HL 68: Poster Session: GaN: devices & preparation & characterization; III-V semiconductors; Photonic crystals; Semiconductor lasers

Presenters are kindly asked to be near their posters at least 17:00–18:00 or to leave a note at the poster indicating a time period of availability for discussions. — Beverages will be served starting at 18:00.

Time: Wednesday 16:00–20:00 Location: Poster A

HL 68.1 Wed 16:00 Poster A

Characteristics of AlGaN Schottky photodiodes for UV-C detection — •Simon Kapanke[1], Jessica Schlegel[1], Andrea Knigge[2], Xuemei Wang[3], Jens Rass[1], Hassan Gargouri[3], Frank Brunner[2], Markus Weyers[2], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstr. 36, 10623 Berlin — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin — [3]SENTECH Instruments GmbH, Schwarzschildstr. 2, 12489 Berlin

We have investigated the influence of absorption layer doping on the photoresponse characteristics of solarblind AlGaN Schottky photodiodes by photocurrent spectroscopy, I-V measurements and device simulations. The responsivity maximum of photodiodes with moderate Si-doping of the $Al_{0.45}GaN$ absorption layer shifts to shorter wavelengths compared to devices with non-intentionally doped absorption layer due to a decreased widths of the space charge region. Additionally, the responsivity can be enhanced by increasing the UV-C transmission of the semi-transparent Schottky contact. Photodetectors with SiO_2 or Al_2O_3 anti-reflection coating showed UV-C responsivities of up to 90 mA/W. The SiO_2 coatings were deposited using a Sentech inductively coupled plasma enhanced chemical vapor deposition (ICPECVD) system SI 500 D and for Al_2O_3 a Sentech atomic layer deposition (ALD) system SI ALD LL was applied. The influence on the spectral and electrical device characteristics of coatings deposited by these techniques in comparison to sputtered SiO_2 will be discussed.

HL 68.2 Wed 16:00 Poster A

Whispering gallery modes in GaN micro- and nanorods by metal-organic vapor phase epitaxy — •Christian Tessarek[1,2], George Sarau[1], and Silke Christiansen[1,3] — [1]Max-Planck-Institut für die Physik des Lichts, Erlangen — [2]Institut für Optik, Information und Photonik, Universität Erlangen-Nürnberg — [3]Institut für photonische Technologien, Jena

Self-assembled catalyst- and mask-free GaN micro- and nanorods on sapphire substrates have been grown by metal-organic vapor phase epitaxy. To obtain these structures a simple three step method was applied consisting of nitridation of the sapphire substrate, deposition of a GaN nucleation layer and growth of GaN rods.

Optical investigations were performed utilizing cathodoluminescence (CL) and photoluminescence (PL). Typical GaN spectra were obtained showing GaN near band edge emission as well as yellow defect band luminescence. In regular hexagonal shaped GaN nano- and microrods whispering gallery modes (WGMs) were observed in the GaN spectra. Q-factors of up to 500 and up to 4000 were measured in CL and PL, respectively.

Further CL investigations will show that the spectral position of the WGMs can be tuned in slighlty tapered GaN nanorods by changing the position of the exposing electron beam. Finally, WGMs were also observed in GaN microrods covered with InGaN quantum wells.

HL 68.3 Wed 16:00 Poster A

DBR for 3D-GaN-LEDs — •Jana Hartmann[1], Lorenzo Caccamo[1], Stephan Merzsch[1], Xue Wang[1], Martin Thunert[2], Helena Franke[2], Rüdiger Schmidt-Grund[2], Hergo-Heinrich Wehmann[1], Marius Grundmann[2], and Andreas Waag[1] — [1]Technische Universität Braunschweig, Institut für Halbleitertechnik, Hans-Sommer-Str. 66, 38106 Braunschweig — [2]Universität Leipzig, Institut für Experimentelle Physik II, Linnéstr. 5, 04103 Leipzig

Until now a lot of efforts have been made to achieve low-cost and efficient white LEDs. A relatively new approach is based on micro or nano three dimensional (3D) pillars. We propose to use 1D-Bragg reflectors (DBR) as backside mirror for enhancement of the forward emission of these 3D-LEDs based on GaN/InGaN MQW.

Nanorods with diameter smaller than 200 nm are used as a core to provide a sufficient large evanescent part of the light wave allowing a high interaction between LEDs and the surrounding. To produce such small structures nanoimprint lithography and colloidal lithography are tested.

