HL 5: Quantum Dots and Wires: Preparation and Characterization I

Time: Monday 9:30–11:00 Location: EW 202

HL 5.1 Mon 9:30 EW 202

Phonon frequency shift in strain-engineered nanowire multi-quantum wells — •Martin Wölz, Manfred Ramsteiner, Vladimir M. Kaganer, Oliver Brandt, Lutz Geelhaar, and Henning Riechert — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5–7, 10117 Berlin, Germany

Technologically relevant epitaxial semiconductor films are biaxially strained if the substrate has a different lattice constant. In planar layers, strain is maximum for coherent growth and can relax only through the formation of crystal defects. In contrast, axial nanowire (NW) heterostructures allow for elastic strain relaxation at the free sidewalls. By choosing appropriate heights of the NW segments, strained insertions can be grown free of defects with arbitrary strain state.

We grew self-induced GaN nanowires (NWs) containing axial (In,Ga)N heterostructures by plasma-assisted molecular beam epitaxy. By varying the heigth of the GaN barriers, we obtained (In,Ga)N insertions with different strain states between the pseudomorphic case and full elastic relaxation.

Linear elastic theory reveals a progressive relaxation from the center of the NW to the sidewall. The resulting broadening of phonon spectra is quantified based on published deformation potentials. We show that resonant Raman spectroscopy can be used to determine the variation of the (In,Ga)N strain state in NW segments.

Finally, we discuss the impact of such strain relaxation in the active region of (In,Ga)N NW light-emitting diodes, where a benefit over conventional planar devices is expected.

HL 5.2 Mon 9:45 EW 202

Stranski-Krastanov growth of InGaN quantum dots — •Konrad Bellmann, Abdul Kadir, Markus Pristovsek, and Michael Kneissl — TU Berlin, Berlin, Deutschland

InGaN based devices with high Indium content suffer from inhomogeneities and high defect densities. InGaN quantum dots (QD) have the opportunity to overcome these drawbacks and could realize green light emitting diodes and laser diodes. We have investigated the growth of capped and uncapped InGaN QDs on GaN templates by metal organic vapor epitaxy (MOVPE). For uncapped InGaN samples with increasing InGaN thickness and Indium contents above 20 % a growth mode transition from 2D to 3D occurs, i.e. Stranski-Krastanov growth mode. The density of QDs increases with increasing amount of InGaN beyond the wetting layer.

As the indium content is increased the wetting layer thickness is reduced. All InGaN layers up to 6nm are fully strained with indium content from 20 % to 30 %.

Overgrowth at low temperature obtains the InGaN QDs. However, overgrowth at higher temperature increases the Indium diffusion and change the QD morphology.

HL 5.3 Mon 10:00 EW 202

Nucleation of self-assembled GaN nanowires on diamond — •Fabian Schuster[1], Florian Furtmayr[1], Andrea Winnerl[1], Reza Zamani[2,3], Joan R. Morante[3], Jordi Arbiol[2,4], Jose Garrido[1], and Martin Stutzmann[1] — [1]Walter Schottky Institut, Technische Universität München, 85748 Garching, Germany — [2]Institut de Ciència de Materials de Barcelona, ICMAB-CSIC, 08193 Bellaterra, Spain — [3]Catalonia Institute for Energy Research, IREC, 08930 Sant Adrià del Besòs, Spain — [4]Institucio Catalana de Recerca i Estudis Avancats, ICREA, 08010 Barcelona, Spain

Diamond with its wide bandgap of 5.48 eV and its reliable p-type doping with boron is a perfect complement to the nitride material system with respect to optoelectronic devices operating in the UV spectral range. Therefore, we demonstrate the nucleation of high-quality, self-assembled, epitaxial GaN nanowires (NWs) on (111) single-crystalline diamond (SCD) substrates without using a catalyst or buffer layer. HRTEM measurements on released NWs show an excellent crystalline quality of the wurtzite crystal structure with m-plane faceting, a low defect density and axial growth along the polar c-axis. X-ray diffraction confirms single domain growth with an in-plane epitaxial relationship of $(10\bar{1}0)_{GaN} \parallel (01\bar{1})_{Diamond}$ as well as some biaxial tensile strain induced by thermal expansion mismatch. In photoluminescence, a strong and sharp excitonic emission reveals excellent optical properties with a comparably low defect recombination.

