

Monolithic, optically-coupled, multi-section mid-IR quantum cascade lasers

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In this work design, fabrication and characterization of multi-section, coupled cavity mid-IR quantum cascade lasers is presented. Devices emitting in different spectral ranges were fabricated. To achieve stable, single mode emission 3-section coupled cavity QCL design is proposed. Devices exhibit tuning of $\sim 3 \text{ cm}^{-1}$ with 35 dB side mode suppression ratio.

The investigated devices were AlInAs/InGaAs/InP lattice matched and strain compensated QCL devices, fabricated by reactive ion etching from InP-based heterostructure, designed for emission in various spectral ranges of 5.x, 9.x and 11.x micrometers.

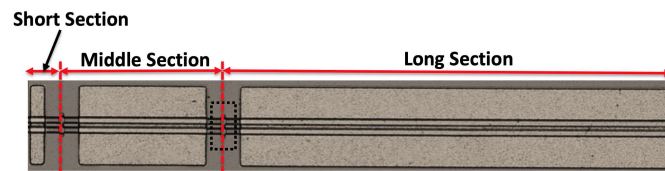


Fig. 1. Optical microscope image of a three-section coupled cavity (3-CC) QCLs heterostructure: close up on single chip

To assess and prove the idea of 3-section QCL, a series of devices were fabricated by means of ICP etching utilizing modified QCL processing scheme. To confirm performance and spectral behavior of the 3 section devices detailed measurements were performed. Characterization included standard light-current-voltage measurements, and spectral and time-resolved spectral characterization. Figure 2a shows a single mode operation spectrum of investigated devices measured at current of $1.3 I_{th}$. Figure 2b presents spectra registered at different temperatures. A single mode operation measured at room temperature for current of $1.3 I_{th}$ was obtained at $\sim 1142 \text{ cm}^{-1}$ ($8.75 \mu\text{m}$). Spectra shows clean, single mode emission, with side mode suppression ratio (SMSR) of 35 dB. A stable, single mode emission was observed in the whole temperature range. The total tuning range was $\sim 7 \text{ cm}^{-1}$, resulting in temperature tuning coefficient of $0.08 \text{ cm}^{-1}/\text{K}$. Spectra show no indication of side modes switching on during operation at elevated temperatures.

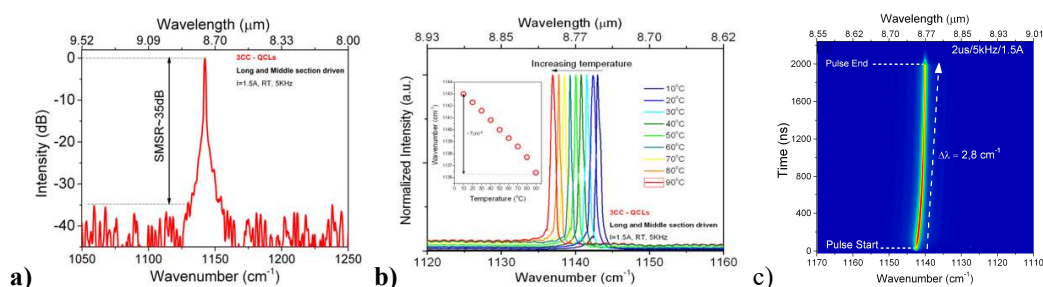


Fig. 2. (a) Spectrum measured at $1.3 I_{th}$ (1.5A) presented in y-log scale showing 35 dB side mode suppression ratio. (b) Emission spectra of 3-section CC QCL operated at the constant current $1.3 I_{th}$ and various heat-sink temperatures. Inset shows the single mode emission shift: wavenumber vs heat sink temperature. (c) Emission TRS spectra of 3-section CC QCL operated at the constant current $1.3 I_{th}$ for $2 \mu\text{s}$ pulse duration.