The DBR layer pairs are composed of yttria stabilized zirconia and Al_2O_3 deposited on sapphire substrates by using pulsed laser deposition. In order to grow nanorods on the sapphire, holes have to be etched into the bottom DBR structure by inductively coupled plasma etching.

First results of lithography, etching process and subsequent metal-organic vapour-phase epitaxial growth of n-doped GaN cores will be presented.

HL 68.4 Wed 16:00 Poster A

Effect of high thermal stress on the internal quantum efficiency of GaInN LED structures — •Fedor Alexej Ketzer, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, TU Braunschweig

We investigate high indium content GaInN based light emitting diodes grown via low pressure MOVPE. The efficiency of such structures is rather small due to the high indium content. In order to improve the efficiency we study the growth of the p-doped GaN layer and rapid thermal annealing (RTA), needed to activate the p-dopants (Mg). Due to the high thermal load these processes influence the quantum well (QW) and therefore the internal quantum efficiency (IQE). Both changes in the geometry of the QW due to diffusion and generation of defects are possible. Therefore the effects can be attributed to changes in radiative or nonradiative recombination as well as a combination of both.

To distinguish the effects on the different recombination processes, the IQE and photoluminescence spectra before and after RTA are compared. Furthermore conditions during RTA and growth of the structures were modified to endorse the results. The IQE was determined by temperature and excitation power dependent photoluminescence. These results help optimize growth and processing of LED structures to achieve high internal and external quantum efficiencies.

HL 68.5 Wed 16:00 Poster A

Effect of barrier height and indium composition on the internal quantum efficiency of (In)AlGaN multiple quantum well structures — •Nikolay Ledentsov Jr.[1], Christoph Reich[1], Frank Mehnke[1], Christian Kuhn[1], Tim Wernicke[1], Tim Kolbe[1], Neysha Lobo Ploch[1], Jens Rass[1], Viola Kueller[2], and Michael Kneissl[1,2] — [1]Institute of Solid State Physics, Technische Universität Berlin, Hardenberg-str. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut, Gustav-Kirchhoff-str. 4, 12489 Berlin, Germany

We studied (In)AlGaN multiple quantum wells (MQWs) emitting in the UV-B spectral region with photoluminescence and electroluminescence spectroscopy. The internal quantum efficiency (IQE) was determined by temperature dependent measurements (5 K - 300 K). The quantum confined Stark effect (QCSE) was investigated by studying the shift of the emission energy with increasing excitation power density. In the first series, $Al_{0.27}Ga_{0.73}N$ MQWs with different $Al_xGa_{1-x}N$ barriers ($0.32 < x < 0.67$) were investigated. Increasing the Al content increased the IQE due to improved carrier confinement. A maximum of the IQE of 24 % at $x = 0.4$ was obtained. Further increase of the Al content in the barriers decreased the IQE due to a stronger QCSE. In the second series, quaternary InAlGaN QWs were investigated. Due to In incorporation, room temperature emission energy shifted from 4.3 eV to 3.9 eV. At low temperatures two peaks were observed. The lower energetic peak was attributed to In-rich clusters. Influence of the In segregation will be discussed.

HL 68.6 Wed 16:00 Poster A

Light trapping in Gallium Nitride nanostructures formed by maskless dry etching — •Anna Haab, Jiehong Jin, Toma Stoica, Beata Kardynal, Andreas Winden, Hilde Hardtdegen, Martin Mikulics, and Detlev Grützmacher — Peter Grünberg Institut (PGI-9), Jülich-Aachen Research Alliance (JARA), Forschungszentrum Jülich, 52425 Jülich, Germany

III-N alloys have attracted much attention as a candidate material system for solar cells, as their band gap can be tuned to cover the solar spectrum. For this application light management is of crucial importance and so patterning is used to reduce surface reflection and therefore to increase efficiency of the photonic devices. In this presentation we show that the simple, maskless reactive ion etching process, using a Cl2/Ar plasma of MOVPE grown GaN layers, can be employed to form arrays of nanowires suitable for light extraction/trapping. Both density and morphology of nanowires (from straight to conical) can be tuned, by varying the inductively coupled plasma power. We performed optimization of procedure to maximize light extraction/trapping in the GaN. The wavelength dependence of absorption was obtained from total transmission and reflection measurements for all samples. Photoluminescence analysis was used to assess potential damage from the etching process. We find that the strongest reduction of reflection is achieved in a dense array of straight nanowires. In such a structure the absorption just above the band gap increased to almost 100%, while the defects did not play a significant role. In future such structures can be used either as an antireflective coating or as substrates for overgrowth.

