MA 23: Spinelectronics/ Spininjection in Heterostructures

Time: Wednesday 16:45–18:45 Location: H 1028

MA 23.1 Wed 16:45 H 1028

First-principles calculations of the spin-orbit effects in a Fe/GaAs interface — •Martin Gmitra[1], Alex Matos-Abiague[1], Claudia Ambrosch-Draxl[2], and Jaroslav Fabian[1] — [1]University of Regensburg, 93040 Regensburg, Germany — [2]University of Leoben, A-8700 Leoben, Austria

The recently discovered tunneling anisotropic magnetoresistance(TAMR) effect in semiconductor heterostructures containing a single ferromagnetic layer is potentially useful for spintronics devices. TAMR essentially means that the tunneling current depends on the direction of the magnetization of the ferromagnet; if strong enough, this anisotropy can give a nice spin-valve-like signal. Important, TAMR has recently been observed in a metallic system, namely, in Fe/GaAs/Au junctions. Surprisingly, while all the bulk components of the system are cubic, the observed anisotropy is twofold, of the C2v class. This suggests that rather than coming from the bulk anisotropy of the density of states, the effect arises from the interface that indeed has a reduced symmetry. A phenomenological model reflecting this symmetry in the form of the Bychkov-Rashba and the Dresselhaus spin-orbit coupling was proposed, giving a quantitative fit to the experiment. Here we report on comprehensive ab initio calculations of the spin-orbit effects stemming from the interface anisotropy, providing strong support to the phenomenological theory. In particular, we have performed FLAPW density functional calculations of an Fe/GaAs slab to extract quantitative information about the proposed model as well as to provide guidance to future experiments.

MA 23.2 Wed 17:00 H 1028

Electrical spin injection from Fe into Si(001): ab-initio calculations — •Phivos Mavropoulos and Stefan Blügel — IFF, Forschungszentrum Jülich, D-52425 Jülich, Germany

Electrical spin injection is highly important for novel spintronics devices. Recent experiments [1] have demonstrated efficient spin injection from Fe into Si with very large spin coherence length of the injected current. In the present contribution we seek a theoretical upper limit for the injection efficiency in Fe/Si(001) junctions. Our calculations of the electronic structure and spin-dependent transport are based on the Korringa-Kohn-Rostoker Green function method [2] within local density functional theory. We show that use of slightly strained Si [3] along the growth axis lifts the degeneracy of the Si conduction band, so that only symmetry-selected Δ_1 states at the center of the surface Brillouin zone carry current. States of such symmetry are absent from the minority-spin bands of Fe at the Fermi level. As a result, the interface allows only spin-selective transmission, allowing in for a high current polarization. We discuss complications arising from interface resonances formed in the minority-spin bands, which reduce the transmission efficiency by resonant tunneling through the Schottky barrier, and we address the problem of reduction of the Fe interface moment when it is strained to match the Si lattice parameter.

[1] B.T. Jonker et at., Nature Physics **3**, 542 (2007).
[2] P. Mavropoulos, N. Papanikolaou, and P.H. Dederichs, Phys. Rev. B **69**, 125104 (2004).
[3] D. Buca et al., Appl. Phys. Lett. **90**, 032108 (2007).

MA 23.3 Wed 17:15 H 1028

Study of spin-injection in the organic semiconductor CuPc by means of spin-resolved two-photon photoemission — •Mirko Cinchetti[1], Kathrin Heimer[1], Oleksiy Andreyev[2], Michael Bauer[2], Huanjun Ding[3], Yongli Gao[3], Stefan Lach[1], Christiane Ziegler[1], and Martin Aeschlimann[1] — [1]Dpartment of Physics, University of Kaiserslautern, 67663 Kaiserslautern, Germany — [2]Institut fuer Experimentelle und Angewandte Physik, Universitaet Kiel, 24098 Kiel, Germany — [3]Deparment of Physics and Astronomy, University of Rochester, Rochester, NY 14267, USA

