DFB Style Slotted Waveguide Interband Cascade Lasers

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OPTAPHI Optical Sensing using Advanced Photo-Induced Effects
A European Double Doctorate Training Network

Slotted Waveguide Interband Cascade Lasers Fabricated Using Photolithography

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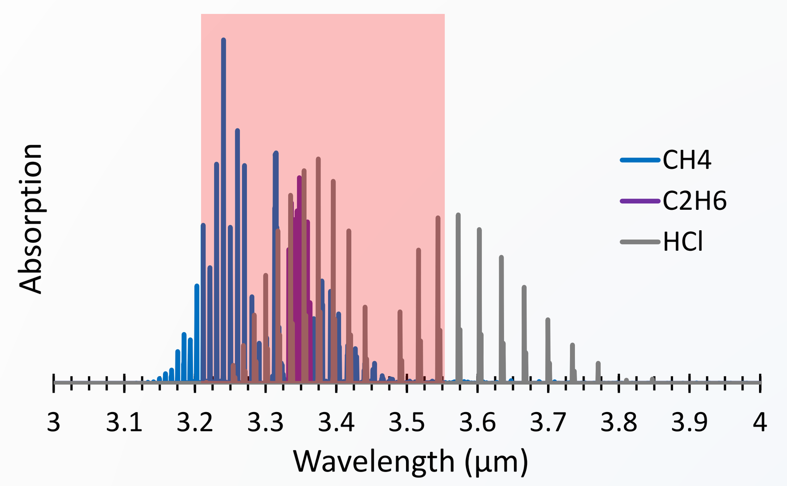
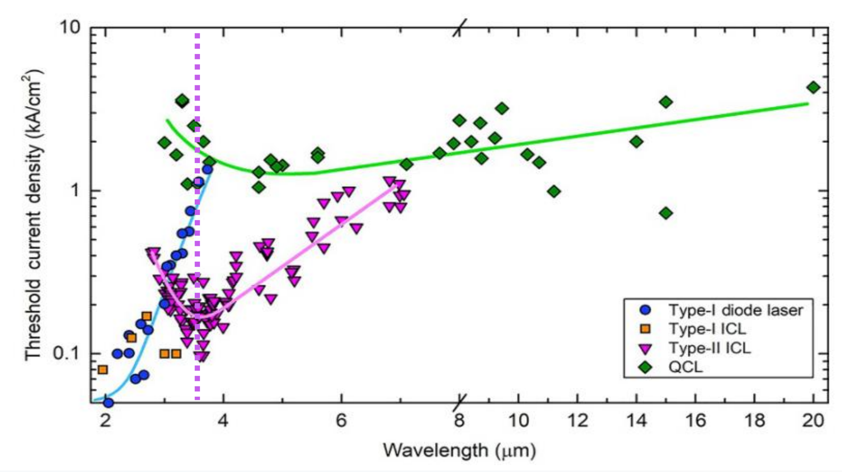
INTERBAND CASCADE LASERS

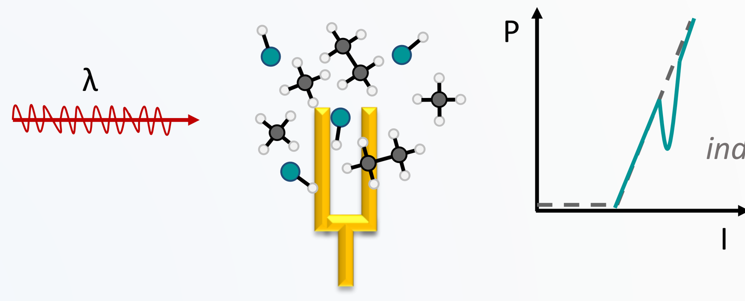
Many gases have strong absorption lines in the mid infrared (MIR) range.





