SYPN 1: Polarization Field Control in Group-III-Nitrides

Time: Thursday 9:30–12:15 Location: H1

Invited Talk SYPN 1.1 Thu 9:30 H1

Growth and applications of N-polar (Al,Ga,In)N — •Stacia Keller and Umesh K Mishra — Electrical and Computer Engineering Department, Univeristy of California, Santa Barbara, CA 93106, USA

While the properties of Ga-polar (Al,In,Ga)N/GaN structures have been widely studied in the past, N-polar nitride films were much less investigated, largely related to difficulties in the growth of smooth N-polar films, in particular by metal organic chemical vapor deposition. Due to the hexagonal symmetry of the GaN crystal, the properties of (Al,Ga,In)N heterostructures grown in both directions are strongly influenced by polarization effects, resulting in strong electric fields in the crystal. The opposite direction of the electric fields in N-polar in comparison to Ga-polar heterostructures is interesting in particular for applications such as enhancement mode transistors, and highly scaled transistors, photodetectors, and solar cells. After a discussion of growth and materials properties of N-polar (Al,Ga,In)N, special emphasis will be given to the fabrication and properties of N-polar GaN/AlGaN and GaN/AlInN transistors. Differences in the properties of N- and Ga-polar two dimensional electron gasses will be addressed as well.

Invited Talk SYPN 1.2 Thu 10:00 H1

Green light-emitting diodes and laser heterostructures on semi-polar GaN(11-22)/sapphire substrates — •Andre Strittmatter — Palo Alto Research Center, Palo Alto, CA, USA

The performance of nitride-based light emitting diodes (LED) and laser diodes (LD) is subject to polarization charges at the interfaces between the quantum well active region and surrounding barrier material. Reduction or even elimination of such interface charges will enable improved light emitters with power-independent emission wavelength and increased internal quantum efficiency. Different strategies exist to reduce or even eliminate the strength of polarization fields in nitride semiconductor light emitting heterostructures. However, for their potential application within device structures further issues such as strain relaxation, In incorporation and material quality due to the growth itself need to be considered. Semi-polar (11-22) oriented heterostructures offer high In incorporation, low polarization fields in InGaN/GaN quantum wells plus reduced cracking vulnerability of thick AlGaN layers which makes them attractive for long wavelength LEDs and LDs. Experimental results are presented demonstrating reduced blue-shift of long-wavelength emitters and lasing at 500 nm.

Invited Talk SYPN 1.3 Thu 10:30 H1

Pros and cons of green InGaN lasers on polar GaN substrates — •Uwe Strauss, Adrian Avramescu, Teresa Lermer, Jens Müller, Christoph Eichler, and Stephan Lutgen — Osram Opto Semiconductors, Leibnizstr. 4, 93055 Regensburg, Germany

One of the big challenges of InGaN lasers is the development of a device for the green spectrum. In 2009, first direct green InGaN lasers are demonstrated. The next step forward to a product will be cw operation at long wavelength $>$ 515nm combined with wall plug efficiencies of several percent and power levels up to 50mW. However, the question about polar or non-polar orientation is still open and researchers investigate different substrates: (1) c-plane GaN: Nichia reported 515nm at 8mW cw operation on this GaN substrate, OSRAM presented R&D samples operating already at 50mW cw and 515nm. (2) Rohm published 499nm lasing on non-polar m-plane GaN. (3) Recently, Sumitomo used semi-polar substrates [20-21] to achieve 520nm lasing with 2mW of cw output power. The longest wavelengths of pulsed lasing were 526nm on c-plane (OSRAM) and 531nm on [20-21] (Sumitomo), respectively. The big advantage of c-plane is that 2 inch c-plane substrates are commercially available in high volume. The wafer size, availability and costs of semi-polar / non-polar substrates are still not clear. We will present recent results on c-plane GaN and we will discuss the advantages and disadvantages related to lasers grown on this orientation. The lasers already reached more than 2% wall plug efficiencies in cw operation at 515nm and power levels of 50mW.

15 Min. Coffee Break

Invited Talk SYPN 1.4 Thu 11:15 H1

Molecular beam epitaxy as a method for the growth of free-standing zinc-blende GaN layers and substrates. — •Sergei Novikov, Thomas Foxon, and Anthony Kent — School of Physics and Astronomy, University of Nottingham, Nottingham, NG7 2RD, UK

The group III-nitrides normally crystallise in the hexagonal (wurtzite) structure. The unique feature of wurtzite group III-nitrides, in comparison with conventional III-V semiconductors, is the existence of very strong electric fields inside the crystal structure. The electric fields can be eliminated in wurtzite material by growing in non-polar directions. However, a direct way to eliminate electric fields would be to use non-polar (001) oriented zinc-blende (cubic) III-nitride layers. The thermodynamically metastable cubic GaN layers have, so far, received less attention than the more familiar hexagonal films.

We have developed a process for growth by molecular beam epitaxy (MBE) of free-standing cubic GaN layers with potential application as substrates. Undoped thick cubic GaN films were grown on semi-insulating GaAs (001) substrates by a modified plasma-assisted molecular beam epitaxy (PA-MBE) method and were removed from the GaAs substrate after the growth. The resulting free-standing GaN wafers with thickness in the 30-100μm range may be used as substrates for further epitaxy of cubic GaN-based structures and devices. We will discuss the fabrication and properties of cubic GaN substrates. The first GaN/InGaN LEDs on our zinc-blende GaN substrates have been demonstrated by our collaborators.

Invited Talk SYPN 1.5 Thu 11:45 H1

Three-dimensional GaN for semipolar light emitters — •Thomas Wunderer[1], Frank Lipski[1], Stephan Schwaiger[1], Ferdinand Scholz[1], Martin Feneberg[1], Klaus Thonke[1], Andrey Chuvilin[1], Ute Kaiser[1], Sebastian Metzner[2], Frank Bertram[2], Jürgen Christen[2], Clemens Vierheilig[3], and Ulrich Schwarz[3] — [1]Ulm University — [2]Otto-von-Guericke-University — [3]University of Regensburg

Semipolar group III-nitrides are thought to be possible candidates for improving the problems of the so-called green gap and the efficiency droop during high current operation. The reduced piezoelectric fields lead to an improved radiative recombination probability even within thick InGaN quantum wells (QWs).

In this paper, a detailed description of the fabrication technology of 3D GaN structures providing semipolar facets will be presented. The high material quality is confirmed by structural and optical investigation methods showing that effective defect reduction can be realized. Extremely low threading dislocation density and stacking fault-free surfaces can be achieved. InGaN QWs deposited on the 3D structures show interesting phenomena as semipolar emitters. Structural properties will be explained by growth models of selective area epitaxy. Besides, the effectiveness of the method will be discussed by evaluating the internal quantum efficiency for different Indium compositions. Therefore, locally resolved measurement methods contributed from several groups are analyzed and combined. Additionally, a complete LED device is demonstrated.