Photonicals™

Laser Diodes & Laboratory Tools

TOPTICA Photonics provides not only state-of-the-art laser systems but also **laser diodes & laboratory tools** – valuable instruments and selected components that are used to upgrade, frequency stabilize or characterize lasers. All around the world scientists in universities and research laboratories as well as R&D specialists and integrators in the industry appreciate our portfolio as a **“selection of the best”**. Being a laser manufacturer, we do not intend to supply everything that can possibly be used in an optics laboratory. We prefer to focus on unique components, especially clever solutions, and just a few high-class instruments, which are superior to alternative products or the only solutions at all.

On the following pages you will find an assortment of such tools. The range includes specialized laser diodes and TO-3-adapters, wavelength meters, spectroscopy cell units, scanning Fabry-Perot Interferometers, beam shaping optics, isolators, proprietary fiber couplers and fibers as well as a versatile function generator allowing for phase coherent switching between frequencies up to 150 MHz.

Electronic laser driving and frequency control modules have already been described in the Photonicals™-Laboratory electronics chapter on pages 44–57.

FP, AR and DFB laser diodes

Laser Diodes

Widest Selection of FP, AR, DFB Diodes and Amplifier Chips

Name your wavelength — we provide it

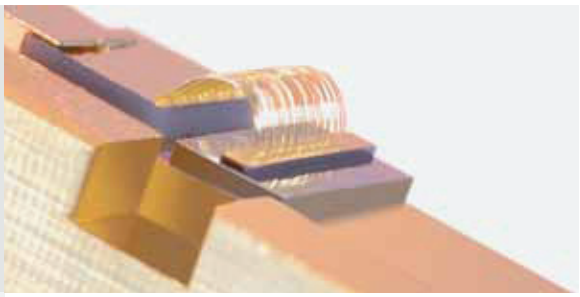
TOPTICA offers a large variety of wavelength-selected single-mode laser diodes and semiconductor amplifier chips from stock. You will find not just standard wavelengths, but also “pearls” for which we are the only supplier in the world.

Broadest wavelength coverage — ECDL approved

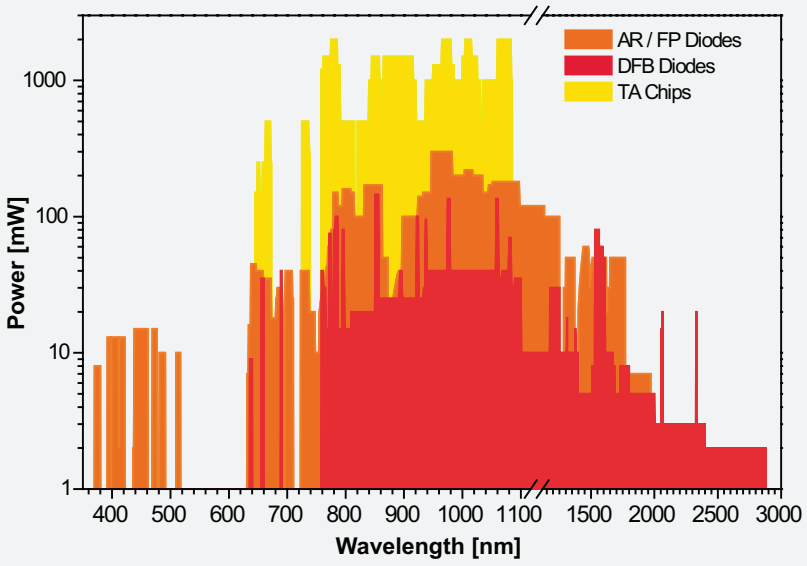
Laser diodes or tapered amplifier chips from TOPTICA are carefully tested in an external cavity, DFB or MOPA (master oscillator power amplifier) configuration and qualified with respect to tuning range, spectral and spatial mode characteristics, power limits and lifetime. Results are disclosed on request in a detailed datasheet. Apart from the broadest wavelength coverage (at present 370 nm .. 2880 nm), this add-on value is highly appreciated by our customers. Should you not be able to find your wavelength of choice or require other specials, simply contact us — and chances are high that we can provide an adequate diode within a very short lead time.

Detailed stock list online

General introductory remarks on Fabry-Perot (FP), anti-reflection coated (AR) and DFB/DBR-type laser diodes are found on page 13 of this catalog. For all of our diode types and amplifiers, regularly updated stock lists with detailed information on free running characteristics as well as tuning ranges and power levels achieved in TOPTICA’s lasers are accessible via our web site www.laser-diodes.com.



