Neutron Scattering Focus Topic
Room: 207 - Session NT+AS+MI-WeM

Applications of Neutron Scattering I

Moderator: V. Lauter, Oak Ridge National Laboratory

8:00am **NT+AS+MI-WeM1 A Deeper Look into Spintronic Material Systems with Neutrons and Synchrotron Radiation**, ***T. Brueckel***, Forschungszentrum Jülich, Germany **INVITED**

The discovery of the Giant Magnetoresistance GMR effect triggered the evolution of Spintronics, i.e. information storage, information processing and information transport using the spin of the electron. While the first Spintronic devices were merely transition metal multilayers, the interest has shifted to include transition metal oxide systems, laterally structured films and magnetic nanoparticles. Scattering techniques applied to model systems are ideal to provide fundamental microscopic information on the spin and domain structure.

In this contribution, we will give an overview highlighting the capabilities of modern neutron and synchrotron x-ray techniques. We will show that neutron scattering under grazing incidence is able to provide unique depth resolved information on magnetization, magnetic correlations and magnetization dynamics relevant for basic and applied research on nanostructured magnetic materials and how synchrotron x-ray scattering can provide complementary element specific information. Examples for current research on patterned metallic multilayers, thin transition metal oxide films and magnetic nanoparticles will be given.

8:40am **NT+AS+MI-WeM3 Magnetic Properties of FePtRh Films and Multilayers Studied by Neutron Scattering**, ***D. Lott***, *J. Fenske*, Helmholtz-Zentrum Geesthacht, Germany, *G.J. Mankey*, Univ. of Alabama, *W. Schmidt*, *K. Schmalzl*, Forschungszentrum Juelich, Germany, *E. Tartakowskaya*, National Academy of Science, Ukraine, *H. Amabye*, ORNL, *F. Klose*, *A. Mulders*, ANSTO, Menai, Australia, *A. Schreyer*, Helmholtz-Zentrum Geesthacht, Germany, *V. Lauter*, ORNL

Ordered FePt alloys with $L1_0$ structure are known as materials with FM order and a high magnetic moment of Fe providing a large magnetization. The large atomic number of Pt on the other hand results in a high magnetic anisotropy. If grown in thin films, the high anisotropy often results in perpendicular magnetization which is the preferred orientation for current magnetic recording media. One way to control the magnetic properties in these materials is through the introduction of a third element into the crystal matrix e.g. Rh. When Rh is added to replace Pt in the equiatomic alloy, new magnetic phases emerge. Here neutron diffraction studies on the magnetic properties of different thick $Fe_{50}Pt_{50-x}Rh_x$ films in dependence on temperature and external magnetic fields allowed us to investigate the rich phase diagram of the system for thin films, e.g. the transition from the FM to AF state in the system with increasing Rh concentration. In particular films with a Rh concentration of about 10% show a temperature dependent AF-FM transition. From the neutron data it was moreover possible to determine the magnetic configurations in dependence on concentration, temperature and magnetic field on a microscopic scale. Based on the observed results a theoretical model considering the changes in the anisotropies could be developed. In a next step magnetic multilayer consisting of $Fe_{50}Pt_{50-x}Rh_x$ bilayers with different Rh concentrations were grown and studied by polarized neutron reflectivity to investigate the magnetic interactions along the lattice matched interfaces. First results will be presented here.

9:00am **NT+AS+MI-WeM4 Spectroscopic and Magnetic Characterization of the Spin-Crossover Transition in Thin Films of $Fe(C_{12}H_8N_2)_2(NCS)_2$.**, ***E.C. Ellingsworth***, *G.J. Szulczewski*, The University of Alabama, Tuscaloosa, *V. Lauter*, Oak Ridge National Laboratory

The octahedral complex bis(1,10-phenanthroline)dithiocyanate iron(II), $Fe(phen)_2(NCS)_2$, is known

to exhibit an abrupt transition between a high and low magnetic spin state from 170 – 180 K in the

bulk phase. As a result, $Fe(phen)_2(NCS)_2$ is an interesting organic semiconductor to study charge and

spin transport in thin films. We synthesized and characterized $Fe(phen)_2(NCS)_2$ according to literature

procedures. Thin films of $Fe(phen)_2(NCS)_2$ were made by vapor deposition onto a variety of substrates

including Si, KBr, Au and Al and characterized by infrared and photoelectron spectroscopy, SQUID

magnetometry, optical microscopy, and polarized neutron reflectometry. The films were found to be

very sensitive to water vapor under ambient conditions, which complicates the structural, chemical and

magnetic analysis of the films. However, appropriate capping layers can be deposited onto the

$Fe(phen)_2(NCS)_2$ thin films to protect them from water vapor before removal from the vacuum system. The

differences in the magnetic behavior of the thin films will be compared to the bulk phase.

