Enhancing Luminescence of GaAsBi Quantum Structures for NIR Emitters

A. Špokas[1], A. Zelioli[1], A. Bičiūnas[1], A. Čerškus[1], B. Čechavičius[1], M. P. Iršėnas[2], A. Vaitkevičius[1,2], E. Dudutienė[1], M. Kamarauskas[1], R. Butkutė[1]

[1] *Center for Physical Sciences and Technology, Saulėtekio av. 3, LT-10257 Vilnius, Lithuania*
[2] *Institute of Photonics and Nanotechnology, Faculty of Physics, Vilnius University, Saulėtekio av. 3, LT-10257, Vilnius, Lithuania*

Near infrared (NIR) is an important region, which uses span from telecommunications to environmental and biological sensing systems, thus requiring stable and efficient emitters. GaAsBi is a compound that has several attractive properties for emitter fabrication. Introduction of Bi into GaAs reduces the energy bandgap at a high rate of 88meV/% [1]. This is advantageous in managing strain in grown layers, since a smaller fraction of host atoms must be replaced to achieve emissions in longer wavelengths. Moreover, spin-orbit splitting energy rapidly increases with introduction of Bi, in this way one of the main drawbacks of current NIR laser diodes Auger non-radiative recombination can be suppressed [2]. Finally, bismide devices have shown capabilities of working in room temperature and have less temperature sensitive wavelength [3]. Molecular beam epitaxy (MBE) growth of dilute bismides presents some challenges. To allow Bi incorporation one must keep the As/Ga beam equivalent pressure ratio close to unity and more importantly, the growth must be done at low temperatures (420 ˚C or lower) [4]. Thus, specific growth procedures must be considered for growth of high quality bismide layers sufficient for device fabrication.

This work focuses on understanding the influence of growth conditions relevant for NIR emitter fabrication. Technological optimization was performed by growing 3 and 5 quantum well (QW) test structures. It was determined that substrate temperature was the limiting factor in the selected growth window (As:Ga - 0.85-1.2, Bi flux >1.4E-7 Torr). In the growth temperature interval from 305 to 365 ˚C, emissions in the range of 0.94 to 1.15 eV were achieved. Furthermore, capping layer temperature and ramping rates had impact on the homogeneity of multiple QWs: slowly cooled (5 ˚C/min) and rapidly heated (25-50 ˚C/min) structures exhibiting narrower emission spectra. Optical measurements were performed to investigate the behaviour of the energy band gap. Atomic force and differential interference contrast microscopy techniques were used to investigate the surface quality of grown structures. A 5xQW - based LED was fabricated and showed room temperature emission at a central wavelength of 1070 nm. Room temperature lasing at 1142nm was achieved from a 3xQW - based laser diode. Both devices had low sensitivity to temperature.

This work was supported by Research Council of Lithuania under Contract No S-LLT-23-3.

[1] S. Francoeur, M. J. Seong, A. Mascarenhas, S. Tixier, M. Adamcyk, and T. Tiedje, "Band gap of GaAs1-xBix, 0<x< 3.6%," Appl. Phys. Lett. **82** (22), 3874–3876 (2003)
[2] K. Alberi, O. D. Dubon, W. Walukiewicz, K. M. Yu, K. Bertulis, and A. Krotkus, "Valence band anticrossing in GaBixAs1-x," Appl. Phys. Lett. **91** (5), 10–13 (2007)
[3] Y. Tominaga, K. Oe, and M. Yoshimoto, "Low temperature dependence of oscillation wavelength in GaAs1-x Bix laser by photo-pumping," Appl. Phys. Exp. **3** (6) (2010)
[4] R. D. Richards, F. Bastiman, C. J. Hunter, D. F. Mendes, A. R. Mohma, J. S. Roberts, J. P. R. David, "Molecular beam epitaxy growth of GaAsBi using As2 and As4," J. Cryst. Growth, **390**, 120–124 (2014)