MA 18: Spindependent Transport II

Time: Wednesday 15:15–18:30 Location: H22

MA 18.1 Wed 15:15 H22

Tunneling magnetoresistance effect with amorphous electrodes — •Martin Gradhand, Christian Heiliger, Peter Zahn, and Ingrid Mertig — Martin Luther University, Institut f. Physik, D06099 Halle, Germany

Structural disorder is often used to explain the discrepancies between experimental [1,2] and theoretical [3,4] results for the tunneling magnetoresistance (TMR). To prove the influence of structural disorder on the TMR ratio experimentally well characterized Fe/MgO/Fe tunnel junctions were investigated theoretically. The screened KKR method based on density functional theory was applied to compute the electronic and magnetic structure self-consistently. The Baranger-Stone scheme based on Green functions was used to calculate the conductance of the planar tunnel junction in the coherent limit of transport. First of all it was shown that amorphous Fe electrodes of finite thickness next to MgO barrier cause a break down of the TMR ratio. Recrystallisation of at least, one monolayer of Fe next to the MgO barrier leads to a recovery of the effect and two crystalline Fe layers cause the same TMR ratio as semi-infinite Fe leads. Structural disorder in the electrodes behind the two crystalline layers does not influence the TMR ratio at all. All results are supported by a detailed theoretical analysis of the transport properties of amorphous and crystalline iron.

[1] S. Ikeda et al., Jpn. J. Appl. Phys. **44**, L1442 (2005)
[2] S. Yuasa et al., Appl. Phys. Lett. **89**, 042 505 (2006)
[3] J. Mathon and A. Umerski, Phys. Rev. B **63**, 220 403 (2001)
[4] W. Butler et al, Phys. Rev. B **63**, 054 416 (2001)

MA 18.2 Wed 15:30 H22

Calculations of electronic tunneling through perovskite barriers — •Daniel Wortmann and Stefan Blügel — Institut für Festkörperforschung, Forschungszentrum Jülich, Germany

Two different effects discussed recently draw a lot of attention to spin polarized tunneling: the experimental verification of the theoretically predicted large tunneling magneto-resistance effect in MgO based junctions and the suggestion to use more complex ferroelectric barrier materials in tunneljunctions. Using our all-electron, full-potential transport code based on the embedding Green function method we investigate electronic tunneling in multilayer systems containing transition metal oxides in the perovskite structure. In particular, we focus on the effect of details of the atomic structure, the lattice distortion and the orbital character at the Fermi-level on tunneling in $SrRuO_3/SrTiO_3/SrRuO_3$ tunneljunctions and the resulting spin-polarization of the current. We discuss the transferability of the symmetry selection effects in MgO barriers and the possible extension to ferroelectric junctions.

MA 18.3 Wed 15:45 H22

Interface structure and transport properties of Fe_3Si/GaAs: An *ab initio* study — •Heike C. Herper and Peter Entel — Theoretische Physik, Universität Duisburg-Essen, Campus Duisburg, Lotharstr. 1, 47048 Duisburg

Ferromagnets (FM) on half metals have attracted interest as electronic contacts for spin-injection, because of their high Curie temperature and the possible existence of a Schottky barrier, which acts as natural tunnel barrier in reverse-biasing. However, the quality of the interface is essential for successful spin-injection. Recently successful spin-injection has been reported for Fe_3Si/GaAs(001), while attempts with pure Fe/GaAs failed due to alloy formation at the interface. Here we investigate the influence of Si on the interface structure, in particular whether alloy formation with GaAs is suppressed. In addition, we study the transport properties of these systems depending on the interface structure.

The electronic and magnetic properties of Fe_3Si/GaAs(001) have been investigated within density functional methods employing the Vienna Ab-initio Simulation Package (VASP) by using the Projector Augmented Wave (PAW) method. The exchange correlation functional is described within the GGA+U method to improve the description of localized d-states and correct the calculated band gap of GaAs. The transport properties of Fe_3Si/GaAs are obtained from the Kubo-Greenwood equation in combination with a Green's function method.

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MA 18.4 Wed 16:00 H22

Ab initio calculations of tunnelling anisotropic magnetoresistance (TAMR) in Fe/GaAs/Au trilayer — Voicu Popescu[1] and •Hubert Ebert[2] — [1]Max-Planck-Institut für Metallforschung, Heisenbergstr. 3, 70569 Stuttgart — [2]Department Chemie/Physikalische Chemie, Universität München, 81377 München

We report results of calculations on the transport properties of Fe/GaAs/Au and magnetic tunnelling junctions (MTJs) that have been obtained using the tight-binding Korringa-Kohn-Rostoker Green function method in a spin-polarised fully relativistic formulation (TB-SPR-KKR).

