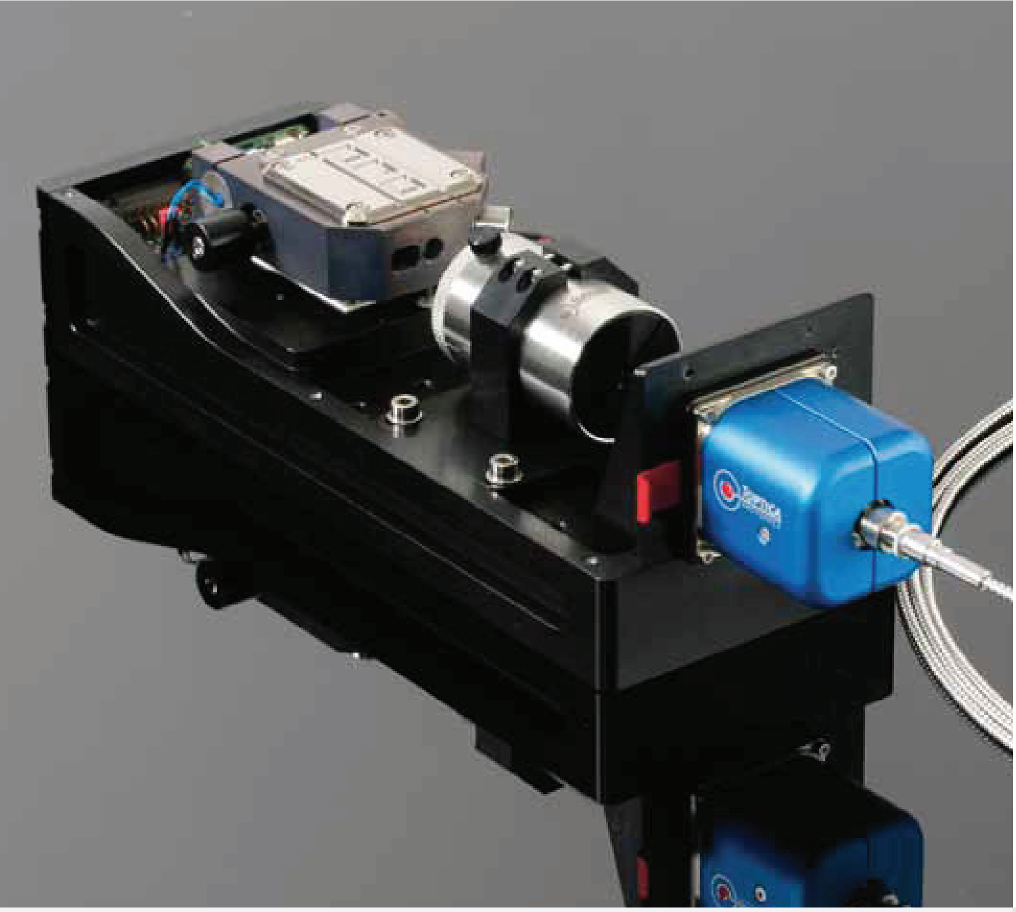


Tunable Diode Lasers

Turning Laser Diodes into Diode Lasers

Laser diodes
Laser diodes are well established in a variety of consumer products, like laser pointers, barcode scanners, or CD/DVD/Blu-ray drives. The success story of these light sources is driven by the fact that they are compact, conveniently operated, cost effective, and highly efficient. However, the emission spectrum of bare laser diodes is broad, and the lasing wavelength is not well defined. The lasing modes are determined by the two facets of the laser diode. The wide gain profile of the semiconductor causes many modes to oscillate simultaneously, each with a different frequency.

Even diodes with a single longitudinal mode exhibit mode-hopping upon slightest variations of the chip temperature or driver current. The result is an imperfect, spectrally unstable output beam that does not meet the demands of many scientific or industrial applications.

Mode selection
Requirements for advanced measurement tasks include a narrow emission linewidth, large coherence length, precise wavelength selection, and tuning or even stabilization of the emission frequency. These superior characteristics are achieved by introducing an additional frequency-selective element into the laser cavity. Precise temperature and current control are a must.

TOPTICA offers two realizations of tunable single-frequency diode lasers. Both make use of grating structures to select and control the emission frequency. One is a grating-stabilized external cavity diode laser (ECDL), which incorporates an optical grating mounted in front of the laser diode. The other approach features laser diodes with gratings built into the semiconductor itself. Two versions of these diodes are used: distributed feedback (DFB) and distributed Bragg reflector (DBR) laser diodes.

Wavelength tuning of an ECDL
In an ECDL, a second resonator is formed between the diode's back facet and the feedback elements. The grating filter, together with the semiconductor gain profile determines the new external lasing mode.

To control the wavelength of an ECDL, the angle of the grating is changed, shifting its spectral filter and at the same time moving the external mode structure of the laser. A large mode-hop free tuning range results from accurate synchronization of the two effects. This can be realized by a properly selected pivot point for the grating movement. Coarse wavelength alignment is often realized with a micrometer screw, automated tuning with a piezo actuator.

By adding a suitable grating, collimation optics and control electronics, a simple laser diode can be transformed into a complete, tunable diode laser system.

FP, AR and DFB Laser Diodes

FP diodes – high power at low cost

In TOPTICA's external-cavity lasers, both Fabry-Perot (FP) diodes and anti-reflection coated (AR) diodes can be used. FP diodes are mass-produced at numerous wavelengths and optimized for output power. With FP diodes, the internal resonator of the diode functions like an etalon, and contributes to the selection of the external lasing mode.
The internal resonator is synchronized with the grating movement by changing the diode current simultaneously. This "feed forward" mechanism significantly increases the laser's mode-hop free tuning range.

