HL 62: Quantum Dots and Wires: Transport Properties I (mainly Quantum Wires)

Time: Wednesday 15:00–17:00 Location: EW 203

HL 62.1 Wed 15:00 EW 203

Low Temperature Conductance Quantization in GaAs Quantum Wires — •Christian Scheller[1], Gilad Barak[2], Loren N. Pfeiffer[3], Ken W. West[3], Amir Yacoby[2], and Dominik M. Zumbühl[1] — [1]Dep. of Physics, University of Basel, Switzerland — [2]Dep. of Physics, Harvard University, Cambridge, Massachusetts, USA — [3]Bell Labs, Lucent Technologies, Murray Hill, New Jersey, USA

We present low temperature quantum transport measurements of cleaved edge overgrowth quantum wires fabricated in GaAs-AlGaAs. When the electron density in the wire is varied using a gate voltage, pronounced conductance plateaus are observed. However, the conductance values of the plateaus are strongly suppressed below the universally expected multiples of $2e^2/h$ [1]. For the lowest mode, the plateau conductance saturates at $\approx 1e^2/h$ at low temperatures $T < 80$ mK and zero external magnetic field. This seems to suggest that the spin degeneracy is lifted, consistent with recent theory [2] predicting helical nuclear magnetism in the Luttinger liquid regime. Using the same setup and a similar chip carrier, we demonstrate electron temperatures down to 11 mK in metallic Coulomb blockade thermometers, suggesting that the sample cools far below 80 mK. We employ transport spectroscopy to investigate the system and further use resistively detected NMR in an attempt to elucidate the role of the nuclear spins. [1] "Nonuniversal Conductance Quantization in Quantum Wires", A.Yacoby et al., Phys. Rev. Lett. 77, 4612 (1996). [2] "Nuclear magnetism and electron order in interacting one-dimensional conductors", Bernd Braunecker, Pascal Simon, and Daniel Loss, Phys. Rev. B80, 165119 (2009).

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Observation of Electron Interference in GaAs/InAs Core/Shell Nanowires — •Önder Gül[1,2], Christian Blömers[1,2], Torsten Rieger[1,2], Mihail I. Lepsa[1,2], Hans Lüth[1,2], Detlev Grützmacher[1,2], and Thomas Schäpers[1,2,3] — [1]Peter Grünberg Institute -9, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA-Fundamentals of Future Information Technology — [3]II. Physikalisches Institut, RWTH Aachen, 52056 Aachen, Germany

Electron and spin interference in mesoscopic semiconductor systems is of fundamental interest for future spin- and quantum-based information technology. In this context, bottom-up device approaches such as templated self-assembled nanowires are particularly interesting.

Here we report on electron wave interference in GaAs/InAs core/shell nanowires grown by molecular beam epitaxy. Magnetotransport measurements were performed at 1.8 K and at magnetic fields up to 10 T. Additionally, gate voltage dependence of magnetotransport characteristics is investigated. Conductance oscillations are observed as a function of the magnetic field as well as the gate voltage. Fourier analysis of data suggests periodicity both in magnetic field and gate voltage. Further, phase-coherent transport properties of these nanowires are unravelled by applying the magnetic field in different orientations as well as by temperature dependent measurements.

HL 62.3 Wed 15:30 EW 203

Structural influences on quantum transport in InAs nanowires — •Robert Frielinghaus[1,4], Kilian Flöhr[2,4], Kamil Sladek[1,4], Stefan Trellenkamp[1,4], Thomas E. Weirich[3,4], Hilde Hardtdegen[1,4], Thomas Schäpers[1,2,4], Claus M. Schneider[1,4], and Carola Meyer[1,4] — [1]Peter Grünberg Institut, Forschungszentrum Jülich, 52425 Jülich, Germany — [2]II. Physikalisches Institut, RWTH Aachen University, 52074 Aachen, Germany — [3]Central Facility for Electron Microscopy GFE, RWTH Aachen University, 52074 Aachen, Germany — [4]JARA Fundamentals of Future Information Technology

