



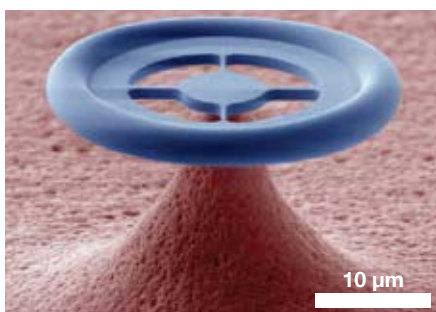
CONTINUOUSLY TUNABLE DIODE LASERS

Mode-hop-free tuning across the full diode spectrum

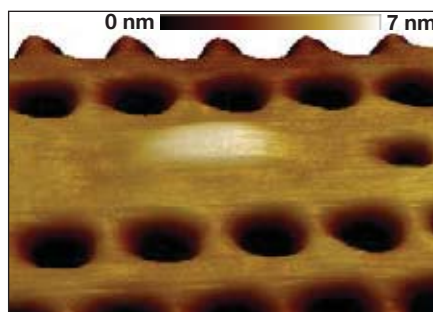
TOPTICA's new family of Continuously Tunable Lasers (CTL) offers a unique feature that has not been available before: Mode-hop-free operation and tuning of a narrow linewidth laser across the full diode gain spectrum at center wavelengths not only in the telecom range. Many demanding applications like quantum dots, micro cavities or molecular spectroscopy require lasers

that tune extremely wide and with highest precision. The unique resonator design of the CTL enables fully automatized motor-driven wavelength scans, as well as highest precision piezo scans. Furthermore the laser diode current can be used to tune or modulate the laser when fast and extremely precise control over the laser frequency is required. The first two members of the CTL series with tuning ranges of

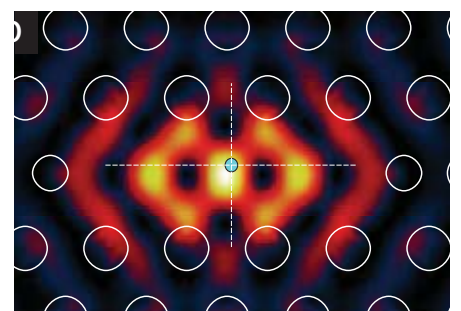
915 – 985 nm and 1530 – 1620 nm are ideally suited for the applications mentioned above. Other favorable properties of TOPTICA's CTLs are its narrow linewidth, the high relative and absolute wavelength accuracy as well as a comfortable touch and remote control via the all-digital versatile DLC pro diode laser controller.



The CTL is ideally suited to examine small structures like μ -cavities. The shown μ -toroid was used by the Tobias Kippenberg group in Lausanne to demonstrate how light can be exploited to control the motion of this mechanical oscillator at a level where quantum mechanics governs its behavior.⁽¹⁾



The CTL can be used to analyze and excite quantum dots and photonic crystal cavities. Here a photonic crystal cavity is shown that has been fabricated around a quantum dot. The group of A. Imamoglu used this system to demonstrate that the quantum dot exciton and the cavity enter the strong-coupling regime of cavity QED.⁽²⁾



DLC CTL

Continuously Tunable Laser

Guaranteed mode-hop-free

Wide mode-hop-free tuning requires excellent mechanical design and perfect alignment – the optical resonator has to be stable on a nm scale. Laser systems with passive resonator design can only achieve mode-hop-free tuning across a few nm up to a few 10 nm.

In order to achieve wider and guaranteed mode-hop-free tuning – even across the full gain spectrum of the diode – not only excellent mechanical design is essential, but also active control is required. The unique SMILE technology (Single Mode Intelligent Loop Engine, patent pending) ensures mode-hop-free operation across the complete gain spectrum of the diode.

The active control loop analyzes several signals in the laser head and optimizes the involved tuning elements. With TOPTICA's SMILE, no mode-hopping occurs.

Options

- Single stage or double stage optical isolation
- FiberDock fiber coupling
- DLC pro Lock frequency stabilization option

Motor & piezo tuning

Motorized coarse tuning happens with a small step size of 5-8 pm, the maximum tuning speed is 10 nm/s. Fast scans are smooth, while slow scans will exhibit individual steps.

