HL 22: Quantum dots and wires: Transport properties

Time: Tuesday 14:00–15:45 Location: H34

HL 22.1 Tue 14:00 H34

Influence of the Current Density on Universal Conductance Fluctuations in GaN Nanowires — •Patrick Uredat[1,2], Pascal Hille[1,2], Jörg Schörmann[1,2], Martin Eickhoff[3], Matthias T. Elm[1,2], and Peter J. Klar[1,2] — [1]Center for Materials Research, Justus Liebig University, 35392 Giessen, Germany — [2]Institute for Experimental Physics I, Justus Liebig University, 35392 Giessen, Germany — [3]Institute of Solid State Physics, University of Bremen, 28359 Bremen, Germany

We present investigations of the magnetotransport properties of single Ge-doped GaN nanowires grown by molecular-beam epitaxy which exhibit quantum-interference effects at low temperatures. By analyzing the emerging quantum-interference effects the phase-coherence length can be determined in different ways, i.e. based on universal conductance fluctuations (UCF) and weak localization effects. As the phase-coherence length is solely defined by inelastic scattering events the phase-coherence is independent of the current applied. Nevertheless, we show, that the magnitude of the conductance fluctuations rms(ΔG) is strongly affected by the applied current density resulting in an alleged reduction of the obtained phase-coherence length. The decrease of the magnitude rms(ΔG) with increasing current density occurs due to more k-states close to the Fermi energy contributing to the transport which smears out the UCF. We provide a theoretical model to describe the influence of applied current density on the UCF which furthermore enables us to obtain the carrier concentration and carrier mobility of a single Ge-doped GaN nanowires.

HL 22.2 Tue 14:15 H34

Carrier Dynamics in $CuInSe_2$ QD Solids studied by THz Spectrocopy — •Michael Deffner[1,2], Friederieke Gorris[1], Shekhar Priyadarshi[1], Christian Klinke[3], Horst Weller[1,2], and Holger Lange[1,2] — [1]Insitute for Physical Chemistry, University Hamburg, Hamburg, Germany — [2]The Hamburg Centre for Ultrafast Imaging, Hamburg, Germany — [3]Department of Chemistry, Swansea University, United Kingdom

$CuInSe_2$ (CIS) is a cheap, low toxic and stable material to be used as an absorber in solar cells. It has a high absorption coefficient and a tunable optical bandgap [1].

Here, the transport properties of quantum dot (QD) films prepared with colloidal $CuInSe_2$ QDs are studied using optical-pump-terahertz-probe. Using post-synthesized ligand exchange, the transport properties can be increased significantly and the low conductance of this QD solid can be overcome.

Our studies confirm the results of traditional four-point or FET-based measurements and show a much higher carrier mobility after photo-excitation for QD films with specific bridging ligands. Nevertheless, the responses of the films are distinctly different for different ligands and will be discussed in this talk.

[1] Nano Lett. 2008, 8, 9, 2982-2987

HL 22.3 Tue 14:30 H34

A quantum-dot heat engine operating close to the thermodynamic efficiency limits — •Martin Josefsson, Artis Svilans, Adam Bruke, Eric Hoffmann, Sofia Fahlvik, Claes Thelander, Martin Leijnse, and Heiner Linke — NanoLund and Solid State Physics, Lund University, Sweden

Particle-exchange heat engines work by using an energy filter to control a thermally driven particle flow between two or more reservoirs at different temperatures. These engines have been predicted to reach the same ideal thermodynamic efficiency limits as those accessible to classic cyclical engines, but this prediction has never been verified. In this work[1] we realize a thermoelectric particle-exchange heat engine based on a quantum dot embedded in a InAs/InP nanowire. We demonstrate an electronic efficiency at maximum power close to the Curzon-Ahlborn efficiency and at the maximum efficiency ($\approx$ 70% of Carnot efficiency) the QD still produces finite power output equal to roughly half of the maximal amount.

These results were obtained by measuring the engine's steady state power output and combining it with the calculated electronic heat flow. This procedure is made possible by an excellent agreement between the modeled and measured generated current, which allows for a quantitative estimate of the heat flow.

[1] Josefsson et al. Nature Nanotechnology 13, 920 (2018)

HL 22.4 Tue 14:45 H34

Local Density of States Fluctuations and Its Influence on the Fermi-edge-singularity in a Quantum Dot — •Jan K. Kühne and Rolf J. Haug — Institut für Festkörperphysik, Leibniz Universität Hannover, Deutschland

Transport measurements in quantum dots can be used as a spectrometer to study the density of states in the connected leads [1]. By tuning the applied source drain voltage, the current through the quantum dot is changed depending on the number of available states in both leads with the corresponding energy.

