HL 25: Transport

Time: Monday 15:45–18:15 Location: POT 151

HL 25.1 Mon 15:45 POT 151

Transport properties of BiTe-SbTe superlattices — •Bogdan Yavorsky[1], Nicki Hinsche[1], Peter Zahn[1], Martin Gradhand[2], Michael Czerner[3], and Ingrid Mertig[1,2] — [1]Institut für Physik, Martin-Luther Universität Halle-Wittenberg, D-06120 Halle, Germany — [2]Max-Plank-Institut für Mikrostrukturphysik, D-06099 Halle, Germany — [3]I. Physikalisches Institut, AG Theorie, Justus-Liebig University Giessen, D-35392 Giessen, Germany

During the last decade BiTe-SbTe multilayers attracted much attention due to their enhanced thermoelectric figure of merit compared to the bulk materials. To shed light on the origin of this enhancement, we studied the electronic structure of $(Bi_2Te_3)_x(Sb_2Te_3)_{N-x}$ superlattices with a fully relativistic screened Korringa-Kohn-Rostoker Green's function method. The electrical conductivity was calculated within the relaxation time approximation of the Boltzmann theory. The effect of composition (x) on the transport near the Fermi energy and the consequences for the thermoelectric properties were studied in detail.

HL 25.2 Mon 16:00 POT 151

Thermoelectric properties of strained silicon — •Nicki F. Hinsche[1], Ingrid Mertig[1,2] und Peter Zahn[1] — [1]Martin-Luther-Universität, Institut für Physik, Von-Seckendorff-Platz 1, 06120 Halle/S. — [2]Max-Planck-Institut für Mikrostrukturphysik, Weinberg 2, D-06120 Halle, Germany

Starting from bulk silicon, we study the change in thermoelectric properties due to symmetry breaking in rolled-up and layered Si [1] which might lead to nanostructured thermoelectrics. Valley splitting in strained Si caused by tetragonal distortion was studied recently with respect to the enhancement of electron mobility [2]. Our results show that the tetragonal distortion has a strong influence on the electronic transport properties. The electronic structure is calculated self consistently within the framework of density functional theory. The transport properties are studied in the diffusive limit applying the Boltzmann theory in relaxation time approximation [3]. In detail, the anisotropy of the electrical conductivity, the thermopower and the resulting powerfactor in the in-plane and off-plane directions are studied in dependence on strain, doping level and temperature [4]. It is shown, that the powerfactor at a given temperature can be enhanced slightly by strain for p-doping, while no enhancement is obtained for n-doping.

[1] F. Cavallo, W. Sigle, and O. Schmidt. *Journal of Appl. Phys.* **103**, 116103 (2008). [2] T. Dziekan, P. Zahn, V. Meded, and S. Mirbt. *Phys. Rev. B* **75**, 195213 (2007). [3] I. Mertig. *Reports on Progress in Physics* **62**, 237 (1999). [4] N.F. Hinsche, I. Mertig and P. Zahn. *submitted*, 2010.

HL 25.3 Mon 16:15 POT 151

Modification of the functional and mechanical properties of Lead Telluride for thermoelectric energy conversion — •Andreas Schmitz, Peter Schorn, and Eckhard Müller — Deutsches Zentrum für Luft- und Raumfahrt e.V., Institut für Werkstoff-Forschung, Linder Höhe, 51147 Köln

Thermoelectric Generators are solid state devices using the Seebeck effect to transform heat differences straight into electricity. Lead telluride is a classical candidate material for thermoelectric conversion in a middle temperature range (250 to 550 °C) and has been used in thermoelectric generator applications for many years. Still the disad*vantageous mechanical properties implicate difficulties for module production and application such as automotive waste heat recovery.

The manufacturing of thermoelectric elements from powders by hot pressing and consecutive pressureless annealing of PbTe leads to a shift of the thermoelectric properties and improved mechanical properties of the material compared to cast PbTe.

Doping is used to optimize the thermoelectric properties of PbTe but may also have an effect on the material*s mechanical properties. Especially doping with acceptor elements has resulted in an increased brittleness of the compound.

In this study the simultaneous effect of doping on the thermoelectric and mechanical properties of sintered PbTe has been studied with a focus on improving mechanical stability and ductility.