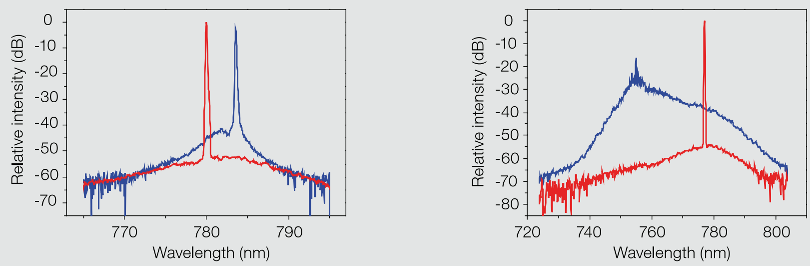
AR diodes for best performance

Diodes with an AR-coated output facet do not lase without external feedback, and the mode selection effect of the internal resonator is less pronounced. The AR coating further improves the tuning properties and mode stability of an ECDL. TOPTICA's DL pro lasers therefore feature AR diodes.

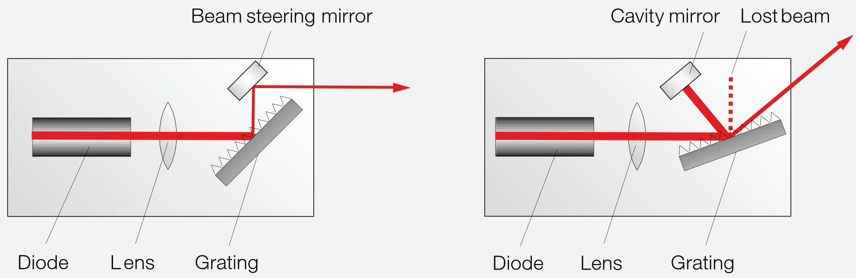
Important specifications for FP- or AR-based ECDLs are the output power available from the stabilized diode, the attainable wavelength range, and the mode-hop free tuning range. All of these specifications are shown in our internet stock lists, www.laser-diodes.com.

DFB diodes with internal grating

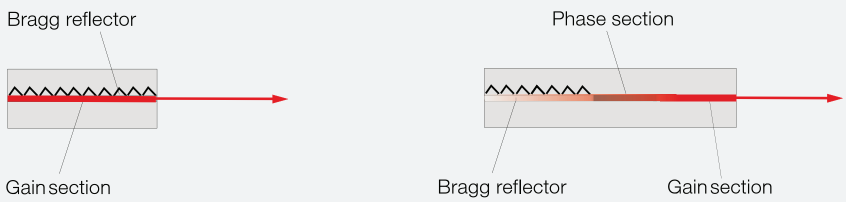
Distributed Feedback (DFB) and Distributed Bragg Reflector (DBR) laser diodes feature a grating structure within the semiconductor chip. The grating restricts the laser emission to a single longitudinal mode. In a DFB diode, the grating is right within the gain section. In a DBR, the grating is spatially separated from the gain section, and an additional phase section serves to maintain mode-hop free conditions during a scan. Frequency tuning is accomplished by thermally or electrically varying the grating pitch, and can span many hundred GHz.



Laser diode with (red) and without (blue) external grating feedback. The left graph shows an FP diode, the right graph an AR diode.



External cavity laser designs: Littrow (left), Littman-Metcalf (right)



Schematics of DFB (left) and DBR (right) laser diodes.

ECDL or DFB?

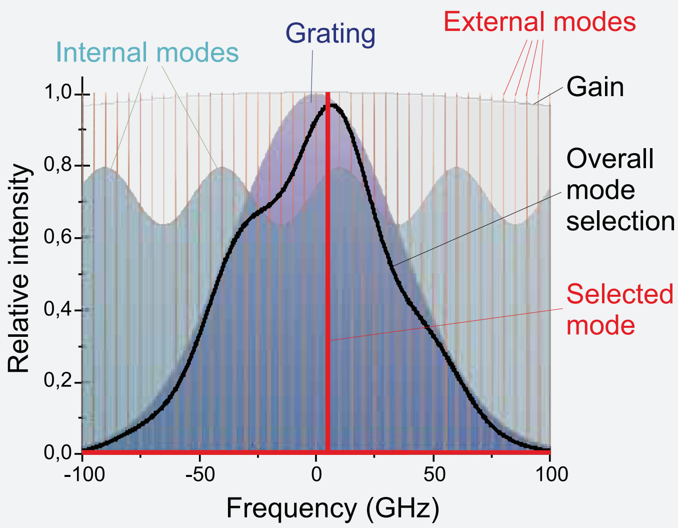
Whether to choose an external cavity diode laser or a DFB/DBR laser depends on the individual application. DFB diodes do not yet offer the wavelength range accessible with Littrow ECDLs. Tunable, narrow-band emission in the blue or red spectral range still remains the realm of external-cavity systems. An ECDL is also the preferred choice for applications that require a broad coarse tuning range, or an ultra-narrow linewidth (1 MHz or below).
The main advantage of a DFB laser is its extremely large continuous tuning range. Mode-hop free scans of several nanometers are routinely attained. Typical DFB laser applications are gas sensing, phase-shifting interferometry, or the generation of tunable cw terahertz radiation. The mechanical design of a DFB laser comprises no alignment-sensitive optical components, making these lasers particularly attractive for applications in rough industrial environments.

Littrow and Littman Configuration

Compact and robust Littrow setup
The most common types of ECDLs are the so-called Littrow and Littman configurations. In both cases, a grating is used to selectively reflect a small range of the diode's emission spectrum back into the laser chip. This optical feedback forces the diode into single-frequency operation. In Littrow configuration, the first-order beam from the grating is directly reflected into the diode. In Littman configuration, the first-order diffracted beam is reflected by a mirror, and passes the grating a second time before being fed back into the laser diode. In both setups, the main contribution to the technical linewidth are usually electronic noise, acoustic noise and vibrations that affect the cavity length. In practical operation, the compact and more robust Littrow cavity often shows a narrower linewidth.

Highest power from Littrow lasers
The Littrow setup has further advantages. As the laser light reflects off the grating only once, losses into other diffraction orders do not occur. The output power of Littrow lasers is thus considerably higher than that of comparable Littman setups. Moreover, Littrow lasers can be operated with both standard Fabry-Perot (FP) diodes and anti-reflection (AR) coated laser diodes, while the Littman design usually employs AR coated diodes. FP diodes provide higher powers, encompass a broader wavelength range and are usually less expensive. However, TOPTICA also integrates AR coated diodes when large tunability is required, and when power plays a secondary role.

