HL 41: Quantum Dots and Wires: Preparation and Characterization II

Time: Wednesday 11:00–12:45 Location: H13

HL 41.1 Wed 11:00 H13

Selective MBE-growth of GaN nanowires on patterned substrates — •Timo Schumann, Tobias Gotschke, Toma Stoica, Friedrich Limbach, and Raffaella Calarco — Institute of Bio- and Nanosystems (IBN-1), Research Center Jülich GmbH, D-52425 Jülich, Germany, and JARA-Fundamentals of Future Information Technology

Self assembled III-nitride nanowires are promising candidates for optoelectronic devices. The precise control of size and position of the nanowires is crucial for further applications.

We demonstrate the selective growth of arranged GaN nanowires by plasma-assisted molecular beam epitaxy on an AlN buffer. The position of each nanowire is controlled by a thin silicon oxide mask, patterned by electron beam lithography.

The dependence of selectivity and nanowire morphology on the growth parameters and mask properties are investigated. We change the substrate temperature and the Ga-flux, retaining nitrogen rich conditions, which are suitable for self-assembled nanowire growth. Samples with different masks are produced, varying the thickness and the layout. The diameter of the holes and their distance from each other vary across the pattern. We discuss the influence of these parameters on the nanowire growth and morphology.

HL 41.2 Wed 11:15 H13

Electrochemical analysis of Si and Mg doped GaN nanowires — •Jens Wallys[1], Sascha Hoffmann[1], Florian Furtmayr[1,2], Markus Schäfer[1], Jörg Teubert[1], Jörg Schörmann[1], and Martin Eickhoff[1] — [1]I. Physikalisches Intstitut, Justus-Liebig-Universität Gießen, Germany — [2]Walter Schottky Institut, Garching, Germany

Due to their high electrochemical stability and the large surface-to-volume ratio, GaN nanowires are promising candidates for applications in the field of photocatalytic water splitting and electrochemical sensors. We have analyzed the electrochemical properties of non intentionally doped, Si-doped and Mg-doped GaN nanowires grown on Si (111) substrates by plasma assisted molecular beam epitaxy.

Bias dependent electrochemical impedance spectroscopy measurements and comparison to an equivalent circuit model allowed extraction of the nanowire electronic properties. The influence of doping on the carrier type and density in the nanowires is discussed.

HL 41.3 Wed 11:30 H13

Vertical and lateral heterostructure of GaN/InGaN within nanowires — •Friederich Limbach[1], Tobias Gotschke[1], Toma Stoica[1], Raffaella Calarco[1], Eli Sutter[2], Ramon Cusco[3], and Luis Artus[3] — [1]Institute of Bio- and Nanosystems (IBN-1), Research Center Jülich GmbH, D-52425 Jülich, Germany, and JARA-Fundamentals of Future Information Technology — [2]Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York 11973, USA — [3]Institut Jaume Almera, Consell Superior d'Investigacions Científiques (CSIC), 08028 Barcelona, Catalonia, Spain

A vertical and lateral GaN/InGaN heterostructure within a nanowire has been grown by plasma assisted molecular beam epitaxy. The resulting wires have a complex morphology which results from a combination of vertical and lateral heterostructure interfaces. Photoluminescence indicates Indium content in the InGaN alloy of approximately 30 % and evidences in addition a high quality of the GaN nanowire. Raman investigation based on the analysis of the LO peak position and its shape reveal a composition variation between 20 % and 30 %. XRD measurements show a peak with an onset at 17.26° that extends to 16.6° also suggesting a spread in compositions. Transmission electron microscopy analysis indicates composition variations along the wire growth direction. In addition insight is gained about the position of the heterointerfaces. This allows an understanding of the complex shape of the nanowire.

HL 41.4 Wed 11:45 H13

MBE grown InN nanowires: Doping effects of Si and Mg — •Tobias Gotschke[1], Friederich Limbach[1], Roberta Caterino[1], Toma Stoica[1], Eike Oliver Schäfer-Nolte[1], Raffaella Calarco[1], and Elli Sutter[2] — [1]Institute of Bio- and Nanosystems (IBN-1) Research Centre Jülich GmbH, D-52425 Jülich, and JARA- Fundamentals of Future Information Technology, Germany — [2]Center for Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York 11973, USA

Si and Mg doped InN nanowires (NWs) were grown by plasma assisted molecular beam epitaxy on Si(111) substrates under nitrogen rich conditions. Influence of dopant flux, substrate temperature and In flux were investigated by means of SEM, PL and Raman. We can show that Si doped InN nanowires can be grown at higher substrate temperatures than the undoped once. By carefully choosing growth parameters the fabricated Si doped nanowires can be optimized in terms of morphology yielding to well separate nanowires with high aspect ratio and smooth sidewalls. The growth parameters chosen for the realization of Mg doped nanowires are very similar to that of undoped InN NWs. Photoluminescence measurements on Si doped nanowires show a band filling effect, which indicates a successful n-doping. PL intensity, peak energy and broadening of the peaks are fluctuating by doping with Mg. An intense LO mode in Raman measurements on InN nanowires has been observed. Mg doped NWs show a narrowing of the Raman peaks. A low energy tail emerges for the LO mode upon high doping with Si.