Specially mounted, selected and qualified tapered amplifier chips.



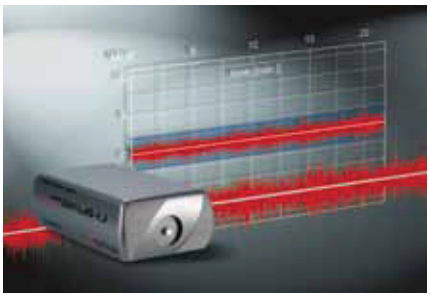
Available wavelengths and power levels with FP/AR laser diodes as used in TOPTICA’s ECDLs, with DFB laser diodes, and with tapered amplifier chips in TA pro configuration. (Availability subject to change without prior notice. Please check online or contact TOPTICA directly.)

Key features

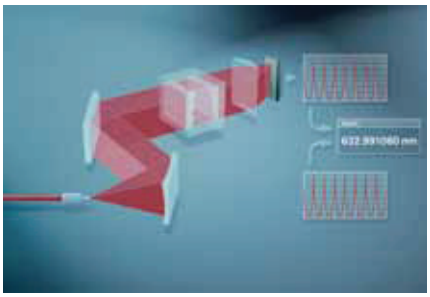
- Unique selection of FP, AR and DFB/DBR diodes, 370 .. 2880 nm
- Tapered amplifier chips, 645 .. 1083 nm
- All laser diodes and amplifiers extensively tested and qualified
- Regularly updated detailed stock list: www.laser-diodes.com

WS / HighFinesse Ångstrom Series

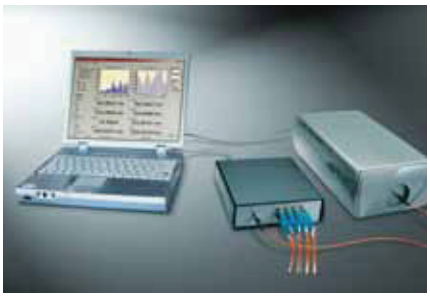
High Precision Wavelength Meters and Spectrum Analysers



WS/Ultimate, highest precision wavelength meter.



Fizeau interferometer setup of WS series.



MultiChannel option for simultaneous measurement of several lasers.

Highest accuracy & highest speed

The wavelength meters of the HighFinesse/Ångstrom series accomplish wavelength measurements with highest accuracy. Both cw and pulsed lasers with narrow-band emission can be examined, monitored and even actively controlled. Various models of the **WS series** are available, covering UV to IR wavelength ranges (192 nm .. 11 µm).

Based on a rugged Fizeau interferometer setup without any moving components, the wavelength meters provide best performance even under harsh conditions. The interferogram is read out by a sensitive CCD array. Sophisticated firmware exploits the interferogram data to calculate the laser wavelength. The result is displayed in nm, Hz, cm^{-1} or eV, whatever you prefer. The sensitivity of the detector unit is in the nW range. High-speed data processing algorithms enable single-pulse measurements up to a repetition rate of 300 Hz.

Convenient operation

Easy handling is guaranteed by a fiber input port which serves to couple the laser radiation into the wavelength meter. The device is computer-controlled via a fast USB interface. Automated long-term measurements can be recorded to assess the frequency stability of a laser system.

Options and accessories

The PID control option permits locking of the laser frequency to arbitrary values, without requiring atomic transitions or cavity transmission peaks. In addition, various functions (sine curve, triangle, etc.) to scan your laser in any desired manner. For monitoring several lasers, the MultiChannel option enables simultaneous wavelength measurements of 2, 4 or even 8 laser systems. The PID option can be combined with the MultiChannel option to stabilize up to 8 lasers simultaneously. Further options allow for linewidth determination, or synchronization to a given experiment via a TTL port.

