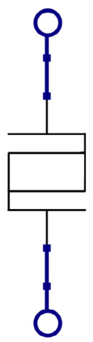


Frequency Comb Quantum Cascade Laser

Optical Frequency Combs are devices emitting light on a wide spectrum consisting of equidistant peaks in frequency space. The distance between these peaks being fixed, typically given by the pulse repetition rate of a train of ultrashort pulses, they can be used as rulers in the frequency domain for Frequency Comb Spectroscopy.

Electro-Optical Characteristics

SPECIFICATIONS	ACRONYM	MIN	TYP.	MAX	UNIT	NOTE
Central Wavelength	CWL	–	7.95	–	µm	1
Output Power	P	100	150	200	mW	2
Optical Frequency Span	OFS	50	60	70	cm-1	3
Number of Comb Teeth	N	100	120	140	–	4
Intermode Beat Frequency	IF	14.67	14.77	14.87	GHz	5
Operating current	I_op	600	800	1000	mA	6
Operation Temperature	T_op	-20	0	20	°C	7
Operation mode	–	–	CW	–	–	8
Delivery time	–	–	8	–	weeks	9
Dissipated Power	–	6	8	10	W	10

Key Features

- Compact and robust device
- Emission in the mid-IR molecular fingerprint region
- Power per comb tooth in the mW range
- FM modulated output with constant output power
- Direct generation of MWIR and LWIR radiation with high wall-plug efficiency
- Can be packaged in HHL or LLH housing

Key Applications

- Dual-comb spectroscopy
- Metrology
- Chemical sensing

CLASS 3B LASER PRODUCT

These specifications may be changed without further notice.

1. Frequency Comb Technology can be applied at any QCL available wavelength, please enquire for the lead time of your wavelength of choice. Presently lasers around 7.95 microns are available.
2. The output power varies with temperature and from one laser to another.
3. The optical frequency span will vary with the current and temperature.
4. Detailed in device's datasheet.
5. For a standard 3 mm long laser.
6. DC
7. Depends on each specific devices. It may be limited towards higher temperatures.
8. Frequency Combs are only stable in CW operation
9. At Reception of Order or specified in the quotation.
10. By the chip, if packaged, the total dissipation may be larger.

In the mid-infrared range, Quantum Cascade Lasers with specifically engineered optical dispersion have been shown to emit broad and powerful optical frequency combs (OFC). As for ultrashort-pulse lasers, the mode spacing of QCL combs is given by cavity length. However, in the case of QCLs, the periodic modulation in the time-domain is of the FM, not AM, type and the output power is constant.

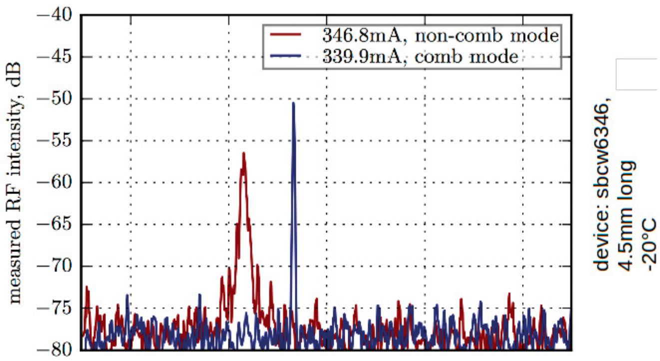
The wide and flat gain spectrum of Broad Gain Lasers make them suitable for operation as Frequency Combs. As the operating range where comb operation can occur is very sensitive to the fine structure of the heterostructure, each QCL-Comb is tested and qualified.

The QCL comb is a stand alone device as it integrates the pump laser and the microcavity in its waveguide contrarily to other comb technologies. This makes it a very compact comb source. Being based on QCL technology, comb devices can be manufactured over all the MWIR and LWIR.

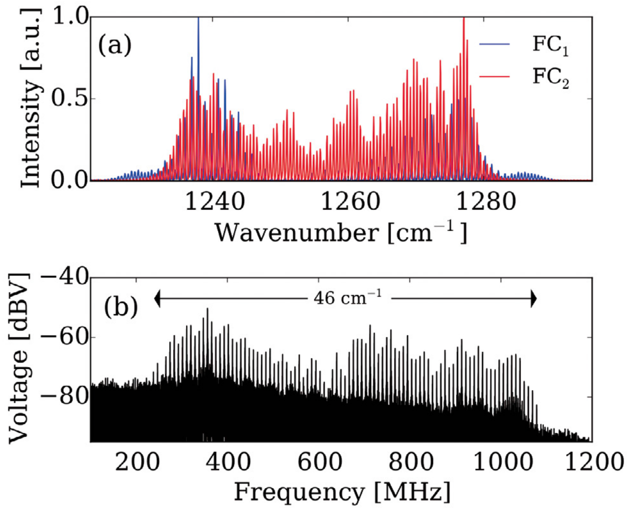
Dual-comb spectroscopy relies on two OFCs, a sample and a local oscillator (LO) comb, with slightly different comb spacings. The heterodyne beat spectrum of two such combs consists of equally spaced peaks mapping the lasers' optical spectra in the RF domain.

While a similar technique has also been demonstrated using standard Fabry-Perot QCLs, the much narrower intermode beat linewidth of QCLs operating in the comb regime allows to stack a much larger number of beat notes within the RF bandwidth of the optical detector, resulting in higher resolution and/or broader spectral bandwidth.

QCL-based dual-comb spectroscopy offers the possibility to acquire high-resolution spectra over a wide spectral range of several tens of cm-1 in a very short acquisition time of the order of µs, i.e. in quasi real time. This technique combines the advantages of DFB-QCLs, i.e. narrrow linewidth and mode-hop-free tuning,with the large wavelength coverage of external cavity QCLs.)



RF Spectrum of a Frequency Comb laser showing comb operation at an operating current of 339 mA



Top: Overlapping optical spectra of two typical Frequency Comb Lasers. Bottom: Mutliheterodyne beating spectrum of two combs, the spectrum spans 46 cm-1 and has a FWHM of 400 kHz

Source: Y. Bidaux et.al., Plasmon-enhanced waveguide for dispersion compensation in mid-infrared quantum cascade laser frequency combs, Optics Letter page 1604, vol. 42, no 8, 2017