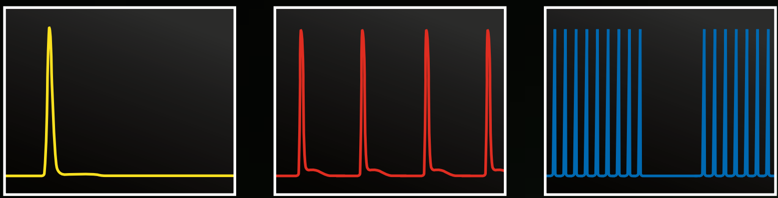
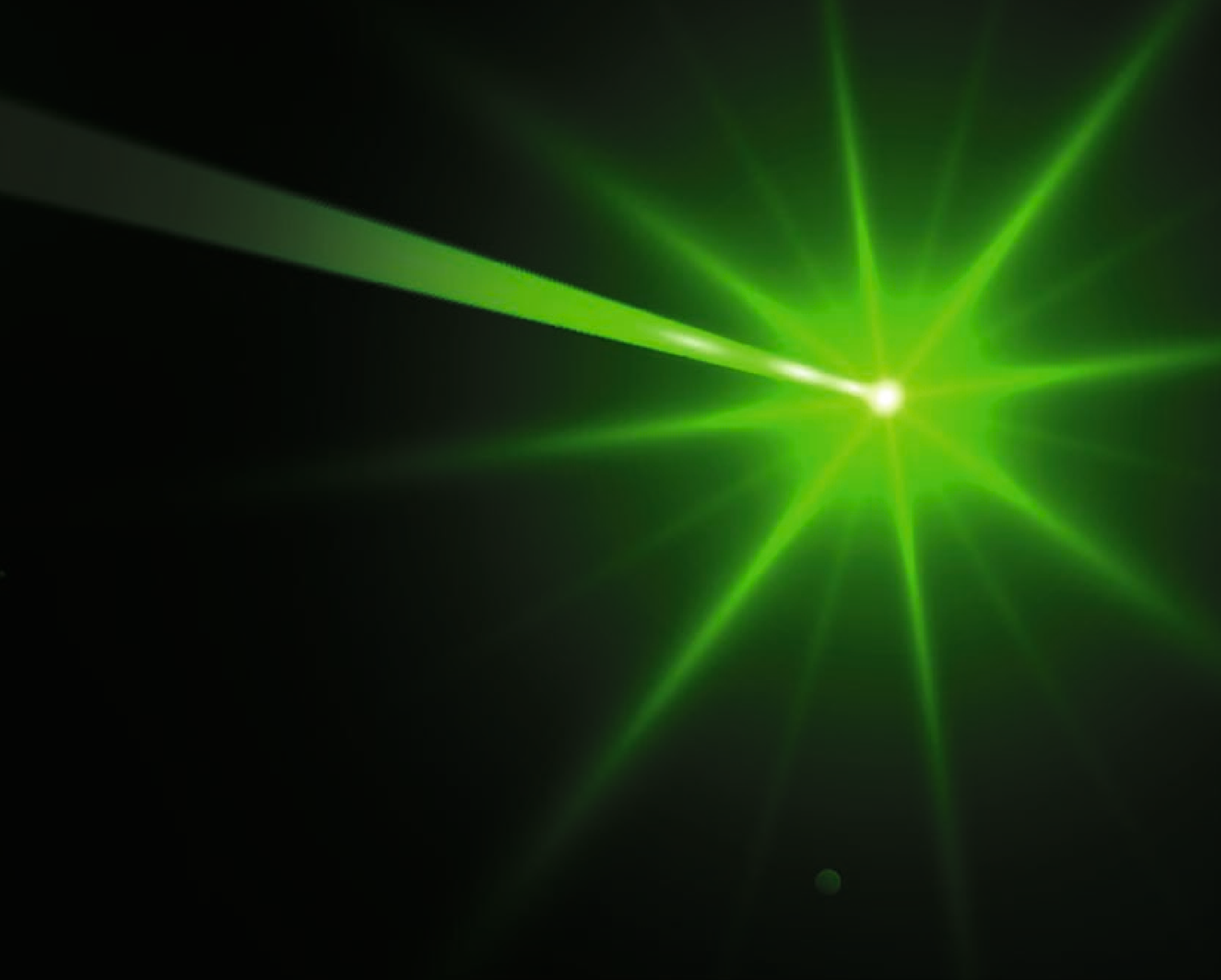
PicoQuant

Diode Lasers

Flexible picosecond pulsed solutions





A Family of Diode Lasers

Compact turn-key diode laser solutions

All PicoQuant laser products are based on small, compact, and reliable laser diodes. Complex driving electronics allow generating a wide variety of picosecond pulsed output patterns that are relevant for both sophisticated research as well as routine applications.

Lasers have become a fundamental tool in today's research and are available in many types, sizes, and operational modes. PicoQuant's philosophy is to provide a wide range of affordable turn-key laser solutions that can be operated without special knowledge or need for cumbersome alignment procedures. Our lasers let you focus on the application rather than on the experimental set-up!

VisUV Platform

- **Flexible combination of up to 3 wavelengths**
- **266, 280, 295, 355, 532, 560 and 590 nm**

VisIR Platform

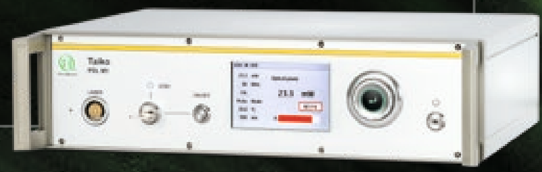
- **High output power**
- **765, 1064 and 1530 nm**

OEM Lasers

- **Diode and fiber amplified solutions**
- **Tailored to your needs**

Taiko PDL M1

- **Smart laser driver**
- **Manual and computer control**
- **Up to 100 MHz repetition rate, power calibration**



PDL 800-D

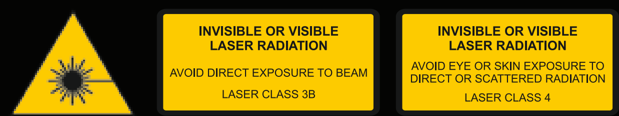
- **Single channel driver**
- **Manual control**
- **Up to 80 MHz repetition rate**

LDH Series: widest choice of laser heads

- **Optional CW operation**
- **266 to 1990 nm**

PDL 828 "Sepia II"

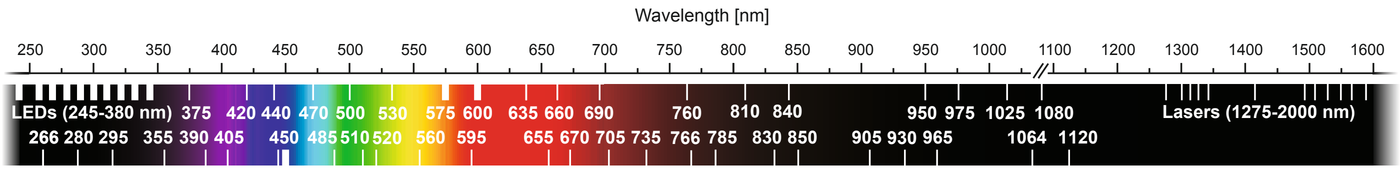
- **Multi channel driver**
- **Computer control for up to 8 laser heads**



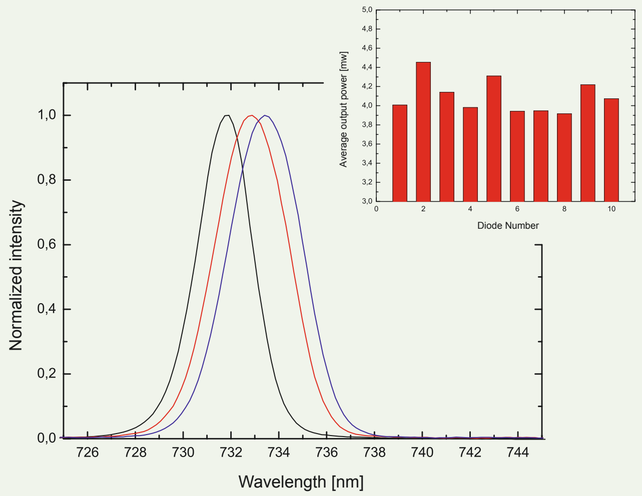
Pulsed Diode Lasers

A great diversity of laser diodes

All PicoQuant lasers are based on diodes which are operated in picosecond pulsed mode using a method called "gain switching". Gain switching essentially consists in the application of a well dosed amount of electric current into the laser diode. By varying this current using sophisticated, proprietary driving electronics, laser pulses with flexible patterns can be produced for various applications, ranging from fluorophore excitation to detector testing, quantum optics, or LIDAR.



