High-temperature ($T = 80$ ℃) operation of a 2 μm InGaSb–AlGaAsSb quantum well laser*

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Abstract: An InGaSb/AlGaAsSb compressively strained quantum well laser emitting at 2 μm has been fabricated. An output power of 82.2 mW was obtained in continuous wave (CW) mode at room temperature. The laser can operate at high temperature ($T = 80$ ℃), with a maximum output power of 63.7 mW in CW mode.

Key words: InGaSb/AlGaAsSb; laser; high-temperature operation
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1. Introduction

Electrically pumped lasers operating at room temperature in the spectral region from 2 to 3.5 μm are in demand from solid-state laser pumping, tunable laser spectroscopy, medical diagnostics and infrared countermeasure (IRCM), etc. Diode lasers grown by molecular beam epitaxy (MBE) on GaSb substrates are promising candidates to answer the needs of these applications. Despite prominent improvements obtained in the last few years[1−6], high-temperature operation still presents a challenge. In this letter, we report high-temperature operation (80 ℃) in CW mode of an uncoated InGaSb/AlGaAsSb quantum well laser.

2. Growth of quantum wells

$In_{0.18}Ga_{0.82}As_{0.16}Sb_{0.84}$ / $Al_{0.35}Ga_{0.65}As_{0.02}Sb_{0.98}$ lattice-matched quantum wells and $In_{0.18}Ga_{0.82}Sb/Al_{0.35}Ga_{0.65}As_{0.02}Sb_{0.98}$ strained quantum wells were grown using VG80H MKII molecular beam epitaxy (MBE). Three 10 nm quantum wells separated by 20 nm wide lattice-matched AlGaAsSb barriers were grown at 540 ℃ on GaSb substrate, and V/III beam flux ration was fixed at 5. Then, a 10 nm GaSb cap layer was grown. The growth rate of GaSb is 0.5 ML/s.

Photoluminescence (PL) measurement of the lattice-matched and compressively strained quantum wells were made at 77 K and the results are presented in Fig. 1. The intensity of InGaSb/AlGaAsSb compressively strained quantum wells are twice as strong as InGaAsSb/AlGaAsSb. The linewidth of InGaSb/AlGaAsSb quantum wells is 63.7 nm, twice smaller than InGaAsSb/AlGaAsSb quantum wells (114.6 nm). InGaSb/AlGaAsSb quantum wells show better performance than InGaAsSb/AlGaAsSb. Meanwhile, the wavelength of InGaSb/AlGaAsSb quantum wells is significantly blue-shifted from 2.13 to 1.80 μm due to InGaSb being 1.1% compressively strained.

3. Device and fabrication

The band structure of the InGaSb/AlGaAsSb strained quantum well laser is shown in Fig. 2. The laser was grown on n-GaSb substrate. The layers of the structure were grown in the following order: a 300-nm-thick n-type GaSb buffer layer (1×10^{18} cm^{-3}, Te), a 1.5 μm $Al_{0.6}Ga_{0.4}As_{0.02}Sb_{0.98}$ n-type (4×10^{17} cm^{-3}, Te) cladding layer, an undoped active zone consisting of three 10 nm compressively strained QWs of $In_{0.18}Ga_{0.82}Sb$ separated by two 20 nm $Al_{0.35}Ga_{0.65}As_{0.02}Sb_{0.98}$ barriers and enclosed between 200 nm $Al_{0.35}Ga_{0.65}As_{0.02}Sb_{0.98}$ spacers, a 1.5 μm p-type $Al_{0.6}Ga_{0.4}As_{0.02}Sb_{0.98}$($5 \times 10^{18}$ cm^{-3}, Be) cladding layer and finally a 0.3 μm p-GaSb cap layer (2×10^{19} cm^{-3}, Be).

Fabry–Pérot lasers with 8-μm-wide metal contact stripes were fabricated using standard photolithography. For the top p-

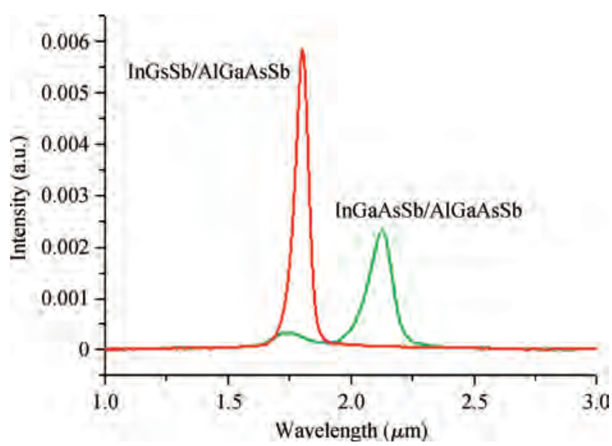

Fig. 1. PL of InGaSb/AlGaAsSb and InGaAsSb/AlGaAsSb quantum wells at 77 K.

