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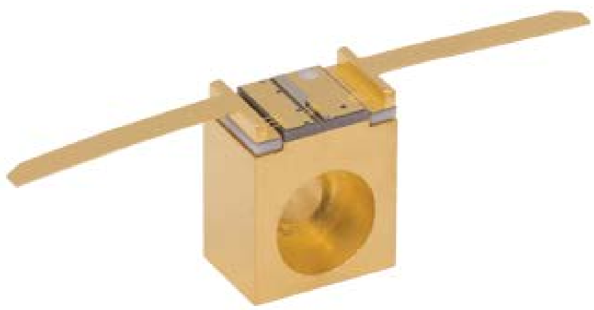
THORLABS

QD5250CM1 - May 5, 2022

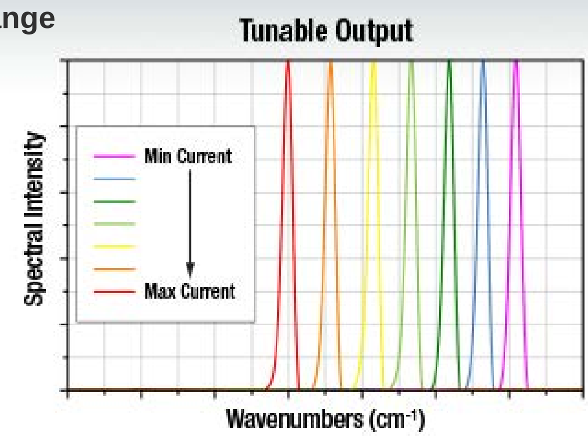
Item # QD5250CM1 was discontinued on May 5, 2022 For informational purposes, this is a copy of the website content at that time and is valid only for the stated product.

QUANTUM CASCADE LASERS (QCLS): DISTRIBUTED FEEDBACK, TWO-TAB C-MOUNT

- **Center Wavelengths Between 4.00 µm and 11.00 µm**
- **Typical Output Power: 40 - 120 mW**
- **Single-Wavelength Emission Tunable within 1 - 5 cm^{-1} Range**
- **Shipped from Stock**



QD9500CM1
Distributed Feedback Laser



(Linewidth Shown is Limited by Measurement Resolution)

OVERVIEW

Features

- Single-Wavelength Distributed Feedback Quantum Cascade Lasers (QCLs)
- Typical Output Power from 40 to 120 mW, Depending on Device
- Center Wavelengths from 4.00 µm to 11.00 µm (Wavenumbers Between 2500 cm^{-1} and 909 cm^{-1})
- Compact Two-Tab C-Mount Package: 6.4 mm x 4.3 mm x 7.9 mm (L x W x H)
- Electrically Isolated from C-Mount
- Custom Wavelengths and Mounts Also Available

MIR Laser Types	
Fabry-Perot	TO Can
	Two-Tab C-Mount
	D-Mount
	Turnkey
Distributed Feedback	Two-Tab C-Mount
	D-Mount
	HHL
	Turnkey

Thorlabs' Distributed Feedback Quantum Cascade Lasers (DFB QCLs) emit at a well defined center wavelength and provide single spatial mode operation. By tuning the input current and operating temperature, the output frequency can be tuned over a narrow range between 1 cm^{-1} and 5 cm^{-1}. These lasers are ideal for chemical sensing (see the *Spectroscopy* tab), optical communications, and other applications. Thorlabs also manufactures Fabry-Perot Quantum Cascade Lasers and Interband Cascade Lasers, which exhibit broadband emission.

Before shipment, the output spectrum, power, and L-I-V curve are measured for each serial-

Laser Diode Selection Guide[a]
Shop by Package / Type
TO Can (Ø3.8, TO-46, Ø5.6, Ø9, and Ø9.5 mm)
TO Can Pigtail, Collimator Output (SM)
TO Can Pigtail (SM)
TO Can Pigtail (PM)
TO Can Pigtail (MM)
Fabry-Perot Butterfly Package
FBG-Stabilized Butterfly Package
VHG-Stabilized Butterfly Package (MM)
MIR Fabry-Perot QCL, TO Can
MIR Fabry-Perot QCL, Two-Tab C-Mount
MIR Fabry-Perot QCL, D-Mount
MIR Fabry-Perot QCL, High Heat Load
Chip on Submount
Single-Frequency Lasers
DFB TO Can Pigtail
VHG-Stabilized TO Can
VHG-Stabilized TO Can Pigtail (SM)
VHG-Stabilized Butterfly Package

numbered device by an automated test station. These measurements are available below and are also included on a data sheet with the laser. These QCLs are specified for CW output. While pulsed output is possible, this application prohibits current tuning, and performance is not guaranteed. Please note that some optical power is emitted through the rear facet; this output is not usable in applications.

Packages
Each DFB quantum cascade laser is mounted on a two-tab C-mount that provides high thermal conductivity and can be secured using a 2-56 or M2 screw with the counterbored Ø2.4 mm (Ø0.09") through hole. As measured from the bottom of the C-mount, the emission height is either 7.15 mm or 7.39 mm depending on the chosen QCL. Click on a laser's blue info icon ( ) and view the *Drawing* tab to find the laser's emission height. QCLs are electrically isolated from their C-mounts. Please see the *Handling* tab for more tips and information for handling these laser packages.

Mounts, Drivers, and Temperature Control
We generally recommend the LDMC20 C-Mount Laser Mount and ITC4002QCL or ITC4005QCL Dual Current / Temperature Controller for use with our distributed feedback QCLs. This device combination includes all the necessary components to mount, drive, and thermally regulate a two-tab C-mount laser. Other compatible current and temperature controllers are listed in the *Drivers* tab.

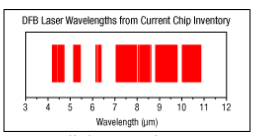
If designing your own mounting solution, note that due to these lasers' heat loads, we recommend that they be mounted in a thermally conductive housing to prevent heat buildup. Heat loads for distributed feedback QCLs can be up to 14.2 W (see the *Handling* tab for additional information).

The typical operating voltage of distributed feedback quantum cascade lasers is 9 - 14 V. These lasers do not have built-in monitor photodiodes and therefore cannot be operated in constant power mode.

ECL Butterfly Package
DBR Butterfly Package
ULN Hybrid Extended Butterfly Package
MIR DFB QCL, Two-Tab C-Mount
MIR DFB QCL, D-Mount
MIR DFB QCL, High Heat Load
Shop By Wavelength

- Our complete selection of laser diodes is available on the *LD Selection Guide* tab above.

Webpage Features	
	Clicking this icon opens a window that contains specifications and mechanical drawings.
	Clicking this icon allows you to download our standard support documentation.
Choose Item	Clicking the words "Choose Item" opens a drop-down list containing all of the in-stock lasers around the desired center wavelength. The red icon next to the serial number then allows you to download L-I-V and spectral measurements for that serial-numbered device.



Click to Enlarge
Available Wavelengths for Custom DFB Lasers

DFB QCLs at Custom Wavelengths

Thorlabs manufactures custom and OEM quantum cascade lasers in high volumes. We maintain chip inventory from 3 µm to 12 µm at our Jessup, Maryland laser manufacturing facility, and can deliver DFB lasers with custom center wavelengths that are qualified to a user-defined wavelength precision.
More details are available on the *Custom & OEM Lasers* tab. To inquire about pricing and availability, please contact us. A semiconductor specialist will contact you within 24 hours or the next business day.

DRIVERS

Use the tables below to select a compatible controller for our MIR lasers. The first table lists the controllers with which a particular MIR laser is compatible, and the second table contains selected information on each controller; complete information on each controller is available in its full web presentation. We particularly recommend our ITC4002QCL and ITC4005QCL controllers, which have high compliance voltages of 17 V and 20 V, respectively. Together, these drivers support the current and voltage requirements of our entire line of Mid-IR Lasers. To get L-I-V and spectral measurements of a specific, serial-numbered device, click "Choose Item" next to the part number below, then click on the Docs Icon next to the serial number of the device.

Table Key
Current Controllers
Dual Current / Temperature Controllers

Laser Mount Compatibility
Thorlabs' LDMC20 C-Mount Laser Mount ships with current and TEC cables for the LDC4005, ITC4001, ITC4002QCL, ITC4005, and ITC4005QCL controllers. If designing your own mounting solution, note that due to these lasers' heat loads, we recommend that they be secured in a thermally conductive housing to prevent heat buildup. Heat loads for distributed feedback QCLs can be up to 14.2 W.