9:20am **NT+AS+MI-WeM5 Nanoscopic Magnetic Phase Separation at the $SrTiO_3(001)/La_{1-x}Sr_xCoO_3$ Interface**, *M. Sharma*, *M.A. Torija*, Univ. of Minnesota, *J. Gazquez*, *M. Varela*, ORNL, *J. Schmitt*, *C. He*, Univ. of Minnesota, *J.A. Borchers*, *M. Laver*, NIST, *S. El-Khatib*, American University of Sharjah, *V. Lauter*, *H. Ambaye*, *R. Goyette*, ORNL, ***C. Leighton***, Univ. of Minnesota **INVITED**

The remarkable functionality of complex oxides, when combined with the favorable lattice matching that is possible at their interfaces, provides many opportunities for new physics and applications. The perovskite manganites and cobaltites are excellent examples, being of interest in gas sensing, catalysis, and as electrodes in ferroelectric memory and solid oxide fuel cells. From the magnetism perspective they have potential for high conduction electron spin polarization, and a variety of functional ground states. However, the same delicate balance between phases that provides such impressive functionality also leads to a serious problem; it can be difficult to maintain desired properties (e.g. high spin polarization and conductivity) close to the interface with a dissimilar oxide. This is exemplified by magnetic tunnel junctions for example, where the interface spin polarization is suppressed and drops rapidly with temperature. In this work, using SrTiO3(001)/La1-xSrxCoO3 [1] as a model system, we have combined epitaxial growth by high pressure oxygen sputtering with atomic-level stuctural characterization (including STEM/EELS imaging [2]), conventional magnetometry, electronic transport, small-angle neutron scattering, and polarized neutron reflectometry. We observe the usual degredation in magnetization and conductivity in the very thin film limit. We demonstrate that this is due to nanoscopic magnetoelectronic phase separation in the interface region [3]. Essentially, nanoscopic ferromagnetic (FM) clusters form in an insulating non-FM matrix near the interface, resulting in reduced magnetization and conductivity, even at compositions that display no such phase separation in bulk. STEM/EELS depth profiling of the chemical composition reveals that this effect has a chemical origin, being due to subtle depth-wise variations in Sr and O content, resulting in reduced hole doping near the interface. Simple thermodynamic and structural arguments for the origin of these variations are provided, based on Sr dissolution energies and the critical link between srain state and O vacancy concentration provided by O vacancy ordering [2,3].

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[1] Torija, Sharma, Fitzsimmons, Varela, Wu and Leighton, *J. Appl. Phys.* **104** 023901 (2008).

[2] Gazquez, Luo, Oxley, Prange, Torija, Sharma, Leighton, Pantiledes, Pennycook and Varela, Nano. Lett. **11** 973 (2011).

[3] Torija, Sharma, Gazquez, Varela, He, Schmitt, Borchers, Laver, El-Khatib, Maranville and Leighton, published online, Adv. Mater. (2011).

10:40am **NT+AS+MI-WeM9 Study of $L1_0$ Ordering in $^{57}Fe/Pt$ Multilayers**, ***K. Srikanti***, Ugc-Dae, Csr, India

Ordered $L1_0$ FePt, FePd and CoPt alloy thin films have large magnetic anisotropy constants suitable for high-density recording media. The $L1_0$ ordered phase is obtained with post growth annealing at high temperatures. However, the high temperature annealing leads to grain growth. The present work is an attempt to lower the transition temperature starting with multilayer precursors. The evolution of the structural and magnetic properties of Si(sub) [^{57}Fe(19Å

)/Pt (25Å)]$_{x10}$ multilayers as a function of vacuum annealing at different temperatures is studied. The film thickness is selected to have equi-atomic stoichiometry. The multilayers are prepared by ion beam sputtering. X-ray

reflectivity (XRR), X-ray diffraction (XRD), and magneto optical Kerr effect (MOKE) and conversion electron Mössbauer spectroscopy (CEMS) are used to characterise the as-deposited and annealed multilayers. Using XRR it is observed that due to intermixing FePt alloy formation takes place with annealing. The XRD indicated the presence of superstructure peaks at 350^0C and above.Mössbauer measurements indicated a clear evidence for the strong exchange coupling between the soft fcc FePt and hard fct FePt phase. The results indicate that the multilayer structure does not transform directly to the ordered fct FePt, rather first an fcc FePt phase is formed and subsequently it gets converted in to the fct FePt phase as a function of annealing. A detailed study on stoichiometric FePt system embedded in Carbon matrix prepared by ion beam sputtering technique will also be discussed.

Few preliminary results of polarised neutron reflectivity measurements on FePt/FeNi exchange spring magnets will be discussed.

11:00am **NT+AS+MI-WeM10 Influence of Capping Layer Rigidity on Properties of Supporting Temperature Sensitive Hydrogel Polymers Using Neutron Reflectivity**, ***M. Dubey***, Los Alamos National Laboratory, *M.S. Jablin*, Carnegie Mellon University, *M. Zhernenkov*, Los Alamos National Laboratory, *R. Toomey*, University of South Florida, *J. Majewski*, Los Alamos National Laboratory

Temperature sensitive hydrogel polymers are utilized as responsive layers in various applications. While the polymer's native characteristics have been studied extensively, details concerning its properties during interaction with bio-related structures are lacking. This work investigates the interaction between a thermoresponsive polymer cushion and different lipid membrane capping layers probed by neutron reflectometry. N-isopropylacrylamide copolymerized with methacroylbenzophenone first supported a lipid bilayer composed of 1,2-Dipalmitoyl-*sn*-Glycero-3-Phosphoethanolamine (DPPE) and subsequently 1,2-Dipalmitoyl-*sn*-Glycero-3-Phosphocholine (DPPC). The polymer-membrane systems were investigated above and below the polymer lower critical solution temperature (37 and 25 °C). While the same cushion supported each lipid membrane, the polymer hydration profile and thickness were markedly different for DPPE and DPPC systems. Since DPPE and DPPC have different bending rigidities, these results establish that the polymer-membrane interaction is critically mediated by the mechanics of the membrane, providing better insight into cell-hydrogel interactions. There has been increased interest in the effect of matrix elasticity on cell lineage specification. Polymeric matrices with known stiffness are utilized as supports to understand the physical effects of *in vivo* tissue microenvironment for therapeutic uses of stem cells. This work focuses on the infleunce of a capping layer on the mechanical properties of the underlying support.

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