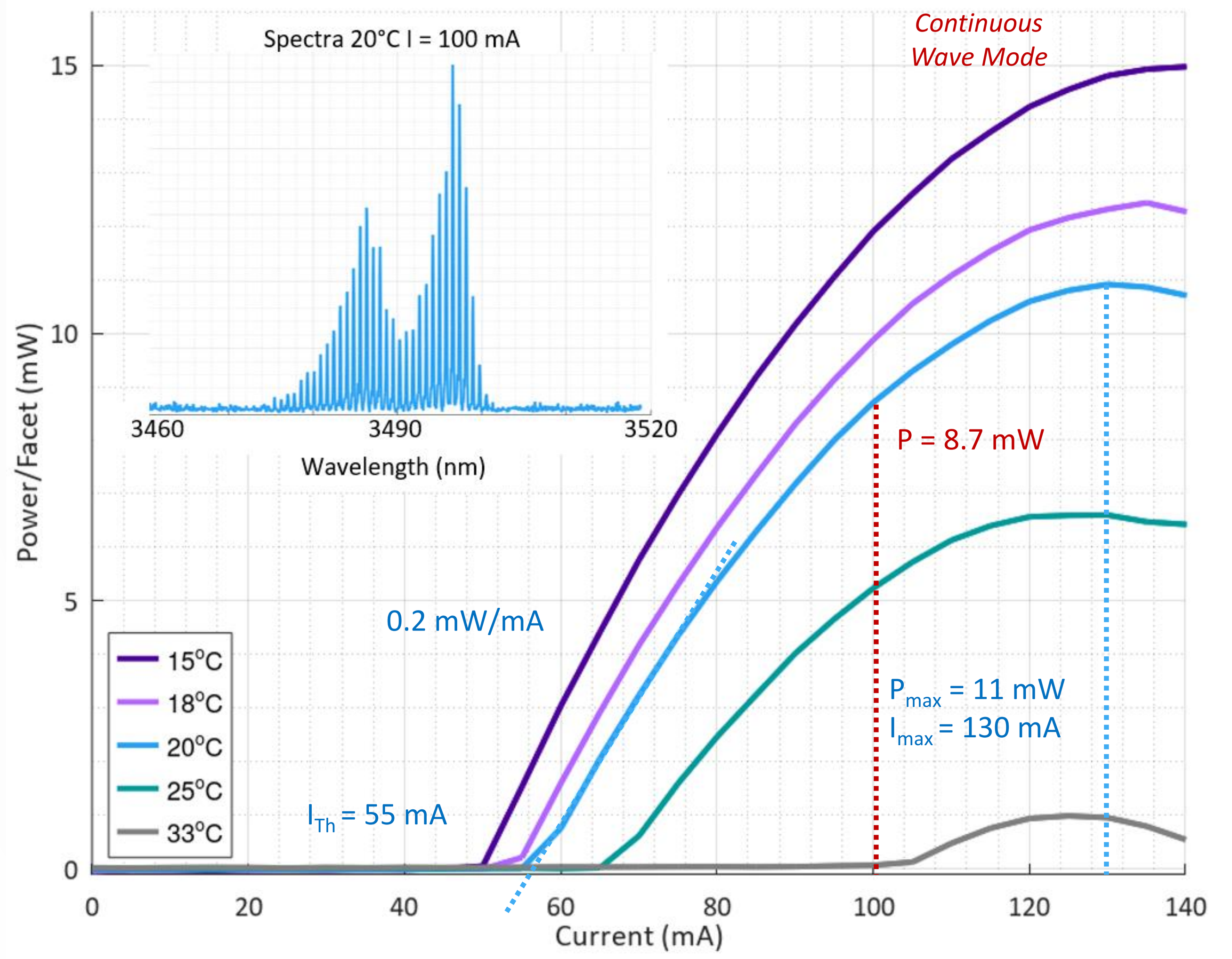
ICLs have the lowest threshold current around 3.5 µm.

Can be combined with detection schemes like for quartz enhanced photoacoustic spectroscopy (QEPAS) for field ready sensors.