Spin injection from a ferromagnetic electrode into thin films of organic semiconductors (OSC) is a fundamental prerequisite for the implementation of OSC-based spintronics devices. All experimental studies done so far to demonstrate the feasibility of spin injection into OSC are based on magnetoresistance or electroluminescence measurements, which result in a spin-dependent signal integrated over the whole spintronics device. Great care has to be taken in the search of spin injection in such experiments, since stray fields may mimic the spin effects. We propose spin-resolved two-photon photoemission as an alternative method allowing to collect direct experimental information about the efficiency of spin injection. As a model system for OSC-based spintronics devices, we have studied the heterojunction between a Cobalt thin film and Copper phthalocyanine (CuPc). We will discuss the crucial role played by the specific interface properties (such as the surface topography of the ferromagnetic electrode and the related growth of the OSC) on the efficiency of spin injection.

MA 23.4 Wed 17:30 H 1028

Magnetic characterization of injector/collector contacts for silicon spintronics — •Daniel Schwarz[1], Theodoros Dimopoulos[1], Thomas Uhrmann[1], Vlado Lazarov[2], Amit Kohn[2], Sascha Weyers[3], Uwe Paschen[3], and Hubert Brückl[1] — [1]Austrian Research Centers GmbH - ARC, Nano System Technologies, Donau-City-Str. 1, 1220 Wien, Austria — [2]Department of Materials, University of Oxford, Parks Road, OX1 3PH, U.K. — [3]Fraunhofer Gesellschaft, Finkenstr. 61, 45057 Duisburg, Germany

Electrical spin-polarized current injection in Si promises a breakthrough in future spintronic devices. Its efficiency depends strongly on the magnetic properties of the ferromagnetic (FM) contacts used for current injection and detection, commonly including a tunneling barrier between the FM metal and Si. We sputter-deposited rectangular, sub-μm FM contacts, embedded into holes in SiO_2 dielectric prepatterned by optical lithography. As a tunneling barrier we used MgO of thickness between 0 and 2.5nm and a $Co_{70}Fe_{30}$(2nm)/$Ni_{80}Fe_{20}$(8nm) bilayer. The antiparallel magnetic state between injector and collector is achieved by tailoring the shape anisotropy. For this, the aspect ratio is varied between 3 and 10. Using magneto-optical Kerr effect, we have studied the dependence of the switching field and its distribution, as a function of the MgO thickness and the aspect ratio, supported by micro-magnetic simulations. Domain structure information is provided by magnetic force microscopy measurements as a function of the magnetic field. The effect of annealing up to 400°C is also discussed. We acknowledge support from the EU project EMAC-Strep 017412.

MA 23.5 Wed 17:45 H 1028

Spin-polarized spin-orbit-split quantum-well states in a metal film — •Andrei Varykhalov[1], Jaime Sánchez-Barriga[1], Alexander M. Shikin[2], Wolfgang Gudat[1], Wolfgang Eberhardt[1], and Oliver Rader[1] — [1]BESSY Berlin — [2]St. Petersburg State University

Elements with high atomic number Z lead to a large spin-orbit coupling. Such materials can be used to create spin-polarized electronic states without the presence of a ferromagnet or an external magnetic field if the solid exhibits an inversion asymmetry. We create large spin-orbit splittings using a tungsten crystal as substrate and break the structural inversion symmetry through deposition of a gold quantum film. Using spin- and angle-resolved photoelectron spectroscopy, it is demonstrated that quantum-well states forming in the gold film are spin-orbit split and spin polarized up to a thickness of at least 10 atomic layers. This is a considerable progress as compared to the current literature which reports spin-orbit split states at metal surfaces which are either pure or covered by at most a monoatomic layer of adsorbates.