The mode-hop free tuning range of Littrow lasers can be greatly enhanced by adding a “feed forward” current modulation (see page 13). The marginal angular change of the output beam apparent with Littrow cavities can be effectively compensated for by a beam steering mirror rotated in parallel with the grating.



Mode selection in ECDLs. The back facet and the feedback elements form the external resonator. The oscillating mode is selected not only by these elements and the semiconductor gain, but also by the internal modes (etalon) of the diode.

Frequency Noise and Laser Linewidth

Frequency noise
High stability and narrow linewidth are often key requirements for scientific diode lasers. Theoretically, the linewidth of grating stabilized diode lasers is given by the Schawlow-Townes formula and therefore very narrow. In reality, however, a number of processes and disturbances have an effect on the laser frequency. Laser current noise for example causes fluctuations of the refractive index within the laser diode itself, and changes the overall optical length of the laser resonator. Acoustic noise and vibrations have a direct influence on the mechanical length of an external resonator, while temperature and air pressure fluctuations cause frequency drifts by changing the refractive index of air.

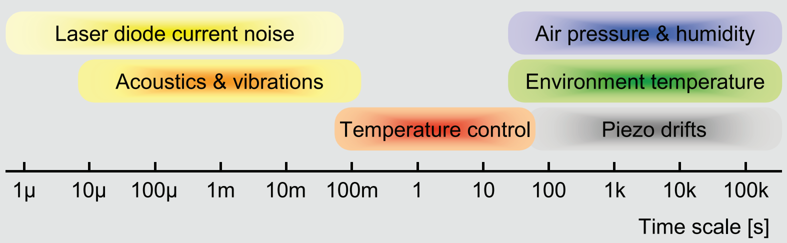
Linewidth and drift
Processes that are faster than the laser frequency measurement itself, add to the laser's **technical linewidth**, while slower processes will cause a **frequency drift** between successive measurements. As fast measurement techniques will not reveal slower drift effects on the linewidth, it is important to always note the time scale of the measurement when specifying linewidth values.

Linewidth and coherence length
Laser linewidth and coherence length are linked by an inverse proportionality. The numerical factor depends on the spectral line shape. For a Gaussian spectral profile, the coherence length is 132 m / (linewidth in MHz).

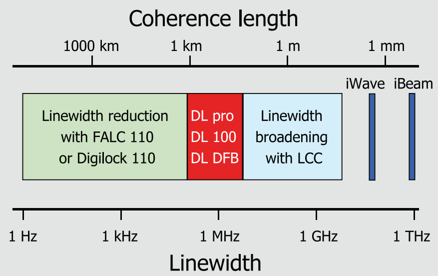
Linewidth measurement
TOPTICA uses different ways to measure laser linewidths. For fast measurements, a delayed self-heterodyne technique is employed. The laser beam is split into two probe beams, one of which is frequency-shifted by an acousto-optical modulator and delayed utilizing a 1 km long fiber. Subsequently, the beams are re-combined on a fast photo detector, the output of which is connected to an RF spectrum analyzer.

The fiber line corresponds to a time delay of 5 µs. Frequency fluctuations within this time contribute to the beat note, the width of which is approximately twice the laser‘s linewidth.

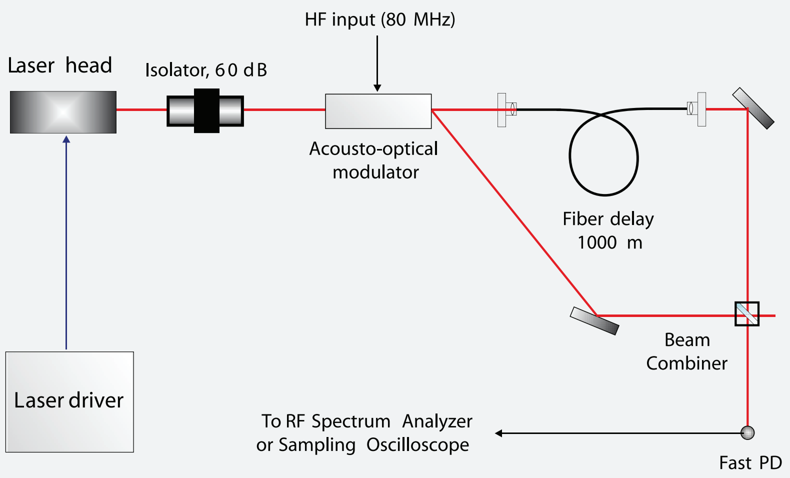
Linewidth measurements on longer time scales are accomplished by measuring the beat width of two identical lasers with a fast detector and an RF spectrum analyzer (sub Hz .. 100 MHz), by using a Fabry-Perot interferometer (MHz .. GHz, see page 63), or by directly determining the coherence length with a Michelson interferometer.



Main causes for frequency variations and their respective time scales.



Coherence coverage of more than 12 decades.



Delayed self-heterodyne linewidth measurement.

DL pro

Ultra-Stable Widely Tunable Littrow Laser

DL pro — the ultimate Littrow diode laser.

First class optomechanics (patented design)

Key features

- Ultra-stable mechanics
- Optimized virtual pivot point
- 30 – 50 GHz mode-hop free tuning
- Convenient and simple coarse tuning
- Fast current AC & DC modulation
- Diode replacement at customer's site
- Patented resonator design (DE 10 2007 028 499)

As the first laser of the pro series, the DL pro has already demonstrated how much even a well-established laser like the DL 100 can be further improved.

Main advantages

For the user the main advantages are large mode-hop free tuning, alignment free operation, and highest acoustic and thermal stability of any ECDL on the market. The result is most reliable and most convenient operation for high-end laboratory work.

To achieve such performance accompanied by ease of use, the DL pro mechanics possesses degrees of freedom exactly where they are needed. Coarse and fine tuning have been skillfully separated: Coarse tuning is performed by a well defined rotation of the grating that precisely selects any requested wavelength within the complete diode gain spectrum. Mode hop free tuning is realized by a system of robust flexure joints that requires only little travel. In the patented design, the laser's grating is rotated around the perfect "virtual" pivot point.

