Laser and optical properties of optically pumped blue InGaN/GaN MQW lasers grown on silicon

E.V. Lutsenko[1], A.V. Danilchyk[1], V.Z. Zubialevich[1], V.N. Pavlovskii[1], A.L. Gurskii[1] and G.P. Yablonskii[1],
Y. Dikme[2], A. Szymakowski[2], H. Kalisch[2] and R.H. Jansen[2],
B. Schineller[3] and M. Heuken[2,3]

[1]Institute of Physics of National Academy of Sciences, F. Skaryna Ave 68, 220072 Minsk, Belarus,
e-mail: lutsenko@dragon.bas-net.by
[2]Institut für Theoretische Elektrotechnik, RWTH Aachen, Germany
[3]AIXTRON AG, Aachen, Germany;

Silicon as substrate is the most promising perspective for the mass production of GaN-based optoelectronic devices. Silicon offers many advantages like high thermal conductivity, large-area availability, low cost and a high crystal quality. The well developed silicon technology comprising cleaving, etching, contact preparation and the control of the electrical conductivity of silicon simplifies the creation of low contact resistances and laser cavities. Si substrates enable the integration of GaN-based light emitting devices with Si electronics.

In this work InGaN/GaN multiple quantum well (MQW) heterostructures were grown in AIXTRON metal organic vapour phase epitaxy (MOVPE) reactors on (111)-oriented Si substrates. The layer design was as follows: GaN(50 nm)/10×(InGaN/GaN)/GaN:Si(600-800 nm)/strain-reducing layer stacks (GaN/AlGaN/AlN)/Si. Photoluminescence (PL) and lasing were excited at T = 20 - 360°C by the radiation of a N_2 laser (h = 3.68 eV, f = 1 kHz, τ_p = 8 ns) and a CW HeCd laser (h = 3.81 eV). PL excitation spectra measured by two monochromator system with a Xe lamp.

The laser action of the blue InGaN/GaN MQW on Si with fine mode structures and TE-polarisation was observed on (Fig. 1) transverse modes. The laser action was obtained up to T = 360°C with excellent temperature stability of the laser parameters up to 250°C (Fig. 2). The maximal values of quantum efficiency, pulse energy and power η_{max} = 5 %, E_{max} = 140 nJ, P_{max} = 18 W of the blue InGaN/GaN MQW lasers on Si exceed the parameters of the similar InGaN/GaN MQW lasers on Al_2O_3 by 1.5 times. The PL behaviour and the optical properties of the InGaN/GaN MQW on Si were investigated as a function of excitation intensity, temperature and excitation wavelength. The intrinsic laser parameters and gain characteristics were studied.

The obtained results give the possibility for the guess that the basic gain mechanism in the InGaN/GaN MQW on Si is gain on localised states created by sufficiently homogeneously distributed In-rich clusters.

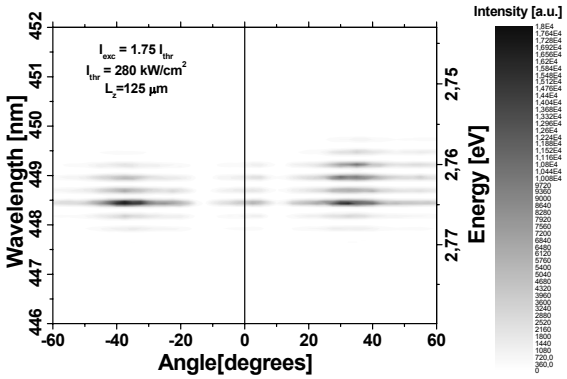

Fig.1. Spectra-angular distribution of the laser radiation in far-field of InGaN/GaN MQW laser grown on Si.

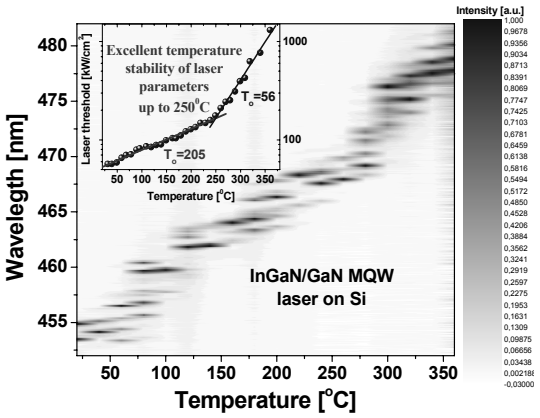

Fig.2. 2D density map of the temperature dependence of the laser spectra of InGaN/GaN MQW laser grown on Si. Insert: threshold-temperature characteristic.