HL 62: Nitrides: Advanced Characterization Techniques

Time: Wednesday 15:15–16:45 Location: POT 51

HL 62.1 Wed 15:15 POT 51

Temperature dependent microscopic energy relaxation in semipolar InGaN SQW imaged by spatio-spectrally-time-resolved cathodoluminescence — •Sebastian Metzner[1], Frank Bertram[1], Jürgen Christen[1], Thomas Wunderer[2,3], Frank Lipski[2], Stephan Schwaiger[2], and Ferdinand Scholz[2] — [1]Inst. of Exp. Physics, OvG-University Magdeburg — [2]Inst. of Optoelectronics, Ulm University — [3]Palo Alto Res. Center Inc., USA

We present ps-time- and nm-spatially resolved cathodoluminescence (CL) spectroscopy at 4. . . 300K of semipolar InGaN SQW on top of {11-22} GaN facets of 3D inverse pyramids, which were grown by MOVPE using hexagonal SiO_2 masks and selective area overgrowth. The microscopic local differences in strain, polarization fields, In-incorporation, and SQW-thickness result in an extremely complex interaction of relaxation, recombination in energy, space, and time via real space transport of the excited carriers. The CL mapping at 300K reveals a huge spectral shift of SQW emission from the center (380nm) to the ridge (535nm) of the inverse pyramids which is accompanied by a drastically increasing recombination time of 200ps (center) to >10ns (ridge) as observed in microscopic CL lifetime maps. To analyze the nanoscopic kinetic in detail, monochromatic spatio-time-resolved CL linescans and local time-delayed spectra have been recorded giving direct access to the microscopic transport mechanism of excited carriers. Using these techniques, we discuss the temperature dependence of energy relaxation via an efficient spatial transfer of carriers inside the SQW from high energy regions near the center towards the ridge.

HL 62.2 Wed 15:30 POT 51

Lateral transport in InGaN/GaN quantum wells: time-of-flight experiments — •Julia Danhof[1,2], Ulrich T. Schwarz[1,2], Yoichi Kawakami[3], and Akio Kaneta[3] — [1]Fraunhofer IAF, Tullastr. 72, 79108 Freiburg, Germany — [2]Institut für Mikrosystemtechnik, Georges-Köhler-Allee 106, 79110 Freiburg, Germany — [3]Kyoto University, Katsura Campus, Nishikyo-ku, Kyoto, 615-2312, Japan

The Indium Gallium Nitride material system is known to have very small lateral charge carrier diffusion constant. In case of quantum well structures this is most likely due to Indium fluctuations and defects. We present a method to directly observe travelling charge carriers in quantum wells by solely optical means. By combining a confocal setup with a pulsed laser, a streak camera and the possibility to perform so called pinhole scans we were able perform time-of flight experiments and observe lateral diffusion in a green emitting InGaN/GaN multiple quantum well. Our measurement results can be described quantitatively by continuity and rate equation. This quantitative description also provides us with a local charge carrier diffusion constant for this sample.

HL 62.3 Wed 15:45 POT 51

A (S)TEM and Atom Probe Tomography Study of InGaN — •Thorsten Mehrtens[1], Stephanie Bley[1], Marco Schowalter[1], Kathrin Sebald[1], Moritz Seyfried[1], Jürgen Gutowski[1], Stephan S.A. Gerstl[2], Pyuck-Pa Choi[2], Dierk Raabe[2], Adrian Avramescu[3], and Andreas Rosenauer[1] — [1]Institut für Festkörperphysik, Universität Bremen, Bremen — [2]Max-Planck-Institut für Eisenforschung GmbH, Düsseldorf — [3]OSRAM Opto Semiconductors GmbH, Regensburg

InGaN is a well suited material for opto-electronic devices such as LEDs and laser-diodes in spite of its high dislocation density. The reason for this is still under discussion, but small fluctuations of the indium concentration or layer thickness are assumed to be the origin. We have investigated an InGaN/GaN multi quantum well structure via quantitative high-angle annular dark field scanning transmission electron microscopy (HAADF-STEM) and atom probe tomography (APT). For the (S)TEM study the preparation process was optimized by low-energy milling in order to reduce amorphous surface layers. The indium concentration of the quantum wells were deduced by comparing HAADF-STEM images, where measured intensities strongly depend on the nuclear charges of the scattering atoms (Z-contrast), with multislice simulations. An indium concentration of around 16% was obtained. This value is in good agreement with the concentrations obtained with APT and energy-dispersive X-ray analysis (EDX).
Existence of short and long-range fluctuations in these layers will be discussed in comparison to μ-photoluminescence measurements.

