HL 33: Poster I: Transport, including Magnetic-Field Effects

Time: Tuesday 18:30–20:30 Location: Poster D1

HL 33.1 Tue 18:30 Poster D1

Atomistic Description of Large Nanostructures based on III-Nitride semiconductors — •Alejandro Molina-Sánchez[1], Alberto García-Cristóbal[1], Andres Cantarero[1], Aleksandrs Terentjevs[2], and Giancarlo Cicero[2] — [1]Instituto de Ciencia de Materiales de la Universidad de Valencia, P.O. Box 22085, E-46071 Valencia, Spain — [2]Physics and Materials Science and Chemical Engineering Departments, Politecnico di Torino, C.so Duca degli Abruzzi 24, 10129 Torino, Italy

Semiconductor nanocolumns exhibiting a growth without dislocatinos and high crystalline quality are of great interest in nanotechnology applications. Specifically, InN-based nanocolumns are good candidates to develop multi-junction solar cells due to their small gap, 0.67 eV, and the posibility of alloying with other nitrides (as GaN and AlN) to cover the entire solar spectrum. A proper description of optical properties of the nanostructures described above can start with an atomistic treatment of the electronic structure in order to keep the essential geometry and symmetry of the objects. Unfortunately, the best description realized with ab initio electronic structure software is strongly limited by the nanocolumn diameter to a few nanometers. By using a combination of ab initio and empirical tight-binding methods, we can connect the quality of the first principles calculations (performed with the Espresso code), with the versatility of an empirical approach. Once we have an ab initio quality parameter set for the empirical tight-binding code, we can study larger nanostructures with this approach, reducing the computation time in orders of magnitud.

HL 33.2 Tue 18:30 Poster D1

Non-linear properties of ballistic electron-focusing devices — •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

This poster has been withdrawn.

HL 33.3 Tue 18:30 Poster D1

Transport through a molecular junction within P(E)-theory — •Denis Kast and Joachim Ankerhold — Institut für Theoretische Physik, Universität Ulm

Directed charge transfer in isolated molecular aggregates originates from a fluctuating environment consisting e.g. of internal vibronic modes or solvent degrees of freedom. Corresponding transfer rates can be derived within the P(E)-formalism known from the theory of Coulomb-blockade in single charge transfer. This methodology can be extended to describe incoherent charge transport through molecular junctions including the electromagnetic environment of the actual circuitry. We present first results for simple molecular junctions and for internal vibronic degrees of freedom in and out of thermal equilibrium. Findings are compared with data from real-time Quantum Monte Carlo simulations.

HL 33.4 Tue 18:30 Poster D1

Electrical Properties of Graphene- Carbon Nanotube junction — •Pablo Thomas Robert, Julien Bordaz, Romain Danneau, and Frank Hennrich — Karlsruher Institut für Technologie, Campus Nord, Institut für Nanotechnologie

Since it has been in 2004 first isolated, it has become one of the hottest research topics in condensed matter physics. The peculiar band structure of this zero-gap semiconductor leads to novel electronics properties and mades it a high promising material for electronic devices. Our aim is to study the electrical transport properties of graphene-nanotube hybrid carbon systems by carrying out 4 point-probe measurements and the graphene/carbon nanotube interface resistance. We want to compare those measurements with the ones obtained when using the metal electrodes standard technique to connect the graphene sheet.

To fabricate our probes, we first deposit on highly doped silicon substrates some graphene by mechanical exfoliation of graphite. After spin-coating a multi-walled carbon nanotube solution on the probe, the nanotubes are then dragged on the graphene sheet using an atomic force microscope in non-contact mode. We also pattern metal contacts on the graphene sheet using standard electron beam lithography followed by ultra-high vacuum metal evaporation.

HL 33.5 Tue 18:30 Poster D1

Pure orbital photocurrents in (111) Si-MOSFETs — •J. Kamann[1], J. Karch[1], P. Olbrich[1], S.A. Tarasenko[2], E.L. Ivchenko[2], T. Schönberger[1], Z.D. Kvon[3], and S.D. Ganichev[1] — [1]THz Center, University of Regensburg, Regensburg, Germany — [2]Ioffe Institute, St. Petersburg, Russia — [3]Institute of Semiconductor Physics, Russian Academy of Sciences, Novosibirsk, Russia

We report on pure orbital photocurrents in (111) grown Si-MOSFET structures. Photocurrents are generated by illumination with a pulsed high power THz laser of several wavelengths. We obtain photon-helicity dependant currents, changing sign when we switch the circular polarization of the incident pulse from left- to righthanded. Furthermore we were able to measure currents that vary with the orientation of linear polarized radiation. In addition to the spin, free carriers in solid states can be characterized by other internal properties, e.g., a valley index in manyvalley semiconductors. In this case, one can consider pure orbit-valley currents, where partial electron fluxes in valleys are nonzero but the net electric current $\sum I_\nu$ vanishes. Here, the role of spin-up and spin-down states is replaced by the valley index: there is no net charge current, but the electrons in different valleys travel in different directions. Si-MOSFETs grown in (111) direction belong to the symmetry group C_{3v}, denying currents that are sensitive to unpolarized or circular polarized radiation under normal incidence. However, a net electric current induced by linearly polarized light is allowed. In this case, the partial fluxes become nonequal and do not compensate each other. This is demonstrated in our experimental results.

