Magnetic Interfaces and Nanostructures Division
Room: East Exhibit Hall - Session MI-ThP

Magnetic Interfaces and Nanostructures Poster Session

MI-ThP1 Investigations of Ni and Co Magnetic Overlayers at the Advanced Photon Source, ***G.D. Waddill***, *T. Komesu*, Missouri University of Science and Technology, *S.W. Yu, J.G. Tobin*, Lawrence Livermore National Laboratory

Magnetic overlayers and bilayers of Ni and Co on Cu(001) have been investigated as a function of coverage, using X-ray Magnetic Circular Dichroism in X-ray Absorption Spectroscopy (XMCD-XAS) and Photoelectron Spectroscopy (PES). These studies were pursued at Beamline 4 at the Advanced Photon Source (APS).

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MI-ThP2 Microstructure, Static and Dynamic Magnetic Properties of Thin Co Films Obtained using DC-Magnetron Sputtering, ***S.A. Maklakov***, *I.A. Ryzhikov, K.N. Rozanov, A.V. Osipov, O.Yu. Kasurkin*, Institute for Theoretical and Applied Electromagnetics RAS (ITAE RAS), Russian Federation, *V.A. Amelichev*, Moscow State University, Russian Federation

Thin Co films possess high value of saturation magnetization, low coercivity and uniaxial magnetic anisotropy. These properties are necessary for high density storage devices, magnetic field sensors and applications for UHF electromagnetic radiation. Consequently Co is perspective material for such employments. There are many influences to affect magnetic film growth. The latter allows one to govern their properties in wide range. Comparative studies of microstructure and magnetic properties (static and dynamic) are essential to develop new approaches for directional obtaining of materials with given frequency dispersion of magnetic permeability.

The results of a comparative study of microstructure (TEM, GIXD), static (VSM) and dynamic (in the range of 0.01 to 10 GHz) magnetic properties of thin Co films are presented. The objects studied were rectangular films (60 x 600 mm) of 20 nm thick on poly(ethylene terephthalate) substrate. High purity (99,95%) cobalt disk target and a rotating drum as a substrate holder was used to obtain Co films.

Under a certain sputtering conditions two different types (with ferromagnetic resonance at 2 and 6 GHz) of Co films were obtained. Both types of films are of nanocrystalline structure. The increase of crystalline size (from 7 to 90 nm) along with the increase of coercivity (from 17 to 110 Oe) and the increase of resonant frequency (from 2 to 6 GHz) was discovered.

Uniaxial crystalline texture discovered was found to effect resonant frequency. When the texture axis is in the film plane, mechanical bending of Co film may cause resonance frequency varying up to 1 GHz. Perhaps the effect is due to magnetostriction mechanism [1].

The relationship obtained allows one to develop new pathways for magnetic materials production.

1. Lagarkov A.N., Kashurkin O.Yu., Maklakov S.A., Osipov A.V., Rozanov K.N., RyzhikovI.A., Starostenko S.N., Iakubov I.T. Influence of magnetoelastic effect on ultra high frequency magnetic properties of thin Fe-N films. // Journal of Communications Technology and Electronics, 2011 (in press).

MI-ThP3 A Facile and Controllable Two-Step Electrodeposition Technique in Synthesis of Nanostructures of Metal Oxides on Carbon Nanotube S, ***J. Yang***, *S. Gunasekaran*, University of Wisconsin-Madison