HL 62.4 Wed 16:00 POT 51

Liquid He Temperature Cathodoluminescence Spectroscopy in a Scanning Transmission Electron Microscope — •Gordon Schmidt, Barbara Bastek, Peter Veit, Frank Bertram, and Jürgen Christen — Institute of Experimental Physics, Otto-von-Guericke-University Magdeburg, Germany

The technique of low temperature scanning transmission electron microscopy cathodoluminescence spectroscopy (STEM-CL) provides a unique and extremely powerful tool for the optical nano-characterization of semiconductors and their heterostructures and interfaces. The combination of cathodoluminescence spectroscopy – in particular at liquid He temperatures – with the high spatial resolution of a scanning transmission electron microscope (STEM) allows a spatial excitation resolution below 5 nm.

Our CL-system is integrated in a field emission (S)TEM (FEI Tecnai F20) equipped with a liquid helium stage (T=10K / 300K) and a light collecting parabolic mirror. Optimizing the excitation conditions, such as TEM acceleration voltage, is necessary to minimize sample damage and prevent luminescence degeneration. Panchromatic as well as spectrally resolved CL imaging is used. In CL-imaging mode the CL-intensity is collected simultaneously to the STEM signal – typically the dark field image signal recorded by an HAADF detector at each pixel. This enables a direct microscopic correlation of structural defects, interfaces and their influence on the luminescence. We will present results of room temperature and liquid helium temperature STEM-CL studies of thin GaN, AlInN and GaN/InGaN heterostructures.

HL 62.5 Wed 16:15 POT 51

Time correlated single Photon Counting on GaN nanowires — •Aram Gorgis, Timur Flissikowski, Carsten Pfüller, Oliver Brandt, and Holger T. Grahn — Paul-Drude-Institut für Festkörperelektronik, Hausvogteiplatz 5-7, 10117 Berlin

GaN nanowires (GaN NWs) received much interest in the last years because they can be grown in excellent quality on foreign substrates such as Si. We have investigated the photoluminescence (PL) of GaN NW ensembles as well as of single GaN NWs in the time domain. For the ensemble, we find the PL transients to be non-exponential even for low excitation densities. This observation agrees with the reports of several other groups.

The NWs constituting the ensemble experience a size distribution, hence the surface-to-volume-ratio can vary significantly from NW to NW. Surface recombination, being inversely proportional to the NW diameter, is thus expected to contribute more to the PL decay of thin NWs than for thick ones. Consequently, the PL decay from a single NW should be exponential, but the decay time may differ from NW to NW.

To obtain PL transients of single, freestanding NWs from the same sample with a high dynamic range, we utilize time-correlated single photon counting which allows even very weak signals to be detected with high signal-to-noise ratio. For all single NWs investigated, we indeed observe a single exponential decay.

HL 62.6 Wed 16:30 POT 51

Highly resolved optical spectroscopy on homoepitaxial AlN layers in magnetic fields — •Benjamin Neuschl[1], Martin Feneberg[1], Klaus Thonke[1], Ramon Collazo[2], and Zlatko Sitar[2] — [1]Institut für Quantenmaterie / Gruppe Halbleiterphysik, Universität Ulm, 89069 Ulm — [2]Department of Materials Science and Engineering, North Carolina State University, Raleigh, North Carolina, USA

We present optical emission spectroscopy studies on high quality c-plane AlN layers homoepitaxially grown by MOCVD on bulk AlN. The best full width at half maximum of an excitonic transition found by macroscopic photoluminescence is below 500 μeV exhibiting the unique sample quality. A detailed analysis of the excitonic bandgap region has been carried out by means of photoluminescence and cathodoluminescence. Temperature and polarization dependent measurements allowed an identification of the observed transitions and the according valence bands.We accomplished magneto photoluminescence measurements on our best sample and found multiple splittings allowing further insight into the nature of the observed transitions.