Self-assembled nanostructures such as InAs nanowires are candidates for future semiconductor nanoscale devices. However their atomic arrangement usually differs from device to device leading to fluctuations in the electrical properties as e.g. the electron phase coherence length. Using a special sample design we present quantum transport measurements together with transmission electron micrographs (TEM) taken from the same individual InAs nanowires. The as-grown nanowires are selectively placed on holes patterned in a TEM membrane. Low-temperature magnetotransport measurements of these suspended nanowires reveal universal conductance fluctuations that allow for the determination of the phase coherence length without any influence of the substrate. Variations in the transport behavior are correlated to the atomically resolved structure observed in TEM.

HL 62.4 Wed 15:45 EW 203

Electrical properties of catalyst-free MBE grown InAs nanowires — •Philipp Geselbracht[1], Stefanie Bolte[1], Dance Spirkoska[1], Simon Hertenberger[1], Verena Hintermayr[1], Markus Döblinger[2], Max Bichler[1], Gerhard Abstreiter[1,3], and Gregor Koblmüller[1] — [1]Walter Schottky Institut and Physik Department, TU München, Garching, Germany — [2]Department of Chemistry, Ludwig-Maxililians-Universität, Munich, Germany — [3]TUM Institute for Advanced Study, Garching, Germany

In this work we report on the electrical properties of catalyst-free, nominally undoped InAs nanowires grown on Si substrates using ultrapure, solid source molecular beam epitaxy (MBE). By applying a wide range of growth parameters we have obtained nanowires with different amount of zinc-blende and wurtzite segments in their crystal structure as investigated by Transmission Electron Microscopy (TEM). We have fabricated planar field effect transistor devices both in global back gate and top gate geometry. From transmission line method, as well as four point I-V measurements we have determined the contact resistance to be <1 kOhm . Our devices are characterized with large ON/OFF ratio and mobility in the range of 2000 cm2/Vs at room temperature confirming the worthiness of the catalyst-free growth mode. Additionally, we will discuss the effect of the gate geometry on the characteristics of the field effect devices and give first insight into wrapped gate devices

HL 62.5 Wed 16:00 EW 203

Growth and electrical characterization of modulation doped core-shell GaAs/AlGaAs nanowires — •Stefanie Bolte[1], Dance Spirkoska[1], Daniel Rudolph[1], Markus Döblinger[2], Max Bichler[1], Gregor Koblmüller[1], and Gerhard Abstreiter[1,3] — [1]Walter Schottky Institut and Physik Department, TU München, Garching, Germany — [2]Department of Chemistry, Ludwig-Maxililians-Universität, Munich, Germany — [3]TUM Institute for Advanced Study, Garching, Germany

In this work we will present the electrical properties of self-catalyzed, modulation (remotely) doped GaAs/AlGaAs core-shell nanowires grown by molecular beam epitaxy. The remote doping with Si deltalayer in the AlGaAs shell, which is deposited on the {110} side facets of the GaAs core, results in the formation of complex one (1d) and two (2d) dimensional electron channels at the interface between the GaAs and the AlGaAs, as shown by nextnano3 simulation of the electron density. The n-type behavior of the doping was confirmed with back gate dependent measurements on the fabricated field effect transistor devices and the occurrence of the persistent photoconductivity effect at low temperatures. Magnetic field studies at low temperatures revealed a complex oscillatory behavior of the magnetoresistance, which is due to the superposition of the 2d and 1d channels of electrons on the side facets and the edges, respectively. Furthermore, we will discuss the dependence of the electrical properties on the crystal structure of the GaAs core, and the feasibility of obtaining high electron mobilities in these systems.

