Vertically emitting InAs LEDs and lasers with cavity formed by gold anode and semiconductor/air interface

N. V. Zotova, N .D. Il'inskaya, S. A. Karandashev, B. A. Matveev, M. A. Remennyi and N. M. Stus',
Ioffe Physico-Technical Institute, Polytechnicheskaya 26, 194021, St.Petersburg, Russia.
FAX: (812) 247 7446, e-mail: bmat@iropt3.ioffe.rssi.ru,
http://www.mirdog.spb.ru/index.htm

There has been remarkable progress in the performance of the mid-IR LEDs that can be used for optical methane and water detection in the 3.0-3.3 μm spectral band. Unfortunately the emission spectrum of the above diodes is strongly effected by the temperature change and thus narrow bandpass filtering is often required to attain desirable peak position stability.

On the other hand creation of a microcavity whose planes are parallel to the p-n junction and cavity length is close to the emission wavelength (L ~ λ) enable to achieve narrow linewidth with temperature insensitive wavelength position and with subsequent increase of the output power. The corresponding resonant cavity LEDs (RC LEDs) and vertical cavity lasers (VCSELs) are well known for the near infrared spectral region while mid-IR RC LEDs are still exotic.

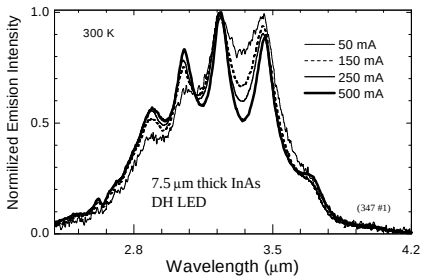

Fig. 1 Room temperature emission spectra of a 7.5-μm thick resonant cavity LED at pumping currents of 50-500 mA.

The report will describe resonant cavity features of the room temperature electroluminescence at 3.3 μm and coherent emission at ~3 μm (77 K) escaping perpendicular to the p-n junction from the flip-chip InAsSbP/InAs double heterostructure (DH) diodes with broad nonalloyed gold anode.

InAsSbP/InAs DHs with n-InAs active layer grown onto heavily doped n^+-InAs(Sn) substrates or/and InGaAsSb/InAsSbP buffers were processed by a two-side wet photolithography into constructions with mesa diameter D_m= 300 and 430 μm. Some devices contained window adjoining the n-InAsSbP cladding with total structures thickness of about 7.5 μm in the active part of the LED, other devices were thinned down to 45-80 μm.

Due to the nonalloyed character of the bottom contact we have been able to measure Fabry-Perot modes in a spontaneous regime in a 45-μm and 7.5-μm thick LEDs (see Fig.) with $\Delta\lambda=\lambda^2/2nL$ (n=3.52) mode spacing at 300 K. The resonant quality factor (fiancée) Q estimated from the mode linewidth and predicted reflectivity of R_1=0.9 (for the anode) and R_2 =0.3 (for the air/semiconductor interface) was as high as 24 and 80 for the 7.5-μm and 45-μm thick LEDs correspondingly. In addition to standard RC LED behavior such as an increase of the spectral brightness of the of the modes, the decrease of the mode linewidth/far field pattern FWHM at the pumping current increase, these LEDs exhibited fine tuning of the mode structure towards short wavelengths with a rate close to that of the tunable diode lasers made from nominally similar materials.

Cooled devices (77 K) lased at thresholds as small as 300 A/cm^2 with one dominant stable mode in the whole 1-2 A pumping current range with blue shift of the line position typical for InAsSbP/InAs system. Data on far field pattern, temperature dependence, output power and 2D- radiation distribution across the outcoupling surface will be also discussed.