ray detection permitting the study of more deeply buried interfaces.@footnote 2d@ Application of the multi-spectroscopy experimental system to the colossal magnetoresistive oxide materials La@sub 1-x@Sr@sub x@MnO@sub 3@ (x = 0.3, 0.4) will also be discussed, including the direct observation of charge localization on Mn in polaron formation@footnote 3a@ and surface stoichiometry characterization.@footnote 3b@ Finally, the prospects for element-specific determinations of local atomic and magnetic structure using photoelectron holography will be considered.@footnote 4@ Work supported by the Dept. of Energy, Basic Energy Sciences, Materials Science and Engineering Division, under Contract DE-AC03-76SF00098. @FootnoteText@ @Footnote 1@J.-M. Bussat, C.S. Fadley, B.A. Ludewigt, G.J. Meddeler, A. Nambu, M. Press, H. Spieler, B. Turko, M. West, G.J. Zizka, IEEE Transactions on Nuclear Science 51, 2341 (2004), with further details at: http://www.physics.ucdavis.edu/fadleygroup. @footnote 2a@S.-H. Yang, B.S. Mun, N. Mannella, S.-K. Kim, J.B. Kortright, J. Underwood, F. Salmassi, E. Arenholz, A. Young, Z. Hussain, M.A. Van Hove, and C.S. Fadley, J. Phys. Cond. Matt. 14, L406 (2002) @footnote 2b@S.-H. Yang, B.S. Mun, and C.S. Fadley, Synchrotron Radiation News 17 (3), 24 (2004) @footnote 2c@S.-H. Yang, B.S. Mun, et al., to be published @footnote 2d@M. Watanabe, B.C. Sell, et al. to be published. @footnote 3a@N. Mannella, A. Rosenhahn, C. H. Booth, S. Marchesini, B. S. Mun, S.-H. Yang, K. Ibrahim, Y. Tomioka, and C.S. Fadley, Phys. Rev. Lett. 92, 166401 (2004) @footnote 3b@N. Mannella et al., to be published. @footnote 4@C.S. Fadley, M.A. Van Hove, A. Kaduwela, S. Omori, L. Zhao, and S. Marchesini, J. Phys. Cond. Mat. 13, 10517 (2001)

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