It has been shown experimentally that the resistance of a MTJ shows a rather strong variation when its magnetisation changes the orientation, either in plane but varying the azimuthal angle, or when it is flipped from in-plane to out-of-plane.

Analogous theoretical investigations on this phenomenon, nowadays commonly termed as Tunnelling Anisotropic Magneto-resistance (TAMR) are presented for MTJs based on metallic (ferromagnetic or non-magnetic) leads. Our results show that a similar dependence is obtained also for such systems and it can be related to the spin-orbit coupling induced magnetic anisotropy at the metal/semiconductor interface. This, in turn, is shown to vary for different terminations (As or Ga) of the semiconductor. A very good qualitative agreement and a reasonable quantitative agreement is found by comparing our results with recent experimental data obtained for a Fe/GaAs/Au junction.

MA 18.5 Wed 16:15 H22

Spin-orbit induced anisotropies in the tunneling magnetoresistance of magnetic tunnel junctions. — •Alex Matos Abiague and Jaroslav Fabian — Institute for Theoretical Physics, University of Regensburg, 93040 Regensburg, Germany

We investigate the spin-orbit coupling effects on the tunneling magnetoresistance of magnetic tunnel junctions. We propose a theoretical model in which the experimentally observed tunneling anisotropic magnetoresistance (TAMR) effect originates from the interplay between the Dresselhaus and Bychkov-Rashba spin-orbit couplings. Changes in the applied bias produce variations of the Bychkov-Rashba spin-orbit coupling strength that can result in a flipping of the axis of the two-fold symmetry of the TAMR. The theoretical calculations are in good agreement with recent experimental results.

MA 18.6 Wed 16:30 H22

current-induced dynamics in spin-valves due to non-standard angular torque dependence — •Martin Gmitra[1] and Jozef Barnas[2] — [1]University of Regensburg, Regensburg, Germany — [2]Adam Mickiewicz University, Poznan, Poland

The spin transfer phenomena in spin-valves are the subject of extensive experimental and theoretical works due to novel design and promising application of new spintronic devices. A standard spin-valve structure contains fixed and sensing magnetic layer separated by nonmagnetic or insulating layer. The current induced motion of the sensing magnetic layer is related to the angular dependence of the spin torque that gives rise to current driven switching between low and high resistive states of the valve above a certain critical value. Additionally, by application of external magnetic field the microwave steady oscillations of magnetoresistance can be induced.

In the talk, the theoretical study of asymmeric spin valve based on the macroscopic model in diffusive transport regime will be presented. Within the approach, the non-standard angular torque dependence is obtained which leads to destabilization of both the low and high resistive states. Moreover, the steady state oscillations are predicted in zero magnetic field within macrospin model. The results open an interesting way for spin transfer oscillators that do not need an applied field.

MA 18.7 Wed 16:45 H22

Point-contact Andreev spectroscopy on Ni_2MnIn and $Ni_{80}Fe_{20}$ — •Lars Bocklage, Jan M. Scholtyssek, Ulrich Merkt, and Guido Meier — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstr. 11, 20355 Hamburg

We measure the spin polarization of permalloy and the Heusler alloy Ni_2MnIn using point-contact Andreev reflection spectroscopy [1]. Permalloy and Ni_2MnIn are interesting materials for spintronic devices. Permalloy yields a highly spin-polarized current within a few nanometers. For the $L2_1$ structure of Ni_2MnIn full spin polarization is predicted at the interface to InAs [2]. Permalloy films are deposited on Si and on Si covered with a thin highly conductive Au layer. The latter almost eliminates the series resistance of the ferromagnetic film and thus facilitates the interpretation of the differential conductance curves. For permalloy we determine a spin polarization of 35%. Ni_2MnIn is evaporated on Si and on in situ cleaved (110) surfaces of InAs. The spin polarization of Ni_2MnIn crucially depends on its crystal structure. For our present Heusler films we determine a spin polarization of about 30%. The low value is presumably caused by the presence of the undesired B2 structure.

[1] L. Bocklage et al., J. Appl. Phys., accepted (2007);
J. M. Scholtyssek et al., J. Magn. Magn. Mat., accepted (2006).

