Beinik — GaAs(111)B in III-V quantum dots and wires on the nanometer scale. This work successfully applied as a tool for investigation of electrical properties. The presented results prove that C-AFM technique might be used to study the surface topography and conductivity simultaneously. Comparison of the corresponding cross-section profiles indicated that InAs nucleation takes place on the [1-10]-oriented step bunches, forming 3 nm-high and up to 70 nm-wide wires of variable length. On the other hand, [1-12]-type steps very rarely appeared to bunches, forming 3 nm-high and up to 70 nm-wide wires of variable length. On the other hand, [1-12]-type steps very rarely appeared to be decorated by InAs, also in agreement with previous TEM studies [1]. The presented results prove that C-AFM technique might be successfully applied as a tool for investigation of electrical properties in III-V quantum dots and wires on the nanometer scale. This work is supported by FWF Project # P19636, OAD project # ES 17/2007, TEC2007-66955 and HU2006-0022. [1] X.M. Zhirin, D.W. Pashley, L. Kamiya, J.H. Neave, B.A. Joyce, J. Cryst. Growth 147 (1995) 234.

Nucleation of Cu-induced GaAs Nanowires on Si(111) and GaAs(111)B — • Steffen Breuer, Maria Wagler, Lutz Geelhaar, Achim Trampert, and Henning Riechert — Paul-Drude-Institut für Festkörperfunktionstechnik, Hausvogteiplatz 5-7, 10117 Berlin

Vertical nanowires (NWs) offer a novel path towards monolithic integration of III-V semiconductors such as GaAs on Si. We studied nucleation and growth of GaAs NWs by the Au-induced vapor-liquid-solid (VLS) mechanism in a molecular beam epitaxy (MBE) chamber on Si(111) and compared it to the homoepitaxial case on GaAs(111)B. NWs grown for 30 min on each substrate are straight and have very similar shapes, lengths and densities, as found by scanning electron microscopy (SEM). We conclude from reflection high-energy electron diffraction (RHEED) patterns that on both substrates the NWs have Wurtzite (W2) crystal structure and are epitaxially aligned to the respective substrate. A series of experiments with growth times between 5 s and 300 s was performed on each substrate. At this early stage, there are significantly more NWs on GaAs(111)B than on Si(111). Apparently, on Si(111) NW formation is delayed. Instead, the early surface is predominantly covered by three-dimensional GaAs islands that have Zinchloride (ZB) crystal structure and a high density of twinning defects, as found by RHEED. We conclude that on Si(111) most Au droplets were inactive initially until the whole surface is covered by coalesced GaAs islands. We speculatively explain this by a model that assumes different interface energies for liquid Au on the two types of substrate.

Ga-assisted growth of GaAs nanowires by molecular beam epitaxy — • Sonja Heiderich, Mihail Ion Lepsa, and Detlev Grutzmacher — 1Institute of Bio- and Nanosystems (IBN-1) and JARA-Fundamentals of Future Information Technology, Forschungszentrum Jülich GmbH, D-52425 Jülich — 2Universität Hamburg, Institut für Angewandte Physik, Jungiusstr. 11, D-20355 Hamburg

An important aim of many research activities is the integration of III-V semiconductor nanowires in the established and cheaper silicon technology to get novel electronic and optoelectronic devices. Until now, III-V semiconductor nanowires have been typically synthesized using Au nanoparticles (catalyst) as a seed and the vapor-liquid-solid (VLS) or vapor-solid-solid (VSS) mechanisms. However, the Au can diffuse into the wire during the growth and affect the electronic transport properties. Therefore the growth of nanowires using the group III element as a seed represent the ideal option. In this report, we present data about the Ga-assisted growth of GaAs nanowires by molecular beam epitaxy (MBE). The nanowires have been grown on (100) or (111) GaAs substrates covered with a thin hydrogen silsesquioxan (HSQ) film. A study varying the growth conditions has been realized. From the analysis of the nanowire diameter and length (growth rate) in different growth conditions, we propose a phenomenological growth model. The model take into account that the growth proceeds via VLS mechanism from Ga droplets which develop at the beginning and are situated over preexisting pinholes in HSQ.
tion, and finally growth of GaN below the seeds. The comparison of the QMS profiles for the first phase with and without Ni showed that Ga incorporation into the Ni seeds is not the growth limiting step. Moreover the tilt of the seed crystal structure in the second phase suggests a bulk diffusion process of Ga into the Ni seeds. Last the observation of a clear RHEED pattern during the whole nucleation is a strong evidence for the vapor-solid-solid mechanism (VSS).

