Record high-power laterally coupled distributed-feedback lasers in the 2-3 μm wavelength range

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Outline

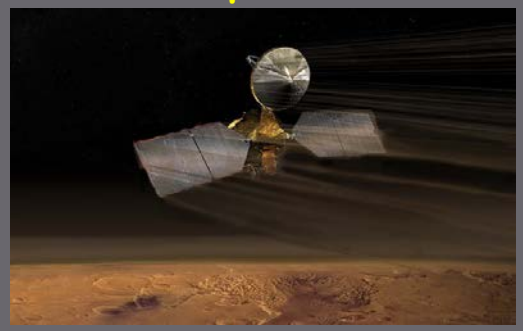
NASA/JPL's interest

Planetary atmospheric studies

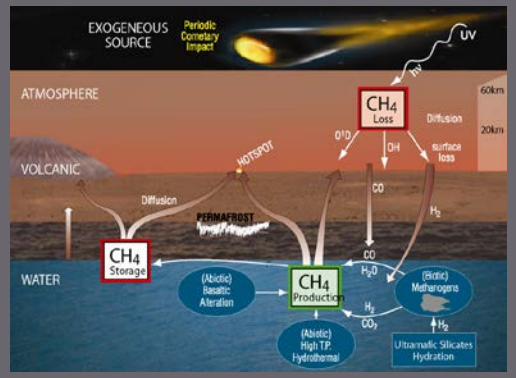
Mars Reconnaissance Orbiter launched in 2005 observed methane in the Martian atmosphere

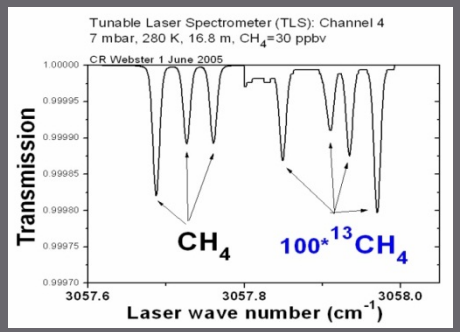
What is the source of methane generation on Mars ?