[2] K. A. Kilian and R. H. Victora, IEEE Trans. Mag. 37, 1976 (2001).

MA 18.8 Wed 17:00 H22

Temperature dependent two-phase behaviour of magnetisation and spin polarisation in NiPt — •Markus Schäfers, Andy Thomas, and Günter Reiss — Bielefeld University, Universitätsstraße 25, D-33615 Bielefeld, Germany

We investigated the temperature dependent behaviour of magnetisation and spin polarisation in NiCu and NiPt alloys. The advantage of these alloys is the reduced Curie temperature compared with pure Nickel. The whole range of magnetisation is accessible in experiment for these alloys.

Magnetic tunnel junctions with these alloys as free electrode were prepared by dc-magnetron sputtering in an UHV system with a base pressure of $1 \cdot 10^{-7}\,mbar$ and argon ion beam etching. TMR ratio was measured temperature dependent with a dc 2-point method. Spin polarisation was calculated by Julliere's formula. Magnetisation was measured with a SQUID for different temperatures.

The NiPt alloy showed a maximum for in-plane magnetisation and spin polarisation at about 190 K. There are indications for a perpendicular magnetic anisotropy at low temperatures in the NiPt alloy.

MA 18.9 Wed 17:15 H22

Transportuntersuchungen an nanoskaligen hybriden Ferromagnet/Nichtmagnet-Metallstrukturen — •Markus Wahle[1], Björn Wilke[1], Saskia Fischer[1], Ulrich Kunze[1], Ellen Schuster[2], Werner Keune[2], Dirk Sprungmann[3] und Kurt Westerholt[3] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Angewandte Physik, Universität Duisburg-Essen, D-47048 Duisburg — [3]Institut für Experimentalphysik/Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

In dieser Arbeit sollen ballistische Transportphänomene in Kombination mit spinabhängigem Transport untersucht werden. Hierzu werden dünne Schichten (< 50 nm) von sowohl ferromagnetischen Metallen (FM) als auch nicht-magnetischen Metallen (NM) mittels Elektronenstrahllithographie und anschließendem Trockenätzprozeß nanostrukturiert. Um die für den ballistischen Transport notwendigen mittleren freien Weglängen von der Größe der Strukturabmessungen zu erreichen, werden epitaktisch gewachsene Metallfilme hoher Reinheit verwendet. Die Qualität von Eisen-, Nickel- und Kupferfilmen wird durch das Restwiderstandsverhältnis ($rrr = R_{300K}/R_{4.2K}$) charakterisiert. Die Geometrie der Zuleitungen bei Drähten und Kreuzstrukturen erweist sich als wichtiger Parameter für den resultierenden anisotropen Magnetowiderstand.

MA 18.10 Wed 17:30 H22

Beeinflussung des CMR Effektes von dünnen epitaktisch gewachsenen PCMO Schichten auf vicinalen STO Substraten — •Peter Moschkau, Julia Fladerer, Jörg Hoffmann und Christian Jooss — Materialphysik Universität Göttingen, Göttingen, Germany

Um den Mechanismus des Metal-Isolator-Übergangs im Magnetfeld, die elektrische Phasenseparation und die dabei relewanten Längenskalen in dünnen PCMO Filmen zu untersuchen, wurde mittels vicinaler STO Substrate eine periodische Defektstruktur eingebracht. Die mit gepulster Laserdeposition hergestellten Filme wurden mit Röntgenspektroskopie, AFM, sowie TEM charakterisiert. Bei Erhöhung des Verkippwinkels (3 ... 10Grad) kommt es zu einem Übergang vom Inselzum Stepflow-Wachstum. Es wird eine elektrische und strukturelle Phasenseparation zwischen einer Polaronen-, Orbital- und Ladungsgeordneten Phase und ungeordneten Phase beobachtet. Bei dieser gehen Nukleation und Wachstum der geordneten Phase an Defekten einher. Elektrische Transporteigenschaften in externen magnetischen Feldern zeigen für Filme auf verkippten Substraten eine in-plane Anisotropie im Verlauf und erreichten Endwiderstand. Es soll der Zusammenhang zwischen Struktur und den elektrischen Eigenschaften als Funktion des Verkippwinkels diskutiert werden.

