HL 72: Quantum wires

Time: Thursday 10:15–11:45 Location: EW 203

HL 72.1 Thu 10:15 EW 203

Random Distribution of Phase Domains in Single Nanowires — •Arman Davtyan, Otmar Loffeld, and Ullrich Pietsch — Naturwissenschaftlich-Technische faculty, University of Siegen, Siegen, Germany

Investigation of the polytype structure of single GaAs nanowires grown on GaAs(111) have been performed using Coherent x-ray Diffraction Imaging (CDI) at the ID1 beamline of ESRF. The high number of twin defects gives rise to the complex speckle pattern instead of expected zinc blende (ZB), twin zinc blende (TZB) or wurtzite (WZ) structural peaks. Because the phase information is lost in the experiment it has to be retrieved by means of Phase Retrieval (PR) procedure. Although fast convergence of retrieved amplitudes the use of different trail phases provides different solutions for the phase pattern. Therefore no unique solution of the stacking fault distribution can be obtained. Here we show that the set of retrieved phase pattern contains hidden statistical information about the average number of the twin defects within the NW. In order to get more inside into the problem we simulated various polytype distributions in highly defective NWs and calculated the resulting speckle pattern. It turned out that already a stack of 2-3 perfect ordered zinc-blende and twinned zinc-blende units provides Bragg like intensity maxima. Therefore the measured speckle pattern can only be interpreted by a completely random distribution of these phase units.

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Electrical properties of freestanding GaAs nanowires investigated by a multi-tip STM — •Matthias Steidl[1], Stefan Korte[2], Weihong Zhao[1], Hubertus Junker[2], Werner Prost[3], Vasily Cherepanov[2], Bert Voigtländer[2], Peter Kleinschmidt[1], and Thomas Hannappel[1] — [1]Photovoltaics Group, Institute for Physics, Technische Universität Ilmenau, D-98684 Ilmenau — [2]Peter Grünberg Institut (PGI-3), Forschungszentrum Jülich, D-52425 Jülich and JARA-Fundamentals of Future Information Technology — [3]CeNIDE and Center for Semiconductor Technology and Optoelectronics, University of Duisburg-Essen, D-47057 Duisburg

We have grown undoped and p-type Zn-doped GaAs-Nanowires (NW) on GaP(111)B using the Au-assisted vapor-liquid-solid growth mode in a metal-organic vapor phase apparatus with different growth procedures. For the electrical characterization we applied a multitip STM as a nanoprober and conducted four-point probe measurements on single free-standing NWs. The doped NWs show highly non-linear I-V curves with diode like behavior. This reveals the existence of a space charge region along the NW axis, which we attribute to variations in the doping concentration. Furthermore, spatially resolved measurements of electron beam induced current (EBIC) indicate the width and localization of this space charge region. These measurements reveal that both the resistivity and the localization of the space charge region is dependent on the growth condition.

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Optical properties of ultrathin GaAs-AlGaAs core-shell nanowires — •Julia Winnerl[1], Bernhard Loitsch[1], Daniel Rudolph[1], Stefanie Morkötter[1], Gianluca Grimaldi[1], Lukas Hanschke[1], Lucas Schweickert[1], Max Bichler[1], Gerhard Abstreiter[1,2], Jonathan Finley[1], and Gregor Koblmüller[1] — [1]Walter Schottky Institut and Physik Department, Technische Universität München, Garching, Germany — [2]Institute for Advanced Study, Technische Universität München, Garching, Germany

III-V semiconductor nanowires (NWs) are known to provide a large field for many applications in electronic and optoelectronic devices. In many of these NW device applications, the electronic properties of the NWs are mostly described by the 3D bulk-like properties of the NW core, in spite of the 1D-like structure of the NWs. Performance enhancements in such NW device applications are expected from exploiting 1D-quantum confinement effects. Here, we present the optical properties of GaAs-$Al_{0.3}Ga_{0.7}As$ core-shell NWs epitaxially grown on silicon with GaAs core diameters below 10 nm. Low-temperature micro-photoluminescence (PL) measurements reveal strongly blue-shifted PL energies (up to ~100 meV) compared to the free exciton emission of GaAs. This indicates strong radial 1D-quantum confinement of the GaAs NW core. In addition, the strongly blue-shifted PL shows some sharp PL lines indicating that additional axial confinement effects of the excitons are present. Time-resolved PL experiments show clear bi-exponential decay transients that could be attributed to different recombination channels of these localized excitons.