Laser and Controller Compatibility

Laser Item #	Wavelength (Wavenumbers)	Current Controllers	Dual Current / Temperature Controllers
QD4500CM1	4.00 - 5.00 µm (2500 - 2000 cm^{-1})	-	ITC4002QCL, ITC4005QCL
QD5500CM1	5.00 - 6.00 µm (2000 - 1667 cm^{-1})	-	ITC4002QCL, ITC4005QCL

QD5250CM1	5.20 - 5.30 µm (1923 - 1887 cm^{-1})	LDC4005	ITC4002QCL, ITC4005, ITC4005QCL
QD6500CM1	6.00 - 7.00 µm (1667 - 1429 cm^{-1})	-	ITC4002QCL, ITC4005QCL
QD7500CM1	7.00 - 8.00 µm (1429 - 1250 cm^{-1})	-	ITC4002QCL, ITC4005QCL
QD8050CM1	8.00 - 8.10 µm (1250 - 1235 cm^{-1})	LDC4005	ITC4001, ITC4002QCL, ITC4005, ITC4005QCL
QD8500CM1	8.00 - 9.00 µm (1250 - 1111 cm^{-1})	-	ITC4002QCL, ITC4005QCL
QD9500CM1	9.00 - 10.00 µm (1111 - 1000 cm^{-1})	-	ITC4002QCL, ITC4005QCL
QD10500CM1	10.00 - 11.00 µm (1000 - 909 cm^{-1})	-	ITC4002QCL, ITC4005QCL

Controller Selection Guide

Controller Item #	Controller Type	Controller Package	Current Range	Current Resolution	Voltage	Cables for LDMC20 Laser Mount
LDC4005	Current	Large Benchtop (263 x 122 x 307 mm)	0 to 5 A	1 mA (Front Panel) 80 µA (Remote Control)	12 V	Included with LDMC20
ITC4001	Current / Temperature	Large Benchtop (263 x 122 x 307 mm)	0 to 1 A	100 µA (Front Panel) 16 µA (Remote Control)	11 V	Included with LDMC20
ITC4002QCL			0 to 2 A	100 µA (Front Panel) 32 µA (Remote Control)	17 V	Included with LDMC20
ITC4005			0 to 5 A	1 mA (Front Panel) 80 µA (Remote Control)	12 V	Included with LDMC20
ITC4005QCL					20 V	Included with LDMC20

HANDLING

Handling Two-Tab C-Mount Lasers

Proper precautions must be taken when handling and using two-tab C-mount lasers. Otherwise, permanent damage to the device will occur. Members of our Technical Support staff are available to discuss possible operation issues.

Do

- Provide External Temperature Regulation (e.g., Heat Sinks, Fans, and/or Water Cooling)
- Use a Constant Current Source Specifically Designed for Lasers
- Observe Static Avoidance Practices
- Be Careful When Making Electrical Connections

Do Not

- Use Thermal Grease
- Expose the Laser to Smoke, Dust, Oils, Adhesive Films, or Flux Fumes
- Blow on the Laser
- Drop the Laser Package

Avoid Static

Since these lasers are sensitive to electrostatic shock, they should always be handled using standard static avoidance practices.

Avoid Dust and Other Particulates

Unlike TO can and butterfly packages, the laser chip of a two-tab C-mount laser is exposed to air; hence, there is no protection for the delicate laser chip. Contamination of the laser facets must be avoided. Do not blow on the laser or expose it to smoke, dust, oils, or adhesive films. The laser facet is particularly sensitive to dust accumulation. During standard operation, dust can burn onto this facet, which will lead to premature degradation of the laser. If operating a two-tab C-mount laser for long periods of time outside a cleanroom, it should be sealed in a container to prevent dust accumulation.

Use a Current Source Specifically Designed for Lasers

These lasers should always be used with a high-quality constant current driver specifically designed for use with lasers, such as any current controller listed in the *Drivers* tab. Lab-grade power supplies will not provide the low current noise required for stable operation, nor will they prevent current spikes that result in immediate and permanent damage.

Thermally Regulate the Laser

Temperature regulation is required to operate the laser for any amount of time. The temperature regulation apparatus should be rated to dissipate the maximum heat load that can be drawn by the laser. For our quantum cascade lasers, this value can be up to 18 W. The LDMC20 C-Mount Laser Mount, which is compatible with our two-tab C-mount lasers, is rated for >20 W of heat dissipation.

The back face of the C-mount package is machined flat to make proper thermal contact with a heat sink. Ideally, the heat sink will be actively regulated to ensure proper heat conduction. A Thermoelectric Cooler (TEC) is well suited for this task and can easily be incorporated into any standard PID controller.

A fan may serve to move the heat away from the TEC and prevent thermal runaway. However, the fan should not blow air on or at the laser itself. Water cooling methods may also be employed for temperature regulation. Do not use thermal grease with this package, as it can creep, eventually contaminating the laser facet. Pyrolytic graphite is an acceptable alternatives to thermal grease for these packages. Solder can also be used to thermally regulate two-tab C-mount lasers, although controlling the thermal resistance at the interface is important for best results.

For assistance in picking a suitable temperature controller for your application please contact Tech Support.

Carefully Make Electrical Connections
When making electrical connections, care must be taken. The flux fumes created by soldering can cause laser damage, so care must be taken to avoid this. Solder can be avoided entirely for two-tab C-mount lasers by using the LDMC20 C-Mount Laser Mount. If soldering to the tabs, solder with the C-mount already attached to a heat sink to avoid unnecessary heating of the laser chip.

Minimize Physical Handling
As any interaction with the package carries the risk of contamination and damage, any movement of the laser should be planned in advance and carefully carried out. It is important to avoid mechanical shocks. Dropping the laser package from any height can cause the unit to permanently fail.

COLLIMATION

Choosing a Collimating Lens

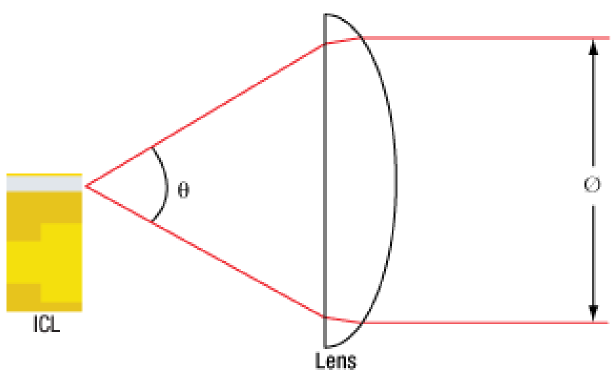
Since the output of our MIR lasers is highly divergent, collimating optics are necessary. Aspheric lenses, which are corrected for spherical aberration, are commonly chosen when the desired beam diameter is between 1 - 5 mm. The simple example below illustrates the key specifications to consider when choosing the correct lens for a given application.

The following example uses our previous generation 3.8 µm Interband Cascade Laser.

Key Specifications

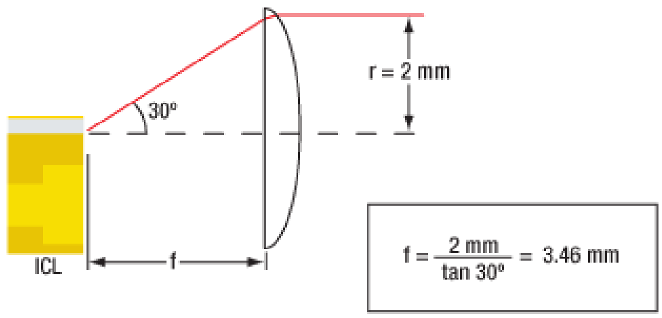
- Center Wavelength: 3.80 µm
- Parallel Beam Divergence Angle: 40°
- Perpendicular Beam Divergence Angle: 60°
- Desired Collimated Beam Diameter: 4 mm (Major Axis)

The specifications for the laser indicate that the typical parallel and perpendicular FWHM divergences are 40° and 60°, respectively. Therefore, as the light propagates, an elliptical beam will result. To collect as much light as possible during the collimation process, consider the larger of these two divergence angles in your calculations (in this case, 60°).



