InGaN Quantum Wells with Increased Internal Efficiency

H. Turski[1], G. Muziol[1], P. Wolny[1], M. Siekacz[1,2], S. Grzanka[1,2], E. Grzanka[1], M. Baranowski[3], R. Kudrawiec[3], C. Skierbiszewski[1,2]

[1] *Institute of High Pressure Physics, Polish Academy of Sciences, Warsaw, Poland*
[2] *Top-GaN Ltd., Warsaw, Poland*
[3] *Institute of Physics, Wroclaw University of Technology, Wroclaw, Poland*

InGaN is the most promising alloy for construction of active region of light emitters due to the fact that its band gap covers the whole visible light spectrum. To obtain quantum wells (QWs) for green laser diodes (LDs) one has to incorporate at least 25% of indium into the well. Unfortunately long wavelengths InGaN QWs suffer from low internal quantum efficiency caused by degradation of crystal quality and increase of build in piezoelectric fields with increasing In content. In spite of those difficulties, green laser diodes (LDs) at 500 - 530 nm have been demonstrated in nitride-based structures grown by metal organic vapor phase epitaxy (MOVPE) either on polar, semipolar and nonpolar substrate orientations [1,2]. On the other hand, the progress in understanding the growth mechanism for nitrides in plasma-assisted molecular beam epitaxy (PAMBE) has led to the demonstration of blue-violet, true-blue, and most recently cyan [3,4] LDs, which in turn has renewed interest in this technology. To decrease the impact of piezoelectric fields in polar structures the concept of graded indium content in QWs has been applied by MOVPE by ramping substrate temperature during QWs growth [3].

Here we report on the construction of efficient InGaN QWs in blue-green region grown by PAMBE. Structures were grown at growth temperature near 650°C using high active nitrogen flux reaching 50 nm/min (GaN equivalent growth rate). For InGaN layers, higher nitrogen flux results in higher crystal quality. In turn, applying higher nitrogen flux for QWs growth results in narrower emission spectra for the same wavelength or sustaining the same full width at half maximum at longer wavelengths [4]. To further improve optical quality of emitters in blue-green and green region the concept of staggered QWs has been adopted to PAMBE structures. For comparison, we grew two series of QWs: standard and staggered. The growth temperature was kept constant through the whole structure but for staggered structures, prior to QW having 25% In and thickness 1.5 to 2.5 nm, thin 0.5 to 1.5 nm InGaN layer with 16-17% In content was grown. Such improvement in structure emitting around 490-515 nm resulted in increase of intensity by the factor of 2 or more for all grown QWs.

We will discuss how thickness and In composition of the thin InGaN layer below QWs and growth parameters of QWs influence emission properties of grown structures, i.e. how it affects emission intensity and decay time of PL.

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