InGaAsSb negative luminescent devices with built-in cavities emitting at 3.9 μm

M. A. Remennyi, B. A. Matveev, N. V. Zotova, S. A. Karandashev , N. M. Stus' and G.N.Talalakin

IOFFE Physico-Technical Institute, Russian Academy of Sciences, Polytekhnicheskaya ul. 26, St. Petersburg, 194021 Russia, email: bmat@iropt3.ioffe.rssi.ru

Over the last decade there has been sufficient progress in design of ambient operating mid-infrared (λ=3÷5 μm) QC lasers and QW detectors that will find numerous applications in spectroscopy and free space communications. However, among cost-effective candidates for the above applications we can also consider electrically and optically pumped light emitting diodes (LEDs) as well as negative luminescent (NL) devices operating at the reverse bias. Due to the enhance of Auger recombination at high (kT/E_g) values and high carrier concentration at injection or "positive luminescence"(PL) mode the NL or "extraction" mode is especially attractive for high temperatures/long wavelength applications.

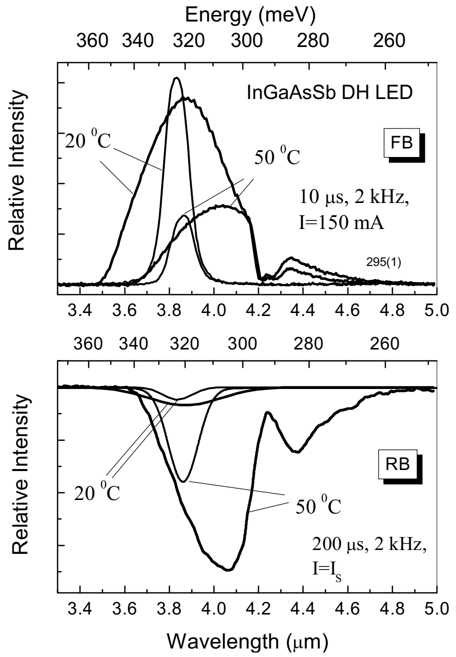

Fig.1 Emission spectra of InGaAsSb diode in PL (top) and NL (bottom) modes. Thick lines refer to uncoated LED at room temperature, while thin lines refer LED incorporated with cavity

The latter was confirmed in InAsSbP/InGaAsSb double heterostructures (DH) with 1-2 μm thick quaternary layers grown onto ~100 μm thick n-InAs substrate ($n=2\cdot10^{18}$ cm^{-3}) that were processed into "flip chip bonded" (or "backside illuminated") circular mesa constructions (D=100÷430 μm) with nonalloyed broad gold anode. While being the same at room temperature for both NL and PL modes (0.74 mW/A), the conversion efficiency at 90°C for NL is 1.3 times higher than for the PL. The outlined difference of NL and PL conversion efficiencies has already been reported for the 5.5 μm InAsSb LEDs [1] and is though to be a characterisitc feature of all III-V narrow band emitters that work in a spontaneous mode.

In our initial "resonant cavity" (RC) experiments we used standard bandpass filter with λ_{max} = 3.9 μm deposited onto Si substrate and attached to the free diode surface by a chalcogenide glass with n=2.6. As an example in Fig.1 we show NL and PL emission spectra of a InGaAsSb diode. As seen from Fig.1 the reduction of the emission bandwidth well below the kT value (down to FWHM=8 meV) for both NL and PL spectra was not followed by a peak power decrease. Unlike the uncoated LEDs the above "RCLEDs" exhibit weak temperature variation of the peak position.

The report will also describe LED design impact on spatial distribution of emission/current crowding as well as designs that enable to increase the outcoupling with immersion lenses and fibres.

References

[1] B. A. Matveev, N. V. Zotova, S. A. Karandashev, M. A. Remennyi, N. M. Stus' and G. N. Talalakin "Towards longwave (5÷6 μm) LED operation at 80°C : injection or extraction of carriers?", IEE Proceedings - Optoelectronics v. 149 (2002) , Issue 1, pp. 33 - 35.