HL 49: Optical Properties

Time: Thursday 9:30–13:00 Location: H14

HL 49.1 Thu 9:30 H14

Quantum confinement effect in prestine and oxygen covered silicon nanocrystals with surface states — •Sudip Chakraborty[1], Subhash V Ghaisas[1], Ch Rajesh[2], and Shailaja Mahamuni[2] — [1]Department of Electronic Science, University of Pune, Pune 411007, India — [2]Department of Physics, University of Pune, Pune 411007, India

Absorption spectra for prestine silicon and oxygen capped silicon nanocrystals (nc) are computed using Time Dependent Local Density Approximation (TDLDA) in the size range 1.0 to 1.5 nm. These clusters show very small Highest occupied Molecular Orbital (HOMO) - Lowest Unoccupied Molecular Orbital (LUMO) gaps. This indicates presence of surface states.The Partial Density Of States (PDOS) for these clusters confirm the presence of surface states when compared to the corresponding ncs with hydrogen passivation. The HOMO-LUMO gaps do not show any size dependence. However the optical absorption gaps show the quantum confinement effect(QCE) for both the types of clusters. The oxygen capped silicon ncs are prepared following the wet chemical route. The optical absorption spectrum of experimentally prepared ncs is compared with the computed one. Experimental results support the theoretical argument explaining the QCE in these clusters.

HL 49.2 Thu 9:45 H14

Finite-difference time-domain simulations of fabricated black silicon nanostructures: Optimal geometries for an antireflective coating — Adam Williamson[1,2] and •Andreas Voerckel[1] — [1]X-FAB Semiconductor Foundries AG, Haarbergstrasse 67 99097 Erfurt, Germany — [2]Technische Universität Ilmenau, Gustav-Kirchhoff-Str. 7, 98693 Ilmenau, Germany

Nano-structured silicon has received a growing and serious amount of interest in industrial technology and university research, particularly in regard to the possibility of such nanostructures in optics, with the primary interest here being black silicon as an anti-reflective coating (ARC) for photodiodes. Current literature now contains a wealth of morphological information to influence structure growth and shape in fluorine-based plasma etching in the presence of oxide-forming or fluorocarbon gas inhibitors [1, 2]. Using the computationally efficient grid-based differential time-domain numerical modeling of the finite-difference time-domain (FDTD) method, approximations to Maxwell's equations are solved to model the optical properties of crystalline black silicon. Multiple geometries, from pillars to more pyramid and needle-like structures, are considered and results are correlated to actual scanning electron microscope (SEM) pictures with corresponding reflection measurements taken in a Cary 5000 UV*VIS spectrophotometer with accompanying integrating (Ulbricht) sphere from 200nm to 800nm to evaluate both diffuse and specular reflection from the silicon surface. Optimal geometries are simulated and the consequences for photodiode applications are discussed.

HL 49.3 Thu 10:00 H14

Disorder in Ga(N,As,P)/GaP MQW structures — •Christian Karcher, Tobias Bertram, Bernardette Kunert, Kerstin Volz, Wolfgang Stolz, Kakhaber Jandieri, Sergei Baranovskii, and Wolfram Heimbrodt — Dept. Physics and Material Sciences Center, Philipps- University of Marburg, Germany

The incorporation of nitrogen into III-V semiconductors has an enormous impact onto the emission characteristics of the host material. We examine these features in pseudomorphically grown multiple-quantum-well heterostructures of the dilute nitride Ga(NAsP)/GaP material system by means of modulated reflectance, photoluminescence- (PL) and PL excitation-spectroscopy. By identifying both the absorption and emission characteristics of the system from 10K up to room temperature, we observe a large stokes shift originating from deep traps formed by nitrogen. The complex temperature behaviour of the resulting emission can be understood in detail by theoretically modelling hopping processes in an exponential distribution of localised states within the band gap. This model explains the s-like temperature shift and the linewidth broadening of the emission as well as the high stokes shift up to room temperature.

HL 49.4 Thu 10:15 H14

Confocal microscopy with cylindrical vector beams and spectroscopy of single silicon nanoparticles — •Anna Chizhik[1], Alexey Chizhik[1], Torsten Schmidt[2], Sebastian Baer[1], Friedrich Huisken[2], and Alfred Meixner[1] — [1]Inst. of physical and theor. Chem.., Univ. of Tuebingen — [2]Lab. Astrophys., Group of the MPI for Astronomy at the Inst. of Solid State Phys., Univ. of Jena

