HL 8: Nitrides: Devices

Time: Monday 9:30–11:30 Location: POT 51

HL 8.1 Mon 9:30 POT 51

Extreme laser background suppression for resonant fluorescence of a quantum emitter — •Meryem Benelajla[1,2], Elena Kammann[1], and Khaled Karrai[1] — [1]attocube systems AG, Eglfinger Weg 2, 85540 Haar bei München — [2]LPCNO INSA CNRS UPS, 135 Av. Rangueil , 31077 Toulouse, France

Semiconductor nanostrustures are promising candidates for developing a broad range of single photon technologies. Relevant demonstrations in this field has been carried out by resonantly coupling a laser beam to a quantum emitter. However, such challenging measurements require the suppression of laser background by several order of magnitudes.One way to do that is to use cross polarization confocal microscopy. Normally, high quality commercial crossed polarizers allows a laser suppression down to 5 to 6 orders of magnitudes. Surprisingly, when used in combination with a confocal microscope, the extinction ratio is boosted up to 9 order of magnitudes. This unexpected but very welcome enhancement finds its origin in the Imbert-Fedorov effect, now commonly referred to as Spin Hall effect of light, which manifests itself in the reflectivity of a Gaussian laser beam off a mirror. In this presentation, we will discuss in details the physics and optics of such a remarkable effect, which we mapped in details for the first time.

HL 8.2 Mon 9:45 POT 51

Realizing tunnel junctions in MOVPE-grown AlGaN-based UVC LEDs emitting at 233 nm — •Verena Montag[1], Luca Sulmoni[1], Frank Mehnke[1], Martin Guttmann[1], Christian Kuhn[1], Norman Susilo[1], Johannes Glaab[2], Tim Wernicke[1], Markus Weyers[2], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institute of Solid State Physics — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Berlin

A highly conductive and UV-transparent p-AlGaN layer is needed to overcome the strong absorption and the poor current spreading of p-contacts in deep UV LEDs. However, transparent p-AlGaN layers exhibit high sheet and contact resistances resulting in very large operating voltages. A promising alternative to standard p-contacts is the injection of holes into the AlGaN quantum well by tunnel heterojunctions (TJs) allowing for low resistivity n-layers and n-contacts on both sides of the device. This way, a transparent top n-AlGaN layer can be used as an excellent current spreading layer together with a metal reflector enhancing the light extraction. We have successfully demonstrated fully transparent AlGaN-based TJ-LEDs emitting at 233 nm grown entirely by MOVPE. A thin GaN interlayer was implemented to enhance carrier tunneling at the TJ interface. Typically, the operation voltages, the output powers and the external quantum efficiencies of a 0.15 mm^2 TJ-LED featuring a 8 nm thick GaN interlayer are 24 V, 83 μW and 0.16%, respectively, measured on wafer at 10 mA in cw operation.

HL 8.3 Mon 10:00 POT 51

GaN:Ge as transparent conductive nitride contact layer for blue tunnel-junction LEDs — •Christoph Berger, Silvio Neugebauer, Cleophace Seneza, Hartmut Witte, Jürgen Bläsing, Armin Dadgar, and André Strittmatter — Otto-von-Guericke-Universität Magdeburg

Using germanium as a shallow donor for n-type GaN films grown by metalorganic vapor-phase epitaxy, we achieve very high electron concentrations of up to 2 x 10^{20} cm^{-3} and low specific bulk resistivities down to 3 x 10^{-4} Ωcm. Under optimized growth conditions, no degradation of the crystalline quality is observed and layers exhibit high optical transparency making highly doped GaN:Ge very attractive for different application fields. One promising application of such n^{++}-layers is the achievement of transparent conductive nitride (TCN) contacts with excellent current spreading on top of LEDs, edge emitting laser diodes or vertical-cavity surface-emitting lasers (VCSELs). Such intrinsic TCN contacts offer significant lower absorption than conventionally used Iindium Tin Oxide layers, which is helpful to increase the output power of light emitting devices or to decrease the threshold current for VCSELs. Therefore, we realized tunnel-junction LEDs by capping conventional pn-LED structures with TCN contacts using GaN:Ge layers. We will discuss structural, electrical and optical characteristics of fabricated tunnel junction LEDs and compare them with standard LEDs.

HL 8.4 Mon 10:15 POT 51

Effects of degradation on the electrooptical properties of UVB-LEDs measured by temperature dependent electroluminescence spectroscopy — •Jakob Höpfner[1], Priti Gupta[1], Martin Guttmann[1], Jan Ruschel[2], Johannes Glaab[2], Tim Kolbe[2], Arne Knauer[2], Tim Wernicke[1], Markus Weyers[2], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institute of Solid State Physics, Berlin, Germany — [2]FBH, Berlin, Germany

The operation of UVB-LEDs induces changes in their electrooptical behaviour, especially a reduction in the emission power. As the lifetime of a device is a key property for its application, it is important to understand the processes governing their degradation behavior. We report an investigation on UVB-LEDs emitting at 310 nm before and after aging (1000 h at 100 mA (67 A cm^{-2}) and heatsink temperature of 70 °C) using temperature(T)–dependent electroluminescence spectroscopy from 20 K – 340 K. Before aging, the external quantum efficiency (EQE) at 10 mA gradually increases with decreasing temperature from 0.8 % at 340 K to 1.8 % at 150 K and then levels off. This is similar to the expected change in radiative recombination efficiency (η_{rad}) with decreasing temperature due to the reduction of the non-radiative recombinations, indicating that EQE(T) is dominated by η_{rad}. After aging, the EQE reduces to 0.45 % (340 K) and the EQE(T) shows a constant increase with decreasing temperature peaking at 1.4 % (80 K). Below 80 K, a sharp droop in EQE is observed in the case of aged LED. These findings indicate a reduction in both η_{rad} and injection efficiency as degradation mechanism in aged LEDs.

