HL 44: Nitrides: Devices

Time: Thursday 15:00–17:00 Location: POT 112

HL 44.1 Thu 15:00 POT 112

Highly doped GaN:Ge/GaN:Mg tunnel junctions for novel GaN-based optoelectronic devices — •Christoph Berger, Armin Dadgar, and André Strittmatter — Otto-von-Guericke-Universität Magdeburg

We report on low resistive GaN-based tunnel junctions (TJs) implemented into optoelectronic devices grown by metalorganic vapor phase epitaxy. Very high donor concentrations, which are mandatory for low-resistive TJs, are achieved by using germanium instead of commonly used silicon. Fabricated TJ-LEDs show an increased light output by more than 60 % in comparison to conventional LEDs employing indium tin oxide contacts while exhibiting a comparable differential resistance of 1.2x10^{-2} Ωcm^2 at a current density of 100 A/cm^2 and no voltage penalty by the TJ. Higher light output is attributed to a better light extraction efficiency due to V-pits formed within the GaN:Ge layer. We currently apply such tunnel-junctions in edge-emitting laser diodes as well as in vertical-cavity surface-emitting lasers. Furthermore, we will demonstrate cascaded LEDs featuring three tunnel junctions and three pn-junctions stacked on top of each other. Overgrowth of the lower LED sections affects their radiative efficiencies. We investigate different annealing concepts for acceptor activation but also the impact of annealing on the radiative recombination in the InGaN active regions.

HL 44.2 Thu 15:15 POT 112

Mitigating damage induced by strongly ionising radiation in nitride layered structures — •Miguel C. Sequeira[1], Mamour Sall[2], Flyura Djurabekova[3], Kai Nordlund[3], Isabelle Monnet[2], Clara Grygiel[2], Christian Wetzel[4], and Katharina Lorenz[5] — [1]HZDR, Dresden, Germany — [2]CIMAP, Caen, France — [3]University of Helsinki, Finland — [4]RPI, New York, USA — [5]INESC-MN, & IST-Universidade de Lisboa, Portugal

Group-III nitrides are well-known for their high radiation resistance, which brings them to extreme radiation environments. GaN is known for having a high resistance to strongly ionising radiation, such as Swift Heavy Ions (SHI) [1,2]. However, the behaviour of other nitrides under this radiation is not well understood especially when in layered structures (e.g. InGaN/GaN in LED). Here, we inspect how InGaN/GaN quantum wells (QW) resist SHI. We solve the Two-Temperature Model (TTM) using Finite Element Methods to show how the high electronic conductivity of InGaN in a QW acts as a heat sink, reducing the intensity of the ion-induced thermal spike in the entire InGaN/GaN structure. Combining TTM-Molecular Dynamics simulations and Transmission Electron Microscopy images show that the presence of QW significantly decreases the overall radiation damage in a device. The results presented here can lead to new radiation damage mitigation techniques, predict functional changes in devices under long radiation exposure, and ultimately improve device design.

[1] M. C. Sequeira et al., Communications Physics (2021); [2] M. C. Sequeira et al., Small (2022)

HL 44.3 Thu 15:30 POT 112

A guide on designing high performance porous GaN DBRs — •Matthias Hoormann[1,2], Frederik Lüssmann[1,2], Florian Meierhofer[1,2], Jana Hartmann[1,2], and Andreas Waag[1,2] — [1]Institute of Semiconductor Technology, Technische Universität Braunschweig, Hans-Sommer-Str. 66, 38106 Braunschweig, Germany — [2]Laboratory for Emerging Nanometrology (LENA), Technische Universität Braunschweig, Langer Kamp 6, 38106 Braunschweig, Germany

Recently, porous GaN etching has gained significant attention, due to its broad variety of convenient applications for optoelectronic devices. Specifically, the introduction of nanoporous layers enables the quasi-epitaxial growth of low refractive index GaN-based compounds for applications such as vertical DBR mirror structures.

Whilst classical DBRs are designed in order to satisfy the quarter-wavelength-condition, porous GaN DBRs are subject to a competition between porosity and optimal constructive interference from the layer thicknesses. It is vital to understand the influence of the porosity, as deviations from typical DBR designs might be advantageous for the device performance as inferred from simulations.

In this contribution, we investigate the influence of different designs and etching parameters on the optical performance of a defined layer structure. Particularly, the interdependency between the etched porosity and the design porosity with respect to the optical device performance is investigated. To determine the porosity, a combination of optical measurements, simulations and a gravimetric approach is used.