MRO spacecraft

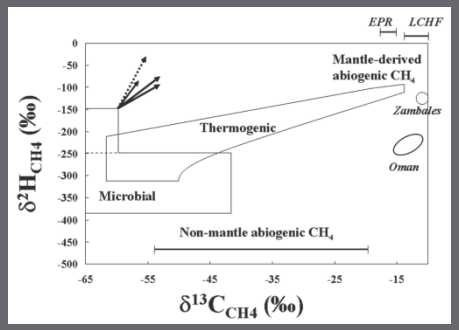


Mars Methane Cycle





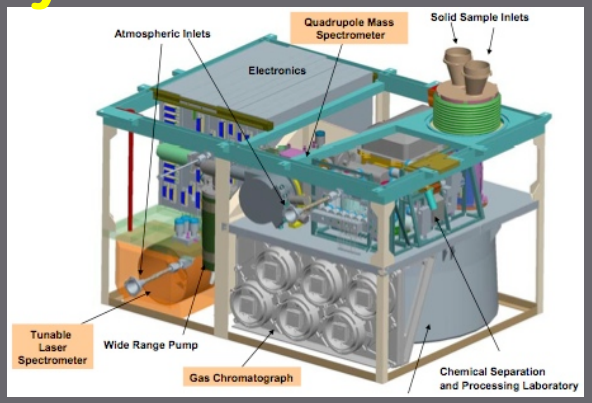
$^{13}CH_4$ Absorption

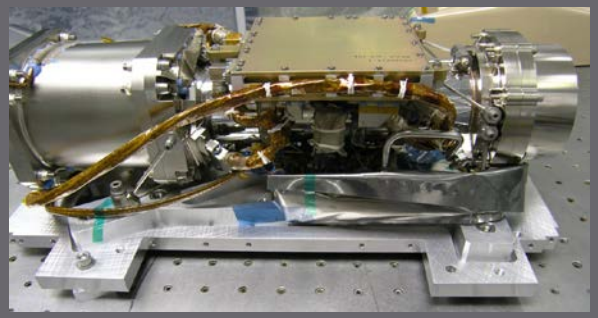


CH_4 Isotopologues

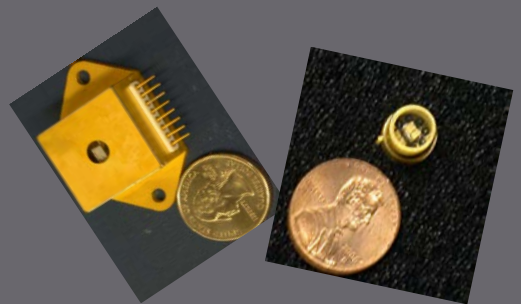
Measurement of isotopic ratio of $^{13}C/^{12}C$ could answer the origin of methane on Mars

Tunable Laser Spectrometer (PI:C. Webster) on Mars Science Laboratory





- Detects CH_4, H_2O, and CO_2
- Total Mass = 4.5 kg
- Power = 25 W,
  16.7 W average
- Two lasers: 2.78 and 3.27 μm
- Landed on Mars August 5th 2012