θ = Divergence Angle
Ø = Beam Diameter

Using the information above, the focal length needed to obtain the desired beam diameter can be calculated:



This information allows the appropriate collimating lens to be selected. Thorlabs offers a large selection of black diamond aspheric lenses for the mid-IR spectral range. Since this laser emits at 3.80 µm, the best AR coating is our -E coating, which provides R_{avg} < 0.6% per surface from 3 to 5 µm. The lenses with focal lengths closest to the calculated value of 3.46 mm are our 390036-E (unmounted) or C036TME-E (mounted) Molded Aspheric Lenses, which have f = 4.00 mm. Plugging this focal length back into the equation shown above gives a final beam diameter of 4.62 mm along the major axis.

Next, we verify that the numerical aperture (NA) of the lens is larger than the NA of the laser:

$$NA_{Lens} = 0.56$$

$$NA_{Laser} \sim \sin(30°) = 0.5$$

$$NA_{Lens} > NA_{Laser}$$

Since $NA_{Lens} > NA_{Laser}$, the 390036-E or C036TME-E lenses will give acceptable beam quality. However, by using the FWHM beam diameter, we have not accounted for a significant fraction of the beam power. A better practice is to use the $1/e^2$ beam diameter. For a Gaussian beam profile, the $1/e^2$ beam diameter is approximately equal to 1.7X the FWHM diameter. The $1/e^2$ beam diameter is therefore a more conservative estimate of the beam size, containing more of the laser's intensity. Using this value significantly reduces far-field diffraction (since less of the incident light is clipped) and increases the power delivered after the lens.

A good rule of thumb is to pick a lens with an NA of twice the NA of the laser diode. For example, either the 390037-E or the C037TME-E could be used as these lenses each have an NA of 0.85, which a little less than twice that of our IF3800CM2 laser (NA 0.5). Compared to the first set of lenses we identified, these have a shorter focal length of 1.873 mm, resulting in a smaller final beam diameter of 2.16 mm.

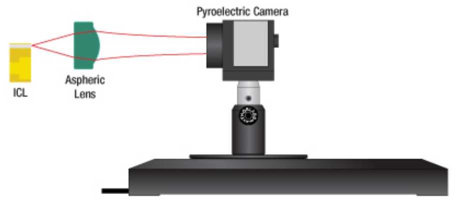
M ² & N B S P ; M E A S U R E M E N T

Beam Profile Characterization of a Mid-IR Laser

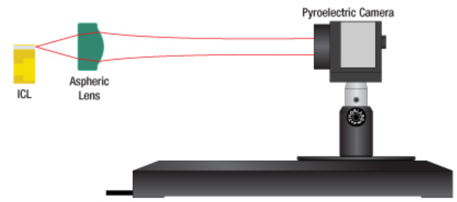
Because quantum cascade lasers (QCLs) and interband cascade lasers (ICLs) have intrinsically large divergence angles, it is necessary to install collimating optics in front of the laser face, as shown in the *Collimation* tab. We are frequently asked what beam quality can be reasonably expected once the beam has been collimated. This tab presents an M^2 measurement we performed using our previous generation 3.80 µm Interband Cascade Laser.

For this system, we obtained $M^2 = 1.2 \pm 0.08$ in the parallel direction and $M^2 = 1.3 \pm 0.2$ in the perpendicular direction. While this is just one example, we believe these results to be representative of well-collimated mid-IR lasers manufactured by Thorlabs, as corroborated by supplementary measurements we have performed in-house.

Experimental Setup



Click to Enlarge
Pyroelectric Camera Upstream of Focus



Click to Enlarge
Pyroelectric Camera Downstream of Focus

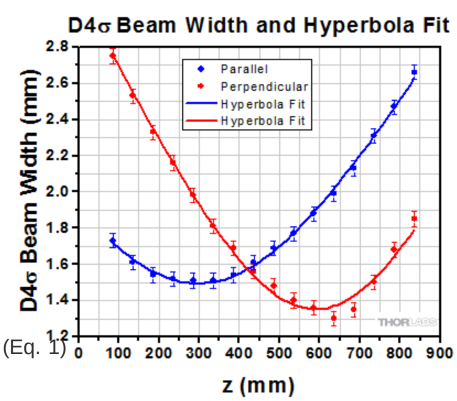
The apparatus we used to determine M^2 is shown schematically in the figure above. In order to ensure that our results were rigorous, all data acquisition and analysis were consistent with the ISO11146 standard.

The previous generation Interband Cascade Laser used for this measurement emitted CW laser light with a center wavelength of 3.781 µm. Our LDMC20 temperature-stabilized mount held the laser's temperature at 25 °C. The output beam was collimated by a C037TME-E lens located immediately downstream of the laser face. This lens was selected because of its large NA of 0.85 (which helped maximize collection of the emitted light) and because of its AR coating (R_{avg} < 0.6% per surface from 3 µm to 5 µm). We measured 10 mW of output power after the lens.

A pyroelectric camera (Spiricon Pyrocam IV) with 80 µm square pixels was scanned along the beam propagation direction, and the beam width was measured along the parallel and perpendicular directions using the second-order moment (D4σ) definition. Hyperbolas were fit to the beam width to extract M^2 for each direction. The camera's internal chopper was triggered at 50 Hz since the pyroelectric effect is sensitive to changes in temperature rather than absolute temperature differences. A ZnSe window was present in front of the detector array to help minimize visible light contributions to the signal.

Data Analysis

Presented to the right are the second-order moment (D4σ) beam widths for the parallel and perpendicular directions as a function of distance from the laser face (denoted as z). Along the parallel direction, we obtained a minimum beam width of 1.5 mm, while along the perpendicular direction, we obtained a minimum beam width of 1.3 mm. The spatial profiles we observed at the two minimum beam width positions, as obtained by the pyroelectric camera, are shown below.



Click to Enlarge
D4σ Beam Width of Collimated IF3800CM2 Laser

The divergence of the beam can be described by a hyperbola, as written in Equation 1:

$$D4\sigma(z) = \sqrt{a + bz + cz^2} \quad \text{(Eq. 1)}$$

In order to obtain the hyperbola coefficients a, b, and c for the parallel and perpendicular directions, we fit the discrete beam width measurements along each direction to hyperbolas, as shown in the graph to the right. These coefficients were substituted into Equation 2 (taking λ = 3.781 µm) to yield M^2.

$$M^2 = \frac{\pi}{8\lambda}\sqrt{4ac - b^2} \quad \text{(Eq. 2)}$$

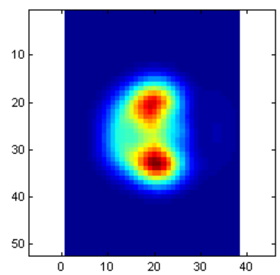
The hyperbola coefficients and M^2 values derived by this method are listed in the table below.

Value	Parallel	Perpendicular
a	3.6 ± 0.1 mm^2	9.7 ± 0.2 mm^2
b	-0.0096 ± 0.0007 mm	-0.0268 ± 0.0008 mm
c	(1.61 ± 0.08) × 10^{-5}	(2.27 ± 0.08) × 10^{-5}

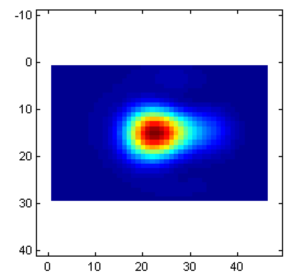
M^2	1.2 ± 0.08	1.3 ± 0.2

The 0.85 NA of the collimating lens we used is the largest NA of any lens for this wavelength range that is offered in our catalog. Despite this large NA, we observed lobes in the far field (shown by the figure below) that are consistent with clipping of the laser-emitted light. An ideal measurement would not contain these artifacts.

As shown by the graph above and to the right, we observed significant astigmatism in the collimated beam: the beam waist of the parallel direction occurred around z = 300 mm, while the beam waist of the perpendicular direction occurred around z = 600 mm. This astigmatism corresponds closely to what is expected for this laser, given that the IF3800CM2 laser is specified with a parallel FWHM beam divergence of 40° and a perpendicular FWHM beam divergence of 60°.



