HL 51: Focus Session: Role of polarization fields in nitride devices II

Continuation of the morning session "Role of polarization fields in nitride devices I"

Organization: André Strittmatter (OvGU Magdeburg) and Michael Jetter (IHFG, U Stuttgart)

Time: Wednesday 15:00–16:45 Location: ER 164

HL 51.1 Wed 15:00 ER 164

Nitrogen vacancies in III-V nitrides as non-radiative recombination centers: a first-principles investigation — •Ying Cui, Christoph Freysoldt, and Jörg Neugebauer — Max-Planck-Institut für Eisenforschung, Max-Planck-Str. 1, 40627 Düsseldorf

For LED technology, one of the unresolved problems is the nature of the non-radiative recombination processes. Theoretical calculations could be an ideal subsidiary to experiment to identify possible non-radiative recombination centers in LEDs where point defects are usually hard to detect. Here, we show an efficient and reliable strategy to study non-radiative recombination centers in III-V nitrides based on density functional theory with the HSE hybrid functional. Our calculations locate the transition state in the capture process by using defect level occupation as a natural reaction coordinate. We compare the results for nitrogen vacancies in the AlN-GaN-InN series and find that they are always efficient non-radiative recombination centers. Systematic trends along the series and implications for alloys are discussed.

HL 51.2 Wed 15:15 ER 164

Analysis of the anisotropic dielectric function of strained semipolar AlGaN — •Michael Winkler[1], Juliane Klamser[1], Martin Feneberg[1], Rüdiger Goldhahn[1], Joachim Stellmach[2], Martin Frentrup[2], Simon Ploch[2], Frank Mehnke[2], Tim Wernicke[2], and Michael Kneissl[2] — [1]Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg — [2]Institut für Festkörperphysik, Technische Universität Berlin

The linear optical responses of thick semipolar ($11\bar{2}2$) AlGaN films are analyzed quantitatively. The samples were grown by metal-organic vapor phase epitaxy on m-plane sapphire substrates spanning the whole composition range between GaN and AlN.

Due to the anisotropic nature of strain and non-vanishing shear-strain elements, the crystal symmetry is no longer wurtzite but monoclinic. This case is covered by **kp**-theoretical calculations yielding energy distances of transitions from different valence sub-bands and corresponding relative oscillator strengths for electric field vectors in different orientations, i.e. different optical polarization directions. These data are translated to model dielectric functions which are compared and fitted to experimental results obtained by spectroscopic ellipsometry.

The quantitative analysis allows a conversion back to wurtzite material yielding direct experimental evidence of the dependence of the crystal field energy on the aluminum concentration.

Invited Talk HL 51.3 Wed 15:30 ER 164

Impact of reduced polarization fields on the optical properties of semipolar nitride quantum wells — •Mitsuru Funato and Yoichi Kawakami — Department of Electronic Science and Engineering, Kyoto University, Kyoto, Japan

Semipolar InGaN and AlGaN quantum wells (QWs) are promising material systems for efficient light emitters and detectors because of the reduced polarization fields. We have been investigating their crystal growth and optical properties, and have demonstrated that the radiative recombination lifetimes are drastically shortened in both the QWs. The shorted lifetimes have consequences; for example, (1) the carrier diffusion is limited, which leads to spatially uniform emission in the microscope level, (2) the AlGaN emission line width is reduced to below 100 meV, and (3) the emission intensity at room temperature is enhanced. In the presentation, we will describe the recent progress in the understanding of the optical properties of the semipolar QWs, with a particular focus on the effect of reduced electric fields.

HL 51.4 Wed 16:00 ER 164

Nonradiative recombination mechanisms in non- and semipolar GaInN/GaN quantum wells — •Manuela Klisch, Torsten Langer, Holger Jönen, Fedor Alexej Ketzer, Heiko Bremers, Uwe Rossow, and Andreas Hangleiter — Institut für Angewandte Physik, TU Braunschweig

Via temperature-dependent time-resolved photoluminescence spectroscopy, we investigate the nonradiative recombination of excess charge carriers in non- and semipolar quantum well structures of varying indium composition grown via metalorganic vapor phase epitaxy on low defect density GaN. We demonstrate that for InN mole fractions of about 30% within the quantum well, the nonradiative carrier lifetimes in m-plane quantum wells match the corresponding values for polar quantum wells of about 100 ps. The shortening of nonradiative lifetimes with increasing indium content is weak compared to polar quantum wells indicating that the mechanisms of defect generation differ among different growth planes. Possibly, this is related to different influences of slip planes on the plastic relaxation of the compressively strained quantum wells. However, comparable nonradiative lifetimes for ($11\bar{2}2$)-, ($20\bar{2}1$)-, m- and a-plane quantum wells have been observed. Due to the small piezoelectric field component perpendicular to the quantum well plane, which reduces the radiative recombination probability in polar quantum wells, this observation is very promising to outperform the internal quantum efficiency of polar quantum wells towards green emission using non- or semipolar quantum wells.

HL 51.5 Wed 16:15 ER 164

Temperature-dependent Electro- and Photoluminescence on InGaN/GaN MQW LEDs — •Pascal Farin[1], Felix Nippert[1], Anna Nirschl[2], Alexander Wilm[2], Ines Pietzonka[2], Martin Strassburg[2], and Axel Hoffmann[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Germany — [2]OSRAM Opto Semiconductors GmbH, Regensburg, Germany

Current state-of-the-art multi quantum well light-emitting diodes (MQW LEDs) suffer from the droop phenomenon, a reduction in IQE at high operating currents. Several mechanisms including the Auger effect as well as saturation of the active region have been proposed to account for it. These have generally been investigated by means of electroluminescence (EL) and photoluminescence (PL). In order to distinguish between the different non-radiative recombination processes the influence of temperature and external electrical fields on the measurements is frequently utilized.

In this work temperature dependent results of EL and PL on InGaN/GaN MQW-LEDs are presented which allows a general comparison between the two measurements and offers insight into the loss mechanisms in these devices.

HL 51.6 Wed 16:30 ER 164

Investigation of the optical characteristics of semipolar InGaN/GaN quantum wells on pyramidal facets — •Martina Dombrowski, Jan Wagner, Michael Jetter, and Peter Michler — Institut für Halbleiteroptik und Funktionelle Grenzflächen and Research Center SCoPE, Universität Stuttgart, Allmandring 3, 70569 Stuttgart, Germany

The InGaN/GaN material system offers the possibility to reach the green spectral regime for semiconductor light emitters. However the development of such devices in an efficient way is still challenging. Strain introduced due to mismatching lattice constants in heterostructures creates a band tilt in the active region, leading to reduced recombination efficiency. One way to overcome this quantum confined Stark effect (QCSE) is to grow the quantum well on semipolar GaN facets. Since up to now semipolar and nonpolar GaN substrates are not widely available we grow pyramidal GaN structures by selected area growth (SAG). The semipolar facets of the pyramids are used as growth plane for InGaN quantum wells and show a reduced QCSE. To separate the influence of the electrical field and the influence of the three dimensional growth both semipolar and c-plane quantum wells were grown at the same spectral position. The optical and time-resolved photoluminescence measurements were performed and we compare the results for both type of samples.