µQ – Miniaturized quantum cascade laser modules

Compact modules with broad spectral tuneability

µQ laser modules
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The Fraunhofer IAF develops tunable quantum cascade lasers for the mid-infrared range. Particularly compact laser modules with unique properties are achieved by combining broadband QCL chips with MOEMS grating scanners to adjust the emission wavelength in an external optical resonator. Two different spectral tuning concepts were developed together with Fraunhofer IPMS, resulting in resonant and non-resonant MOEMS scanners. Resonant grating scanners enable very high spectral scan speeds of up to 1 kHz and are therefore ideal for real-time spectroscopy. Non-resonant grating scanners, on the other hand, enable spectral scan speeds with repetition rates up to several 10 Hz. Furthermore, those scanners allow for programmable and flexible wavelength tuning-trajectories as well as to approach individual emission wavelengths.

Features

- Complete in-house production chain: design, epitaxy, process, structure, coating, characterization, module development, up to the application system
- Central wavelengths in the range 4–11 µm
- Compact and robust design due to the use of micro-electro-mechanical grating scanners
- Different spectral scan speeds: 0–50 Hz or ~1 kHz
- Pilot series production
- Application development

Applications

- Laser-based IR spectroscopy
- Real-time spectroscopy for fast quality and process control
- Hand-held sensors
- Photothermal and photoacoustic IR spectroscopy

~1
kHz spectral scan speed

More information:

µQ – Quantum cascade laser modules

Our µQs are jointly developed by Fraunhofer IAF and Fraunhofer IPMS and are customized depending on the application. Here we describe some general specs as well as the different possibilities for QCL material and grating scanner concepts.

QCL chips

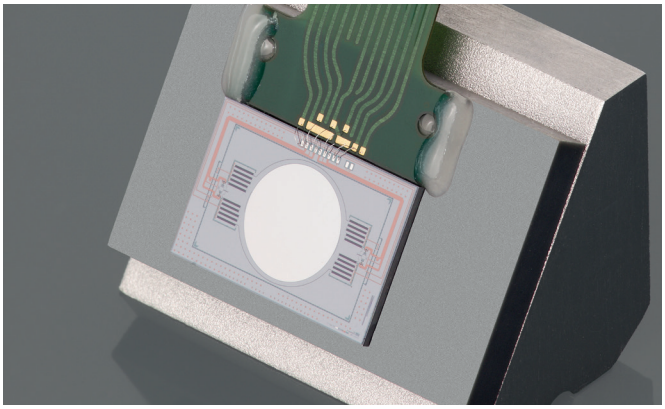
- Material AlGaAs/InGaAs on InP
- Central wavelengths in the range of 4–11 µm
- Power/Spectral coverage
  - Pulsed:
    - Spectral coverage: 200–300 cm^{-1} (typ.)
    - Line width < 2 cm^{-1}
    - Average optical output power 10 to > 100 mW depending on wavelength
  - CW:
    - Spectral coverage > 100 cm^{-1} (typ.)
    - Line width < 90 MHz (typ.)
    - Power: some 100 mW
- Beam profile Gaussian, $M^2 < 2$ (typ $M^2 < 1.5$)
- Beam size < 3.5 mm ($1/e^2$)
- Polarization linear, vertical

MOEMS scanner

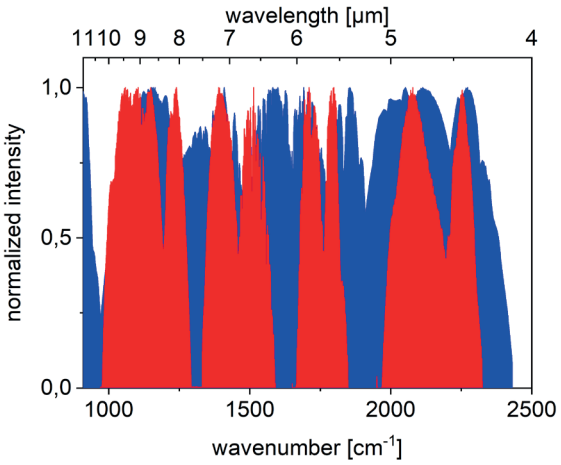
- Resonant:
  - Trajectories sinusoidal
  - Frequency: 1 kHz
- Non-resonant:
  - arbitrary, or selection of individual wavelengths
  - Frequencies: 0…~ 50 Hz
- Integrated position sensor for wavelength determination
- Blaze and lattice constants adapted to spectral ranges of the QCL chip

Module

- Size (L × W × H) 60 mm × 45 mm × 20 mm
- Laser driver
  - Pulsed: integrated in the module
  - CW: integrated in the module or separately (depending on max. required current)
- Electronics
  - OEM electronic controller
  - Integrated temperature controller
  - Programmable pulse source and laser current source



Resonant MOEMS grating scanner
© Fraunhofer IPMS



Examples for tuning ranges of pulsed (blue) and cw-tested (red) quantum cascade laser chips
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