Beam Profile at Beam Waist of Parallel Direction
(Each Pixel is 80 µm Square)



Beam Profile at Beam Waist of Perpendicular Direction
(Each Pixel is 80 µm Square)

SPECTROSCOPY

Gas-Phase Spectroscopy Using Distributed Feedback Lasers

Distributed Feedback Quantum Cascade Lasers (DFB QCLs) offer many attractive features for spectroscopy. They emit at a single wavelength within the mid-IR, where many gaseous species characteristically absorb. Moreover, their emission wavelength is easily tuned (typical tuning range: 1 - 5 cm^{-1}) by changing the drive current and operating temperature of the laser, making them ideal for isolating narrow gas absorption lines. Finally, they offer relatively high output power (typically 40 - 120 mW at rollover current), helping improve measurement sensitivity.

Thorlabs' DFB QCLs emit at wavelengths that range from 4.00 to 11.00 µm (2500 cm^{-1} to 909 cm^{-1}). If we do not stock the wavelength required for your application, custom wavelengths are available by contacting Tech Support.

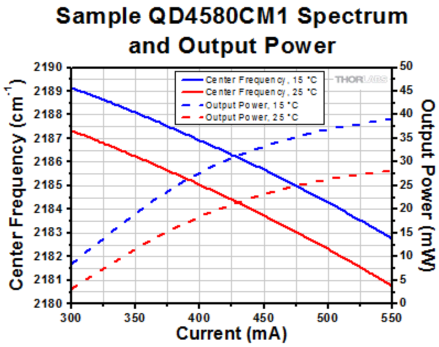
Selected Distributed Feedback QCLs[a]		
Item #	**Nominal Center Frequency**	**Targeted Gas(es)**
QD8050CM1	1242 cm^{-1} (8.05 µm)	CH_4 (Methane) HONO (Nitrous Acid)
QD5250CM1	1905 cm^{-1} (5.25 µm)	NO (Nitric Oxide)

a. This table is intended as a reference. Each DFB QCL is a unique device with its own spectrum, and does not necessarily emit at the exact absorption line required for a given experiment. To verify that the QCL you receive will meet your needs, please download its data sheet. Click "Choose Item" below, then click on the Docs icon ( ) next to the serial number of the laser.

The tuning range of individual DFB QCLs depends greatly on the actual laser device. Each DFB QCL is a unique device with its own threshold current, rollover current, and spectrum. With typical lasers, it is usually preferable to operate the laser at or near the rollover current, since the output power is lowest at threshold and highest at rollover. On the other hand, the wavelength of DFB QCLs changes as a function of the current, so operating at the rollover current is not always possible in spectroscopy measurements, which require specific wavelengths. (It is important to note that the output power is not constant over the entire tuning range.)

Tuning Example

To demonstrate DFB QCLs' tunability, we measured the center wavelength of a previous-generation QD4580CM1 laser as a function of drive current, from threshold to near rollover, at 15 °C and 25 °C. Over the entire temperature and drive current range, we obtained center wavelengths from 4.568 µm to 4.586 µm (2189.14 cm^{-1} to 2180.77 cm^{-1}), spanning a range of 18 nm (8.37 cm^{-1}), with output power ranging from 3.2 mW (at threshold current) to 39.1 mW (at near-rollover current). Since the laser is capable of operating at 35 °C, even broader wavelength tuning is also achievable.



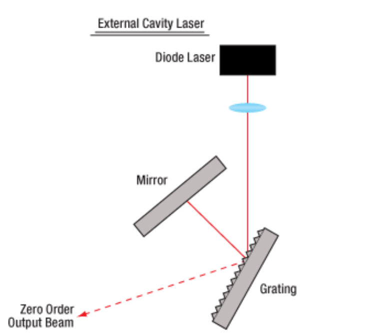
Click to Enlarge
DFB QCL Center Frequency as Function of Temperature and Drive Current

Sample QD4580CM1[a] Spectrum and Output Power				
Current	15 °C		25 °C	
	Center Frequency	Output Power	Center Frequency	Output Power
300 mA	2189.14 cm^{-1} (4.568 µm)	8.4 mW	2187.34 cm^{-1} (4.572 µm)	3.2 mW
350 mA	2188.12 cm^{-1} (4.570 µm)	19.6 mW	2186.26 cm^{-1} (4.574 µm)	11.9 mW
400 mA	2186.92 cm^{-1} (4.573 µm)	28.3 mW	2185.05 cm^{-1} (4.577 µm)	18.9 mW
450 mA	2185.71 cm^{-1} (4.575 µm)	33.7 mW	2183.78 cm^{-1} (4.579 µm)	23.5 mW
500 mA	2184.33 cm^{-1} (4.578 µm)	37.1 mW	2182.34 cm^{-1} (4.582 µm)	26.6 mW
550 mA	2182.76 cm^{-1} (4.581 µm)	39.1 mW	2180.77 cm^{-1} (4.586 µm)	28.2 mW

a. The QD4580CM1 is a previous-generation laser.

SFL GUIDE

ECL, DFB, VHG-Stabilized, and DBR Single-Frequency Lasers



Click to Enlarge
Figure 1: ECL Lasers have a Grating Outside of the Gain Chip

A wide variety of applications require tunable single-frequency operation of a laser system. In the world of diode lasers, there are currently four main configurations to obtain a single-frequency output: external cavity laser (ECL), distributed feedback (DFB), volume holographic grating (VHG), and distributed Bragg reflector (DBR). All four are capable of single-frequency output through the utilization of grating feedback. However, each type of laser uses a different grating feedback configuration, which influences performance characteristics such as output power, tuning range, and side mode suppression ratio (SMSR). We discuss below some of the main differences between these four types of single-frequency diode lasers.

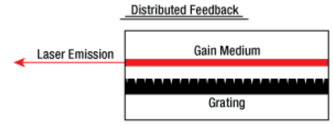
External Cavity Laser

The External Cavity Laser (ECL) is a versatile configuration that is compatible with most standard free space diode lasers. This means that the ECL can be used at a variety of wavelengths, dependent upon the internal laser diode gain element. A lens collimates the output of the diode, which is then incident upon a grating (see Figure 1). The grating provides optical feedback and is used to select the stabilized output wavelength. With proper optical design, the external cavity allows only a single longitudinal mode to lase, providing single-frequency laser output with high side mode suppression ratio (SMSR > 45 dB).

One of the main advantages of the ECL is that the relatively long cavity provides extremely narrow linewidths (<1 MHz). Additionally, since it can incorporate a variety of laser diodes, it remains one of the few configurations that can provide narrow linewidth emission at blue or red wavelengths. The ECL can have a large tuning range (>100 nm) but is often prone to mode hops, which are very dependent on the ECL's mechanical design as well as the quality of the antireflection (AR) coating on the laser diode.

Distributed Feedback Laser

The Distributed Feedback (DFB) Laser (available in NIR and MIR) incorporates the grating within the laser diode structure itself (see Figure 2). This corrugated periodic structure coupled closely to the active region acts as a Bragg reflector, selecting a single longitudinal mode as the lasing mode. If the active region has enough gain at frequencies near the Bragg frequency, an end reflector is unnecessary, relying instead upon the Bragg reflector for all optical feedback and mode selection. Due to this "built-in" selection, a DFB can achieve single-frequency operation over broad temperature and current ranges. To aid in mode selection and improve manufacturing yield, DFB lasers often utilize a phase shift section within the diode structure as well.



Click to Enlarge
Figure 2: DFB Lasers Have a Bragg Reflector Along the Length of the Active Gain Medium

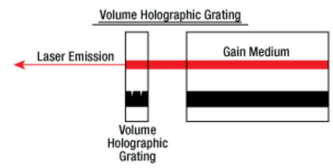
The lasing wavelength for a DFB is approximately equal to the Bragg wavelength:

$$\lambda = 2n_{eff}\Lambda$$

where λ is the wavelength, n_{eff} is the effective refractive index, and Λ is the grating period. By changing the effective index, the lasing wavelength can be tuned. This is accomplished through temperature and current tuning of the DFB.

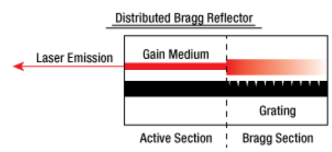
The DFB has a relatively narrow tuning range: about 2 nm at 850 nm, about 4 nm at 1550 nm, or at least 1 cm^{-1} in the mid-IR (4.00 - 11.00 µm). However, over this tuning range, the DFB can achieve single-frequency operation, which means that this is a continuous tuning range without mode hops. Because of this feature, DFBs have become a popular and majority choice for real-world applications such as telecom and sensors. Since the cavity length of a DFB is rather short, the linewidths are typically in the 1 MHz to 10 MHz range. Additionally, the close coupling between the grating structure and the active region results in lower maximum output power compared to ECL and DBR lasers.