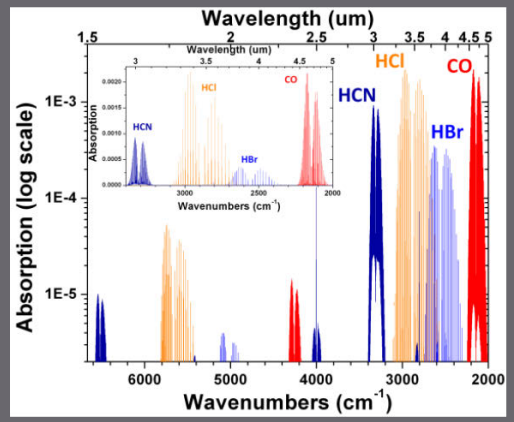
NASA/JPL's interest

Spacecraft environmental monitoring

Early Fire Detection on the ISS

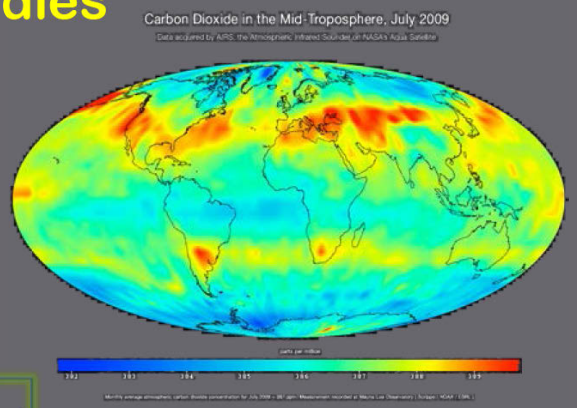
Laptop battery fire

PVC

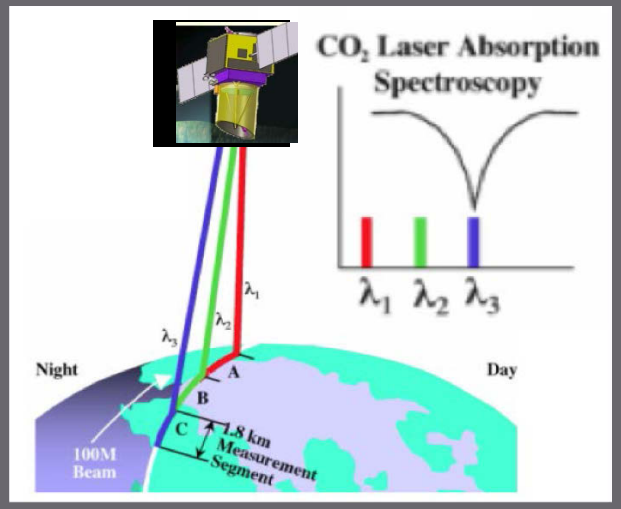


NASA/JPL's interest

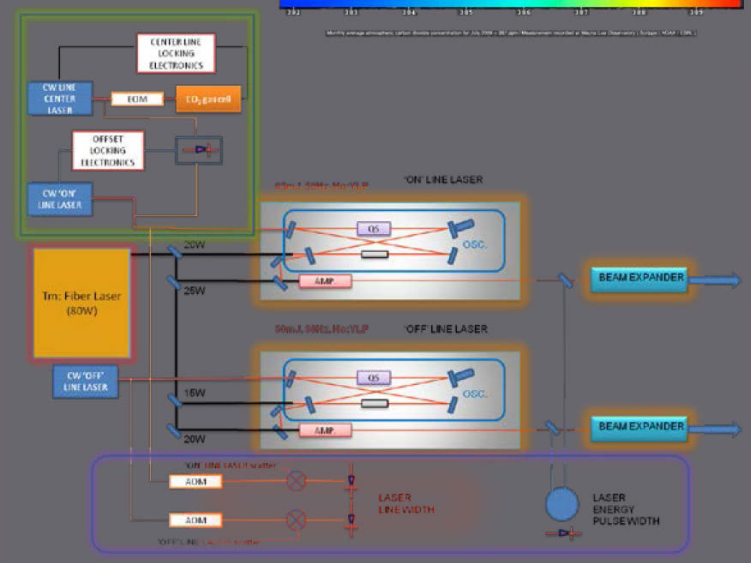
Earth atmospheric studies



Global-scale atmospheric measurements of CO2 and other GHG's



Use LIDAR technique in 2 μm spectral region



Block diagram of LIDAR transmitter

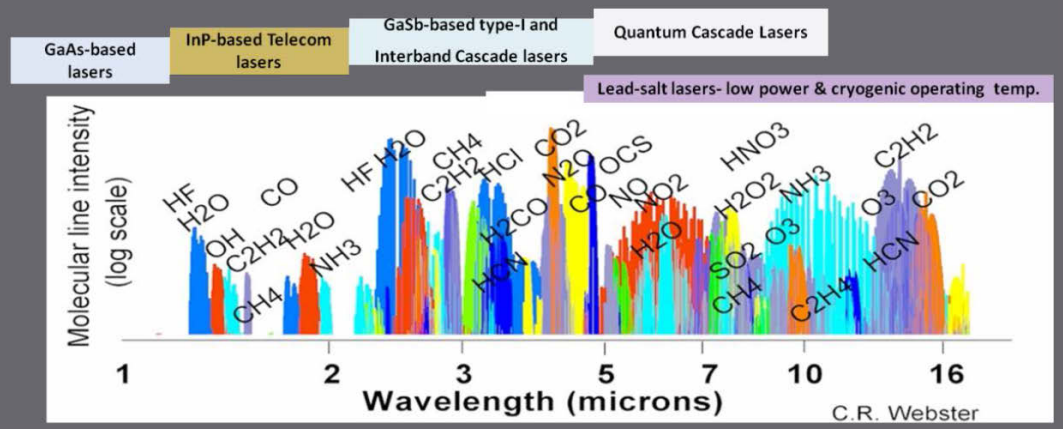
Seed laser requirements:

- PM fiber package
- >50 mW power
- <100KHz linewidth
- >1 MHz long term frequency stability

Laser based instruments

In-situ or remote instruments

Wavelength of interest mostly in th 2-5 μm range



Most applications require 10-100 mW output

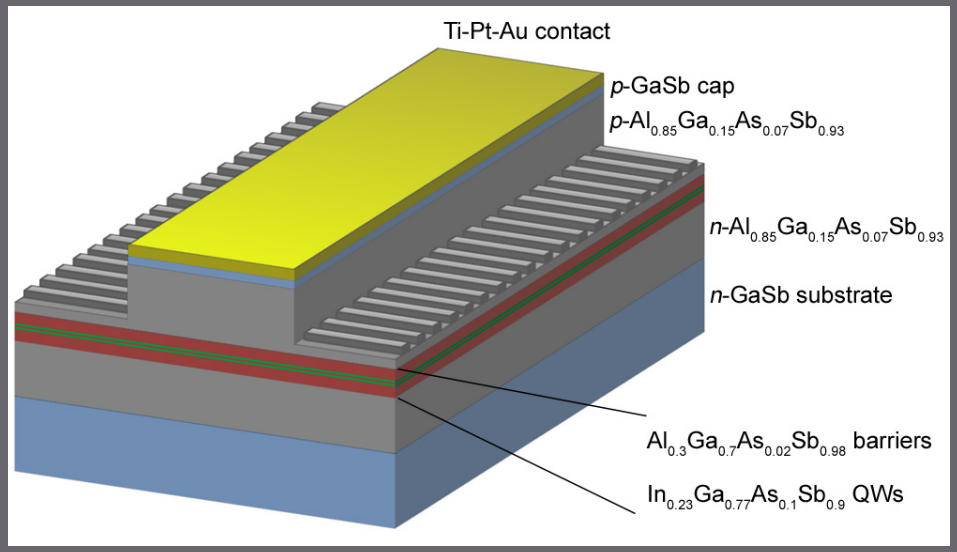
Some application require very low power consumption