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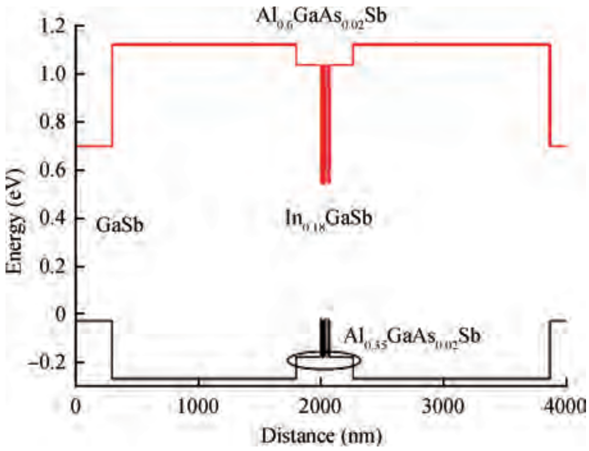

Fig. 2. Schematic energy-band diagram of 2 μm laser.

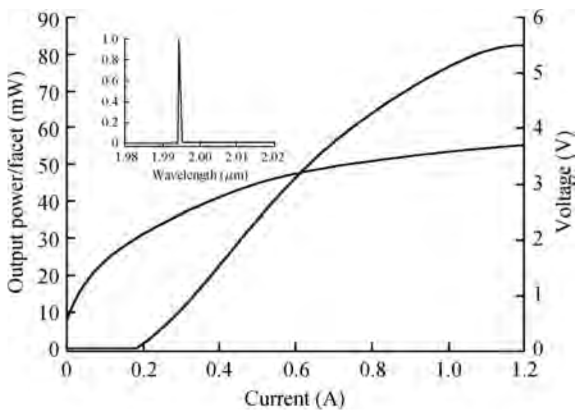

Fig. 3. I–V and P–I curve of 8 × 800 μm laser at 2 μm.

and back n-contacts, Ti/Pt/Au and Au/Ge/Ni were deposited, respectively. 800-μm-long lasers were mounted p-side down onto copper heat sinks. The facets were not treated.

4. Results

The lasers emitted at 2 μm in CW mode at room temperature. Figure 3 shows the spectrum of an 800-μm-long diode at room temperature in CW mode at 450 mA current. The emission wavelength is 1.995 μm with 0.35 nm linewidth. The output power reaches a value of 82.2 mW at 1.2 A in CW mode at room temperature.

Figure 4 shows the CW output power versus current (P–I) characteristics for temperatures between 20 and 80 ℃. The maximum power was 63.7 mW at 80 ℃ in CW mode under a drive current of 1 A.

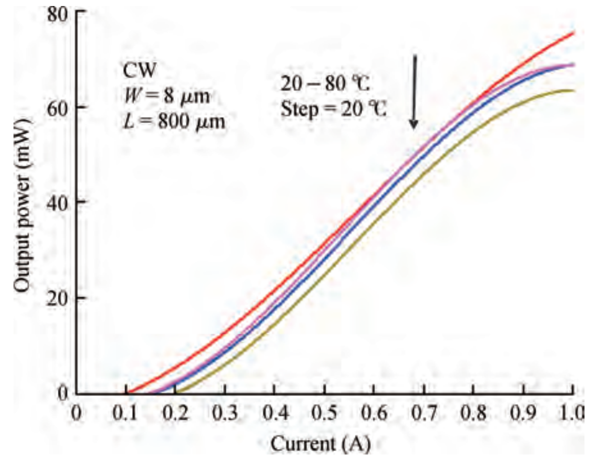

Fig. 4. Output power versus current at different temperatures (20–80 ℃).

5. Conclusions

An InGaSb/AlGaAsSb compressively strained quantum well laser grown by MBE was presented. Optical characterizations were carried out and showed CW operation at room temperature with a maximum output power of 82.2 mW at 1.2 A. In addition, the laser can operate at high temperature (T = 80 ℃), with a maximum output power of 63.7 mW under the drive current of 1 A in CW mode.

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