DS 9: Semiconductor Nanophotonics: Materials, Models, Devices - GaN based Photonics II

Time: Monday 16:00–17:15 Location: H 2032

Invited Talk DS 9.1 Mon 16:00 H 2032

GaN-Photonics on Silicon — •Alois Krost — Institute of Experimantal Physics, Otto-von-Guericke University Magdeburg

In spite of large efforts there is still a lack of available homosubstrates for group-III nitrides. Currently, GaN-based devices are usually grown on transparent sapphire or Silicon carbide substrates. These are either insulating or very expensive and not available in large diameter. Silicon is the substrate of choice because of its cheapness, availability of large and high-quality substrates combined with good thermal conductivity and insulating or conductive electrical properties. In the last years fundamental problems such as the huge thermal mismatch leading to cracks have been overcome by several approaches such as (Al,Ga)N buffer layers, low-temperature AlN interlayers, or growth on patterned substrates. Most of the recent work and published device results have been for GaN growth on (111) silicon substrates, with the first commercial chips, mainly HEMTs, now available by several companies with diameters up to 150 mm. Meanwhile, we have also obtained the first MOVPE-grown, crack-free, GaN-based LED on (100) silicon after the insertion of multiple AlN interlayers in the buffer structure paving the way towards integrated optoelectronics with GaN-on-Silicon technology. However, for optoelectronics the situation is more challenging than with electronic applications because Si is a non-transparent substrate and 94 % of the generated light is absorbed. Thus, GaN-on-Si LEDs cannot compete with those on transparent substrates unless substrate removal is performed. Our latest results on this topic will be reported.

DS 9.2 Mon 16:30 H 2032

Analysis of the growth mechanisms for InGaN alloys in MOVPE — •Martin Leyer, J. Stellmach, M. Pristovsek, and M. Kneissl — Technische Universität Berlin, Institut für Festkörperphysik, Sekr. EW 6-1, Hardenbergstr. 36, 10623 Berlin

The realisation of light emitting devices and lasers in the green spectral range requires high quality InGaN layers with an Indium content of 20% or more. However, the growth of such is very challanging due to layers shows phenomena like binodal decomposition and strain, resulting in a significant reduction of the efficiency in these devices. To understand the mechanism of InGaN growth, thick (∼200 nm) layers were grown on GaN/sapphire templates. The growth temperature was systematically changed from 700°C to 800°C in 10°C steps. In-situ spectroscopic ellipsometry allowed to determine growth rate and surface roughness. XRD $\omega - 2\Theta$ measurements yield two main peaks up to growth temperatures of 790° C. The indium incorporation varies between 0.19%/°C for the first and 0.39%/°C for the second InGaN layer. Reciprocal space mapping around the (1 0 . 5) reflex revealed two growth regimes, indicating two different growth mechanisms. For temperatures above 750°C we found two fully strained InGaN layers. Below 750°C only the first InGaN layer was fully strained. At temperatures below 750°C first a fully strained layer grows up to a critical layer thickness. Exceeding this critical thickness the growth mode changes from 2D to 3D. Above 750°C an interplay of indium segregation and strain is the dominating process, resulting in the growth of fully strained InGaN layers with different indium content.

DS 9.3 Mon 16:45 H 2032

MOVPE grown Indium Nitride Quantum Dots — •C. Meissner[1,2], S. Ploch[1], M. Pristovsek[1], and M. Kneissl[1] — [1]Institut für Festkörperphysik, Technische Universität Berlin, Hardenbergstr. 36, EW6-1, 10623 Berlin — [2]ISAS - Institute for Analytical Sciences, Albert-Einstein-Str. 9, 12489 Berlin

Very little attention has been devoted to the growth of indium nitride quantum dots (InN QDs) despite a number of interesting applications, e.g. in infrared emitters or solar cells. We studied the growth of InN QDs on GaN/sapphire templates in a horizontal metalorganic vapor phase epitaxy (MOPVE) reactor investigated by in-situ spectroscopic ellipsometry (SE). The temperature, V/III ratio and growth time were systematically varied during InN quantum dot growth. Insitu ellipsometry allows us to observe the growth processes even for submonolayer coverages. After growth the samples were investigated by standard characterization methods like atomic force microscopy, high resolution x-ray diffraction and photoluminescence.

Our studies showed that growth temperatures between 500°C and 550°C and V/III ratios above 5000 yield quantum dot like structures. Immediately after TMIn flow is switched off the ellipsometry-transients exhibit a clear dip, what can be attributed to desorption of excess Indium or a ripening process. At lower growth temperatures the QD density increases to 10^{11} cm^{-2} while the size decreases with mean height of a few nanometer and diameters as small as 16 nm. We will also discuss first experiments to overgrow the InN QDs with a GaN layer, which is a prerequisite step for the application of QDs in optical devices.

DS 9.4 Mon 17:00 H 2032

Recombination Kinetics of Localized Excitons in InGaN/GaN Quantum Dots — •Momme Winkelnkemper, Mattias Dworzak, Till Bartel, Axel Hoffmann, and Dieter Bimberg — Technische Universität Berlin, Institut für Festkörperphysik, Hardenbergstraße 36, D-10623 Berlin, Germany

The suitability of InGaN/GaN heterostructures for optoelectronic devices is sensitively affected by the built-in piezo- and pyroelectric fields, which affect the emission wavelengths as well as recombination dynamics via the quantum-confined Stark effect. In the present work, we study the photoluminescence (PL) decay of InGaN/GaN quantum dots (QDs) and its dependence on the built-in piezo- and pyroelectric fields. The decay of the ensemble photoluminescence (PL) is found to be strongly non-exponential, while all single-QD measurements yield exponential decays. We show that the non-exponential decay of the ensemble PL is well explained with a broad distribution of excitonic lifetimes within the QD ensemble. Using an inverse Laplace transformation, we derive an energy-dependent decay-time distribution function, which agrees well with the single-QD decay times. Within the framework of eight-band k.p theory, we calculate the dependence of the radiative excitonic lifetimes on structural parameters, such as QD height, lateral diameter, and chemical composition. The built-in piezoand pyroelectric fields cause a sensitive dependence of the radiative lifetimes on the exact QD geometry and composition, resulting in a broad lifetime distribution even for moderate variations of the QD structure.