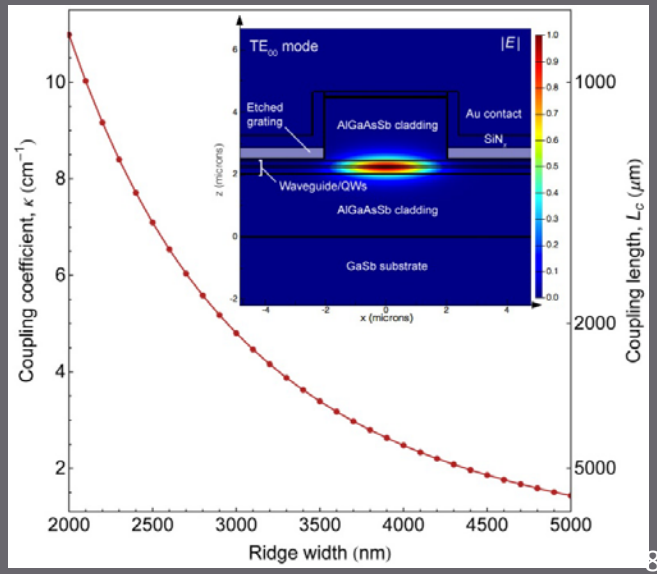
All applications require high spectral purity (single longitudinal mode)

Some degree of tunability

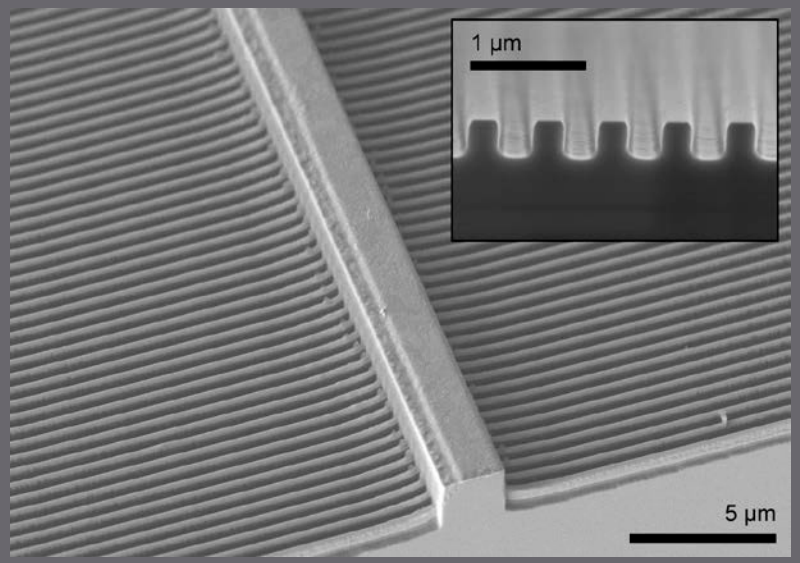
Laterally coupled distributed-feedback (LC-DFB) lasers @ 2 μm wavelength

- Laser material systems for 2-μm emission:
  - Strained InGaAs QWs on InP: Power limited by Auger recombination and poor carrier confinement
  - GaSb-based structures: Regrowth difficult (esp. on Al-containing layers) – prevents buried grating fabrication
- DFB lasers can be realized with AlGaAsSb/InGaSb lasers using laterally coupled gratings:
  - Devices with metallic gratings work well, but additional absorption loss is introduced
  - **GaSb-based LC-DFB lasers with etched gratings should exhibit lower loss and higher power**



