

DS 32: Spins in organics

Time: Wednesday 16:30–18:45

Location: H 0111

DS 32.1 Wed 16:30 H 0111

Organized nanoscale assemblies of metal-free organic magnets: Electronic structure and stability from ultra high vacuum to air exposure. — ●FRANCESCA CICCULLO, REZA KAKAVANDI, and MARIA BENEDETTA CASU — Institute of Physical and Theoretical Chemistry, Tübingen, Germany

Metal-free organic-based magnets are relatively new materials with open-shell structure that may offer new opportunities for applications based on the presence of spatially delocalized unpaired electrons. Essential tools such as X-ray Photoelectron Spectroscopy (XPS) and Near Edge X-ray Absorption Fine structure (NEXAFS) Spectroscopy are used to study the electronic structure and the paramagnetic character of nitronyl nitroxide radicals. The molecule-substrate interface and the thin film properties are investigated, focusing on their impact on the magnetic character of the systems. Our work also identifies a quantitative correlation between the results obtained by the simultaneous use of X-ray photoemission and electron spin resonance spectroscopy. This result can be used as a standard diagnostic tool in order to link the (in-situ-measured) electronic structure with classical ex-situ paramagnetic investigations.

DS 32.2 Wed 16:45 H 0111

Peculiar Transport Properties of Nanosized Vertical Organic Spin-Valves — ●ROBERT GÖCKERITZ¹, NICO HOMONNAY¹, TIM RICHTER¹, ALEXANDER MÜLLER¹, BODO FUHRMANN², and GEORG SCHMIDT^{1,2} — ¹Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany — ²Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany

Organic spin-valves are seen as promising candidates for future spintronic devices based on organic semiconductors. So far most publications report on devices with lateral dimensions of more than 100 micrometer. We present a fabrication process for vertical organic spin-valve devices which offers the possibility to continuously scale down organic spin-valves down to the 100 nm regime. The process uses oxide windows as lateral limitations of the devices and shadow masks during deposition of the active layers. Samples of a LSMO/Alq₃/MgO/Co layer stack with lateral dimensions between 100 micrometer and 500 nm have been fabricated and characterized. Upon downscaling we observed a non-linear behavior of the resistance area product and furthermore for similar nanosized devices a large variation of the magnetoresistance between +90% and -170%. These results indicate that the transport is merely determined by pinholes with a certain statistical distribution and that transport and magnetoresistance are mainly dominated by tunneling at the pinhole sites where the organic layer is thin enough.

DS 32.3 Wed 17:00 H 0111

TSCuPc/Au Hybrid Trench Devices: a Comparative Study of Solution Processed and Thermally Evaporated Molecular Channels — ●SREETAMA BANERJEE^{1,2}, DANIEL BÜLZ¹, DANNY REUTER^{2,3}, KARLA HILLER², THOMAS GESSNER^{2,3}, DIETRICH R. T. ZAHN¹, and GEORGETA SALVAN¹ — ¹Semiconductor Physics, Technische Universität Chemnitz, Germany — ²Zentrum für Mikrotechnologien, Technische Universität Chemnitz, Germany — ³Fraunhofer ENAS, Chemnitz, Germany

Organic semiconductors have potential applications in the spintronics field due to the weak spin scattering mechanism in organic molecules, which implies that the spin polarization of the carriers can be maintained for a much longer time (in the range μs to ms) than in inorganic materials. Cost-efficient, wafer level fabrication of such devices is one of the main challenges in this field. Currently e-beam lithography is used for fabricating the required small electrode gap dimensions. Previously, we reported an alternative approach for fabricating laterally stacked organic trench devices using conventional optical lithography, where paramagnetic (CoPc, CuPc) and diamagnetic Alq₃ molecules were evaporated to form the organic channels. It was observed that the molecules form a membrane between the electrodes. In this work, solution processing of organic materials was tested by drop-coating of water-soluble 3,4',4'',4'''-copper(II) phthalocyanine-tetrasulfonic acid tetrasodium salt (TSCuPc). Using this approach it was possible to fill the trenches. A comparative study of a solution processed device and

a device with evaporated channel material is presented.