Tuning between and across many of these steps is possible with the built-in piezo. A future software/firmware release will enable the CTLs to scan even more smoothly with micro steps of the motor.

Hands-off

The DLC CTL is a hands-off laser system that requires no alignment or maintenance. The cavity is optically closed and stable by design, usually without the necessity of readjusting movable parts for cavity optimization.

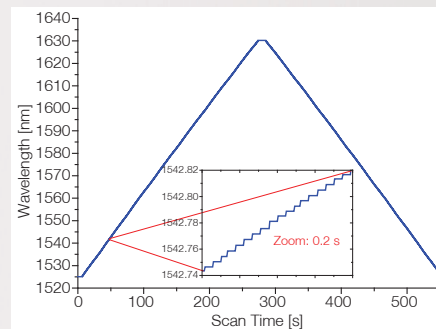
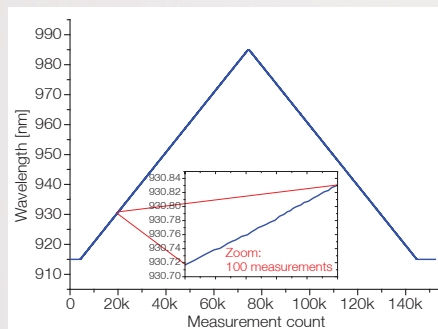
If ever required, the integrated FLOW feature (Feedback Light Optimization Wizard) optimizes the cavity upon the touch of a button. This optimization reestablishes stable and mode-hop-free operation across the complete tuning range. It can be performed in the field (no shipping back to the factory is necessary). Due to the excellent and innovative patent pending design of the CTL, activation of the FLOW will only be necessary if the laser has experienced large mechanical shock or temperature changes.



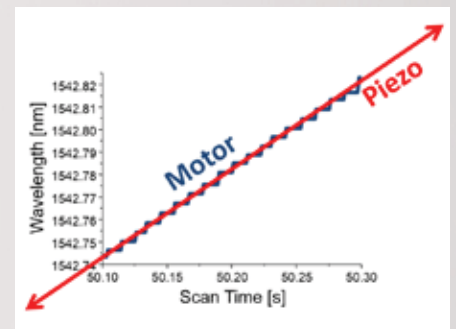
Laser system DLC CTL: The mode-hop-free widely tunable laser is controlled by TOPTICA's all digital DLC pro controller.

Key Features

- Mode-hop-free tuning:
915 nm - 985 nm or 1530 - 1620 nm
- Up to 80 mW
- Flexible motor, piezo and current tuning with high accuracy and small step sizes
- Low-noise and powerful digital control with DLC pro
- High frequency AC & DC current modulation inputs
- Hands-off operation with SMILE and FLOW



Fast (left) and slow (right) scans of CTL 950 and CTL 1550, respectively. The insets show the smooth fast scan in the left measurement and reveal small steps with the slow scan on the right when zooming into the measured data.



Wide tuning with motor & steps (5 or 8 pm), fine tuning with piezo \approx 50 GHz (across > 30 motor steps). Micro steps and combined scans of motor and piezo will be enabled by future software releases.

DLC CTL

Continuously Tunable Laser

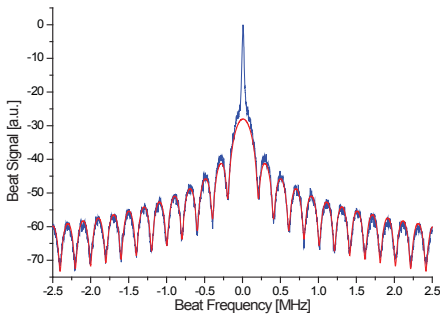
The CTL series lasers are operated with TOPTICA's all digital and versatile DLC pro diode laser controller.

