HL 23: Quantum dots and wires: Transport properties I

Time: Tuesday 11:00–13:00 Location: EW 201

HL 23.1 Tue 11:00 EW 201

Determining doping concentration and mobility in GaN nanowires by opto-electrical characterization — •Thomas Richter, Michel Marso, Ralph Meijers, Raffaella Calarco, Detlev Grützmacher und Hans Lüth — Institue of Bio- and Nanosystems (IBN1) and Centre of Nanoelectronic Systems for Information Technology, Research Center Jülich, D-52425 Jülich, Germany

Nanostructures such as semiconductor nanowires have an increasing interest as possible candidates for novel beyond-CMOS nanodevice concepts. This is strongly motivated by their already proven high versatility and practical applications. Nevertheless of these promising achievements, there are still great challenges concerning fundamental questions of physics in those nanoscaling devices. Properties like the doping and resulting electrical transport are an important field of research. We report the growth of GaN nanowires by plasma-assisted molecular beam epitaxy on Si (111) substrate. These nanowires vary in density and diameter from 20 to 300 nm. For the electrical characterisation the nanowires GaN have then been transferred to a Si (100) substrate covered with a layer of SiO2. Single nanowire devices have been fabricated by e-beam patterning technique. The electrical transport properties of the resulting metal-semiconductor-metal nanostructures are analyzed by means of current voltage measurements. The transport in nanowires is extremely sensitive to the wire diameter due to the size dependent recombination barrier. This effect is used to determine doping level and mobility of the nanowires and to confirm our previously developed surface recombination model for GaN nanowires.

HL 23.2 Tue 11:15 EW 201

Controlling electrons in InAs-nanowire quantum dots — •Marc Scheffler[1], Stevan Nadj-Perge[1], Leo P. Kouwenhoven[1], Magnus T. Borgström[2], Rienk Algra[2], and Erik P.A.M. Bakkers[2] — [1]Kavli Institute of Nanoscience Delft, Delft, The Netherlands — [2]Philips Research Laboratories, Eindhoven, The Netherlands

Quantum dots are an established technique to trap and control electrons in a solid; in particular towards the long-term perspective of quantum computation. Here we show how tunable quantum dots can be created in InAs nanowires by local gating, with the final goal of spin manipulation. While we can observe the influence of the electron spin already in a single quantum dot, the case of a double quantum dot is even more interesting: adjusting the coupling between the two dots, we present the different stability diagrams from independent to strongly coupled dots. In the interacting regime the electron spin plays an important role that can govern the transport through the double dot and thus allows for direct observation of the spin state in the dot.

HL 23.3 Tue 11:30 EW 201

Room temperature memory operation of an in-plane quantum-wire transistor with embedded quantum dots — •Christian R. Müller, Lukas Worschech, Jan Heinrich, Sven Höfling, and Alfred Forchel — Technische Physik, Universität Würzburg, Am Hubland, 97074 Würzburg, Germany

Memory operation of an in-plane gated quantum-wire transistor with embedded quantum dots is demonstrated at room temperature. The quantum-wire transistor is realized by electron beam lithography and wet chemical etching on the basis of a GaAs/AlGaAs heterostructure with self-assembled InAs quantum dots. Room temperature memory operation of the quantum dots was observed, when they were positioned approximately in the center of a Si-doped AlGaAs spacer, where the conduction band shows a minimum. The charge state of the quantum dots is read out by transport measurements with the threshold voltage of the quantum wire reflecting the charge state. The memory operation is due to a pronounced charging and discharging of the quantum dots which is achieved by sweeping up and down the gate voltage at the electrically isolated side gates. In such quantum-wires, threshold hysteresis of a few 100 mV is observed at room temperature.

HL 23.4 Tue 11:45 EW 201

Electrochemical p-doping modification of carbon nanotubes with Prussian Blue — •Alicia Forment-Aliaga[1], Ralf Thomas Weitz[1], Marko Burghard[1], and Klaus Kern[1,2] — [1]Max-Planck Institute for Solid State Research, Stuttgart, Germany — [2]Institut de Physique des Nanostructures, EPFL, Lausanne, Switzerland

Electrochemical modification is an effective method to tune the properties of carbon nanotubes. In this communication, we report on the modification of individual carbon nanotubes (SWCNTs) by electrodeposition of the molecular magnet Prussian Blue (PB) FeIII4[FeII(CN)6]3*nH2O (n=14-16). While previous studies have primarily addressed the electrocatalytic properties of PB-modified bulk nanotube electrodes,1 the motivation behind the present work is to investigate the influence of inorganic coatings on the charge transport characteristics of individual SWCNTs. The formation of PB under the applied electrochemical conditions has been proven by various characterization techniques. In contrast to metallic SWCNTs whose electrical conductivity remained largely unaffected, semiconducting tubes exhibited a strongly altered behavior after PB deposition. Specifically, in the latter case, the conductance vs. gate voltage curves were substantially shifted toward more positive gate voltages, indicative of enhanced p-type doping of the tubes. Temperature-dependent measurements revealed that the threshold voltage decreases significantly upon cooling, which is attributed to freezing out of the hole transfer from PB to the underlying nanotubes. 1 J. Li et al. Adv. Funct. Mater. 2007, 17, 1574