DS 32.4 Wed 17:15 H 0111

The Influence of a Magnetic Field on Organic Field Effect Transistors: Comparison between Metal-Free and Metal-Phthalocyanines — ●DANIEL BÜLZ¹, SREETAMA BANERJEE^{1,2}, DIETRICH R. T. ZAHN¹, and GEORGETA SALVAN¹ — ¹Semiconductor Physics, Technische Universität Chemnitz, Germany — ²Zentrum für Mikrotechnologien, Technische Universität Chemnitz, Germany

Organic semiconductors are of great interest in today's electronics because of their tunable optical and electrical properties. Especially they are suitable for spintronics due to their weak spin scattering compared to inorganic materials, which results in longer spin lifetimes.

It was shown, that some of these materials respond to an external magnetic field with a change of resistivity. Furthermore, it is reported that organic field effect transistors (OFETs) are suitable to measure this dependence [1]. Therefore we here investigate OFETs made from different metal-free and metal-phthalocyanines in order to compare the influence of the metal center on the magnetic field dependence.

[1] T. Reichert, T. P. I. Saragi; *Organic Electronics* **13**, 377-383, 2012

DS 32.5 Wed 17:30 H 0111

Computational scanning of phthalocyanine hetero-structures for molecular spintronic applications — ●TOBIAS BIRNBAUM, TORSTEN HAHN, and JENS KORTUS — Institut für Theo. Physik, TU BA Freiberg, Leipziger Str. 23, 09599 Freiberg

The combination of different functionalized metal phthalocyanines was found to lead to new charge- and spin transfer compounds. The high degree of freedom in functionalization and/or metal center allows the controlled engineering of charge transfer and spin with respect to optimizing properties for possible application of these materials in molecular spintronic applications [1,2]. We will present an extensive computational study of metal phthalocyanines functionalized with electron donating and electron accepting side groups. The trends in frontier energy levels are analyzed and from the level alignment between individual molecules promising candidates for new hetero-structures can be selected. For selected examples we demonstrate that this simplified procedure is actually capable to deliver a correct forecast. A subsequent spatial sampling of a phthalocyanine dimer configuration space is studied in terms of a cost-benefit analysis. Although the method utilizes spin-resolved all-electron DFT calculations, the information on stability, possible spin groundstates, as well as coupling constants can be worth the effort. The detailed analysis is used as input to guide further experimental studies.

[1] R. Friedrich, S. Lindner, T. Hahn, C. Loose, S. Liebing, M. Knapfer, and J. Kortus, *Phys. Rev. B* **87**, 115423 (2013). [2] R. Friedrich, B. Kersting, and J. Kortus, *Phys. Rev. B* **88**, 155327 (2013).

DS 32.6 Wed 17:45 H 0111

Energy level alignment at the ordered C60/Co(0001) hybrid interface — ●JOHANNES STÖCKL, MARTIN LAUX, NORMAN HAAG, JOHANNES SEIDEL, ROMAN FETZER, NICOLAS GROSSMANN, BENJAMIN STADTMÜLLER, MIRKO CINCHETTI, and MARTIN AESCHLIMANN — Department of Physics and Research Center OPTIMAS, University of Kaiserslautern, Erwin-Schroedinger-Strasse 46, 67663 Kaiserslautern, Germany

The future success of organic semiconductors in spin memory devices depends strongly on our ability to tailor and control the structural properties and the energy level alignment at hybrid interfaces formed between the organic molecules and ferromagnetic surfaces. Hence, many studies focused on the electronic properties of prototype molecules like Alq₃ on Co(100) [1]. On this ferromagnetic substrate, however, the molecular films usually lack any long range order due to the strong molecule substrate interaction and the low thermal energy of the adsorbates. To overcome this limitation, we studied the growth of (sub)monolayer films of C60 adsorbed on hcp Co(0001) using LEED, STM and spin resolved photoemission spectroscopy (SR-PES). For sub-monolayer coverage LEED and STM indicate that the C60 molecules form long-range ordered islands after thermal activation. The size of these islands increases with increasing coverage. The

SR-PES data show a significant reduction of the spin polarization in comparison to the clean Co(0001) surface which we correlate to the suppression of a Co-surface state by the molecular adsorbates.