The nano dimensions of materials are comparable to the size of the target analyte biomolecule, higher catalytic reaction, better affinity binding or more efficient molecule-capturing may occur, leading to high sensitivity. And it is possible to use nanoparticle tags for designing electrical bioaffinity assays with remarkable sensitivity and multiplexing ability. So far, efforts have always been made to design novel nanomaterials useful in solving emerging bioanalytical problems such as rapidness, anti-interfering ability, specificity, stability and sensitivity. Synergies of nanocomposite materials, generally retaining the functional properties of each component and possibly yield synergistic effects via cooperative interactions, have exploited a new area to miniaturize and optimize nano-scale sensors and electronics. The synergistic interesting new features include but not limited to increased surface area, enhanced electrocatalytic activities, improved biocompatibility, promoted electron transfer and better invulnerability against intermediate species. A lot of efforts have been made to fabricate nanocomposite materials of metals/metal oxides nanostructures and carbon materials, using a number of techniques, including sputtering, sol–gel, hydrothermal, microwave and electrodeposition from different precursor solutions containing complex agents. Among these, electrodeposition is the easiest, most controllable, environment-friendly and robust technique for synthesis of metal/ metal oxides NPs, in which, the size, density, composition and even the shape of NPs could be well-controlled by electrodeposition potential, time, concentration and composition of metal precursor solutions.

Herein, we report a general two-step approach of electrodeposition useful in facile, controllable and 'green' electrochemical synthesis of metal oxide NPs onto carbon supports, using carbon nanotubes (CNTs) as an example. First, metal nanostructures were electrochemically deposited onto carbon supports at a constant potential with the density, size, shape and elctrocatalytic activities of the produced nanostructures well-controlled by the time and deposition potential applied as well as the concentration of the precursor solution. Then the as-deposited metallic nanostructures were oxidized into metal oxide nanostructures by repetitive potential cycling with extent of oxidation and generation of metal oxides controlled by the number of potential circles.The as-synthesized metal oxides-CNTs composites were characterized and applied as a glucose sensor for illustration of their electrocatalytic properties.

MI-ThP4 Magnetic Properties and Size Control of $Zn_{0.95}Mn_{0.05}O$ Nanorods Deposited by Pulsed Laser Deposition, ***T.C. Wu***, *Y.C. Yeh, D.R. Liu, D.Y. Chiang*, National Applied Research Laboratories, Taiwan, Republic of China

The well-aligned ZnO nanorods with 5 at.% of Mn doping ($Zn_{0.95}Mn_{0.05}O$) were deposited on silicon (100) substrates by pulsed laser deposition at three different substrate temperatures ranged from 600 ℃ to 700 ℃, while the structure with and without a ZnO seed layer were both considered. The magnetic and structural properties of $Zn_{0.95}Mn_{0.05}O$ nanorods has been characterized by X-ray diffraction (XRD), energy-dispersive X-ray spectroscopy (EDX), scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM), and superconducting quantum interference device (SQUID). We demonstrate that the distribution and diameter of well-aligned $Zn_{0.95}Mn_{0.05}O$ nanorods are controllable, which strongly depend on the substrate temperature. Also, the magnetic properties are directly controlled by the morphologies of $Zn_{0.95}Mn_{0.05}O$ nanorods, and are thus appropriate for further applications.

MI-ThP5 Characterization of Metal Oxides Tunnel Barriers for use in a Non-Local Spin Detection Device, ***A. Matsubayashi***, College of Nanoscale Science and Engineering, the University at Albany-SUNY

Metal oxides can be utilized as interfacial layers between ferromagnetic metals and graphene to achieve spin injection into graphene. Utilizing the spin of the electron as well as its charge has the potential to be utilized for logic devices in the post CMOS era. The goal of our research is to inject and readout spins using a non-local measurement device. However the efficient spin injection has been realized its difficulty due to the conductivity mismatch problem1,2. In order to achieve the efficient spin injection, it has been determined that the insertion of a few nanometers of a tunnel barrier between the ferromagnetic metal and the graphene increases the contact resistance and measured spin lifetime3. However, non-uniformity of the tunnel barriers (pinholes)4 lowers the quality of the interface barrier. In this study, we investigate the fabrication of tunnel barrier on graphene using various metal oxides such as aluminum oxide grown under UHV conditions directly on the graphene. Graphene samples were loaded into an ultrahigh vacuum MBE (Molecular Beam Epitaxy) machine. D esired thickness of metals were deposited from a Knudsen cell. Samples were then transferred back into the load lock and exposed to approximately 130 mTorr of pure O2 for 20 min. Several measurements were performed including scanning electron microscopy, X-ray photoelectron spectroscopy, and angle resolved XPS characterize the electrical and structural quality of the films and their suitability for to be utilized as a tunnel barrier in graphene spin measurements.