We study the transport properties of a self-assembled InAs quantum dot at low temperatures and observe strong fluctuations in the local density of states (LDOS) in dependence of magnetic field B and voltage V. This results in lines of constant differential conductance with a constant slope dB/dV. It is known that interaction effects in quantum dots, such as the Fermi-edge-singularity (FES), strongly depend on the dimensionality and the density of states in the leads [2]. By comparing the LDOS and the interaction due to the FES we find a clear anti-correlation between the strength of the FES and the number of states in the emitter.

[1] T. Schmidt, et al., Phys. Rev. Lett. 78, 1540 (1997).
[2] J. K. Kühne, et al., accepted in Phys. Status Solidi B (2018).

HL 22.5 Tue 15:00 H34

Excess noise in $Al_xGa_{1-x}As$/GaAs based quantum rings — •Christian Riha[1], Sven S. Buchholz[1], Olivio Chiatti[1], Dirk Reuter[2], Andreas D. Wieck[3], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, D-12489 Berlin — [2]Optoelektronische Materialien und Bauelemente, Universität Paderborn, D-33098 Paderborn — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum

The characteristics of electrical noise provide various information about an electronic system. In ballistic 1D quantum devices [1] excess noise was already found to be related to an electron's transmission probability. In this work, cross-correlated noise measurements are performed in etched $Al_xGa_{1-x}As$/GaAs based ballistic quasi 1D quantum rings [2] at a bath temperature of $T_{\mathrm{bath}} = 4.2$ K in equilibrium. The measured white noise exceeds the thermal noise expected from the measured electron temperature T_{e} and the electrical resistance R of the devices. This excess noise decreases as T_{bath} increases and is not observable anymore at $T_{\mathrm{bath}} \geq 12$ K. Furthermore, a reduction of the excess noise is observed when one arm of a quantum ring becomes electrically non-conducting. This excess noise is not observed in 1D-constrictions that share a comparable length and width with the quantum rings. The results suggest that the excess noise is a result of electron interference in the quantum ring.

[1] C. Riha *et al.*, Phys. Status Solidi A **213**, 571 (2016).
[2] C. Riha *et al.*, Appl. Phys. Lett. **106**, 083102 (2015).

HL 22.6 Tue 15:15 H34

Multigate Structures for the Realization of Electrostatically Tunable Devices — •Thomas Grap[1,2], Felix Riederer[1], and Joachim Knoch[1] — [1]Institute of Semiconductor Electronics, RWTH Aachen, Germany — [2]Peter Grünberg Institute 11, FZ Jülich, Germany

One-dimensional (1-D) materials such as nanowires (NW) and nanotubes (NT) have attracted a great deal of attention as buildings blocks of future nanoelectronics systems. This interest is in part due to the small geometry that allows realizing optimum scalability of the devices. In addition, NW and NT enable one-dimensional electronic transport that has a number of benefits such as a rather long mean free path for scattering.

In order to characterize such nanostructures, we developed a template structure, which allows to electrostatically tune 1-D materials on the nanoscale and thus exploit quantum effects. We present a study on a multi-gate device architecture where a large number of buried gates (on the order of 10 and more) are fabricated in a damascenelike process. The gates exhibit lengths well below 10nm and are placed next to each other with a few nanometers inter-gate distance. Each gate is contacted individually via Ebeam-lithography, so that this devicelayout enables a tight control over the potential distribution within a 1-D nanostructure. First measurements of the electronic transport along a VLS-grown InAs-NW by applying appropriate voltages to the buried multi-gates are presented.

HL 22.7 Tue 15:30 H34

Thickness dependence of the magnetic field induced metal-insulator transition in graphite — •Laetitia Paula Bettmann, Jose Luis Barzola Quiquia, Markus Stiller, and Pablo Esquinazi — Division of Superconductivity and Magnetism, Felix-Bloch Institute for Solid State Physics, University of Leipzig, 04103 Leipzig, Germany

We have measured the temperature dependence of the resistance and magnetoresistance of bulk and multigraphene samples prepared from a natural graphite sample from Sri Lanka. The samples were measured at different constant magnetic fields in order to observe the well-known magnetic-field-induced metal-insulator transition in graphite. Our results indicate that the transition has a thickness dependence, i.e. in the case of thin samples (thickness less than 30 nm) this effect vanishes. We attribute the field induced metal-insulator transition to the presence of metallic-like two-dimensional interfaces formed between the crystals, which disappear when the sample thickness is of the order of the single crystalline regions of the sample. Our experimental results can be well understood using a model, which takes explicitly into account the interfaces contributing in parallel to the semiconducting crystalline regions.