Magnetic Interfaces and Nanostructures
Room: Zuni - Session MI+EM-TuA

Spintronics
Moderator: S.-W. Hla, Ohio University

2:00pm **MI+EM-TuA1 All-Electric Spintronics with Quantum Point Contacts: From Spin Physics to Spin Electronics**, ***P. Debray***, University of Cincinnati **INVITED**

The controlled creation, manipulation, and detection of spin-polarized currents by purely electrical means remains a central challenge and objective of spintronics. One approach to meet this challenge has been to rely on coupling of the electron orbital motion to its spin. Attempts have been made to use the Rashba spin-orbit coupling as a tool to achieve this objective. Despite intense effort there has so far been no report of any success. In this talk, I will present experimental evidence that a quantum point contact made from a semiconductor with intrinsic spin-orbit coupling can generate completely spin-polarized current when its lateral confinement is made highly asymmetric by tuning the bias voltages of the side gates that create it. Such quantum point contacts can be used as all-electric spin polarizer or detector. I will discuss how they can replace the ferromagnetic electrodes of conventional spin valves to yield all-electric spin valves with very high On/Off values. By avoiding the use of ferromagnetic contacts or external magnetic fields, the use of such quantum point contacts will make feasible the development of a variety of semiconductor spintronic devices.

2:40pm **MI+EM-TuA3 Incorporation of Mn Atoms into N-polar Wurtzite GaN(000-1) Surface Studied using Scanning Tunneling Microscopy**, ***A.V. Chinchore***, *K. Wang, M. Shih, A.R. Smith*, Ohio University Nanoscale and Quantum Phenomena Institute

There has been much interest in dilute magnetic semiconductors. Mn-doped gallium nitride was proposed as a possible dilute magnetic semiconductor with Curie temperature above room temperature [1]. Consequently, many studies have been carried out to investigate the growth and properties of Mn-doped GaN. Despite much work however, not much is known about the location of Mn atoms in the GaN surface. We present in this new study evidence for the precise position of Mn atoms in the nitrogen polar wurtzite GaN (000-1) surface.

The N-polar GaN (000-1) surface is prepared by molecular beam epitaxy using a Ga effusion cell and a rf N-plasma source on sapphire substrates. The growth is monitored in-situ using reflection high energy electron diffraction. The as-grown GaN surface shows a smooth 3×3 reconstruction. The sample is transferred in-situ to the analysis chamber where it is imaged using room-temperature scanning tunneling microscopy (STM). The as-grown sample surface shows large terraces of 3×3 reconstruction. Transferring the sample back to the growth chamber, Mn is then deposited onto the 3×3 surface at a rate of about 0.01 monolayers (ML's) per second for a total of about 0.3 ML, at a sample temperature of 250 ˚C. After this, the surface remains in a 3×3 structure.

STM images of the surface after Mn deposition show a modified 3×3 reconstruction including almost uni-axial trench-like structures over large areas which are not seen on the clean GaN surface. The closely-spaced trenches run along [11-20], and they are separated by an even number of gallium adlayer rows. The position of these features also coincides precisely with Ga adlayer row positions. A model for this structure involving Mn atoms within the GaN(000-1) adlayer has been developed. Additional work exploring the coverage dependence of this structure is also underway. This work has been supported by DOE (Grant No.DE-FG02-06ER46317) and NSF (Grant No.0304314). Equipment support from ONR is also acknowledged.

[1] T. Dietl, H. Ohno, F. Matsukura, J. Cibert, and D. Ferrand, Science 287, 1019 (2000).

3:00pm **MI+EM-TuA4 Formation of Ferromagnetic MnGa Monolayers on GaN(0001) Studied by STM**, ***K. Wang***, *A.V. Chinchore, M. Shi, A.R. Smith*, Ohio University Nanoscale and Quantum Phenomena Institute

Ferromagnetic (FM) metal/semiconductor bilayers are of great interest due to their importance in novel spintronics applications, such as spin injection and spin light-emitting diodes[1]. It has been shown[2] that δ-MnGa, a FM alloy with T_C higher than room temperature (RT), can be grown epitaxial on top of w-GaN(0001) with sharp interface and controllable magnetism. Here we report detailed studies on the formation of the first few MnGa monolayers formed by depositing up to 3 monolayers (ML's) of Mn onto w-GaN(0001) "1x1" surface at elevated substrate temperature. Mn-induced surface reconstructions and formation of smooth Mn_xGa_{1-x} crystalline monolayer films are observed by reflection high-energy electron diffraction (RHEED), Auger electron spectroscopy as well as in-situ RT-scanning tunneling microscopy (RT-STM). RHEED data showed well-ordered surface reconstructions exhibiting mainly 1/3rd and 2/3rd order streaks along [1-100] directions at lower than around 0.5 ML of Mn coverage, while two different sets of reconstruction streaks could be identified depending upon the Mn coverage. Two different types of atomic row-like features both running along close-packing direction of GaN, but having different row-row spacings, are observed with STM at room temperature. The unit-cells derived are consistent with RHEED observation. At higher than around 0.5 ML, atomically smooth MnGa layers start to cover up the surface as shown by both RHEED and STM; the epitaxial relationship is derived as d-MnGa[011]//GaN[0001] and d-MnGa[001]//GaN[11-20]. Structural and electronic properties at representative stages will be presented, as well as possible magnetic properties of MnGa ML's. This work has been supported by DOE (Grant No.DE-FG02-06ER46317) and NSF (Grant No. 0730257). Equipment support from ONR is also acknowledged.

[1] S.A. Wolf *et al*, Science **294**, 1488 (2001).

[2] E. Lu *et al*, Phys. Rev. Lett. **97**, 146101 (2006); K.K. Wang *et al*, Mater. Res. Soc. Symp. Proc. 1118-K06-06 (2009).

4:40pm **MI+EM-TuA9 Chemical Switching of Coupled Molecular Spins: On and Off**, *C. Waeckerlin, D. Chylarecka, A. Kleibert, K. Mueller*, Paul Scherrer Institute, Switzerland, *C. Iacovita*, University of Basel, Switzerland, *F. Nolting, T.A. Jung,* ***N. Ballav***, Paul Scherrer Institute, Switzerland

Herein we present a unique approach to reversibly control between the *on* and *off* state of the spin of an organometallic molecule coupled to a ferromagnetic substrate by a chemical switch. Such an ultimate degree of control was achieved via modification of the coordination strength of the central metal ion of the organometallic molecule by an external ligand. Thus the regulation of oxygen affinity in hemoglobin by iron-porphyrin moiety as shown in nature has been used as a designed concept to perform the switching event of single molecular spin. Use of external stimuli to control single molecular spins at magnetic-interfaces is of potential interest for spintronics and quantum information.

5:00pm **MI+EM-TuA10 The Spin-Resolved Electronic Structure of the Strongly Correlated $M^{II}[TCNE]^{\bullet-}$ Magnets**, *S.J. Janjua*, University of Missouri-Kansas City, *K.I. Pokhodnya*, North Dakota State University, *J. Trunk*, Brookhaven National Laboratory, *C.S. Olson*, North Dakota State University, *J.C. Sutherland, E. Vescovo*, Brookhaven National Laboratory, ***A.N. Caruso***, University of Missouri-Kansas City

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