HL 68.7 Wed 16:00 Poster A

Influence of chemical treatments and the attachment of functional molecules on the surface properties of GaN — •Georg Eichapfel[1], Marcel Himmerlich[1], Stefan Krischok[1], Stefan U. Schwarz[2,3], Volker Cimalla[2], and Oliver Ambacher[2,3] — [1]Institut für Physik and Institut für Mikro- und Nanotechnologien, TU Ilmenau, PF 100565, 98684 Ilmenau — [2]Institut für Mikrosystemtechnik, Albert-Ludwigs-Universität Freiburg, Georges-Köhler-Allee 106, 79110 Freiburg — [3]Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastraße 72, 79108 Freiburg

The functionalization of GaN surfaces is a promising pathway for the realization of semiconductor-based biosensors. Several approaches for the attachment of biosensitive functionalizations to GaN have already been reported in the literature. A detailed knowledge about the mechanisms of molecule attachment and surface reactions are of great importance to understand the electrical behavior of processed sensors. Within this framework, the surface pretreatment and the resulting functional groups play a crucial role. We present photoelectron spectroscopy investigations on the chemical modification of GaN(0001) surfaces and their interaction with ethene. Changes in the surface composition and the formed chemical bonds are characterized and their influence on the electronic properties is discussed. The results are compared with the surface properties of GaN sensor structures that have been thermally or photochemically functionalized with 1-alkenes.

HL 68.8 Wed 16:00 Poster A

Quantification of internal electric fields in InGaN/GaN quantum wells by differential phase contrast microscopy — •Matthias Lohr[1], Ralph Schregle[1], Ines Pietzonka[2], Martin Strassburg[2], Robert Leute[3], Ferdinand Scholz[3], Knut Müller[4], Andreas Rosenauer[4], and Josef Zweck[1] — [1]Fakultät für Physik, Universität Regensburg — [2]Osram Opto Semiconductors, Regensburg — [3]Institut für Optoelektronik, Universität Ulm — [4]Institut für Festkörperphysik, Universität Bremen

LEDs and laser diodes play an important role in our daily lives. A very promising and intensively studied material system is GaN with InGaN quantum wells. It is capable to cover the whole visible spectral range by changing the In content. When trying to tune the output wavelength from blue to green light however, big problems in efficiency emerged. In the literature this became known as the "green gap". An important property of the non-centrosymmetric GaN crystal and possible cause of the efficiency droop is the internal piezoelectric field.

In this work direct and quantitative measurements of InGaN/GaN heterostructures combining STEM and differential phase contrast (DPC) method will be shown. The detected signal is related to the product of the piezoelectric field strength and the sample thickness. The calibration of the inelastic mean free path (IMFP) of electrons in GaN was determined by HAADF STEM and EELS. Using this data, the thickness became accessible. Based on the IMFP thickness maps in combination with calibrated DPC measurements, fields in the range from 10-100 MV/m have been measured in different samples.

HL 68.9 Wed 16:00 Poster A

Investigations of electrolyte/ group-III-nitride interfaces with electrical methods — •Martin Gottschalk, Hartmut Witte, Armin Dadgar, and Alois Krost — Otto-von-Guericke-Universität Magdeburg, Institute of Experimental Physics, MB 4120,39016 Magdeburg

Group-III-nitride materials are well established for detecting chemicals, gases, biological and radiation releases as well as for local stimulation of chemical or biological reactions. Hereby, the electronic properties of the surfaces control the interaction with the different atmospheres and liquids. Therefore, for any application of group-III-nitrides as sensors or actuators these interfaces must be investigated in detail to enable a control of their properties. We focused our investigations on the interface between different group-III-nitride materials such as p-type and n-type GaN, AlGaN, InGaN and InAlN with electrolytes containing chlorine ions. The measurements include cyclic voltammetry and electrochemical impedance- and CV-spectroscopy. To characterize the semiconductor surfaces before contacting with electrolytes we used Hall-effect measurements and CV-characteristics and surface scanning potential spectroscopy. In a systematic study for all investigated materials the redox potentials and the potentials for the hydrogen production were given as well as results of the surface carrier concentrations.