Examples



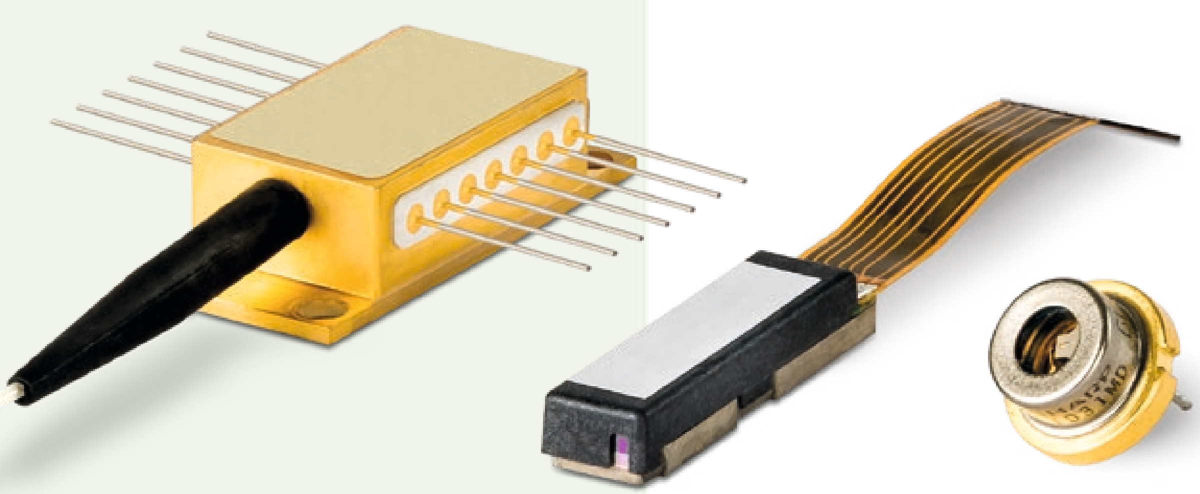
Each laser diode in a batch is unique in its emission properties, as can be seen from the variation of its central emission wavelength. Another indicator is the maximum achievable output power in pulsed mode, as shown in the inset for 10 randomly picked diodes of the same type.

Each laser diode is unique

A general characteristic of laser diodes is their uniqueness. Although they are manufactured in great numbers following a single process, every unit is slightly different from others in the same batch. As a consequence, emission properties such as central wavelength, shortest pulse width, or achievable output power do slightly vary from diode to diode. On the upside, these variations allow selecting diodes that are best suited for a specific application.

Widest spectral coverage

Diode lasers are available with many different wavelengths ranging from the ultraviolet (UV) up to the mid-infrared (MIR) spectral range. Currently more than 120 laser head types are available from PicoQuant with wavelengths between 266 and 1990 nm, based on directly emitting laser diodes or using frequency conversion techniques.



Gain switching for ps pulses

Picosecond pulses are generated by injecting a given number of charge carriers into the laser diodes active region within a very short time. When the carrier density exceeds the lasing threshold, a relaxation occurs in the form of a short optical pulse. This permits generating picosecond pulses with a minimum of decay, ringing, or background after the pulse.

Fast and short pulses

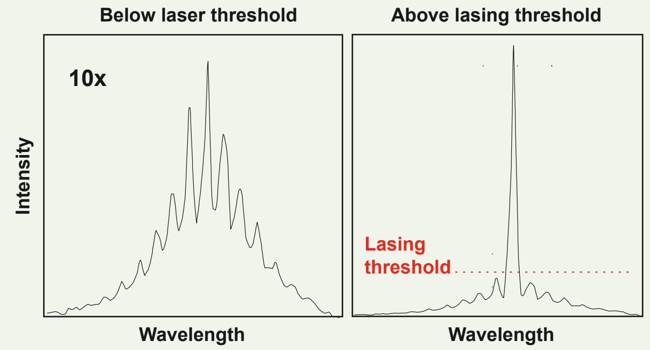
Depending on the laser head, diodes can be pulsed at repetition rates ranging from single shot up to 40, 80, or even 100 MHz. They deliver optical pulse widths down to 30 ps and typical average output powers of a few mW at maximum repetition rate. When operated in continuous wave mode, our diodes can achieve average powers of up to 500 mW.

Turn-key systems

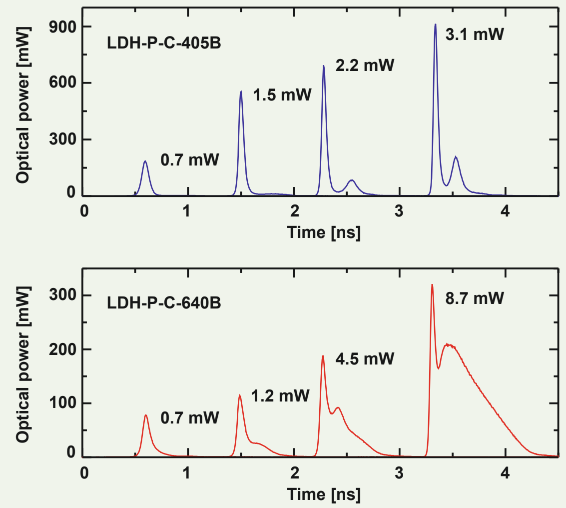
All PicoQuant laser devices are designed as turn-key systems with a focus on reliability and ease-of-use. The devices are either stand-alone units or consist of two basic components: a driver and a laser head. Both types are compact units with little to no user adjustable parts, thus eliminating the need for cumbersome beam alignment.

PicoQuant's laser drivers are designed as universal units, meaning that a wavelength change only requires to plug in in another laser head.

Examples



Besides the always occurring spontaneous emission, the diode will emit a short laser pulse when operated above the lasing threshold. However, a small amount of spontaneous emission is still present in the output and can be removed by a suitable laser clean-up filter.

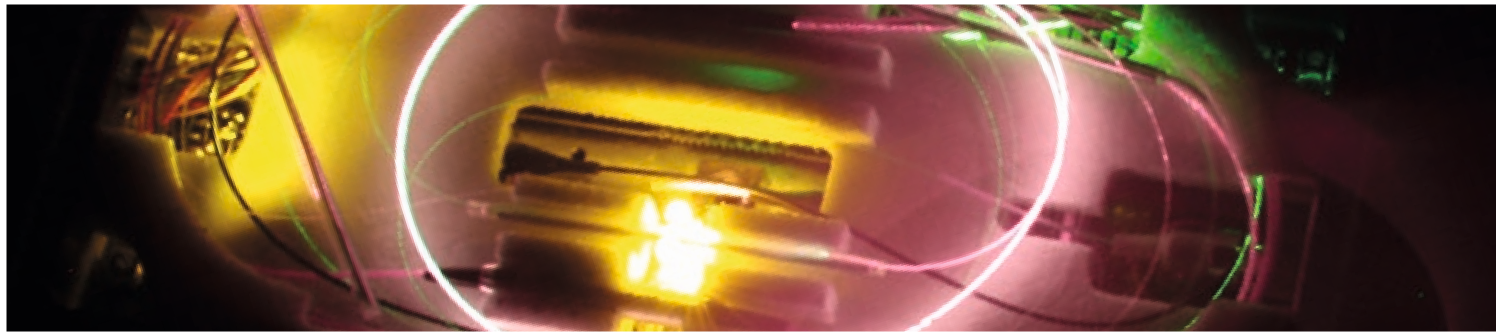


Typical pulse profiles of "blue" and "red" laser heads of the LDH-P Series. The upper image shows the emission profile of an LDH-P-C-405B and the lower image that of an LDH-P-C-640B. The different curves are generated by changing the driving current of the laser diode using the corresponding laser driver settings.

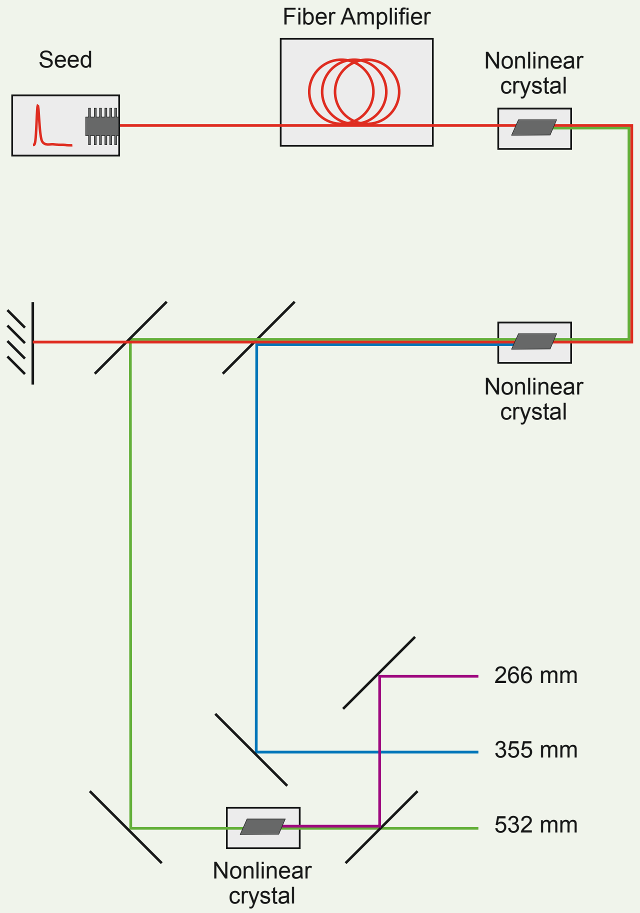
Fiber Amplified Diode Lasers

High output power and wavelength conversion

Diode lasers can also be used as seed for fibre amplification. Fiber amplification not only provides higher optical output power in the infrared, but also enables efficient wavelength conversion techniques, generating discrete wavelengths in the ultra-violet, green, yellow, or red spectral ranges.



Example



Scheme of a multi beam fiber amplified laser module from the VisUV platform series including second, third, and fouth harmonic generation from a 1064 nm oscillator.

An infrared diode laser is used as a seed for a multi-stage fiber amplifier in a Master Oscillator Fiber Amplifier (MOFA) arrangement.
A series of nonlinear frequency conversion crystals are used to generate emission wavelengths in the visible and UV spectral range.

The MOFA concept

Our fiber amplified laser diode systems are based on a Master Oscillator Fiber Amplifier (MOFA) concept with optional wavelength conversion. The master oscillator (seed diode) generates infrared picosecond light pulses with variable repetition rates of up to 80 MHz using PicoQuant's proven gain-switching techniques. The diode output is connected to a fiber amplifier, which boosts the seed laser pulses while maintaining other beam characteristics like, the emission wavelength, polarization, and short pulse width.