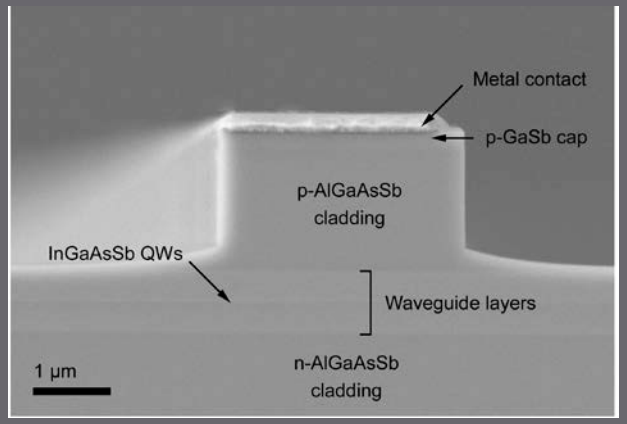


2-µm DFB laser fabrication

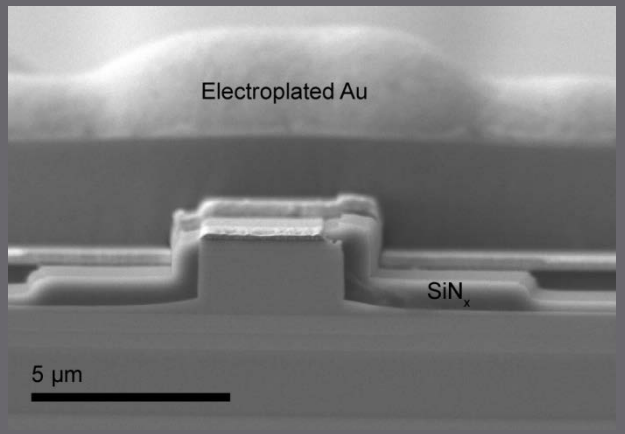


- Single-mode laser ridges partially etched into low-index waveguide cladding layer
- Second-order gratings etched alongside ridges
- SiN_x isolation layer deposited by PECVD, followed by electroplating of thick Au top contacts

