

# DFB Style Slotted Waveguide Interband Cascade Lasers

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**Abstract**—The first demonstration of single-mode behaviour of interband cascade lasers (ICLs) using a slotted waveguide is presented. Side mode suppression ratios (SMSRs) between 10 - 15 dB are observed for temperatures of 15 - 21.5°C for injection currents near the maximum before the thermal rollover and after this point. This provides a benchmark for the amount of modulation of the refractive index in the cladding required to interact with the longitudinal cavity modes. Threshold currents of 90 mA are achieved with an output power of 2.2 mW. This is an increase by 35 mA and a decrease by 7.8 mW from the Fabry-Pérot style ICLs with multi-mode output.

**Keywords**—*interband cascade laser; surface grating; single-mode laser*

GaSb materials are used to create laser sources for the sensing of petrochemical gases such as methane, ethane, or carbon dioxide, for example [1]. Distributed feedback (DFB) interband cascade lasers (ICLs) have already been fabricated for single mode, low threshold currents for these types of applications in the 3 - 5  $\mu\text{m}$  spectral range. DFB style waveguides are a well known design but are expensive and time consuming to fabricate since they require e-beam lithography. In the telecommunications spectral range around 1.5  $\mu\text{m}$ , single mode emission is achieved using a different design called the slotted waveguide. DFB lasers have patterns with sizes less than the wavelength of emission whereas slotted lasers have larger patterns and can therefore be fabricated using photolithography as a simpler and more economical alternative [2].

Simulations are used to optimise the wavelength the slots will filter from multi-mode Fabry Pérot cavities and ensure they only filter one wavelength. This is done by changing the spacing, size, depth, and number of slots to be etched in the upper cladding of the ICLs. A strong filtering effect from the slots are observed in Figure 1 where the spectra of a Fabry-Pérot cavity ICL is shown in comparison to the slotted ICL. In fact, single mode emission is measured at 15°C with an injection current of 150 mA with a side mode suppression ratio (SMSR) of 14.5 dB for the narrow ridge lasers that have approximately 300 slots. However, when the number of slots decreases to 225, other modes are no longer suppressed though the spectra is narrowed. This can be due to the decrease in reflective response and the broadening of the mirror peaks. The comparison for the slotted lasers with single and multimode is shown in Figure 2.

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1. J. Meyer et al, Photonics, 7, 75 (2020)

2. Q. Lu et al, IEEE Photonics Technology Letters, 22, 11 (2010)

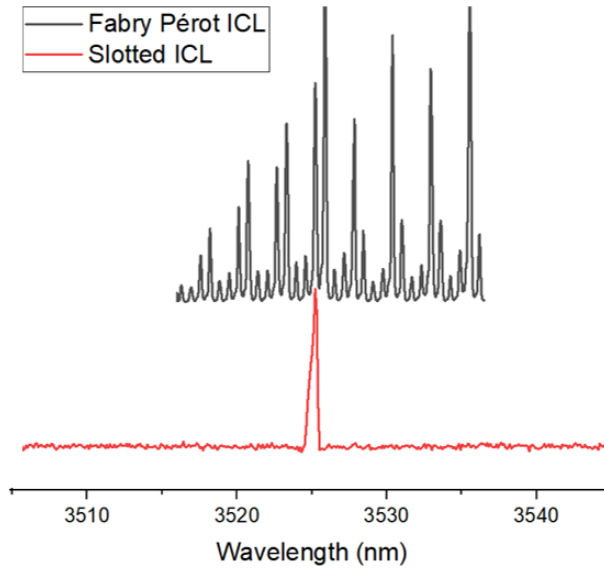


Fig. 1. Fabry-Pérot ICL Spectra vs Slotted ICL Spectra. The slot spacing etched into the upper cladding manages to isolate one of the cavity modes.

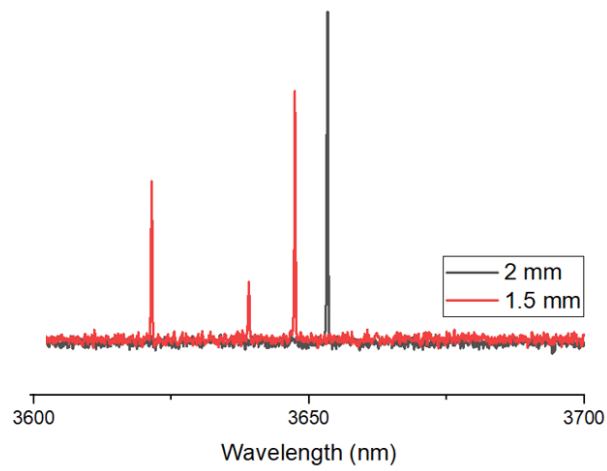


Fig. 2. Effect of the slots on the single mode behaviour of the ICLs - adding more slots increases the reflectivity and thus SMSR of the lasers.