HL 102: Quantum dots and wires: Transport

Time: Friday 11:15–13:15 Location: H13

HL 102.1 Fri 11:15 H13

Momentum matching in magnetotunneling spectrocopy on quantum dots coupled to a two-dimensional electron gas — •D. Zhou[1], A. Beckel[1], B. Marquardt[1], A. D. Wieck[2], D. Reuter[2], M. Geller[1], and A. Lorke[1] — [1]Faculty of Physics and CENIDE, University of Duisburg-Essen, Germany — [2]Chair for Applied Solid State Physics, Ruhr-Universität Bochum, Germany

We present results from magnetotunneling spectroscopy of self-assembled InAs QDs, weakly coupled to a 2DEG by a GaAs/AlGaAs tunneling barrier. The QDs are embedded in a heterostructure field-effect-transistor using the 2DEG as reservoir as well as detector. A magnetic field applied in the plane of the 2DEG is used to shift the alignment of the wave functions of the two systems in momentum-space. A time-resolved measurement technique is employed to directly determine the tunneling rates as a function of the magnetic field [1].

We find a strong suppression of the tunneling current by almost two orders of magnitude for fields up to 12 T. However, we find an enhancement in tunneling rates for small magnetic fields (<4 T). Comparison between the calculated and measured tunneling probabilities allows us to obtain detailed information on the QD states, such as size and anisotropy of the wave functions. We conclude that resonant tunneling between the dots and the 2DEG is affected by a nonvanishing momentum component perpendicular to the tunneling current even without an applied magnetic field, i. e. a momentum mismatch that significantly affects the tunneling probability.

[1] A. Beckel et al., Appl. Phys. Lett. **100**, 232110 (2012).

HL 102.2 Fri 11:30 H13

Magnetotransport in nanostructured InAs-based High Electron Mobility Transistors — •Olivio Chiatti[1], Sven S. Buchholz[1], Wolfgang Hansen[2], and Saskia F. Fischer[1] — [1]Neue Materialien, Institut für Physik, Humboldt-Universität zu Berlin, D-10099 Berlin — [2]FG Wachstum, Institut für Angewandte Physik, Universität Hamburg, D-20148 Hamburg

The controlled creation, manipulation and detection of spin-polarized currents entirely by electrical means is the holy grail of spintronics. A possible tool to this end is the spin-orbit coupling in narrow-gap semiconductors, which couples the momentum (orbital motion) of an electron to its spin. Using nanostructures to filter specific momentum modes using electric fields, it should be possible to create and detect spin-polarized currents. [1] Recently, quantum point contacts (QPCs) fabricated in nominally symmetric InAs quantum well structures have been reported to generate spin-polarized currents, when asymmetric gate voltages are applied. [2]

We have fabricated QPCs with in-plane gates in InAs quantum well structures, and performed magnetotransport measurements at temperatures down to 300 mK and in magnetic fields up to 10 T. We investigate the effects of symmetric and asymmetric gate voltages. Here, we present the results of our measurements and discuss their implications for investigations of the spin-orbit coupling in InAs.

[1] Silsbee, *J. Phys.: Condens. Matter* **16**, R179 (2004)
[2] Debray *et al.*, *Nature Nanotech.* **4**, 759 (2009)

HL 102.3 Fri 11:45 H13

Magnetically induced quantized electron transport through localized magnetic fields in a quantum point contact — •Bernd Schüler, Mihai Cerchez, Hengyi Xu, and Thomas Heinzel — Heinrich Heine University Düsseldorf, Condensed Matter Laboratory, Universitätsstr. 1, 40225 Düsseldorf, Germany

Quantum Dots (QD) in two-dimensional electron gases are typically defined by nano-patterned gate electrodes [1]. While magnetically confined QDs have been proposed theoretically to show some specific phenomena [2], their experimental implementation is still at an early stage [3]. We have designed a ferromagnet/semiconductor hybrid structure device which allows us to form a QD by combining electrostatic potentials with localized magnetic fields in the form of two magnetic spikes at sub-micron distances. While numerical simulations of this system predict Coulomb blockade in the closed regime and Fano type resonances in the open system [4], we observe experimentally transmission resonances in the open system which can be interpreted as signatures of zero-dimensional states weakly bound by the magnetic field profile.