Laser ridge cross section



With SiN_x isolation layer and top contact pad



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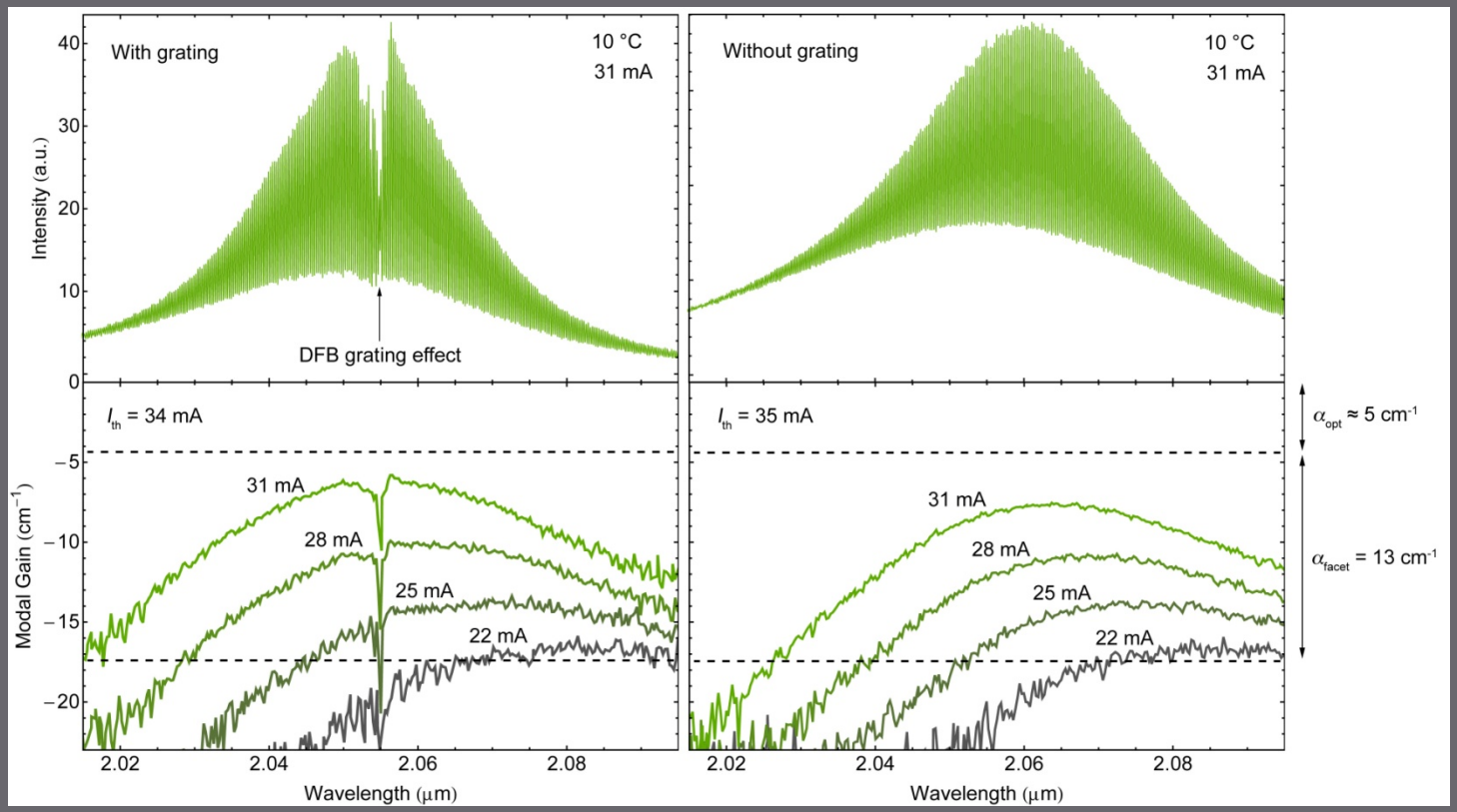
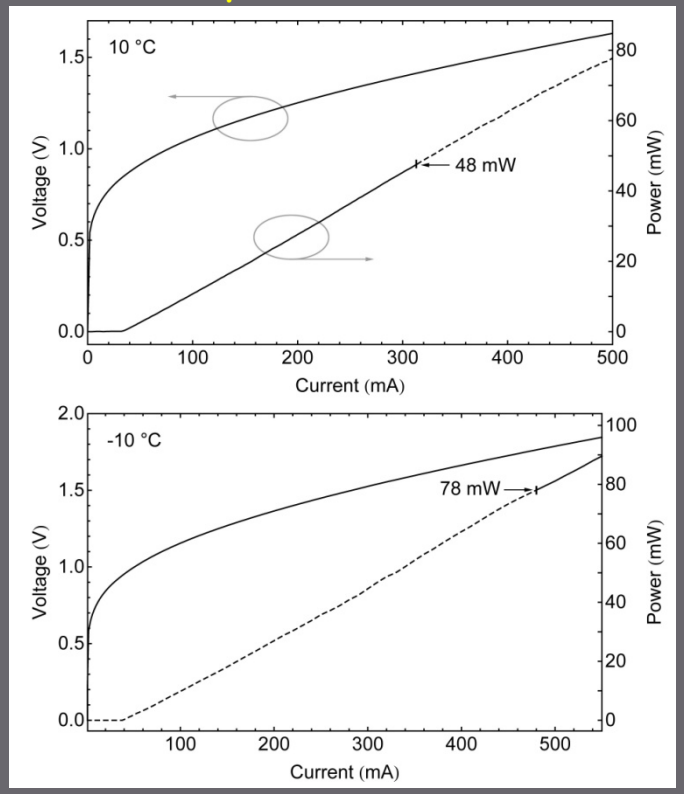
Sub-threshold spectral characterization



- Grating effect is clearly visible in sub-threshold electroluminescence spectra
- **No observed increase in waveguide loss away from Bragg wavelength compared with Fabry-Perot lasers**

