MA 24: Spinelectronics / Spin Injection in Heterostructures

Time: Thursday 10:15–12:45 Location: H22

MA 24.1 Thu 10:15 H22

Spin-orbit coupling fields in Fe/GaAs junctions — •Martin Gmitra[1], Alex Matos-Abiague[1], Claudia Ambrosch-Draxl[2], and Jaroslav Fabian[1] — [1]Univesity of Regensburg, 93040 Regensburg, Germany — [2]University of Leoben, 8700 Leoben, Austria

The existence of the spin-orbit fields induced by the interface structure in Fe/GaAs junctions is proven from first-principles calculations. While the underlying symmetry of the fields follows that of the interface, the specific realization of the symmetry depends on the electron momentum and energy. The calculated atomic-layer-resolved expectation values of the Bloch states' spins show that the spin-orbit fields peak at the GaAs side of the interface. The employed technique is applicable to ferromagnetic junctions in general. This work has been supported by SFB 689.

MA 24.2 Thu 10:30 H22

Spin Injection and Extraction in Fe/GaAs — •Bernhard Endres, Frank Hoffmann, Dieter Schuh, Georg Woltersdorf, Christian Back, and Günther Bayreuther — Universität Regensburg, Institut für Experimentelle und Angewandte Physik

Majority spin injection into GaAs(001) has recently been observed from Fe [1] and FeCo [2] epitaxial contacts. Consequently, minority polarization is expected in the semiconductor when the tunneling current is reversed from electron injection to extraction. This was clearly observed for FeCo contacts [2], but a complex bias dependence of the spin polarization was found in the case of Fe contacts changing from sample to sample [1]. In order to find out whether this discrepancy originates from a different band filling in the two materials or from specific interface properties, the GaAs structure [2] and an epitaxial Fe contact layer were grown in two connected MBE chambers without breaking the vacuum. After lithographic patterning the spin polarization in the GaAs, P_n, was measured by MOKE across a cleaved edge as described in ref. 2. P_n as a function of magnetic field reproduces the switching behavior of the Fe contact. The bias dependence of P_n showed the same sign reversal as previously seen for FeCo [2] in contrast to the behavior found in ref. 1. This rules out the material-specific band structure to be the origin of previous contrasting results, and it indicates that spin injection is crucially affected by interface properties like Schottky barrier profile or interfacial bands which in turn depend on the specific growth conditions. [1] X. Lou et al., Nature Phys. 3, 197 (2007); [2] P. Kotissek et al., Nature Phys. 3, 872 (2007)

MA 24.3 Thu 10:45 H22

In situ fabrication of lateral Cu/Co spin-valves to create pure spin currents — •Julius Mennig, Frank Matthes, Daniel E. Bürgler, and Claus M. Schneider — Institut für Festkörperforschung (IFF-9) and JARA-FIT, Forschungszentrum Jülich GmbH, D-52425 Jülich, Germany

Pure spin currents attain more and more attention in the field of spintronics. Common structures to investigate this phenomenon are lateral spin-valves. Previous experiments showed that the quality of the interfaces between the magnetic and non-magnetic elements is of outmost importance. In order to obtain optimized interface conditions, we fabricate and investigate lateral spin-valves by in-situ ultra-high vacuum (UHV) methods (MBE, Auger, FIB, SEMPA) instead of the commonly used lithography and the ex situ transport measurements. Electrical 4-point measurements with external magnetic field can also be done in situ.

We prepared Cu/Co spin valves with clean, non-oxidized interfaces and a Cu track widths of 250 - 300 nm. The nanomagnets have a length up to 4 micrometer and a width of 200 - 300 nm. We measured the AMR dependence on magnetic field to investigate the switching fields and coupling behavior of the two nanomagnets and confirm our conclusions with SEMPA. The results leads to spin valves with a modified design, in which we detect pure spin currents with Lock-In technique with constant current amplitude in order to avoid AMR influences.

MA 24.4 Thu 11:00 H22

Optical detection of spin-pumped magnetization in a $Ni_{81}Fe_{19}$/Cu multilayer — •Frederik Fohr[1], Jaroslav Hamrle[1], Helmut Schultheiss[1], Alexander A. Serga[1], Burkard Hillebrands[1], Yasuhiro Fukuma[2], Le Wang[2], and YoshiChika Otani[2] — [1]FB Physik and Landesforschungszentrum OPTIMAS, TU Kaiserslautern, 67663 Kaiserslautern, Germany — [2]ASI RIKEN, and ISSP, University of Tokyo, Japan.

