MA 49: Spin-dependent Transport/ Spin Torque

Time: Thursday 10:45–13:00 Location: HSZ 04

MA 49.1 Thu 10:45 HSZ 04

Correlating transmission and local electronic structure in planar junctions: An analysis tool for spin-dependent transport calculations — •Peter Bose[1], Peter Zahn[2], Ingrid Mertig[1,2], and Jürgen Henk[1] — [1]Max Planck Institute of Microstructure Physics, Halle, Germany — [2]Martin Luther University Halle-Wittenberg, Halle, Germany

Calculations of spin-dependent transport in planar tunnel junctions are typically analyzed by means of transmission and spectral-density maps that display the transmittance or spectral densities in the two-dimensional Brillouin zone at a fixed energy. A visual inspection of these maps in order to reveal, e. g., which layers or which orbitals determine the conductance is not only tedious but also ambiguous.

We propose to analyze spin-dependent transport calculations quantitatively and without ambiguity by correlating transmission and spectral-density maps. Since spectral-density maps can be resolved with respect to atom, angular momentum, and spin, the resulting correlation coefficients reveal unequivocally detailed features of the conductances. Salient properties of our method are discussed for selected planar junctions.

MA 49.2 Thu 11:00 HSZ 04

EuS Spin Filter Tunnel Contacts to Silicon with various doping concentrations — •H. Doganay, M. Müller, R. Schreiber, and C. M. Schneider — IFF-9, FZ Jülich

Utilizing spin filter (SF) materials as tunnel barrier is a unique method to generate highly spin-polarized currents. We studied electrical and magnetic properties of EuS SF tunnel contacts to silicon with the emphasis of different Si doping concentrations. First, we explored the magnetic properties of EuS on Si(100) in thickness regime of tunnel barriers. Our studies indicated that thin EuS/Si films exhibit bulk-like magnetic properties above $d \geq 3\,nm$ [1]. Furthermore, we studied the morphology of Si/EuS($d = 1{-}6$nm)/Au sample surfaces by AFM and found that magnetization M correlates with roughness. We investigated the electrical transport properties across EuS/Si(100) interfaces for different n-Si doping concentrations. Transport experiments on Si(100)/Au junctions revealed the respective Schottky barrier profile. We analyzed both spin injection and -detection conditions of R(T) and I(V) characteristics of EuS/Si(100) contacts. By fitting the temperature-dependent I(V) characteristics we determined the exchange splitting of a 4 nm thick EuS SF barrier as 0.30eV, which is comparable to the bulk value ($\Delta E_{xc}(EuS_{bulk})$=0.36eV). Moreover, we found that SF in EuS/Si is bias-dependent, with the maximum tunneling SP occurring at medium bias voltages ($0.40 < V < 0.70$). In summary, our experiments demonstrate a successful integration EuS as a tunnel barrier to n-Si(100) for different n-Si doping concentrations.[1] M. Müller *et al.*, submitted to JAP

MA 49.3 Thu 11:15 HSZ 04

Ab initio theory of tunneling anisotropic magnetoresistance in Fe/GaAs/Ag(001) system — Rudolf Sykora and •Ilja Turek — Charles University, Faculty of Mathematics and Physics, DCMP, Prague, Czech Republic

The electronic structure and transport properties of epitaxial magnetic tunnel junctions Fe/GaAs/Ag(001) are studied theoretically by means of a first-principles tight-binding linear muffin-tin orbital (TB-LMTO) method. The effect of the spin-orbit interaction is treated as an on-site perturbation to a scalar-relativistic TB-LMTO Hamiltonian and the ballistic conductance of the system is calculated within the Kubo-Landauer formalism. Particular attention is paid to the dependence of the conductance on the orientation of magnetization direction of the Fe electrode and on the thickness of the GaAs barrier. The calculated tunneling anisotropy magnetoresistance (TAMR) ratio exhibits a non-monotonic thickness-dependence with a maximum around 8 nm of GaAs, in rough agreement with the barrier thickness used in recent experiments on TAMR in similar systems. This behavior as well as hot spots found in the $k_{\parallel}$-resolved conductances are explained in terms of a hybridization of interface resonances formed on both sides of the junction.