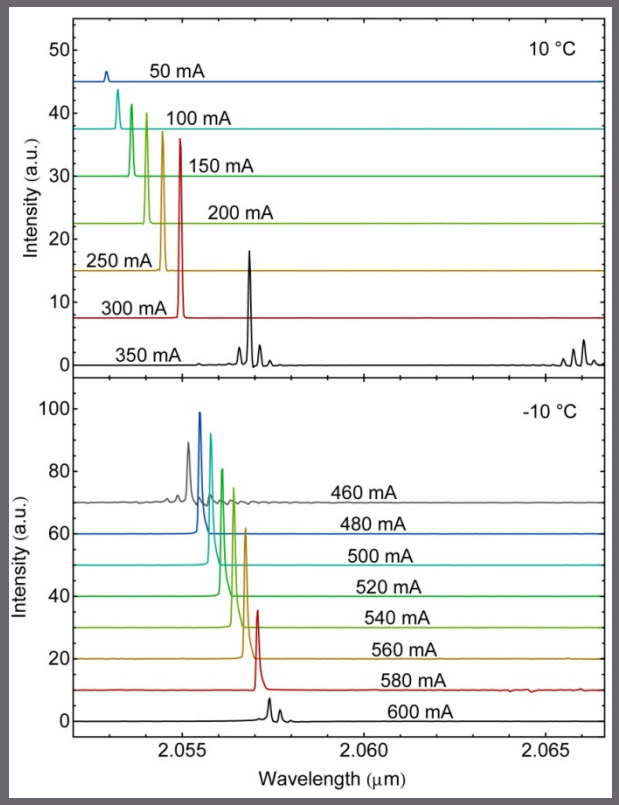
2-µm LC-DFB laser performance

Light-current-voltage performance



- Regimes of single-mode (solid line) and multimode (dashed line) emission are observed
- Single-mode output exceeds 80 mW at -10 ° C

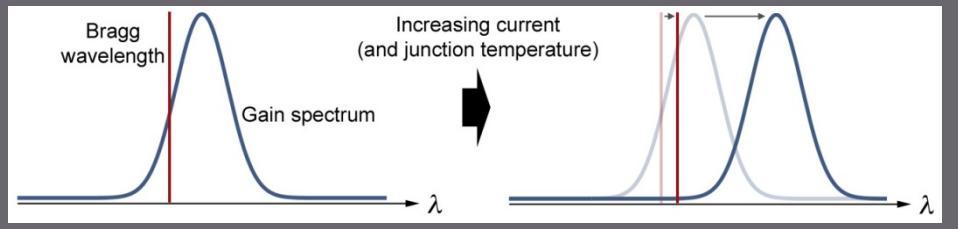
Laser emission spectra vs. current

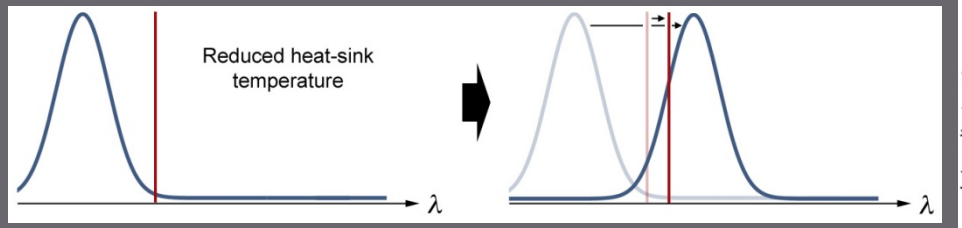


- DFB emission wavelength tunes continuously with increasing current (or temperature)
- Thermal tuning rate is 0.20 nm/°C