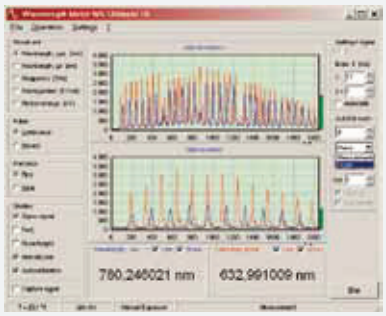
Key features

WS Series

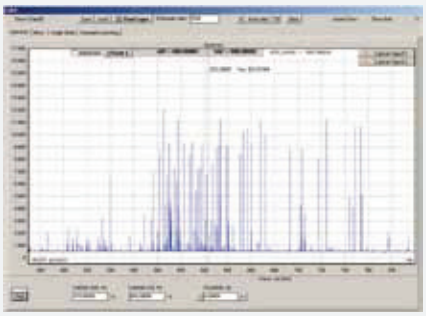
- Unmatched absolute accuracy up to 2 MHz
- Measurement ranges from UV to IR (192 nm .. 11 µm)
- For pulsed and cw lasers
- Sensitivity down to nW light power
- Up to 300 Hz acquisiton speed
- MultiChannel option
- PID control

Options

MultiChannel	Simultaneous measurement of 2, 4, or 8 lasers
PID control	Locks your laser to any wavelength or tunes it along arbitrary functions. Can be combined with MultiChannel option
Linewidth option	Calculates the laser linewidth using the interferogram data
Diffraction grating	For spectral analysis of broad linewidth lasers
TTL	For synchronization of experiment and measurement



Wavelength meter display (WS/Ultimate-10 plus MultiChannel option)



Typical measurement of the spectrum of a gas discharge lamp. The HDSA resolves lines over the entire visible spectral range.

Spectrum analysis for experts

The **Laser Spectrum Analyser LSA** and the **High Definition Spectrum Analyser HDSA** options provide spectral information of both pulsed and cw light sources. The LSA is designed for multi-line or broadband spectra e.g. of gas discharge lamps, superluminescent diodes, laser diodes and LEDs. The HDSA analyzes spectra of arbitrary complexity, processing the entire spectral range from 400 nm to 900 nm at once, while maintaining the HighFinesse principle of avoiding any “moving optics”.

Key features

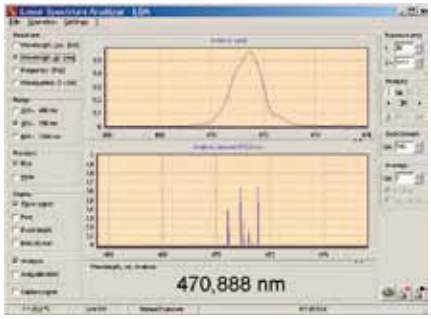
High Definition Spectrum Analyser

- Spectral range: 400 .. 900 nm
- Absolute Accuracy: 3 GHz
- Wavelength deviation sensitivity: 0,6 GHz
- Analyzes entire spectral range at once
- Extreme sensitivity: 500 pJ @ 633 nm
- Resolution: $\lambda/\Delta\lambda$ = 15000, e.g. 40 pm (33 GHz) @ 600 nm, 50 m multimode fiber
- Built-in calibration source

Key features

Laser Spectrum Analyser

- 350 .. 1120 nm UV and IR versions
- Absolute Accuracy: 6 GHz
- Wavelength deviation sensitivity: 1 GHz
- Sensitivity: 5 nJ @ 633 nm
- Low stage spectral resolution: ($\lambda/\Delta\lambda_{FWHM}$): 500
- High stage spectral resolution ($\lambda/\Delta\lambda_{FWHM}$): 20000 (SM fiber), 10000 (50 µm fiber)
- max. spectral range: 3 THz on both sides of central peak
- Linewidth measurement included accuracy: 10 %
- Built-in light source for autocalibration



Spectral analysis of Neon discharge lamp by LSA.

Specifications WS-Series Wavelength Meters

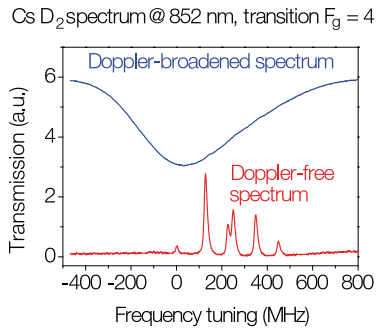
			LSA	WS5	WS6-600	WS6-200	WS7	WSU-30	WSU-10	WSU-2
Measurement range	Standard	350 .. 1120 nm	●	●	●	●	●	●	●	●
	UV	248 .. 1100 nm	●	●	●	●	●	●	●	
	UV-II	192 .. 800 nm	●	●	●	●	●			
	IR	800 .. 1750 nm		●	●	●	●	●	●	
	IR-II	1000 .. 2250 nm		●	●	●	●			
	IR-III	2 .. 11 µm				●				
Absolute accuracy		192 .. 370 nm [pm]	6	3	0.6	0.4	0.2	0.1	0.1	0.1
		370 .. 1100 nm [MHz]	6000	3000	600	200	60	30	10*	2**
		1100 .. 2250 nm [MHz]	4000	2000	400	150	40	20	10	
		2 .. 11 µm [MHz]				200				
Calibration			Built-in	Built-in	Built-in	Built-in ***	External	External	External	External