HL 33.6 Tue 18:30 Poster D1

Magnetoconductance switching in arrays of oval quantum dots — •Christian Morfonios — PCI Heidelberg

Employing oval shaped quantum billiards connected by quantum wires as the building blocks of a linear quantum dot array, we calculate the ballistic magnetoconductance in the linear response regime. Optimizing the geometry of the billiards, we aim at a maximal finite- over zero-field ratio of the magnetoconductance. This switching effect arises from a relative phase change of scattering states in the oval quantum dot through the applied magnetic field, which lifts a suppression of the transmission characteristic for a certain range of geometry parameters. It is shown that a sustainable switching ratio is reached for a very low field strength, which is multiplied by connecting only a second dot to the single one. The impact of disorder is addressed in the form of remote impurity scattering, which poses a temperature dependent lower bound for the switching ratio, showing that this effect should be readily observable in experiments.

HL 33.7 Tue 18:30 Poster D1

Magneto-Transport Studies on Evenly Curved Two-Dimensional Electron Systems in Semiconductor-Microtubes with Hall Bar Contact-Geometry — •David Sonnenberg, Karen Peters, Stefan Mendach, Andrea Stemmann, and Wolfgang Hansen — Institut für Angewandte Physik und Zentrum für Mikrostrukturforschung, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg, Germany

We present magneto-transport studies on evenly curved two-dimensional electron systems (2DES) in InGaAs-microtubes. The microtubes are fabricated from epitaxial films, by releasing thin strained semiconductor layers from the substrate. Strain relaxation causes the film hosting the 2DES to roll-up into tubes with micrometer sized diameters. The rolled-up 2DES are prepared in a Hall-bar contact-geometry along the curvature of the microtube. Low-temperature magneto-transport measurements are performed with current direction parallel to the modulation of the perpendicular magnetic-field component. An asymmetric behaviour of the Hall resistance in dependence of the magnetic field orientation will be discussed.

HL 33.8 Tue 18:30 Poster D1

Serial arrays of square Quantum Hall devices for resistance standards — •Jens Könemann, Franz-Josef Ahlers, Klaus Pierz, and Hans Werner Schumacher — Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig

Combining several Hall bars in series or in parallel with the help of the multiple series connection technique [1] allow to realize quantum

resistance standards for resistance values from, e.g., 100 Ω to 1 MΩ. One of the necessary checks for verifying such a device as a resistance standard comprises the reversal of the magnetic field orientation. However, for serial arrays such a reversal intrinsically results in different resistance values for the two field orientations. Here, we propose a scheme to circumvent this restriction. It relies on interchanging the voltage and current probes together with the magnetic field inversion using a totally symmetric design based on square Hall bars. First device realizations are presented.

[1] F. Delahaye, J. Appl. Phys., Vol. 73, 7914 (1993).

HL 33.9 Tue 18:30 Poster D1

Anomalous magnetotransport of magnetic 2DHGs in the quantum-Hall regime — •Stefan Knott[1], Ursula Wurstbauer[1], Thomas Hirschmann[1], Werner Wegscheider[2,3], and Wolfgang Hansen[1] — [1]Institut für Angewandte Physik, Universität Hamburg, Germany — [2]Institut für Experimentelle und Angewandte Physik, Universität Regensburg, Germany — [3]Solid State Physics Laboratory, ETH Zürich, Switzerland

The interaction of localized magnetic moments with a two-dimensional hole gas is studied with low-temperature magnetotransport measurements. The hole gas is confined in manganese modulation-doped InAlAs/InGaAs/InAs quantum wells grown by molecular beam epitaxy. If Mn ions are inside the quantum well the holes are strongly localized at zero field, while it shows quantized transport at high field featuring Shubnikov-de Haas oscillations and the quantum-Hall effect. Here we present high-field data that show pronounced deviation from the behavior of samples with no Mn ions in the quantum well: The Hall voltage is neither linear nor monotonous and the 1/B-periodicity is not given anymore. Moreover, a significant weak anti-localization signature is present still at 4.2K in samples without Mn ions in the channel, indicating strong spin orbit coupling. The observed temperature dependency of both types of samples and possible explanations will be discussed.