MA 49.4 Thu 11:30 HSZ 04

Quantum conductance between the STM tip and magnetic clusters on metal surfaces: ab initio studies — •Kun Tao[1], Ivan Rungger[2], Stefano Sanvito[2], and Valeri.S Stepanyuk[1] — [1]Max-Planck-Institute of Microstructure Physics, Halle, Germany — [2]School of Physics and CRANN, Trinity College, Dublin, Ireland

We perform ab inito calculations to investigate the quantum conductance between the STM tip and magnetic clusters adsorbed on metal surfaces. Based on the nonequilibrium Green's function method, we perform spin polarized transport calculations. Our results give clear evidence that the conductance of a single atomic junction in the contact regime is close to G0/2 (G0 is the quantum of conductance) for ferromagnetic electrodes and to G0 for nonmagnetic ones[1]. Our results demonstrate that a conductance of G0/2 originates from a combination of partially open majority and minority channels. We also studied the tunneling magnetoresistance (TMR) effect between the spin-polarized STM tip and magnetic clusters on metal surfaces. It is found that the TMR effect in the junction strongly depends on the tip-substrate distance.

[1] Kun Tao, I. Rungger, S. Sanvito, V.S. Stepanyuk, Phys. Rev. B. 82, 085412 (2010)

MA 49.5 Thu 11:45 HSZ 04

Thermal activated domain wall depinning: Extraction of the non-adiabatic contribution — •Jan Heinen[1], Mathias Kläui[1,2], Olivier Boulle[3], Gregory Malinowsky[4], Christian Ulysse[5], and Giancarlo Faini[5] — [1]Fachbereich Physik, Universität Konstanz, 78457 Konstanz, Germany — [2]SwissFEL, Paul Scherrer Institut, 5232 Villigen PSI, Switzerland and Laboratory for Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne (EPFL), 1015 Lausanne, Switzerland — [3]INAC, CEA, 38054 Grenoble, France — [4]Laboratoire de physique des solides, Université Paris-sud, 91405 Orsay, France — [5]Phynano Team, Laboratoire de Photonique et de Nanostructures, CNRS, 91460 Marcoussis, France

We report time resolved measurements of the extraordinary hall effect (EHE) on perpendicularly magnetized nanowires with narrow domain wall (DW) structures. Using Co/Pt multilayer nanowires, we have previously shown that despite Joule heating effects it is possible to deduce the non-adiabacity factor β [1] and determined the contribution of spin torque and Oersted field effects from DW depinning experiments [2]. Time resolved experiments to measure the extraordinary hall voltage of a Hall cross show the existance of multiple metastable pinning sites, which can be used to study thermally activated depinning. The variation of an applied external field and the variation of current allows us to extract of the non-adiabaticity factor β.

References: [1] O. Boulle et al., Phys. Rev. Lett. 101, 216601 (2008). [2] J. Heinen et al., Appl. Phys. Lett. 96, 202510 (2010).

MA 49.6 Thu 12:00 HSZ 04

A direct approach to measure the nonadiabatic spin transfer torque parameter — •Ming Yan[1] and Riccardo Hertel[1,2] — [1]Institut für Festkörperforschung, Elektronische Eigenschaften, Forschungszentrum Jülich GmbH — [2]Institut de Physique et Chimie des Matériaux de Strasbourg, Université de Strasbourg, CNRS UMR 7504

The nonadiabatic spin transfer torque parameter β plays an important role in spin dynamics driven by electric current. Measuring β is however usually difficult due to the entanglement of β with the spin polarization rate P. Although various methods to extract the value of β have been suggested, a direct measurement which does not require a model-dependent comparison with numerical simulations is to date elusive. The recently reported dynamic properties of transverse domain-walls in thin cylindrical nanowires [1] provide an approach to measure P and β directly and independently. Driven by a magnetic field or/and an electric current, this type of domain wall precesses around the wire while propagating along the wire. Measuring the linear velocity of the domain wall driven by an electric current allows a direct determination of P. The precessional frequency of the domain wall is proportional to β. The value of β can be unambiguously determined by measuring the frequency shifts caused by electric currents from the Larmor precession of the domain wall. An excellent agreement is achieved between analytical calculations and micromagnetic simulations.

[1] M. Yan, A. Kákay, S. Gliga, and R. Hertel, Phys. Rev. Lett. 104,

057201 (2010).

