Magnetic Interfaces and Nanostructures
Room 102B - Session MI-TuA

Magnetic Phenomena in Organic Systems

Moderators: Gary Mankey, University of Alabama, Mikel Holcomb, West Virginia University

2:20pm **MI-TuA1 Promises and Challenges of Organic Spintronics**, ***Christoph Boehme***, University of Utah **INVITED**

While the term "Spintronics" was originally introduced as label for technologies that represent information through spin states rather than charge states, it is nowadays oftentimes used solely in the context of spin-polarization, spin-injection, and spin-transport effects, for all of which spin-orbit interaction plays an important role. Many organic semiconductors display only weak spin-orbit coupling and charge transport via hopping through localized electronic states which are exposed to hydrogen induced strong local and random hyperfine fields. These materials therefore appear at first glance to be entirely unsuitable for spintronics. However, they also exhibit pronounced spin-related effects not seen in materials with strong spin-orbit coupling[1-3] which can be used for alternative, different approaches to spintronics based, for instance, on spin-permutation symmetry states of charge carrier pairs which, in contrast to spin-polarization states, are not directly dependent on temperature and magnetic field strength[4]. Weak spin-orbit coupling can also promote long spin-coherence times and thus, allow for electrically readable spin memory of electron-[5] or nuclear-spins[6]. The successful implementation of organic spintronics will require a fundamental understanding of the microscopic electronic processes that are to be utilized for such technologies. In this presentation, some of the progress as well as challenges[7] for the exploration of these spin-dependent processes will be reviewed. Measurements of spin-coupling types and strengths of charge carriers will be discussed[2] as well as examples for unusual physical behaviors of these materials, such as an electrically detectable spin-Dicke effect caused by charge carrier spin collectivity[8].or the presence of an inverse spin-Hall effect[9].

[1] D. R. McCamey et al., *Nature Materials* **7**, 723 (2008); [2] D. R. McCamey, et al., *Nature Commun*. **6**:6688, 7688 (2015). [4] W. J. Baker et al., *Nature Commun.***3**, 898 (2012); [5] W. J. Baker et al., *Phys. Rev. Lett.***108**, 267601 (2012); [6] H. Malissa, et al., *Science***345** 1487, (2014); [7] C. Boehme and J. M. Lupton, *Nature Nano.***8**, 612 (2013); [8] D. P. Waters, et al., *Nature Physics***11**, (11) 910 (2015); D. Sun et al., *Nature Materials***15**, doi:10.1038/nmat4618 (2016).

3:00pm **MI-TuA3 Spin-Polarized STM Observation of Hybridization at the Interface between Different 8-hydroxyquinolates and the Cr(001) Surface**, ***Daniel Dougherty***, *J. Wang, A. Deloach,* North Carolina State University

The field of organic spintronics has focused dominant attention on organic emitters such as tris-(8-hydroxyquinolate) aluminum (Alq3). This particular molecule has been reported to show large magnetoresistive effects including a 300% effect nanoscale tunnel barriers [1] that is tied to molecular orbital mixing at the magnetic electrode interface. Here we report on a direct study of this orbital mixing using spin polarized scanning tunneling microscopy and local spectroscopy measurements. We focus on the well-known Alq3 molecule adsorbed on a Cr(001) surface and report evidence for spin polarized interface states near the Fermi level. When the adsorbate is replaced with the paramagnetic variant Crq3, the interface remains polarized but the magnetic states are significantly farther from the Fermi level. These results will be discussed in the broad context of molecular orbital control if interfacial polarization in tunneling devices.

[1]Barraud et al., Nat. Phys. 6, 615 (2010).

3:20pm **MI-TuA4 Charge Transport in Thin Films of a Molecular Spin-Crossover Compound**, ***Greg Szulczewski***, *E. Ellingsworth,* The Univeristy of Alabama

Spin-crossover in molecular complexes containing divalent Fe ions (six d-electrons) is a phenomena associated with a reversible change in the magnetic state (diamagnetic to paramagnetic and vice versa) as a function of temperature, pressure or optical excitation. In this study we demonstrate the growth of bis(1,10-phenanthroline)dithiocyanato iron (II) or $Fe(phen)_2(NCS)_2$ thin films, a well-known spin crossover material. A detailed SQUID magnetometry and spectroscopic analysis using Raman, IR, UV-Vis, and XPS, indicates that the as-deposited films are largely a diamagnetic compound that can be best described as $Fe(phen)_3(NSC)_2$. Upon annealing the films under high vacuum, the diamagnetic compound can be converted into a paramagnetic compound, which is consistent with the formation of $Fe(phen)_2(NCS)_2$. The annealed films are polycrystalline as revealed by x-ray diffraction and exhibit a spin-crossover transition near 180 K. The DC electrical conductivity of these films was measured from 100-300 K. A small (but repeatable) change in the electrical conductivity was observed. An unequivocal interpretation of this observation is difficult because of competing factors. For example, the unit cell expands across the spin-crossover transition, the geometric structure of the molecule changes, and the frontier molecular orbital energies also change. The relative contribution of these factors will be discussed in detail.

