MA 13 Spinabhängiger Transport I

Zeit: Samstag 10:45–13:15 Raum: TU EMH225

MA 13.1 Sa 10:45 TU EMH225

Interplay of atomic ordering and TMR-effect of Co_2MnSi Heusler electrodes in magnetic tunnel junctions — •Andreas Hütten, Sven Kämmerer, Jan Schmalhorst, and Günter Reiss — Department of Physics, University of Bielefeld, 33615 Bielefeld, germany

We have demonstrated that the full Heusler compound Co_2MnSi integrated as one of the magnetic electrodes in technological relevant MTJs is currently characterized by a maximum spin polarization of 66% at 20K. This limitation can mainly be associated with two experimental findings. Firstly, the formation of a step like barrier which is already created during plasma oxidation while preparing the AlO_x tunnel barrier and which is a direct consequence of the oxygen affinity of the Heusler elements Mn and Si. Secondly, it is difficult to avoid Co-Mn antisite formation at the Co_2MnSi AlO_x-barrier interface. The Co-Mn antisite formation has qualitatively been monitored using the normalized x-ray diffraction intensities of the Co_2MnSi superlattice reflections as a function of the resulting TMR-effect and has additionally been simulated by the intercalation of thin Co layers in between Co_2MnSi and AlO_x.

MA 13.2 Sa 11:00 TU EMH225

Optimization and characterization of Co_2MnGe based magnetic tunneling junctions — •Erik Verduijn and Kurt Westerholt — Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, 44780 Bochum

Heusler compounds are materials of great potential in the field of spintronics due to their predicted 100% spin polarization at the Fermi level. We have studied the spin polarization of such Heusler compounds, in particular the Co_2MnGe compound via the magnetotransport properties of magnetic tunneling junctions (MTJs) with Heusler as base electrode and Co as counter electrode. Optimization of the tunnel barrier layer, surface roughness of the base electrode and magnetic properties are critical to the quality of the MTJs and our approach to these issues will be discussed in some detail. Magnetotransport measurements indicate the junctions fullfill all properties expected of good quality MTJs. Furthermore measurements of the TMR effect of these junctions indicate the Co_2MnGe layers we have prepared to have a significant spin polarization, at least as large as that of elemental Co. Although this spin polarization is far from the predicted 100% it is significant, considering the difficulties in both growth of the Heusler layer and succesfull intergration into a MTJ, that any spin polarization has been measured whatsoever. These difficulties e.g. magnetic and crystalline properties of the Heusler layers, surface roughness and interdiffusion and their relation to the measured spin polarization will be presented.

MA 13.3 Sa 11:15 TU EMH225

Low temperature measurement of hot electron energy effects in semi-epitaxial magnetic tunnel transistors — •Thomas Hagler, Martin Dumm, Claus Bilzer, Wolfgang Kipferl, and Günther Bayreuther — Universität Regensburg, Universitätsstr. 31, 93040 Regensburg

A magnetic tunnel transistor with Al_2O_3 tunneling barrier, spin-valve metallic base and epitaxial CoFe/GaAs Schottky barrier has been used to probe the energy dependence of hot electron transport at low temperatures. The magnetocurrent ratio (MCR) reaches values up to 900% in our ultrathin microstructured three terminal devices. The effect of hot electron energy has been studied in the range of 0.6 eV - 2.2 eV. We observe a clear maximum of the MCR at about 1.5 eV electron energy. With increasing temperature ($5\,K < T < 185\,K$) the MC remains almost constant, but a rapidly growing spin-independent additional current is measured, due to increasing collector leakage.

MA 13.4 Sa 11:30 TU EMH225

Ballistic Magneto-Current in Magnetic Tunnel Junctions — •Jan Bornemeier, Guenter Reiss, and Hubert Brueckl — University of Bielefeld, Department of Physics, Universitaetstr. 25, 33615 Bielefeld

The combination of a magnetic tunnel junction and a Schottky barrier allows the observation of spin scattering of ballistic electrons at energies around 1eV. For this layer stacks of 4-10nm Co/ 1.8nm Alox/ 4nm Py/ 12nm MnIr/ 50nm Cu/ 50nm Au on (100)-GaAs are deposited and subsequently patterned by e-beam lithography. The injected current is (depending on the base thickness) 4-5 orders of magnitude smaller than the tunnel current. The adjustable current amplitude and the high spin-polarization make these hybride junctions a promising candidate as spin injector into semiconductors. Varying the base thickness, the spin attenuation length of the majority electrons can be estimated to be 50+/-8nm at 10K and 1.2V bias.