References:

[1] P. C. van Son, H. van Kempen, and P. Wyder, Phys. Rev. Lett. **58**, 2271 (1987)

[2] G.Schmidt, D. Ferrand, L. W. Molenkamp, A. T. Filip, and B. J. van Wees, Phys. Rev. B **62**, 4790 (2000)

[3] E. I. Rashba, Phys. Rev. B **62**, 16267 (2000)

[4] W. Han, K. Pi, K. M. McCreary, Y. Li, J. J. I. Wong, A. G. Swartz, and R. K. Kawakami, Phys. Rev. Lett. **105**, 167202 (2010)

MI-ThP6 *In Situ* Scanning Tunneling Spectroscopy on Ordered, Epitaxial $La_{5/8-x}Pr_xCa_{3/8}MnO_3$ Films, ***Z. Gai***, Oak Ridge National Laboratory, *M. Gao*, Chinese Academy of Sciences, *P.C. Snijders*, *H.W. Guo*, *T.Z. Ward*, Oak Ridge National Laboratory, *H.J. Gao*, Chinese Academy of Sciences, *J. Shen*, Fudan University, China

Scanning probe microscopy has been shown to be a potent tool to investigate the structural, electronic, magnetic properties as well as their spatial distributions of strongly correlated perovskite manganites. Differences in tunneling spectra were interpreted to originate from the metallic and insulating phases in the material. However, questions were raised and still remain whether SPM on manganites probes bulk characteristics or is limited to surface properties. Complicating factors in this discussion are that most scanning probe studies either were performed on rather rough or grainy (and thus not very well ordered) surfaces, or on surfaces that were contaminated due to exposure to ambient air. Such ill-defined surfaces exhibit many localized surface states that often give rise to non-equilibrium occupation of states, and associated artifacts in scanning tunneling spectroscopy (STS) data, often masking or overwhelming possible bulk contributions. However, an STM does probe the electronic structure at the surface and this can include both surface and bulk contributions. Therefore, even on ideally ordered surfaces such as *in situ* grown and studied epitaxial manganite films, it is still unclear whether surface states (or even surface ground states that are different from their bulk counterparts) that are induced by the broken symmetry of the surface will overwhelm the bulk contributions in STS. We report temperature dependent scanning tunneling spectra recorded on *in situ* grown, single crystalline epitaxial $La_{5/8-x}Pr_xCa_{3/8}MnO_3$ (x=0.3) (LPCMO) films with different thicknesses: 100 nm and 25 nm. On the 100 nm LPCMO film, the tunneling spectra show a higher metal-insulator transition temperature as compared to the 25 nm LPCMO film. Consistently, bulk transport data for the two thicknesses of LPCMO films also show different metal-insulator transition temperatures, thus revealing that tunneling spectroscopy on manganites is sensitive to the bulk electronic structure and not limited to surface effects.

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MI-ThP7 Promise of New Multiferroics: Synthesis and Characterization of Epitaxial $NiTiO_3$ Films, ***T. Varga***, *T. Droubay*, *M.E. Bowden*, *S.A. Chambers*, *B. Kabius*, *W.A. Shelton*, *P. Nachimuthu*, *V. Shutthanandan*, Pacific Northwest National Laboratory

In a search for new multiferroic materials where the direction of magnetization can be switched by an applied electric field, we have looked for materials in which polarization and magnetization are strongly coupled. Recent theory calculations predicted that the family of compounds $MTiO_3$ (M = Mn, Fe, Ni), in a certain polymorphic structure (acentric *R3c*), are promising candidates where a polar lattice distortion can induce weak ferromagnetism. Guided by these insights, a rhombohedral phase of Ni TiO_3 has been prepared in epitaxial thin film form, whose structure is very close to that predicted to be a multiferroic. The synthesis of such new epitaxial films, their full structural characterization along with our first-principles DFT calculations to predict the desired $NiTiO_3$ structure and its stability are reported .

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