HL 62.6 Wed 16:15 EW 203

Hall Measurements on InAs Nanowires — •Christian Blömers[1,3], Thomas Grap[1,3], Stefan Trellenkamp[2,3], Mihail I. Lepsa[1,3], Detlev Grützmacher[1,3], Hans Lüth[1,3] und Thomas Schäpers[1,3,4] — [1]Peter Grünberg Institut (PGI-9), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [2]Peter Grünberg Institut (PGI-8), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany — [3]JARA - Fundamentals of Future Information Technology — [4]II. Physikalisches Institut, RWTH Aachen, 52074 Aachen, Germany

In search of novel concepts for the realization of nanoelectronic devices, semiconductor nanowires grown by "bottom-up" techniques have shown great promise. Without any doubt, the knowledge about the free carrier concentration n_{el} is crucial for the fabrication of such devices on the nanometer scale. The most common method to determine n_{el} in nanowires is to utilize the field effect in a gate measurement setup. However, within this method, uncertainties such as the density of surface states between the nanowire and the dielectric material or the resulting nanowire capacitance influence results. Additionally, source and drain electrodes tend to screen the gate potential in devices of small size. Here we report on Hall measurements on InAs nanowires as an alternative method to determine n_{el}. By electron beam lithography we are able to fabricate side contacts to single nanowires to realize a Hall-measurement geometry. The side contacts allow us to measure a Hall-voltage, from which we deduce the carrier concentration in the wires.

HL 62.7 Wed 16:30 EW 203

Four-point electrical characterization and gas sensing properties of CuO nanowire devices — •Stephan Steinhauer, Elise Brunet, Giorgio Cataldo Mutinati, and Anton Köck — Health & Environment Department, Molecular Diagnostics, AIT Austrian Institute of Technology GmbH, 1220 Vienna, Austria

Metal oxide nanowires have recently attracted much attention as they may be used in numerous potential applications, especially in highly sensitive gas detecting devices. Unlike other metal oxides, cupric oxide (CuO) is known as a p-type semiconductor with a narrow band gap around 1.2eV. In order to gain a better understanding of CuO nanowire transport properties, we characterize them in a four-point configuration and investigate the influence of the surrounding gas atmosphere.

CuO nanowires are synthesized by thermal oxidation of resistively heated Cu wires at ambient conditions. By this method, CuO nanowires with lengths up to 100 micrometer and typical diameters between 30 and 150 nanometer can be fabricated. After the transfer to silicon substrates, single CuO nanowires are contacted in a four-point configuration by optical and electron beam lithography using a metal lift-off process. The temperature dependence of nanowire transport properties is investigated in four-point and two-point measurements in order to evaluate specific conductance and contact resistance. When operated as conductometric gas sensors, CuO nanowires show a strong interaction with the surrounding gas due to the high surface to volume ratio and are able to detect very small concentrations of the toxic gases CO and H2S in the low ppm range.

HL 62.8 Wed 16:45 EW 203

Optimal finite volume discretization of Schrödinger equations for cylindrical symmetric nanowires — •Paul Nicolae Racec — Weierstrass Institute Berlin, Mohrenstr. 39, 10117 Berlin, Germany — National Institute of Materials Physics, PO Box MG-7, 077125 Bucharest Magurele, Romania

We present a finite volume scheme for the one-particle effective mass Schrödinger equation with mixed boundary conditions, more precisely the Wigner-Eisenbud problem, on a bounded domain with cylindrical symmetry. Hence, we reduce the 3D problem to one in the (r, z) plane. We use linear triangular finite elements, structured meshing and the lumping approximation in the variational formulation of the discretized 2D problem. In order to remove the r^{-1} singularity, we approximate within every element the metric $r\,dr\,dz \simeq r_U^{(e)}\,dr\,dz$ and $1/r \simeq 1/r_U^{(e)}$, where $r_U^{(e)}$ is the r-coordinate of the circumcenter of the triangular element. We analyze the influence of the size and shape of the finite elements on the accuracy of the eigenvalues and eigenfunctions. We study a free-particle case and a nanowire resonant tunneling diode. In case of equilateral finite elements, we obtain a second order convergence for the eigenvalues, which is independent of the ratio m_r^*/m_z^*, where m_r^* and m_z^* are the r and z components of the effective mass tensor of the nanowire. In case of anisotropic masses, the optimal finite element shape is obtained with a grid, which is finer in the direction of the smaller effective mass.

This is a joint work with Stanley Schade and Hans-Christoph Kaiser.