This ensures not only flexibility and future compatibility, but also lowest noise and drift (digital signals do not drift) and convenient operation via touch

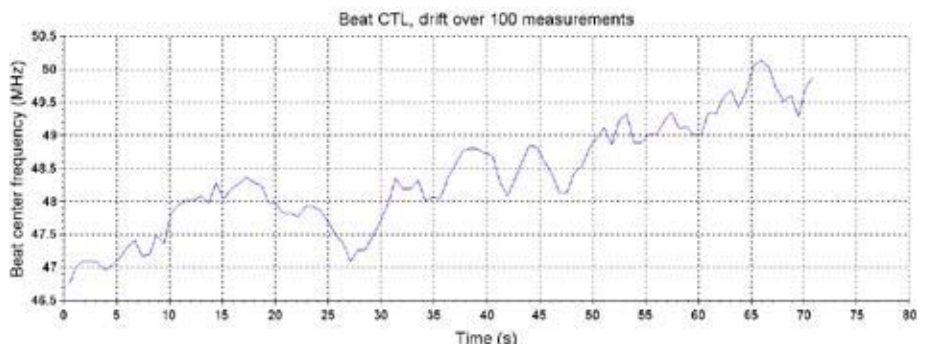
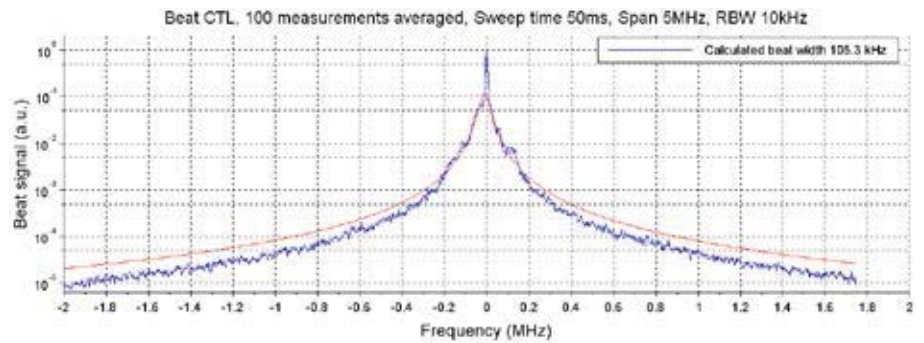
screen, knobs and remote control. Remote control of the laser operation is possible via USB and TCP/IP, either with a PC graphical user interface or by integrating the DLC pro into customers' software via a powerful command language.

Low noise and drift

Low noise and low drift are important features for the practical use of a narrow laser linewidth. The CTL linewidth has been measured to be approx. 5 kHz on short time scales (5 μ s) and about 100 kHz with 50 ms sweep time (see below).



Measurement of the CTL 950 linewidth with a self-heterodyne beat experiment with a 1 km (5 μ s) delay fiber. The result is a linewidth of approximately 5 kHz.



Top: Average of 100 centered beat measurements with 50 ms sweep time each: Beat width \approx 100 kHz. Bottom: Change of center frequency in 70 seconds: Drift < 5 MHz.

User interfaces

Two comfortable user interfaces are provided for intuitive operation and control. A touch screen with four additional knobs shows the most important information and offers direct access to all necessary controls. Remote control via computer/ethernet is possible with the supplied comprehensive and powerful PC graphical user interface.



“Future ready”

The digital nature and the future-oriented design of the DLC pro allow an easy integration of new features that are coming soon: Intensity stabilization, micro frequency steps and more. They will be available as software / firmware updates. TOPTICA's DLC CTL is “future ready”.



More than motor control: The DLC CTL digital control electronics features also all functionality of the DLC pro for DL pro lasers, including the optional DLC pro Lock for frequency stabilization.