HL 33.7 Wed 15:45 BEY 81 Catalyst free selective area MBE growth of InN nanocolumns on Si — •Boris Landgraf, Christian Denker, Jörg Malin- dretos, and Angela Rizzi — IV. Physikalisches Institut, Georg-August Universität Göttingen, 37077 Göttingen, Germany

Nowadays InN nanocolumns (NCs) are studied for many possible applications, e.g. as single devices - nanowire transistors - as well as ensembles in solar cells. A size and position controlled growth of nanocolumns is highly desirable. It allows a detailed study and optimization of the growth mechanism and is mandatory for the growth of axial and radial heterostructures. To maintain the high purity of MBE grown nanocolumns a catalyst free approach is preferable.

The selective area MBE growth of InN NCs has been investigated by using various masking materials. Electron beam lithography is applied to pattern the material masks with different layouts in order to determine the diffusion length of the indium on the respective materials. Subsequently nanocolumns were grown on the patterned substrates. It will be shown that the size and position of the InN nanocolumns can be controlled by the use of appropriate mask patterns and materials.

HL 33.8 Wed 16:00 BEY 81 GaN and InN nanowires: Si and Mg doping — Stoma Stoca, Eli Sutter, Ralph Meijers, Ratan Debnath, Kulananda Jeganathan, Thomas Richter, Michel Marso, Hans Luth, and Raffaella Calarco — 1Institute of Semiconductor Nanoelectronics (IBN-1), Research Centre Jülich GmbH, D-52425 Jülich, Germany, and 2Institute of Functional Nanomaterials, Brookhaven National Laboratory, Upton, New York 11973 — 3Department of Physics, Bharathidasan University, Trichirappalli - 620 025, India — 4University of Luxembourg, Faculty of Sciences, Technology and Communication - 6, rue Richard Coudenhove-Kalergi, L-1359 Luxembourg

Doping is essential for the realization of optoelectronic devices and represents a complex task if related to nanowires. We have studied GaN and InN nanowires (NWs) doped by Si and Mg obtained by catalyst-free MBE on Si(111) in N-rich conditions. Increasing the Si amount the morphology as well as the density of the wires changes. Successful n-doping of GaN nanowires has been shown by electrical and optoelectrical measurements. Due to the sensitivity of the electrical transport to the wire diameter (size dependent surface barrier), it was possible to determine the doping level of single nanowire. A small amount of Mg increases the tendency of the wires to coalesce. For InN nanowires doped with Si a reduced NWs density is observed as compared to the undoped counterpart. The Mg doping does not change the morphology of the NWs as compared to the undoped however some stacking faults at the tip could be observed.

15 min. break

HL 33.9 Wed 16:30 BEY 81 In-situ RHEED study on the morphology of MBE-grown GaN nanowires — •Matthias Knelangen, Achim Trampert, Lutz Geelhaar, and Henning Riechert — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin, Germany

GaN nanowires are defect-free, quasi 1-dimensional nanocrystals. Although the fabrication of nanowires is well established, there is still a lack of understanding of the initial nucleation and the catalyst-free self-organized growth mechanism. In this work, we will present an in-situ RHEED study of the nucleation process of GaN nanowires growth on Si (111) substrates.