Conversion to ultra-violet, green, or red

The high pulse energies of the amplified infrared lasers (1030, 1064, 1530 nm) permit efficient wavelength conversion using second, third, or even fourth harmonic generation. In that way, it is possible to generate picosecond pulses at 266, 280, 295, 355, 515, 532, 560, 590 or 766 nm with adjustable repetition rates up to 80 MHz.

Clean pulse shapes

In contrast to directly pulsed laser diodes, fiber amplified lasers show a clean temporal pulse shape, which is also independent from the selected power level. The pulse width of fiber amplified laser is below 100 ps (FWHM).

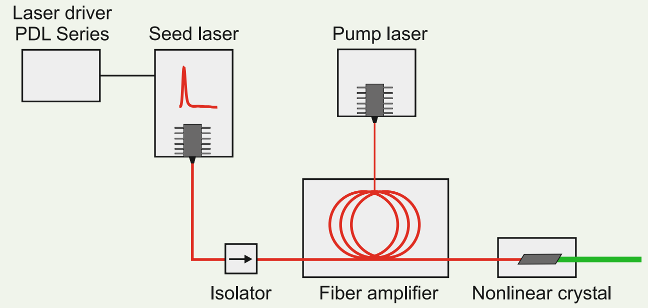
Up to several Watts of average power

Fiber amplified lasers are available in a variety of types including dedicated laser heads with fiber pigtailed or collimated free beam output or standalone high power laser modules. Such laser can achieve average power levels up to 1.5 W. The output beam from this laser head type has typically a lower ellipticity than those from directly pulsed laser diodes and coupling efficiency into single-mode fibers reaches values greater than 50 %.

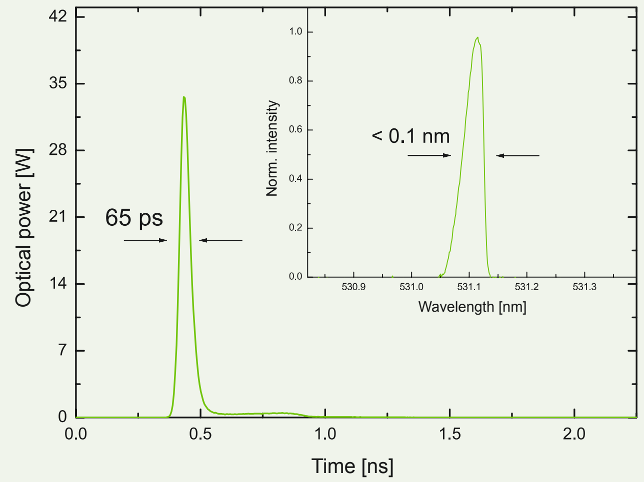
Repetition rates up to 80 MHz

Our fiber amplified lasers have an upper repetition rate limit of 80 MHz. Some models can also achieve repetition rates as low as 1 Hz.

Examples



Scheme of a frequency doubling fiber amplified laser. A picosecond diode laser is used as a seed for a fiber amplifier in a Master Oscillator Fiber Amplifier (MOFA) arrangement. An optional nonlinear crystal is added to convert the emission wavelength.



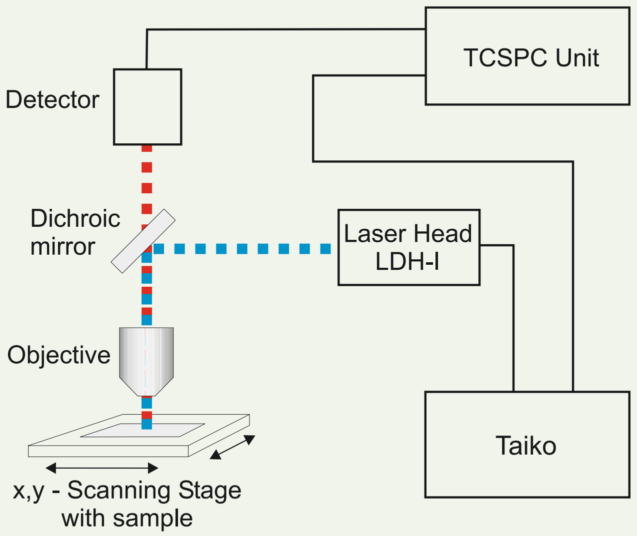
Typical pulse and spectral emission profile of a high power 532 nm laser (LDH-P-FA-530XL). The output pulse width is considerably shorter than that of the infrared seed laser. The average output power of this laser reaches 200 mW at a repetition rate of 80 MHz.

Taiko PDL M1

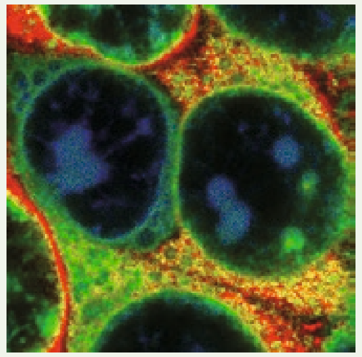
Smart picosecond pulsed diode laser driver

The Taiko is a smart, universal laser driver that can operate and monitor any laser head from the LDH-I Series. The strengths of the Taiko are flexibility and ease-of-use, making it accessible even to novice laser users. Changing the emission wavelength is as simple as plugging in a different laser head and the Taiko will automatically recognize its operational parameters.

Examples



Sketch of a basic Fluorescence Lifetime Imaging (FLIM) set-up. The sample is scanned and the fluorescence lifetime determined for each pixel is displayed in a false color scheme. Lifetimes are usually obtained via TCSPC, a method requiring short laser pulses with variable repetition rates – a condition perfectly fulfilled by PicoQuant's diode lasers.



FLIM image of macrophage cells incubated with CdSe/ZnS quantum dots of two sizes. The sample was excited by a laser from the LDH Series at 470 nm and the fluorescence lifetime image was acquired using the time-resolved confocal microscope MicroTime 200 from PicoQuant.

Image courtesy of Yury Rakovich, CSIC Material Physics Center, Spain.

Take full control

The Taiko smart driver interfaces with laser heads from the LDH-I Series to read out and display various operational parameters. These include central and current emission wavelength, laser head temperature, repetition rate, as well as an estimation of current output intensity.

Every LDH-I head is calibrated during manufacturing with regards to its intensity / output power curve and temperature dependent wavelength shift. The Taiko is thus able to provide an indication of current output power and central wavelength during operation.

Setting of the output power can be done either by relative percentage values of intensity or by absolute calibrated values of optical power (mW, W). Due to its extended high power capability, the Taiko can drive an even wider range of laser heads, including our latest generation of high power, multi mode diodes.

- *Repetition rate: single shot to 100 MHz*
- *External trigger input*
- *User-defined bursts patterns*
- *Free power adjustment in calibrated values of optical power (mW, W)*
- *Pulsed and continuous wave operation*
- *Very low jitter*

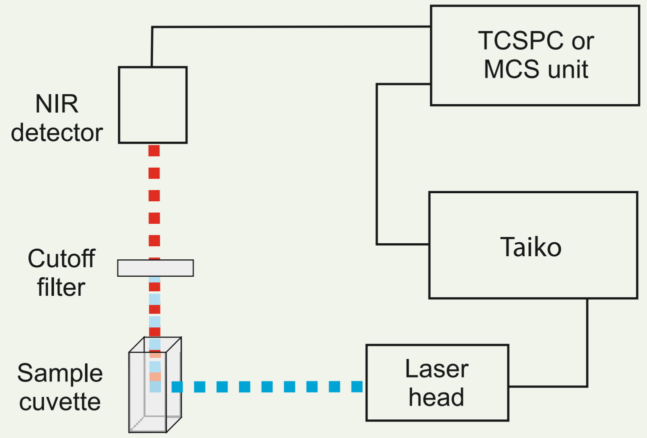
Flexible pulse patterns

The Taiko laser driver supports arbitrary internal repetition rates ranging from single shot (1 Hz) to 100 MHz, as well as operation in continuous wave mode or external triggering. It can also generate user-defined burst sequences consisting of up to 17 million pulses with freely selectable burst periods. Using burst mode is of great value for time-resolved phosphorescence measurements or other applications where larger amounts of excitation energy have to be periodically deposited into a sample.

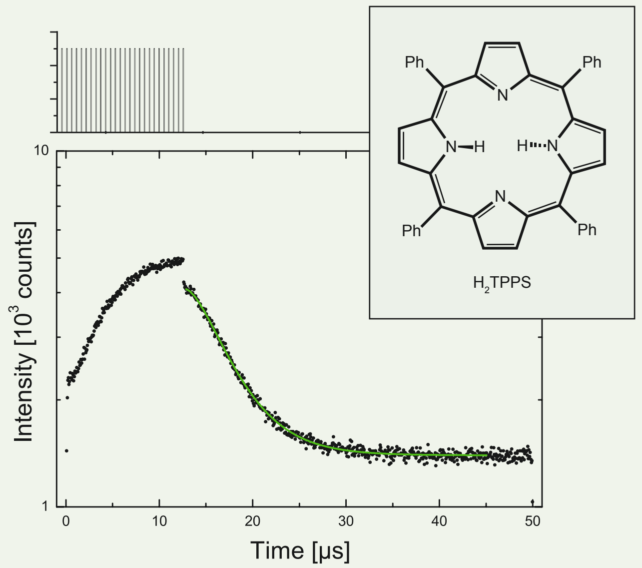
Intuitive user interfaces

Control the Taiko either via its intuitive "one button control" local interface or remotely by PicoQuants laser driver software (requires USB connection).

Examples



Sketch of a basic set-up to study singlet oxygen, whose reactive properties can be used to destroy cancer cells in photodynamic therapy. The sample is excited by a pulsed laser and the lifetime of the emitted fluorescence is detected with a NIR sensitive detector using Time-Correlated Single Photon Counting (TCSPC) or Multi-Channel Scaling (MCS).