MA 23.6 Wed 18:00 H 1028

Room temperature operation of a magnetic tunnel transistor with an epitaxial spin valve base — Alexander Spitzer, •Julien Vigroux, Juergen Moser, and Guenther Bayreuther — Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Regensburg, 93040, Germany

We present a magnetic tunnel transistor (MTT) with room temperature operation. The performance of MTTs is usually limited to temperatures far below 300K due to strongly temperature dependent leakage currents of the Schottky barrier. These leakage currents originate from defects created by Ar-sputtering processes during patterning of the MTT. The leakage currents dominate the collector current IC and therewith reduce the magneto current ratio (MCR) which is the normalized difference in IC for parallel and antiparallel alignment of the ferromagnetic layers in the MTT. To overcome this hurdle, two approaches are possible: The use of either wet chemical etching to remove those defects or film deposition through shadow masks. We show that both lead to a strong reduction of the leakage current. As a base contact for our MTT we use a fully epitaxial FeCo/Au/FeCo spin valve grown on n-GaAs(001). A Ta emitter grown on an Al2O3 tunnel barrier provides the hot electron emitter current IE. Depending on the thickness of the magnetic layers our MTTs show MCRs over 1000 % at 11K. Support by Deutsche Forschungsgemeinschaft (SFB 689) and Marie Curie RTN "ultrasmooth" is gratefully acknowledged.

MA 23.7 Wed 18:15 H 1028

Transport properties of embedded MgO-based ferromagnetic MIS diodes for silicon spintronics — •Thomas Uhrmann[1], Theodoros Dimopoulos[1], Daniel Schwarz[1], Vlado Lazarov[2], Amit Kohn[2], Sascha Weyers[3], Uwe Paschen[3], and Hubert Brückl[1] — [1]Austrian Research Centers GmbH - ARC, Nano System Technologies, Donau-City-Str. 1, 1220 Wien, Austria — [2]Department of Materials, University of Oxford, Parks Road, OX1 3PH, U.K. — [3]Fraunhofer Gesellschaft, Finkenstr. 61, 45057 Duisburg, Germany

The major challenges in the field of semiconductor spin-electronics is the efficient electrical injection of spin polarized carriers into the semiconductor, their manipulation and subsequent detection.

Here we will focus on the electrical characterization of embedded sub-μm MIS tunneling diodes dedicated for spin injection and detection in silicon, using MgO as tunneling barrier. The conductivity mismatch theory predicts, that only within a narrow window of resistance values optimized spin injection efficiency is obtained. With respect to this, we report the influence of the tunneling barrier thickness (varied between 0.5 and 2.5 nm) and of the n- and p-doping density (from 10^{15} to 10^{18} cm^{-3}) on the electrical transport properties of isolated cells and injector-collector pairs. For this we used current-voltage measurements as a function of the temperature and of the magnetic field. The effect of the annealing, up to 400^{o}C, on the transport and structural properties of the diodes is also discussed.

We acknowledge support from the EU project EMAC-Strep 017412.

MA 23.8 Wed 18:30 H 1028

Role of interface short range order in of CoFeB/MgO/CoFeB magnetic tunnel junctions — •Gerrit Eilers[1], Marvin Walter[1], Kai Ubben[1], Michael Seibt[1], Talaat Al-Kassab[2], Volker Drewello[3], Andy Thomas[3], Günter Reiss[3], and Markus Münzenberg[1] — [1]IV. Phys. Inst., Universität Göttingen — [2]Institut für Materialphysik, Universität Göttingen — [3]Fakultät für Physik, Universität Bielefeld

Magnetic tunnel junctions consisting of CoFeB/MgO/CoFeB trilayers have been of great interest in research just recently. Due to their high magneto resistance they are a promising candidate for the fabrication of spin torque MRAM devices. For future writing concepts like current induced magnetic switching magnetic tunnel junctions (MTJs) with thin barriers are necessary to provide sufficient high current densities. In such elements the TMR is strongly dependent on the electron transmission at the metal / oxide interfaces. Therefore the quality of the interfaces is of great significance and should be optimized on the nano-scale. With the objective to correlate electrical transport properties (I/V characteristics, TMR) with the geometrical and chemical interface roughness, the structural analysis was made by cross-sectional TEM, energy dispersive X-ray spectroscopy (EDX) and Atom Probe Tomography (APT). The distribution of the layer elements, especially the Boron, through the layer stack is of particular interest and an up to now unsolved mystery.

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