Volume-Holographic-Grating-Stabilized Laser
A Volume-Holographic-Grating-(VHG)-Stabilized Laser also uses a Bragg reflector, but in this case a transmission grating is placed in front of the laser diode output (see Figure 3). Since the grating is not part of the laser diode structure, it can be thermally decoupled from the laser diode, improving the wavelength stability of the device. The grating typically consists of a piece of photorefractive material (typically glass) which has a periodic variation in the index of refraction. Only the wavelength of light that satisfies the Bragg condition for the grating is reflected back into the laser cavity, which results in a laser with extremely wavelength-stable emission. A VHG-Stabilized laser can produce output with a similar linewidth to a DFB laser at higher powers that is wavelength-locked over a wide range of currents and temperatures.



Click to Enlarge
Figure 3: VHG Lasers have a Volume Holographic Grating Outside of the Active Gain Medium

Distributed Bragg Reflector Laser
Similar to DFBs, Distributed Bragg Reflector (DBR) lasers incorporate an internal grating structure. However, whereas DFB lasers incorporate the grating structure continuously along the active region (gain region), DBR lasers place the grating structure(s) outside this region (see Figure 4). In general a DBR can incorporate various regions not typically found in a DFB that yield greater control and tuning range. For instance, a multiple-electrode DBR laser can include a phase-controlled region that allows the user to independently tune the phase apart from the grating period and laser diode current. When utilized together, the DBR can provide single-frequency operation over a broad tuning range. For example, high end sample-grating DBR lasers can have a tuning range as large as 30 - 40 nm. Unlike the DFB, the output is not mode hop free; hence, careful control of all inputs and temperature must be maintained.



Click to Enlarge
Figure 4: DBR Lasers have a Bragg Reflector Outside of the Active Gain Medium

In contrast to the complicated control structure for the multiple-electrode DBR, a simplified version of the DBR is engineered with just one electrode. This single-electrode DBR eliminates the complications of grating and phase control at the cost of tuning range. For this architecture type, the tuning range is similar to a DFB laser but will mode hop as a function of the applied current and temperature. Despite the disadvantage of mode hops, the single-electrode DBR does provide some advantages over its DFB cousin, namely higher output power because the grating is not continuous along the length of the device. Both DBR and DFB lasers have similar laser linewidths. Currently, Thorlabs offers only single-electrode DBR lasers.

Conclusion
ECL, DFB, VHG, and DBR laser diodes provide single-frequency operation over their designed tuning range. The ECL can be designed for a larger selection of wavelengths than either the DFB or DBR. While prone to mode hops, it also provides the narrowest linewidth (<1 MHz) of the three choices. In appropriately designed instruments, ECLs can also provide extremely broad tuning ranges (>100 nm).

The DFB laser is the most stable single-frequency, tunable laser of the four. It can provide mode-hop-free performance over its entire tuning range, making it one of the most popular forms of single-frequency laser for much of industry. It has the lowest output power due to inherent properties of the continuous grating feedback structure.

The VHG laser provides the most stable wavelength performance over a range of temperatures and currents and can provide higher powers than are typical in

DFB lasers. This stability makes it excellent for use in OEM applications.

The single-electrode DBR laser provides similar linewidth and tuning range as the DFB (<5 nm). However, the single-electrode DBR will have periodic mode hops in its tuning curve.

CUSTOM & OEM LASERS

Custom & OEM Quantum Cascade and Interband Cascade Lasers

At our semiconductor manufacturing facility in Jessup, Maryland, we build a wide range of mid-IR lasers and gain chips. Our engineering team performs in-house epitaxial growth, wafer fabrication, and laser packaging. We maintain chip inventory from 3 µm to 12 µm, and our vertically integrated facilities are well equipped to fulfill unique requests.

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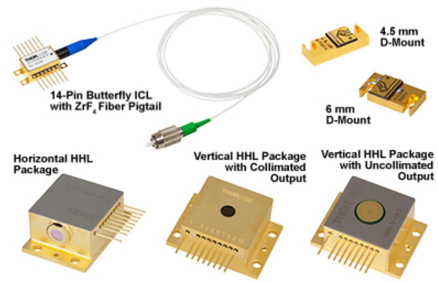
Wire Bonding a Quantum Cascade Laser on a C-Mount



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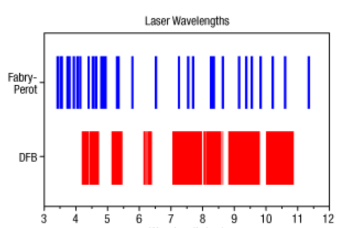
Some of Our Available Packages

High-Power Fabry-Perot QCLs
For Fabry-Perot lasers, we can reach multi-watt output power on certain custom orders. The available power depends upon several factors, including the wavelength and the desired package.

DFB QCLs at Custom Wavelengths
For distributed feedback (DFB) lasers, we can deliver a wide range of center wavelengths with user-defined wavelength precision. Our semiconductor specialists will take your application requirements into account when discussing the options with you.

The graphs below and photos to the right illustrate some of our custom capabilities. Please visit our semiconductor manufacturing capabilities presentation to learn more.

Contact Us



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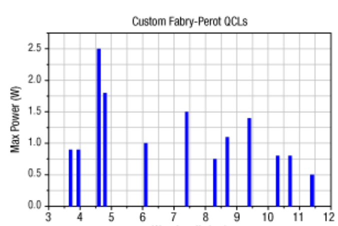
Available Wavelengths for Custom QCLs and ICLs



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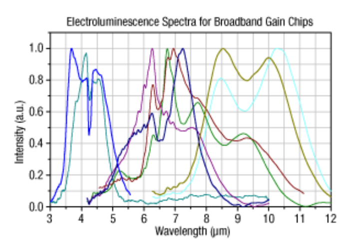
Maximum Output Power of Custom Fabry-Perot QCLs



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Electroluminescence Spectra of Available Gain Chip Material

INSIGHTS

Insights into QCLs and ICLs

Scroll down to read about:

- QCLs and ICLs: Operating Limits and Thermal Rollover

Click here for more insights into lab practices and equipment.

Insights
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QCLs and ICLs: Operating Limits and Thermal Rollover

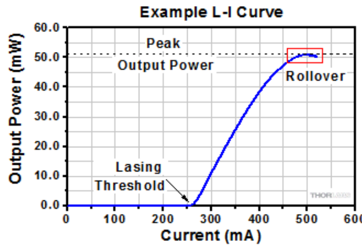

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Figure 1: This example of an L-I curve for a QCL laser illustrates the typical non-linear slope and rollover region exhibited by QCL and ICL lasers. Operating parameters determine the heat load carried by the lasing region, which influences the peak output power. This laser was installed in a temperature controlled mount set to 25 °C.

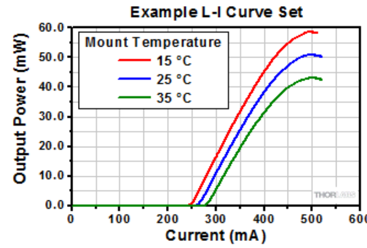

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Figure 2: This set of L-I curves for a QCL laser illustrates that the mount temperature can affect the peak operating temperature, but that using a temperature controlled mount does not remove the danger of applying a driving current large enough to exceed the rollover point and risk damaging the laser.

The light vs. driving current (L-I) curves measured for quantum and interband cascade Lasers (QCLs and ICLs) include a rollover region, which is enclosed by the red box in Figure 1.

The rollover region includes the peak output power of the laser, which corresponds to a driving current of just under 500 mA in this example. Applying higher drive currents risks damaging the laser.

Laser Operation

These lasers operate by forcing electrons down a controlled series of energy steps, which are created by the laser's semiconductor layer structure and an applied bias voltage. The driving current supplies the electrons.

An electron must give up some of its energy to drop down to a lower energy level. When an electron descends one of the laser's energy steps, the electron loses energy in the form of a photon. But, the electron can also lose energy by giving it to the semiconductor material as heat, instead of emitting a photon.