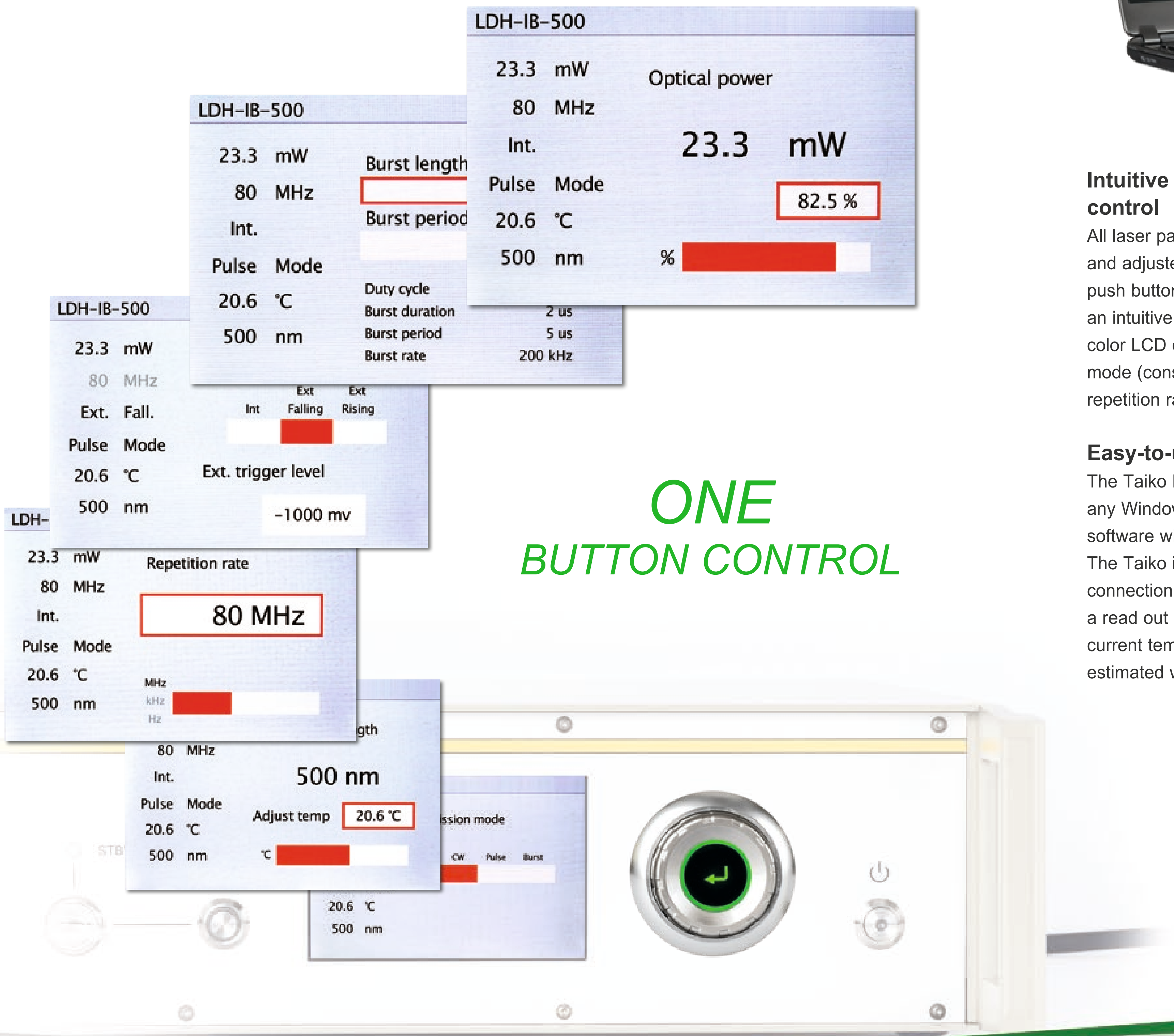


Time-resolved singlet oxygen emission produced by H_2TTPS in acetone using burst mode excitation. Multiple laser pulses are used to deposit energy into the sample before being stopped long enough to capture the comparably slow decay of the sample. A tail fit yields a lifetime of 3.4 ± 0.3 µs, which is in excellent agreement with published values.

Taiko PDL M1

Remote or local control

The Taiko PDL M1 can be controlled either locally via an easy-to-use, menu based interface or remotely through a user friendly control software via USB connection. With the additional Software Development Kit (SDK), programmers can create their own software interfaces.



ONE
BUTTON CONTROL

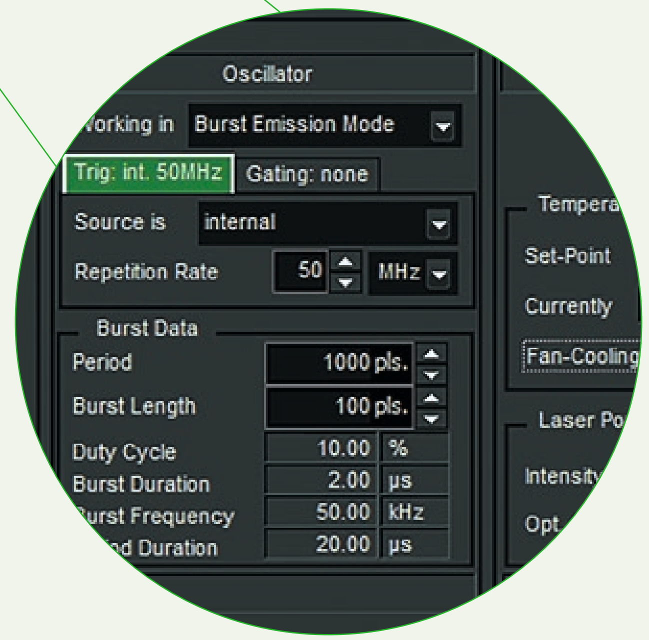
Intuitive menu-based local control

All laser parameters can be accessed and adjusted locally via a unique dial and push button combination that allows navigating an intuitive menu-based system on the Taiko's color LCD display. Set power intensity, operation mode (constant pulse, burst, continuous wave), and repetition rate with just a few twists.

Easy-to-use software interface

The Taiko PDL M1 can also be operated remotely from any Windows™ based PC through a dedicated control software with a user-friendly graphical user interface. The Taiko is connected to the PC via a standard USB connection. Both local and remote interfaces provide a read out of relevant laser head information such as current temperature, repetition rate, operation mode and estimated wavelength shift and optical output power.

Example



All functions of the Taiko PDL M1 can be easily configured and controlled through a dedicated control software. This includes setting the operation mode, triggering, repetition rate and/or burst pattern, laser power as well as laser diode temperature and wavelength. A "laser soft lock" allows switching the laser head off through the software interface.

PDL 828 “Sepia II”

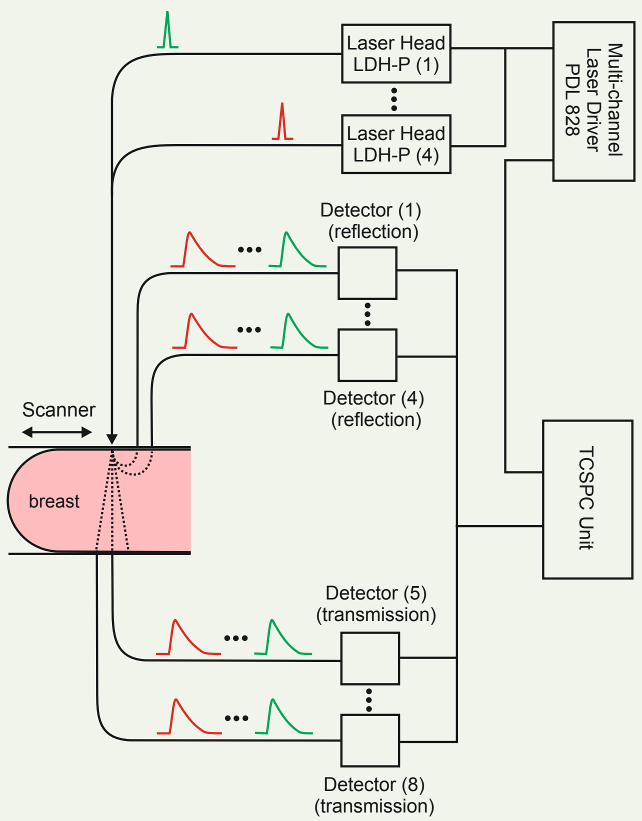
Multichannel picosecond diode laser driver

The PDL 828 “Sepia II” is a high-end, ultra flexible diode laser driver for numerous applications ranging from time-resolved fluorescence spectroscopy to quantum optics and diffuse optical tomography. It is designed as a modular driver unit for all laser heads from the LDH-P/D and LDH-FA Series, as well as pulsed LEDs from the PLS Series.

- *Up to 8 laser or LED heads*
- *External triggering*
- *Flexible sequences and burst patterns*
- *Modular design, computer control*

Example

Optical mammography



Sketch of a basic set-up for optical mammography. Optical mammography is a method of breast cancer diagnosis, which uses laser light instead of X-rays. The breast tissue is imaged in vivo simultaneously with pulsed laser radiation of several wavelengths in combination with time-resolved transmission and reflection measurements to estimate optical properties of different types of breast tissue and tumors.

The possibility to define a variable burst length for each connected laser head make the PDL 828 “Sepia II” an ideal choice for optical mammography as this allows compensating for different laser pulse energies or for different tissue transmission properties.

Driver solution with ultimate flexibility

The PDL 828 “Sepia II” provides maximum flexibility for multiple wavelengths applications such as diffuse optical tomography. It can drive any combination of up to eight laser or LED heads in parallel or user-defined sequence. The whole system is easily configured and controlled through a dedicated control software via USB connection. A software library for custom development is also provided.