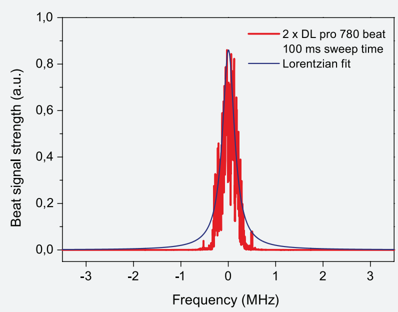
The compact and stable external cavity resonator has its first mechanical resonance above 4 kHz – one reason for its superior acoustic stability. Special care has been taken in choosing dimensions and materials to reduce frequency drifts due to variations of the ambient temperature. Notwithstanding its stability, the DL pro is easy to align. The experienced user can even exchange the laser diode himself.

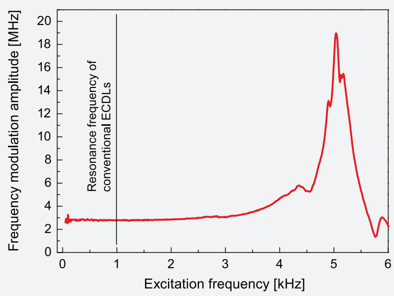
Selected antireflection-coated (AR) diodes

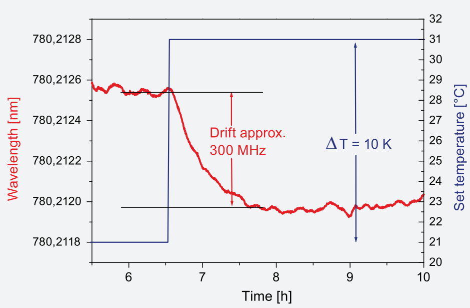
In the DL pro only carefully selected AR coated laser diodes are used. Four standard wavelengths are available, providing most stable single-mode operation and easy handling. Other wavelengths are available as DL 100 / pro design (see page 18).

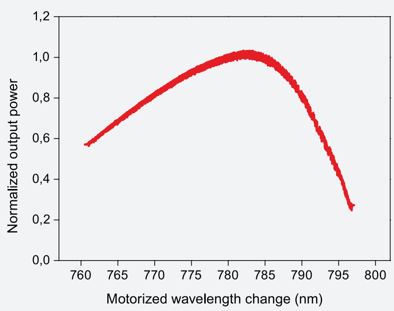
Motorization

The DL pro can also be equipped with a motor for wavelength selection. The user can then choose the wavelength using coarse or fine dials on the control box or via computer control using an RS 232 interface. The wavelength can be set to any value within the gain bandwidth of the diode with an accuracy of approximately 0.2 nm by software commands.









Top left: Measured beat signal of two free running DL pro 780 averaged over 10 centered sweeps with a sweep time of 100 ms each. The resulting beat width is 308 kHz, the linewidth approx. 150 kHz.

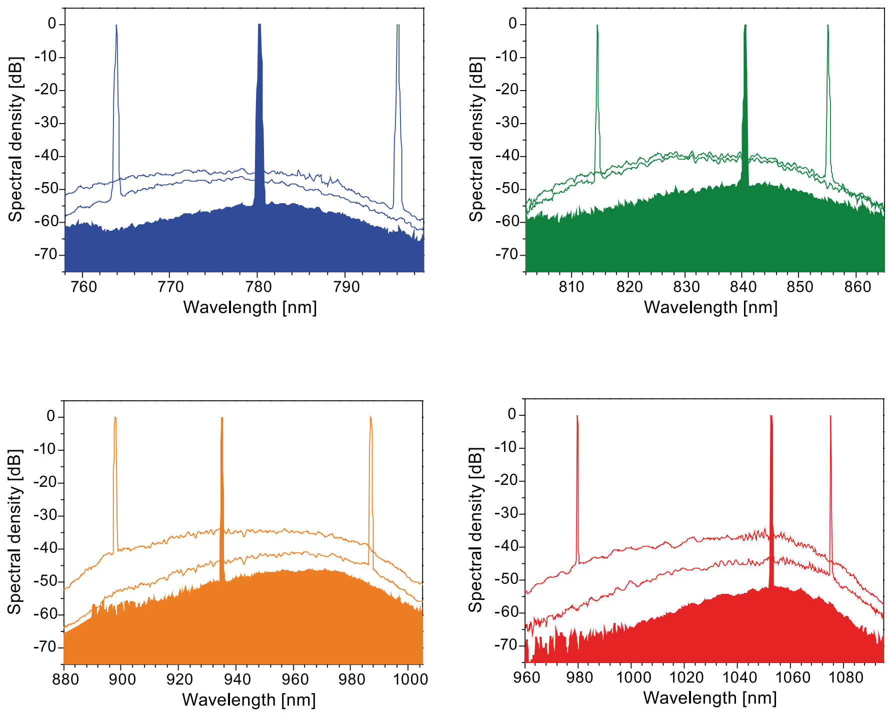
Top right: DL pro piezo transfer function. The first acoustic resonance is above 4 kHz.

Bottom left: Laser frequency response to a 10 K air temperature change (laser and electronics inside climate chamber).

Bottom right: Alignment free coarse tuning over tens of nm (motorized).

Standard Systems DL pro

Wavelengths and Specifications



Normalized spectra of DL pro lasers. The peaks indicate the center wavelength and the tuning range of the respective model. Top left: DL pro 780, top right: DL pro 850, bottom left: DL pro 940, bottom right: DL pro 1040.

Specifications				
	DL pro 780	**DL pro 850**	**DL pro 940**	**DL pro 1040**
Wavelength range	760 nm – 790 nm or 770 nm – 795 nm	815 nm – 845 nm or 825 nm – 853 nm	910 nm – 985 nm	980 nm – 1075 nm
Output power*	30 mW – 80 mW	30 mW – 80 mW	30 mW – 80 mW	20 mW – 50 mW
Typical mode-hop free tuning range**	30 GHz – 50 GHz			
Typical linewidth (5 μs)	100 kHz			
ASE (dB)	< -35 .. -55 dB			
* depending on wavelength ** depending on power For further specifications and available options, please see pages 21–23.				