[1] see, e.g., L. P. Kouwenhoven et al., in Mesoscopic Electron Transport, Series E: Applied Sciences (Eds. L. L. Sohn, L. P. Kouwenhoven and G. Schon (Kluwer, 1997). [2] S.J. Lee et al., Phys. Rep. 394, 1, 2004 [3] A. Tarasov et al., Phys. Rev. Lett. 104, 186801, 2010 [4] H. Xu et al. Phys. Rev. B 84, 035319, 2011

HL 102.4 Fri 12:00 H13

Magnetization of modulation-doped quantum dots prepared from InP/InGaAs heterostructures — •Florian Herzog[1], Benedikt Rupprecht[1], Susanne Goerke[1], Marc Wilde[1], Thomas Schäpers[2], Hilde Hardtdegen[2], Sebastian Heedt[2], Christian Heyn[3], and Dirk Grundler[1] — [1]Physik.-Dep. E10, TU München, D-85748 Garching — [2]Peter Grünberg Institute (PGI-9), FZ Jülich, D-52425 Jülich — [3]Institute of Applied Physics, University of Hamburg, D-20355 Hamburg

High-mobility 2D electron systems (2DESs) formed in modulation-doped InP/InGaAs heterostructures exhibit strong spin-orbit coupling due to both Rashba and Dresselhaus effects. We etched arrays of mesoscopic (diameter $d = 3$ μm) and nanoscopic dots ($d = 400$ nm) out of 2DESs to study the effect of lateral confinement on spin-orbit coupling. On such samples, we performed highly sensitive torque magnetometry at a few 100 mK. We report de Haas-van Alphen oscillations in the magnetization for both mesoscopic and nanoscopic dots observed up to a filling factor of $\nu = 28$. Electron densities are found to be as large as for the unpatterned 2DESs, but oscillation amplitudes are drastically smaller. We attribute this to a depletion region at the dot borders. Financial support by the DFG via the priority program “SPP 1285 - semiconductor spintronics” and NIM is gratefully acknowledged.

HL 102.5 Fri 12:15 H13

Investigation of Spin-Orbit Coupling in Differently Doped InAs Nanowires — •Sebastian Heedt[1], Thomas Gerster[1], Isabel Wehrmann[1,2], Kamil Sladek[1], Hilde Hardtdegen[1], Detlev Grützmacher[1], and Thomas Schäpers[1,3] — [1]Peter Grünberg Institut (PGI-9) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]OSRAM Opto Semiconductors GmbH, 93055 Regensburg, Germany — [3]II. Physikalisches Institut, RWTH Aachen University, 52056 Aachen, Germany

Low-temperature quantum transport is presented for top-gated InAs nanowires prepared by selective area metalorganic vapor phase epitaxy. The carrier concentration and the band profile can be controlled by means of doping or the application of a gate voltage. Phase-coherent transport is investigated for temperatures down to 30 mK and magnetic fields up to 10 T. Utilizing an analytical model for the low-field quantum conductivity correction, we are able to extract the phase coherence length l_ϕ and the spin relaxation length l_{so}. The model applies for diffusive wires with diameters falling short of l_ϕ. It accounts for spin relaxation under linear Rashba and linear and cubic Dresselhaus spin-orbit coupling. To investigate these effects, superimposed universal conductance fluctuations have to be eliminated by averaging magnetic field dependent measurements across a wide gate voltage range. Thus, individual nanowires with different doping concentrations are investigated to gain information on how the doping of the highly spin-orbit coupled InAs nanowires impacts the spin-lifetime.