* ± 200 nm around calibration wavelength ** ± 2 nm around calibration wavelength *** except IR-III

CoSy & Spectroscopy Cells

Compact Spectroscopy Unit & High-Quality Gas Cells

CoSy—measurement head and control unit.



Doppler-free and Doppler-broadened absorption spectrum of Cesium. All hyperfine and cross-over lines are resolved.

Key features

- Doppler-free saturation spectroscopy
- Subtraction of Doppler background
- Intensity normalization
- Magnetic field coils
- Fiber coupling

High quality spectroscopy cells.

Compact Saturation Spectroscopy Unit

Saturation spectroscopy is a well-established technique for precise frequency stabilization of tunable lasers. The usage of two counter-propagating laser beams within the same absorption volume serves to select a class of atoms with zero velocity in the direction of the beam. Hence, Doppler broadening of atomic absorption lines is suppressed, greatly increasing the resolution of the acquired absorption spectra.

Ideal for laser locking

The CoSy module comprises all optical and electronic components for Doppler-free spectroscopy in a compact, fiber-coupled unit. A laser can easily be stabilized to an absorption signature, using the regulator modules of the SYS DC 110 series (pages 46–53), or the stand-alone LaseLock (page 55). Frequency stabilities well below 1 MHz, are easily attained. Corresponding to relative uncertainty on the ~10^{-9} level.

CoSy components

The CoSy measurement head contains the spectroscopy cell, optics and photodetectors. The absorption cell is thermally stabilized in order to provide a constant vapor pressure. The CoSy Control unit includes the power supply module, the signal processing board, the temperature controller, and output signal connectors. Both Doppler-broadened and Doppler-free spectra are simultaneously available. Small magnetic fields (DC & AC) can be applied by integrated Helmholtz coils

Spectroscopy Cells

TOPTICA also offers a range of individual spectroscopy cells. Cells are available in several sizes and fillings. Standards are Rb, Cs and K. Please check our stock list for available cells.
www.toptica.com/products/cells.pdf

Specifications CoSy

Dimensions of glass cell	ø 26 mm x 25 mm or ø 26 mm x 15 mm
Available fillings	(COSY-RB) Rubidium; mixture of ^{85}Rb and ^{87}Rb (COSY-CS) ^{133}Cs (COSY-XX) Other cells on request
Fiber input power	1 µW .. 3 mW, depends on required resolution and SNR
Gain of photo detector amplifiers	Adjustable via range switch (coarse) and trim potentiometer (fine)
Set temperature of glass cell	Adjustable via trim potentiometer, range 10 .. 40 °C (no cooling below room temperature)
Electronic outputs (BNC sockets)	A: Doppler-free absorption spectrum B: Doppler-broadened absorption spectrum I: Optical input power level
Integrated field coil	AC or DC magnetic field for Zeeman spectroscopy, magnetic flux density: range ±70 µT
Housing dimensions	CoSy head 80 x 80 x 114 mm^3 CoSy control 88 x 125 x 209 mm^3
Operating voltage for CoSy control	100 .. 120 V / 220 .. 240 V AC, 50 .. 60 Hz (auto detect)

FPI 100

Fabry-Perot Interferometer and Detector Unit

Confocal scanning interferometer
The Fabry-Perot Interferometer FPI 100 comprises a confocal scanning interferometer and a photodetector unit in a single, compact and rugged device.

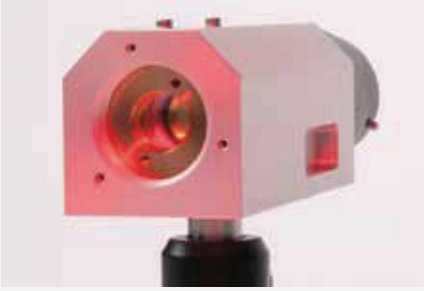
Scanning Fabry-Perot interferometers are established tools for monitoring the spectral characteristics of continuous-wave (cw) lasers. When high resolution, as well as fast and convenient operation, is required, the confocal interferometer design is the most appropriate solution.

