MA 50: Spincaloric Transport (jointly with TT)

Time: Thursday 9:30–12:00 Location: HSZ 403

MA 50.1 Thu 9:30 HSZ 403

Tunnel magneto-Seebeck effect in $MgAl_2O_4$ based magnetic tunnel junctions — •Torsten Huebner[1], Alexander Boehnke[1], Ulrike Martens[2], Andy Thomas[3], Günter Reiss[1], Markus Münzenberg[2], and Timo Kuschel[1,4] — [1]CSMD, Physics Department, Bielefeld University, Germany — [2]IFP, Greifswald University, Germany — [3]IMW, IFW Dresden, Germany — [4]University of Groningen, The Netherlands

The tunnel magneto-Seebeck (TMS) effect describes the changing Seebeck coefficient of a magnetic tunnel junction (MTJ) depending on the relative magnetization alignment of its ferromagnetic electrodes. This effect has been measured in several material systems and with different experimental methods [1-4]. In our study, we focus on MTJs with $MgAl_2O_4$ (MAO) barrier, because of its theoretical advantages in comparison to MgO [5,6]. We find a distinct maximum of the TMS effect at a nominal barrier thickness of 2.6 nm, almost doubling the effect ratio measured at standard barrier thicknesses of (1.8-2.0) nm.

[1] Walter et al., Nat. Mater. 10, 742 (2011)
[2] Liebing et al., Phys. Rev. Lett. 107, 177201 (2011)
[3] Boehnke et al., Rev. Sci. Instrum. 84, 063905 (2013)
[4] Huebner et al., Phys. Rev. B 93, 224433 (2016)
[5] Zhang et al., Appl. Phys. Lett. 100, 222401 (2012)
[6] Miura et al., Phys. Rev. B 86, 024426 (2012)

MA 50.2 Thu 9:45 HSZ 403

Quantitative disentanglement of spin Seebeck, intrinsic anomalous Nernst, and proximity-induced anomalous Nernst effect in NM/FM bilayers — •Panagiota Bougiatioti[1], Christoph Klewe[1,2], Daniel Meier[1], Orestis Manos[1], Olga Kuschel[3], Joachim Wollschläger[3], Laurence Bouchenoire[4,5], Simon D. Brown[4,5], Jan-Michael Schmalhorst[1], Günter Reiss[1], and Timo Kuschel[1,6] — [1]CSMD, Physics Department, Bielefeld University, Germany — [2]ALS, Berkeley, California, USA — [3]Fachbereich Physik, Universität Osnabrück, Germany — [4]XMaS, ESRF, Grenoble, France — [5]University of Liverpool, UK — [6]University of Groningen, The Netherlands

In this project, we investigate thermal transport phenomena by separating the anomalous Nernst effect (ANE) contribution (intrinsic and proximity-induced) from the spin Seebeck effect (SSE) voltage on sputter-deposited $Pt/NiFe_2O_{4-x}$ samples. On one hand, we observe a distinct increase of the SSE with the increase of the bandgap energy and the decrease of conductivity, whereas the ANE decreases. On the other hand, a proximity-induced ANE could only be identified in the metallic $Pt/Ni_{33}Fe_{67}$ bilayer. This was verified by the investigation of static magnetic proximity effects via x-ray resonant magnetic reflectivity [1-3]. Further, we determined a maximum moment of 0.48 μ_B per spin-polarized Pt atom in the $Pt/Ni_{33}Fe_{67}$ bilayer.

MA 50.3 Thu 10:00 HSZ 403

Magneto-Seebeck Tunneling Across a Vacuum Barrier — •Cody Friesen, Hermann Osterhage, and Stefan Krause — Department of Physics, University of Hamburg, Jungiusstr. 11A, 20355 Hamburg, Germany

The tunneling magneto-Seebeck effect has been intensively studied both for its potential applications in e.g. waste heat recycling in electronics, and for the insights it can provide into fundamental solid state phenomena [1]. Previously, spin-resolved measurements have been performed using planar magnetic tunneling junctions [2], which limits the achievable spatial resolution.

We have investigated (magneto-)Seebeck tunneling across a vacuum barrier using spin-polarized scanning tunneling microscopy (SP-STM) [4], at low temperatures ($T = 50$ K) and UHV conditions. A 15 mW fiber-coupled diode laser was used to heat only the magnetic STM tip, creating a controllable temperature differential across the junction. With this approach the contribution of different surfaces to magneto-Seebeck tunneling has been probed on the Fe/W(110) monolayer system. The first laterally resolved experimental results will be shown and discussed in terms of tunneling thermovoltage and associated magneto-Seebeck coefficients.