4:20pm **MI-TuA7 Single Organic Radicals on Metal Surfaces: A Model System for Spin-1/2 Kondo Physics**, ***Peter Wahl***, University of St Andrews, UK **INVITED**

The Kondo effect is one of the most intensely investigated many-particle problems in solid-state physics. While it was discovered originally in dilute magnetic alloys, the same physics emerges in seemingly unrelated contexts, such as the zero-bias anomalies observed in quantum dots or the dynamical behavior close to a Mott transition. The simplicity of the underlying hamiltonian – a single spin coupled by an exchange interaction J to a bath of conduction electrons – contrasts the complex physics emerging from it as well as the challenges met in theoretical calculations. Apart from being a drosophila for electronic correlation effects, the single impurity Kondo effect is an elementary building block for model lattice systems relevant for strongly correlated electron materials such as high temperature superconductors.

Studies of transition metal atoms on metal surfaces by low temperature scanning tunneling microscopy and spectroscopy have renewed interest in the Kondo problem by providing access to local properties; however a quantitative comparison with theoretical predictions remained challenging.

Here I present a study of an organic radical with a single spin ½ on Au(111) [1]. Tunneling spectra reveal a zero bias anomaly as would be expected for a Kondo system, yet comparison of the temperature and magnetic field dependence of the zero bias anomaly with predictions of the Kondo effect in the strong coupling regime are in apparent disagreement. Detailed comparison with theoretical models reveals quantitative agreement with the original Kondo model in the weak coupling regime.

1. Y. Zhang et al., Nat. Commun. 4, 2110 (2013).

5:00pm **MI-TuA9 Tunneling in III-N Heterostructures for Low Power Electronics**, ***Patrick Fay***, *W. Li, L. Cao, K. Pourang,* University of Notre Dame*; S. Islam,* Cornell University*; C. Lund,* University of California at Santa Barbara*; H. Ilatikhameneh, R. Rahman, T. Amin,* Purdue University*; D. Jena,* Cornell University*; S. Keller,* University of California at Santa Barbara*; G. Klimeck,* Purdue University **INVITED**

Continuing increases in circuit complexity and capability for logic and computation applications as well as for emerging low-power systems require fundamental advances in device technology and scaling. Due to power constraints, devices capable of achieving switching slopes (SS) steeper than 60 mV/decade are essential if conventional computational architectures are to continue scaling. Similarly, low power systems such as mobile devices and distributed sensing applications also benefit from devices capable of delivering high performance in low-voltage operation. Tunneling field effect transistors (TFETs) are one promising alternative to achieve these objectives. A great deal of work has been devoted to realizing TFETs in Si, Ge, and narrow-gap III-V materials, but the use of III-N heterostructures and the exploitation of polarization engineering in particular offers unique opportunities. From physics-based simulations, GaN/InGaN/GaN heterostructure TFETs offer the potential for achieving switching slopes approaching 20 mV/decade with on-current densities exceeding 100 μA/μm in nanowire configurations. In this talk, the operational principles of III-N-based TFETs will be described, and device design and performance considerations will be discussed. In addition, experimental efforts demonstrating heterostructure backward diodes in III-N heterostructures as well as progress towards nanostructure-based III-N FETs and TFETs will be reviewed.

5:40pm **MI-TuA11 A Spins-Inside Quantum Processor**, *T. Fujita,* Delft University of Technology, The Netherlands*; L.M.K. Vandersypen,* Delft University of Technology, The Netherlands*;* ***T. Hensgens***, Delft University of Technology, The Netherlands **INVITED**

A quantum computer holds the promise of solving some problems that are beyond the reach of the most powerful supercomputers. Due to theoretical and experimental breakthroughs in the last few years, we are now at a

point where the feeling grows that a large-scale quantum computer can actually be built. Increasingly, this requires bridging the disciplines, from physics to engineering, materials science and computer science. In this talk, I will present the start-of-the-art in quantum computing and outline the challenges ahead, with a focus on electron spin qubits in semiconductors.

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