HL 68.10 Wed 16:00 Poster A

Dislocation related luminescence properties in multiple InGaN quantum well structures — •Manuel Frey[1], Ingo Tischer[1], Matthias Hocker[1], Dario Schiavon[2], Matthias Peter[2], and Klaus Thonke[1] — [1]Institut für Quantenmaterie, Gruppe Halbleiterphysik, Universität Ulm, 89081 Ulm — [2]OSRAM Opto Semiconductors GmbH, Leibnizstraße 4, 93055 Regensburg, Germany

The development of InGaN/GaN quantum well structures during the last years resulted in green LEDs with high quantum efficiency.
The indium content and the strain in the InGaN layers increases with the growing number of QWs. Among others, the density of threading dislocations and stacking faults increases leading to V-pit formation when a critical thickness of the QWs is exceeded.
Spatially and spectrally resolved low voltage cathodoluminescence measurements on multiple InGaN/GaN based QWs allow to determine the effect of dislocations and strain on the luminescence properties of multiple QW samples.

HL 68.11 Wed 16:00 Poster A

Design of a high temperature Hall measurement setup — •Dominik Beck, Matthias Hocker, and Klaus Thonke — Institute of Quantum Matter / Semiconductor Physics Group, Ulm University, D-89081 Ulm, Germany

A Hall measurement setup is developed for the temperature dependent characterization of iron doped gallium nitride and other highly resistive materials. For this purpose the whole setup has to meet some special technical requirements.

The Hall chamber has to be vacuum tight to prevent samples from oxidation and other modifications due to reactions with environmental gases. For the thermal activation of deep impurities, the setup is designed to reach temperatures up to 800 °C. Thermal isolation is realized with cascaded stainless steel shields, and water cooling of the outer walls keeps them at low temperature.

Another important point is the measurement of very small electrical currents due to the high resistivity of the samples. The whole setup is optimized for these low currents and high voltages up to 100 V for Hall and Van der Pauw measurements.

Furthermore, the whole setup is designed for minimal size to fit the given geometry of the magnetic pole pieces.

HL 68.12 Wed 16:00 Poster A

Growth of AlN by pulsed and conventional MOVPE — •Hanno Kröncke, Timo Aschenbrenner, Stefan Figge, and Detlev Hommel — Universität Bremen, Institut für Festkörperphysik

Due to low accessibility of pure aluminium nitride substrates, AlN-templates are appropriate for the growth of optoelectronic device emitting in the UV spectral region and high power / frequency electronic devices.

We have grown metal polar AlN layers up to 2 μm thickness on c-plane sapphire either by conventional metal organic vapor phase epitaxy (MOVPE) at 1270 °C or in pulsed growth mode at 1050 °C. For both methods we investigated different concepts of nucleation and the influence of V/III ratio and atmospheric conditions. The layers are atomically flat, showing pits in a density lower than $1 \cdot 10^7\,\mathrm{cm}^{-2}$ and

edge type dislocations in the density of $3 \cdot 10^{10}\,\mathrm{cm}^{-2}$ (pulsed) and $5 \cdot 10^{9}\,\mathrm{cm}^{-2}$ (conventionally).

In contrast to other publications on pulsed growth, our growth rate (1μm/h) is much higher than 1 ML/cycle, requiring a different growth mode, which was investigated by *in situ* reflectivity measurements.

For conventionally grown samples we investigated the influence of the growth atmosphere on the growth rate and applied a simple model based on diffusion, viscosity and gas flow velocity. In general the best quality is obtained by low V/III ratio of 100, pure hydrogen atmosphere at 50 Torr at 1250 °C.

HL 68.13 Wed 16:00 Poster A

Epitaxial growth of smooth GaAs layers on non-miscut GaAs (111)A and GaAs (111)B substrates — •Julian Ritzmann[1], Rüdiger Schott[1], Dirk Reuter[2], Arne Ludwig[1], and Andreas D. Wieck[1] — [1]Lehrstuhl für Angewandte Festkörperphysik, Ruhr-Universität Bochum — [2]Arbeitsgruppe für optoelektronische Materialien und Bauelemente, Universität Paderborn

(111)A and (111)B oriented GaAs is known for their large piezoelectric effect and light emitting efficiency. Also, these surfaces allow for highly anisotropic etching. The growth by molecular beam epitaxy on these surfaces is however rather challenging and only a limited range of growth parameters leads to smooth layers.

In this work we investigate conditions for the MBE growth of GaAs layers on GaAs (111)A and (111)B substrates without miscut. The samples were grown under different III/V-ratios, different substrate temperatures and growth rates. Atomic force and scanning electron microscopy were used for imaging the surface morphology and photoluminescence measurements were performed to study the optical properties of our samples.