DL 100/pro design

pro Technology at Every Wavelength

DL 100/pro design – leading edge tunable diode laser

Key features
· Ultra stable mechanics
· Optimized virtual pivot point for best mode-hop free tuning
· Widest wavelength coverage 370 .. 1770 nm
· Customized versions
· Diode replacement possible at customer's site
(Regularly updated diode stock list: www.laser-diodes.com)

Widest wavelength coverage in pro design

The DL 100 / pro design combines the favorable properties of the DL pro with the wide wavelength coverage of the DL 100:

Like the DL 100 / pro design offers a superior mechanical setup in pro technology. The patented design provides the basis of the most stable external cavity diode lasers (ECDL), with respect to acoustical, mechanical and thermal disturbances. At the same time, it allows for easy coarse tuning across the complete gain spectrum of the integrated laser diode. The DL 100 / pro design is particularly easy to operate and tune, and enables a much more convenient operation than traditional ECDLs. It is thus ideally suited for integration into complex and demanding experiments like Bose-Einstein condensation or quantum computing.

While the DL pro is available at four key wavelengths, making use of exceptional high-quality AR-coated laser diodes, the DL 100 / pro design can be equipped with any laser diode. A wide variety of diodes, including AR and FP diodes, has been characterized in our DL 100, and is readily available. Wavelengths range from 370 .. 1770 nm, powers reach up to 400 mW. With the same diode, a DL 100 / pro design will perform better than a DL 100 in many respects. The most important improvements are: much better mechanical stability (acoustic and thermal), simpler coarse tuning, and with suitable diodes wider mode-hop free tuning.

Available AR and FP-type diodes, along with their power and tuning specifications when integrated in the DL 100 / pro design, are listed on TOPTICA's website www.laser-diodes.com. For options like isolators, beam shaping and Fiber coupling please refer to pages 21–22. Specifications are summarized on page 23.

Laser head (inside view) with pro technology ECDL resonator.

Customized versions

Customized versions of the DL 100 / pro design are available. For example:

- Special resonator for narrow linewidths
- Motorized wavelength selection
- Optimized versions for certain laser diodes or applications

Customized versions are not available for every wavelength and laser diode. Please enquire and let us know about your needs. We will find the perfect solution for you.

DL 100

External Cavity Diode Lasers in Littrow Design

The ECDL standard

TOPTICA's DL 100 evolved in research laboratories and is based on pioneering work led by Theodor Hänsch. The original design was optimized and adopted for integrating all kinds of laser diodes, configurations and options. By now, thousands of DL 100s have been sold, and this laser was the foundation of further very successful developments at TOPTICA. Today, available wavelengths range from 370 nm to 1770 nm.

Modular design

The DL 100 is still a flexible laboratory tool for hands-on research: Its diode laser head comprises a mounting base which serves as a heat sink, a temperature sensor and Peltier cooler for active temperature control, a laser diode holder with a collimator and a grating mount with piezo actuator for precise tuning. The control and supply units are designed as modular plug-ins: The Peltier cooler is connected to the DTC 110 Diode Temperature Control. The Diode Current Control DCC 110 ensures ultra low noise operation of the DL 100, and the high voltage scan controller SC 110 drives the piezo actuator for mode-hop free tuning. In addition, TOPTICA offers a variety of electronic regulator modules to stabilize the laser frequency (for a full description see pages 46–53).

Variety of laser diodes

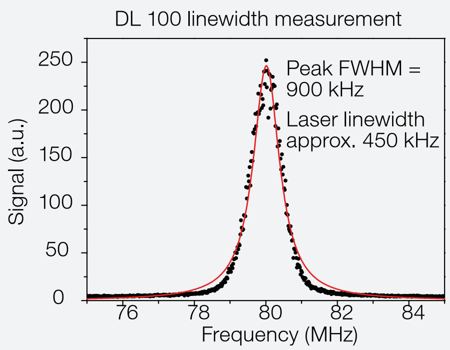
The laser diode itself can be easily exchanged by replacing the diode holder without dismantling the setup. The DL 100 is available with both AR and FP diodes. FP diodes normally deliver higher power at lower cost, while AR coated diodes offer wider tuning, more stable single-mode behavior and narrowest linewidths.

High quality for smaller budgets

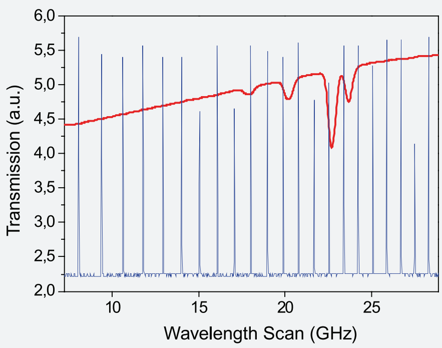
The DL 100 Diode Laser Series with the SYS DC control electronics is your complete step into the "World of Diode Lasers". Due to the strong emphasis on passive mechanical stability, low thermal expansion and drifts, a sound performance of the DL series is guaranteed – at an economic price. For available options see page 21.

DL 100 – one of the most common lasers in research laboratories.

Key features
· Widest wavelength coverage 370 .. 1770 nm, up to 300 mW
· Coarse tuning up to 110 nm
· Mode-hop free tuning up to 30 GHz
· Single-frequency operation
· Free running linewidth 100 kHz .. 1 MHz (5 µs)
· AR & FP diodes
(Regularly updated diode stock list www.laser-diodes.com)



Linewidth of DL 100, determined with a delayed self-heterodyne beat setup (integration time 5 µs). The FWHM of the beat signal is equal to two times the laser linewidth (450 kHz).



DL 100 frequency sweep over four Rb absorption lines (red), utilizing feed forward. FPI transmission peaks (blue, FSR 1 GHz) are shown for reference.