Different mirror sets
The FPI 100 is available with eight different mirror sets and three photo detectors for wavelength ranges between 330 and 3000 nm. The standard mirror reflectivity is 99.9 %, other reflectivities are available upon request. The customer can choose between free spectral ranges (FSR) of 1.0 GHz or 4.0 GHz. For both models, typical finesse values of about 1000 are attained, translating into a spectral resolution of 1 MHz or 4 MHz, respectively. Thus, even narrow laser lines can be resolved.

Key features

- Convenient mode analysis of diode lasers
- Eight mirror sets available for wavelengths 330 .. 3000 nm
- Free spectral range 1 GHz or 4 GHz, finesse > 400 (typ. 1000)
- Reduction of short-term linewidth of diode lasers possible (please inquire)

Options	
Mirror exchange kit	Quick adaptation to new wavelength ranges
	Eight different mirror sets available for wavelengths 330 .. 3000 nm (see page 64)
Photo diode exchange kit	Matches the diode sensitivity to the incident light wavelength
	Three models available, wavelength ranges • 330 .. 1100 nm (FPI-PD-EXCK-VIS) • 900 .. 1700 nm (FPI-PD-EXCK-NIR • 1500 .. 3000 nm (FPI-PD-EXCK-IR)
	Auto-aligned unit with built-in focusing lens
Scanning option	Stand-alone scan generator miniScan (page 65) with integrated photodiode amplifier
	Piezo element in FPI can also be driven with SC 110 module (see page 47)
Fiber coupler kit	Convenient coupling via FC/APC fiber connector



Scanning Fabry-Perot interferometer and detector unit.

Mirror exchange kit.

Photo diode exchange kit.

FPI 100

Fabry-Perot Interferometer and Detector Unit

FPI 100 base units						
Article number	**Wavelength range**	**FSR**	**Finesse** Spec.	Typ.	**Resolution** Typ.	**Aperture**
FPI 100-0355-y	330 .. 380 nm	y = 1 : 1 GHz y = 4 : 4 GHz	> 200	500	1 or 4 MHz	7 mm
FPI 100-0400-y	380 .. 430 nm		> 300			
FPI 100-0500-y	430 .. 660 nm		> 400	1000		
FPI 100-0750-y	615 .. 885 nm		> 400			
FPI 100-0980-y	825 .. 1200 nm		> 400			
FPI 100-1500-y	1200 .. 1700 nm		> 400			
FPI-100-2000-1**	1700 .. 2550 nm	1 GHz	> 200	500	2 MHz	
FPI-100-2800-1**	2650 .. 3000 nm	1 GHz	> 200	500	2 MHz	

* Tolerance of FSR ±0.5%
** Requires miniScan 100 and PDA-S (not miniScan 102)
Base unit includes piezo stack for scanning, mirrors, and photodetector.
Not included: HV scan generator or fiber adapter – please see options below.
Mirror sets of all FPI articles are also available as mirror exchange kits.

Options and accessories

Drivers and detectors		
Article number	**Description**	**Specifications**
SC 110	Scan unit	Voltage ramp 0 .. +150 V
miniScan 100	Scan unit	Voltage ramp 0 .. +100 V
PDA-S	Photo diode amplifier	Variable gain (3.3 x 10^4 V/A to 1 x 10^7 V/A), 6 levels, 30 kHz bandwidth
miniScan 102	Scan unit with integrated photo diode amplifier	Voltage ramp 0 .. +100 V Variable gain (3.3 x 10^4 V/A to 1 x 10^7 V/A), 6 levels, 30 kHz bandwidth

Photo diode exchange kits		
Article number	**Description**	**Wavelength coverage**
FPI-PD-EXCK VIS	Photo diode VIS	330 .. 1100 nm
FPI-PD-EXCK NIR	Photo diode NIR	900 .. 1700 nm
FPI-PD-EXCK IR	Photo diode IR	1500 .. 3000 nm

Fiber coupler kit	**FPI-FCK FC/APC**	**Standard socket type FC/APC**
We also offer other fiber accessories. Please inquire.		

miniScan 100 / 102

Scan Generators with Piezo Driver and Photo Diode Amplifier

Scan units for FPI 100—and more
The miniScan modules (miniScan 100 and miniScan 102) comprise a scan generator with piezo driver. The units have been designed for scanning interferometers such as TOPTICA's FPI 100 (see pages 63–64), but can also be used independently for everyday laboratory tasks. Output amplitude and frequency range have been adapted to low voltage piezo actuators (up to 100 V output, 2.5 mA).