[1] G. Bauer *et al.*, Nat. Mater. **11**, 5 (2012).
[2] M. Walter *et al.*, Nat Mater **10**, 10 (2011).
[3] R. Wiesendanger, Rev. Mod. Phys. **81**, 4 (2009).

MA 50.4 Thu 10:15 HSZ 403

Interface dependent magnon mode coupling in insulating ferrimagnets — •Joel Cramer[1,2], Er-Jia Guo[1,3], Andreas Kehlberger[1], Gerhard Jakob[1], and Mathias Kläui[1,2] — [1]Institut für Physik, Johannes Gutenberg-Universität Mainz, 55128 Mainz, Germany — [2]Graduate School of Excellence Materials Science in Mainz, 55128 Mainz, Germany — [3]Quantum Condensed Matter Division, Oak Ridge National Laboratory, Oak Ridge, 37830 TN, USA

One of the contemporary challenges of magnon spintronics is the profound understanding of magnon mode dependent transport and interface transmission. To approach this problem, we present temperature dependent spin Seebeck (SSE) measurements in uncompensated (yttrium iron garnet (YIG) [1]) and compensated (e.g. gadolinium iron garnet (GdIG) [2]) insulating ferrimagnets. In YIG, a giant enhancement of the SSE amplitude is observed at low temperatures. Despite the bulk origin of the spin current generation, the temperature dependence varies with the used heavy metal (HM) detection layer. Systematic studies including transmission electron microscopy (TEM) reveal that this effect is due to the altered atomistic composition of YIG at the interface. In compensated ferrimagnets, the opposite contribution of distinct magnon modes leads to a sign change of the spin current at low temperatures [3]. We show that different HM layers as well as a modified GdIG surface morphology result in varied interface couplings of these modes, expressed by a temperature shift of the sign change.

[1] Guo et al., Phys. Rev. X 3, 031012 (2016) [2] Cramer et al., (under review) [3] Geprägs et al., Nature Comm. 7, 10452 (2016)

MA 50.5 Thu 10:30 HSZ 403

Quantitative disentanglement of spin Seebeck, intrinsic anomalous Nernst, and proximity-induced anomalous Nernst effect in NM/FM bilayers — •Panagiota Bougiatioti[1], Christoph Klewe[1,2], Daniel Meier[1], Orestis Manos[1], Olga Kuschel[3], Joachim Wollschläger[3], Laurence Bouchenoire[4,5], Simon D. Brown[4,5], Jan-Michael Schmalhorst[1], Günter Reiss[1], and Timo Kuschel[1,6] — [1]CSMD, Physics Department, Bielefeld University, Germany — [2]ALS, Berkeley, California, USA — [3]Fachbereich Physik, Universität Osnabrück, Germany — [4]XMaS, ESRF, Grenoble, France — [5]University of Liverpool, UK — [6]University of Groningen, The Netherlands

In this project, we investigate thermal transport phenomena by separating the anomalous Nernst effect (ANE) contribution (intrinsic and proximity-induced) from the spin Seebeck effect (SSE) voltage on sputter-deposited $Pt/NiFe_2O_{4-x}$ samples. On one hand, we observe a distinct increase of the SSE with the increase of the bandgap energy and the decrease of conductivity, whereas the ANE decreases. On the other hand, a proximity-induced ANE could only be identified in the metallic $Pt/Ni_{33}Fe_{67}$ bilayer. This was verified by the investigation of static magnetic proximity effects via x-ray resonant magnetic reflectivity [1-3]. Further, we determined a maximum moment of 0.48 μ_B per spin-polarized Pt atom in the $Pt/Ni_{33}Fe_{67}$ bilayer.

[1] T. Kuschel et al., Phys. Rev. Lett. 115, 097401 (2015)
[2] T. Kuschel et al., IEEE Trans. Magn. 52, 4500104 (2016)
[3] C. Klewe et al., Phys. Rev. B 93, 214440 (2016)

15 min. break.

MA 50.6 Thu 11:00 HSZ 403

Pumping laser excited spins through MgO barriers — •Ulrike Martens[1], Jakob Walowski[1], Thomas Schumann[1], Maria Mansurova[1], Alexander Boehnke[2], Torsten Huebner[2], Guenter Reiss[2], Andy Thomas[3], and Markus Muenzenberg[1] — [1]Institut für Physik, EMAU Greifswald, Germany — [2]CSMD, Physics Department, Bielefeld University, Germany — [3]Institute for Metallic Materials, IFW Dresden, Germany