Heat Build Up

Lasers are not 100% efficient in forcing electrons to surrender their energy in the form of photons. The electrons that lose their energy as heat cause the temperature of the lasing region to increase.

Conversely, heat in the lasing region can be absorbed by electrons. This boost in energy can scatter electrons away from the path leading down the laser's energy steps. Later, scattered electrons typically lose energy as heat, instead of as photons.

As the temperature of the lasing region increases, more electrons are scattered, and a smaller fraction of them produce light instead of heat. Rising temperatures can also result in changes to the laser's energy levels that make it harder for electrons to emit photons. These processes work together to increase the temperature of the lasing region and to decrease the efficiency with which the laser converts current to laser light.

Operating Limits are Determined by the Heat Load

Ideally, the slope of the L-I curve would be linear above the threshold current, which is around 270 mA in Figure 1. Instead, the slope decreases as the driving current increases, which is due to the effects from the rising temperature of the lasing region. Rollover occurs when the laser is no longer effective in converting additional current to laser light. Instead, the extra driving creates only heat. When the current is high enough, the strong localized heating of the laser region will cause the laser to fail.

A temperature controlled mount is typically necessary to help manage the temperature of the lasing region. But, since the thermal conductivity of the semiconductor material is not high, heat can still build up in the lasing region. As illustrated in Figure 2, the mount temperature affects the peak optical output power but does not prevent rollover.

The maximum drive current and the maximum optical output power of QCLs and ICLs depend on the operating conditions, since these determine the heat load of the lasing region.

Date of Last Edit: Dec. 4, 2019

4.00 - 5.00 µm Center Wavelength DFB QCL

Item #	Info	Center Wavelength[a]	Tuning Range (Typ.)	Power[b]	Max Operating Current[b]	Wavelength Tested	Spatial Mode
QD4500CM1	i	Varies from 4.00 to 5.00 µm (2500 - 2000 cm^{-1})	2 cm^{-1}	40 mW (Typ.)	500 mA[c]	Yes	Single

a. This laser emits at a well defined wavelength that can be tuned over a narrow range. Each device has different optical characteristics. To get the spectrum

and output power of a specific, serial-numbered device, click "Choose Item" below, then click on the Docs Icon next to the serial number. If you need a wavelength that is not listed below, please contact us.
b. Do not exceed the maximum optical power or maximum drive current, whichever occurs first.
c. Please note that the absolute maximum current is determined on a device-by-device basis. It is listed on the device's data sheet. To view, click "Choose Item" below, then click on the Docs Icon next to the serial number.

Part Number	Description	Price	Availability
QD4500CM1	DFB QCL, 4.00 - 5.00 µm CWL, 2 cm^{-1} Tuning, 40 mW, Two-Tab C-Mount	$6,000.00 Volume Pricing Available	Today
QD4500CM1	4.626 - 4.629 µm, 21 mW Max, Distributed Feedback QCL	$6,000.00 Volume Pricing Available	7-10 Days
QD4500CM1	4.666 - 4.679 µm, 35 mW Max,Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today
QD4500CM1	4.496 - 4.506 µm, 184 mW Max, Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today

5.00 - 6.00 µm Center Wavelength DFB QCLs

Item #	Info	Center Wavelength[a]	Tuning Range (Typ.)	Power[b]	Max Operating Current[b]	Wavelength Tested	Spatial Mode
QD5500CM1[c]		Varies from 5.00 to 6.00 µm (2000 to 1667 cm^{-1})	2.5 cm^{-1}	40 mW (Typ.)	700 mA[d]	Yes	Single
QD5250CM1[c]		Varies from 5.20 to 5.30 µm (1923 - 1887 cm^{-1})	4 cm^{-1}	120 mW (Typ.)	660 mA	Yes	Single

a. These lasers emit at a well defined wavelength that can be tuned over a narrow range. Each device has different optical characteristics. To get the spectrum and output power of a specific, serial-numbered device, click "Choose Item" below, then click on the Docs Icon next to the serial number. If you need a wavelength that is not listed below, please contact us.
b. Do not exceed the maximum optical power or maximum drive current, whichever occurs first.
c. If broadband emission is preferred, please consider our 5.30 µm Fabry-Perot Lasers.
d. Please note that the absolute maximum current is determined on a device-by-device basis. It is listed on the device's data sheet. To view, click "Choose Item" below, then click on the Docs Icon next to the serial number.

Part Number	Description	Price	Availability
QD5500CM1	DFB QCL, 5.00 - 6.00 µm CWL, 2.5 cm^{-1} Tuning, 40 mW, Two-Tab C-Mount	$6,000.00 Volume Pricing Available	Today
QD5500CM1	5.440 - 5.451 µm, 101 mW Max, Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today
QD5500CM1	5.454 - 5.465 µm, 52 mW Max, Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today
QD5500CM1	5.390 - 5.401 µm, 50 mW Max, Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today
QD5500CM1	5.408 - 5.415 µm, 73 mW Max, Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today
QD5500CM1	5.325 - 5.331 µm, 41 mW Max,Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today
QD5500CM1	5.334 - 5.344 µm, 203 mW Max,Distributed Feedback QCL	$6,000.00 Volume Pricing Available	Today
QD5500CM1	5.337 - 5.345 µm, 36 mW Max,Distributed Feedback QCL	$6,000.00 Volume Pricing Available	7-10 Days
QD5250CM1	DFB QCL, 5.20 - 5.30 µm CWL, 4 cm^{-1} Tuning, 120 mW, Two-Tab C-Mount	$6,000.00 Volume Pricing Available	Lead Time

6.00 - 7.00 µm Center Wavelength DFB QCL

Item #	Info	Center Wavelength[a]	Tuning Range (Typ.)	Power[b]	Max Operating Current[b]	Wavelength Tested	Spatial Mode
QD6500CM1		Varies from 6.00 to 7.00 µm (1667 - 1429 cm^{-1})	2 cm^{-1}	40 mW (Typ.)	650 mA[c]	Yes	Single

a. This laser emits at a well defined wavelength that can be tuned over a narrow range. Each device has different optical characteristics. To get the spectrum and output power of a specific, serial-numbered device, click "Choose Item" below, then click on the Docs Icon next to the serial number. If you need a wavelength that is not listed below, please contact us.
b. Do not exceed the maximum optical power or maximum drive current, whichever occurs first.
c. Please note that the absolute maximum current is determined on a device-by-device basis. It is listed on the device's data sheet. To view, click "Choose Item" below, then click on the Docs Icon next to the serial number.

Part Number	Description	Price	Availability
QD6500CM1	**DFB QCL, 6.00 - 7.00 µm CWL, 2 cm^{-1} Tuning, 40 mW, Two-Tab C-Mount**	**$6,000.00** **Volume Pricing Available**	**Today**
QD6500CM1	**6.078 - 6.090 µm, 24 mW Max, Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD6500CM1	**6.066 - 6.076 µm, 22 mW Max, Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**

7.00 - 8.00 µm Center Wavelength DFB QCLs

Item #	Info	Center Wavelength[a]	Tuning Range (Typ.)	Power[b]	Max Operating Current[b]	Wavelength Tested	Spatial Mode
QD7500CM1[c]		Varies from 7.00 to 8.00 µm (1429 - 1250 cm^{-1})	1.5 cm^{-1}	40 mW (Typ.)	600 mA[d]	Yes	Single

a. These lasers emit at a well defined wavelength that can be tuned over a narrow range. Each device has different optical characteristics. To get the spectrum and output power of a specific, serial-numbered device, click "Choose Item" below, then click on the Docs Icon next to the serial number. If you need a wavelength that is not listed below, please contact us.
b. Do not exceed the maximum optical power or maximum drive current, whichever occurs first.
c. If broadband emission is preferred, please consider our 7.70 µm Fabry-Perot Lasers.
d. Please note that the absolute maximum current is determined on a device-by-device basis. It is listed on the device's data sheet. To view, click "Choose Item" below, then click on the Docs Icon next to the serial number.