DL DFB

Diode Lasers with Largest Mode-Hop Free Tuning Range

DL DFB / DL DFB TO-3 laser head with optional FiberDock fiber coupler

DL DFB BFY, compact laser head for butterfly-packaged DFB diodes

Key features

- Every wavelength between 760 nm and 2880 nm available
- **New**: Compact laser head DL DFB BFY for butterfly-type laser diodes
- High output power up to 150 mW
- Mode-hop free tuning up to 1400 GHz (4 nm)
- Single-frequency operation, linewidth typ. 1 .. 4 MHz (5 µs)
- No alignment-sensitive components: reliable performance even in a harsh environment

(Regularly updated diode stock list: www.laser-diodes.com)

Wide tuning, wide wavelength range
TOPTICA's DL DFB lasers offer wide tunability, narrow linewidth and high output power in a compact and very rugged setup. Systems can be provided at any wavelength between 760 and 2880 nm. A large variety of wavelengths is usually available from stock, but customized wavelengths can also be realized, even in low quantities and within short lead times.

The absence of any alignment-sensitive opto-mechanical components ensures high long-term stability and reliability. The DL DFB therefore opens new possibilities for projects that require automated operation, e.g. in alkaline spectroscopy, gas sensing, holography, or the generation of tunable cw terahertz radiation. Our customers have successfully used the robust design of the DL DFB in the most adverse environmental conditions – in the Arctic, in fire research settings, and even in airborne experiments.

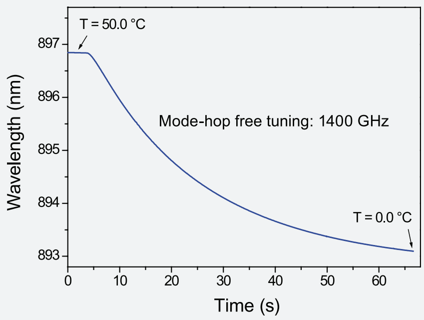
Frequency tuning
Frequency tuning of DFB lasers is accomplished by varying either the chip temperature ($\Delta\nu/\Delta T$ ~25 GHz/K) or the operating current ($\Delta\nu/\Delta I$ ~1-5 GHz/mA). Thermal tuning achieves mode-hop free scan ranges of several hundred GHz, at a moderate tuning speed of ~100 GHz/s. Vice versa, electric tuning spans a smaller frequency range, but functions up to MHz rates.

The sensitivity of DFB diodes to temperature and current variations calls for highly precise driver electronics. With TOPTICA's current and temperature controllers of the SYS DC 110 series (see pages 46–53), DL DFB lasers achieve a typical frequency stability of 3 MHz RMS @ 3 min, and 20 MHz RMS @ 10 hours – which corresponds to a temperature stability below 1 mK.

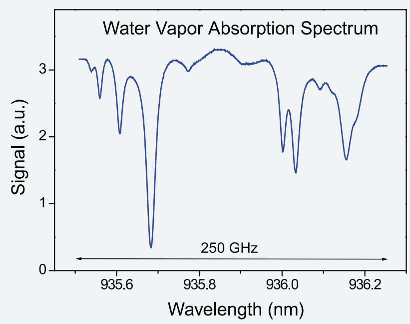
Laser heads for different packages
TOPTICA offers three versions of DL DFB laser heads, in order to accommodate different diode package designs. The standard DL DFB laser head incorporates TOPTICA's patented ColdPack (see page 66), where four thermoelectric elements heat, cool or stabilize the laser temperature.

TO-3 diode packages with built-in TEC and thermistor, available at selected DFB wavelengths, are mounted into the DL DFB TO-3 laser head.

Last not least, a new and compact butterfly mount (DL DFB BFY) incorporates fiber-pigtailed laser diodes, which feature a miniature isolator and coupling optics inside a hermetically sealed housing. All laser heads can be configured for free-space or fiber output, and can optionally be equipped with a DL-Mod PCB for high-frequency modulation or linewidth manipulation.



Thermal frequency tuning of a DL DFB.



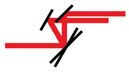
Absorption spectrum of water vapor, recorded with a thermally tuned DL DFB at 935 nm.

Options DL Series

Laser	DL pro	DL 100 / pro design	DL 100	DL DFB
SP/DL 100	Included	Included	Included	Not needed
DL-Mod	Included	Included	Optional	Optional
Isolator 30 dB	Optional*	Optional*	Optional*	Optional*
Isolator 60 dB	Optional*	Optional*	Optional*	Optional*
APP J expanding	Optional*	Optional*	Optional*	Optional*
APP compact	Optional*	Optional*	Optional*	Optional*
FiberDock	Optional	Optional	Optional	Optional

*not for all wavelengths and/or not in combination with all other options.

Beam angle compensation mirror: SP/DL 100

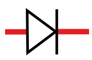


In TOPTICA's Littrow-type ECDLs, the beam angle compensation mirror is mounted parallel to the grating to eliminate a change of the output beam angle when tuning the laser. It is included in the DL 100 and DL pro, and not needed for the DL DFB.

High frequency modulation PCB: DL-Mod

The PCB includes AC and DC coupled laser diode current modulation inputs on the laser head. The DC coupled input has an electrical -3 dB bandwidth of 20 MHz. The AC coupled input can be configured for an electrical bandwidth > 300 MHz.
The optical modulation bandwidths are generally lower and depend on the properties of the diode.

Single-stage isolator: Isolator 30 dB

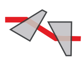


Isolators are used to protect the laser diode against back reflections. This not only prevents damage to the diode but also ensures untroubled tuning and single-frequency operation. Fiber coupling with angle polished fibers (both ends) requires at least a single-stage isolator. See also page 67.

Double-stage isolator: Isolator 60 dB

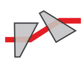
Double-stage isolators are needed if reflections from the experiment into the laser are expected. Fiber coupling with non-angle polished fibers also requires a double-stage isolator. See also page 67.

