HL 45 Quantenpunkte und -drähte: Transporteigenschaften II

Zeit: Montag 15:00–17:30 Raum: TU P-N202

HL 45.1 Mo 15:00 TU P-N202

Magnetfeldabhängige Kapazitätsspektroskopie des Löchersystems von InAs-Quantenpunkten — •Peter Kailuweit[1], Dirk Reuter[1], Andreas D. Wieck[1], Ulrich Zeitler[2], Oliver Wibbelhoff[3] und Axel Lorke[3] — [1]Lehrstuhl für angewandte Festkörperphysik, Ruhr-Universität Bochum, Universitätsstraße 150, 44780 Bochum — [2]High Field Magnet Laboratory, University of Nijmegen, Toernooiveld 7, 6525 ED Nijmegen, Netherlands — [3]Fakultät für Experimentalphysik, Universität Duisburg-Essen, Lotharstraße 1, 47048 Duisburg

Nachdem das sukzessive Laden der elektronischen s- und p-Zustände in InAs-Quantenpunkten weitgehend beobachtet und geklärt ist, bleibt das kompliziertere Löchersystem noch relativ unverstanden. Mittels Kapazitätsspektroskopie wurden daher Schottkydioden mit eingebetteten InAs-Quantenpunkten untersucht.

Durch ein parallel zur Probenfläche angelegtes Magnetfeld wurde den tunnelnden Löchern ein zusätzlicher Impuls verliehen. Durch Wahl geeigneter Messfrequenzen lässt sich der Einfluß des magnetfeldinduzierten Impulses auf die Tunnelwahrscheinlichkeit bestimmen.

Dies erlaubt es, durch Messung bei verschiedenen Magnetfeldern die Aufenthaltswahrscheinlichkeit der Löcher im k-Raum für die einzelnen Ladungspeaks auszutesten und somit praktisch die Wellenfunktion abzubilden. Es wurden die ersten sechs Ladungspeaks untersucht.

HL 45.2 Mo 15:15 TU P-N202

Shot noise measurements at the Fermi Edge Singularity of InAs quantum dots — •N. Maire[1], T. Lüdtke[1], R. J. Haug[1], and K. Pierz[2] — [1]Institut für Festkörperphysik, Universität Hannover, D-30167 Hannover — [2]Physikalisch-Technische Bundesanstalt, Bundesallee 100, D-38116 Braunschweig

We investigate the noise properties of self-assembled InAs quantum dots embedded into a GaAs-AlAs-GaAs heterostructure. The *I*-*V*-characteristic shows a step-like dependence which can be directly linked to resonant tunneling through the ground states of single quantum dots. This allows us to measure the noise properties of single 0-dimensional states. We furthermore observe a strong overshoot of the current amplitude of a particular step with increasing magnetic fields and decreasing temperatures which we interpret as an electron-electron interaction effect, a so called Fermi Edge Singularity (FES).

The resulting noise power shows a frequency independent spectrum, the so called shot noise. This noise power is suppressed compared to the theoretical value $2eI$ of a single tunneling barrier as it is indeed expected for a double barrier resonant tunneling structure. This suppression is characterized by the dimensionless Fano factor $\alpha = S/2eI$; S being the average noise power density. We now analyze the FES in detail by measuring the Fano Factor for increasing magnetic fields up to 15 T and varying temperatures down to approx. 300 mK and compare the results with theoretical predictions.

HL 45.3 Mo 15:30 TU P-N202

Theorie des kohärenten Stroms durch Quantenpunktmoleküle — •Tobias Zibold, Matthias Sabathil und Peter Vogl — Walter Schottky Institut, Technische Universität München, Am Coulombwall 3, 85748 Garching

Wir präsentieren eine quantitative, theoretische Untersuchung des ballistischen Ladungsträgertransports durch Quantenpunktmoleküle aus vertikal gestapelten InAs Quantenpunkten in einer InP Barriere. Hierzu verwenden wir eine kürzlich entwickelte (CBR) Methode [1], mit der eine effiziente Berechnung der ballistischen I-V-Kennlinie des vollständig dreidimensionalen Bauelements mit realistischen Quantenpunkten einschließlich Wetting Layern möglich ist. Die I-V-Kennlinie zeigt mehrere ausgeprägte Resonanzen und bietet eine Fülle an Informationen, die zu optischer Spektroskopie komplementär ist: die Energiedifferenz zwischen dem Grund- und dem ersten angeregten Zustand, die Kopplung zwischen den Quantenpunkten, die laterale Verschiebung sowie Größe und Form der Quantenpunkte. Wir können das berechnete Spektrum mit einfachen physikalischen Konzepten erklären und qualitative Tendenzen vorhersagen. Der Vergleich mit experimentellen Daten [2] ergibt eine gute Übereinstimmung mit unseren Berechnungen. Die CBR Methode basiert auf der Lösung der Schrödingergleichung und berücksichtigt die realistische Bandstruktur einschließlich Verspannungen und piezoelektrischer Ladungen. [1] D. Mamaluy et al., J. Appl. Phys. 93, 4628 (2003), [2] T. Bryllert et al., Appl. Phys. Lett. 82, 2655 (2003).