Part Number	Description	Price	Availability
QD7500CM1	**DFB QCL, 7.00 - 8.00 µm CWL, 1.5 cm^{-1} Tuning, 40 mW, Two-Tab C-Mount**	**$6,000.00** **Volume Pricing Available**	**Today**
QD7500CM1	**7.307 - 7.325 µm,185 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**7-10 Days**
QD7500CM1	**7.308 - 7.333 µm,258 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD7500CM1	**7.815 - 7.824 µm,90 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**

8.00 - 9.00 µm Center Wavelength DFB QCLs

Item #	Info	Center Wavelength[a]	Tuning Range (Typ.)	Power[b]	Max Operating Current[b]	Wavelength Tested	Spatial Mode
QD8050CM1		Varies from 8.00 to 8.10 µm (1250 - 1235 cm^{-1})	2.5 cm^{-1}	100 mW (Typ.)	1000 mA	Yes	Single
QD8500CM1[c]		Varies from 8.00 to 9.00 µm (1250 - 1111 cm^{-1})	2.5 cm^{-1}	100 mW (Typ.)	900 mA[d]	Yes	Single

a. These lasers emit at a well defined wavelength that can be tuned over a narrow range. Each device has different optical characteristics. To get the spectrum and output power of a specific, serial-numbered device, click "Choose Item" below, then click on the Docs Icon next to the serial number. If you need a wavelength that is not listed below, please contact us.
b. Do not exceed the maximum optical power or maximum drive current, whichever occurs first.
c. If broadband emission is preferred, please consider our 8.35 µm Fabry-Perot Lasers.
d. Please note that the absolute maximum current is determined on a device-by-device basis. It is listed on the device's data sheet. To view, click "Choose Item" below, then click on the Docs Icon next to the serial number.

Part Number	Description	Price	Availability
QD8050CM1	**Customer Inspired! DFB QCL, 8.00 - 8.10 µm CWL, 2.5 cm^{-1} Tuning, 100 mW, Two-Tab C-Mount**	**$6,000.00 Volume Pricing Available**	**Today**
QD8050CM1	**Customer Inspired! 8.052 - 8.077 µm, 115 mW Max,Distributed Feedback QCL**	**$6,000.00 Volume Pricing Available**	**Today**
QD8050CM1	**Customer Inspired! 8.013 - 8.049 µm, 50 mW Max, Distributed Feedback QCL**	**$6,000.00 Volume Pricing Available**	**Today**
QD8500CM1	**DFB QCL, 8.00 - 9.00 µm CWL, 2.5 cm^{-1} Tuning, 100 mW, Two-Tab C-Mount**	**$6,000.00 Volume Pricing Available**	**Today**
QD8500CM1	**8.860 - 8.900 µm, 115 mW Max, Distributed Feedback QCL**	**$6,000.00 Volume Pricing Available**	**Today**
QD8500CM1	**8.561 - 8.591 µm, 79 mW Max, Distributed Feedback QCL**	**$6,000.00 Volume Pricing Available**	**Today**

9.00 - 10.00 µm Center Wavelength DFB QCL

Item #	Info	Center Wavelength[a]	Tuning Range (Typ.)	Power[b]	Max Operating Current[b]	Wavelength Tested	Spatial Mode
QD9500CM1		Varies from 9.00 to 10.00 µm (1111 - 1000 cm^{-1})	2.5 cm^{-1}	60 mW (Typ.)	800 mA[c]	Yes	Single

a. This laser emits at a well defined wavelength that can be tuned over a narrow range. Each device has different optical characteristics. To get the spectrum and output power of a specific, serial-numbered device, click "Choose Item" below, then click on the Docs Icon next to the serial number. If you need a wavelength that is not listed below, please contact us.
b. Do not exceed the maximum optical power or maximum drive current, whichever occurs first.
c. Please note that the absolute maximum current is determined on a device-by-device basis. It is listed on the device's data sheet. To view, click "Choose Item" below, then click on the Docs Icon next to the serial number.

Part Number	Description	Price	Availability

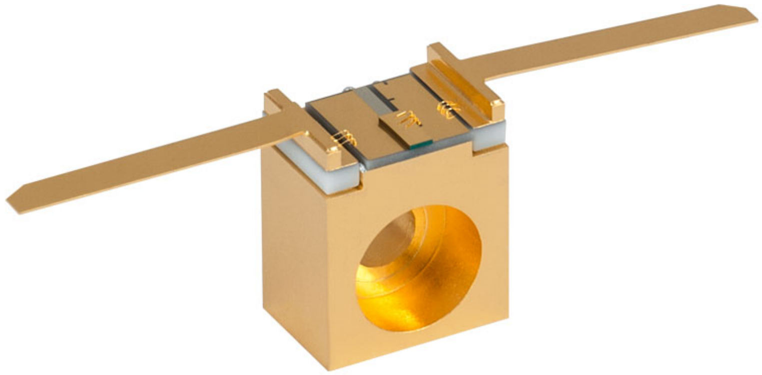
QD9500CM1	**DFB QCL, 9.00 - 10.00 µm CWL, 2.5 cm^{-1} Tuning, 60 mW, Two-Tab C-Mount**	**$6,000.00** **Volume Pricing Available**	**Today**
QD9500CM1	**9.445 - 9.459 µm, 153 mW Max, Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD9500CM1	**9.623 - 9.645 µm, 121 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD9500CM1	**9.600 - 9.624 µm, 137 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD9500CM1	**9.622 - 9.646 µm, 192 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**

10.00 - 11.00 µm Center Wavelength DFB QCL

Item #	Info	Center Wavelength[a]	Tuning Range (Typ.)	Power[b]	Max Operating Current[b]	Wavelength Tested	Spatial Mode
QD10500CM1		Varies from 10.00 to 11.00 µm (1000 - 909 cm^{-1})	2 cm^{-1}	40 mW (Typ.)	600 mA[c]	Yes	Single

a. This laser emits at a well defined wavelength that can be tuned over a narrow range. Each device has different optical characteristics. To get the spectrum and output power of a specific, serial-numbered device, click "Choose Item" below, then click on the Docs Icon next to the serial number. If you need a wavelength that is not listed below, please contact us.
b. Do not exceed the maximum optical power or maximum drive current, whichever occurs first.
c. Please note that the absolute maximum current is determined on a device-by-device basis. It is listed on the device's data sheet. To view, click "Choose Item" below, then click on the Docs Icon next to the serial number.

Part Number	Description	Price	Availability
QD10500CM1	**DFB QCL, 10.00 - 11.00 µm CWL, 2 cm^{-1} Tuning, 40 mW, Two-Tab C-Mount**	**$6,000.00** **Volume Pricing Available**	**Today**
QD10500CM1	**10.362 - 10.392 µm, 49 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD10500CM1	**10.416 - 10.443 µm, 111 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD10500CM1	**10.313 - 10.344 µm, 77 mW Max,Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**
QD10500CM1	**10.533 - 10.564 µm, 44 mW Max, Distributed Feedback QCL**	**$6,000.00** **Volume Pricing Available**	**Today**



Specs | Spectrum | L-I-V Curve | Far Field | Drawing

Optical Electrical Characteristics (T_{CASE} = 25 °C, CW Current Operation)				
Characteristic	**Min**	**Typ.**	**Max**	**Unit**
Wavelength at Minimum Operating Power	5.20	5.25	5.30	µm
Tuning Range	-	4	-	cm^{-1}
Temperature Tuning	-	-0.19	-	cm^{-1}/°C
Side Mode Suppression	20	-	-	dB
Optical Output Power	20	120	-	mW
Beam Divergence (FWHM) - Perpendicular	-	52	-	deg.
Beam Divergence (FWHM) - Parallel	-	41	-	deg.
Forward Voltage	-	10.2	12.0	V
Operating Current	-	-	660	mA
Threshold Current	-	380	450	mA
Slope Efficiency	-	0.75	-	W/A

Absolute Maximum Ratings[a] (T_{CASE} = 25 °C)		
Characteristic	**Value**	**Unit**
Optical Output Power (CW)	250	mW
LD Reverse Voltage	1	V
Operating Current	660	mA
Operating Temperature[b]	15 to 35	°C
Storage Temperature[b]	-40 to 85	°C

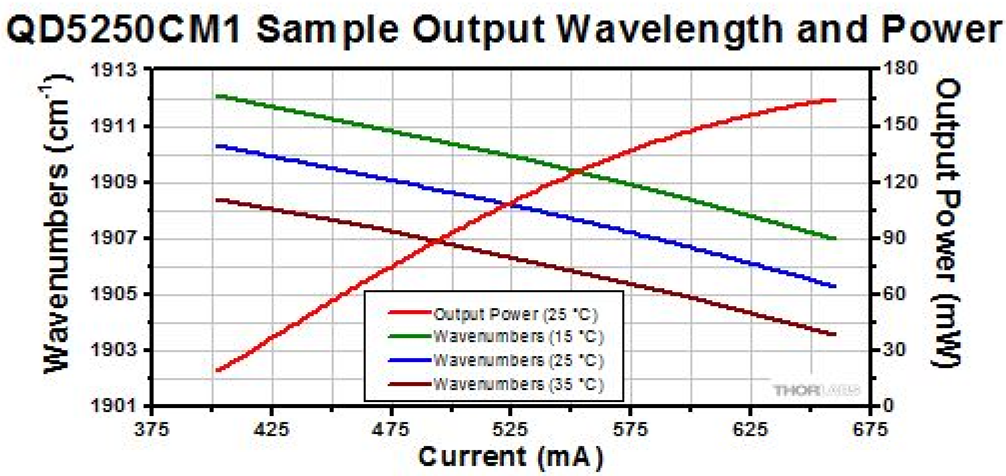
a. These lasers have not been extensively tested beyond the values shown in this table. Device damage may occur if these values are exceeded.
b. Non-condensing environment. Single mode performance is tested and guaranteed at 25 °C.