Adjustable anamorphic prism pair: APP J



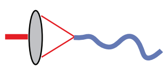
TOPTICA's patented adjustable anamorphic prism pairs are used to expand or compress a laser beam in one direction, by a factor between 2 and 5. The main application is to render an elliptical diode laser beam circular. See also page 66.

Compact prism pair for beam compression: APP compact



The compact prism pair is used for beam compression only. The compressed circular beam is small enough for using inexpensive small aperture isolators, and the fiber coupling efficiency is enhanced by approximately 10 %. The compression ratio is set at the factory.

Fiber coupler: FiberDock™

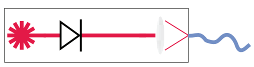


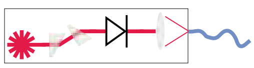
TOPTICA's patented fiber coupler provides highest single-mode fiber coupling efficiencies, easy alignment and at the same time highest stability. TOPTICA additionally offers a wide range of single-mode and polarization maintaining fibers, including fiber-optic beam splitters. Optical isolation is mandatory for fiber-coupled diode laser systems. See also page 68.

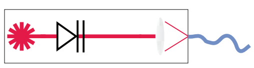
Configurations DL Series

Diode Lasers DL 100, DL pro, DL DFB

Configurations		Available wavelengths		
Configuration I	**Consists of**	**DL pro & DL 100/pro design**	**DL 100**	**DL DFB**
	• DL 100, DL pro, DL DFB + Modulation PCB DL-Mod (optional)	Given by available laser diodes (www.laser-diodes.com)		

Configuration II	Consists of			
	• DL 100, DL pro, DL DFB • Isolator 30 dB + FiberDock (optional) + Modulation PCB DL-Mod (optional)	390 nm – 490 nm 600 nm – 1110 nm 1170 nm – 1220 nm 1285 nm – 1730 nm	390 nm – 490 nm 600 nm – 930 nm 1170 nm – 1220 nm	640 nm – 930 nm 1170 nm – 1220 nm 2330 nm

Configuration III	Consists of			
	• DL 100, DL pro, DL DFB • APP compact, compressing • Isolator 30 dB + FiberDock (optional) + Modulation PCB DL-Mod (optional)	395 nm – 415 nm 600 nm – 1200 nm 1260 nm – 1500 nm	395 nm – 415 nm 600 nm – 1200 nm 1260 nm – 1500 nm	640 nm – 1200 nm 1260 nm – 1500 nm

Configuration IV	Consists of			
	• DL 100, DL pro, DL DFB • Isolator 60 dB + FiberDock (optional) + Modulation PCB DL-Mod (optional)	405 nm – 408 nm 640 nm – 900 nm 1515 nm – 1585 nm	405 nm – 408 nm 640 nm – 900 nm 1515 nm – 1585 nm	640 nm – 900 nm

*Please check stock list for diode availability.

Fixed-frequency versions for non-tuning applications

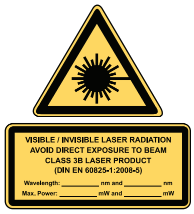
DL 100/R, DL pro/R: fixed-frequency laser – no piezo actuator, no Scan Control.

Sample applications for DL/R lasers:

- Interferometry
- Holography
- Raman spectroscopy

Other custom configurations are available on request.

Specifications DL Series



Specifications				
Laser	**DL 100**	**DL pro**	**DL 100 / pro design**	**DL DFB**
Center wavelengths	370 .. 488 nm* 632 .. 1770 nm*	780, 850, 940, 1040 nm	370 .. 488 nm* 632 .. 1770 nm*	640, 660, 690 nm 760 - 2880 nm
Typical power range	3 .. 300 mW	Max. 50 .. 80 mW	3 .. 300 mW	2 .. 140 mW
Typical coarse tuning range	2 .. 140 nm	≥ 30 nm	2 .. 140 nm	2 .. 6 nm
Typical mode-hop free tuning range	≥ 20 GHz	30 .. 50 GHz	20 .. 50 GHz	1000 GHz
Typical linewidth (5 µs integration time)	0.1 .. 1 MHz	100 kHz	0.1 .. 1 MHz	1 .. 4 MHz
Typical output beam characteristics	3 mm x 1 mm, 1 mm x 1 mm with APP C			
Beam height	53.9 ± 0.5 mm	50 ± 0.3 (58 ± 0.3 mm with expanding APP J)		53.9 ± 0.5 mm
Typical polarization	Linear, approx. 100:1			
Fiber coupling efficiency**: min. (typ.)	55 (65) %			
Fiber coupling efficiency with APP**: min. (typ.)	65 (75) %			
Typical long-term drift with ambient temperature	400 MHz / K	<< 100 MHz / K	< 100 MHz / K	< 100 MHz / K
Control electronics	SYS DC 110			
Environment temperature (operating)	15 .. 30 °C			
Environment temperature (transport)	0 .. 40 °C			
Humidity	Non condensing			
Operating voltage	100 .. 120 V / 220 .. 240 V AC, 50 .. 60 Hz (auto detect)			
Power consumption	typ. < 100 W max. 300 W			
Size head (L x W x H)	228 x 80 x 79.4 mm³	240 x 90 x 90 mm³	240 x 90 x 90 mm³	228 x 80 x 79.4 mm³
Size electronics (L x W x H)	385 x 465 x 148 mm³	385 x 465 x 148 mm³	385 x 465 x 148 mm³	385 x 465 x 148 mm³
*Spectral coverage with gaps.**With TOPTICA's FiberDock: -15 % for < 470 nm, efficiency varies when tuning widely.				

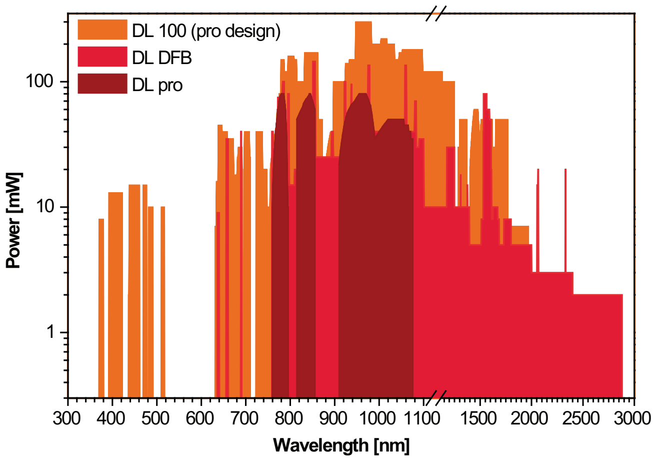
The given specifications are obtained with TOPTICA control units DCC 110, DTC 110, and SC 110 in the rack system SYS DC 110. Actual data strongly depends on the chosen laser diode. TOPTICA offers full assistance in finding the best laser diode for your application.