Being the paramount material silicon revealed new magnificent outlooks with the development of nanotechnology. During last years the research on silicon nanoparticles has been one of the hottest topics. However, many of their photoluminescence (PL) properties are still unclear. Combining the confocal microscopy, spectroscopy, and cylindrical vector beams (also known as higher order laser modes) we reveal new details of fundamental PL properties of Si/SiO2 core-shell systems and hollow SiO2 shells. We show that the emission from both systems may originate from defects of the SiO2 structure or at the Si-SiO2 interface. This result demonstrates the effect of *break-down* of the quantum confinement in small Si/SiO2 nanoparticles, which limits the PL tunability and thus, applications in Si optical nanostructures, especially in the short wavelength range. Using the technique of cylindrical vector beams we demonstrate that SiO2 nanoparticles and Si/SiO2 nanocrystals, where the PL originates from defects, possess linear transition dipole moment (TDM). Moreover, we precisely determine the 3-dimensional orientation of single nanoparticle TDM and show such dynamical effects as TDM sudden flipping.

HL 49.5 Thu 10:30 H14

Transmission and Reflection Measurements on Rolled-up Microtubes — •Stephan Schwaiger, Markus Bröll, Jochen Kerbst, Jens Ehlermann, Ricardo Costa, Andreas Rottler, Andrea Stemmann, Yuliya Stark, Detlef Heitmann, and Stefan Mendach — Institut für Angewandte Physik, Universität Hamburg, Jungiusstrasse 11, 20355 Hamburg

Strained metal-semiconductor nano layers can be rolled-up into microtubes with a rolled-up carped like shape [1]. The walls of these microtubes represent effective media with anisotropic permittivity. Finite difference time domain simulations show that the microtubes can be used for imaging below the diffraction limit. To characterize the imaging behaviour of the microtubes we performed transmission and reflection measurements. The transmission through the walls of the tubes can be measured by placing a tapered optical single mode fiber inside the microtube. Holes which are prepared into the tip of the fiber by means of focused ion beams act as light emitters illuminating the microtube from the inside. Subsequently the transmitted light is detected by an optical microscope. Comparison of the measurements with calculations using the transfer matrix method show that the walls of the tubes can be described with an effective plasma frequency which can be tuned within the visible and near infrared regime by changing the metal and semiconductor layer thickness ratio [2]. We gratefully acknowledge support by the DFG through GrK 1286 and SFB 508.

[1] V. Ya. Prinz et al., Physica E 6, 828 (2000)
[2] S. Schwaiger et al., Physical Review Letters 102, 163903 (2009)

HL 49.6 Thu 10:45 H14

FIB implantation induced site-selectively grown self-assembled InAs QDs in a light emitting μ-diode — Minisha Mehta[1], •Cedrik Meier[1], Dirk Reuter[2], Andreas D. Wieck[2], Stefan Michaelis de Vasconcellos[2], Tim Baumgarten[1], and Artur Zrenner[1] — [1]Physics Department, University of Paderborn, Paderborn , Germany — [2]Applied Solid State Physics, Ruhr University of Bochum, Bochum, Germany

We present an approach for fabrication of intentionally positioned epitaxial InAs QDs in a micron sized light emitting diode. For site-selective growth, a combination of molecular beam epitaxy (MBE) and focused ion beam (FIB) implantation technology in an all-ultra-high-vacuum (UHV) setup has been employed. Single dot occupancy of almost 55 % on FIB patterned nano-depressions was successfully achieved. Thereafter, carrier injection and subsequent radiative recombination from the positioned InAs/GaAs self-assembled QDs was investigated by embedding these QDs in the intrinsic part of a GaAs-based micron sized p-i-n junction device. Few or single dot are expected to be electrically addressed in these devices. We report results

from electroluminescence (EL) measurement which proves the single dot characteristics of our device. The EL spectra consist of sharp emission lines and their dependence on injection current shows linear behavior for exciton and quadratic behavior for biexciton recombination. Furthermore, estimation of built-in dipole moment in InAs quantum dots due to stark shift in EL spectra will be given. Financial support by the BMBF via the NanoFutur grant 03X5509-NanoPhox and the NanoQuit program.

15 Min. Coffee Break

HL 49.7 Thu 11:15 H14

Optical and electrical properties of metal-insulator-semiconductor devices with stepped insulator layer — •Wolfgang Brezna[1], Jürgen Smoliner[1], Kevin Stella[2], Domocos Kovacs[2], and Detlef Diesing[2] — [1]Institut für Festkörperelektronik, Technische Universität Wien — [2]Institut für Physikalische Chemie, Universität Duisburg Essen

A preparation procedure based on localized electrochemical oxidation unites multiple metal-insulator-semiconductor (MIS) junctions (also arrays) in a single device. The "stepped-MIS" enables a comparative study of several MIS junctions of different oxide thicknesses on one silicon wafer. We present a Si(n-type)-SiO_x-Au four-step device with oxide thicknesses of 0, 1, 2.5, and 4 nm. Each step is partially covered with a 20 nm thick Au-electrode. The samples are characterized by internal photoemission using variable wavelengths (300 -1600 nm) and capacitance - voltage experiments. The "1 nm" junction shows an increased photo-sensitivity compared to the "0 nm" junction (MS system). The internal photoemission drops by two orders of magnitude when increasing the oxide thickness from 1 to 4 nm. The photoemission is increased by two orders of magnitude, when the sample is biased by 1 Volt in the depletion region (reverse voltage direction).