Modular assembly

A PDL 828 “Sepia II” consists of a mainframe including a power supply into which a controller module with computer interface, an oscillator module, and up to eight laser driver modules can be integrated.

Powerful oscillator module

The oscillator and burst generator module has eight trigger outputs (channels) which can be combined to be activated at the same time or individually activated in a sequence. Multiple pulses can be output from single or combined channels before the next one becomes active. Each channel can be delayed on a picosecond time scale relative to the others. Furthermore, the oscillator has its own (delayable) synchronization output and external trigger input.

Flexible laser driver module

A laser driver module is required for each laser or LED head that needs to be driven simultaneously. They can also be operated independently through heir internal low-jitter oscillator at six fixed, user-selectable frequencies (from 2.5 to 80 MHz). All emitted laser pulses are accompanied by a matching synchronization output.

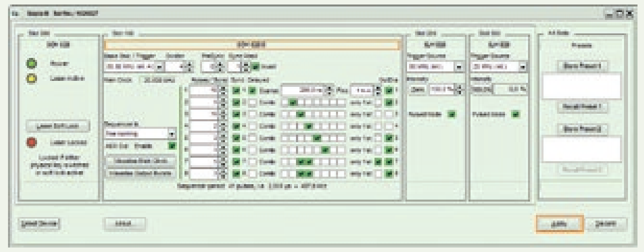
Complete laser power control

Laser emission intensity can be easily adjusted via an internal voltage setting in steps of 0.1 % of its full scale value and supports easy switching between CW and pulsed operation mode.

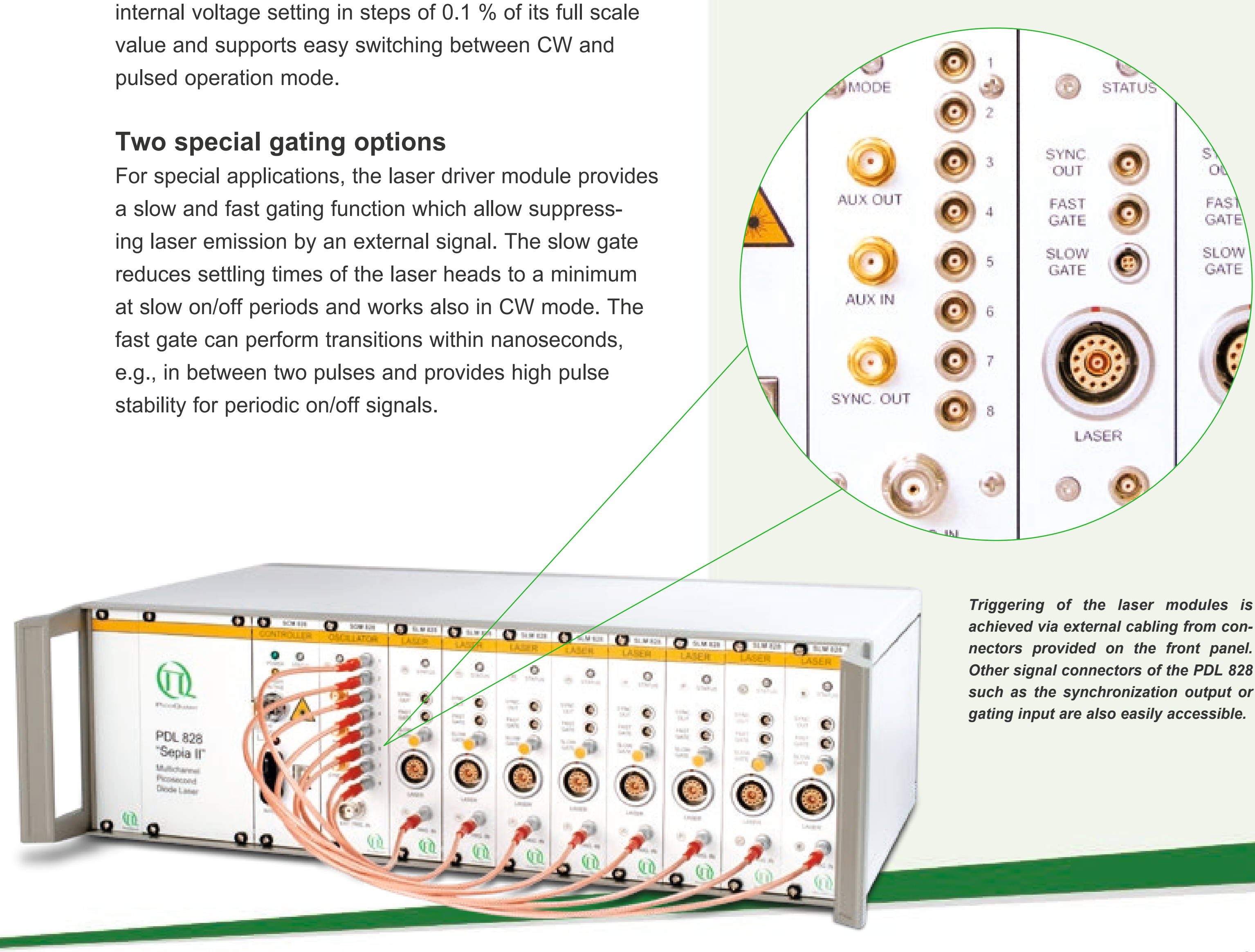
Two special gating options

For special applications, the laser driver module provides a slow and fast gating function which allow suppressing laser emission by an external signal. The slow gate reduces settling times of the laser heads to a minimum at slow on/off periods and works also in CW mode. The fast gate can perform transitions within nanoseconds, e.g., in between two pulses and provides high pulse stability for periodic on/off signals.

Examples



All functions of the PDL 828 “Sepia II” are easily configured through a dedicated control software, including the oscillator module’s repetition rate, burst length, as well as control of the synchronization signal. A “laser soft lock” button allows switching the laser heads off from within the software. A delay function allows shifting the output of individual channels by ± 1 ms in 25 ps steps.



Triggering of the laser modules is achieved via external cabling from connectors provided on the front panel. Other signal connectors of the PDL 828 such as the synchronization output or gating input are also easily accessible.

PDL 800-D

Picosecond pulsed diode laser driver

The PDL 800-D is PicoQuant's renowned laser driver for single wavelength applications with a proven track record for outstanding reliability. It is designed as a universal driver for all laser heads from the LDH and LDH-FA Series as well as for pulsed LEDs from the PLS Series. The driver features local manual control and is suitable even for novice laser operators. Wavelength changes are as simple as plugging in a different laser or LED head.

- *Repetition rate: single shot to 80 MHz*
- *External triggering*
- *Very low jitter*

Repetition rates up to 80 MHz

The PDL 800-D provides driving pulses for laser/LED heads with repetition rates up to 80 MHz, which are derived from two internal, low-jitter crystal oscillators with base frequencies of 1 and 80 MHz. These base frequencies can be divided by user-selectable factors of 2, 4, 8, 16, or 32 to generate repetition rates ranging from 31.25 kHz to 80 MHz.

External trigger input/synchronization output

Virtually any repetition rate from 1 Hz to 80 MHz can be generated by using the external trigger functionality of the PDL 800-D. All laser pulses are accompanied by a synchronization signal, which is ideally suited to trigger other devices in the set-up such as Time-Correlated Single Photon Counting (TCSPC) electronics.

Manual laser power control

The optical output power can be easily adjusted via a potentiometer to match the excitation power requirements of the application.

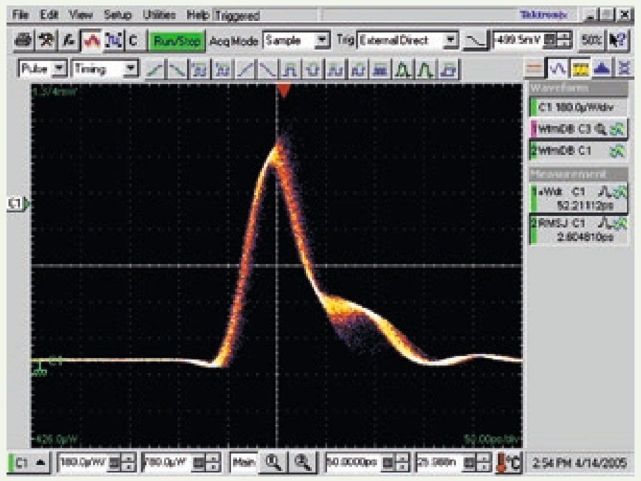
The PDL 800-D can operate laser heads from the LDH-D Series in continuous wave (CW) mode. Optical output power in CW mode can also be adjusted through the same potentiometer.

Gating options

For special applications such as scanning experiments, the PDL 800-D provides slow and fast gating options that allow suppressing laser emission by an external signal. The slow gate reduces settling times of laser heads to a minimum at slow on/off periods and works also in CW mode. The fast gate can perform transitions within nanoseconds, i.e. in between two pulses. The fast gate also provides high pulse stability when the on/off signal is periodic and fast.

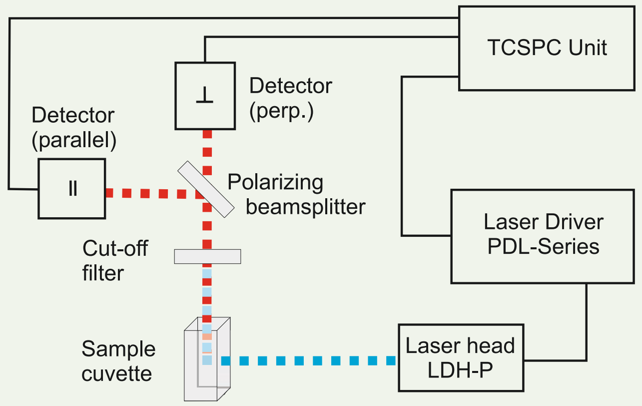
Example

The PDL 800-D features the lowest possible pulse-to-pulse jitter at internal triggering. Measurement results with a jitter of only 2.6 ps as shown here are a proof of this high stability.

