HL 30: Nano Wires: Growth and Characterization

Time: Tuesday 10:15–11:45 Location: FOE Anorg

HL 30.1 Tue 10:15 FOE Anorg

Autocatalytic growth of GaAs nanowires on Si (111) using different SiO_x templates — Daniel Rudolph[1], Simon Hertenberger[1], Xiaodong Wang[1,2], •Watcharapong Paosangthong[1], Max Bichler[1], Gerhard Abstreiter[1], Jonathan J. Finley[1], and Gregor Koblmüller[1] — [1]Walter Schottky Institut, TU München, Garching, Germany — [2]Pohl Institute of Solid State Physics, Tongji Univ., Shanghai, P.R. China

We investigated the autocatalytic growth of GaAs nanowires (NWs) by molecular beam epitaxy on three different kinds of substrate templates: Si (111) coated with (a) an ultrathin layer of amorphous SiO_x, (b) an ultrathin layer of thermal SiO_2, and (c) a layer of thermal SiO_2 with periodic hole patterns defined by electron beam lithography. For the latter, we have investigated the effect of growth temperature and V/III ratio on the vertical NW growth yield and growth selectivity. The grown NWs were characterized using scanning electron microscopy (SEM), high resolution x-ray diffraction (HRXRD), transmission electron microscopy (TEM) and photoluminescence (PL) spectroscopy: SEM images and in-situ reflection high energy electron diffraction studies identified the growth to be mediated by the vapor liquid solid mechanism. A good epitaxial relationship between NWs and the Si substrate is confirmed by HRXRD measurements. TEM analysis revealed the crystal structure to be predominantly zincblende but shows the occurrence of twin boundaries and stacking faults. These results are supported by spatially resolved single NW PL spectroscopy measurements which exhibit the optical signature of zincblende GaAs.

HL 30.2 Tue 10:30 FOE Anorg

MBE growth of axial AlGaAs/GaAs heterostructure nanowires — •Torsten Rieger, Mihail Ion Lepsa, Thomas Schäpers, Hans Lüth, and Detlev Grützmacher — Institute of Bio- and Nanosystems (IBN-1) and JARAFundamentals of Future Information Technology, Forschungszentrum Jülich GmbH, D-52425 Jülich

Nanowire (NW) heterostructures are promising candidates for future (opto-)electronic devices but only little is known about their growth, especially in the case of axial heterostructures containing different group III elements. Here we report about the molecular beam epitaxial (MBE) growth of axial AlGaAs/GaAs heterostructure NWs on GaAs (111)B substrates spin-coated with a thin layer of hydrogen silesquioxan (HSQ). No Au is used to catalyze the growth. We have investigated the influence of Al beam flux, growth time and substrate temperature on the NW growth. It is found that even small amounts of Al reduce the axial growth but strongly promote growth on the amorphous oxide and NW sidewalls leading to unintentionally grown core/shell NWs. Up to an Al amount corresponding to 20%, the axial growth rate is still higher than the layer growth rate. This demonstrates the possibility to grow axial AlGaAs/GaAs heterostructure nanowires using self-catalyzed growth, although the switching back from AlGaAs to GaAs is found to be challenging, mainly due to growth on the amorphous oxide.

HL 30.3 Tue 10:45 FOE Anorg

Doping dependence of the electrochemical properties of GaN:Si nanowires. — •Jens Wallys[1], Florian Furtmayr[1,2], Rudolph Matz[1], Marcus Rohnke[3], and Martin Eickhoff[1] — [1]I. Physikalisches Institut, Justus-Liebig-Universitaet Giessen — [2]Walter Schottky Institut, Technische Universitaet Muenchen — [3]Physikalisch-Chemisches Institut, Justus-Liebig-Universitaet Giessen

Recently, the interest in self assembled nanowires (NW) increased due to their low density of structural defects, the possibility of doping and embedding III-N heterostructures, which allow the realization of novel nanoscale optoelectronic devices, such as light emitters and chemical sensors. For these applications understanding and control of dopant incorporation is an important issue. While investigations based on electron microscopy or optical methods provide valuable information, the determination of the doping concentration in NWs is still problematic since many conventional methods (e.g. Hall measurements) are not applicable.