HL 49.8 Thu 11:30 H14

Optical characterization of $AgGaSe_2$ thin films grown by Chemical Close Spaced Vapor Transport (CCSVT) — •Christoph Merschjann[1], Barys Korzun[1,2], Anastasia Karkatzinou[1,3], Thomas Schedel-Niedrig[1], and Martha Christina Lux-Steiner[1] — [1]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Berlin, Germany — [2]Scientific-Practical Materials Research Centre of NAS of Belarus, Minsk, Belarus — [3]National Technical University of Athens, Athens, Greece

Thin films ($d \approx 3\,\mu$m) of n-type chalcopyrite $AgGaSe_2$ were successfully grown on glass and glass/molybdenum substrates using the technique of Chemical Close Spaced Vapor Transport (CCSVT). Scanning electron microscopy of the prepared layers shows a morphology typical for polycrystalline chalcopyrites. The electronic properties of the films are investigated by means of optical transmission/reflection and photoluminescence spectroscopy. While the absorption spectra of the films exhibit clear and distinct bandgaps, their photoluminescence comprises various unreported emission peaks, thus pointing to a rich intrinsic defect structure.

The results are compared to those published for single-crystalline $AgGaSe_2$, and possible consequences for the application of this material as thin-film solar cell absorber layer are discussed in the presentation.

HL 49.9 Thu 11:45 H14

Optical properties of high-quality cubic AlN, GaN, AlGaN and AlN/GaN MQWs grown on 3C-SiC — •Marcus Röppischer[1], Christoph Cobet[1], Norbert Esser[1], Georg Rossbach[2], Rüdiger Goldhahn[2], Martin Feneberg[3], Benjamin Neuschl[3], Klaus Thonke[3], Thorsten Schupp[4], Klaus Lischka[4], and Donat As[4] — [1]ISAS - Institute for Analytical Sciences, 12489 Berlin — [2]Institut für Physik, Technische Universität Ilmenau, 98684 Ilmenau — [3]Institut für Halbleiterphysik, Universität Ulm, 89069 Ulm — [4]Department Physik, Universität Paderborn, 33098 Paderborn

It was recently demonstrated, that the quality of zincblende group-III nitrides can be considerably improved if bulk 3C-SiC(001) is used as the substrate for the deposition of the films by molecular beam epitaxy. For example, phase-pure cubic GaN and AlN has been achieved, and intersubband absorption of short-period GaN/AlN MQWs in the infra-red was demonstrated. Despite this progress, fundamental optical properties of these materials have not been reported so far. In this contribution, we present a comprehensive characterization of cubic AlN, GaN, AlGaN and related MQWs. The shape of the dielectric functions (DF) from 0.56 eV up to 20 eV, as obtained by ellipsometry, as well as photoreflectance (PR), photo- (PL) and cathodoluminescence (CL) spectra will be discussed in detail.

HL 49.10 Thu 12:00 H14

Longitudinal-transverse splitting of individual excitonic polaritons in ZnO derived from ellipsometry — •Munise Cobet[1], Christoph Cobet[2], Markus R. Wagner[1], Norbert Esser[2], and Axel Hoffmann[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, 10623 Berlin — [2]ISAS- Institute for Analytical Sciences, 12489 Berlin

The complex dielectric tensor of ZnO in the regime of the excitonic transitions is determined with ellipsometry and analyzed concerning the quantization of the electromagnetic field in terms of coupled polariton-eigenmodes. Negative sections in the real part indicate the significant formation of polaritons for the dipole-allowed excitons of the three upper valence-bands $\Gamma_7, \Gamma_9, \Gamma_7$. The transverse-longitudinal splittings which separate the upper polariton branch from the lower branch are deduced precisely for each subband and for different strain levels. Mainly for $\mathbf{E}\|$c, additional absorption peaks are observed at the longitudinal B-exciton and closely above. One is considered to be a mixed-mode and the other is seen as a consequence of interference effects in an exciton free surface layer which is also visible in Reflectance Anisotropy Spectroscopy (RAS). Furthermore, the effect of d-level-hybridization on valence-band-symmetries is evaluated by the effective number of electrons n_{eff} in high energy data between 3 and 32 eV. CdS polaritonic spectra were also measured as a reference and further support the inversed ordering of valence bands (negative spin-orbit splitting) in ZnO.