HL 45.4 Mo 15:45 TU P-N202

Mode coupling of spatially coincident electron wave guides — •S.F. Fischer[1], G. Apetrii[1], U. Kunze[1], D. Schuh[2], and G. Abstreiter[2] — [1]Werkstoffe und Nanoelektronik, Ruhr-Universität Bochum, D-44780 Bochum — [2]Walter Schottky Institut,Technische Universität München, D-85748 Garching

Mode coupling phenomena in electron wave guides lead to wave function mixing and splitting of degenerate one-dimensional (1D) energy levels. The direct experimental determination of splitting energies demands coherent ballistic electron transport and high 1D-subband spacings (>10 meV). Nanolithography with an atomic force microscope enables us to prepare spatially coincident 1D electron systems which meet these requirements and for which massive wave function mixing is expected. Quantum point contacts were fabricated from a modulation doped GaAs/AlGaAs system with a 30 nm wide square quantum well with two occupied 2D subbands. We find a rich mode spectrum by recording transconductance maxima at 2 K as a function of gate voltage and magnetic field. Magnetotransport spectroscopy of unprecedented resolution allows the proper identification of heretofore unresolved subtle interference induced by mode coupling. Imaging the of transconductance vs. drain- and gate voltage enables the direct determination of splitting energies (> 2 meV).

HL 45.5 Mo 16:00 TU P-N202

Quantum transport in single-walled carbon nanotubes — •Carola Meyer, Pablo Jarillo-Herrero, Sami Sapmaz, and Leo Kouwenhoven — Kavli Institute of Nanoscience, Delft University of Technology, PO Box 5046, 2600 GA, Delft, The Netherlands

Single-walled carbon nanotubes (SWCNTs) are one-dimensional conductors, either metallic or semiconducting depending on their chirality. In the past years, the study of quantum transport through SWCNTs has revealed many quantum phenomena, e.g. quantum dot shell filling, Fabry-Perot-like interference, Kondo effect, etc. Recently, few electron-hole dots on semiconducting SWCNTs have been demonstrated in our group, and the behavior in a magnetic field has been studied. It is possible to fabricate gate structures to deplete certain parts of these semiconducting tubes, i.e. to create tunable barriers. This opens up the opportunity for a scalable electron spin quantum computing concept, if microwaves can be coupled to the system. The unique properties of SWCNTs, i.e. small spin orbit coupling, small phonon density of states, and small abundance of nuclear spins, are expected lead to long coherence times of electron spins in the dots. Here, we will present our concept, discuss the main problems that have to be solved and show first attempts towards a device that could be used for quantum computing.

HL 45.6 Mo 16:15 TU P-N202

Impact of source/drain contacts on the performance of carbon nanotube field-effect transistors — •Joachim Knoch[1], Siegfried Mantl[1], Yu-Min Lin[2], Z Chen[2], Phaedon Avouris[2], and Joerg Appenzeller[2] — [1]Institut fuer Schichten und Grenzflaechen, ISG-1, Forschungszentrum Juelich — [2]IBM T.J. Watson Research Center, Yorktown Heights, NY10598 USA

Carbon nanotube field-effect-transistors (CNFETs)are attracting an increasing attention as building blocks of a future nano-electronics. In most of today's CNFETs, metallic contacts are used made of e.g. titanium in contact with the nanotube. This contact plays the crucial role for carrier injection into the channel and it was found that CNFETs rather behave as Schottky barrier (SB) devices than conventional MOSFETs. Models capturing scaling aspects of CNFETs consequently consider a metallic electrode in direct contact with the nanotube. However, a closer look at CNFET data also reveals discrepancies between predictions of the existing SB-models and measured CNFET characteristics. A particularly obvious aspect is the often encountered asymmetric ambipolar or even unipolar appearance of $I_d - V_{gs}$ curves for thin gate oxides, an observation that cannot be explained by existing models. Here, we present an extended SB-model where current injection from the metal contacts into the channel does not happen directly but is mediated by a "metal-poisoned" nanotube underneath the contacts. With this model the experimentally observed IV characteristics can be reproduced and over a large gate voltage range.

HL 45.7 Mo 16:30 TU P-N202

Conductance anomalies in nonlinear transport through a quantum point contact — •M. Fleischer[1], D.J. Schefzyk[1], D.A. Wharam[1], D.A. Ritchie[2], and M. Pepper[2] — [1]Institut für Angewandte Physik, Universität Tübingen, Auf der Morgenstelle 10, D-72076 Tübingen — [2]Cavendish Laboratory, University of Cambridge, Madingley Road, Cambridge CB3 0HE, UK

Transport measurements of quantum point-contacts lead to the well-known conductance quantisation in units of $G_0 = \frac{2e^2}{h}$. We have investigated point-contacts defined in the two-dimensional electron gas of a GaAs/AlGaAs heterostructure. The differential conductance exhibits plateaux at the expected integer multiples of G_0 and their half-integer counterparts at finite bias. In addition, there is a distinct step below the first plateau, widely known as the "0.7-structure", as well as a corresponding step below the second plateau, at about $1.6\,G_0$. At finite bias, both additional steps first develop into plateaux at about $0.8\,G_0$ and $1.5\,G_0$ respectively, then into side plateaux at intermediate values in analogy to the integer/half-integer structure, leading to a pattern of intersecting diamonds in the transconductance. The possible origin of extra steps has been considered in a numerical calculation of one-dimensional subbands.

