APPLICATION NOTE

NEW GROWTH METHOD FOR InGaN BASED QW BY PA-MBE IN COMPACT 21

Introduction

Following active research studies on the growth kinetics of InGaN layers (Application Note: 608 29 P 42), Professor S. V. Ivanov and his team at the Ioffe Institute, Saint Petersburg, developed a new technique to grow InGaN quantum wells demonstrating higher photoluminescence (PL) intensity.
In their first studies, they have established that reducing the growth temperature (~630°C) allows to increase indium incorporation in the layer without degrading its structural quality (low temperature reduces phase separation). More over, indium incorporation efficiency at these temperature range is increased with a GaN MBE buffer.
Keeping in mind these results, new active work has been turned over to the growth process. A new growth technique has been elaborated for the fabrication of InGaN quantum wells (QW) structures comprising InGaN layers with different In content, grown under different stoichiometric conditions. The stoichiometry and composition are controlled only by variation of the RF-power (Q) of the plasma cell, while all other technological parameters (Ga and In fluxes, N_2 flow rate, substrate temperature) are kept constant. This approach is called the Q-modulation technique. The QW samples were characterized by photoluminescence and demonstrated the intensity similar to the state-of-the-art InGaN QW structures grown by MOVPE.

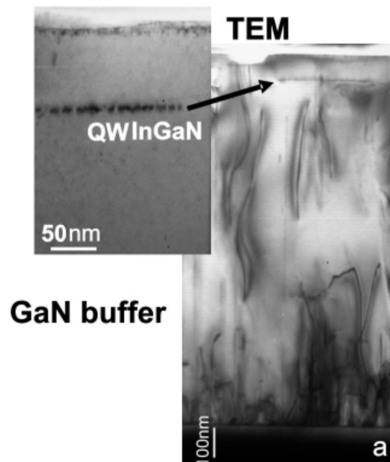

Fig 1: Cross sectional TEM image of the MBE grown InGaN/GaN SQW structure

Experimental

The group-III (Ga, In) and activated nitrogen (N*) fluxes were calibrated by using *in-situ* optical interference measurements of growth rates of binary GaN and InN compounds grown under different stoichiometric conditions controlled by RHEED. The c-sapphire substrates were covered by 1-µm-thick GaN buffer layer grown by PA-MBE. More details can be found in the references [1,2].
Series of 3-5 nm thick $In_xGa_{1-x}N$/ $In_yGa_{1-y}N$ multiple quantum well (MQW) structures with the barrier and well compositions of x=0.01-0.45 and y=0.30-0.55 respectively, has been grown using the Q-modulation technique [2].

TEM image

InGaN/ GaN SQW

TEM image of InGaN/GaN QW structure exhibit typical cross sectional views of the GaN PA MBE buffer and the QW region (Fig. 1). The strong dark dot-like line contrast of the InGaN QW reflects the nanoscale stress/composition variation in the QW caused by the InGaN inhomogeneities which resemble quantum dots. The typical lateral size of such fluctuations does not exceed 5 nm [1].

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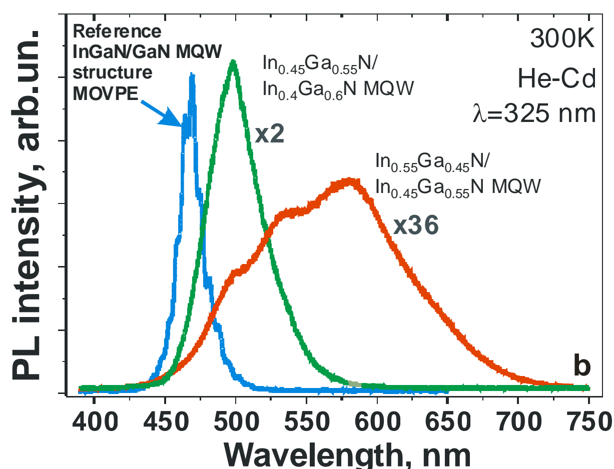
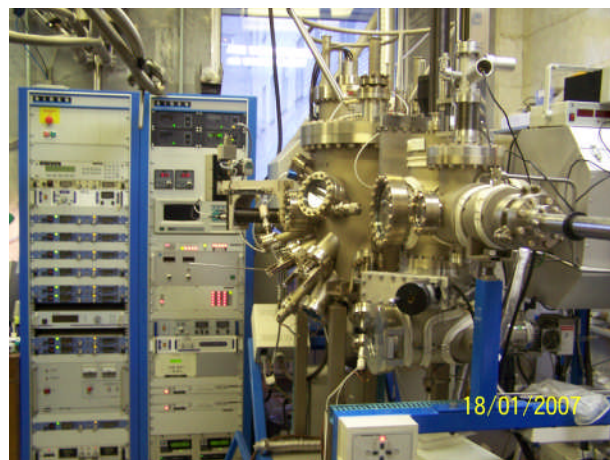


Fig 2: Room temperature PL spectra of MBE grown $In_xGa_{1-x}N$/ $In_yGa_{1-y}N$ MQW structures



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Optical properties

$In_xGa_{1-x}N$/ $In_yGa_{1-y}N$ MQW

Room temperature PL spectra of the multiple quantum well (MQW) structures grown under the same conditions were recorded (Fig. 2). The MQW structures demonstrate bright room temperature PL in the green red spectral range with the integral PL intensity comparable to that of a reference state-of-the-art MOVPE MQW structure.

Conclusion

The results demonstrate applicability of a low temperature (600-650°C) PA-MBE growth method, so called Q- modulation technique, to achieve InGaN/GaN low dimensional nanostructures with intense room temperature photoluminescence within the 480-580 nm range, which can serve as the active region of light emitting devices.

About the Ioffe Physico Technical Institute (http://www.ioffe.ru/)

The Ioffe Physico-Technical Institute of the Russian Academy of Sciences is one of largest Russian institutions for research in physics and technology, and employs a staff of 1,100 researchers. It was founded in 1918 in St Petersburg and run for several decades by Abram F. Ioffe. The Institute was directed for a long time by Prof. Zhores I. Alferov, winner of the 2000 Nobel Prize in physics, who has been encouraging the development of modern semiconductor technologies in the Ioffe Institute, in particularly MBE. First MBE setup - RIBER 1000 - has been purchased by Prof. Alferov in 1979 for development of AlGaAs.

About Riber (www.riber.com)

RIBER is a leading supplier of MBE processing equipments and related services. The company offers a wide range of tools, from R&D systems for most compounds to volume production platforms, and provides a global service network with 495 operational systems worldwide (at the end of 2007). RIBER plays a key role in the development of MBE technology via several Process Technology Centers (PTC) providing customer solutions from epitaxial growth through device processing.

References:

[1] S.V. Ivanov, V.N. Jmerik, T.V. Shubina, S.B. Listoshin, A.M. Mizerov, A.A. Sitnikova, M.H. Kim, M. Koike, B.-J. Kim, P. S. Kop'ev, *InGaN-based epilayers and quantum wells with intense room temperature photoluminescence in the 500–650nm range*, J. Crystal Growth 301–302 (2007) 465–468.

[2] S.V. Ivanov, V.N Jmerik, B.J. Kim, M. Moike, M.H. Kim; *Method of growing InGaN based multilayer structures by plasma assisted MBE and manufacturing group III nitride light emitting device using the same*, paten publication RU2007101787 (issued 17.01.2007)

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