Continuous-wave operation of InAsSb/InP quantum-dot lasers near 2 μm at room temperature

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Abstract: InAsSb quantum-dot lasers near 2 μm were demonstrated in cw operation at room temperature with a threshold current density of below 1 kA/cm^2, output power of 3 mW/facet and a differential quantum efficiency of 13%.

OCIS codes: (140.5060) Semiconductor lasers

1. Introduction

There are increasing interests in InAs quantum-dot (QD) lasers for long wavelength applications, however, the performance of the InAs QD lasers, especially in the wavelength region of 2 μm, is still limited [1]. Recently, we have achieved high density InAsSb QDs on InP using metalorganic vapor-phase epitaxy (MOVPE). Efficient photoluminescence (PL) in the wavelength range from 1.7 to 2.2 μm has been observed at room temperature [2]. In this paper, we report room temperature cw operation of InAsSb QD lasers based on InP substrate at wavelength near 2 μm.

2. Device design and growth

The InAsSb QD laser was grown by MOVPE on an InP (001) substrate. The active region of the laser consists of a single-stack InAsSb QDs self-assembled in a slightly tensile-strained (less than −0.5% mismatch) InGaAs quantum well with thickness of 7 nm, which is further sandwiched between 150 nm InGaAsP (λg=1.35 μm). Growth temperatures were in the range of 500–550 °C for the InAsSb QD layers, and 625 °C for the rest of structures.

3. Results

The InAsSb dots have an average lateral size of around 35 and 4 nm in height with an area density of $4x10^{10}$ /cm^2. Room-temperature photoluminescence measurement showed a ground-state peak at 1.98 μm at the edge of a 2 inch wafer with a spectral full width at half maximum of 34 meV, indicating a good homogeneity of the QDs.

Ground-state cw lasing at room temperature has been achieved with the lasing wavelength of 1.96 μm. Figure 1 shows typical QD lasing spectra with three or four broadened longitudinal modes with mode spacing of 2.6 nm at different injection current. Given an effective refractive index of 3.4, the Fabry-Perot longitudinal mode spacing should be about 0.37 nm at wavelength of 1.95 μm, there should be 6–7 Fabry-Perot longitudinal modes within each broadened longitudinal mode, which are not visible here due to the resolution of the monochrometer. From the spectra, the homogeneous and the inhomogeneous broadening are estimated to be 1 and 3–5 meV.

Figure 2 shows the single facet light output characteristics versus current of a 1.5- mm-cavity-length laser operating cw measured at different temperatures. At 10 °C, the threshold current and threshold current density are about 55 mA and 916 A/cm^{-2} respectively, the output power exceeds 3 mW/facet and the differential slope efficiency is about 13%. The characteristic temperature T_0 is 35 K at temperatures below 15 °C and 20 K above 20 °C. With increasing temperature, the differential slope efficiency decreases gradually to 11% at 20 °C then drops abruptly to about 3% at 25 °C. Further optimization is in process.

4. Reference

[1] T. Rotter, A. Stintz, and K. J. Malloy , "Long wavelength quantum dash lasers grown on InP substrates", CThI6, CLEO'2003, Baltimore, Maryland 2003.
[2] Y. Qiu and D. Uhl, "Self-assembled InAsSb quantum-dots on (001) InP substrate", (unpublished).

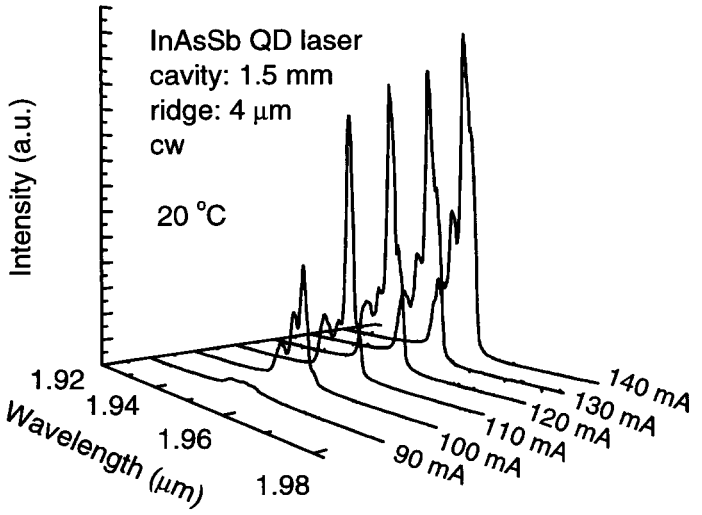

Fig. 1. Ground-state cw lasing spectra of a 1.5-mm-cavity-length laser measured at different currents at 20 °C.

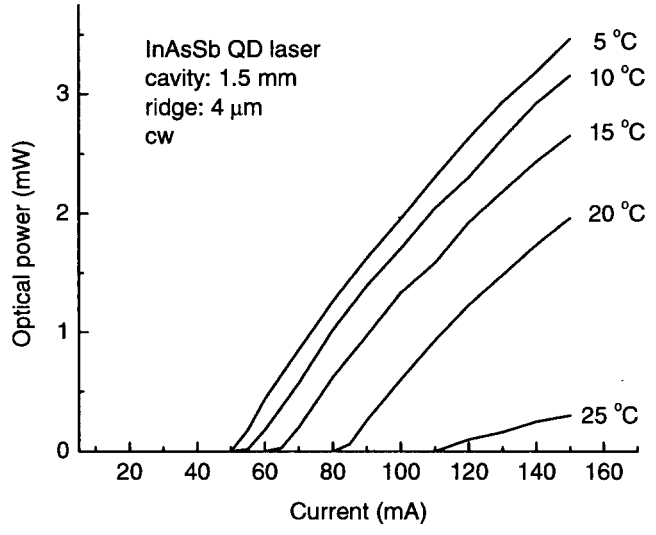

Fig. 2. Light vs current for a 1.5-mm-cavity-length laser without facet coating measured at different temperatures.