The miniScan 102 features an additional low-noise photo detector amplifier (transimpedance amplifier, i.e. current-to-voltage converter). It is ideally suited for reading out FPI transmission signals, e.g. to monitor the longitudinal mode properties of tunable lasers.

miniScan 102—scan generator with photo diode amplifier.

Key features

- miniScan 100 / 102: Stand-alone scan generators for scanning interferometers
- miniScan 102: Integrated transimpedance amplifier for photo detectors

Specifications

Scan generator (miniScan 100 and miniScan 102)	
Frequency	100 mHz .. 200 Hz (linear ramp), adjustable via 3-stage range switch (coarse) and potentiometer (fine)
HV amplifier	0 .. +100 V output, max. 2.5 mA
Offset and amplitude of output signal	Adjustable via potentiometer
Trigger output	TTL (+5 V)
Operating voltage	100 .. 120 V / 220 .. 240 V AC, 50 .. 60 Hz (auto detect)
Dimensions	125 x 88 x 205 mm^3

Photo diode amplifier (miniScan 102)	
Gain	Adjustable from 3.3 x 10^4 V/A to 1 x 10^7 V/A, via 6-stage switch (coarse) and potentiometer (fine, 10 – 100 %)
Offset of output signal	Adjustable via potentiometer
Output coupling	AC (10 Hz), AC-HF (300 Hz) or DC coupling
Detection bandwidth	30 kHz

ColdPack

TO-3 Adapter with TECs and Thermistor

TO-3 adapter with integrated TECs and thermistor.

Thermal control made easy
The ColdPack is a TO-3 style package with integrated thermistor and thermoelectric coolers. It offers full thermal control of laser diodes built into 9 mm (SOT-148) or 5.6 mm (TO-18 or MG) packages. Four thermoelectric elements serve to stabilize the laser temperature or rapidly cool/heat the diode, as required by the application in mind. The actual temperature can be monitored online by means of an integrated thermistor (10k NTC).

For ultra-precise temperature regulation, we recommend using the ColdPack in conjunction with our Diode Laser Temperature Control DTC 110 (page 47) to achieve a thermal stability below 1 mK.

The ColdPack lends itself particularly to frequency control of Distributed Feedback laser diodes (page 13): a temperature sweep of 40 K corresponds to approx. 1000 GHz of frequency tuning.

Key features

- Precise temperature stabilization and rapid cooling / heating
- Suitable for frequency tuning of DFB laser diodes
- Adapter kit for 9 mm or 5.6 mm laser diodes
- Patented design (DE19926801)

Technical data	
The ColdPack includes 4 thermoelectric modules in series	
Q_{max}	11.2 W
T_{min}	0° C
T_{max}	50° C
U_{max}	17.2 V
I_{max}	1.2 A

APP J

Adjustable Anamorphic Prism Pair

APP J, anamorphic prism pair for flexible laser beam shaping.

Rendering diode laser beams circular
Diode lasers usually feature an elliptical beam profile. Often, however, a circular beam shape is preferred, e.g. for mode-matching to an external resonator, or to obtain supreme fiber coupling efficiencies. The APP J is an adjustable anamorphic prism pair, which circularizes an elliptical beam: It either expands or compresses one of the beam axes while leaving the other axis unchanged. The result is a perfectly circular beam. Since each laser diode exhibits its own individual beam ellipticity, the APP J offers a magnification or compression ratio continuously variable between 2 and 5.

An outstanding feature: the output beam remains exactly parallel to the incident beam with a constant displacement of 8 mm, independent of the magnification or compression ratio.

The housing can easily be fixed on any standard mirror mount or post.