MA 13.5 Sa 11:45 TU EMH225

Spin-polarized tunneling in Fe/X/MgO/Fe (X=V,Cr) — •Jussi Enkovaara, Daniel Wortmann, and Stefan Blügel — Forschungszentrum Jülich, Institut für Festkörperforschung, 52425 Jülich

We present first-principles calculations on Fe/X/MgO/Fe system where the X element is V or Cr. Fe/MgO/Fe is a prototype system for tunneling magnetoresistance (TMR). Previous experimental and theoretical investigations have reported large magnetoresistance in epitaxial junctions. By adding layers of V or Cr on the one side of the junction, we can study the effect of interfacial electronic structure on the tunneling conductance.

The calculations are done within the density-functional theory with the full-potential linearized augmented plane wave (FLAPW) method. The novel embedded Green function method enables us to treat semi-infinite junctions and to calculate the ballistic conductance within the Landauer formalism. The results show large changes in the conductance already when one layer of V or Cr is inserted in the system. These findings can be interpreted in terms of the symmetry of the contributing electronic states.

MA 13.6 Sa 12:00 TU EMH225

Interfacial coherence and sign of spin polarization — •Andy Thomas[1], Biswarup Satpati[2], and Jagadeesh Moodera[1] — [1]Francis Bitter Magnet Lab., MIT, Cambridge, USA — [2]Institute of physics, Bhubaneswar, India

The inverse TMR in magnetic tunnel junction $La_{0.7}Sr_{0.3}MnO_3$/ $SrTiO_3$(STO)/ Co structures investigated by DeTeresa et. al. was explained by the influence of interface bonding between the Co and the STO barrier. The d-band matching caused the d-electrons to tunnel predominantly and hence the sign of spin polarization P was negative [1].

Our recent results disagree with this general conclusion. Direct measurements of P in FM/STO/Al structures using the Meservey-Tedrow technique (SPT) gave values of P to be +31 % for Co, and +29 % (+10 %) for Fe (Ni) respectively. These values agree fairly well with values found for Al_2O_3 already 30 years ago, and thus the theoretical explanation of the d-band match in these structures is not generally valid and has to take additional parameters into account (e.g. [2]).

To look further into the coherence of the interface structure and the sign of spin polarization, the interfaces are investigated with HR-TEM and compared to the TEM images of [3]. Factors that determine the sign of P are discussed to give input for a more complete theoretical explanation.

Supported by NSF and Humboldt Foundation funds. [1] DeTeresa et. al., PRL **82**, 4288 (1999), [2] Oleinik et. al., PRB **65**, 020401 (2001), [3] Pailloux et. al., PRB **66**, 014417 (2002)

MA 13.7 Sa 12:15 TU EMH225

Tunneling in Fe/MgO/Fe: Influence of interface structure and bias voltage — •Christian Heiliger, Bogdan Yu. Yavorsky, Peter Zahn, and Ingrid Mertig — Martin-Luther-University Halle-Wittenberg, Department of Physics, Von-Seckendorff-Platz 1, 06120 Halle, Germany

Newest experimental results of Fe/MgO/Fe tunnel junctions [1] show a strong dependence of the tunnel magnetoresistance on the sample and in particular the interface quality. An elaborate experimental analysis of the interface composition in Fe/MgO/Fe tunnel junctions reveals the formation of a mixed Fe/O layer [2]. To elucidate their influence on conductance and tunneling magnetoresistance (TMR) electronic structure calculations have been performed. A screened Korringa-Kohn-Rostoker (KKR) method based on density-functional theory was applied. The Landauer conductance of planar junctions was calculated using the Baranger-

Stone scheme by means of Green functions. The influence of structural relaxation, formation of a mixed Fe/O-layer and the finite bias voltage on conductance and TMR are discussed.

[1] S. Yuasa, T. Nagahama, A. Fukushima, Y. Suzuki and K. Ando, Nature mat. AOP (31 October 2004); doi: 10.1038/nmat1257

[2] H. L. Meyerheim, R. Popescu, J. Kirschner, N. Jedrecy, M. Sauvage-Simkin, B. Heinrich, and R. Pinchaux, Phys. Rev. Lett. 87, 076102 (2001).