General Specifications[a]	
Characteristic	**Value**
Spatial Mode	Single Mode
Wavelength Tested	Yes

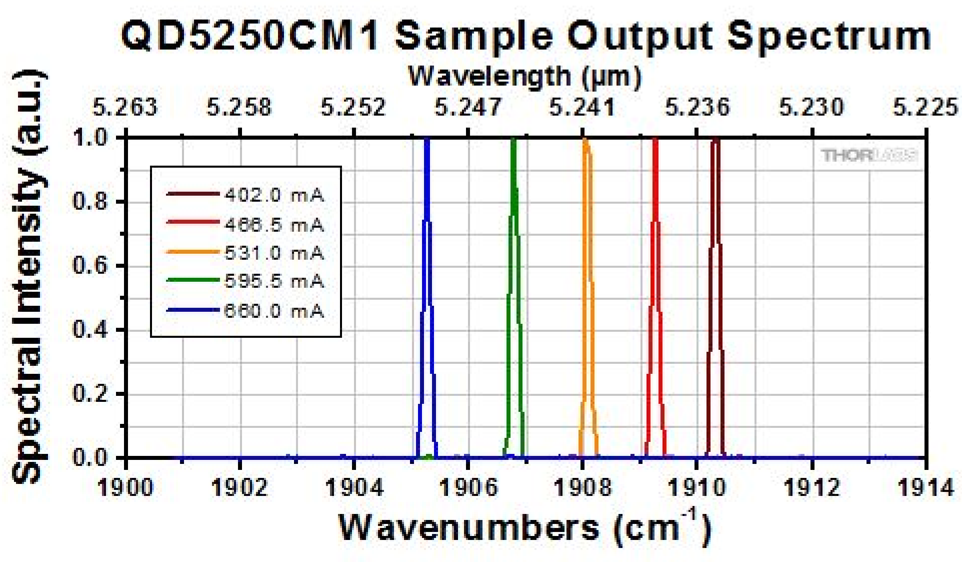
a. If broadband emission is preferred, please consider our 5.30 µm Fabry-Perot Lasers.

Specs | **Spectrum** | L-I-V Curve | Far Field | Drawing

All values are measured at 25 °C, unless otherwise indicated. To view an Excel file that lists the measured spectral and L-I-V characteristic values of the sample QCL shown below, please click here. Serial-number-specific documentation is available by clicking "Choose Item" on the left side of the price box.

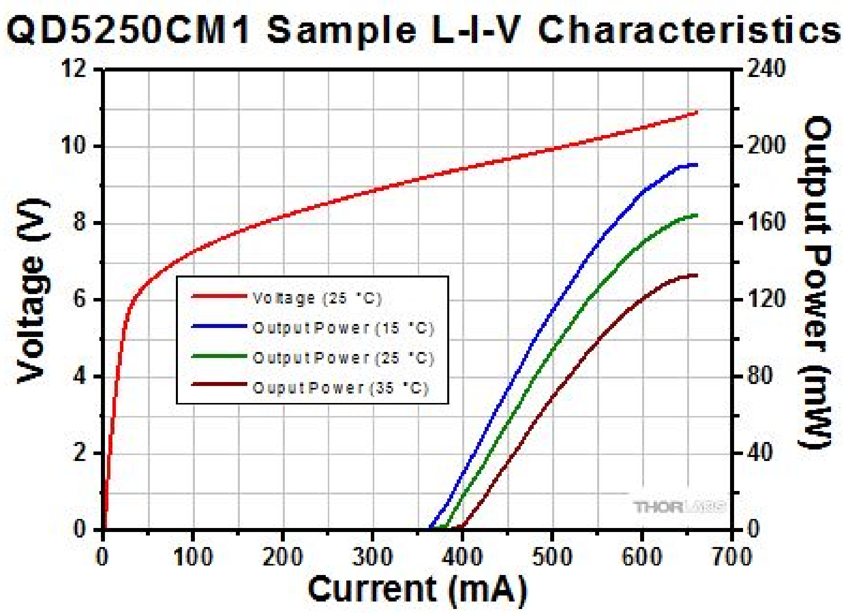


The graph above shows the center wavelength and output power of a sample QD5250CM1 Distributed Feedback Laser as a function of current.



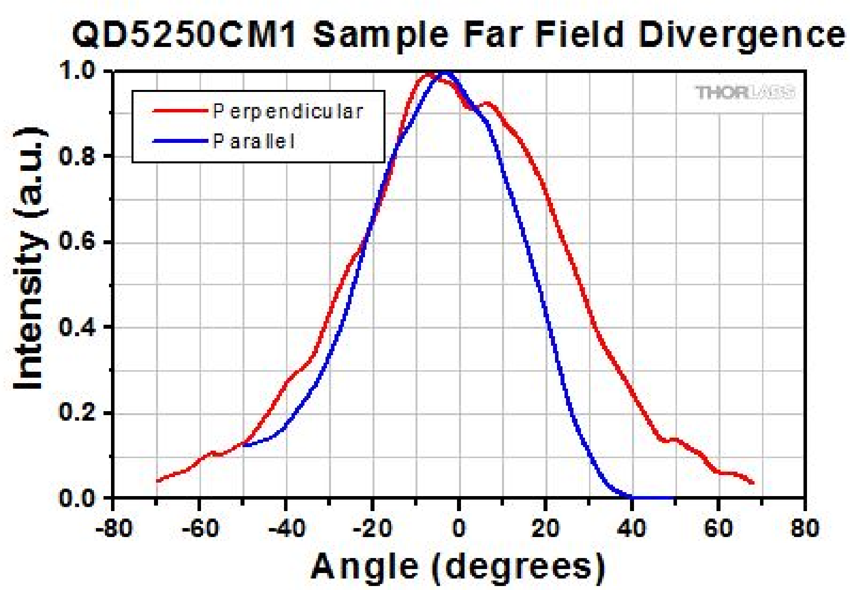
The graph above shows the spectrum of a sample QD5250CM1 as a function of current. The intensity has been normalized at each current step and is therefore not comparable between steps. The apparent linewidth is limited by the measurement resolution, which is 0.125 cm^{-1} (3.75 GHz). In similar QCLs, we have measured <25 MHz linewidths, although those measurements were also resolution-limited.

Specs | Spectrum | **L-I-V Curve** | Far Field | Drawing



All values are measured at 25 °C, unless otherwise indicated. To view an Excel file that lists the measured spectral and L-I-V characteristic values of the sample QCL shown above, please click here. Serial-number-specific documentation is available by clicking "Choose Item" on the left side of the price box.

Specs | Spectrum | L-I-V Curve | **Far Field** | Drawing



All values are measured at 25 °C. To view an Excel file that lists all of the measured spectral, L-I-V, and far field characteristic values of the sample QCL shown above, please click here. Serial-number-specific documentation is available by clicking "Choose Item" on the left side of the price box.

Far field divergence values are measured at 25 °C and at a distance of 89.4 mm from the laser. The detector's aperture is Ø10 mm, and the sampling step size is 3°. The angle subtended by the detector is 6.4°.

Specs | Spectrum | L-I-V Curve | Far Field | Drawing