Key features

- Beam shaping for diode lasers, e.g. for increased fiber coupling efficiency
- Variable magnification or compression ratio (2 .. 5)
- Beam aperture 8 mm
- No angle shift of output beam
- Patented design (DE10017884)

Adjustable prism pairs			
Article number	**Wavelength (nm)**	**Compression / magnification**	**Trans-mission (typ.)**
APP J 390-420	390 .. 420	2 : 1 .. 5 : 1	95 %
APP J 600-1100	600 .. 1100		
APP J 1100-1500	1100 .. 1500		

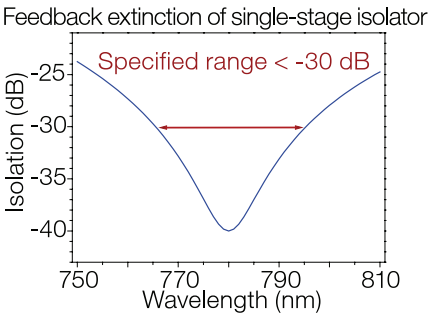
Optical Isolators

Feedback Protection for Diode Lasers

Optical isolation—why?
Diode lasers, in particular highly coherent, spectrally narrow external-cavity or DFB laser systems, are sensitive to optical feedback from reflective surfaces. Weak back-reflections from lenses, mirrors and optical fibers or from other laser beams (e.g. optical amplifiers) adversely affect the laser's coherence. Even worse, strong feedback may lead to irreversible damage of the laser diode itself. We therefore recommend the use of optical isolators to protect your diode laser from unwanted feedback.

Principle of operation
An optical isolator permits the transmission of polarized light in one direction only. Its principle is based on the Faraday effect, i.e. the rotation of the light polarization axis in a crystal within a strong magnetic field. The main components are an entrance polarizer, then the Faraday rotator – typically a terbium gallium garnet (TGG) crystal inside a permanent magnet – and an exit polarizer oriented at 45° relative to the first polarizer. Since light from diode lasers is usually linearly polarized, the orientation of the entrance polarizer can be made to match the polarization axis. The Faraday element then rotates the polarization axis by 45°, hence the light passes the second polarizer without attenuation. As the Faraday effect is independent of the direction of light propagation, stray light travelling backwards is highly suppressed by the two polarizers.

Optical isolators for different wavelengths and beam sizes.



Typical extinction curve of a single-stage isolator at 780 nm. The maximum extinction ratio is -40 dB. The red arrow indicates a range of approx. 25 nm, where the extinction is still < -30 dB.

Options

Single-stage isolators: extinction ratio > 30 dB

Recommended for fiber coupling of DL100, DL pro, DL DFB lasers into angle polished fibers

Double-stage isolators: extinction ratio > 60 dB

Recommended for seed laser protection in MOPA configurations or SHG setups

Fiber coupling of TA, DLX, BoosTA

Fiber coupling of any laser into PC polished fibers or fiber-optic beam splitters

Feedback protection during resonator alignment, e.g. FPI

TOPTICA can fine-tune the isolators to provide maximum transmission (> 90 % per stage) and at the same time maximum extinction at any wavelength of interest.

Key features

- Excellent feedback protection by high-quality polarization optics
- Best isolation and highest transmission at the same time
- Wide wavelength range available (UV to NIR)
- 3 .. 5 mm aperture
- Single-stage (isolation > 30 dB) and double-stage (isolation > 60 dB) models

FiberDock™ and FiberOut

Universal Fiber Coupler and Fiber Collimator

Universal fiber coupler.

Patented flexure mounts with << 1 µm coupling accuracy.

Convenient handling

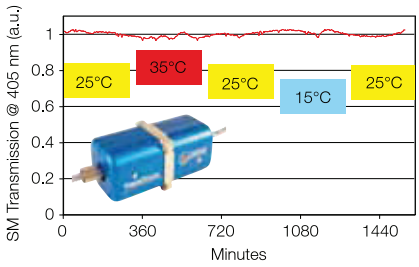
The FiberDock is a conveniently aligned fiber coupler, suitable for both TOPTICA laser systems and third party lasers. The FiberOut is a compact, easy-to-use output collimator for any fiber-coupled laser system.

TOPTICA's patented FiberDock (US 7,321,706, EP 1,666,944) is a compact, rugged coupler designed for easy use, yet providing all required degrees of freedom for maximum coupling efficiencies. All six alignment axes (2 x X/Y, Z, and Theta) are decoupled, and mechanical hysteresis is reduced to a minimum. Once aligned, all axes can be individually locked.

Based on the laser & fiber parameters, a suitable focusing lens is selected. The FiberDock can be mounted on various adaptors (supplied by TOPTICA) or fixed directly to your laser device.

Flexible output collimation

The FiberOut is a rugged, inexpensive collimator that lends itself to both FC/PC and FC/APC-type connectors. It can be equipped with a variety of lenses, matching different fiber mode-field diameters and output beam sizes. The lens position is adjustable along the optical axis.