HL 49.11 Thu 12:15 H14

Near band edge luminescence of ZnN thin layers — •Ronny Kirste[1], Jebreel M. Khoshman[2], Martin E. Kordesch[3], Markus R. Wagner[1], Jan-Hindrik Schulze[1], Gordon Callsen[1], and Axel Hoffmann[1] — [1]Institut für Festkörperphysik, TU Berlin, Berlin, Germany — [2]Al-Huessin Bin Talal University, Ma-an, Jordan — [3]Department of Physics and Astronomy, Ohio University, Athens, OH 45701, United States

The novel material ZnN may help to understand the nitrogen doping in ZnO. Additionally, ZnN is a possible candidate for optical devices like hot and cold mirrors. However, nearly none of the basic physical properties are known, so far. Even the band gap of ZnN is still under discussion. In this contribution we present PL measurements for 200nm thick ZnN samples grown on SiO2 via RF sputtering. The successful ZnN growth was confirmed by XRD. PL measurements in different ambient gases indicate that the low energy signal between 2.0 and 3.0 eV which sometimes is attributed to ZnN is indeed related to surface oxygen. On the other hand a high energy peak at 3.41 eV arises, which is attributed to the ZnN layer. Temperature dependent measurements were performed revealing a shift of this peak from 3.41 eV at 4.2 K to 3.44 eV at room temperature. Finally, time resolved measurements were performed in order to understand the origin of the high energy signal.

HL 49.12 Thu 12:30 H14

Spin induced second harmonic generation in europium chalcogenides — Benjamin Kaminski[1], •Marco Lafrentz[1], Roman V. Pisarev[2], Dmitri R. Yakovlev[1,2], Victor V. Pavlov[2], Volodya A. Lukoshkin[2], Andre Henriques[3], Gunther Springholz[4], Günther Bauer[4], Eduardo Abramof[5], Paulo H. O. Rappl[5], and Manfred Bayer[1] — [1]Experimentelle Physik II, Technische Universität Dortmund, D-44221 Dortmund, Germany — [2]Ioffe Physico-Technical Institute, Russian Academy of Sciences, 194021 St. Petersburg, Russia — [3]Instituto de Fisica, Universidade de Sao Paulo, 05315-970 Sao Paulo, Brazil — [4]Institut für Halbleiter- und Festkörperphysik, Johannes Kepler Universität Linz, 4040 Linz, Austria — [5]LAS-INPE, 12227-010 Sao Jose dos Campos, Brazil

The second harmonic generation (SHG) in Europium chalcogenides EuX (X=O, S, Se, and Te) is fordbidden in the electric dipole and the electric quadrupole approximations due to the centrosymmetrical crystal lattice and the electronic band structure with an odd parity 4f-5d band gap transition. However we have found SHG signals in the vicinity of the band gap of 2.2-2.4eV in EuTe and EuSe in external magnetic fields. Further magnetic field and temperature investigations revealed that the SHG signals are induced by a ferromagnetic spin component, which strongly enhances the magnetic-dipole transition. This new type of spin induced susceptibility opens access to various classes

of centrosymmetric magnetic materials by second harmonic generation spectroscopy.

HL 49.13 Thu 12:45 H14

Trionic Optical Potentials for Charge Carriers in Semiconductors — •Martin Schuetz, Michael G. Moore, and Carlo Piermarocchi — Michigan State University, East Lansing, Michigan, USA

Optical trapping of neutral particles has led to remarkable advances in precision measurement, quantum information, and addressing fundamental longstanding questions in condensed matter physics. Despite recent advances in the optical and electronic control in semiconductor systems, a similar laser-induced technique to trap and manipulate charged carriers in semiconductor devices has not yet been investigated. In this talk, we will propose analogues optical trapping potentials for charge carriers embedded in a semiconductor quantum well by driving the trion resonance with intense, detuned laser light. Accordingly, the Stark energy is modified in proportion to the light intensity at the carrier location, which serves as a source of mechanical potential energy for the carrier. We show that this novel trion-mediated potential exhibits a non-local character, but can confine carriers at the lengthscale of optical wavelengths.The model is extended to the new paradigm of a spin-selective carrier lattice in a true Solid State environment which is potentially much simpler to engineer and control than similar lattices in AMO physics. Our results suggest the possibility of new single-carrier semiconductor devices with promising applications in quantum information processing, and exploring the physics of interacting electrons in the presence of a periodic potential readily controllable in space and time.