HL 46: III-V semiconductors: mainly wires and dots

Time: Tuesday 15:00–16:15 Location: H15

HL 46.1 Tue 15:00 H15

Cathodoluminescence spectroscopy of single GaN/AlN quantum dots directly performed in a scanning transmission electron microscope — •Frank Bertram[1], Gordon Schmidt[1], Markus Müller[1], Silke Petzold[1], Peter Veit[1], Jürgen Christen[1], Aparna Das[2], and Eva Monroy[2] — [1]Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany — [2]CEA/CNRS group Nanophysique et Semiconducteurs, INAC/SP2M, CEA-Grenoble, France

In this study we will present a nanoscale optical and structural characterization of a III-nitride based quantum dot (QD) heterostructure. A 1 μm thick AlN layer grown on a sapphire substrate using metal organic vapor phase epitaxy (MOVPE) serves as template for the further growth process. Subsequent, a stack of 10 GaN QD layers, each embedded in 50 nm thick AlN barrier, were grown under an optimized plasma-assisted molecular beam epitaxy process on an AlN-MOVPE/sapphire template. The cross-section high angle annular dark field image (HAADF) in a scanning transmission electron microscope (STEM) clearly reveals the GaN QD layers. The comparison of the HAADF image with the simultaneously recorded panchromatic cathodoluminescence mapping at 16 K exhibits a spot like luminescence distribution of the upper six QD layers solely, indicating no formation of the first four intentionally grown QD layers. Addressing a very few to single QDs we observe a broad luminescence between 3.0 eV and 4.0 eV originating from the superposition of the single emission lines.

HL 46.2 Tue 15:15 H15

Epitaxial Grown InP Quantum Dots on a GaAs Buffer Realized on GaP/Si(001) Templates — •Walter Hartwig, Michael Wiesner, Elisabeth Koroknay, Matthias Paul, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

The increasing necessity of higher computational capacity and security in the information technology requires originally technical solutions, which today's standard microelectronics, as their technical limits are close, can't provide anymore. One way out offers the integration of III-V semiconductor photonics with low-dimensional structures in current CMOS technology, enabling on-chip quantum optical applications, like quantum cryptography or quantum computing. Challenges in the heteroepitaxy of III-V semiconductors and silicon are the mismatches in material properties of the both systems. Defects, like dislocations and anti-phase domains (APDs), inhibit the monolithic integration of III-V semiconductor on Si. We present the growth of a thin GaAs buffer on CMOS-compatible oriented Si(001) by metal-organic vapor-phase epitaxy. To circumvent the forming APDs in the GaAs buffer a GaP on Si template (provided by NAsP$_{III/V}$ GmbH) was used. The dislocation density was then reduced by integrating several layers of InAs quantum dots in the GaAs buffer to bend the threading misfit dislocations. On top of this structure we grew InP quantum dots embedded in a Al$_x$Ga$_{1-x}$InP composition and investigated the photoluminescence properties.

HL 46.3 Tue 15:30 H15

Measurement of Thermoelectric Properties of Indium Arsenide Nanowires — •Philipp Mensch[1], Siegfried Karg[1], Bernd Gotsmann[1], Heinz Schmid[1], Pratyush Das Kanungo[1], Volker Schmidt[1], Hesham Ghoneim[1], Mikael Björk[2], Valentina Troncale[1], and Heike Riel[1] — [1]IBM Research, Switzerland — [2]QuNano AB, Sweden

Low-dimensional semi-conducting nano-structures are promising systems to achieve a high figure of merit (ZT) for thermoelectric devices. We report on the thermoelectric properties of indium arsenide (InAs) nanowires (NWs). High ZT values for thin InAs and other III-V NWs are predicted from simulations [1]. We present temperature-dependent measurements of ZT - determining the electrical conductivity σ, the Seebeck coefficient S and the thermal conductivity κ using thermoelectric test structures for single NWs. NWs were grown by MOCVD and in-situ doped with sulfur. They were transferred to SiO$_2$ or Polyimide coated substrates. A resistive heater and four contacts to the NW, each of them serving as resistive thermometer, were structured by electron beam lithography, deposition of a nickel/platinum bilayer and lift-off technique. S and σ were measured for different doping levels with σ ranging from 30 S/cm to 2000 S/cm. S ranges from 10 μV/K for the highest doped NWs up to 180 μV/K for undoped NWs. Using a self-heating technique [2], a thermal conductivity of $\kappa = 1.8\,\mathrm{W/mK}$ was determined, being a factor of 30 lower than in bulk InAs.