HL 68.14 Wed 16:00 Poster A

Effects of substrate temperature and annealing on structural properties of GaP/Si(100) grown by gas-source molecular-beam epitaxy — •Emad Hameed Hussein, Shabnam Dadgostar, Fariba Hatami, and W. Ted Masselink — Department of Physics, Humboldt Universtät zu Berlin, Newtonstrasse 15, D-12489 Berlin, Germany

Gallium phosphide (GaP) was grown epitaxially on silicon (100) substrates using gas-source molecular-beam epitaxy. In this study, two growth methods are compared: one-step and two-step growth. In the case of one-step growth, the GaP was grown directly onto the desorbed Si surface at a single substrate temperature between 250°C to 550°C, followed by thermal annealing. In two-step growth, the GaP includes two layers grown at different temperatures. The differences between these methods as well as the effects of growth and annealing temperatures on crystal structure were studied using X-ray diffraction measurements and scanning electron microscopy. Samples grown in two steps method show a better surface quality compared with that grown by one-step. A structurally coherent crystalline GaP layer, on the other hand, was successfully grown by two-step method, as confirmed by asymmetric x-ray curves.

HL 68.15 Wed 16:00 Poster A

In situ characterization of MOVPE grown GaPN/GaP/Si(100) for photoelectrolysis — •Oliver Supplie[1,2], Helena Stange[1,2], Matthias M. May[1,2], Christian Höhn[1], Christian Koppka[3], Katja Tonisch[3], Henning Döscher[1,3,4], and Thomas Hannappel[1,3,5] — [1]Helmholtz-Zentrum Berlin, Institut für Solare Brennstoffe — [2]Humboldt-Universität zu Berlin, Institut für Physik — [3]TU Ilmenau, Institut für Physik, Fachgebiet Photovoltaik — [4]NREL, Golden, CO, USA — [5]CiS Forschungsinstitut für Mikrosensorik und Photovoltaik, Erfurt

A photoelectrochemical diode consisting of a Si bottom and a lattice-matched GaPN top cell promises both high photovoltaic energy conversion efficiency and supply of the minimum voltage necessary for photoelectrolysis [1]. Existing devices based on GaPN-on-Si heterostructures, however, suffer from low efficiency due to material quality issues [2]. To achieve in situ control, we monitor the whole MOVPE-preparation with reflection anisotropy spectrom and mass spectrometry in order to compare the established GaP/Si(100) preparation [3] to the dilute nitride system with regard to surface preparation and principal MOVPE growth parameters. We benchmark the in situ signals (i) after contamination-free MOVPE-to-UHV transfer with surface science techniques such as low energy electron diffraction and photoelectron spectroscopy as well as (ii) ex situ by high-resolution X-ray diffraction, photoluminescence and atomic force microscopy.

[1] Döscher et al., *ChemPhysChem* **13**:2899. [2] Geisz et al., *EU-PVSEC* **19**(2004). [3] Döscher et al., *JAP* **107**:123523.

HL 68.16 Wed 16:00 Poster A

Impact of growth temperature on the interface quality of AlP/GaP superlattices grown using gas-source molecular-beam epitaxy — •Shabnam Dadgostar, Fariba Hatami, and William.Ted Masselink — Department of physics, Humboldt-Universität zu Berlin, Newtonstrasse 15, D-12489 Berlin, Germany

High-Q optical cavities in GaP can be realized by incorporating epitaxially grown AlP/GaP Bragg reflectors. Such Bragg reflectors can be prepared as single crystals using gas-source molecular-beam epitaxy, growing the distributed Bragg reflectors adjacent to an active region for optical emission. Electrical transport through such structures depends critically on the interface roughness between the AlP and GaP layers. We have studied the effect of growth temperature on the interface roughness and found the optimum temperature for growth of AlP/GaP superlattice on GaP (100) substrate. For our applications we used structures with AlP and GaP layer thicknesses of 48 and 40 nm. Both scanning electron microscopy and high-resolution x-ray diffraction measurements indicate that interface roughness is minimized for a growth temperature of 450°C.

HL 68.17 Wed 16:00 Poster A

Bandgap engineering of GaAs by ion-implantation and flash lamp annealing — •Kun Gao, Slawomor Prucnal, Wolfgang Skorupa, Manfred Helm, and Shengqiang Zhou — Institute of Ion Beam Physics and Materials Research, Helmholtz-Zentrum Dresden-Rossendorf (HZDR), P. O. Box 510119, Dresden 01314, Germany

Gallium arsenide based materials have outstanding performances in light-emitting devices in virtue of their remarkable efficiency and thermal stability.

