SHORT NOTE

Blue Laser on High N_2 Pressure-Grown Bulk GaN

I. Grzegory[1], M. Boćkowski[1], S. Krukowski[1],
B. Łucznik[1], M. Wróblewski[1], J.L. Weyher[1],
M. Leszczyński[2], P. Prystawko[2], R. Czernecki[2], J. Lehnert[2], G. Nowak[2],
P. Perlin[3], H. Teisseyre[3], W. Purgał[3], W. Krupczyński[3],
T. Suski[4], L.H. Dmowski[4], E. Litwin-Staszewska[4],
C. Skierbiszewski[4], S. Łepkowski[4]
and S. Porowski

High Pressure Research Center, Polish Academy of Sciences, UNIPRESS*
Sokołowska 29/37, 01-142 Warsaw, Poland

(Received December 28, 2001)

In this note we report briefly on the details of pulsed-current operated "blue" laser diode, constructed in our laboratories, which utilizes bulk GaN substrate. As described in Ref. [1] the substrate GaN crystal was grown by HNPSG method, and the laser structure was deposited on the conducting substrate by MOCVD techniques (for the details see Sec. 2 and Sec. 4 of Ref. [1], respectively).

The laser diode is separate confinement heterostructure device. The active layer of the laser is $In_{0.09}Ga_{0.91}N/In_{0.01}Ga_{0.99}N$ 5 repetition multiple quantum well. The active layer is stacked between two 0.1 μm GaN:Si and GaN:Mg waveguiding layers. The n-type cladding is 120 repetition 25 Å/25 Å GaN/$Al_{0.15}Ga_{0.85}N$ silicon doped superlattice. p-type cladding is formed by Mg doped 0.36 μm thick $Al_{0.08}Ga_{0.92}N$ layer. The structure is capped by 0.1 μm highly Mg doped GaN contact layer. The device was processed as narrow stripe, oxide isolated laser. The stripe width is 10 μm. The laser diode was operated under pulsed current conditions with pulse width of 200 ns and the frequency of 1 kHz. The diode was tested at temperatures between -40°C and -10°C. Figure 1 shows the emission spectra below the threshold current while Fig. 2 demonstrates the lasing spectrum just above the threshold.

*The numbers above refer to the staff of: (1) Crystal Growth Laboratory, (2) Laboratory of Epitaxy, (3) Laboratory of Processing, and (4) Physical Properties Laboratory, respectively.

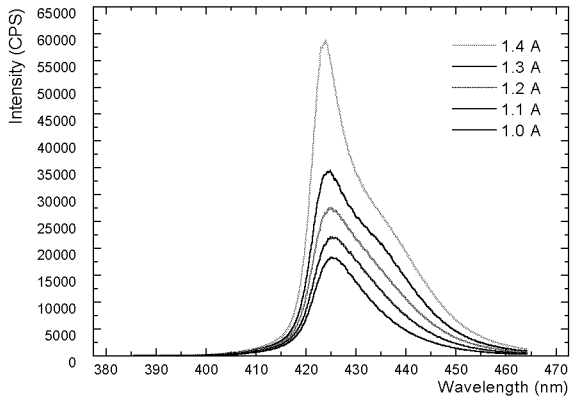

Fig. 1. The emission spectra below lasing threshold, measured at $T = -40°C$. Operating currents are indicated in the legend. Biasing parameters are as specified in the text.

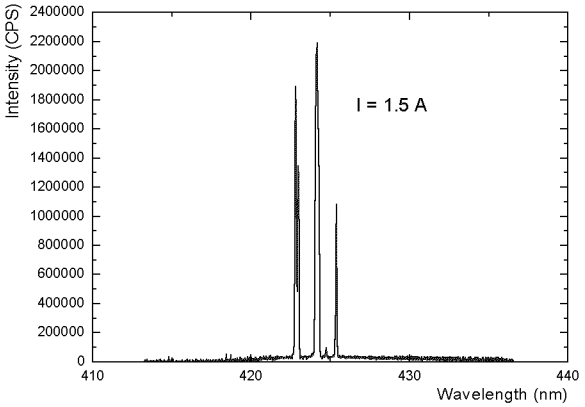

Fig. 2. The emission spectrum of the laser diode above threshold, measured at $T = -40°C$. The diode is run at the current of 1.5 A. Biasing parameters are as specified in the text.