MA 49.7 Thu 12:15 HSZ 04

Probing the Nonadiabaticity of the Spin-Torque via direct Imaging of Current induced Vortex Domain Wall Excitations — •M. Stärk[1,2], A. Bisig[1,3], J. Rhensius[2,4], C. Moutafis[1], J. Heidler[1], G. Kiliani[2], M. Kläui[1,2], H. Stoll[3], L.J. Heyderman[4], B. Van Waeyenberge[5], and T. Tyliszczak[6] — [1]SwissFEL, PSI, 5232 Villigen and Laboratory of Nanomagnetism and Spin Dynamics, Ecole Polytechnique Fédérale de Lausanne, 1015 Lausanne, Switzerland — [2]Universität Konstanz, 78457 Konstanz, Germany — [3]Max-Planck-Institut für Metallforschung, 70569 Stuttgart, Germany — [4]Labor für Mikro- und Nanotechnologie, PSI 5232 Villigen, Switzerland — [5]Ghent University, 9000 Ghent, Belgium — [6]Advanced Light Source, 94720 Berkeley LBNL, USA

Magnetic vortex domain walls, where the magnetization curls in the plane of the wire around a central vortex core, are candidates for novel memory devices based on current induced domain wall motion or vortex core switching. Here we report on the investigation of the interaction between vortex domain walls and microwave spin polarized currents, employing time-resolved scanning transmission x-ray microscopy (STXM). Beyond the one dimensional quasi particle treatment of magnetic domain walls we describe the wall as a composite object consisting of a vortex and two half-vortices. From the phase-shift of the response of the different topological defects, we measure the adiabatic and non-adiabatic spin torque terms to test predictions of the correlations between the different spin torque terms and the local magnetization gradients.

MA 49.8 Thu 12:30 HSZ 04

Low spin current-driven dynamic excitations and metastability in spin-valve nanocontacts with unpinned artificial antiferromagnet — •Moritz Eggeling[1], Theodoros Dimopoulos[1], Thomas Uhrmann[1], Ole Bethge[2], Rudolf Heer[1], Volker Hoeink[1], and Hubert Brueckl[1] — [1]Austrian Institute of Technologie GmbH - Devision Nano Systems, Donau-City-Str. 1, 1220 Vienna, Austria — [2]Institute for Solid State Electronics, Vienna University of Technology, Floragasse 7, 1040 Vienna, Austria

This work concerns the dynamic excitation of non-uniform, vortex-like magnetic states due to spin-transfer torque in spin-valve nanocontacts, employing an unpinned artificial antiferromagnet of CoFe/Ru/CoFe as polarizer and amorphous CoFeB as free layer. The frequency spectra are in the sub-gigahertz regime for circular contacts of 150 to 200 nm in diameter. The critical current density, marking the onset of the dynamic excitation, attains considerably low values, while the dynamic spectra show reversibility with respect to the DC current. The oscillation power strongly depends on the in-plane magnetic field, assuming maximum values in the vicinity of the free layer's magnetization switching. The maximum in power is accompanied by a minimum in the oscillation linewidth. We also show that for specific current and magnetic field windows metastable dynamic states are excited, believed to induce linewidth broadening.

MA 49.9 Thu 12:45 HSZ 04

Domain Wall Manipulation With a Magnetic Tip — •Thim Stapelfeldt, Robert Wieser, Elena Y. Vedmedenko, and Roland Wiesendanger — Institute of Applied Physics and Microstructure Advanced Research Center, University of Hamburg

A theoretical concept of local manipulation of magnetic domain walls is introduced. In the proposed procedure a domain wall is moved by a magnetic tip, as used in a scanning tunneling microscope, placed above a magnetic nanostripe and than moved along it's long axis with a current flowing through the vacuum barrier. The angular momentum from the spin polarized current exerts a torque on the magnetic moments underneath the tip and leads to a displacement of the domain wall, when the tip approaches the wall. Particularly, the manipulation of a ferromagnetic 180° transverse domain wall has been studied by means of Landau-Lifshitz-Gilbert dynamics and Monte-Carlo simulations. Several operation modes corresponding to different relative orientations of the tip and the sample magnetization have been considered. The position dependent magnetic conductivity G corresponding to experimentally derived I/U curves have been obtained for each geometry.