HL 23.5 Tue 12:00 EW 201

Determination of the specific resistance of individual freestanding ZnO nanowires with the low energy electron point source microscope — •Dirk Henning Weber[1], André Beyer[1], Berthold Völkel[1], Eva Schlenker[2], Andrey Bakin[2], Andreas Waag[2], and Armin Gölzhäuser[1] — [1]Physik supramolekularer Systeme, Universität Bielefeld — [2]Institut für Halbleitertechnik, Technische Universität Braunschweig

A low energy electron point source (LEEPS) microscope is used to determine the electrical conductivity of individual freestanding ZnO nanowires in UHV. The nanowires were contacted with a manipulation tip and I-V curves were taken at different wire lengths. From those, the specific resistance was calculated and separated from the contact resistance. By comparing the specific resistances of ZnO nanowires with diameters between 1100 and 48 nm, a large surface contribution for the thin nanowires was found. A geometric model for separation between surface and bulk contributions is given. The results of electrical transport measurements on vapor phase grown ZnO nanowires will be discussed, as well as the size dependence of the wire resistance.

HL 23.6 Tue 12:15 EW 201

Carbon nanotube nano-electromechanics — •Andreas K. Hüttel, Benoit Witkamp, Menno Poot, Samir Etaki, and Herre van der Zant — Molecular Electronics and Devices, Kavli Institute of Nanoscience, Delft University of Technology, PO Box 5046, 2600 GA Delft, The Netherlands

Single wall carbon nanotubes (SW-CNTs) excel in many ways as a nano-electromechanical system. With their high Young's modulus, extreme flexibility, smoothness on a molecular level, small cross-section and low mass, they promise possibilities of observing the quantization of mechanical motion. In addition, their electronic structure is well-characterized, enabling the identification of mechanical effects.

We present low-temperature transport measurements targetting both the longitudinal (stretching) and the transversal (bending) vibration mode of suspended SW-CNTs. Data on low-bias current suppression in short (100nm) CNT quantum dots points towards "phonon" or "distortion" blockade mechanisms. In addition, indications of mechanical modes in higher-order tunneling are shown. Different sample geometries and fabrication techniques are discussed.

HL 23.7 Tue 12:30 EW 201

Franz-Keldysh effect in GaN nanowires — •Raffaella Calarco[1], Toma Stoica[1], Ralph Meijers[1], Thomas Richter[1], Anna Cavallini[2], Laura Polenta[2], Marco Rossi[2], and Hans Lüth[1] — [1]Institute of Bio- and Nanosystems (IBN1) and cni - Center of Nanoelectronic Systems for Information Technology, Research Centre Jülich, 52425 Jülich, Germany — [2]Phys.Department and CNISM, University of Bologna, Viale Berti Pichat 6/2, 40127 Bologna, Italy

In recent years III-nitride based nanowires have attracted a lot of interest because of their potential applications for nanoelectronic devices [1]. Due to the large surface-to-volume ratio of the wires, the optoelectronic properties as well as growth processes are essentially dependent on the wire diameter. We have studied GaN NWs obtained by catalyst-free radio frequency PAMBE on Si(111) in N-rich conditions [2-4]. Surface Photovoltage Spectroscopy and Spectral Photoconductivity (SPC) measurements have been carried out to analyze the near band-edge absorption in GaN nanowires [5]. A strong diameter dependence of the band absorption tail was found by SPC measurements. The band-edge tailoring and its wire-diameter dependence can be explained by the Franz-Keldysh effect induced by the electric field at the wire surface. The experimental values of the absorption tail are well in agreement with the results obtained by simulating the electric field in a cylindrical model. [1] Y. Huang etal. Science 294, 9, 1313 (2001). [2] R. Calarco et al.Nano Letters 5, 981 (2005). [3] A. Cavallini et al. Nano Letters, 6(7), 1548 (2006). [4] R. Meijers et al. J.Cryst. Growth, 289, 381 (2006) [5] A. Cavallini et al. Nano Letters, 7, 2166 (2007).

HL 23.8 Tue 12:45 EW 201

Local Density of States in Mesoscopic Samples from Scanning Gate Microscopy — •Marco G. Pala[1], Benoit Hackens[2], Frederico Martins[3], Hermann Sellier[3], Vincent Bayot[2], Serge Huant[3], and Thierry Ouisse[3] — [1]IMEP-LAHC-MINATEC, CNRS, INPG and UJF, BP 257, 38016 Grenoble, France — [2]CERMIN, DICE Lab, UCL, B-1348 Louvain-la-Neuve, Belgium — [3]Institut Néel, CNRS, and UJF, BP 166, 38042 Grenoble, France

We study the relationship between the local density of states (LDOS) and the conductance variation ΔG in scanning-gate-microscopy experiments on mesoscopic structures [1]. This is a weakly invasive technique, applicable to nanostructures patterned in subsurface two-dimensional (2D) electron gases. The probe is used as a scatterer which locally modifies the electron flow properties, and generates 2D conductance maps as a function of the tip position.

We present an analytical model showing the correspondence between the conductance shift ΔG and the LDOS in the single-channel transmission regime. We analyze the physical conditions for the validity of this relationship both for one-dimensional and two-dimensional systems when several channels contribute to the transport [2]. We focus on realistic Aharonov-Bohm rings including a random distribution of impurities and analyze the LDOS-ΔG correspondence by means of exact numerical simulations, when localized states or semi-classical orbits characterize the wavefunction of the system.

[1] F. Martins et al., Phys. Rev. Lett. **99**, 136807 (2007)
[2] M.G. Pala et al., To be published.