We present a study of the tunnel magneto-Seebeck (TMS) effect in MgO based magnetic tunnel junctions (MTJs). The electrodes consist of CoFeB with in-plane magnetic anisotropy. The temperature gradients which generate a voltage across the MTJs layer stack are created using laser heating. Using this method, the temperature can be controlled on the micrometer length scale: here, we investigate, how both,

the TMS voltage and the TMS effect, depend on the size, position and intensity of the applied laser spot. For this study, a large variety of different temperature distributions was created across the junction. We recorded two-dimensional maps of voltages generated by heating in dependence of the laser spot position and the corresponding calculated TMS values. The voltages change in value and sign, from large positive values when heating the MTJ directly in the centre to small values when heating the junction on the edges and even small negative values when heating the sample away from the junction. Those zero crossings lead to very high calculated TMS ratios.
Funding by DFG SPP 1538 is acknowledged

MA 50.7 Thu 11:15 HSZ 403

Thermally Induced Spin Transfer Torque on MgO-based magnetic tunnel junctions using microresonators — •Hamza Cansever[1,2], Ciaran Fowley[1], Rysard Narkovicz[1], Ewa Kowalska[1,2], Yuriy Aleksandrov[2], Oguz Yildirim[1], Aleksandra Titova[1,2], Kilian Lenz[1], Jürgen Lindner[1], Jürgen Fassbende[1], and Alina M. Deac[1] — [1]Helmholtz Zentrum Dresden Rossendorf Institute of Ion Beam Physics and Materials Research — [2]TU Dresden Institute of Solid State Physics

Magnetic tunnel junctions have been commonly used in spintronics applications, such as magnetic random access memory (M-RAM), spin transfer torque RAM (STT-RAM) and hard disc drive (HDD) because of high storage capacity. A spin polarized current flowing through a ferromagnetic layer can exert spin-transfer-torque (STT) on the local magnetization. When we apply thermal gradient across the junction we can induce what is called thermal spin transfer torque (T-STT). In this study, the microresonator FMR technique is used in order to analyze how the ferromagnetic resonance signal corresponding to the free layer of an in-plane MgO-based tunnel junction device is modified in the presence of a temperature gradients across the barrier. Details of resonator fabrication and preliminary measurements are presented. This work is supported by DFG-SPP1538.

MA 50.8 Thu 11:30 HSZ 403

Quantitative separation of the anisotropic magnetothermopower and planar Nernst effect by the rotation of an in-plane thermal gradient — •Oliver Reimer[1], Daniel Meier[1], Michel Bovender[1], Lars Helmich[1], Jan-Oliver Dreessen[1], Jan Krieft[1], Jan-Michael Schmalhorst[1], Andreas Hueutten[1], Guenter Reiss[1], and Timo Kuschel[1,2] — [1]CSMD, Physics Department, Bielefeld University, Germany — [2]University of Groningen, The Netherlands

A ferromagnet exposed to a thermal gradient ∇T in an external magnetic field $\vec{H}$ generates a spin current parallel to ∇T (longitudinal spin Seebeck effect [1]) which can be detected in materials with high spin orbit coupling (e.g. Pt) by the inverse spin Hall effect. Up to now, all spin caloric experiments employ a spatially fixed ∇T. The use of a recently reported new experimental setup allows the rotation of an in-plane ∇T [2]. In this talk, it will be shown, that combined with a rotatable external magnetic field, the rotation of ∇T reveals a phase shift of the magnetothermopower angular dependence with respect to the magnetization direction in a permalloy thin film. Supported by a theoretical model this phase shift allows to unambiguously separate the Seebeck voltage, the anisotropic magnetothermopower and the planar Nernst effect within one experiment.

[1] K. Uchida et al., Appl. Phys. Lett. 97, 172505 (2010)
[2] O. Reimer et al., arXiv: 1609.08822 (2016)

MA 50.9 Thu 11:45 HSZ 403

Insights into the spin-orbit coupling mediated thermoelectric properties of half metallic full Heusler alloys — •Voicu Popescu and Peter Kratzer — Faculty of Physics and CENIDE, University Duisburg-Essen, 47057 Duisburg, Germany

We have performed first-principles investigations on the native defects in the half-metallic ferromagnetic full Heusler alloys Co$_2$TiZ (Z one of the group IV elements Si, Ge, Sn). We modelled the defects as dilute alloys, and treated them in the coherent potential approximation within the framework of the full potential spin-polarized relativistic Korringa-Kohn-Rostoker Green function method. The self-consistent potentials determined this way were used to calculate the residual resistivity via the Kubo-Greenwood formula and, based on its energy dependence, the Seebeck coefficient of the systems. The latter is shown to depend significantly on the type of defect, variations that are related to subtle changes in the electronic structure around the half-metallic gap induced by the spin-orbit coupling. Amongst the different investigated intrinsic defects, two of them exhibit a negative Seebeck coefficient, in good agreement with the available experimental data.