Temperature sensitivity and wavelength dependence of the recombination processes of GaInAsSb/GaSb mid-infrared lasers

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There are numerous applications for lasers in the 2-3µm mid-infrared spectral window. Type-I Sb-based quantum well interband diode lasers have yielded good results in this spectral range, but are still highly temperature sensitive with low characteristic temperature, (T_0), values of typically <40K around room temperature (RT) [1]. Hence there is a need for further optimization. In type-I interband devices, the band gap largely determines the wavelength, and 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 emitting at 2.3µm and 2.6µm. The dependence of J_{th} and its current components on the band gap of these devices is studied using hydrostatic pressure. 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 (fig.1). This value is similar to the as-grown 2.3µm devices 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 relatively little benefit in terms of T_0 and that reducing the Auger process is a more important consideration.

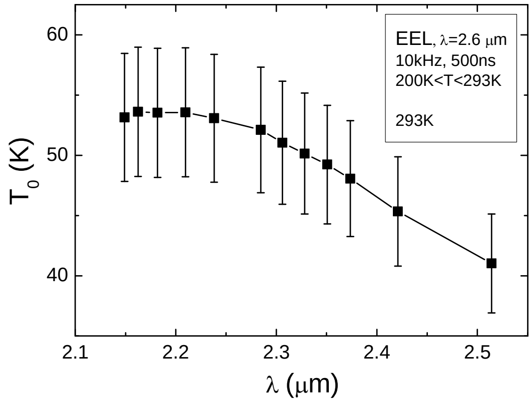

Fig. 1: Wavelength dependence of T_0 in the temperature range of 200-293 K. The lasing wavelength was tuned using high hydrostatic pressure.

[1] A.D. Andreev et al., Appl. Phys. Lett., **7**, 2743 (1999).