HL 33.10 Tue 18:30 Poster D1

Collective Excitations of Interacting Two-Dimensional Electrons in High Magnetic Fields — •Guenther Meissner and Uwe Schmitt — Theoretische Physik, Universitaet des Saarlandes, Postfach 151150, D-66041 Saarbruecken

A hierarchy of fractional quantum Hall states at odd-denominator rational filling factors of the lowest Landau level is associated with a correspoding hierarchy of liquid phases. At sufficiently high magnetic fields such liquid phases are terminated by an insulating phase which could be identified as being a quantum solid phase related to the Wigner crystal. Therefore, we have explored, in as far, as a many-body approach for interacting two-dimensional electrons in high magnetic fields [1] is suitable for investigating collective excitations of these states. Composites of 1, 2, and 3 electron charges (e), with 3, 5, and 7 magnetic flux quanta (ch/e), respectively, are considered in view of recent experimental invastigations of magneto-rotons [2]. The anyonic statistics of the resulting fractionally charged quasiparticles of charge e/3, e/5, and e/7 is of importance for studying topological order and might find application for building a topological quantum computer.

[1] G. Meissner, Physica B 184, 66 (1993). [2] I.V. Kukushkin, J.H. Smet, V.W. Scarola, V. Umansky, and K. von Klitzing, Science, 324, 1044 (2009).

HL 33.11 Tue 18:30 Poster D1

Spin photocurrents in diluted magnetic semiconductors — •M. Schmalzbauer[1], P. Olbrich[1], S.D. Ganichev[1], S.A. Tarasenko[2], V.V. Bel'kov[2], Ch. Brinsteiner[1], W. Eder[1], D.R. Yakovlev[2,3], V. Kolkovsky[4], W. Zaleszczyk[4], G. Karczewski[4], T. Wojtowicz[4], and D. Weiss[1] — [1]THz Center, University of Regensburg, Germany — [2]Ioffe Physico-Technical Institute, Rus. Academy of Sciences, St. Petersburg, Russia — [3]Exp. Physics 2, TU Dortmund, Germany — [4]Institute of Physics, Warsaw, Poland

We report on the observation of spin photocurrents resulting from the zero-bias spin separation in diluted magnetic semiconductors (DMS). We show that in (001)-grown (Cd,Mn)Te/(Cd,Mg)Te quantum wells the absorption of THz radiation leads to pure spin currents. Although the electric current is zero, spin up and down carriers pile up on opposed sample edges. By means of an in plane magnetic field $\boldsymbol{B}$ the balance between the spin currents is disturbed due to the Zeeman splitting and leads to a electron flow increasing with $\boldsymbol{B}$. In DMS this conversion is strongly enhanced due to the giant Zeeman splitting and the spin-dependent exchange scattering of e^- by Mn^{2+} ions polarized in the external magnetic field [1]. Both contributions affect the balance between the contrarily spin flows additionally and give rise to the electric current. For weak $\boldsymbol{B}$ and a degenerated 2DEG the scattering mechanism dominates the conversion. We demonstrate the importance of the spin-dependent scattering in the current generation giving an additional access to the manipulation of spin-polarized currents.

[1] S.D. Ganichev *et. al.*, *Phys. Rev. Lett.* **102**, 156602 (2009)

HL 33.12 Tue 18:30 Poster D1

Tuning of Structure Inversion Asymmetry (SIA) by the δ-Doping Position in (001)-Grown GaAs Quantum Wells (QW) — •Vera Lechner[1], Sebastian Stachel[1], Peter Olbrich[1], Leonid Golub[2], Dieter Schuh[1], Werner Wegscheider[1], Vasily Belkov[2], and Sergey Ganichev[1] — [1]Terahertz Center, University of Regensburg, Germany — [2]Ioffe Institute, St. Petersburg, Russia

We demonstrate that the preparation of QWs with various δ-doping layer positions accompanied by measurements of the magnetogyrotropic photogalvanic effect (MGPE) [1] allows to grow samples with controllable SIA. The THz-laser induced MPGE in the presence of an in-plane magnetic field B measured in n-type GaAs structures originates from bulk inversion asymmetry (BIA) and SIA and therefore reflects their behaviour. We show that for a proper experimental geometry, currents measured along and perpendicular to B are proportional to BIA and SIA, respectively [2]. We studied a set of samples with fixed QW width and different δ-doping positions as well as with fixed doping position but different in the QW width. Our experiments prove that shifting the δ-doping layer from one side of the QW to the other results in a change of sign of the SIA-caused MPGE. We were able to grow structures without Rashba constant and structures with equal Rashba and Dresselhaus spin splittings. We also detected a MPGE-caused current in undoped samples via carrier generation with near-infrared light.

