HL 12: Quantum Dots and Wires: Arsenides

Time: Monday 12:00–13:30 Location: POT 151

HL 12.1 Mon 12:00 POT 151

Calculation of the Diameter dependent Polytypism in GaAs Nanowires — •Volker Pankoke, Peter Kratzer, and Sung Sakong — Fakultät für Physik Universität Duisburg-Essen, Lotharstr. 1,47048 Duisburg, Germany

The formation energies of GaAs nanowires (NWs) have been calculated from a structural motif approach, supporteed by first-principles data of small diameter wires. The calculated nanowires are cut from the bulk material in [111] direction and [0001] direction for zinc blende (ZB) and wurtzite (WZ) structure, respectively. Afterwards the hydrogen free surfaces were completely relaxed. GaAs bulk material has ZB structure,but the ground state of nanowires also depends on surfaces and edges.We considered wires with hexagonal cross sections with {11-20} and {10-10} facets in case of wurtzite structure, and {10-1} and {11-2} for zinc blende structure.

We performed both density functional calculations and structural motif expansion for several of these different wires and found, that the wurtzite formation energy of small nanowires with diameters less than 80 Å is lower than the zinc blende one, due to the lower surface energy of wurtzite. This still holds if edges are negligible. The influence of additional dangling bonds at the edges and its effect on the WZ ZB transition is discussed.

HL 12.2 Mon 12:15 POT 151

Spatially resolved photocurrent spectroscopy on a single pn-doped GaAs nanowire — •Daniel Sager[1], Christoph Gutsche[2], Andrey Lysov[2], Matthias Offer[3], Ingo Regolin[2], Werner Prost[2], Franz-Josef Tegude[2], Axel Lorke[3], and Gerd Bacher[1] — [1]Werkstoffe der Elektrotechnik & CeNIDE, Universität Duisburg-Essen, Bismarckstr. 81, 47057 Duisburg, Germany — [2]Halbleitertechnologie & CeNIDE, Universität Duisburg-Essen, Lotharstr. 55, 47048 Duisburg, Germany — [3]Experimentalphysik & CeNIDE, Universität Duisburg-Essen, Lotharstr. 55, 47048 Duisburg, Germany

Due to their geometry, nanowires based on direct bandgap semiconductors are seen as ideal candidates for photovoltaic applications. Therefore, a detailed knowledge of the light to charge conversion process is essential for the future device design of solar cells. This can be accessed by spatially and temporally resolved photocurrent spectroscopy.

Single GaAs nanowires grown by metal-organic vapour phase epitaxy have been doped with Zn and Sn for p- and n-type doping, respectively, to create a doping transition in axial direction [1]. With spatially resolved photocurrent spectroscopy electron-hole pairs are photo-generated and the resulting current is measured as a function of the laser spot position. A photocurrent, which is proportional to the light illumination is found. We demonstrate maximum photocurrent generation directly at the pn-junction, which is strongly decreasing if the laser spot is placed outside the junction.

[1] I.Regolin, et al., J. Cryst. Growth (2010), doi:10.1016/j.jcrysgro.2010.08.028

HL 12.3 Mon 12:30 POT 151

Dynamic and directional modulation of the optical emission of individual GaAs nanowires using surface acoustic waves — •Jörg B. Kinzel[1], Daniel Rudolph[2], Gerhard Abstreiter[2], Jonathan J. Finley[2], Gregor Koblmüller[2], Achim Wixforth[1], and Hubert J. Krenner[1] — [1]Lehrstuhl für Experimentalphysik 1, Universität Augsburg, Germany — [2]Walter Schottky Institut, Technische Universität München, Germany

The influence of surface acoustic waves (SAW) on the optical emission of individual GaAs nanowires (NW) is investigated by micro photoluminescence (μ-PL) spectroscopy at low temperatures. In time-integrated experiments we observe a pronounced quenching of the NW emission as the amplitude of the SAW is increased. This quenching is maximum for SAW propagation along the NW axis and minimum in a perpendicular arrangement. This observation can be readily understood by a SAW-induced break-up of electron-hole pairs which is suppressed for the perpendicular configuration since the NW diameter $\sim 50-100$ nm is significantly smaller the SAW wavelength ~ 5 μm By introducing a tunable phase relation between the exciting laser pulse and the radio frequency signal exciting the SAW we observe a clear oscillation of the PL signal. In addition, time-correlated single photon counting (TCSPC) spectroscopy proves that this effect arises from a dynamic modulation of the NW emission with the frequency of the SAW.

