Influence of band offset and Auger recombination on the temperature sensitivity of GaInAsSb/GaSb mid-infrared lasers

A. B. Ikyo[1], I .P. Marko[1], K. Hild[1], A. R. Adams[1], S. Arafin[2], M.C. Amann[2] and S. J. Sweeney[1]

[1]*Advanced Technology Institute and Department of Physics, University of Surrey, Guildford, Surrey GU2 7XH, United Kingdom*

[2]*Walter SchottkyInstitut, TechnischeUniversitätMünchen, Am Coulombwall 3, 85748 Garching, Germany*

e-mail: a.b.ikyo@surrey.ac.uk

250 words

There are numerous applications for lasers in the 2-3µm mid-infrared spectral window. Existing interband lasers suffer from increased threshold current density (J_{th}) with increasing temperature due to non-radiative processes such as Auger recombination and carrier leakage which limit their maximum operating temperature. In type-I interband devices, the band gap determines the wavelength, hence investigating the effects of band gap shift on the device properties provides a means of optimisation. In this work, temperature and hydrostatic pressure have been used independently to tune the bandgap of GaInAsSb type-I edge emitting lasers. The dependence of J_{th}, Auger current (J_{Auger}) and radiative current (J_{rad}) on the band gap of these devices is presented. Results show that by applying pressure, the T_0 of the 2.6µm device increases from 37±5K up to ~53±5K when operating at 2.3µm under pressure. This value is similar to the as-grown 2.3µm for which T_0 =59±5K. However, J_{th} is ~25% higher compared to an as-grown 2.3µm device. This difference is due to the fact that the as-grown 2.3µm device maintains larger band offsets than the pressure-tuned 2.3µm device. Hence, the reduced J_{th} of the as-grown device may be associated with a lower carrier leakage current. Whilst the larger band offset helps reduce J_{th} it makes little difference to its temperature sensitivity in these type-I GaInAsSb/GaSb devices. This indicates that further optimisation of the band offset would bring little benefit in terms of T_0 and that reducing the Auger process would be of much larger benefit.

100 words

Bandgap dependent properties of type-I GaInAsSb/GaSb based lasers emitting at 2.3µm and 2.6µm have been investigated. The 2.6µm device is pressure-tuned to operate at 2.3µm with T_0=53±5K similar to the as-grown 2.3µm device; T_0=59±5K. Whilst the T_0 values are similar at 2.3µm, the J_{th} of the pressure-tuned 2.3 µm laser is ~25% higher than the as-grown 2.3µm laser due to higher carrier leakage as a result of its lower band offsets. However, as we show, T_0 is fundamentally linked to Auger recombination and for high temperature operation plays a stronger role which should be considered in the device design.