HL 42 Quantum dots and wires: Preparation and characterization I

Time: Thursday 11:00–13:00 Room: POT 51

HL 42.1 Thu 11:00 POT 51

Silicon Dioxide Nanowires with Embedded Au/Si Nanoparticles — •Florian M. Kolb, Andreas Berger, Herbert Hofmeister, Eckhard Pippel, Margit Zacharias, and Ulrich Gösele — Max-Planck-Institut für Mikrostrukturphysik, 06120 Halle(Saale)

By combining SiO evaporation with the VLS mechanism (1), apart from crystalline silicon nanowires with an amorphous oxide shell, also amorphous nanowires with chains of periodically embedded nanoparticles can be observed. We found that this unusual nanowire morphology consists of pure SiO_2 with embedded Au/Si nanoparticles, using Energy-Dispersive X-Ray Spectroscopy (EDXS), Electron Energy-Loss Spectroscopy (EELS) and High-Resolution TEM (HRTEM). Experimental results suggest that the formation of the nanoparticle chains is induced by oxygen. Combined with the SiO-VLS growth, we propose a model for the formation mechanism of the nanoparticle chains, in which the nanoparticles originate from the liquid Au/Si nanowire tip. Possible applications for this special nanowire morphology are discussed.
(1) F. M. Kolb, H. Hofmeister, R. Scholz, M. Zacharias, U. Gösele, D. D. Ma, S.-T. Lee. J. Electrochem. Soc. **151** (7) G472 (2004)

HL 42.2 Thu 11:15 POT 51

Axial and radial growth of GaN-nanowires by molecular beam epitaxy — •C. Chèze[1], L. Geelhaar[1], Ph. Komninou[2], Th. Kehagias[2], Th. Karakostas[2], W. Weber[1], R. Averbeck[1], and H. Riechert[1] — [1]Infineon Technologies, D-81370 Munich, Germany — [2]Aristotle University of Thessaloniki, Department of Physics, GR-54124 Thessaloniki, Greece

GaN-nanowires were grown on c-plane sapphire substrates by solid-source molecular beam epitaxy (MBE) employing a RF plasma source for the incorporation of nitrogen. The formation of nanowires is induced by a thin layer of Ni that is sputtered onto the substrates and annealed prior to the growth of GaN. The orientation of the nanowires is perpendicular to the substrate, and their length is fairly uniform. Cross-section transmission electron microscopy (XTEM) observations reveal that the nanowires are single crystalline and have a wurtzite structure. Growth under N-rich conditions proceeds in axial direction, i.e. the nanowires become longer. In contrast, under Ga-rich conditions the nanowires grow in radial direction, i.e. they become thicker. Under both conditions, the growth rate in the dominant direction (either axial or radial) is about two orders of magnitudes greater than the growth rate in the respective other direction. Thus, both length and diameter can be controlled by choosing the appropriate N/Ga-flux-ratio and growth duration.

HL 42.3 Thu 11:30 POT 51

Thermal conductivity of gases from power-dependent Raman spectroscopy on silicon nanowires — •Harald Scheel[1], Stephanie Reich[2], Carola Nisse[1], and Christian Thomsen[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin, Germany — [2]Department of Materials Science and Engineering, Massachusetts Institute of Technology, Cambridge, Massachusetts 02139-4307

The Raman spectra of silicon nanowires are studied as a function of laser excitation power and the molar mass of surrounding gases. We find that the thermal conductivity of a gas determines the nanowire temperature, which can be detected by a change in the Raman frequency. We can thus distinguish different gases by their thermal conductivities.

