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 2-3 μm 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 2.3 μm and 2.6 μm. 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 2.6 μm device increases from 37±5K up to ~53±5K when operating at 2.3 μm under pressure (fig.1). This value is similar to the as-grown 2.3 μm devices for which \( T_0 = 59±5K \). However, \( J_{th} \) is ~25% higher compared to an as-grown 2.3 μm device. This difference is due to the fact that the as-grown 2.3 μm device maintains larger band offsets than the pressure-tuned 2.3 μm 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.