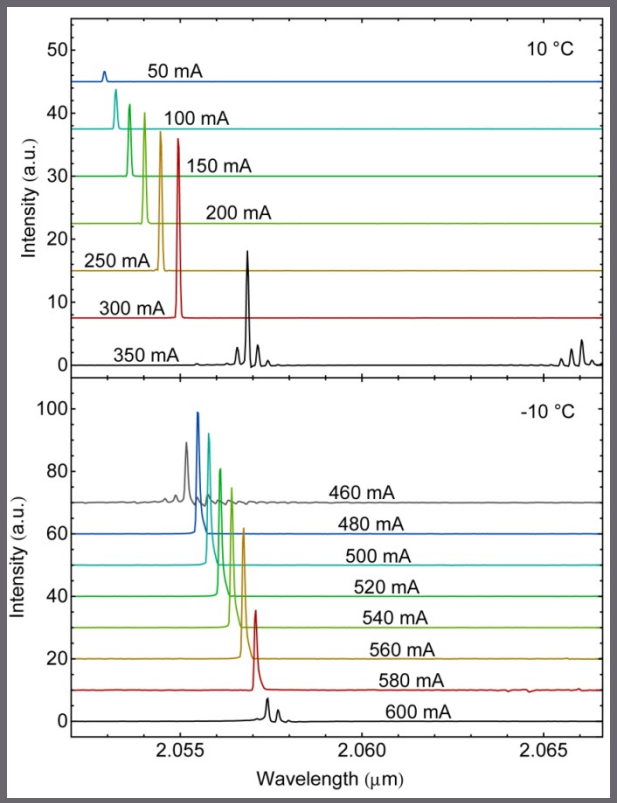
2-µm LC-DFB laser performance

Thermal tuning of gain spectrum





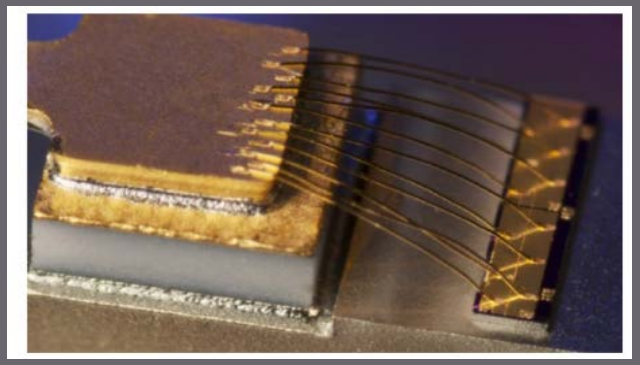
Laser emission spectra vs. current



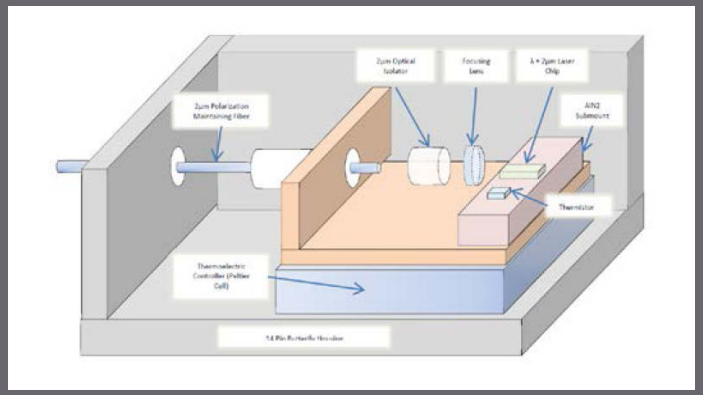
- Single-mode operation corresponds to the Bragg wavelength overlapping the gain spectrum
- Thermal tuning of the gain spectrum is an order of magnitude more severe than DFB tuning (> 2 nm/° C)

Hermetic sealed package

- Polarization Maintained fiber coupled output
- Built-in isolator with sufficient isolation to prevent unwanted feedback

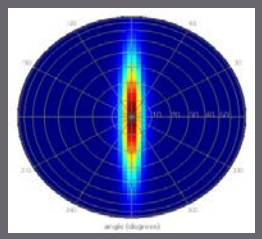


Diode laser at 2.05 μm

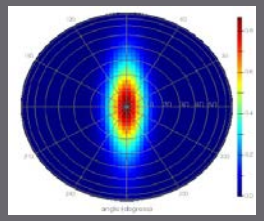


Schematic of Internal components of the package

Optimization of the laser structure for efficient coupling into fiber



Measured coupling efficiency 10%



Measured coupling efficiency 35%

Laterally coupled distributed-feedback (LC-DFB) lasers @ 2.65 μm

Summary