HL 8.5 Mon 10:30 POT 51

Speeding up LED design using experimental device data in the nextnano software — •Maria Cecilia da Silva Figueira, Alex Trellakis, Takuma Sato, Carola Burkl, and Stefan Birner — nextnano GmbH, Lichtenbergstr. 8, 85748 Garching b. München, Germany

We present a simple but a very efficient way to speed up the design or optimization of new devices, by importing experimental data of a previous design or prototype directly into a simulator.

The commercial nextnano software is a semiconductor nanodevice simulation tool that has been developed for predicting and understanding a wide range of electronic and optical properties of quantum structures such as internal quantum efficiency (IQE) or the emission spectrum. A very valuable feature of nextnano is the possibility to include experimental profiles for simplifying the process of writing the required input files for the new structure.

As a case study, an UVB LED structure developed at RIKEN was simulated after importing the doping profiles measured with SIMS into the nextnano software. A methodology was developed in order to identify the best characteristics of a new layer in the structure ("Final Barrier"), simulating strain and self-consistent Schrödinger-Poisson-Current equations. As result of the optimization process the internal quantum efficiency was estimated around 66% for an AlGaN Final Barrier with molar fraction 14% of Al content, thickness between 6 to 8 nm, operating at 6.7 V.

HL 8.6 Mon 10:45 POT 51

Thermal management of ultraviolet LEDs and VCSELs: computer-aided multiphysics optimization — •Giulia Cardinali[1,2], Filip Hjort[2], Michael Alexander Bergmann[2], Johan Gustavsson[2], and Åsa Haglund[2] — [1]Department of Electronics and Telecommunications, Politecnico di Torino, Turin, Italy — [2]Department of Microtechnology and Nanoscience, Chalmers University of Technology, Gothenburg, Sweden

Thermal management is crucial to push the power conversion efficiency above the current limit of 10% in UV LEDs and to enable lasing in UV VCSELs. Numerical simulations have been used to study thermal transport in AlGaN-based vertical-cavity surface-emitting lasers (VCSELs) with dielectric distributed Bragg reflectors (DBRs) and thin-film flip-chip LEDs. The VCSELs technology suffers from poor thermal dissipation through to the DBRs: AlN or diamond heat spreading layers showed to be the most effective way to reduce the internal temperature while maintaining a short optical cavity length. Transfer matrix simulations show a resonance wavelength shift rate with temperature of 6 × 10^{-3} nm/K, one order of magnitude lower than the value reported for GaN VCSELs with thermally conductive bottom epitaxial DBR. In UVB LEDs to enhance the vertical heat transport the mesa should be in contact with the carrier over the whole area by avoiding air gaps. In that way, thermal performance becomes less dependent upon the exact alignment during the flip-chip bonding process.

HL 8.7 Mon 11:00 POT 51

Characterization of GaN-based FinFETs Grown by Molecular Beam Epitaxy — •Fabian Becker, Florian Pantle, and Martin Stutzmann — Walter Schottky Institut and Physics Department, Technische Universität München, Garching, Germany

Gallium nitride (GaN) is a promising candidate for high power and high frequency electronic applications due to its superior material properties like a high electronic breakdown field, large bandgap, high electron mobility and high electron saturation velocity. An approach to overcome spacial limitations of planar devices is the utilization of vertical 3D structures like nanofins. GaN fin-shaped field effect transistors (FinFETs) gain increasing interest due to a higher active channel area and a better controllability of the gate. Further, GaN nanofins selectively grown by molecular beam epitaxy (MBE) are expected to have a higher crystal quality and reduced defect densities compared to their counterparts fabricated by top-down etching techniques.

Here, we present the fabrication and electrical characterization of MBE-grown GaN FinFETs with various fin dimensions on different substrates. In addition, the nanofins are evaluated by scanning electron microscopy and characterized by Raman and photoluminescence spectroscopy.

HL 8.8 Mon 11:15 POT 51

AlGaN-based UVC-LEDs on AlN/sapphire templates with low threading dislocation density — •Daniel Hauer Vidal[1], Norman Susilo[1], Arne Knauer[2], Sylvia Hagedorn[2], Johannes Enslin[1], Tim Wernicke[1], Markus Weyers[2], and Michael Kneissl[1] — [1]Technische Universität Berlin, Berlin, Deutschland — [2]Ferdinand-Braun-Institut, Berlin, Deutschland

AlGaN-based ultraviolet light emitting diodes (UV LEDs) near 265 nm have applications for the desinfection of water, surfaces and medical equipment. However, most devices are grown on AlN/sapphire templates, which have a high threading dislocation density (TDD). One method to reduce the TDD to around 2×10^9 cm^{-2} are epitaxially laterally overgrown (ELO) AlN/sapphire-templates. They are produced by overgrowing a sapphire template with 0.8 μm of AlN. This layer is then patterned with 1.5 μm thick ridges and subsequently overgrown with several μm of AlN until coalescence. Recently a new approach was developed using high temperature annealing (HTA). In this method a AlN/sapphire template is face to face annealed at temperatures above 1500°C. The annealing step leads to a restructuration of the AlN layer, which produces templates with TDDs at around 1×10^9 cm^{-2}. Another method to reduce the TDD within the active region is to manipuilate the growth mode using different susbtrat off-cut angles. In this study we compare UVC-LEDS grown by metalorganic vapor phase epitaxy on HTA, ELO AlN/sapphire and their combination HTA-ELO. Finally UVC-LEDs are realised on HTA-ELO showing an emission power of 47 mW at 350 mA and 265 nm.