Magnetic Interfaces and Nanostructures
Room: 311 - Session MI+EM-MoM

Interfacial Effects in Oxide Heterostructures
Moderator: Greg Szulczewski, The University of Alabama

8:40am **MI+EM-MoM2 Linear Dichroism of $La_{0.7}Sr_{0.3}MnO_3$ Magnetic Dead Layers**, ***Robbyn Trappen***, *M.B. Holcomb, J. Zhou, C.-Y. Huang,* West Virginia University, *Y.-H. Chu, V. Tra,* National Chiao Tung University, Taiwan, Republic of China

Magnetic dead layers are a phenomenon in which a normally ferromagnetic material loses its magnetization below a critical thickness, which poses a problem for thin film applications. Density functional calculations predict the behavior of the dead layer in complex oxide films to be antiferromagnetic, which is attributed to interdiffusion of the magnetic film into the neighboring layers. Here, we investigate the transition from ferromagnetic to antiferromagnetic behavior in the complex oxide $La_{0.7}Sr_{0.3}MnO_3$ using x ray magnetic linear and circular dichroism on the Mn L-edge (2p to 3d transition). These measurements were taken at the Advanced Light Source at Lawrence Berkeley National Labs. If the mechanism of the formation of the dead layers is understood, it can potentially be reversed and the same physics may be able to even enhance the magnetization beyond its bulk parameter.

9:00am **MI+EM-MoM3 Magnetotransport at the Superconducting $LaAlO_3/SrTiO_3$ Interface**, ***Stefano Gariglio***, *D. Li, A. Fête, W. Liu, J.-M. Triscone,* University of Geneva, Switzerland **INVITED**

The conducting interface between the two band insulators $LaAlO_3$ and $SrTiO_3$ has drawn a large share of attention, as it presents a variety of exciting electronic properties that are tunable by an electric field [1].

At low temperatures, magnetotransport analysis has revealed a strong Rashba spin-orbit interaction originating from the breaking of inversion symmetry [2] and, in field effect devices, the ground state has been tuned from an insulating to a superconducting state. I will discuss these results in light of recent magnetotransport experiments in field-effect devices to probe the evolution across the phase diagram of the weak localization /weak anti-localization transport regime, its relation to the strength and anisotropy of the superconducting state.

Moreover, this interface naturally provides a versatile system to artificially build stacks of multiple 2D superconductors that would allow coupled 2D superconducting layers to be studied. I will show that we can prepare metallic and superconducting interfaces with $LaAlO_3$ layers grown on an artificial $SrTiO_3$ film [3].

[1] A. D. Caviglia *et al.*, Nature **456**, 624 (2008). [2] A. D. Caviglia *et al.*, Phys. Rev. Lett. **104**, 126803 (2010); A. Fête *et al*., Phys. Rev. B **86**, 201105 (2012). [3] D. Li *et al.* Appl. Phys. Lett. Mat. **2**, 012102 (2014).

9:40am **MI+EM-MoM5 Symmetry Breaking in Strained Vanadium Dioxide Films**, ***Mengkun Liu***, UC San Diego **INVITED**

We report on nanoscopic aspects of the insulator-to-metal transition (IMT) in a canonical correlated electron material, vanadium dioxide (VO2). Using scattering-type scanning near-field optical microscopy (s-SNOM) and spectroscopy (nano-FTIR), we revealed unique phase separation in strained VO2 films at sub-micrometer scale over a wide temperature range (320K-380K). Investigating the three dimensional formation of this microscopic stripe state, we resolved the enigma of the macroscopic electronic anisotropy and disentangled distinct stages of the VO2 phase transition with spontaneous symmetry breaking [Phys. Rev. Lett. 111 (9), 096602 (2013), Appl. Phys. Lett. 104 (12), 121905 (2014) and follow-up studies]. With these results we demonstrated that the novel spectroscopic techniques of near-field optics provide powerful and universal methodologies for studying mesoscopic and interfacial physics for many classes of transition metal oxides and phase transition materials.

10:40am **MI+EM-MoM8 Interface Assisted Molecular Spintronics**, ***Karthik Raman***, Indian Institute of Science, India **INVITED**

The adsorption of molecules on magnetic surfaces offers a new directionality to the study of molecular spintronics. The creation of new interface states formed by the hybridization of molecular orbitals with the spin-polarized bands of the surface leads to the development of a unique electronic and magnetic character. Such a richness of the interface spin-chemistry allows developing new handles to functionalize the properties of the adsorbed molecules, opening up a molecular-genome initiative to develop spin-functional tailor-made devices. Along with the exploration of single molecular magnets, the use of carbon based aromatic molecules, both non-magnetic and open shell magnetic systems, have presented many interesting interface phenomena. In addition to the experimental demonstrations, these studies share a strong theoretical support from computational *ab initio* interface modeling. The mechanism of inducing molecular magnetism with stability up to room temperature, inducing interface magnetic exchange coupling with strengthens of the order of thermal energy at and above room temperature, enhancement in the magnetic anisotropy of the surface and the spin-filtering property demonstrating interfacial magnetoresistance opens up a new channel to develop molecular designs for applications in sensor, memory and computing applications. This talk shall drive interest in the emergent subfield of interface assisted molecular spintronics, by presenting a strong foundation of the interface spin-physics and spin-chemistry and propose novel schemes promoting the use of advanced spectroscopy tools for the investigation of molecular spin responses. Efforts to template molecules on surfaces offer a way forward towards molecular scaling-up, providing a future outlook to the field.