If GaN growth is initiated directly on Si, the RHEED pattern turns faint and blurry, characteristic for the formation of an amorphous SiNxNy layer. After GaN nucleation, the RHEED spots are broadened, indicating a tilt of the wires with respect to the substrate. The superposition of two different azimuthal RHEED patterns and the in-dependence to substrate rotation demonstrate the loss of in-plane orientation.

When growing on a smooth AlN buffer, the RHEED shows a clear transition from the AlN reflection pattern to a GaN transmission pattern. The two characteristic azimuths do correspond, showing the epitaxial alignment between AlN and GaN. HRTEM images show that the AlN layer relaxes by formation of misfit dislocations. The GaN/AlN interface is defect-free, so there is no plastic relaxation in the nanowires. Additional ex-situ TEM and XRD experiments will complement this RHEED study to investigate the overall strain of GaN and AlN.

HL 33.10 Wed 16:45 BEY 81 Local electrical analysis of a single semiconductor nanowire by Kelvin probe force microscopy — •Sasa Vinaj, André Lochthofen, Wolfgang Merith, Ingo Regolin, Christoph Gutsche, Kai Bleeker, Werner Probst, Franz Josef Tegude, and Gerda Bacher — 1Werkstoffe der Elektrotechnik & CeNIDE, Universität Duisburg-Essen, Bismarckstr. 1, 47057 Duisburg, Germany — 2Halbleitertechnologie & CeNIDE, Universität Duisburg-Essen, Lotharstr. 55, 47048 Duisburg, Germany

Semiconductor nanowires open a wide range of innovative and exciting electronic and optoelectronic applications. For future device design a detailed knowledge of the local electrical potential is essential. This can be easily accessed by non-contact Kelvin Probe Force Microscopy (KPFM) without damaging the fragile nanowires.

Single GaAs nanowires grown by metal-organic vapour phase epitaxy have been investigated with KPFM. In order to prove the efficiency of p-type doping by ion implantation of Zn [1], the local voltage drop across a biased nanowire was measured quantitatively. From the resistance of the nanowire found, an effective carrier concentration of $6 \times 10^{17}$ cm$^{-3}$ could be estimated. Alternatively, a GaAs nanowire was doped during growth with Si and C for n- and p-type doping, respectively. We could localize the doping transition inside the nanowire via KPFM measurements and found a depletion zone of about 350 nm.


HL 33.11 Wed 17:00 BEY 81 Ion Beam Induced Alignment of Semiconductor Nanowires — •Christian Borschel, Raphael Niepelt, Sebastian Geburt, Christoph Gutsche, Ingo Regolin, Werner Probst, Franz-Josef Tegude, Daniel Stichtenoth, Daniel Schwen, and Carsten Ronning — 1Institute for Solid State Physics, University of Jena, Max-Wien-Platz 1, 07743 Jena, Germany — 2Institute for Semiconductor Technology, University of Duisburg-Essen, Lotharstraße 55, 47057-Duisburg, Germany — 3II. Institute of Physics, University of Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen, Germany

4Department of Materials Science and Engineering, University of Illinois @ Urbana-Champaign, 1304 W. Green St., Urbana, IL 61801, USA

GaAs nanowires were grown on top of $<100>$ GaAs substrates, mainly adopting the epitaxial relation and thus growing with an angle of about 35$^\circ$ off the substrate surface. These perfectly straight nanowires were irradiated with different kinds of energetic ions. Depending on ion species, energy, and fluence, we observed that the nanowires headed down towards the surface or up. The intensity of the bending increased with ion fluence. In the case of upwards bending, alignment of the nanowires along the incident ion beam direction could be achieved. The experiments have been simulated to obtain vacancy and interstitial distributions using a special version of TRIM, which accounts for the geometry of the nanowire. The simulated distributions indicate vacancy and interstitial formation within the implantation cascade as the key mechanism for bending.