HL 25.4 Mon 16:30 POT 151

Tunable transverse rectification in density-modulated 2D-systems — •Andy Quindeau[1], Arkadius Ganczarczyk[1], Martin Geller[1], Axel Lorke[1], Dirk Reuter[2], and Andreas D. Wieck[2] — [1]Experimental Physics and CeNIDE, Universität Duisburg-Essen — [2]Chair of Applied Solid State Physics, Ruhr-Universität Bochum

We investigate tunable transverse rectification in a density-modulated two-dimensinal electron gas (2DEG) at temperatures between 1.8 K and 200 K. The 2DEG is patterned into a Hall bar geometry. Using gate electrodes we induce two stripes of different charge carrier densities running parallel to the channel. The resulting density gradient perpendicular to the channel induces a transverse voltage, which - due to the symmetry of the device - does not change polarity when the current direction is reversed. The experimental results can be reproduced to some extent using a simple ballistic billiard model [1, 2].

To acquire a deeper insight into the physics behind this transverse rectification effect, further experiments and theoretical approaches are presented. For example, we study the voltage probes potentials of an ungated 2DEG-hallbar, where a parabolic source-drain voltage and temperature dependence can be observed. Furthermore, first theoretical results, based on the Boltzmann equation in the relaxation time approximation [3], give further insights into the observed experimental data.

[1] A. Ganczarczyk *et al.*, preprint:arXiv:0804.0689v3 (2009).
[2] A. Ganczarczyk *et al.*, AIP Conf. Proc. 1199, 143 (2009).
[3] S. Rojek, D. Urban, F. Hucht, and J. König, unpublished.

HL 25.5 Mon 16:45 POT 151

Giant negative photoresistance of ZnO single crystals — •Jose Barzola-Quiquia[1], Pablo Esquinazi[1], Silvia Heluani[2], Manuel Villafuerte[3], and Andreas Pöppl[4] — [1]Division of Superconductivity and Magnetism, University of Leipzig, D-04103 Leipzig, Germany — [2]Laboratorio de Física del Sólido, Dpto. de Física, FCEyT, Universidad Nacional de Tucumán, 4000 S. M. de Tucumán, Argentina — [3]Dpto. de Física, Laboratorio de Física del Sólido, FCEyT, Universidad Nacional de Tucumán, Argentina and CONICET, 4000 S. M. de Tucumán, Argentina — [4]Division of Magnetic Resonance of Complex Quantum Solids, University of Leipzig, D-04103 Leipzig, Germany

ZnO is a wide band gap semiconductor exhibiting the largest charge-carrier mobility among oxides. ZnO is a material with potential applications for short-wavelength optoelectronic devices, as a blue light emitting diodes and in spintronics. In this contribution we have measured the temperature dependence (30 K $<$ T $<$ 300 K) of the electrical resistance of ZnO single crystals prepared by hydrothermal method in darkness and under the influence of light in the ultraviolet range. The resistance decreases several orders of magnitude at temperatures T $<$ 200 K after illumination. Electron paramagnetic resonance studies under illumination reveal that the excitation of Li acceptor impurities is the origin for the giant negative photoresistance effect. Permanent photoresistance effect is also observed, which remains many hours after leaving the crystal in darkness.

15 min. break

HL 25.6 Mon 17:15 POT 151

Thermal Probing of Heat Generation in Biased Silicon Nanowires — •Fabian Menges[1,2], Heike Riel[1], Andreas Stemmer[2], and Bernd Gotsmann[1] — [1]IBM Research - Zurich, 8803 Rueschlikon, Switzerland — [2]ETH Zurich, 8092 Zurich, Switzerland

The limited spatial resolution of conventional thermal imaging techniques hinders the local thermophysical characterization of nanoscale electronic devices. In contrast, the demand to study heat conduction and generation in nanosystems is steadily increasing. While novel materials and device geometries tend to impede heat conduction, localized regions of increased heat generation, so-called "hot spots", limit device performance and reliability. New methods are needed to understand the manifold coupling between thermal, electrical and structural device properties. To address this issue, a vacuum-operated scanning thermal microscope was developed to allow for thermal characterization of active nanoscale electronic devices. The key element of the microscope is a microfabricated heatable silicon probe, which allows probing temperature distributions with lateral resolution below 20 nm. Self-heating of a silicon nanowire was studied in-situ as a function of applied voltages. The observed temperature distributions are governed by the ratio of heat conduction along the nanowire and heat dissipation across the nanowire-substrate interface. Furthermore, nanoscopic thermal hot spots were observed at internal junctions of a silicon nanowire diode as a function of current direction. The results are discussed in relation to nanoscale thermal management in electronic devices.