HL 12.4 Mon 12:45 POT 151

Impact of growth conditions on morphology, structure and electrical properties of MOVPE grown InAs nanowires — •A. Penz[1,3], M. von der Ahe[1,3], K. Sladek[1,3], S. Wirths[1,3], K. Weis[1,3], C. Blömers[1,3], C. Volk[1,3], F. Dorn[2,3], T. Weirich[2,3], T. Schäpers[1,3], H. Hardtdegen[1,3], and D. Grützmacher[1,3] — [1]Institute of Bio- and Nanosystems (IBN-1), Forschungszentrum Jülich, 52428 Jülich, Germany — [2]GFE, Gemeinschaftslabor für Elektronenmikroskopie — [3]JARA - Fundamentals of Future Information Technology

The bottom-up assembly of semiconductor nanowires holds promise for future nanoelectronic devices. The high room temperature carrier mobility and the narrow direct bandgap make InAs an eligible material for this application. However, as recently reported, the conductivity of InAs nanowires could be influenced detrimentally by crystal defects such as twin planes and stacking faults. In this contribution, we report on different strategies to affect the nanowire crystallographic structure. Growth is performed by selective area MOVPE on partially masked substrates. The influence of growth rate, substrate orientation and Si doping on morphological, structural and electrical properties was investigated by scanning and transmission electron microscopy and two-and four-terminal measurements. It is found that especially the growth rate reduces the stacking fault density. Furthermore we observe an increase of conductivity and a decrease of nanowire aspect ratio with higher doping concentration. A correlation between doping, growth rate and electrical characteristics will be presented.

HL 12.5 Mon 13:00 POT 151

Strain-tuning of the excitonic fine structure splitting in semiconductor quantum dots — •Johannes D. Plumhof[1], Vlastimil Krapek[2], Fei Ding[1], Klaus D. Jöns[3], Robert Hafenbrak[3], Petr Klenovsky[2], Andreas Herklotz[1], Kathrin Dörr[1], Armando Rastelli[1], Peter Michler[3], and Oliver G. Schmidt[1] — [1]IFW Dresden, Helmholtzstr. 20, D-01069 Dresden — [2]Institute of Condensed Matter Physics, Masaryk University, Kotlářská 2, 61137 Brno, Czech Republic — [3]Institut für Halbleiteroptik und Funktionelle Grenzflächen, University of Stuttgart, Allmandring 3, 70569 Stuttgart

For the creation of polarization entangled photon pairs from semiconductor quantum dots (QDs) it is important to decrease the fine structure splitting (FSS) of the neutral exciton to energies comparable to the emission linewidth. We employ a piezoelectric actuator (PMN-PT) to manipulate the excitonic emission of GaAs/AlGaAs as well as InGaAs/GaAs QDs embedded in $\approx$200 nm thick (Al)GaAs membranes. By attaching the membranes on the PMN-PT we can apply anisotropic strain to the nanostructures. Polarization resolved μ-photoluminescence spectroscopy is used to estimate the excitonic FSS as well as the orientation of the linear polarization of the emitted light. The strain makes it possible to manipulate the FSS in a range of 70 μeV. We also observe rotations of up to 70° of the linear polarization of the light emitted by neutral excitons. These effects can be explained as an strain-induced anticrossing of the bright excitonic states.

HL 12.6 Mon 13:15 POT 151

Fabrication and optical properties of GaAs quantum dots by filling of self-assembled nanoholes — •David Sonnenberg, Andreas Graf, Christian Heyn, and Wolfgang Hansen — Institut für Angewandte Physik, Universität Hamburg, 20355 Hamburg, Germany

We study a novel type of GaAs quantum dots (QDs), which are formed by filling of self-assembled nanoholes in semiconductor surfaces during molecular beam epitaxy. Here, we report on the fabrication and optical properties of these QDs. In our case, the local droplet etching (LDE) process is started with the generation of Al droplets on the AlAs surface. Using appropriate process temperatures, nanoholes are drilled beneath the liquid droplets into the substrates. After drilling, the holes were partially filled with GaAs in order to create strain-free GaAs QDs. The only partial filling results in highly uniform QDs

with size precisely controlled by the filling level [1]. The generation of very homogeneous QD ensembles is demonsrated by photoluminescence (PL) linewiths of less than 10 meV. Micro-PL measurements of single QDs show sharp excitonic lines and linewiths combarable to the established InAs QDs [2]. We discuss here PL measurements on single and ensembles of LDE GaAs QDs as function of the QD size.

[1] Heyn et al., Appl. Phys. Let. 94, 183113 (2009)
[2] Heyn et al., Nanoscale Res. Lett. (2010) 5:1633-1636