MA 13.8 Sa 12:30 TU EMH225

Growth and x-ray analysis of Fe/MgO/Fe(100) layers — •Christian Tusche[1], Holger Meyerheim[1], Jürgen Kirschner[1], Nathalie Jedrecy[2], and Gilles Renaud[3] — [1]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle — [2]LMCP Univ. Paris VI, 4 place Jussieu, F-75252 Paris — [3]CEA-Grenoble, 17 rue des Martyrs, F-38054 Grenoble

For the theoretical understanding of epitaxial tunneling-magnetoresistance (TMR) systems, a detailed knowledge of the geometrical structure at the FM/insulator interface plays a crucial role. As reported before for the prototype Fe/MgO/Fe(100) system, a FeO_x ($x \approx 0.6$) interface layer in formed during MgO deposition onto Fe(100), significantly affecting the TMR effect[1,2]. Surface x-ray diffraction (SXRD) experiments on the structure of the second Fe/MgO interface were carried out at the European Synchrotron Radiation Facility (ESRF).

While for deposition of about 0.5ML Fe in oxygen background pressure $p_{O_2} = 10^{-7}$ mbar a stoichiometric FeO interface is formed, for Fe-deposition under UHV conditions a substoichiometric FeO_x ($x \approx 0.3$) layer grows on an oxygen depleted MgO-layer. Furthermore, well defined layer by layer growth of subsequently deposited Fe is only observed in the case of the oxygen saturated MgO/FeO interface.

Our results may have considerable importance for the optimization of the Fe/MgO/Fe(100) TMR structure, since the symmetry of the TMR geometric structure is decisive for the TMR-amplitude.

[1] H.L. Meyerheim et al., Phys. Rev. Lett **87** (2001) 076102

[2] W.H. Butler et al., Phys. Rev. B **68** (2003) 092402

MA 13.9 Sa 12:45 TU EMH225

Kompensation des Gesamtmoments in NiFe/CoGd/NiFe für magnetische Tunnelelemente — •Andrea Niemeyer, Günter Reiss und Hubert Brückl — Universität Bielefeld, Fakultät für Physik, Universitätsstr. 25, 33615 Bielefeld

Schichtpakete aus Seltenen Erden und Übergangsmetallen lassen sich aufgrund einer antiparallelen Austauschkopplung bei geeigneter Wahl der Schichtdicken so einstellen, dass das totale magnetische Moment Null wird. Eine solche Kompensation des magnetischen Moments erreichten wir mit NiFe/CoGd/NiFe Schichtstapeln erstmals bei Raumtemperatur.

Es wurden magnetische Tunnelelemente hergestellt, deren hartmagnetische Elektrode aus NiFe/CoGd/NiFe mit einer antiferromagnetischen MnIr Schicht durch "Exchange Biasing"gepinnt wurde. Dabei wird ausgenutzt, dass es einen Zusammensetzungsbereich des CoGd gibt, in dem eine antiparallele Kopplung von CoGd zu NiFe besteht. Abhängig von der Schichtdicke bzw. Zusammensetzung der CoGd-Legierung findet bei geeigneten Werten eine Kompensation des totalen magnetischen Moments statt, bei der erhöhte Schaltfelder und eine geringe Néel-Kopplung zu beobachten sind. Zusätzlich wurde der Übergang von positivem zu negativem Nettomoment sowohl in Abhängigkeit von der CoGd Dicke, als auch temperaturabhängig, beobachtet.

MA 13.10 Sa 13:00 TU EMH225

Orbital effects in spin-polarized tunneling thru SRO/STO/SRO — •Daniel Wortmann[1], Kiyoyuki Terakura[2], and Stefan Blügel[1] — [1]IFF, Forschungszentrum Jülich, D-52425 Jülich, Germany — [2]Creative Research Initiative "Sousei", Hokkaido University, Sapporo, Japan

We present ab-initio calculations of spin-polarized tunneling in a $SrRuO_3/SrTiO_3/SrRuO_3$ three-layer junction where $SrRuO_3$ is a ferromagnetic metal and $SrTiO_3$ forms a insulating barrier. Both $SrRuO_3$ and $SrTiO_3$ crystallize in the Perovskite structure with nearly identical lattice constants. Thus epitaxial heterojunctions can be formed with a small tetragonal distortion off an ideal cubic structure. Employing the Landauer formula, the tunneling conductance was calculated within the framework of the DFT using the Green function FLAPW method. The Green function itself was obtained from an embedding approach to account for the semi-infinite leads attached to the tunneljunction. Due to the magnetic exchange splitting in $SrRuO_3$, bands of different orbital character contribute to the tunneling current in the two spin channels. While the minority t_2g-bands contribute strongly to the tunnel current, for the majority spin these states are only available in a small part of the two-dimensional Brillouin zone. Together with a filtering effect, which is explained in terms of the complex bandstructure of $SrTiO_3$, this leads to a significant spin-polarization of the conductance. This cannot be directly linked to the spin-polarization of the density of states of the system, but rather is a consequence of the orbital character of the states.