QEPAS Tuning Fork

MULTIMODE FABRY – PÉROT ICLS



ICL Dimensions:
w = 8 µm, L = 1.6 mm

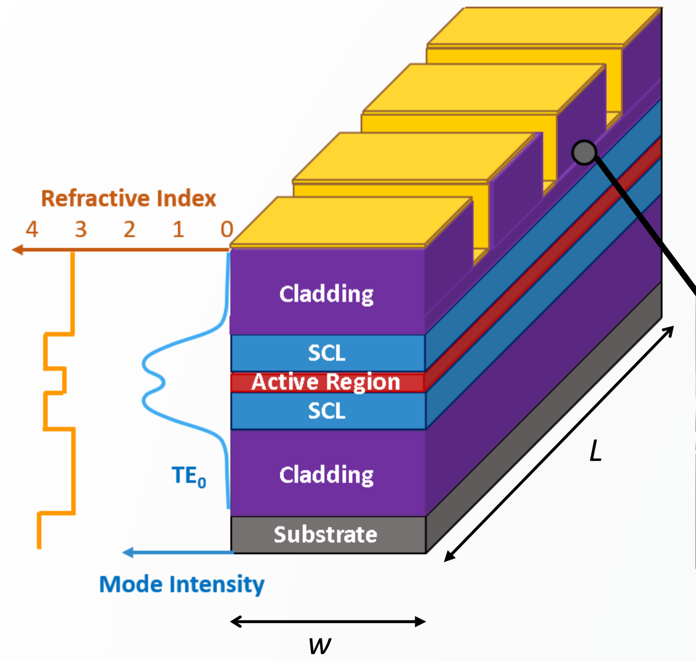
Typical power-current (PI) characteristics are shown for a FP ICL with cleaved, uncoated facets as temperature is varied. This laser was operational, with 1 mW of output, up to 33°C.

Complete ICL structure for a MIR source around 3 – 4 µm with low power consumption.

Contact Layer
Cladding: AlSb/InAs (Si) 1.9 µm
Transition Layer
Separate Confinement Layer: GaSb Te⁻ - 450 nm
Transition layer
Active Region W type II QW x7 - 290 nm
Transition layer
Separate Confinement Layer: GaSb Te⁻ - 450 nm
Transition Layer
Cladding: AlSb/InAs (Si) 3.2 µm
Transition Layer
Buffer
Substrate GaSb: Te

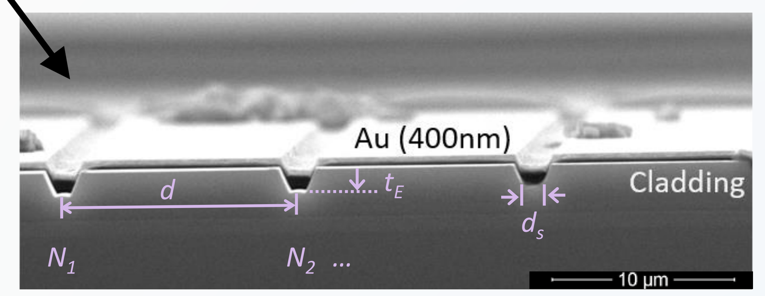
SLOTTED LASER WAVEGUIDE

WAVEGUIDE DESIGN AND SIMULATION



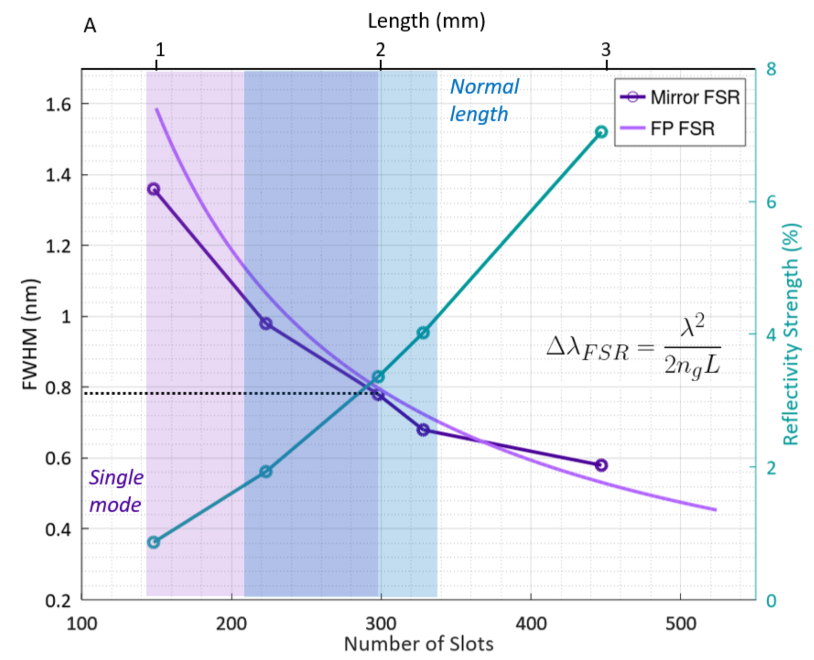
Slots are periodic defects in the waveguide that change the effective refractive index and produce interfaces for constructive or destructive interference.