- [1] Steil et al., Nature Physics 9, 242 (2013)

DS 32.7 Wed 18:00 H 0111

Spin pumping through C_{60} thin films — ●TIM RICHTER¹, MARTIN WAHLER¹, MATTHIAS GRÜNEWALD¹, ROBERT GÖCKERITZ¹, and GEORG SCHMIDT^{1,2} — ¹Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany — ²Interdisziplinäres Zentrum für Materialwissenschaften, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle (Saale), Germany

Spin pumping and inverse spin-Hall effect (ISHE) are well established as methods for the creation and detection of pure spin currents [1]. Recently it has been shown that these methods can also be used to investigate pure spin currents in organic materials [2]. Here we use yttrium iron garnet (YIG) deposited by pulsed laser deposition as a source for spin pumping and sputtered platinum (Pt) for the detection via ISHE in order to investigate the propagation of spin currents in an organic material, namely C_{60} . C_{60} is a small molecule which can be deposited by UHV evaporation. In our sample thin films of C_{60} are sandwiched between YIG and Pt. The sample is then excited by ferromagnetic resonance (FMR) inducing a spin current from the YIG through the C_{60} into the Pt where it is detected as a DC ISH-voltage. For layers of C_{60} which have a thickness of less than 10 nm we observe the ISHE. These results indicate that we observe merely a tunnelling through the C_{60} rather than spin diffusion which is also in agreement with typical transport in undoped C_{60} .

- [1] Saitoh et al., Appl. Phys. Lett. 88, 182509, (2006)

- [2] Watanabe et al., Nat. Phys. 10, 308, (2014)

DS 32.8 Wed 18:15 H 0111

Transferring spin into an extended π -orbital of a large molecule — ●T. ESAT¹, T. DEILMANN², B. LECHTENBERG³, C. WAGNER¹, P. KRÜGER², R. TEMIROV¹, F.B. ANDERS³, M. ROHLFING², and F.S. TAUTZ¹ — ¹Peter Grünberg Institute (PGI-3), FZ Jülich, Germany — ²Institut für Festkörpertheorie, Universität Münster, Germany — ³Lehrstuhl für Theoretische Physik II, TU Dortmund, Germany

The electronic and magnetic properties of molecules can be tuned in a wide range by charge transfer from molecules[1] and metal surfaces[2-4] or by doping with atoms[5].

In this work we tune the electronic structure by doping archetypal organic molecules with single metal atoms. An on-surface chemical reaction leads to electron spin transfer into a π -orbital that extends over the whole molecule, unlike in common molecular magnets where the spin usually resides in a d- or f-orbital of a metal ion that is shielded by organic ligands. We show that this complex has an unpaired spin which interacts with electrons in the metallic substrate and forms a Kondo singlet state. The advantage of such a radical may lie in its propensity to interact magnetically with its neighbours, offering the potential to harness this coupling.

- [1] I. Fernández-Torrente et al., Phys. Rev. Lett. 108, 036801 (2012)

- [2] R. Temirov et al., Nanotechnology 19 (6), 065401 (2008)

- [3] C. Toher et al., Phys. Rev. B 83, 155402 (2011)

- [4] A. Greuling et al., Phys. Stat. Sol.(b) 250, 2386 (2013)

- [5] C. Krull et al., Nature Materials 12, 337-343 (2013)

DS 32.9 Wed 18:30 H 0111

Interface-assisted sign inversion of Magnetoresistance in Molecular Spin Valves based on Novel Lanthanide Quinolines — ●AMILCAR BEDOYA-PINTO¹, SARA GOMEZ², EUGENIO CORONADO², and LUIS HUESO¹ — ¹CIC nanoGUNE, San Sebastián, Spain — ²Instituto de Ciencia Molecular (ICMoL), Valencia, Spain

Molecules have recently emerged as promising materials for spintronics, owing to their weak spin relaxation mechanisms. However, the rules that govern spin injection and transport in molecules are not yet fully understood. In this work, combining advanced molecular synthesis and device engineering, we study how i) the magnetic nature of the molecule and ii) the ligand hybridization at the metal interface impacts the spin injection and transport in molecular spin-valve devices. We have synthesized novel $[\text{NaLn}(5,7\text{Clq})_4]$ molecules with lanthanide ion centers exhibiting distinct magnetic behavior (diamagnetic Y/ single-ion magnet Dy), and assembled them in spin valve structures using Co and NiFe electrodes. While the magnetic nature of the molecule does not have any major effect on the spin injection and transport properties, the hybridization of metal and molecular ligand states is found to have a strong impact on the interface spin polarization. Spin valves featuring a $[\text{Na}[\text{Ln}(5,7\text{Clq})_4]/\text{Co}$ interface exhibit a positive magnetoresistance, typically found in other molecule/FM metal systems; whereas the interaction of $[\text{Na}[\text{Ln}(5,7\text{Clq})_4]$ with NiFe triggers a negative magnetoresistance, i.e., an inversion of the interface spin polarization. These results highlight the potential of molecules to tailor spin-dependent properties at the interface level.