Ultimate thermal stability during temperature cycling.

Key features

- Highest single-mode coupling efficiency
- Simple and straight-forward adjustment
- Optimized for stability during temperature cycling

Specifications

Fiber type	MM, SM, PM
Connector	FC/PC and FC/APC
Wavelength range	350 nm .. 3000 nm
Size	40 x 40 x 41,5 mm^3 (W x H x L)
Coupling efficiency	Up to 85 % in a SM fiber Up to 90 % in a MM fiber
Clear aperture	Up to 6 mm (depending on lens, typ. > 4.5)

Fibers, Splitters and Combiners

Standard and Customized Components

Key features

- MM, SM and PM fibers
- "Longlife" fibers especially for blue/violet wavelengths
- Fiber splitters and combiners (SM, PM)

TOPTICA offers a wide range of multi mode (MM), single mode (SM), and polarization maintaining (PM) fibers, specialty fibers and fiber splitters/combiners. Standard fibers (MM, SM, PM, 350 nm .. 1800 nm) are listed online: http://www.toptica.com/fibers.html.

We also supply fiber splitters and combiners in SM (400 nm .. 1600 nm) and PM (760 nm .. 1600 nm) versions, with various ratios and configurations. They can be used for tapping off probe beams, or for beam combination in beat experiments (e.g. cw-THz applications, page 84).

VFG 150

Versatile Function Generator*

Based on latest Direct Digital Synthesizer (DDS) and Field Programmable Gate Array (FPGA) technology, TOPTICA offers with the VFG 150 not only another 150 MHz arbitrary waveform generator but a novel approach to phase-controlled, coherently driven experiments in atom, ion and condensed matter physics.

Phase-controlled frequency switching of RF signals

The VFG 150 allows the user to predetermine the amplitude, frequency and phase of its sinusoidal output with a dwell time down to 5 ns. The frequency generator can be operated in two different frequency switching modes. Phase-continuous switching preserves the actual phase when changing from one frequency to another. In phase-coherent mode, the phase at the switching time is set such that the new RF oscillates in phase with a virtual RF of the same frequency started at the beginning of the experimental sequence. Additionally, it allows for a user-defined phase offset maintaining the phase information of a given frequency all the time.

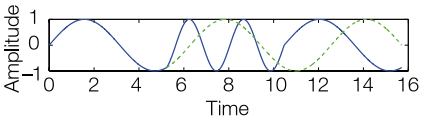
Unlike arbitrary waveform generators, which are limited by their internal memory, the VFG 150 can emit infinitely long signal trains with a very high complexity.

*Developed with Siegen University, group of Prof. Wunderlich.

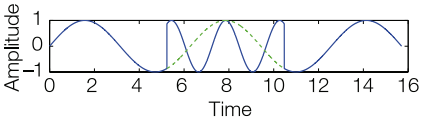
VFG 150—more than just an arbitrary waveform generator.

Key features

- Frequency switching modes: phase-continuous, phase-coherent
- Frequency range 1 .. 150 MHz
- USB 2.0 computer interface with streaming capability
- Infinitely-long random sequences, not limited by storage capacity



Phase-continuous switching. The phase of the output signal after switching back from an intermediate frequency to the initial frequency is different from its initial phase, leading to a smooth amplitude change without discontinuities.



Phase-coherent switching. Even when switching back and forth between various frequencies the phase of each frequency is preserved. Additionally a user controlled phase offset can be added.

Specifications

Frequency range	1 .. 150 MHz
Frequency resolution	32 bit, better than 50 mHz resolution
Frequency switching modes	Phase-continuous and phase-coherent switching
Frequency switching time	Internal trigger: 5 ns External trigger: Less than 100 ns from trigger pulse
Maximum amplitude	-4 dBm**
Noise level	Better than -70 dB within 1 kHz band of carrier
Dynamic range	Better than 50 dB
Types of pulses supported	Any pulse with up to 1000 steps and down to 5 ns dwell time, e.g. Blackman, Gaussian, Gaussian chirped, etc.
Maximum length of sequences	Unlimited
Inputs	Trigger 5 V CMOS, digital coupler isolated External clock 5 V CMOS, digital coupler isolated
Outputs	Synthesized waveform up to -4 dBm** into 50 Ω, transformer isolated Auxiliary digital outputs 4 x 5 V TTL into 50 Ω

**The maximum amplitude depends on the frequency and is lower at the extremes of the frequency range.