The dominant emission wavelength is 425 nm. Typically from two up to four distinctive modes were observed. Figure 3 presents the optical emission for the increasing current. Output power in a pulse reached almost 8 mW at 2 A. The measurement has been made at nominal temperature $T = -40°C$. The sharp decrease in efficiency in the high current region can be associated with the device heating and higher real temperature of the device.

The increase in the optical output of the device in function of the current is presented in more detail in Fig. 4. In left column the camera presents eye-view perspective of the device below and above the threshold. In right column the optical power measured in pulse is shown.

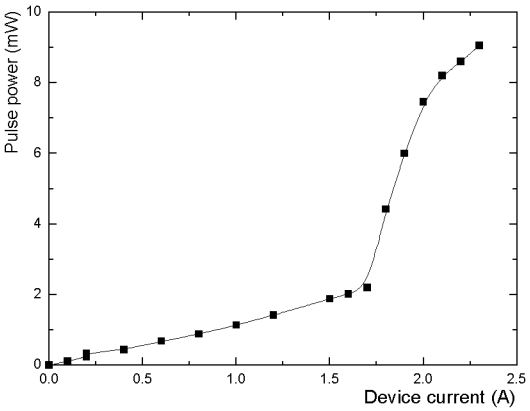

Fig. 3. Output power (in pulse) as a function of the device current. All parameters measured at −40°C.

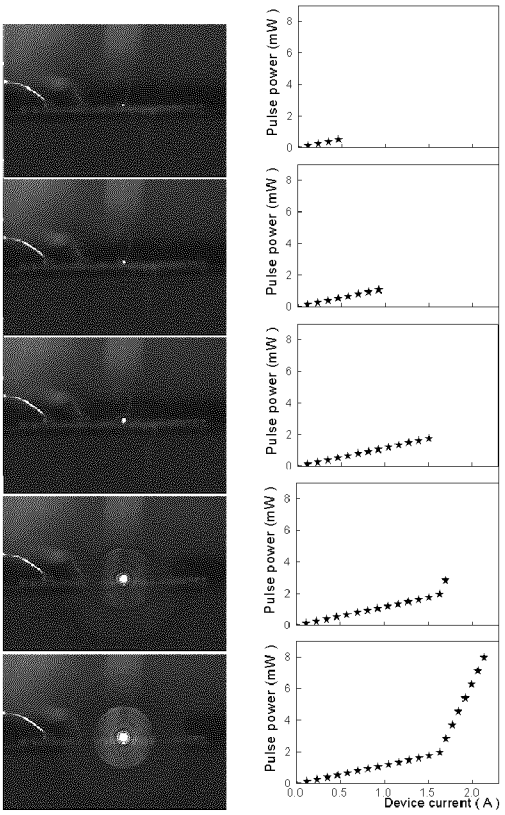

Fig. 4. Optical emission of the laser diode for increasing electric current: left column — camera view; right column — output power (in pulse). The measurement has been made at −40°C.

The laser diode is a first laser diode realized on true bulk GaN substrate in HPRC and the 8th institution worldwide to ever demonstrate the current injection laser based on GaN [2]. We believe that this achievement opens a path to fast development of dislocation-free high-power laser diodes operating in blue and UV spectral range.

Acknowledgments

All research which led to the development of this device has been performed within Governmental Strategic Program: "Development of Blue Optoelectronics" (established by the State Committee for Scientific Research and Ministry of Economics) project no. 8 T11 G 001 2000 C/5013, and supported by EU Project "Center of Excellence" no. ICA1-CT-2000-70005. We would like to acknowledge gratefully the collaborating institutions in Poland: Institute of Electronic Materials Technology, Electrical Measuring Instrument Works — LUMEL S.A., Institute of Electron Technology, Institute of Physics of Polish Academy of Sciences, Institute of Optoelectronics of Military Academy of Technology, Institute of Experimental Physics of Warsaw University, Institute of Vacuum Technology, Institute of Microsystems Technology of Wrocław University of Technology, and many foreign laboratories which helped us in both scientific and technological aspects of this project.

References

[1] I. Grzegory, S. Krukowski, M. Leszczyński, P. Perlin, T. Suski, S. Porowski, *Acta Phys. Pol. A* **100 Supplement,** 57 (2001).

[2] S. Nakamura, G. Fasol, *The Blue Laser Diodes*, Springer-Verlag, Berlin 1997.