We report on Brillouin light scattering (BLS) investigations of induced magnetization from a $Ni_{81}Fe_{19}$-layer to an adjacent copper-wedge via the spin-pumping effect.

The intensity of the detected BLS signal contains information about the precessing magnetization in the $Ni_{81}Fe_{19}$-layer, which is decaying exponentially with the optical penetration depth, and about the spin pumped magnetization in the copper-wedge, which is decaying with the much longer spin diffusion length. The detected signal in the copper-wedge is a sum of contributions from different depths of the wedge, weighted by the decaying intensity of the probing laser light as well as by the decaying spin-pumped magnetization.

To separate both contributions of the signal experimentally, additional BLS scans were performed on a reference sample, prepared with an interlayer between $Ni_{81}Fe_{19}$ and copper to block the spin pumping. The measurements on both samples are discussed and compared to their respective calculated BLS intensities.

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MA 24.5 Thu 11:15 H22

Control of magnetic domain formation and domain wall movement in Permalloy nanowires — •Saleh Getlawi, Markus König, Michael R Koblischka, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany

Nanoscale magnetic systems have been attracting much attention from both fundamental and technical reasons. For magnetoelectronic applications it is essential to have a variety of structures, where sizes and shapes are precisely controlled with high accuracy. Permalloy nanowires were fabricated using electron beam lithography and the lift-off technique. We have studied the control of magnetic domain formation, domain wall movement and magnetization reversal in magnetic nanowires. The switching field of the nanowires was observed using magnetic force microscopy. The experimental results were compared to those obtained by micromagnetic simulations.

MA 24.6 Thu 11:30 H22

Growth and characterization of ferromagnetic MnGa on GaN — •Christian Zube, Amilcar Bedoya-Pinto, Daniel Broxtermann, Till Benter, Jörg Malindretos, and Angela Rizzi — IV. Physikalisches Institut Universität Göttingen,D-37077 Göttingen

In the last years, the δ- phase of MnGa, which has a Curie temperature well above 300 K, gained great interest as a spin-injector for GaAs [1], achieving spin injection efficiencies of 5% at 2 K.

Recent results of MnGa growth on GaN [2] showed a nearly perfect epitaxial match between MnGa(111) and GaN(0001) layers exhibiting magnetic anisotropy along out-of-plane and in-plane directions.

We studied the MBE-growth of Mn_xGa_{1-x} on GaN(0001) templates with the aim of achieving spin injection through the MnGa/GaN interface, varying the Mn content x from 0.3 to 0.6. In order to obtain a smooth interface, different substrate temperatures and annealing methods have been investigated. The growth has been monitored in situ by *RHEED*. Magnetic and electrical transport properties have been measured in a temperature range from 2 to 400 K and magnetic fields up to 50 kOe. *XRD* and *EDX* measurements showed a strong dependence of these properties on stoichiometry and structure. Samples prepared in the van-der-Pauw and Hall-Bar geometry showed an anomalous hall effect, confirming spin polarized carrier transport in the MnGa layer. As a first step to characterize the electrical properties of the MnGa/GaN interface, Schottky diodes have been fabricated.

[1] Adelmann et al, APL 89 (2006),Nr. 11

[2] Lu et al, PRL 97 (2006)

MA 24.7 Thu 11:45 H22

In-situ fabrication of lateral organic spin-valve structures with sub-100nm channel-length — •Matthias Grünewald[1,3], Frank Würthner[2], Georg Schmidt[1,3], and Laurens W. Molenkamp[1] — [1]Experimentelle Physik 3, Universität Würzburg, Am Hubland, 97074 Würzburg — [2]Organische Chemie 2, Universität

Würzburg, Am Hubland, 97074 Würzburg — [3]Institut für Physik, Martin-Luther-Universität Halle-Wittenberg, 06099 Halle

Many spin-valves (SVs) based on an organic semiconductor (OSC) layer sandwiched between two ferromagnetic electrodes have been demonstrated recently. It is, however, still unclear whether the observed effect is based on GMR or TMR because intermixing during the metal deposition on top of the OSC layer can reduce the effective layer thickness. Lateral transport structures using an OSC layer deposited in the gap between two electrodes avoid this possible side effect, but may suffer from interface contamination or oxidation during the lithography process.

