Origin of non-radiative losses in thick InGaN/GaN QWs

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Abstract

Efficient white light emitters require a drastic increase in efficacy of green LEDs. For this purpose we investigate InGaN quantum wells embedded in GaN, grown on c-sapphire by MOCVD. The QW thickness is varied between 2.2 nm and 3.8 nm, tuning the emission from 490 nm and 540 nm. The Indium content of the active regions is around 20%. The samples show a very large Stokes shift ranging from 200 meV (for 2.2 nm thick wells) to 500 meV (for 3.8nm thick wells). This is due to the quantum-confined Stark effect, as can be seen in the power-dependent blue shift of the emission. Temperature-dependent photoluminescence shows a drastic decrease in room temperature efficiency for well thicknesses above 3nm, indicating a strong increase in non-radiative losses in these samples. One cause for this is a longer radiative recombination time because of the larger spatial separation of electrons and holes. However, in addition, there may also be an increased amount of defects in the material grown closer to its critical thickness. To evaluate this, we perform time- and spectrally- resolved photoluminescence and find that the thinner samples conform to a Pseudo-DAP-Model, where electrons and holes are randomly distributed along the interfaces, which leads to a slight red-shift in emission over time after excitation. At 3.8nm thickness however, the red-shift is much more pronounced and time-delayed spectra show a constant emission on the red flank. This cannot be explained by QCSE or the Pseudo-DAP-Model and is a clear indicator of long-lived defect states.