References:

1. N. Atodiresei & K. V. Raman, "Interface assisted spintronics: tailoring at the molecular scale", MRS Bulletin (**July** 2014).

2. K. V. Raman, 'Focusing on the molecular scale', Nature Nanotechnology ***8***, 886 (2013).

3. K. V. Raman *et. al.*, 'Interface engineered templates for molecular spin memory devices', Nature ***493***, 509 (2013).

4. K. V. Raman, J. Chang, J. S. Moodera, 'New method of spin injection into organic semiconductors using spin filtering tunnel barriers', *Org. Electronics**12***, 1275 (2011).

5. K. V. Raman, S. M. Watson, J. H. Shim, J. A. Borchers, J. Chang, J. S. Moodera , "Effect of molecular ordering on spin and charge injection in rubrene", *Phy. Rev. B**80***, 195212 (2009).

11:20am **MI+EM-MoM10 Coverage-Dependent Surface Magnetism of Iron Phthalocyanine on an O-Fe(110) Surface**, ***Jack Rowe***, *D.B. Dougherty*, North Carolina State University, *E. Vescovo*, National Synchrotron Light Source

Iron phthalocyanine adsorbed on an oxygen covered Fe(110) surface shows a complex coverage-dependent spin polarization during growth of the first molecular monolayer. Spin polarization is modified at low submonolayer coverages, absent at intermediate submonolayer coverages, and re-appears in modified form for a complete monolayer. This is attributed to coverage-dependent adsorption configurations from a random adsorption system to a packed monolayer with a well-defined interfacial spin polarization. In addition, we report on the observation of a rotation of the spin direction of photoelectrons in the presence of molecules, which is attributed to molecular modifications of surface magnetic anisotropy.

11:40am **MI+EM-MoM11 Time Resolved Imaging At 10Ghz And Beyond Using The Ssrl Scanning Transmission X-Ray Microscope**, ***Hendrik Ohldag***, SLAC National Accelerator Laboratory, *S. Bonetti, R. Kukreja,* Stanford University, *J. Frisch, H. Duerr, J. Stoehr,* SLAC National Accelerator Laboratory

Understanding magnetic properties at ultrafast timescales is crucial for the development of new generations of magnetic devices. Such devices will employ the spin torque or spin Hall effect, whose manifestation at the nanoscale is not yet sufficiently understood, which is why studies addressing these effects are of great fundamental significance as well. The samples of interest are often thin film magnetic multilayers with thicknesses in the range of a atomic layers. This fact alone presents a sensitivity challenge in STXM microscopy, which is more suited toward studying thicker samples. In addition the relevant time scale is of the order of 10 ps, which is well below the typical x-ray pulse length of 50 – 100 ps. Altogether this means that pushing the time resolution of a synchrotron x-ray microscopy experiment is synonymous with improving the signal to noise ratio on the detector and providing stable, low jitter excitation to not further dilute the already small magnetic signals.

The SSRL STXM is equipped with a single photon counting electronics that effectively allows us to use a double lock-in detection at 476MHz (the x-ray pulse frequency) and 1.28MHz (the synchrotron revelation frequency). The pulsed or continuous sample excitation source is synchronized with the synchrotron source with a few picosecond drift over 24 hours. This setup currently allows us to achieve a signal to noise ratio of better than 10000, enabling us to detect miniscule variations of the x-ray absorption cross section.

In this talk I will describe the time resolved STXM setup developed at SSRL and present firsts results that have been obtained using the instrument in collaboration with an outstanding group of external users. The instrument operates in ultra high vacuum (~10^{-8}torr) and allows us to apply electrical pulses to our samples that can be placed in out of plane magnetic fields up to 0.8 Tesla or in plane magnetic fields up to 0.3 Tesla. We have used the instrument to successfully image spin waves excited in spin-torque and spin Hall oscillators with nano contacts of the size of ~100nm. We also succeeded in imaging different excitation modes of magnetic samples in ferromagnetic resonance at 9.6GHz excitation frequency, where the opening angle of the precession cone is of the order of 10mrad.

The facility that is dedicated to ultrafast studies of materials under electric and magnetic fields is open to general users who are interested in this field.

Authors Index

Bold page numbers indicate the presenter