Here we report the fabrication of lateral SV structures using a combination of optical lithography and shadow evaporation. The process allows for the in-situ deposition of two ferromagnetic contacts with different coercive fields, separated by a gap of about 80 nm, and covered by a layer of the n-type OSC perylene-diimide. Magnetic and electrical properties are investigated, and gate dependent measurements are performed showing clear gate action. Magnetotransport studies at room temperature show SV action with a magnetoresistance ratio of up to 50% and I/V characteristics indicate lateral tunneling.

MA 24.8 Thu 12:00 H22

Structural and transport properties of Permalloy nanowires — •Saleh Getlawi, Michael R Koblischka, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany

The study of the relationships between geometry and structure of magnetic nanowires on the one hand and their electron transport properties on the other hand is a growing research area of current importance. Permalloy nanostructres with contact pads of various designs (diamonds, ellipses, rectangles, squares) were prepared by electron-beam lithography and the lift-off process in order to find the optimally suited structure for measurements of the magnetoresisance and magnetoimpedance and simultaneous domain observation by means of magnetic force microscopy (MFM). Fur this purpose, all samples were equipped with four current/voltage electrodes made of Pt by employing a dual-beam focused-ion beam system. The obtained MFM images were compared to micromagnetic simulations.

MA 24.9 Thu 12:15 H22

Preparation of Permalloy nanostructures using focused ion beam methods — •Saleh Getlawi, Michael R Koblischka, and Uwe Hartmann — Institute of Experimental Physics, Saarland University, Campus C 6 3, D-66123 Saarbrücken, Germany

Focused ion beam (FIB) milling is a powerful and versatile tool for the maskless fabrication of structures and devices at micro- and nanometer scales. The approach is based on the milling and deposition capabilities of a focused ion beam, where the latter is achieved by ion-beam-assisted decomposition of a metalorganic gas precursor of the specific material that has to be deposited. The combination of FIB and scanning electron microscopy in the same unit (so-called dual-beam unit) further expands the capabilities of the approach by the possibility of performing electron-beam-assisted deposition and inspection. Permalloy nanowires with electrical contacts patterned by FIB-Pt deposition were prepared in the dual-beam unit. Various types of notches to pin magnetic domain walls were additionally fabricated by means of FIB. The fabrication parameters for a structural modification of the Permalloy structures without too strongly affecting the material properties were determined previously [1]. Magnetic force microscopy was employed for an observation of the resulting magnetic domain structures.

[1] S.Getlawi et al., Superlatt. and Microstruct. 44 (2008) 699.

MA 24.10 Thu 12:30 H22

HAXPES studies of FeCoB-MgO-FeCoB tunnel junctions. — •X. Kozina[1], G. Stryganyuk[1], B. Balke[1], G.H. Fecher[1], C. Felser[1], S. Ikeda[2], H. Ohno[2], and E. Ikenaga[3] — [1]Institute of Inorganic and Analytical Chemistry, Johannes Gutenberg - University, Mainz, Germany — [2]Research Institute of Electrical Communication, Tohoku University, Sendai, Japan — [3]Japan Synchrotron Radiation Research Institute, SPring-8, Hyogo, Japan

This work reports on hard X-ray photoelectron spectroscopy of FeCoB-MgO-FeCoB magnetic tunnel junctions. The studies were performed on both the lower part of a tunnel junction only as well as on the full junction. The multilayer structures were deposited on SiO wafers with the sequence Ta/Ru/Ta/FeCoB/MgO/AlO_x or Ta/Ru/Ta/FeCoB/MgO/FeCoB/Ta/AlO_x. The final samples were annealed at temperatures of 520 K to 920 K. Core level spectroscopy reveals clearly the thermally stimulated interlayer diffusion of boron. The efficiency of the boron transfer between FeCoB and the contiguous Ta layer increases at higher annealing temperatures. Valence band spectroscopy shows strong changes of the electronic structure with increasing annealing temperature and shows a good agreement with the calculated density of states. The dependence of the tunnel magnetoresistance on the annealing temperature is explained for by the combined effects of an improved crystalline structure together with a change in the spin polarization at the Fermi energy caused by the removal of boron from the FeCoB layer.

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