In this contribution we present the successful doping of N, P, Bi, and In into GaAs lattice. First the dopant atoms are implanted into the GaAs wafers. After implantation, the GaAs wafer becomes amorphous within the as-implanted range. Post thermal annealing restores the initial properties of the matrix and leads to formation of the GaAs:X (X:dopants) layers. The optical properties were investigated by μ-Raman spectroscopy, temperature dependence photoluminescence. By N-doping we have successfully narrowed the bandgap. From Bi and In doped GaAs we obtain a strong luminescence peaking at 1.3 μm. On the other hand, Zn-doping has suppressed such luminescence. It is also noticeable that the 1.3 μm light emission only have a slight redshift (about 20 nm) and 60% intensity decline as the temperature rises from 20 K to room temperature. Our investigation suggests that after flash lamp annealing GaAs based materials exhibit a promising prospect on applications of light emitters and detectors, especially for optical communication devices.

HL 68.18 Wed 16:00 Poster A

Treatment of light emitting equipment on the base of III-V semiconductive compound for information visual reflection systems — •Ia Trapaidze[1], Maia Jgenti[1], Lia Trapaidze[2], and Gela Goderdzishvili[1] — [1]Dep. of Physics, Georgian Technical University, 77 Kostava Ave. IV block, 0175, Tbilisi, Georgia — [2]Dep. of Physics, Tbilisi State University, 3 Chavchavadze Ave., 0179 Tbilisi, Georgia

This work includes new methods of treatment and optimization technological processes of light emitting equipment on the base of III-V semiconductive compound. By using local rust thermal method we created high effective light emitting integral scheme. Also was fulfilled new type of integral scheme in the different area of visible spectrum. For made equipment we investigated spectraphotometrical and electro physical parameters. In future we plan to create structures working little consumption current with light radiation elements and will make different configuration semiconductive indicators on the base of these structures.

HL 68.19 Wed 16:00 Poster A

Optical gain and lasing in GaNAsP/BGa(As)P heterostructures grown on (001) silicon substrate — •Markus Finkeldey[1], Nektarios Koukourakis[1], Nils C. Gerhardt[1], Martin R. Hofmann[1], Martin Zimprich[2], Kerstin Volz[2], Wolfgang Stolz[2], and Bernardette Kunert[3] — [1]Photonics and Terahertztechnology, Ruhr-Universität Bochum, Germany — [2]Material Science Center and Faculty of Physics, Philipps-University Marburg, Germany — [3]NAsP III/V GmbH, Marburg, Germany

The realization of electrically pumped lasers on silicon is a huge challenge on the way to optoelectronic integrated circuits. One approach is the heteroepitaxial growth of direct band gap III/V semiconductors on indirect Si. However, the large lattice mismatch between III/V materials and Si leads to a formation of high misfit and threading dislocation densities, reducing the efficiency and lifetime of the lasers dramatically. The dilute nitride material GaNAsP is a very promising candidate to overcome these obstacles. Due to its direct band gap and its capability for lattice matched growth on (001) silicon substrate, GaNAsP is perfectly qualified as an active material for lasers on silicon. Here we investigate gain and temperature dependent lasing in optically pumped GaNAsP/BGa(As)P heterostructures grown on silicon substrate. We obtained high modal gain values at room temperature comparable to the values in common III-V laser materials. However the observed strong dependence of the laser threshold on excitation wavelength indicates significant carrier leakage, which has to be suppressed in order to increase the efficiency in electrically pumped devices.

HL 68.20 Wed 16:00 Poster A

Non-exponential photoluminescence transients in GaNAsP lattice matched to (001) silicon substrate — •Nils C. Gerhardt[1], Nektarios Koukourakis[1], Markus Finkeldey[1], Martin R. Hofmann[1], Martin Zimprich[2], Kerstin Volz[2], Wolfgang Stolz[2], Kakhaber Jandieri[2], Florian Gebhard[2], Sergei Baranovskii[2], and Bernardette Kunert[3] — [1]Photonics and Terahertztechnology, Ruhr-Universität Bochum, Germany — [2]Material Science Center and Faculty of Physics, Philipps-University Marburg, Germany — [3]NAsP III/V GmbH, Marburg, Germany