Small d_s = small FWHM of reflectivity peak

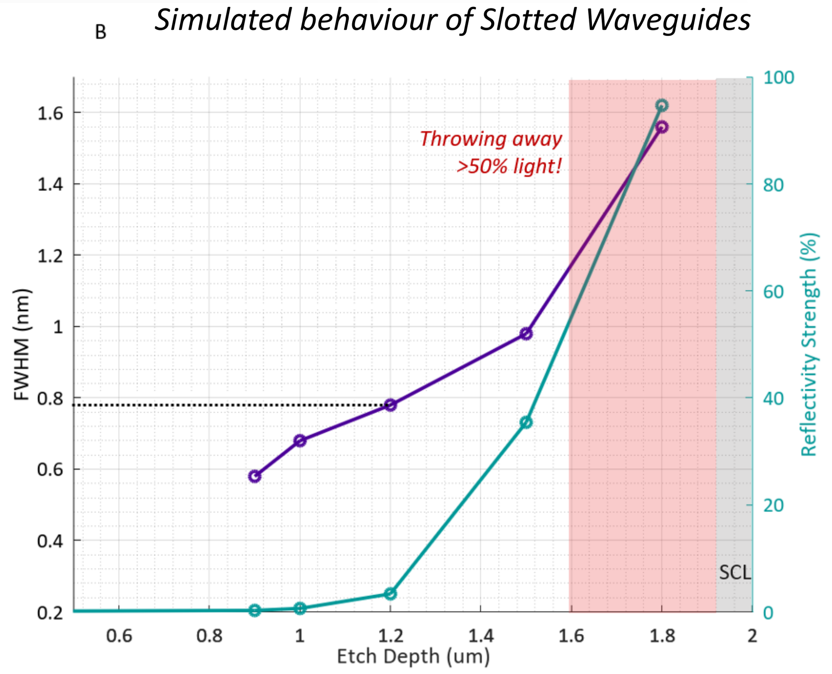


Small d = larger mirror free spectral range

Change d = change of supported wavelengths



Increasing N = increasing Cavity Length