HL 42.4 Thu 11:45 POT 51

Field effect transistors with silicon nanowires as active region — •W. M. Weber[1,2], E. Unger[1], A. Graham[1], M. Liebau[1], G. Duesberg[1], C. Cheze[1], L. Geelhaar[1], H. Riechert[1], P. Lugli[2], and F. Kreupl[1] — [1]Infineon Technologies AG. 81370 Munich, Germany — [2]Technische Universität München, Institute for Nanoelectronics. 80333 Munich, Germany

The steadily increasing requirements for future electronic semiconductor applications demand large efforts in the miniaturization and performance increase of new transistors. Catalytically grown silicon nanowires (Si-NW) are promising elements for such devices combining bottom-up processing and excellent electrical characteristics. Here, we present experimental results on field effect transistors using thin Si-NWs (diameter below 25 nanometers) as the active regions. Nanowires were grown by chemical vapour deposition using Au as catalyst. Subsequently, the Si-NWs were transferred to test chips for electrical characterization. Test chips consist of a patterned electrode structure on top of an oxide layer serving as gate dielectric. 3-terminal measurements are possible by using the entire substrate as a back-gate. For NiSi, CoSi, and PdSi source and drain contacts, the output characteristic implies Schottky barriers. Although the Si-NWs are nominally undoped, they show p-type behaviour for these contact metals. The transfer characteristic can be modulated by more than 7 orders of magnitude. The on current is as high as 1 micro-ampere for a single 1 micrometer long and 23 nanometers thick wire as the active region. Also, devices with short gate lengths down to 18 nanometers were investigated.

HL 42.5 Thu 12:00 POT 51

Growth of ZnO Nanorods for Optoelectronic and Spintronic Applications — •A. Che Mofor, Andrey Bakin, Abdel-Hamid El-Shaer, Eva Schlenker, and Andreas Waag — Institute of Semiconductor Technology, Technical University Braunschweig, Hans-Sommer-Str. 66, D-38106 Braunschweig

ZnO has a wide band gap of 3.37 eV at room temperature, it is transparent, radiation resistant with lasing achievable at temperatures well above 300 K. If successfully doped with magnetic impurities, ZnO and its nanostructures would be an interesting candidate for spintronic applications. Growth of ZnO nanorods using metal catalysts and graphite at relatively high temperatures (usually above 1000° C) has been reported. These methods are associated with impurities that may not be detected by conventional crystal characterisation methods like transmission electron microscopy and x-ray diffractometry. We report on the growth of ZnO nanorods by employing a specially designed horizontal vapour transport system with elemental sources at relatively low temperatures without catalysis. We employed 6N elemental Zn carried by N2 gas and 99.995% O2 gas as reactants. The ZnO nanorods were grown directly on 6H-, 4H-SiC and (11-20)Al2O3 substrates at growth temperatures from 650 to 800° C and pressure 10-25 mbar. X-ray diffraction rocking curves with a full width at half maximum (FWHM) of 0.23° and room temperature photoluminescence peaks of high intensity and FWHM of 90 meV were obtained. ZnO nanorods with widths of 80-900 nm and lengths of 4-12 μm and density of 109 cm-2 were noted. Different approaches for nanodevice realisation shall also be presented.

HL 42.6 Thu 12:15 POT 51

Advanced and selective growth of ZnO nanopillars in wet chemical solution — •Bianca Postels, Marc Kreye, Hergo-H. Wehmann, and Andreas Waag — Institut für Halbleitertechnik, Technische Universität Braunschweig, Hans-Sommer-Str. 66, 38106 Braunschweig, Germany

ZnO nanostructures have a large potential for interesting applications in optoelectronics and sensor technologies. Different methods like MOCVD, VPE and ACG (Aqueous Chemical Growth) can be used for generating a variety of nanostructures. In recent years, ACG became more and more interesting, being a low temperature ($< 95°$) and low cost approach. Usually, the ACG process is based on the creation of a nucleation layer followed by the growth of ZnO nanopillars in aqueous solution.