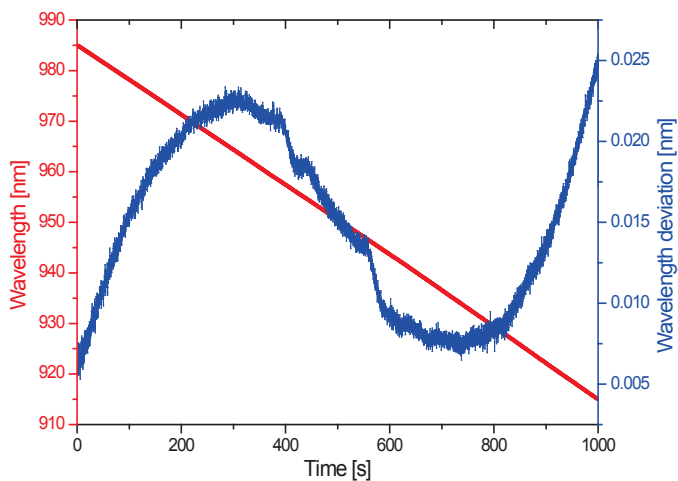
Class 3B Laser Product EN 60825-1:2007. Visible or invisible laser radiation. Avoid direct exposure to beam. Caution - Class 3B visible or invisible laser radiation when open. Avoid exposure to the beam. Magnetic fields may be present which may affect the operation of certain pacemakers.

Specifications

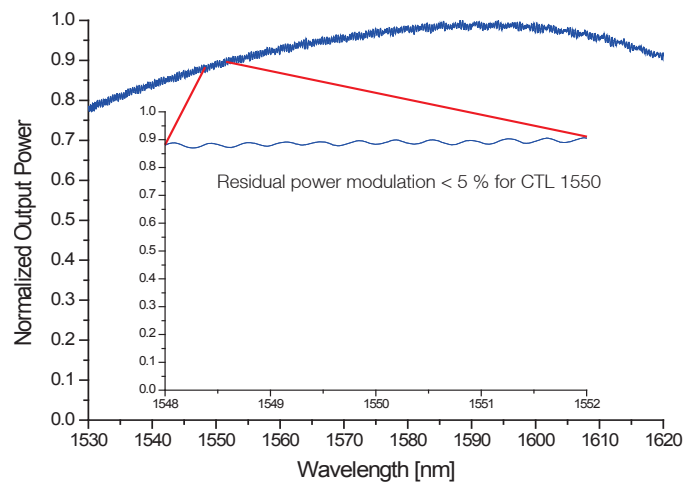
Continuously Tunable Lasers

Specifications		
	CTL 950	CTL 1570
Wavelengths*	915 - 985 nm	1530 - 1620 nm
Absolute accuracy	< 100 pm	< 150 pm
Relative accuracy (repeatability)	< 10 pm	< 10 pm
Linewidth (5 μ s)	< 100 kHz	< 100 kHz
Output power	max. 80 mW	max. 50 mW
Max. scan speed	10 nm/s	10 nm/s
Motor step size	5 μ m	8 μ m
Piezo scan	60 GHz	35 GHz
Piezo step size	<10 kHz	< 5 kHz
Output beam characteristics	TEM ₀₀ , typ. between 1 mm x 1 mm and 1 mm x 3 mm	
Beam height	(50 \pm 0.3) mm	
Polarization	vertical, typically 100:1	
Typ. residual power modulation while scanning	10 %	< 5 %
Fiber coupling efficiency	typically > 50% at gain max.	
Environment temperature (operating)	15 - 30 °C	
Environment temperature (transport)	0 - 40 °C	
Humidity	non-condensing	
Size head (H x W x D)	(90 mm x 150 mm x 250 mm) or (90 mm x 150 mm x 370 mm)	
Size electronics (H x W x D)	154 mm x 450 mm x 348 mm	
Weight head	8.1 kg	
Weight electronics	9 kg	
Operating voltage	100 - 120 V / 220 - 240 V AC, 50 - 60 Hz (auto detect)	
Power consumption	typically < 50 W	

* Wavelength range will be continuously expanded. Please inquire for your wavelength of choice.



Guaranteed mode-hop-free: CTL 950 scanning from 915 nm to 985 nm. The right axis shows the deviation between set wavelength and the wavelength measured with a wavelength meter. A mode-hop would appear as a clearly visible sharp step.



Output power as a function of the wavelength of the CTL 1550. Due to the large gain profile of the integrated laser diode, the output power varies smoothly by only ~20% over the whole specified tuning range.