High-efficiency electron-beam pumped green semiconductor lasers based on multiple quantum disk sheets

M.M. Zverev[1*], S.V. Sorokin[2], I.V. Sedova[2], D.V. Peregoudov[3], S.V. Ivanov[2], and P.S. Kop'ev[2]

[1]State Research Center of the RF Troitsk Institute for Innovation and Fusion Research, Troitsk, Moscow region 142190, Russia; *e-mail: mzverev@triniti.ru;

[2]Ioffe Physico-Technical Institute of RAS, 26 Politekhnicheskaya street, St. Petersburg 194021, Russia;

[3]Moscow State Institute of Radio Engineering, Electronics and Automations, Vernadsky pr. 78, Moscow 117454, Russia.

Electron- beam- pumped (EBP) green semiconductor lasers can be successfully used for numerous applications, such as the projection television, optical communication through plastic fibers and so on. However, the application of such lasers was restricted by the high value of threshold current density and high value of the electron beam energy. Sufficient progress in development of the EBP – lasers has been achieved using semiconductor heterostructures instead of bulk materials as the laser active elements. The lasing with microgun excitation was demonstrated for blue-green spectral region at cryogenic temperatures [1,2]. Recently, the low-threshold room-temperature blue-green EBP lasers have been reported [3,4]. The value of external quantum efficiency per facet of 1.6% was measured [3].

In this paper we report on the room-temperature green lasers with the efficiency up to 4% per one facet. The ZnSe-based structures under study were grown by molecular beam epitaxy on GaAs (100) substrates on top of epitaxial 0.5-μm-thick GaAs buffer layers. The structures consisted of a 0.7 μm-bottom ZnMgSSe cladding layer followed by the ZnSSe/ZnSe alternately-strained superlattice (SL) waveguide. The active recombination region was placed in the middle of the waveguide. The structure was capped by a 0.2 μm-top ZnMgSSe cladding layer followed by a 5 nm thick ZnSe layer. No doping of the layers was used. The following design of the active region was grown: three sheets of self-organized coherent CdSe quantum disks (QDs) each embedded in a 10-nm ZnSe QW were placed equidistantly inside the 0.4-μm-thick SL waveguide. In contrary to structures studied before in [3,4], here we used the waveguide with extended width and three quantum wells with QDs. Thus, we could use the energy of the exciting electron beam more efficiently.

The electron beam with the energy up to 25 keV, pulse width of 50 ns and repetition rate up to 10 Hz was used as a pumping source. All measurements were done at room temperature.

The lasing was observed in the energy range of 12-25 keV. With decreasing the energy from 25 keV the threshold current density J_{th} decreases slightly, reaching the minimum at the energy of 18-20 keV, and then grows up again below ~18keV. The peak values of the output light power and quantum efficiency depend on the cavity length. The 12 W pulse output power (in one direction) and efficiency of ~2% were obtained for cavity length of 1 mm. The efficiency of ~4% and output power of ~9 W were measured with the 0.55 mm cavity length. The lasing wavelengths were in the 532-535 nm range with the spectral width of about 2nm.

References

[1]. Herve D., Accomo R., Molva E., Vanzetti L., Paggel J.J., Sorba L., Francioci A. Appl. Phys.Lett. **67**, 2144 (1995).

[2]. Herve D., Molva E., Vanzetti L., Sorba L., Franciosi A. Electron. Lett. **31**, 459 (1995).

[3]. Zverev M.M., Sorokin S.V., Sedova I.V., Peregoudov D.V., Ivanov S.V., Kop'ev P.S., Phys. Stat. Sol. (b) **229**, 1025 (2002).

[4]. Zverev M.M., Sorokin S.V., Sedova I.V., Ivanov S.V., Kop'ev P.S., Peregoudov D.V. XI Conference on Laser Optics, St. Petersburg, 2003, ThR3-p19.