In this contribution we will show that by using ACG we are able to generate highly homogeneous and vertically aligned, densely packed (˜ 1e10 cm-2) wafer scale arrays of ZnO nanopillars on various substrate materials, e.g. Si (100, 111) and ITO coated glass as well as on polymer substrates (PEN foil, silicones). Results from detailed structural and electrical analysis will be reported. Even though grown at low temperatures in aqueous solution, the nanopillars show a surprisingly good optical quality at room temperature. To achieve selective growth, we grew on samples without nucleation layer structured with different metals on various substrate materials. We observed homogenous, densely packed arrays of ZnO nanopillars on metals, whereas on pure substrate materials only low density growth occurs.

HL 42.7 Thu 12:30 POT 51

HR-TEM characterization of InGaAs Nanowhiskers — •Daniela Sudfeld[1], Jochen Kästner[1], Günter Dumpich[1], Ingo Regolin[2], Victor Khorenko[2], Werner Prost[2], Franz Josef Tegude[2], Stephan Lüttjohann[3], Cedrik Meier[3], and Axel Lorke[3] — [1]Departments of Physics, Experimental Physics, AG Farle, University of Duisburg-Essen, Lotharstr. 1, D-47048, Duisburg, Germany — [2]Solid State Electronics Dept., University of Duisburg-Essen, Lotharstr. 55, ZHO, D-47048 Duisburg, Germany — [3]Departments of Physics, Experimental Physics, University of Duisburg-Essen, Lotharstr. 1, D-47048, Duisburg, Germany

$In_xGa_{1-x}As$ nanowhiskers were grown by metal-organic vapour-phase epitaxy (MOVPE) on (111)B GaAs substrates using the vapour-liquid-solid growth mode. The diameter of the nanowhiskers was defined by monodisperse gold nanoparticles deposited on the GaAs substrate. The whiskers have been analyzed by high-resolution X-ray diffractometry (HR-XRD), micro-photoluminescence (μ-PL) and high-resolution transmission electron microscopy (HR-TEM) including energy-dispersive X-ray spectroscopy (EDS). This study is focussed to determine the lattice structure and the composition of the nanowhiskers. A detailed analysis of the lattice structure by high-resolved bright-field images reveal a fcc (111) phase as resulting from XRD measurements. Using the law of Vegard an indium concentration of 27.6 atom% has been determined in good agreement with our EDS-studies. In addition, EDS line scans perpendicular to the growth direction indicate a homogeneous growth and the presence of indium inside the seed gold particle.

HL 42.8 Thu 12:45 POT 51

Magnetic Properties of Vanadium-doped ZnO-nanorods — •Eva Schlenker[1], Augustin Che Mofor[1], Bianca Postels[1], Marc Kreye[1], Andrey Bakin[1], Andreas Waag[1], Carsten Ronning[2], Joachim Lüdke[3], Volker Janke[3], Sibylle Sievers[3], and Martin Albrecht[3] — [1]Institut für Halbleitertechnik, Technische Universität Braunschweig, Braunschweig, Germany — [2]II. Physikalisches Institut, Georg-August-Universität Göttingen, Göttingen, Germany — [3]Physikalisch-Technische Bundesanstalt (PTB), Braunschweig, Germany

There has been much focus on the properties of the wide-bandgap semiconductor ZnO, not only for opto- but also for magneto-electronic applications. According to theoretical predictions, ZnO doped with transition metals is a promising candidate to exhibit ferromagnetism with a Curie temperature exceeding 300 K.

We report on our results concerning ZnO-nanorods grown by aqueous chemical growth and vapour phase epitaxy. The samples have been implanted with V ions, reaching concentrations up to 1.8 at.%. Photoluminescence (PL) measurements performed after the implantation process reveal a severely defective material. Subsequent annealing at 600 °C leads to a structural recovery of the matrix and therefore restores the original PL intensity. In order to clarify if the ZnVO-nanorods show ferromagnetism, we carried out Magnetic Force Microscopy (MFM) and Superconducting Quantum Interference Device (SQUID) measurements. The MFM measurements were performed either with or without application of an external magnetic field, both on ensembles as well as on single detached rods. The scans clearly display a magnetic contrast.