The novel dilute nitride material GaNAsP which can be grown lattice-matched on silicon substrate is a very promising material for future integrated, electrically pumped lasers on silicon. Here we present an experimental and theoretical study of the time-resolved photoluminescence (PL) of GaNAsP/BGa(As)P heterostructures grown on (001) silicon substrate. The results show a s-shape behaviour for the temperature dependent PL peak energy and a strong non-exponential behaviour for the PL transients, indicating a significant impact of disorder-induced localization effects. A detailed comparison with theoretical calculations based on Monte-Carlo simulations reveals that the non-exponential PL transient is due to a combination between the fast capture of carriers in non-radiative centers and the slow radiative recombination via localized states. The impact of the localization effects depends strongly on the material composition and growth conditions. Remarkably, the experimental results indicate an unexpected decrease of localization and disorder effects with increasing N content.

HL 68.21 Wed 16:00 Poster A

Time-resolved luminescence studies of rare earth doped III-nitrides grown at high temperature and high pressure — •Oliver Beck[1], Tristan Koppe[1], Takashi Taniguchi[2], Hans Hofsäss[1], and Ulrich Vetter[1] — [1]2. Physikalisches Institut, Georg-August-Universität Göttingen, Friedrich-Hund-Platz 1, 37077 Göttingen — [2]National Institute for Materials Science, Namiki 1 - 1, Tsukuba, Ibaraki 305-0044, Japan

We report on luminescence studies of rare earth doped III-nitrides that are synthesized under high temperature and high pressure conditions. The samples are excited with a femtosecond laser system at various wavelengths between 193nm and 1000 nm and the luminescence is collected with a Streak Camera at different time scales in the wavelength range 200-800 nm at room temperature. A special focus is drawn on rare earth doped 2H-AlN as a high power laser material, with a comparison to rare earth doped boron nitride.

HL 68.22 Wed 16:00 Poster A

Investigation of the effective mass in diluted nitride semiconductors — •Faina Lomakina[1,2], Oleksiy Drachenko[1], Harald Schneider[1], Amalia Patanè[3], and Manfred Helm[1,2] — [1]Institute of Ion Beam Physics and Material Research, Helmholtz-Zentrum Dresden-Rossendorf, 01314 Dresden, Germany — [2]Technische Universität Dresden, 01062 Dresden, Germany — [3]The University of Nottingham, Nottingham NG7 2RD, United Kingdom

Dilute nitride semiconductors (DNS), such as GaAsN, with a nitrogen content y of a few percent or even less, have attracted considerable current interest due to the giant bowing effect. That, in turn, offers the possibility to tailor the band structure of new devices, like LEDs, lasers, solar cells, and infrared photodetectors by varying the nitrogen content [1]. Determining proper values of the effective mass (EM) of DNS is a topic of interest because of the inconsistency of previous results (e.g. [2,3]). To clarify the conflict we study a series of GaAsN and InAsN samples (y=0%-1.9%) by cyclotron resonance (CR) spectroscopy, Fourier spectroscopy and photoluminescence spectroscopy in magnetic fields in order to deduce the EM via the CR frequency, plasma frequency and the dielectric shift, respectively. First results of CR measurements indicate that the EM is not significantly affected by the nitrogen doping in contrast to previous publications.

[1] A. Erol, Dilute III-V Nitride Semiconductors and Material Systems, Springer-Verlag Berlin Heidelberg (2008) [2] F. Masia et al. Appl. Phys. Lett. 82, 4474 (2003) [3] Y. J. Wang et al. Appl. Phys. Lett. 82, 4453 (2003)

HL 68.23 Wed 16:00 Poster A

A numerical framework to analyze the nature of guided light in waveguide quantum electrodynamics — •Christoph Martens[1] and Kurt Busch[1,2] — [1]Max Born Institute for Nonlinear Optics and Short Pulse Spectroscopy, Max Born Str. 2A, 12489 Berlin, Germany — [2]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik & Photonik, Newtonstr. 15, 12489 Berlin, Germany

Low-dimensional waveguiding structures combined with embedded single emitters are the basic building blocks of quantum-photonic circuits. The photon transport through such systems is primarily determined by strong quantum interference of single- or few-photon states caused by the restriction of the radiation to the waveguiding elements before and after the scattering. This leads to interesting transport properties, e.g. *interaction–induced radiation trapping* [1] or a variety of the *Hong-Ou-Mandel effect* [2].