HL 25.7 Mon 17:30 POT 151

Controlling the transport properties of InAs nanowires by Si doping — •Karl Weis[1,3], Stephan Wirths[1,3], Andreas Winden[1,3], Kamil Sladek[1,3], Thomas Weirich[2,3], Thomas Schäpers[1,3], Hilde Hardtdegen[1,3], Hans Lüth[1,3], Nataliya Demarina[1,3], and Detlev Grützmacher[1,3] — [1]Institut für Bio- und Nanosysteme (IBN), Forschungszentrum Jülich, Germany — [2]Gemeinschaftslabor für Elektronenmikroskopie, RWTH Aachen, Germany — [3]JARA, Fundamentals of Future Information Technology

InAs nanowires are attractive building blocks for nanoelectronic devices, e. g. field-effect transistors. For concrete applications, it is important to understand the interplay between their crystal structure and transport properties. By doping, the latter can be tuned.

We fabricated InAs nanowires by selective-area metal-organic vapour phase epitaxy. Using Si_2H_6 as a dopant, samples with five different doping levels, each set comprising 30 to 100 nanowires (typical length and diameter: $3\,\mu$m and 100 nm, respectively), were prepared.

From *I-V* measurements and field effect transistor measurements using a SiO_2 back gate, we get a clear positive correlation between doping level and conductivity/carrier concentration/mobility. The conductivity can be tuned between (12.9 ± 0.8) S/cm and (560 ± 120) S/cm. Furthermore, transmission electron micrographs show an influence of doping on the crystal structure of the wires. Magneto-transport measurements are performed to quantify the effect of stacking faults on the conductivity. At low temperatures around 4 K, the *I-V* characteristics show indications of single electron tunneling.

HL 25.8 Mon 17:45 POT 151

Field dependent transport properties and conductance fluctuations of InSb nanowires — •huijun yao[1], h. yusuf günel[1], christian blömers[1], weis karl[1], yennai wang[2], jia grace lu[2], detlev grützmacher[1], and thomas schäpers[1] — [1]Institute of Bio- and Nanosystems (IBN1) and JARA-FIT Jülich-Aachen Research Alliance, Research Center Jülich GmbH, D-52425 Jülich, Germany — [2]Department of Physics & Astronomy, University of Southern California, Los Angeles, California, 9008-0484, USA

Due to the precise structural control, semiconductor nanowires provide a new class of nanoscale building blocks for a broad range of disciplines like quantum optics, electronics, nanosensing, and biotechnology. In this respect, InSb- based nanowires are very promising candidates for applications in spintronics and spin-based quantum information technology, owing to the fact that bulk InSb has a high electron mobility, a strong spin-orbit coupling and a narrow band gap (0.16 eV) at room temperature. The measured InSb nanowires were synthesized by using a physical vapor transport method with gold nanoparticles as a catalyst. The basic transport parameters, e.g., conductivity, electron concentration, and mobility were determined by performing current-voltage and back-gate field-effect measurements in the temperature range from 4.2 to 300 K. Universal conductance fluctuations were studied systematically by performing magnetotransport measurements at temperature down to 0.3 K. From the root-mean square of the fluctuation amplitude and from the correlation field Bc information on the phase-coherence length was obtained.

HL 25.9 Mon 18:00 POT 151

Anomalous galvanomagnetism, cyclotron resonance and microwave spectroscopy of topological insulators — •Ewelina M. Hankiewicz and Grigory Tkachov — Würzburg University

The surface quantum Hall state, magneto-electric phenomena and their connection to axion electrodynamics have been studied intensively for topological insulators. One of the obstacles for observing such effects comes from nonzero conductivity of the bulk. To overcome this obstacle we propose to use an external magnetic field to suppress the conductivity of the bulk carriers. The magnetic field dependence of galvanomagnetic and electromagnetic responses of the whole system shows anomalies due to broken time-reversal symmetry of the surface quantum Hall state, which can be used for its detection. In particular, we find linear bulk dc magnetoresistivity and a quadratic field dependence of the Hall angle, shifted rf cyclotron resonance, nonanalytic microwave transmission coefficient and saturation of the Faraday rotation angle with increasing magnetic field or wave frequency [1].

[1] G. Tkachov and E. M. Hankiewicz, arXiv:1011.2756 (2010).