HL 44.4 Thu 15:45 POT 112

PL enhancement from Mie resonant silicon-rich-nitride nanodisks — •Krishna Koundinya Upadhyayula and Jörg Schilling — Martin Luther Universität Halle-Wittenberg, Halle

PECVD grown silicon-rich-nitride (SRN) exhibits refractive indices up to 3.5 and a broad luminescence in the visible up to near IR wavelengths making it a viable candidate for a photonic platform for biosensing at the therapeutic window. After a fundamental study on the origin of this photoluminescence (PL) in SRN using spectral and time resolved PL, we demonstrate the impact of Mie resonances on the luminescence by fabricating single Mie resonant SRN nano-disks with sizes on the order of a few 100nm. Comparing the measured PL-spectra with theoretically modelled transmission and emission spectra from finite element simulations, the observed PL-peaks could be attributed to the coupling of the emitters to electric dipole, magnetic dipole and higher order multipole Mie resonances. Furthermore, we created 2D periodic arrays of such SRN-Mie resonators with periods between 300-500nm and an absolute size of 100mm2 using interference lithography. The fabricated arrays exhibited an up to 27x enhancement of the room-temperature PL compared to that of an unstructured sample increasing further up 54x after hydrogen passivation. Tuning the structure parameters, we identify the remaining impact of the individual Mie-resonances in the spectra and the features caused by the grating/Bragg-resonances of the collective photonic crystal structure. Ongoing time resolved measurements will elucidate the impact of Purcell enhancement on the observed PL due to the Mie resonances.

15 min. break

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UVC-LEDs grown on HTA-AlN templates with low dislocation densities and high Si doping for strain management — •Tim Mampe[1], Sarina Graupeter[1], Giulia Cardinali[1], Sylvia Hagedorn[2], Tim Wernicke[1], Markus Weyers[2], and Michael Kneissl[1,2] — [1]Technische Universität Berlin, Institute of Solid State Physics, Hardenbergstraße 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut (FBH),Gustav-Kirchhoff-Straße 4, 12489 Berlin, Germany

High temperature annealing (HTA) of AlN layers reduces the threading dislocation density of such layers on sapphire substrates below 10^9 cm^{-2} enabling UVC-LEDs with improved efficiencies. However, the HTA AlN-layers are under high compressive strain after cooling down, which can lead to strain relaxation and defect formation during further LED heterostructure growth. The in-plane lattice constant can be increased by growing a Si-doped AlN layer on HTA-AlN. In this work we investigate the influence of such an AlN:Si-layer on the growth of UVC-LEDs emitting at 265nm on AlN/sapphire substrates with silicon doped as well as undoped AlN layer and different sapphire offcut angles (0.1°, 0.2°, 0.5°). We will discuss the morphology as well as the strain state of AlN and AlGaN layers as well as the electro-optical properties of multi quantum-well (MQW) and LED structures.

HL 44.6 Thu 16:30 POT 112

Intensity fluctuations of infrared and green photodiodes at constant current and its correlation with voltage fluctuations — •Danylo Bohomolov and Ulrich T. Schwarz — Chemnitz University of Technology, Chemnitz, Germany

One important issue for display and sensing applications in LEDs is the fluctuation of light intensity over time. The physical reasons behind this are not fully understood yet, e.g. defect-related blinking is dicussed. In addition, it is known that the noise of these devices has a strong correlation with their lifetime. Consequently, the noise of the infrared and green micro-LEDs will be measured here, after which the similarity of their behaviour will be investigated. Standard derivation and corner frequency between flicker noise and thermal noise are chosen as the main comparison parameters. For this purpose, their spectral power density of intensity fluctuations of the emitted light at constant current is investigated. We use a linear controlled precision current source. A large area Si photodiode with amplification capability is used as detector, and the signal is measured using a low-noise transimpedance amplifier and a 24-bit analog-to-digital converter. In parallel, the voltage of the LED is measured to correlate fluctuations in voltage and intensity. We observe oscillations in the frequency range from 1 Hz to 15 kHz. The first measurements of the infrared LEDs showed the presence of 1/f and Johnson-Nyquist noise in this frequency range as expected.

HL 44.7 Thu 16:45 POT 112

Theoretical improvement of 40% in efficiency of AlGaN UV LED using evolution strategies optimization algorithm — •Lucie Leguay and Andrei Schliwa — Institute of Solid-State Physics, Technische Universität Berlin, Hardenbergstr. 36, 10623 Berlin

Nowadays, LED light sources can be found in many technologies ranging from smart lamps to high-quality screen displays. In particular, ultraviolet (UV) LED light can be used to sterilise surfaces and food, to purify air and water and to detect gas and diseases.

However, the nitride-based existing technology is still lacking efficiency. One way to enhance the performance of such devices is to improve their design with optimization algorithms such as evolutionary algorithms which are inspired by biological evolution.

We report an increase of 40% in the theoretical internal quantum efficiency (IQE) of an AlGaN UV-emitting multiple quantum well nanostructure using an evolution strategies algorithm paired with the simulation sofware nextnano++.