In this contribution we present our numerical framework that is used to investigate the dynamics of photon transport in waveguiding systems in the presence of quantum impurities. The framework encloses multi-level atoms of different configurations as impurities, waveguides with nonlinear dispersion relations for photons, and time-dependent driving fields. With the help of this, we can monitor the evolution of certain initial few-photon states in time domain and real space to reveal and understand physical phenomena in these systems.

[1] P. Longo *et al.*, Phys. Rev. Lett. **104,** 023602 (2010)
[2] P. Longo *et al.*, Optics Express **20,** 12326 (2012)

HL 68.24 Wed 16:00 Poster A

Design and Optimization and Fabrication of Photonic Crystal Structures for Single Photon Applications — •Carlo Barth[1], Michael Adler[1], Jürgen Probst[2], Max Schoengen[2], Bernd Löchel[2], Janik Wolters[1], and Oliver Benson[1] — [1]Nano-Optics, Institute of Physics, Humboldt-Universität zu Berlin, Newtonstraße 15, D-12489 Berlin, Germany — [2]Helmholtz-Zentrum Berlin für Materialien und Energie GmbH, Albert-Einstein-Straße 15, D-12489 Berlin

Photonic crystals are a promising platform for integrated optical hybrid networks on the single photon level. In the last years the controlled coupling of single emitters to photonic crystal cavities has been strikingly demonstrated in several experiments [1]. For future integrated single photon devices efficient wave guiding and coupling structures will be needed. The latter ones are particularly important, as they form the interface between photonic chips and the macroscopic measurement equipment. Our latest results on the design and fabrication of high efficient couplers with large directivity, as well as their integration into photonic networks are presented.

[1] J. Wolters, A.W. Schell, G. Kewes, N. Nüsse, M. Schoengen, H. Döscher, T. Hannappel, B. Löchel, M. Barth, O. Benson. Enhancement of the zero phonon line emission from a single nitrogen vacancy center in a nanodiamond via coupling to a photonic crystal cavity. Applied Physics Letters 97(14):141108, 2010.

HL 68.25 Wed 16:00 Poster A

Photon correlations in one-dimensional coupled resonator optical waveguides — •Matthias Moeferdt[1], Peter Schmitteckert[2], and Kurt Busch[1,3] — [1]Humboldt-Universität zu Berlin, Institut für Physik, AG Theoretische Optik und Photonik, Newtonstr. 15, 12489 Berlin, Germany — [2]Institut für Nanotechnologie, Karlsruher Institut für Technologie (KIT), 76344 Eggenstein-Leopoldshafen, Germany — [3]Max-Born-Institut, Max-Born-Str. 2A, 12489 Berlin, Germany

We numerically simulate the propagation of wave packets containing two photons in a one-dimensional coupled resonator optical waveguide, equipped with a side-coupled two-level system.

The two-level system causes an effective photon-photon interaction, resulting in radiation trapping in the immediate neighborhood of the

two-level system, as well as strong correlations between the reemitted photons.

To study these correlations, we compute the correlation functions and employ a two-dimensional representation of the two-photon wavefunction in order to visualize the photon transport. We show that its nature depends strongly on the position of the initial pulse in the band.

HL 68.26 Wed 16:00 Poster A

Systematic analysis of intracavity dispersion and absorption effects of a modelocked semiconductor laser — •Benjamin Döpke[1], Jan C. Balzer[1], Andreas Klehr[2], Götz Erbert[2], Günther Tränkle[2], and Martin R. Hofmann[1] — [1]Chair for Photonics and Terahertz Technology, Ruhr-Universität Bochum, D-44801 Bochum, Germany — [2]Ferdinand Braun Institute, D-12489 Berlin, Germany

Modelocked multi-section semiconductor laser diodes are a promising source for ultrafast pulses. They offer a potentially compact and cost-effective alternative to pulsed Ti:sapphire lasers. In addition they have a higher flexibility of the design wavelength compared to fiber lasers. However, in spite of a gain bandwidth greater than 50 nm, intracavity dynamics governed by dispersion limit the obtainable modelocked bandwidth, resulting in typical compressed pulse-widths of more than 200 fs.

We present a systematic study of intracavity dispersion and absorption effects of a multi-segment triple quantum well ridge waveguide semiconductor laser with a central wavelength of 850 nm in an external cavity. The external cavity consists of a folded 4f grating compressor. A spatial light modulator in the Fourier plane of the compressor enables us to modify spectral phase and amplitude. This allows fine-grained control of resonator dispersion and losses in various operating conditions of the laser.