HL 102.6 Fri 12:30 H13

Electrical characterization of free-standing GaAs nanowires by multitip STM — •Stefan Korte[1], Vasily Cherepanov[1], Bert Voigtländer[1], Matthias Steidl[2,3], Weihong Zhao[2,3], Peter Kleinschmidt[2,3], Thomas Hannappel[2,3,4], and Werner Prost[5] — [1]Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, 52425 Jülich, Germany, and JARA-Fundamentals of Future Information Technology — [2]TU Ilmenau, Institut für Physik, Fachgebiet Photovoltaik, D-98684 Ilmenau — [3]Helmholtz-Zentrum Berlin, Institut Solare Brennstoffe und Energiespeichermaterialien, D-14109 Berlin — [4]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik, D-99099 Erfurt — [5]Center for Semiconductor Technology and Optoelectronics (ZHO), University of Duisburg-Essen, Germany

III-V semiconductor nanowires are promising candidates for future solar cell designs. p-doped GaAs nanowires are grown on an n-doped GaP(111)B substrate by Au-assisted metal-organic vapor-phase epitaxy (MOVPE). For electrical characterization these free-standing nanowires were contacted using a multitip STM. Four point probe measurements reveal their electrical transport properties. The conductance profile along the nanowires and the diode characteristics of the pn-junction to the substrate were measured. Also the elastic mechanical deformation of nanowires and the influence of bending on their resistance has been studied.

HL 102.7 Fri 12:45 H13

Ultrafast photocurrents and THz generation in single InAs-nanowires — •Nadine Erhard[1], Paul Seifert[1], Leonhard Prechtel[1], Simon Hertenberger[1], Helmut Karl[2], Gerhard Abstreiter[1], Gregor Koblmüller[1], and Alexander W. Holleitner[1] — [1]Walter Schottky Institut, TU München, 85748 Garching, Germany — [2]Institute of Physics, University of Augsburg, 86135 Augsburg, Germany

We apply a recently developed pump-probe photocurrent spectroscopy to clarify the ultrafast temporal interplay of the different photocurrent mechanisms occurring in single InAs-nanowire-based circuits with a picosecond time-resolution [1]. The data are interpreted in terms of a photo-thermoelectric current and the transport of photogenerated holes to the electrodes as the dominating ultrafast photocurrent contributions. Moreover, THz radiation is generated in the optically excited InAs-nanowires, which is interpreted in terms of a dominating photo-Dember effect [2]. The results are relevant for nanowire-based optoelectronic and photovoltaic applications as well as for the design of nanowire-based THz sources. Financial support by the ERC-grant NanoREAL is acknowledged.

[1] L. Prechtel, M. Padilla, N. Erhard, H. Karl, G. Abstreiter, A. Fontcuberta i Morral, and A. W. Holleitner, Nano Lett. 12, 2337 (2012).

[2] Nadine Erhard et al., Annalen der Physik (2013).

HL 102.8 Fri 13:00 H13

Optoelectronic properties of individually positioned InAs nanowires — •Jan Overbeck, Andreas Brenneis, Julian Treu, Simon Hertenberger, Gerhard Abstreiter, Gregor Koblmüller, and Alexander Holleitner — Walter Schottky Institut and Physik-Department, TU München, 85748 Garching, Germany

Small bandgap semiconducting nanowires offer a promising approach to fabricating nanoscale light-sensitive devices like broadband solar cells or mid-infrared photodetectors. We discuss the optoelectronic properties of individually positioned InAs nanowires on p-Si(111) substrates. The substrates exhibit a top layer of SiO_2 which is structured via e-beam lithography creating holes in the oxide with a diameter of ~ 80 nm. The nanowires are then grown vertically on the patterned substrates by solid-source molecular beam epitaxy. To fabricate optoelectronic devices, the nanowires are subsequently contacted via a thin, semitransparent metal film evaporated on top of an insulating layer (BCB). The p-Si substrate forms the second contact of the optoelectronic two-terminal devices. We discuss spatially resolved photocurrent measurements which give insights into the interplay of optoelectronic dynamics in single nanowires and in the Si-substrates.