

Homogenization of InGaN Quantum Wells and Its Relationship with Decomposition at Elevated Temperatures

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In our studies we focus on examination of influence of p-type layers growth temperature on changes of indium distribution within the InGaN/GaN Quantum Wells (QWS) just before their decomposition and on determining of its relationship with the decomposition process itself.

To investigate how the growth temperature of p-type layers affects QWs emitting light in blue-cyan region, we used LED structures with QWs overgrown by p-type layers in temperatures range 830°C – 930°C. All samples were grown by MOCVD method on two types of substrates: sapphire template and GaN bulk crystal.

In case of QWs grown on sapphire template Electroluminescence (EL) data show us that just before decomposition at 930°C, optical power of the emitted spectra increase, and at the same time, wavelength and also FWHM decrease with increasing p-type growth temperature up to 905°C. These results strongly suggest that just before decomposition of the QWs, In atoms homogenization process take place. Additionally, Photoluminescence Spectra measured in temperature range from 13K up to 300K (TPL) indicate that S-Shape exist in sample overgrown with p-type layer at 830°C. S-Shape decrease with increasing p-type growth temperature. HR-XRD measurements show that these changes are related only to decreasing average indium content in MQWs without worsening of the structural quality what is in good agreement with EL and TPL measurements. TEM images confirm also that decomposition of MQWs up to 905°C in case of blue-cyan emission does not occur. When we are close or just in the moment of the decomposition of the MQWs (in this case 930°C) we can observe in HR-XRD measurements, worsening of the quality of MQWs, oscillation (Pendelosing fringes) almost disappear. Wavelength and FWHM of measured EL peaks dramatically increase and optical power decrease. One possible explanation of the all observed changes in EL, TPL, HR-XRD and TEM measurements is the reduction or rearrangement of the indium clusters within InGaN MQWs before their decomposition.

The situation is a bit different in the case of QWs grown on a GaN bulk substrate. In this case decomposition process starts at higher temperatures but it runs rapidly and is not preceded by the homogenization process.

The most important question in our study is determining the relationship between homogenization and decomposition process.

All above results means that up to 905°C we are in the “safe” range of the p-type growth temperature and within this range we should use as high temperature as possible independently on substrate.