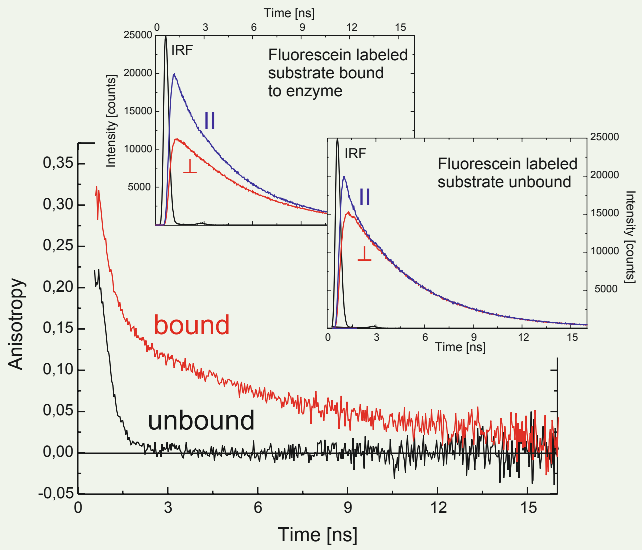


Examples

Measurement of fluorescence anisotropy



Basic set-up for fluorescence anisotropy measurements. The fluorescence anisotropy of a sample describes the spatial distribution of the emission and can therefore be used to gather information about orientation, movement, or association/dissociation processes. A typical set-up determines the ratio of fluorescence decay contributions with parallel and perendicular polarization.



Example of a fluorescence anisotropy measurement of a fluorescein labeled substrate in the presence and absence of a binding enzyme. Upon binding to the enzyme, the mobility of the substrate changes, as can be clearly seen in the anisotropy curves.

Laser Combining Unit (LCU)

One housing, outstanding flexibility

PicoQuant's Laser Combining Unit (LCU) is a flexible platform that allows combining the optical output of up to 5 laser heads into a single mode, polarization maintaining fiber. Using the LCU in conjunction with the PDL 828 „Sepia II" driver provides a convenient and easy-to-use solution for realizing any type of multi-color excitation patterns.

One housing, outstanding flexibility

The open architecture of the LCU provides outstanding flexibility in terms of wavelength combination: nearly every laser head from our LDH and LDH-FA series can be integrated into it. You can even integrate two laser heads with identical emission wavelengths as required for applications such as 2-focus fluorescence correlation spectroscopy. Adding or exchanging laser heads is easily done on-site and the LCU's design make routine adjustments a simple task.

Multiple beams, one fiber

The combined laser beams are coupled into a single optical fiber at the LCU's output port.

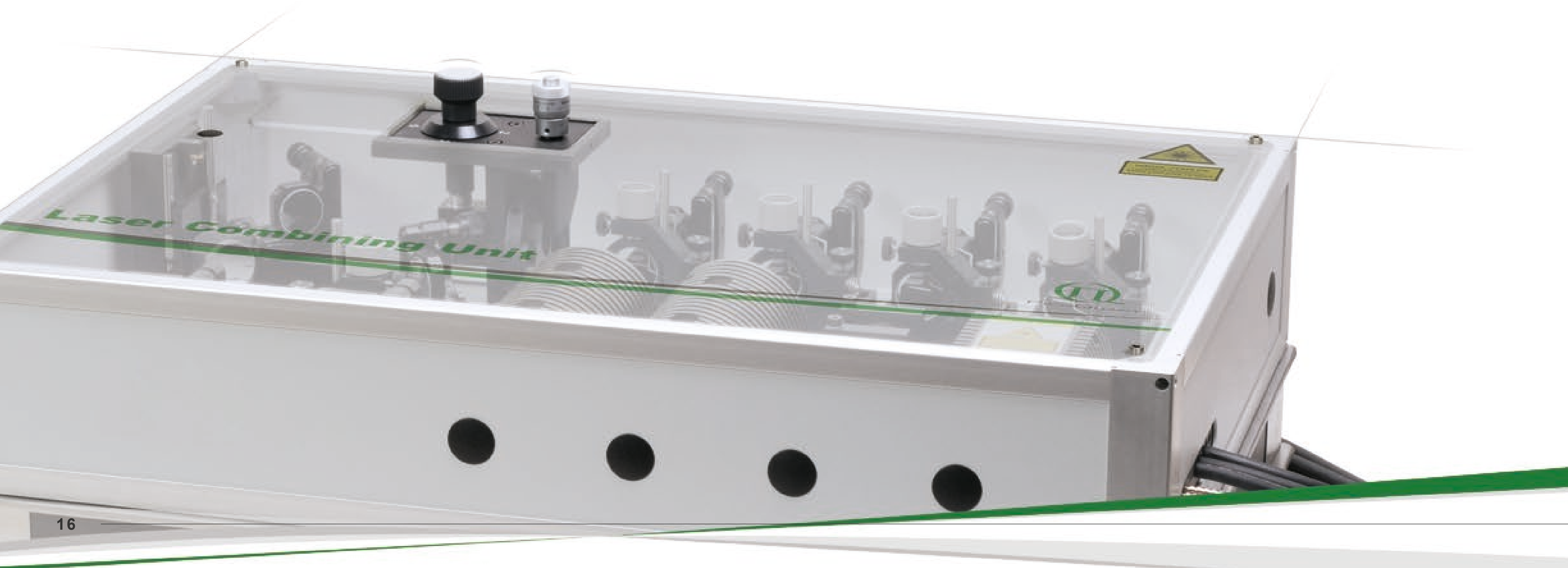
Various types are available, such as single mode polarization maintaining fibers, ideal for confocal microscopy or multi mode fibers that provide increased optical power throughput with slight compromises in beam quality.

Complex pulse patterns at your fingertips

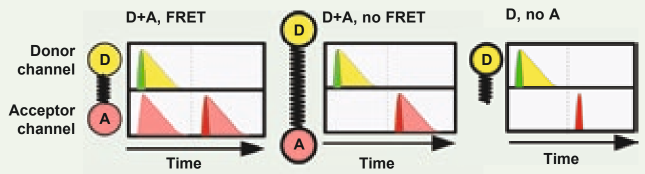
When used together with the PDL 828 „Sepia II" driver, each LCU laser head can be operated in pulsed, burst, or continuous wave mode. This laser driver allows generating a nearly unlimited variety of pulse patterns where multiple laser sources can emit pulses simultaneously, sequentially, or in combination with any other laser.
The pulses from each laser head can easily be temporally delayed with an accuracy down to the ps range, which is invaluable for STED microscopy.

Expanding beyond the LCU

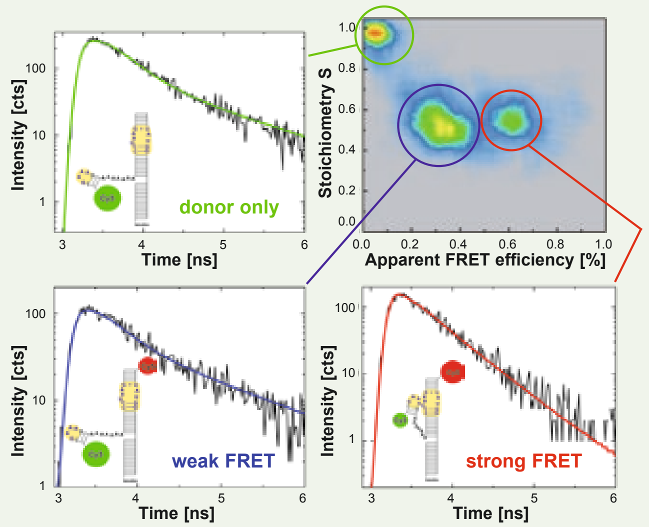
The oscillator module of the PDL 828 „Sepia II" supports control for up to 8 lasers, meaning that three external lasers (e.g., high power depletion laser VisIR-765-HP „STED" or multiple UV line laser VisUV) can be synchronized with the LCU's integrated lasers. Furthermore, the optical output of super-continuum lasers can also be coupled into the LCU.



Examples



In Pulsed-Interleaved Excitation two laser pulses are used sequentially to excite the donor and the acceptor molecule independently. The resulting fluorescence emission patterns can be used to discriminate between molecules showing FRET, molecules that do not show FRET and molecules without the acceptor molecule.



FRET analysis of freely diffusing RNA. The experiment aimed at localizing interactions between specific elements of RNA secondary structure, in this case a GAAA tetraloop motif (Cy3 label, green) and its corresponding receptor region (Cy5 label, red). Using PIE it was possible to calculate a 2D plot of FRET efficiency versus stoichiometry, that enables easy identification of subpopulations for further FRET evaluation.

Data courtesy of Julie Fiore and David Nesbitt, University of Boulder, USA

Laser Diode Heads

Widest selection of laser heads

PicoQuant offers the largest selection of picosecond pulsed laser diode and LED heads currently available on the market. Thanks to a proprietary fiber amplification technology, the product range includes high-powered modules and wavelengths that are not available from directly pulsed laser diodes.

A large selection of laser heads

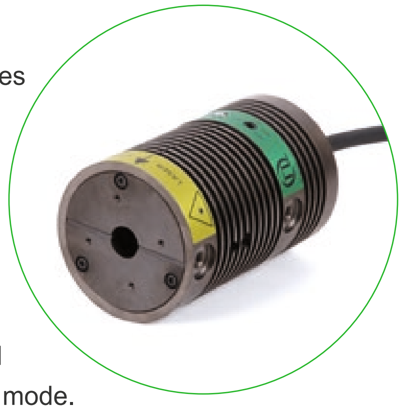
PicoQuant's current portfolio spans four series of laser heads with more than 120 different models, covering a wavelength range from 266 to 1990 nm and optical power levels ranging from a few µW up to 450 mW. Our development is focused on constantly extending our product range to meet the needs of the most challenging applications out there.