[1] V.V. Belkov and S.D. Ganichev, Sem. Sci. Tec. 23, 114003 (2008) [2] V. Lechner et al., Appl. Phys. Lett. 94, 242109 (2009)

HL 33.13 Tue 18:30 Poster D1

Towards a local spin-valve signal in all-semiconductor lateral spin injection devices. — •Christian Wolf, Andreas Einwanger, Mariusz Ciorga, Martin Utz, Dieter Schuh, and Dieter Weiss — Universität Regensburg, Universitätsstrasse 31, D-93040 Regensburg

In our recent experiments [1] we demonstrated a successful all-electrical spin injection and detection scheme in lateral semiconductor devices using (Ga,Mn)As/GaAs spin Esaki diode structures as spin aligning contacts. The experiments were performed in a $non-local$ configuration, i.e., without a charge current flowing between injector an detector contacts.

In this paper we explore a possibility of an observation of a *local* spin-polarized charge current between source an drain in similar devices. According to Fert *et al.*[2] a local spin valve (SV) signal is proportional to $(\rho_N \lambda_{sf}/r_b)\cdot(\lambda_{sf}/L)$, where ρ_N, λ_{sf} are, respectively, the resistivity and spin diffusion length in the semiconducting channel, r_b is the unit area interface resistance and L a source-drain separation. Taking advantage of the relatively low value of r_b in Esaki diode contacts ($\sim 10^{-8}\Omega\cdot m^2$) in our devices, we optimize the latter in order to obtain a measurable local SV signal. The optimization involves (i) increasing a spin diffusion length of the semiconductor channel by lowering its doping and (ii) decreasing the source-drain distance.

[1] M. Ciorga *et al.*, Phys. Rev. B **79**, 165321 (2009)
[2] A. Fert *et al.* IEEE Trans. on Electr. Dev. **54**, 921 (2007).

HL 33.14 Tue 18:30 Poster D1

Linear and non-linear noise spectroscopy of fluctuating signals — •Rachel Fainblat, Sebastian Starosielec, Jörg Rudolph, and Daniel Hägele — AG Spektroskopie der kondensierten Materie, Ruhr-Universität Bochum, Germany

Spin noise spectroscopy has recently become a popular tool for studying incoherent dynamics in semiconductor spin systems. The usually measured (linear) noise power spectrum however can not discriminate between noise mechanisms that yield e.g. either Gaussian or non-Gaussian noise. An extension to non-linear noise spectroscopy is therefore highly desirable. We have implemented a real-time measurement systems that apart from the linear noise spectrum also calculates a non-linear noise spectrum. The non-linear spectrum is based on the square of the original noise signal and contains expectation values up to the fourth order. The non-linear spectrum is especially sensitive to

correlations between spectral frequency components and non-Gaussian behaviour of the noise amplitude. As a demonstration we measure strong frequency correlations in the signal of FM radio broadcasting. On the contrary, the white photon shot noise of a laser above threshold shows no frequency correlations within the measured range from 0 to 90 MHz. We also performed measurements on biased and unbiased resistors (industrial metal-film and carbon) exhibiting white and 1/f-noise, respectively. The possible application of non-linear fluctuation spectroscopy for studying magnetic phase-transitions will be pointed out.

HL 33.15 Tue 18:30 Poster D1

Electron spin relaxation in bulk GaN: Temperature and magnetic field dependence — Jan Heye Buss, Jörg Rudolph, •Henning Hillebrand, and Daniel Hägele — AG Spektroskopie der kondensierten Materie, Ruhr-Universität Bochum, Germany

Spin-orbit coupling (SOC) is the main reason for spin relaxation in most semiconductors (SC). A thorough understanding of SOC is therefore essential, e.g. for the realization of spintronic devices requiring long spin relaxation times. In contrast to the extensive research on SOC in SCs with zinc-blende structure, the effect of SOC on the electron spin dynamics in GaN with wurtzite structure was only rarely studied. We present measurements of the temperature (T = 80 - 300K) and magnetic field (B = 0 - 1T) dependence of the electron spin relaxation time in bulk wurtzite GaN by time-resolved Kerr-rotation. The observed temperature dependence and an intrinsic anisotropy [1] of the spin relaxation are explained by the D'yakonov-Perel mechanism with a k-linear (Rashba-like) and k^3-dependent (Dresselhaus-term) contribution to the conduction band splitting.

[1] J. H. Buss et al., Appl. Phys. Lett. **95**, 192107 (2009)