[1] Mingo, Erratum APL 84, 2652 (2004)

[2] S. Karg, et al., J. Electron Mat. (2012) in press

HL 46.4 Tue 15:45 H15

The investigation of alloy formation during InAs nanowires growth on GaAs (111)B substrate — •Muhammad Saqib[1], Andreas Biermanns[1], Anton Davydok[1], Torsten Rieger[2], Thomas Grap[2], Mihail Lepsa[2], and Ullrich Pietsch[1] — [1]Feströphysik, Universität Siegen, Walter-Flex-Str. 3, Siegen 57072, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungzentrum Jülich, Jülich 52425, Germany

A possible way to obtain nanowires is the growth in molecular beam epitaxy (MBE) on the (111) oriented surface of the desired substrate, covered by a thin oxide layer. A crucial parameter in this method is the initial thickness of the oxide layer, often determined by an etching procedure. In this contribution, we report on the structural investigation of two different series (etched and unetched) of NWs samples. Vertically aligned InAs nanowires (NWs) doped with Si were self-assisted grown by molecular beam epitaxy on GaAs [111]B substrates covered with a thin SiO$_x$ layer. Using a combination of symmetric and asymmetric X-ray diffraction we study the influence of Si supply on the growth process and nanostructure formation. We find that the number of parasitic crystallites grown between the NWs increases with increasing Si flux. In addition, we observe the formation of a Ga$_{0.2}$In$_{0.8}$As alloy if the growth is performed on samples covered by a defective (etched) oxide layer. This alloy formation is observed within the crystallites and not within the nanowires. The Gallium concentration is determined from the lattice mismatch of the crystallites relative to the InAs nanowires. No alloy formation is found for samples with faultless oxide layers.

HL 46.5 Tue 16:00 H15

Imaging the local density of free charge carriers in doped InAs nanowires — •Benedikt Hauer[1], Kamil Sladek[2], Fabian Haas[2], Thomas Schäpers[2], Hilde Hardtdegen[2], and Thomas Taubner[1] — [1]I. Institute of Physics (IA), RWTH Aachen Univerity, Sommerfeldstraße 14, 52074 Aachen, Germany — [2]Peter Grünberg Institute (PGI-9), Forschungszentrum Jülich, 52425 Jülich, Germany

Semiconductor nanowires are promising candidates for future nanoelectronic devices. While the bottom-up approach for their growth could simplify the device fabrication, their quantitative characterization remains challenging. We use scattering-type scanning near-field optical microscopy (s-SNOM) to investigate the local density of free electrons in Si-doped InAs nanowires grown by selective-area metalorganic vapor phase epitaxy (SA-MOVPE) [1].

In s-SNOM the evanescent electric field at the apex of an illuminated tip is used to probe a sample at a strongly sub-wavelength resolution. This method is highly sensitive to variations in the sample permittivity around Re(ε) ≈ -2 [2]. The use of tunable mid-infrared lasers therefore allows addressing the plasma frequency of free charge carriers in highly doped nanowires [3]. Here, we demonstrate that the sensitivity of s-SNOM is sufficient to detect a slight unintended variation in the carrier concentration during the growth process. Furthermore, using model calculations, we give an estimate of the local density of free electrons.

[1] S. Wirths *et al.*, J. Appl. Phys. 110, 053709 (2011).

[2] B. Hauer *et al.*, Opt. Express 20, 13173 (2012).

[3] J. Stiegler *et al.*, Nano Lett. 10, 1387 (2010).