HL 5.4 Mon 10:15 EW 202

Dotiereffizienz phosphordotierter Silizium-Nanokristalle in einer Siliziumdioxidmatrix — •Sebastian Gutsch, Andreas Hartel, Daniel Hiller und Margit Zacharias — Albert-Ludwigs-Universität (IMTEK/Nanotechnologie), Freiburg, Deutschland

Silizium Nanokristalle (SiNCs) eingebettet in einer Siliziumoxynitridmatrix wurden mittels PECVD und anschließender Temperung bei 1150°C in Inertgasatmosphäre hergestellt [1]. Die Kristallisation erfolgte größenkontrolliert über einen Superlattice-Ansatz [2], wobei ein alternierender Schichtstapel bestehend aus 3.5 nm dicken siliziumreichen Oxinitridschichten (SRON) und 4 nm dicken Siliziumdioxidschichten abgeschieden wurde. Aus TEM Messungen wurde eine durchschnittliche Größe von 3.5+/-0.5 nm ermittelt. Die Dotierung wurde durch Beimischung von geringen Mengen Phosphin im Prozessgas erreicht. Die Stöchiometriebestimmung der SRON Schichten und Phosphorquantifizierung erfolgte durch kombinierte XPS und dynamische SIMS Messungen. Ein Modell basierend auf einer Poissonverteilung von PL-nichtstrahlenden Defekten und P-Dotanden ermöglicht die Berechnung von Defekten und P-Dotanden pro SiNC als Funktion der Dotierkonzentration. Dazu werden werden zusätzlich Photolumineszenz-Spektren von mit Wasserstoff passivierten und unpassivierten Proben verglichen. Eine Abschätzung der Dotiereffizienz der Silizium Nanokristalle wird aus der Kombination von Modell und Messung vorgenommen und diskutiert.

[1] Hartel et al., TSF, 520, 121 (2011)
[2] Zacharias et al., APL, 80, 661 (2002)

HL 5.5 Mon 10:30 EW 202

Thermodynamic theory of the phase separation in nonstoichiometric silicon oxide films — •Andrey Sarikov[1] and Magrit Zacharias[2] — [1]V. Lashkarev Institute of Semiconductor Physics NAS Ukraine, Kiev, Ukraine — [2]IMTEK, University of Freiburg, Freiburg im Breisgau, Germany

Nonstoichiometric silicon oxide films (SiOx, $x < 2$) are perspective for optoelectronic applications due to the temperature stimulated phase separation in them and the formation of amorphous or crystalline Si nanoinclusions capable of light emission, in the silicon oxide matrix.

In this work, a thermodynamic theory of the phase separation in nonstoichiometric silicon oxide films is proposed. The expressions for the free energy of nonstoichiometric silicon oxide and silicon oxide with amorphous and crystalline Si nanoinclusions are derived. The free energy of amorphous Si / Si oxide and crystalline Si / Si oxide systems as a function of the relative concentration of separated silicon, the initial silicon oxide stoichiometry, and the temperature is studied. By the free energy minimization, the equilibrium stoichiometries of silicon oxide and the solubilities of Si in SiO2 in contact with amorphous and crystalline silicon are determined. An especial attention is given to the strain appearing as a result of phase separation. The account of strain contribution to the free energy of Si / Si oxide systems enables a comprehensive description of the dependence of the equilibrium stoichiometry of phase separated silicon oxide films on the initial silicon oxide composition and the temperature.

HL 5.6 Mon 10:45 EW 202

Raman study of zinc blende and wurtzite CdSe/CdS heteronanocrystals — •Amelie Biermann[1], Raquel Gomes[2], Holger Lange[1], Zeger Hens[2], and Christian Thomsen[1] — [1]TU Berlin, Institut für Festkörperphysik, EW5-4, 10623 Berlin, Germany — [2]University of Ghent, Physics and Chemistry of Nanostructures, Krijgslaan 281-S3, Ghent, B-9000, Belgium

CdSe based heteronanocrystals offer a wide range of potential applications in the field of optoelectronics. Especially colloidal CdSe-CdS core-shell nanocrystals are currently of high interest because they offer new technics of application, e.g. printing of devices from a solution. The possibility to synthesize defined nanocrystals with a precise control over their size enables the use in systems like biological sensors, LEDs, lasers and solar cells.

The magnitude of the coupling of excited carriers to phonons in the CdSe core contributes to the time scales of different photophysical processes of high significance for those applications. These processes include for example carrier multiplication rates, and relaxation times and are strongly influenced by the states in the interface region of core

and shell. In our contribution we present a systematic Raman study of wurtzite and zinc blende CdSe/CdS core-shell structures, revealing the structural details of the sample as well as the exciton-phonon coupling strength via the Huang-Rhys factor.