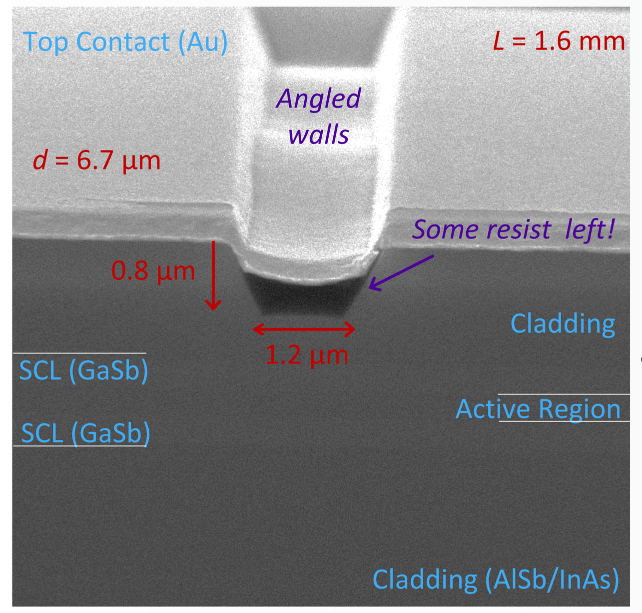
Deeper slots = more reflective slots

Narrow slots = difficult to process with photolithography

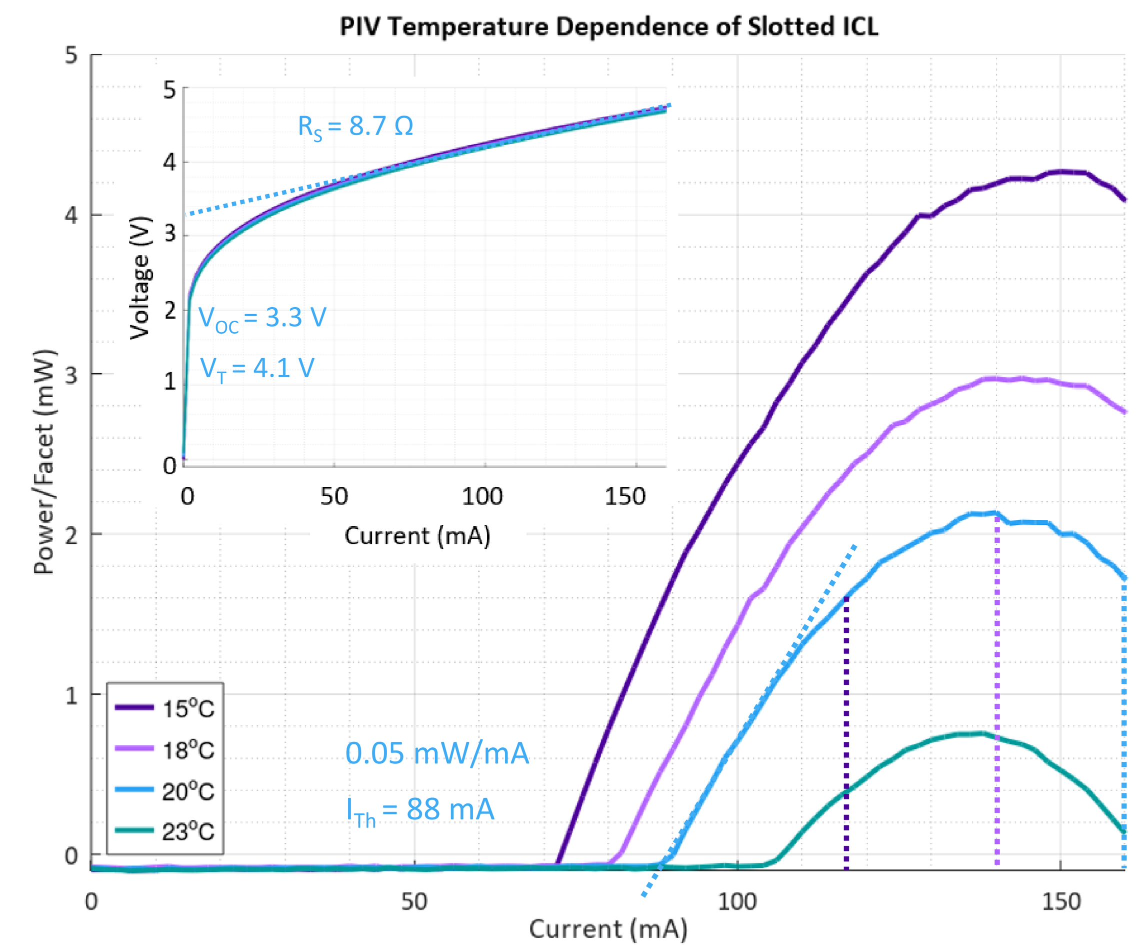
Need mirror FWHM narrow enough to overlap with one cavity mode