LDH-I Series

LDH-I Series features smart laser heads solely compatible with the Taiko PDL M1 driver. Heads from this series provide laser lines in the spectral range from 375 to 1950 nm and include a power as well as wavelength calibration. When coupled with a Taiko PDL M1, their optical output power and emission wavelength can be controlled in both pulsed and continuous wave modes.

Compatibility: Taiko PDL M1

LDH-P/D Series



Classic laser head series with directly pulsed laser diodes, and emission lines covering the spectral range from 375 to 1990 nm. These laser heads can be operated either in pulsed or CW mode.

Compatibility: PDL 800-D, PDL 828 "Sepia II"

PLS Series

The pulsed LEDs of the PLS Series are the fastest miniature sub-nanosecond pulsed LED sources commercially available with emission wavelengths ranging from 245 to 600 nm and repetition rates up to 40 MHz.

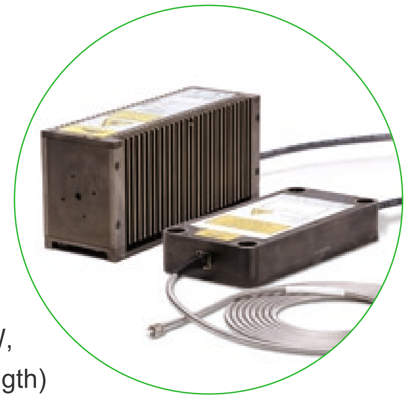
Compatibility: PDL 800-D, PDL 828 "Sepia II"

LDH-D-TA Series

This laser head series provides emission wavelengths at 532, 561, or 594 nm. The LDH-D-TA Series offers picosecond light pulses in a spectral range that is not available from directly pulsed laser diodes.

Compatibility: PDL 800-D, PDL 828 "Sepia II"

LDH-P-FA Series



Laser heads from the LDH-P-FA Series are based on MOFA concept with optional frequency conversion. They provide high-powered (1 to 450 mW, depending on wavelength) picosecond light pulses at 266, 355, 515, 532, 560, 766, 1064, or 1532 nm.

Compatibility: PDL 800-D, PDL 828 "Sepia II"

- *Wavelength range from 266 to 1990 nm*
- *Average power up to 450 mW*
- *Repetition rate: single shot to 100 MHz*
- *Pulse width down to 30 ps*

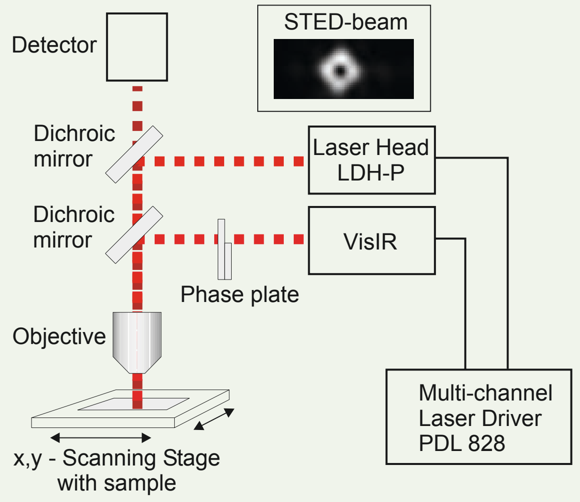
VisIR

High power picosecond laser

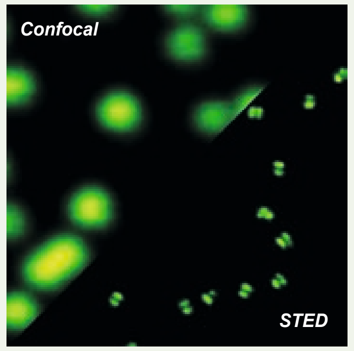
The VisIR platform is a stand-alone high power laser device that generates picosecond pulsed laser emission at 766, 1064 or 1532 nm with an output power of more than 1.5 W at repetition rates from single shot up to 80 MHz. It is available in either short (< 70 ps) or long pulse (500 ps) versions with enhanced pulse energies of more than 150 nJ.

Examples

Stimulated Emission Depletion (STED) Microscopy



Sketch of a basic set-up for STED Microscopy, a technique allowing imaging with resolutions beyond the diffraction limit. The fundamental principle of STED lies in the deactivation of excited molecules through stimulated emission at longer wavelengths than the observation wavelength. The high powered depletion beam is shaped like a "donut" by using a segmented phase plate. As a consequence, only fluorescence from the donut center can be detected, thus increasing the optical resolution.



Confocal and STED images of specially labeled DNA origami with two rows of 11 dye molecules with a distance of 71 nm. The resolution enhancement due to STED is clearly visible.

Samples were provided by GATTAquant GmbH and the Tinnefeld Lab, TU Braunschweig, Germany.

Compact, stand-alone device

The VisIR is a stand-alone unit with a special design for optimal heat dissipation, which enables stable and reliable long-term operation at high output power levels. It can be operated at 12 different internally selectable repetition rates between 31.25 kHz and 80 MHz or triggered externally at any repetition rate between single shot and 80 MHz. This feature is extremely useful for perfect synchronization with other lasers, e.g., with the excitation laser in a Stimulated Emission Depletion (STED) set-up.

VisIR-765-HP "STED"

The high powered VisIR-765-HP "STED" is specially designed for STED depletion with pulse widths of 500 ps at 766 nm and average power of more than 1.5 W. This allows for higher pulse energy with moderate peak power, which is optimal for time-resolved STED microscopy. The lower peak power reduces photobleaching in the sample, while the pulse duration is still short enough for fluorescence lifetime analysis.

- *Emission wavelengths: 766, 1064 or 1532 nm*
- *Average power > 1.5 W*
- *Pulse widths: 70 ps or 500 ps*
- *Repetition rate: single shot to 80 MHz*
- *External triggering*
- *Collimated output*
- *Excellent beam quality*

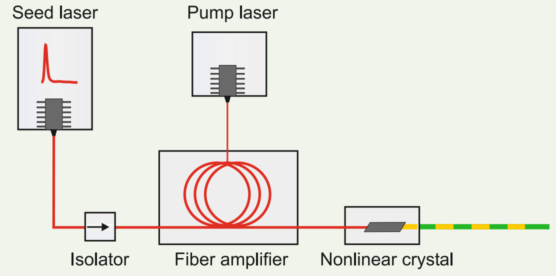
Excellent beam quality

The VisIR features a nearly perfectly circular and Gaussian shaped beam profile (TEM_{00}), with a specified M^2 value of less than 1.1. This excellent beam quality permits accurate beam shaping as required for high quality STED microscopy.

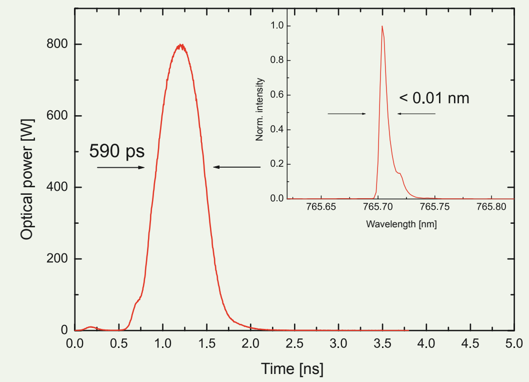
A versatile module

The VisIR is commonly used as excitation laser for fluorescence and photoluminescence lifetime measurements, as a depletion laser for STED microscopy, as well as in LiDAR or other ranging application.

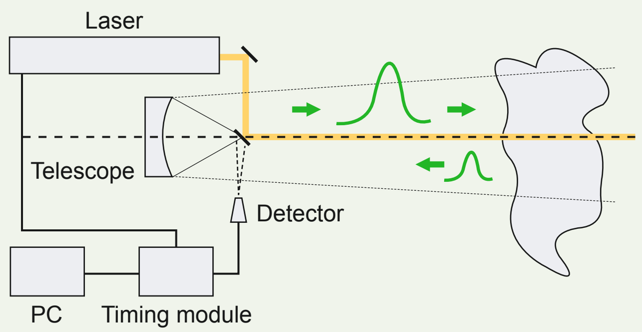
Examples



Scheme of the VisIR-765-HP "STED". A picosecond pulsed diode laser operating at 1532 nm is used as a seed for a fiber amplifier in a MOFA arrangement. The infrared emission is then converted to 766 nm using single pass second harmonic generation.



Typical pulse profile of the VisIR-765 "STED" along with the spectral emission profile.



Scheme of a LiDAR (Light Detection And Ranging) set-up.
After a laser pulse is sent out, photons can be scattered back by many objects, such as small particles in the atmosphere or large objects. The back scattered photons are collected and histogramed as a function of the time difference between the original pulse and their arrival time. Based on this information, the distance travelled by each photon can be computed.

