Mėlynų ir žalių InGaN kvantinių šulinių auginimas MOVPE būdu naudojant impulsinius metalo-organikos srautus

Growth of blue and green InGaN MQWs by MOVPE using pulsed metalorganic flow

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In recent decade indium gallium nitride (InGaN) alloys became widely used for manufacturing of blue, green and white light-emitting diodes (LEDs) [1]. By changing the ratio of In to Ga atoms in the active layer the band gap of InGaN can be adjusted through the entire visible spectrum. Nevertheless, still remain issues for LED technology improvements yet to be achieved for very effective 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. Also, 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 In segregation effect.

In this work blue and green InGaN/GaN multi-quantum wells (MQWs) were grown on GaN template (c-plane sapphire substrate) by low-pressure conventional and pulsed MOVPE using AIXTRON 3x2" closed-coupled flip-top showerhead reactor. Trimethylgallium, trimethylindium and ammonia were used as Ga, In and N precursors, respectively. The pulsed InGaN QWs growth was conducted by modulating the flow of In and Ga precursors into the reactor chamber, while maintaining the flow of ammonia constant [3]. Appropriate selection of pulse and pause time duration of metal precursor supply allowed an increase of V/III ratio to suppress creation of nitrogen vacancies and indium segregation.

InGaN MQWs structures for 450-530 nm wavelength were grown at different temperatures from 780 ^{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. The conventional or pulsed growths of the MQWs were carried out for all temperatures. The duration of metal-organic (MO) precursor pulses varied from 20 s down to 5 s and pauses from 3 s up to 20 s. The MO precursor pulse duration was defined to test the influence of pauses between MO pulses for growth of double (20 s), single (10 s) or partial (5 s) InGaN quantum well monolayer. 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 – by photoluminescence (PL).

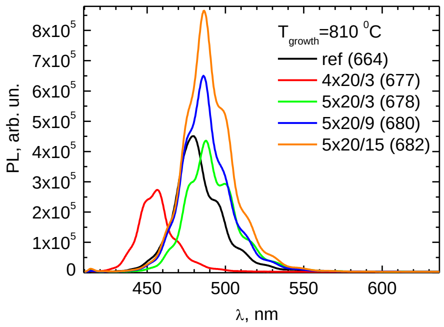

Figure 1. PL of MQWs grown at 810 ^{0}C temperature at different regimes: conventional growth as a reference (black) and pulsed growth using 20 s MO pulses with different pause durations (color).

The variation in pulse and pause durations provided evidence that at certain growth temperatures the appropriate selection changes the PL efficiency up to two times (see Figure 1). The pause duration has to be decreased with the increased growth temperature (820-830°C) in order to secure In incorporation. On the other hand at lower growth temperatures (810-780°C) to enhance the PL efficiency for the green MQWs shorter MO pulse and longer pause durations have to be used. Further ways to improve the incorporation of In via pulsed growth in the reactor will be discussed in the presentation.

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Keywords: InGaN MQW, MOVPE, pulsed growth.

References

[1] Eds. T.Y. Seong, J. Han, H. Amano, H. Morkoc, ”III-Nitride Based Light Emitting Diodes and Applications (Topics in Applied Physics)”, Springer-Verlag GmbH, Germany (2013).

[2] A. Žukauskas, M.S. Shur, R. Gaska, “Introduction to solid-state lighting”, Wiley, Canada (2002).

[3] A. Kadys et. al, *J. Electron. Mater.* **44** (2015), 188.