MA 18.11 Wed 17:45 H22

Interplay of multiferroic behaviour, electronic phase separation and colossal resistance effects in $Pr_{1-x}Ca_xMnO_3$ — •C. Jooss[1], S. Schramm[1], P. Moschkau[1], J. Hoffmann[1], L. Wu[2], T. Beetz[2], R. Klie[2], M. Beleggia[2], and Y. Zhu[2] — [1]Institut für Materialphysik, Univ. Göttingen, Friedrich Hund Platz 1, 37077 Göttingen — [2]Brookhaven National Laboratory, Upton NY 11973, USA

$Pr_{1-x}Ca_xMnO_3$ in the doping range between 0.3 ¡ x ¡ 0.5 represent an extremely interesting manganite system for the study of the interplay of different kinds of ordering (charge, orbital, lattice and spin) and the related drastic changes of the transport properties. TEM reveals the presence of electronic and structural phase separation in the chemically homogeneous material between a Zener polaron orbital and charge ordered and disordered phase in a broad temperature and doping regime. The Zener polaron (ZP) type ordering is additionally confirmed by atomic resolution EELS measurements. The ratio of the ZP ordered and disordered phases strongly depend on temperature. The ZP-ordered phase is multiferroic, showing anitferromagnetic order and weak ferroelectric polarisation due to a non-centrosymmetric distortion of the MnO6 octahedra involved in the ZP. In-situ TEM imaging with applied electric currents, we show that local ZP- and charge-ordered domains can be set into motion, be dissolved and reformed by an electric current. This represents a common mechanism for the resistance change at low and room temperatures. In addition, the CMR effect will be analyzed in the background of the determined ordered structure.

MA 18.12 Wed 18:00 H22

Magnetotransport in thin LSMO:CeO_2 nanocomposite films — •Markus Esseling[1], Hamish Gordon[2], Christian Stingl[1], Kai Gehrke[1], Vasily Moshnyaga[1], and Konrad Samwer[1] — [1]I. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany — [2]Cavendish Laboratory, J.J. Thomson Avenue, Cambridge CB3 0HE, UK

Due to the chemical phase separation of the highly spin-polarized manganite LSMO and the insulating CeO_2 it is possible to prepare nanocomposite films. Using the columnar growth mode of the LSMO on Al_2O_3-substrates the microstructure of the films results in LSMO-grains which are separated by the CeO_2-phase. Therefore the system builds a lateral TMR-structure.

$(LSMO)_{1-x}:(CeO2)_x$ nanocomposite films with a thickness ≈70nm were prepared by MAD-technique with $0 \leq x \leq 0{,}5$. The temperature of the metal-insulator transition decreases systematically with increasing CeO_2-content, whereas the influence on the Curie-temperature is not so strong. The system shows a low-field magnetoresistance (LFMR) up to 60% for the x = 0.2 sample, which is near the percolation threshold. To study the effect of the number of involved grains some samples were microstructured into current stripes of well-defined width. A strong influence on the temperature dependence of the resistance is observed, whereas the LFMR is nearly unchanged. The effect of the quality of the interfaces LSMO/CeO_2 will be discussed.

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MA 18.13 Wed 18:15 H22

Magnetothermal transport in the spin-1/2 chains of copper pyrazine dinitrate — •Alexandr V. Sologubenko[1], Kai Berggold[1], Thomas Lorenz[1], Achim Rosch[2], Efrat Shimshoni[3], Matt D. Phillips[4], and Mark M. Turnbull[4] — [1]II. Physikalisches Institut, Universität zu Köln, 50937 Köln, Germany — [2]Institut für Theoretische Physik, Universität zu Köln, 50937 Köln, Germany — [3]Department of Mathematics–Physics, University of Haifa at Oranim, Tivon 36006, Israel — [4]Carlson School of Chemistry and Department of Physics, Clark University, Worcester, MA 01610

We present experiments on the thermal transport in the spin-1/2 chain compound copper pyrazine dinitrate $Cu(C_4H_4N_2)(NO_3)_2$. The heat conductivity shows a surprisingly strong dependence on the applied magnetic field B, characterized at low temperatures by two main features. The first one appearing at low B is a characteristic dip located

at $\mu_B B \sim k_B T$, that may arise from Umklapp scattering. The second one is a plateau in the quantum critical regime, $\mu_B|B - B_c| < k_B T$, where B_c is the saturation field at $T = 0$. The latter feature clearly points towards a momentum and field independent mean free path of the spin excitations, contrary to theoretical expectations.

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