HL 83: Focus Session: III-Nitride Heterostructures for Optoelectronics - Polarization Reduction, Green Gap and High In-containing Alloys

Despite tremendous progress, the optoelectronic properties of GaN and related compounds still pose a rich field for scientific research. The aim of this session is to bring together leading experts on materials, characterization, and theory in order to discuss the physics of group-III nitride-based heterostructures and various approaches to realize future optoelectronic devices. Open questions are in particular the so-called *green gap* describing lower efficiency in GaN based green light emitters as opposed to their blue and ultraviolet counterparts, polarization of the crystal structure, as well as high-In containing alloys for light emitters in the entire visible range. (Organizers: Bernd Witzigmann, University of Kassel and Frank Bertram, University of Magdeburg)

Time: Thursday 15:00–18:15 Location: EW 201

Invited Talk HL 83.1 Thu 15:00 EW 201

Compositional instability in InGaN and InAlN thick films with high indium content — •Fernando Ponce — Department of Physics, Arizona State University, Tempe, AZ 85287, USA

Control on the indium content in InGaN and AlGaN alloys is important to achieve high efficiency light emitting devices operating in the visible regime, or to achieve ultraviolet light emitting structures that are lattice matched to GaN. For existing growth methods, there seems to exist limits at ~ 20% in the indium content for both the InGaN and AlGaN alloys. This talk will cover the microstructural and optical manifestations of compositions instability in thick epilayers.

Topical Talk HL 83.2 Thu 15:30 EW 201

Nitride laser diodes - from arrays to tapered resonator devices — •Piotr Perlin — Institute of High Pressure Physics, Sokolowska 29/37, 01-142 Warsaw, Poland

We presently observe, an increasing demand for high optical power laser diodes operating in the wavelength range between 370 and 530 nm. This demand is biased by new applications like UV curing, printing or RGB sources for large optical displays. In order to construct truly high power laser diodes, nitrides technology should go along the similar (though not identical) way the arsenide devices went years ago. Laser diode arrays including large arrays and mini-arrays belong to this class of previously tested solutions. Within this presentation I will discuss perspectives and challenges related to the construction of multi-emitters devices, demonstrating the capabilities of reaching multi-Watt range of optical powers. I will also point out the possibility of dramatically improve the optical beam quality of high power nitride laser diode by using a tapered resonator. I will show that by using this geometry a M2=1.5 high power devices could be demonstrated.

Topical Talk HL 83.3 Thu 16:00 EW 201

Advantages and issues of m-plane freestanding GaN substrates grown by halide vapor phase epitaxy for InGaN and AlGaN epitaxial growth — •Shigefusa Chichibu[1], Kouji Hazu[1], Pierre Corfdir[2], Jean-Daniel Ganière[2], Benoît Deveaud-Plédran[2], Nicolas Grandjean[2], Shuich Kubo[3], Hideo Namita[3], Satoru Nagao[3], Kejji Fujito[3], and Kenji Shimoyama[3] — [1]Tohoku Univ., Sendai, Japan — [2]EPFL, Lausanne,Switzerland — [3]Mitsubishi Chemical Corp., Ushiku, Japan

We will discuss the subject given in the title. As long as coherent growth is maintained, the degree of tilt and twist mosaics of the epilayers is similar to the substrate. However, the formation of basal-plane stacking faults (BSFs) is hard to avoid in the case of lattice-mismatched thick films. For the pseudomorphic $In_xGa_{1-x}N$ ($x \leq 0.14$) films, improved quantum efficiency and short radiative lifetime are achieved for the near-band-edge emission. As the surface flatness is improved, however, the In-incorporation efficiency becomes lower than the cases for c-plane growth and m-plane growths on defective GaN bases. Atomically smooth and coherent m-plane AlGaN/GaN heterostructures exhibit a luminescence signal originating from the recombination of 2DEG and photoexcited holes. Slight but nonzero, grown-in anisotropic tilt mosaics of the substrates give rise to the formation of surface striations and inclined planes, and also planar-defect networks in the epilayers. The origins of characteristic CL intensity patterns will be discussed, using the spatio-time-resolved CL and conventional time-resolved PL measurements.

Coffee Break (15 min)

Invited Talk HL 83.4 Thu 16:45 EW 201

Low Temperature Growth Methods for Overcoming Perceived Limitations in III-Nitride Epitaxy — •W. Alan Doolittle, Michael Moseley, and Brendan Gunning — Georgia Institute of Technology, Atlanta GA, USA

Historically, III-Nitride epitaxy has been performed at relatively high temperatures leading to excellent material quality in the wide bandgap regime. However, this mindset when applied to the moderate to low bandgap alloys, has resulted in serious issues with phase separation, loss of uniformity and limitations in the ability to p-dope materials. Herein, a new approach centered around substantially colder epitaxy is described and is shown to result in non-phase separated InGaN grown throughout the immiscibility gap and p-type GaN and InGaN with hole concentrations well above the previously perceived limits. High structural and electronic quality is maintained even at significantly lower temperatures using extremely metal rich growth conditions. Structural, electronic and optical properties are presented and the compromises versus benefits low temperature epitaxy imposes are discussed.

Topical Talk HL 83.5 Thu 17:15 EW 201

Nonpolar and semipolar GaN on GaN, Si, and Sapphire substrates — Vitaliy Avrutin, Natalia Izioumskaia, Ümit Özgür, and •Hadis Hadis Morkoç — Virginia Commonwealth University, Richmond, VA 23284-3072

Polar nature of GaN necessitates investigating non-polar and semi-polar orientations to circumvent adverse effects. In this presentation, mainly the growth and optical properties of non-polar, namely (11bar00) orientation, and semi-polar, namely (11bar01) and (112bar2) orientations, of GaN and InGaN/GaN heterostuctures will be discussed. (11bar00) and (11bar01)-oriented GaN layers were grown on patterned Si substrates, while (112bar2) GaN films on m-sapphire by metal organic chemical vapor deposition (MOCVD). For (11bar01)GaN films grown at high reactor pressure (200 Torr), steady-state and time-resolved PL measurements have revealed bright luminosity and very long carrier decay times (1.8 ns), which are comparable to those for the state-of-the-art c-plane GaN templates prepared by in situ epitaxial lateral overgrowth using silicon nitride nano-network. Low reactor pressure of 30 Torr required for the growth of m-plane GaN on Si(112) leads to weaker luminescence and rapid carrier decay likely due to carbon contaminations, which both could be improved significantly by subsequent overgrowth at higher pressures. The long radiative lifetimes for the (11bar01)GaN layers show that the semipolar material has a great promise for light emitting and detecting devices.

Topical Talk HL 83.6 Thu 17:45 EW 201

What causes the efficiency droop in GaN-based LEDs ? — •Joachim Piprek — NUSOD Institute, Newark, DE 19714-7204, USA

GaN-based light-emitting diodes (LEDs) suffer from a reduction (droop) of the quantum efficiency with higher injection current. This droop phenomenon is subject to intense research worldwide, as it delays general lighting applications of GaN-based LEDs. Many proposals have been published in recent years to explain the efficiency droop, but none is generally accepted today. Among the proposed droop mechanisms are enhanced Auger recombination, reduced hole injection, and density-activated Shockley-Read-Hall recombination within the quantum wells. However, different sample preparation and measurement conditions as well as the application of different mathematical models and material parameters lead to a confusing and sometimes contradicting variety of efficiency droop observations and explanations. This talk reviews and contextualizes different droop models within a simple framework and it intends to bring more clarity to the ongoing droop discussion.