HL 69: Nitrides: LEDs

Time: Thursday 10:15–11:30 Location: POT 51

HL 69.1 Thu 10:15 POT 51

Optical polarization of UV-A and UV-B (In)(Al)GaN multiple quantum well light emitting diodes — •Tim Kolbe[1], Arne Knauer[2], Joachim Stellmach[1], Chris Chua[3], Zhihong Yang[3], Sven Einfeldt[2], Patrick Vogt[1], Noble M. Johnson[3], Markus Weyers[2], and Michael Kneissl[1,2] — [1]Institute of Solid State Physics, TU Berlin, Hardenbergstr. 36, 10623 Berlin, Germany — [2]Ferdinand-Braun-Institut, Leibniz-Institut für Höchstfrequenztechnik, Gustav-Kirchhoff-Str. 4, 12489 Berlin, Germany — [3]Palo Alto Research Center, 3333 Coyote Hill Road, Palo Alto, CA 94304, USA

The optical polarization of the in-plane electroluminescence of (0001) oriented (In)(Al)GaN multiple quantum well light emitting diodes (LEDs) in the spectral range from 288 nm to 386 nm has been investigated. A decrease of the intensity of transverse-electric (TE) polarized light relative to transverse-magnetic (TM) polarized light with decreasing emission wavelength is found. This effect is attributed to rearrangement of the valence bands at the gamma-point of the Brillouin zone with changing aluminum and indium mole fractions in the (In)(Al)GaN quantum wells. For shorter wavelengths the crystal-field split-off hole band moves closer to the conduction band relative to the heavy and light hole bands. As a consequence TM polarized emission from the split-off hole band becomes more dominant for LEDs with a decreasing emission wavelength. A polarization of zero (that means that the intensities of the TE polarized light and the TM polarized light are the same) is found for LEDs emitting near 300 nm. For shorter wavelengths the emitted light is mainly TM polarized.

HL 69.2 Thu 10:30 POT 51

Processing of III-nitride thin film light emitting diodes via wafer bonding and laser lift-off — •Christian Gossler, Rüdiger Moser, Michael Kunzer, Klaus Köhler, and Ulrich Schwarz — Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastraße 72, D-9108 Freiburg

High-brightness thin film (Al,In)GaN-based light emitting diodes are generally manufactured by wafer bonding and laser lift-off of the sapphire substrate. This technique is the key for a drastic improvement of light extraction efficiency due to the possibilities of roughening the outcoupling surface and employing a reflective backside contact.

We present the development of a rapid thin film process not using lithographic structuring. A novel bonding scheme based on the eutectic system Aluminium-Germanium is shown. The 2 inch GaN-on-sapphire epiwafers are prepared by depositing 1 μm Aluminium via electron beam evaporation in a shadow mask process. The bonding to a Germanium wafer occurs at high vacuum well above the eutectic temperature of $T = 693\,$K. For laser lift-off we use an excimer laser work station emitting at $\lambda = 248\,$nm with a homogenized laser spot of up to $2\,\text{mm} \times 2\,\text{mm}$. Additionally, the GaN layer is separated into mechanically isolated areas prior to wafer bonding by fabricating trenches via picosecond laser processing to improve yield and process control. The thin film LEDs are characterised via electroluminescence and possible effects of the laser trenching are discussed.

HL 69.3 Thu 10:45 POT 51

Micromachining with picosecond laser pulses: A versatile tool for the fabrication of optoelectronic devices — •Rüdiger Moser, Michael Kunzer, Christian Gossler, Klaus Köhler, Ulrich Schwarz, and Joachim Wagner — Fraunhofer-Institut für Angewandte Festkörperphysik, Tullastrasse 72, D-79108 Freiburg, Germany

Picosecond (ps) lasers provide a universal tool for material processing. Due to the short laser pulses material is removed by a process called "cold ablation", with minimal thermal damage to neighbour regions. As a result, better defined structures with smother and cleaner side walls can be fabricated than with "long-pulse" lasers. This offers new possibilities for laser processing in semiconductor technology for both semiconductor materials and contact or bond metallizations. The fabrication of semiconductor devices typically requires lithography steps, which are time consuming and expensive. Therefore one would like to avoid these steps at least for development and prototyping. One way to do so is to replace lithography steps by direct laser writing. In this presentation we report on the development of ps laser processes to directly pattern the semiconductor surface with trenches and mesas for the fabrication of GaN-based LEDs. The laser processed devices are electrically and optically characterised and compared with conventionally fabricated test devices. Furthermore the realization and use of high quality shadow masks for e.g. deposition of ohmic contact metallizations is reported and compared with results obtained using nanosecond laser processing.

HL 69.4 Thu 11:00 POT 51

High n-type crack-free GaN layers on Si substrates by Ge doping — •Armin Dadgar, Jürgen Bläsing, Annette Diez, and Alois Krost — Institut für Experimentelle Physik, Otto-von-Guericke-Universität Magdeburg, Universitätsplatz 2, 39106 Magdeburg

GaN based growth on silicon substrates usually requires strain-engineering methods to avoid tensile stress after cooling from growth temperature. Silicon doping required for contacting and current spreading is known to induce additional tensile stress during growth originating in edge dislocation climb. Consequently, the typically inferior material quality for GaN on Si in comparison to GaN grown on sapphire leads to high tensile stresses for highly Si doped layers, limiting freedom in device design and performance. We present that germanium doping enables the growth of thick highly n-type doped layers on silicon substrates not influencing strain evolution. By this, it enables a possible improvement of GaN-on-Si LEDs. We also conclude that the mechanism of dislocation climb in the case of silicon doping is not dominated by surface roughening but by silicon-nitride induced dislocation masking which does not apply for germanium.

HL 69.5 Thu 11:15 POT 51

All-optical determination of absolute quantum efficiency values of GaInN-based light-emitters — •Bastian Galler, Matthias Sabathil, Ansgar Laubsch, Tobias Meyer, Lutz Höppel, Gertrud Kräuter, Hans-Jürgen Lugauer, Asako Hirai, Martin Strassburg, Matthias Peter, Andreas Biebersdorf, Ulrich Steegmüller, and Berthold Hahn — OSRAM Opto Semiconductors GmbH, Leibnizstraße 4, 93055 Regensburg, Germany

The efficiency droop of GaInN-based light-emitting diodes (LEDs) gets more and more significant for increasing wavelengths and thus contributes to the well-known green gap [1]. A major reason for this behaviour is that multi-quantum-well (MQW) operation is harder to achieve under electroluminescence conditions for LEDs with high indium content due to higher transport barriers. A possibility to circumvent this difficulty is optical pumping of a large number of green-emitting quantum wells. Using a UV-LED as an electrically driven pump for a green 40x MQW glued directly on its top, we show that this system can outperform direct green LEDs at large current densities. In addition to that, the combination of LED and converter platelet allows for an absolute quantum efficiency determination of the converter structure in contrast to conventional photoluminescence experiments. We use this method to obtain further evidence that the droop is due to a QW-internal loss process. Furthermore, we propose this approach as a general tool for the evaluation of other light-emitting structures that cannot be pumped electrically.

[1] T. Mukai et al., Jpn. J. Appl. Phys., Part 1 38 (1999).