HL 75: Quantum Dots: Transport Properties II

Time: Thursday 14:45–16:15 Location: POT 151

Invited Talk HL 75.1 Thu 14:45 POT 151

Spectroscopy on self-assembled quantum dots: Transport meets optics — •Martin Geller — Faculty of Physics and CENIDE, University of Duisburg-Essen, Lotharstr. 1, 47057 Duisburg, Germany

Self-assembled quantum dots (QDs) are nanoscopic semiconductor islands in a crystalline matrix material. After more than 20 years, these "artificial atoms" are still of great interest to study fundamental physics in low-dimensional systems. They have entered commercially available products and have visionary future perspectives in quantum information processing.

After a general introduction, I will summarize the transport (like capacitance-voltage spectroscopy) and optical methods (like micro-photoluminescence) on self-assembled QDs. Afterwards, I will introduce the time-resolved conductance spectroscopy [1] and show a combination of "transport and optics". In an optical detection scheme, based on resonance fluorescence, the electron tunneling (and quantum jumps), photo-induced electron capture and Auger-recombination can be observed time-resolved on a single self-assembled dot [2].

[1] B. Marquardt, et al., Nature Commun. **2**, 209 (2011); A. Beckel, et al., Phys. Rev. B **89**, 155430 (2014). [2] A. Kurzmann, et al., Phys. Rev. Lett. **117**, 017401 (2016); A. Kurzmann, et al., Appl. Phys. Lett. **108**, 263108 (2016); A. Kurzmann, et al., Nano Lett. **16**, 3367 (2016).

HL 75.2 Thu 15:15 POT 151

Thermal energy and charge currents in multi-terminal nanorings — •Christian Riha[1], Tobias Kramer[1,2], Christoph Kreisbeck[1], Olivio Chiatti[1], Sven S. Buchholz[1], Andreas D. Wieck[3], Dirk Reuter[4], and Saskia F. Fischer[1] — [1]Novel Materials Group, Humboldt-Universität zu Berlin, D-12489 Berlin — [2]Zuse-Institut für Informationstechnik, D-14195 Berlin — [3]Angewandte Festkörperphysik, Ruhr-Universität Bochum, D-44780 Bochum — [4]Optoelektronische Materialien und Bauelemente, Universität Paderborn, D-33098 Paderborn

We study thermal energy and charge transfer close to the quantum limit in a ballistic nanodevice experimentally [1] and theoretically [2]. The device consists of multiply connected one-dimensional electron waveguides and is based on an AlGaAs/GaAs heterostructure. A global top-gate steers the thermal energy and charge transfer in the presence of a temperature gradient, which is established by a heating current. Thermal noise measurements allow to estimate the heat transfer and shows the device to act as a switch for charge and thermal energy transfer. Wave-packet simulations, that are based on the multi-terminal Landauer-Büttiker approach, confirm the experimental finding of a mode-dependent redistribution of the thermal energy current, if a scatterer breaks the device symmetry.

[1] C. Riha *et al.*, Appl. Phys. Lett. **106**, 083102 (2015)
[2] T. Kramer *et al.*, AIP Advances **6**, 065306 (2016)

HL 75.3 Thu 15:30 POT 151

Comparison of the carrier transfer properties between an electrolyte and GaInN- and GaNP-nanowires — •Jan Philipps[1], Sara Hölzel[1], Pascal Hille[1], Jörg Schörmann[1], Jan Stehr[2], Irina Buyanova[2], Charles Tu[3], Detlev Hofmann[1], and Martin Eickhoff[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universität Gießen, Germany — [2]Department of Physics, University of Linköping, Sweden — [3]Department of Electrical and Computer Engineering, University of California, San Diego, USA

$Ga_{1-x}In_xN$ nanowires with In concentrations x of about 0.3 and GaP/GaN_xP_{1-x} core/shell nanowires (x $\sim$ 0.08) show interesting properties for the charge carrier transfer from the semiconductor into an electrolyte, which might be used for sensing applications or catalytic water splitting. The transfer can be initiated by visible light and depending on an applied bias electron- or hole-transfers are achieved. The processes can be monitored by photocurrent measurements or in more detail by electron paramagnetic resonance experiments using spin trapping agents. We find that the processes strongly affect the near bandgap emission in $Ga_{1-x}In_xN$ nanowires but have only minor effect on the emission of GaP/GaN_xP_{1-x} nanowires. The results will be discussed in the frame of the surface band bending model of the semiconductor/electrolyte interface.

HL 75.4 Thu 15:45 POT 151

Electron transport through coupled semiconductor quantum dots — •Simon Liebing, Torsten Hahn, and Jens Kortus — TU Bergakademie Freiberg, Institute for Theoretical Physics, Germany

The electronic structure for single- (CdS, ZnSe) and coupled-quantum dots (CdS-ZnSe) were calculated by means of density functional theory (DFT)[1]. Additionally, for the coupled dots we investigated transport characteristics based on NEGF transport theory [2]. We observe that the coupling strength depends strongly on the relative orientation of the dots with respect to the atoms which model the contact.

In contrast to single dots, the current-voltage curves in case of the coupled dot system shows clearly rectification behavior. The rectification can be understood in detail based on our electronic structure calculation, which also show that weak coupling between the dots is a requirement for the found rectification behavior.

[1] M. Pederson et. al., Phys. Status Solidi b 217, 197. (2000).
[2] J. Enkovaara et al., JOP: Condensed Matter 22, 253202 (2010).

HL 75.5 Thu 16:00 POT 151

Determining tunneling times in Ge hut wires via single-shot measurements — •Lada Vukušić, Josip Kukučka, Hannes Watzinger, Elisabeth Lausecker, and Georgios Katsaros — IST Austria

Group IV semiconductors are an attractive platform for spin qubits, with electron spin coherence times in isotopically purified Si exceeding 0.5 s [1]. Nevertheless, for fast gate manipulation, holes should be more suitable due to the stronger spin-orbit coupling. Purely HH states have been predicted to show long dephasing and, under certain conditions, relaxation times [2]. Here we work with Ge hut wires, a system which has been recently shown to confine almost purely HH states [3]. For determining the hole-spin relaxation time, a charge sensor is needed. Recently, we have realized for the first time charge sensing in Ge hut wires, which is based on both capacitive and tunnel coupling between two hut wires [4]. For achieving a fast readout, the charge sensor has been connected to a radio frequency reflectometry setup [5]. With this configuration we have measured the single-hole tunnel time between the two quantum dots to be about 10 us, which is two orders of magnitude smaller than the predicted spin relaxation time [6]. Thus, it is perfectly suitable for performing spin readout measurements.

[1] J. T. Muhonen et al., Nature Nano 9, 986 (2014); [2] D. V. Bulaev and D. Loss, PRL 95, 076805 (2005); [3] H. Watzinger et al., Nano Letters 16, 6879 (2016); [4] A. Morello et al., Nature 467 (2010); [5] N. Ares et al., PR Applied 5, 034011 (2016); [6] A. F. Zinov'eva et. al., Jetp Lett. 82, 302 (2005);