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Photoluminescence excitation measurements on ultrathin GaAs-AlGaAs core-shell nanowires — •Gianluca Grimaldi, Bernhard Loitsch, Daniel Rudolph, Stefanie Morkötter, Lukas Hanschke, Lucas Schweickert, Max Bichler, Gerhard Abstreiter, Jonathan Finley, and Gregor Koblmüller — Walter Schottky Institut, Technische Universität München, Garching, Germany

Thin semiconductor nanowires (NWs) can achieve quantum confinement of carriers in the radial direction, potentially enhancing performances of NW-based devices. Using a novel reverse-reaction growth scheme, GaAs-AlGaAs core-shell NWs with tunable core diameters down to below 10 nm can be epitaxially integrated on silicon [1].

Here we report on micro-photoluminescence spectroscopy (μ-PL) and photoluminescence excitation spectroscopy (PLE) on GaAs-AlGaAs core-shell NWs with ultrathin core diameters (7-20 nm). Along with the blueshift of PL, arising from radial confinement in the thin NW core, multiple sharp peaks are observed, with FWHM below 100 μeV. Power-dependent PL reveal saturation of these peaks for high excitation power, further suggesting presence of localized exciton states. PLE experiments show resonances, whose energy distance is smaller than what expected for excited states of the radial confinement, suggesting that additional confinement in the axial direction is present. The axial localization is attributed to the presence of wurtzite and zincblende stacking along the NWs.

Reference: [1] B. Loitsch, et al., in review (2014)

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Optical characterization of high-periodicity InGaAs-InAlAs-based core-shell nanowire arrays — •Maximilian Speckbacher[1], Julian Treu[1], Thomas Stettner[1], Stefanie Morkötter[1], Markus Döblinger[2], Sonja Matich[1], Kai Saller[1], Max Bichler[1], Markus Christian Amann[1], Jonathan Finley[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-Maximilians-Universität München, Munich, Germany — [3]TUM Institute for Advanced Study, Garching, Germany

$In_{1-x}Ga_xAs$ nanowires (NWs), site-selectively grown by molecular beam epitaxy (MBE) on Si(111) substrates and passivated insitu with an according lattice matched $In_{1-x}Al_xAs$ shell, were analyzed in depth using micro-photoluminescence (μ-PL). Varying both Ga- as well as Al-content allows for effective bandgap engineering, tuning the peak emission over a broad range across the important telecommunication regime. The core-shell NWs significantly enhance peak intensities compared to the unpassivated case with emission even up to room-temperature. This opens numerous opportunities for advanced NW-based heterostructures, such as integrated nanophotonic sources on Si (for hybrid III/V-Si photonics) and NW-based photovoltaics.

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Angle dependent magnetoconductance oscillations and Hall measurements in GaAs/InAs Core/Shell Nanowires — •Patrick Zellekens[1,2], Fabian Haas[1,2], Nathalia Demarina[1,2], Torsten Rieger[1,2], Mihail Lepsa[1,2], Detlev Grützmacher[1,2], Hans Lüth[1,2], and Thomas Schäpers[1,2] — [1]Peter Grünberg Institute (PGI-9 and PGI-2), Forschungszentrum Jülich, 52425 Jülich, Germany — [2]JARA – Fundamentals of Future Information Technologies

GaAs/InAs core/shell nanowires contain a cylindrical tube like conductor in the narrow bandgap InAs shell wrapping the wide bandgap GaAs core. These core/shell nanowires have been subject of flux dependent quantum transport measurements.

In this contribution, we present angle dependent magnetotransport measurements of GaAs/InAs core/shell nanowires with Hall contacts at various temperatures in a magnetic field applied at different tilt angles to the wire axis. Thereby it is possible to measure the crossover from flux periodic magnetoconductance oscillations ($B_{\|}$) to the regime of universal conductance fluctuations ($B_{\perp}$). A detailed analysis show clear indications of an anisotropic phase coherence length.

The same approach is also used to measure the Hall voltage in this nanowires for different temperatures and gate voltages to calculate the carrier concentration and mobility.