In this study we investigated various Si-doped GaN NWs grown by plasma assisted molecular beam epitaxy. In order to determine the Si concentration we performed electrical impedance spectroscopy measurements of NW-ensembles. This allows us to extract the surface capacitance and surface resistance via numerical fitting of electrical equivalent circuits to the experimental spectra. The obtained results were compared to time of flight - secondary ion mass spectroscopy measurements as an alternative approach. In addition, the effect of NW-ageing is addressed.

HL 30.4 Tue 11:00 FOE Anorg

Effects of doping profile on the optoelectronic properties of GaN nanowires — •Friederich Limbach[1,2], Tobias Gotschke[1,2], Toma Stoica[1], Carsten Pfüller[2], Oliver Brandt[2], Achim Trampert[2], Sebastian Geburt[3], Carsten Ronning[3], and Raffaella Calarco[1,2] — [1]Institute of Bio- and Nanosystems (IBN-1), Research Centre Jülich GmbH, 52425 Jülich, Germany, and JARA-FIT Fundamentals of Future Information Technology — [2]Paul-Drude-Institute for Solid State Electronics, Hausvogteiplatz 5-7, 10117 Berlin, Germany — [3]University Jena, Inst Solid State Phys, D-07743 Jena, Germany

GaN NWs with two different doping profiles were grown on Si(111) substrates in nitrogen rich conditions without any catalyst using an AlN buffer layer. In one case Si was supplied during the first 2 hours of the growth followed by 30 min without supply of any doping species, subsequently growth was continuing for an additional 2 hours with supplying Mg (Type-A). In the other case the reverse structure was fabricated, starting with Mg doping and ending with Si doping (Type-B). For all samples of type-B, the DAP signal in PL, μ-PL and CL is less intense than the NBE peak and in some cases almost not detectable. In contrast Type-A samples show a very strong DAP signal. By combining PL, μ-PL and CL results, we concluded that during the first stages of the growth of GaN NWs, the incorporation of Mg is hampered, while in the later phase of the growth, the Mg is more effectively incorporated and acts as an acceptor in the GaN matrix.

HL 30.5 Tue 11:15 FOE Anorg

Kelvin probe force microscopy on doping transitions in single semiconductor nanowires — •Sasa Vinaji[1], Wolfgang Mertin[1], Christoph Gutsche[2], Andrey Lysov[2], Ingo Regolin[2], Werner Prost[2], Franz-Josef Tegude[2], 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

In order to realize innovative electronic and optoelectronic devices with semiconductor nanowires, controlled doping has to be achieved. Therefore detailed knowledge about the doping level and the local position of the doping transition is essential. This can be accessed by non-contact Kelvin Probe Force Microscopy (KPFM) without damaging the sensitive nanowire [1].

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 [2]. The nanowires show macroscopic diode-like IV-characteristics. With KPFM single nanowires have been analyzed, and a pn-junction has been localized inside the nanowires with a depletion zone of about 180 nm. Additionally, different biases have been applied and the variation of the depletion width has been investigated.

[1] S. Vinaji, et al., Nanotechnology 20, 385702 (2009), [2] I.Regolin, et al., J. Cryst. Growth (2010), doi:10.1016/j.jcrysgro.2010.08.028

HL 30.6 Tue 11:30 FOE Anorg

Microstructures and electronic properties of one-dimensional ZnO nanostructures — •Peter Hess, Yong Lei, Martin Peterlechner, and Gerhard Wilde — Inst. f. Materialphysik, WWU Münster

One-dimensional (1-D) ZnO nanostructures were systematically investigated concerning their micro-structures and their photoluminescence properties. The main focus of this work is on the assembly of nanowires of different shapes and sizes to investigate their properties. The ZnO 1-D and 2-D structures were prepared using a Chemical Vapour Deposition (CVD) system with ZnO/C mixtures as sources, Au-coated silicon or sapphire as substrates, and an argon and oxygen gas flow as a distributor and oxidation source. Depending on the conditions during the CVD process, different kinds of ZnO nanostructures were obtained. The morphology of the ZnO nanostructures was checked by SEM while the photoluminescence properties were investigated using a spectrometer. Additionally, the crystalline structures, the growth direction, and the lattice spacing of ZnO nanostructures were characterized using TEM. First experiments were also conducted concerning the electrical properties of the Nanowires.