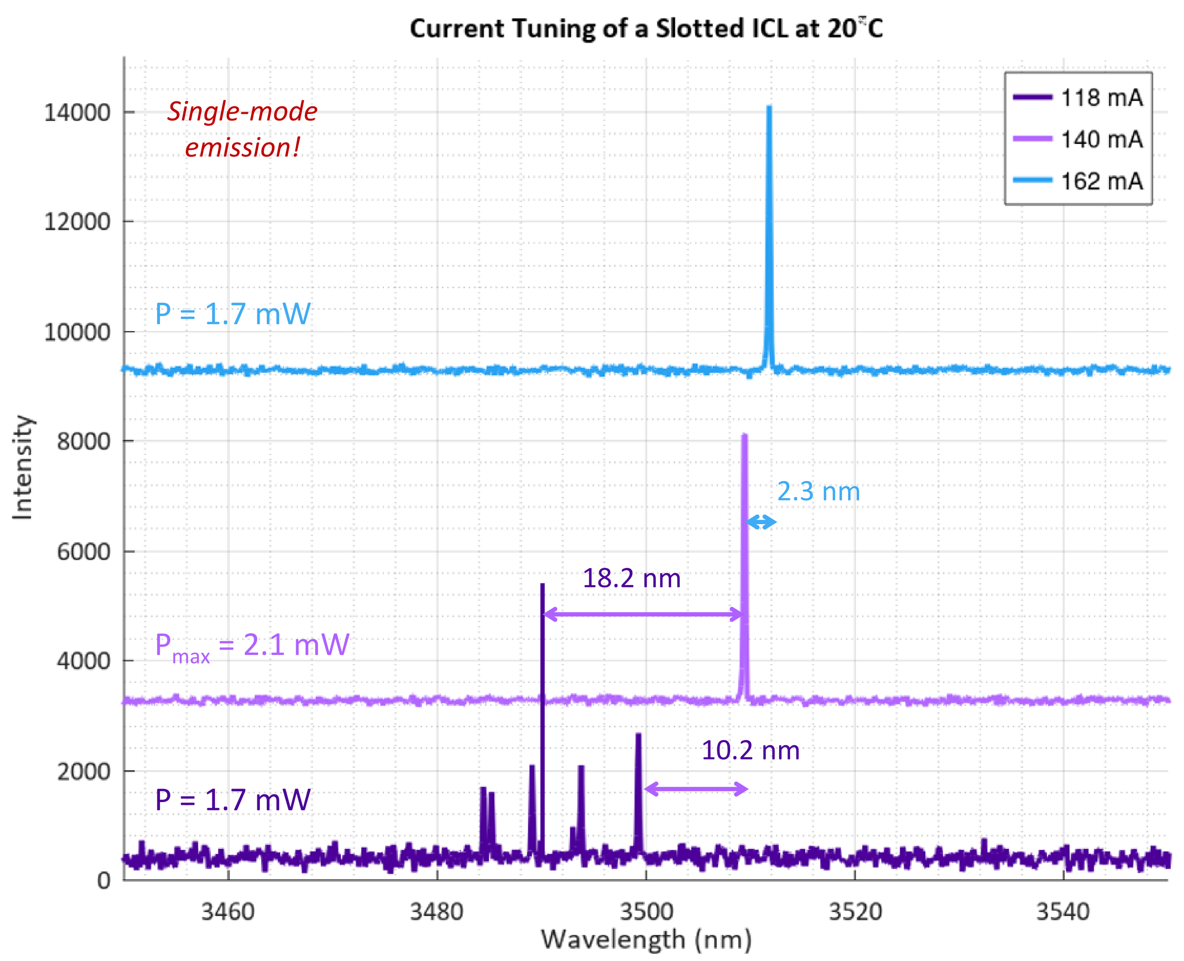
Need enough reflectivity interact with modes without killing transmission

SLOTTED ICL PERFORMANCE



Cleaved broad area ridge for a view of the slot cross section





CONCLUSIONS AND NEXT STEPS

- Demonstration of the performance for first slotted ICL: 2.1 mW output at 20°C with I_T = 88 mA
- Single-mode emission at 3.5 µm but small current and temperature operating range
- Fewer modes supported in comparison to FP ICLs for all current and temperature operating conditions
- Optimize the design and process to have more consistent single-mode emisison (wider slots, but deeper!)
- Integrate two slot patterns into a Vernier style laser for broadband tuning

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