HL 41.5 Wed 12:00 H13

MOVPE overgrowth of InN quantum dot like structures — •Christian Meissner[1,2], Michael Högele[1], Raimund Kremzow[1], Markus Pristovsek[1], and Michael Kneissl[1] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstraße 36, EW6-1, 10623 Berlin — [2]ISAS - Institute for Analytical Sciences, Albert-Einstein-Straße 9, 12489 Berlin

Indium nitride (InN) quantum dots could be used an alternative material for applications at the standard telecommunication wavelength of 1.55 μm. We showed that the density and size of InN quantum dots grown in Volmer-Weber growth mode can be controlled by growth temperature and total amount of InN on the surface. For light emitting devices those quantum dot like structures need to be overgrown. Therefore, we studied systematically the overgrowth process by MOVPE of InN quantum dots on GaN/sapphire with a density of 10^{10} cm^{-2}. Different capping strategies were monitored by in-situ ellipsometry which allows investigations on a submonolayer scale of the InN/GaN system with 11% lattice mismatch. Additional characterisation was done by atomic force microscopy, x-ray and photoluminescence measurements.

The main problem of indium segregation from InN QDs into the first capping layers and the formation of InGaN is observed by XRD with a gallium content of less than 20%. Thus for overgrowth a high growth rate is needed, but the material quality must still be maintained. Further investigations with InGaN capping layers to reduce the strain during overgrowth have been done.

HL 41.6 Wed 12:15 H13

DLTS measurements on GaSb/GaAs quantum dots — •Annika Högner[1], Tobias Nowozin[1], Andreas Marent[1], Dieter Bimberg[1], Chi-Che Tseng[2], and Shih-Yen Lin[3] — [1]Institut für Festkörperphysik, TU Berlin, Hardenbergstr. 36, 10623 Berlin — [2]Institute of Photonics Technologies, NTHU, Taiwan — [3]Institute of Optoelectronic Sciences, NTOU, Taiwan

Memory devices based on hole storage in self-organized quantum dots offer significant advantages with respect to storage time and scalability. Recently, we demonstrated a first prototype based on InAs/GaAs quantum dots at low temperatures [1]. To enable feasible storage times at room temperature the localisation energy of the quantum dots has to be increased by using other material systems. A first step in this direction is the use of GaSb quantum dots within a GaAs matrix.
We have characterized self-organized GaSb/GaAs quantum dots embedded into a n$^+$p-diode structure. DLTS measurements on hole emission were conducted and yield a strong peak from which a mean emission energy of about 400 meV can be extracted. The reference sample without the quantum dots (containing only the wetting layer) shows no such peak.

[1] A. Marent, T. Nowozin, J. Gelze, F. Luckert, and D. Bimberg, "Hole-based memory operation in an InAs/GaAs heterostructure",

Appl. Phys. Lett. (in press).

HL 41.7 Wed 12:30 H13

Investigating Axial Zinc Doping Profile in Galliumarsenide Nanowires with Kelvin Force Microscopy and Scanning Microwave Microscopy — •Matthias Fenner[1], Hassan Tanbakuchi[1], C. Gutsche[2], A. Lysov[2], I. Rgolin[2], W. Prost[2], and F.-J. Tegude[2] — [1]Agilent Technologies, Campus Kronberg, 61476 Kronberg, Germany — [2]Center for Nanointegration, University of Duisburg-Essen, Duisburg, Germany

Nanowires with a nominal change of the doping along the nanowire axis were grown. Fabrication of high quality doping and material transitions is well established in bulk semiconductors. This is callenging especially for III-V nanowires, where a complete model of the vapour-liquid-solid (VLS) growth mechanism is still pending. We employed two atomic force microscopy (AFM) methods for dopant profiling of GaAs nano wires: Kelvin Force Microscopy (KFM) and Scanning Microwave Microscopy (SMM). KFM indirectly measures the dopant density via the surface potential [1, 2]. SMM measures the capacitance of the tip sample junction with resolutions in the attofarad and nanometer range. By means of a local capacitance spectroscopy method (dC/dV) SMM directly maps the dopant density in semiconductors [3]. The two methods show transitions from undoped to doped regions in the nanowires as well as gradients along the axis of the wires.

[1] C. Baumgart, M. Helm, H. Schmidt, Phys. Rev. B 80, 085305 (2009). [2] S. Vinaji et al., Nanotechnology 20 (2009) [3] F. Michael Serry, Agilent Application Note 5989-8818EN, http://cp.literature.agilent.com/litweb/pdf/5989-8818EN.pdf, 2008.