How to choose your DL configuration

1. Select suitable laser diode (FP, AR, DFB – please see pages 12–14). Check diode availability via the appropriate internet stock list (www.laser-diodes.com). For DL pro please refer to page 16. Inquire directly with TOPTICA for all other wavelengths.

2. Select one of the standard configurations from page 22, or inquire about your custom configuration.

3. Contact your local TOPTICA distributor for an individualized quotation.



Available standard wavelengths of DL 100, DL pro and DL DFB.

BlueMode

High Power and Coherence at Blue/Violet Wavelengths

BlueMode – replacing gas lasers made easy

Key features

- For interferometry, holography, quantum cryptography, photonic down-conversion
- 50 mW @ 405 nm free beam output
- **New**: 20 mW @ 445 nm, 30 mW @ 488 nm
- Linewidth < 5 MHz (< 0.003 pm), coherence length > 25m
- Built-in feedback protection (30 dB optical isolator)
- Optional fiber coupling with highest efficiencies (typ. 60 % in single-mode fiber)

New standards for interferometry and holography

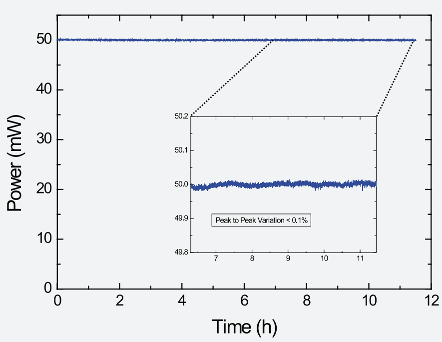
The BlueMode laser sets new records at blue-violet wavelengths: It is the first laser that unites high power, high coherence and superior mode stability in a compact and rugged design. BlueMode is based on proprietary technology, developed by TOPTICA for demanding measurement tasks in both scientific research and industrial applications. Available wavelengths are 405 nm, 445 nm and 488 nm. OEM solutions are provided upon request.

To-date, interferometry and holography in the blue-violet spectral range were bound to deal with bulky, power consuming gas ion lasers. Intense blue laser diodes have been available but their coherence length was restricted to a few millimeters at most. Conventional grating-stabilized lasers, on the other hand, provided a spectrally narrow emission line, but their single-frequency output power was limited to below 15 mW.

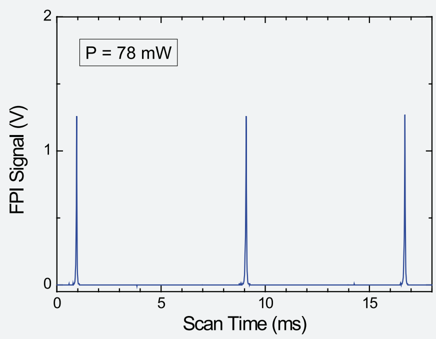
BlueMode—High power at a single frequency

The BlueMode laser delivers 50 mW @ 405 nm, and up to 30 mW @ 488 nm. The spectral line width is below than 5 MHz, a coherence length greater than 25 m is guaranteed. The wavelength stability is < 0.05 pm/h and the long-term power stability is better than 0.5 % (STD/mean, in constant environmental conditions). Combined with an excellent long-term coherence stability, this renders the laser a perfect fit for applications which require lowest intensity and frequency noise, and continuous single-frequency operation.

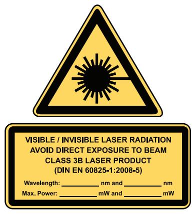
The output beam diameter is approx. 1 mm and thus close to that of conventional ion lasers, making the transition to a BlueMode laser a smooth process in existing instrumentation. Optionally, the laser light can be coupled to single-mode fibers using TOPTICA's OEM proven FiberDock unit. Due to the patented flexure mount unit, easy adjustment and highest coupling efficiencies are achieved.



Long-term power stability of BlueMode. The inset shows a peak-to-peak variation of < 0.1 % in a 5-hour measurement.



Spectrum of BlueMode laser, recorded with a scanning Fabry Perot interferometer (FPI 100). Single-frequency operation is obtained even at maximum power.



Specifications BlueMode Series			
Operation	cw, single (fixed) frequency		
Wavelength	405 nm	445 nm	488 nm
Wavelength tolerance	±3 nm		
Wavelength selection	u.r.		
Wavelength tuning	No		
Wavelength stability	< 0.05 pm/h*		
Linewidth	< 5 MHz (< 0.003 pm)		
Coherence length	> 25 m		
ASE suppression	> 40 dB		
Output power**	50 mW	20 mW	30 mW
Power stability	Typ. 0.5% (STD/mean) @ 10 h*		
Relative intensity noise	≤ -135 dB (50 kHz -100 MHz)		
Polarization	Linear, > 100:1, 90°		
Beam profile	M^2 < 1.5 (< 1.2 typ.)		
Optical isolation	Built-in (30 dB)		
Laser head dimensions	240 x 90 x 90 mm^3		
Fiber coupling	Optional, typ. 60 % in SM fiber		
Electronics	SYS DC110, 12" rack		
Warm-up time	< 5 min		
Environmental temperature (operating)	15 .. 35°C		
Environmental temperature (transport)	0 .. 40°C		
Humidity	Non condensing		
Operating voltage	100 .. 120 V / 220 .. 240 V AC		
50 .. 60 Hz (auto detect)			
Power consumption	Typ. < 20 W, max. 300 W		
* At constant environmental conditions ** behind isolator