HL 45.8 Mo 16:45 TU P-N202

Determination of electron and hole localization in InAs/GaAs quantum dots via direct observation of tunneling escape — •Martin Geller, Erik Stock, Christian Kapteyn, Roman Sellin, and Dieter Bimberg — Institut für Festkörperphysik, TU Berlin, Hardenbergstr. 36, D-10623 Berlin

We have determined the tunneling barrier height, which is equal to the entire ground state localization energy, for electrons and holes in InAs/GaAs quantum dots (QDs). For the first time this important value was obtained by measuring the tunneling time constant as function of an applied external electric field in time resolved capacitance measurements. Previously, we had shown that time resolved capacitance spectroscopy (DLTS) is a powerful tool to study thermal emission processes and thermal activation energies in QDs. However, for electrons - but also for holes - the competing tunneling process in an applied electric field makes it impossible to measure directly the localization energy. In fact, for electrons only the quantization energy can be derived, due to tunneling through the tip of the triangular barrier, and the hole localization energy is always underestimated. With this new developed method via direct observation of tunneling escape in capacitance transients, the obtained localization energy is 240 meV for the electrons and 190 meV for the holes. These values are in very good agreement with our predictions from 8-band k·p calculations. The work was funded by the SANDiE Network of Excellence of the European Commission, contract number NMP4-CT-2004-500101 and SFB 296 of DFG.

HL 45.9 Mo 17:00 TU P-N202

Determination of the electron confinement in self-organized 1.3 μm InGaAs/GaAs quantum dots by capacitance-voltage measurements — •Marcus Gonschorek, Heidemarie Schmidt, and Marius Grundmann — Universität Leipzig, Fakultät für Physik and Geowissenschaften, 04103 Leipzig, Germany

Using capacitance-voltage (CV) measurements we observe that due to electrons confined in InGaAs quantum dots the space charge behaviour of the n-GaAs-Schottky host diode is modified by additional plateau-like structures. We solved self-consistently the one-dimensional Poisson and drift-diffusion equation as a function of the voltage applied to the Schottky contact where the zero-dimensional density of the electron quantum dot states is modelled by Gaussian broadened lines. By comparing experimental and theoretical CV data obtained for differently doped n-GaAs Schottky diodes ($1 \times 10^{16} - 5 \times 10^{16}$ cm^{-3}) where identical layers of self-organized InGaAs quantum dots are incorporated, we show that the growth-related doping profile has a significant effect on the CV data. In order to determine the electron confinement in self-organized 1.3 μm InGaAs quantum dots, we carefully consider the temperature dependence of the Schottky barrier energy and use the CV data measured in the temperature range from 4 up to 310 K to separate the growth-related doping effects[1] from the quantum dot related charging effects. [1] R. Wetzler, A. Wacker, E. Schöll, C.M.A. Kapteyn, R. Heitz, and D. Bimberg, Appl. Phys. Lett. 77, 1671 (2000).

HL 45.10 Mo 17:15 TU P-N202

Elektrische Eigenschaften von nanoskaligen Ionenspuren — •A.K. Nix[1], D. Schwen[1], J.H. Zollondz[1], C. Ronning[1], C. Trautmann[2], H. Krauser[3] und H. Hofsäss[1] — [1]II. Physikalisches Institut, Universität Göttingen, Friedrich-Hund-Platz 1, D-37077 Göttingen — [2]Gesellschaft für Schwerionenforschung, Planckstr. 1, D-64291 Darmstadt — [3]Hochschule Harz Wernigerode, Friedrichstr. 57-59, D-38855 Wernigerode

In isolierenden tetraedisch gebundenen amorphen Kohlenstoffschichten (ta-C) können durch Bestrahlung mit schnellen schweren Ionen, z.B. Uran oder Gold, graphitische Ionenspuren erzeugt werden. Diese Ionenspuren mit hohem Aspektverhältnis und Durchmesser von ca. zehn Nanometer besitzen eine deutlich höhere Leitfähigkeit als ihre umgebende Matrix. Sie haben somit die Möglichkeit, als vertikale leitende Verbindungen in Multilagen zu dienen. An diesen Ionenspuren wurden Strom-Spannungs-Kennlinien mithilfe eines Rasterkraftmikroskops (AFM) unter Anlegen einer Biasspannung aufgenommen. Für die Untersuchung des elektrischen Ladungstransports wurden temperaturabhängige IV-Kennlinien aufgenommen, wobei ein Ensemble von Ionenspuren mit aufgedampftem Gold kontaktiert wurde. Weiterhin wurden auch Experimente durchgeführt, um eine einzelne Spur zu kontaktieren.