GROWTH OF InGaN QWs BY MOVPE USING PULSED PRECURSOR FLOW

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In recent years indium gallium nitride (InGaN) alloys became widely used in commercially available blue, green and white light-emitting diodes (LEDs) [1]. By changing the ratio of indium to gallium atoms in the layer the band gap of InGaN can be adjusted through the entire visible spectrum. Despite remarkable advances in LED technologies, there still remain lots of issues for further improvements yet to be achieved for solid-state lighting [2]. The attempts to manufacture LEDs for longer wavelengths (high In concentration in InGaN) encounter problems due to increased strain, defect density, decreased thermal stability, high influence of internal electric field, carrier localization and enhanced phase separation. On the other hand the growth of InGaN structures by metal-organic vapour phase epitaxy MOVPE at relatively low temperatures results in low decomposition efficiency of ammonia and diffusivity of atoms at crystal surface, which are the main reasons for metallic In droplets formation. To avoid formation of In droplets, very high V/III ratios were used providing enough atomic nitrogen, however, limiting the growth rate and maximizing consumption of nitrogen precursor at the same time.

In this work InGaN/GaN MQWs were grown on GaN template (c-plane sapphire substrate) by low-pressure conventional and pulsed MOVPE using AIXTRON 3x2" closed-coupled showerhead reactor. Trimethylgallium (TMGa), trimethylindium (TMIn) and ammonia were used as Ga, In and N precursors, respectively. The pulsed MOVPE process of InGaN QWs growth was conducted by modulating the flow of In and Ga precursors into the chamber, while maintaining the flow of ammonia constant [3]. Appropriate selection of pulse time duration of metal precursor supply allows to increase V/III ratio and to suppress creation of nitrogen vacancies. On the other hand, the pulsed growth mode cannot completely prevent spinodal decomposition process, however, thin layers could be expected to be grown without distinct thickness fluctuations.

InGaN MQWs structures for 450-550 nm wavelength were grown at different temperatures from 790 ^{0}C up to 830 ^{0}C. The period of structure was about 9-10 nm: GaN barrier 6 nm, InGaN quantum well layer (3-3.5) nm. During the conventional or pulsed growth of the MQWs growth temperature was kept constant. The length of metal-organic precursor pulse was defined to test the influence of pauses between MO pulses for growth of double or single InGaN monolayer. The duration of MO precursor pulses varied from 20 s down to 10 s and pauses from 3 s up to 20 s. InGaN alloy composition, layers thickness and crystal grating tensions in heterostructures were estimated from X-ray diffraction (XRD) measurement. Sample surface was investigated by atomic force microscopy (AFM), optical properties were investigated by photoluminescence (PL).

The impact of pulse and pause duration provided evidence that at certain growth temperatures the appropriate pulse and pause selection change the PL efficiency up to two times (see Figure 1). The pause has to be decreased with the growth temperature (820-830 ^{0}C) in order to secure the incorporation of In into the QW (see Figure 2). On the other hand to increase the PL efficiency at lower growth temperatures (810-790 ^{0}C) for the green MQWs shorter MO pulses and longer pauses have to be used: best results were obtained using 10 s duration MO pulses (one monolayer per pulse). Further ways to improve the incorporation of In via pulsed growth in the CCS reactor will be discussed in the presentation.

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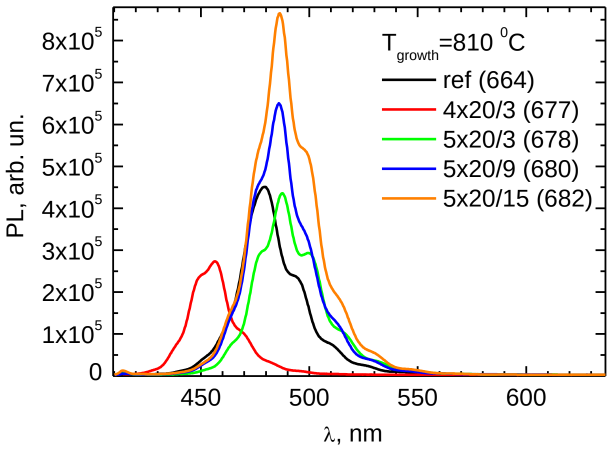

Figure 1. PL of MQWs grown at 810 ^{0}C temperature in different regimes: black line represents conventional grown QWs us a reference, color lines shows pulsed grown QWs using 20 s MO pulses at different pause durations.

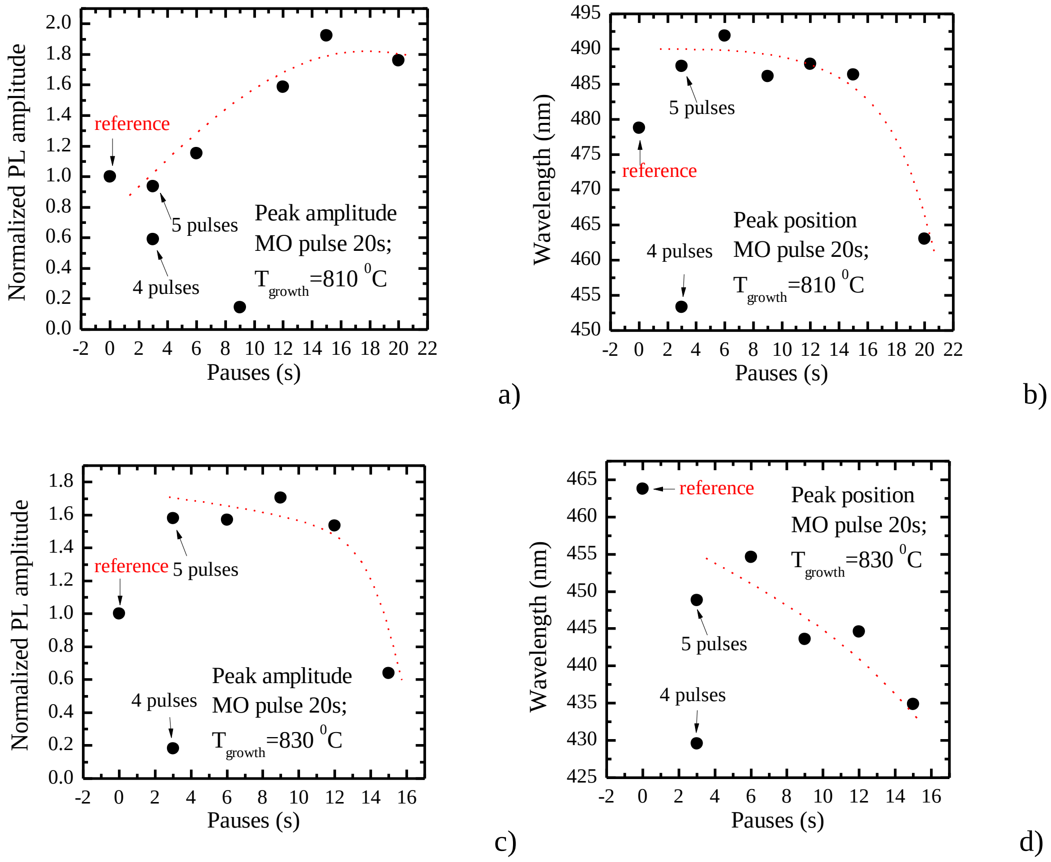

Figure 2. PL peak amplitude and position dependence on pause duration for 20 s MO pulse duration and two different growth temperatures: 810 ^{0}C a,b) and 830 ^{0}C a,d).

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