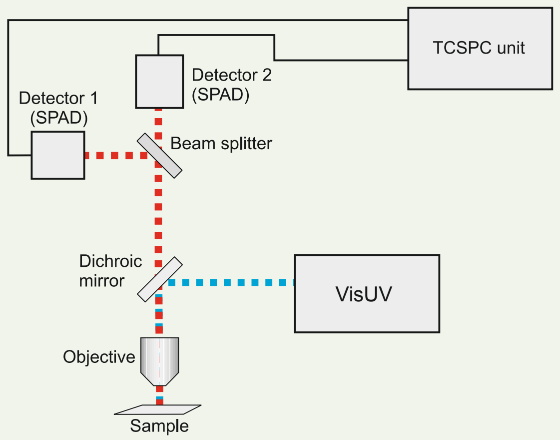
VisUV

Picosecond laser: UV, green, yellow, and orange

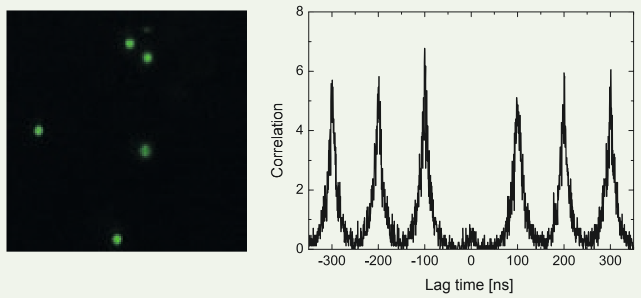
The VisUV platform series features stand-alone, high power laser devices that generate picosecond pulsed laser emission with a broad selection of wavelengths. It is based on a Master Oscillator Fiber Amplifier (MOFA) concept with sophisticated frequency conversion.

Examples

Measurement of fluorescence antibunching



Sketch of a basic set-up for the measurement of fluorescence antibunching. Antibunching can be used to identify single emitters in the observation volume. In a typical set-up, the beam is split 50/50 on to two detectors connected to a single TCSPC unit for data acquisition.



This example shows a Fluorescence Lifetime Imaging (FLIM) image and antibunching measurement of Nitrogen Vacancy (NV) centers in diamond, excited at 532 nm. The FLIM image was first used to locate the NV centers. The missing peak at lag time zero in the anti-bunching trace then proves that there is indeed only a single fluorescent emitter in the nanocrystal under investigation.
Sample courtesy of J. Wrachtrup, University of Stuttgart, Germany.

Broad range of wavelengths and pulse widths

VisUV modules are available with emission wavelenghts at 266, 280, 295, 355, 532, 560 or 590 nm with repetition rates ranging from single shot to up to 80 MHz. Modules are available with either short (< 85 ps) or long pulses (sub ns) with enhanced pulse energy up to more than 150 nJ. The VisUV can be configured to provide one, two, or even three laser output beams with different wavelengths.

Compact, stand-alone device

The VisUV is a stand-alone unit with a special design for optimum heat dissipation, which enables stable and reliable long-term operation at high output power levels. It can be operated at 12 different internally selectable repetition rates between 31.25 kHz and 80 MHz or triggered externally at any repetition rate between single shot and 80 MHz.

- *Emission wavelengths: 266, 280, 295, 355, 532, 560, and 590 nm*
- *Average power up to 750 mW*
- *Pulse width < 85 ps*
- *Repetition rate: single shot to 80 MHz,*
- *External triggering*
- *Collimated output*
- *Excellent beam quality*

Excellent beam quality

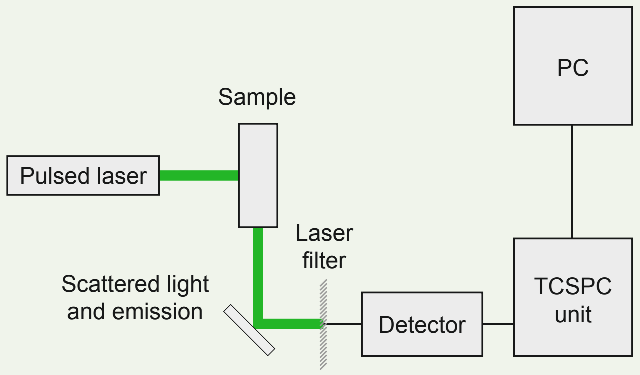
The VisUV features a nearly perfectly circular and Gaussian shaped beam profile (TEM_{00}), with a specified M^2 value of less than 1.1 (typically 1.02). This excellent beam quality permits accurate beam focusing for confocal application.

Versatile platform

The VisUV is commonly used as excitation laser for fluorescence and photoluminescence lifetime measurements, for Raman spectroscopy, as well as for LiDAR or other ranging application.

Example

Time gated Raman spectroscopy



In Raman spectroscopy, a sample is illuminated with high-intensity, monochromatic light. Some of the photons hitting the sample molecules (ca. 1 in 10^6) are inelastically scattered and the energy lost or gained by the photon corresponds to a vibrational or rotational mode of the molecule. CW mode lasers emitting in the visible, near infrared or near UV are commonly used as excitation sources. This can, however, lead to strong fluorescence masking the Raman signals.

Since Raman scattering occurs on a time scale much shorter than fluorescence (sub-picosecond vs. nanoseconds), the fluorescence background can be suppressed by "time gating". By setting a boundary condition, photons with late arrival times (stemming from fluorescence) are excluded from the decay fit. Thus, the contribution from fluorescence is significantly reduced and the signal-to-noise ratio improves.

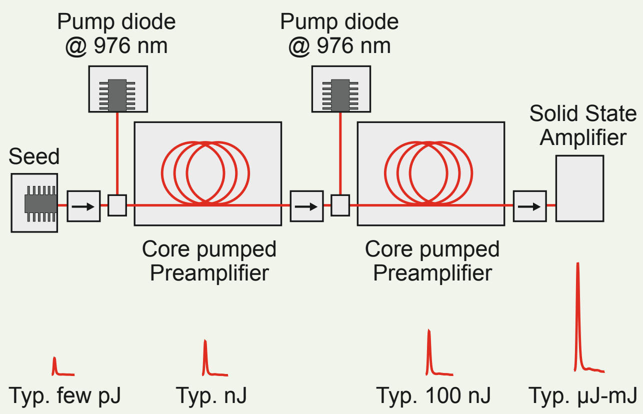
Customized OEM Solutions

Pulses on demand, tailored to your needs

PicoQuant can provide a wide range of customized OEM laser solutions based on our well established picosecond pulsed and fiber amplified diode laser technologies. We also offer nanosecond diode switching, pulse shaping, and continuous wave modulation.

Example

Solid state booster



Working principle of a solid state booster used in one of PicoQuant's OEM lasers. Light pulses from a seed laser diode are amplified in a first fiber stage (preamplifier) before passing a second fiber stage and finally frequency converted via a non-linear crystal (optional).

YOU HAVE A
SPECIAL REQUEST?

WE DESIGN A
SOLUTION.

The combination of laser diodes with fiber amplification and additional solid state amplifiers is ideally suited for generating high powered picosecond light pulses with energies of up to several µJ and pulse-on-demand capability. This broad and proven technological basis makes it possible for PicoQuant to provide a wide range of OEM modules for large scale manufacture or system integration.

An expanding world of applications

OEM lasers cover a wide range of applications including semiconductor diagnostics, testing of detectors and cameras, ranging / LiDAR, seeding of amplifiers, material processing, free-space data transmission, fluorescence lifetime measurements, or time-resolved refractometry, to name only a few. They can easily be incorporated in larger systems such as readers, wafer testers, optical devices, or µJ laser systems for micromachining.

Our strength: individual solutions

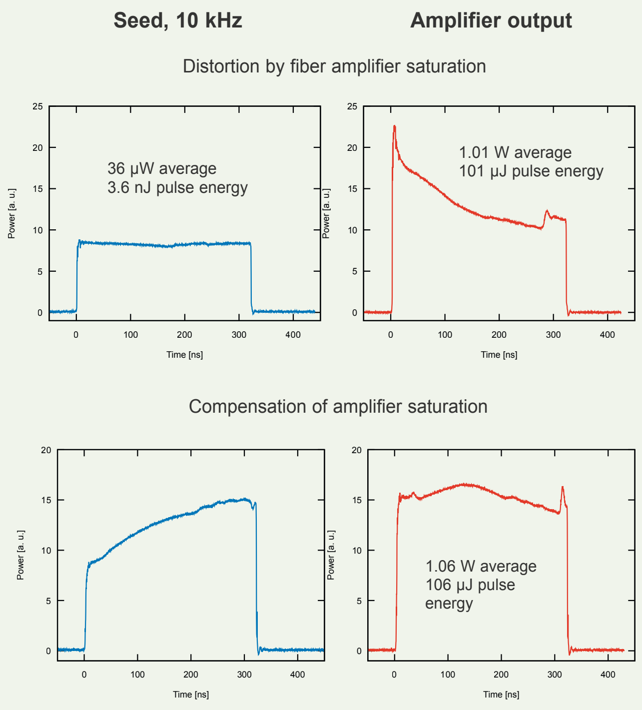
Our strength lies in designing and engineering individual solutions where we can fulfill our customer's needs with regard to system integration in various industry fields. Our OEM modules can be used for any application where diode lasers are helpful to increase production efficiency or control process.
Design and engineering are based on customer needs in order to offer completely integrated solutions. Manufacturing and testing are done at PicoQuant and high quality products can be delivered on demand. We will gladly develop special designs or custom made solutions upon request.
For all applications and designs, the customer can choose between:

- Internal or external power supply
- Fixed or variable repetition rate/modulation frequency
- Fixed or variable output power
- Fixed or variable pulse width, pulse shaping, modulation depth
- Free space output or fiber coupling
- Cooled or uncooled design
- Rugged design, special materials
- And many more

- *Compact design*
- *Custom housing*
- *Programmable pulse shapes*
- *Picosecond to nanosecond pulsed and modulated operation*
- *Adapted to customer's needs, optics, and application*

Example

Pulse shaping



Programmable pulse shapes can be used to compensate for saturation effects of fiber amplifiers, which exhibits strong gain-saturation especially in nanosecond pulse regime. The example shows the output of a fiber amplifier with and without compensation by pulse shaping of the seed pulse.

Fiber Coupling

Increase flexibility in light delivery

All diode laser heads can also be coupled into optical fibers, which enhances their flexibility but also influences beam characteristics. Fiber coupled laser heads are as easy to use as conventional ones and usually do not need realignment.

Altered emission properties

Coupling a laser beam into an optical fiber always alters its emission properties.

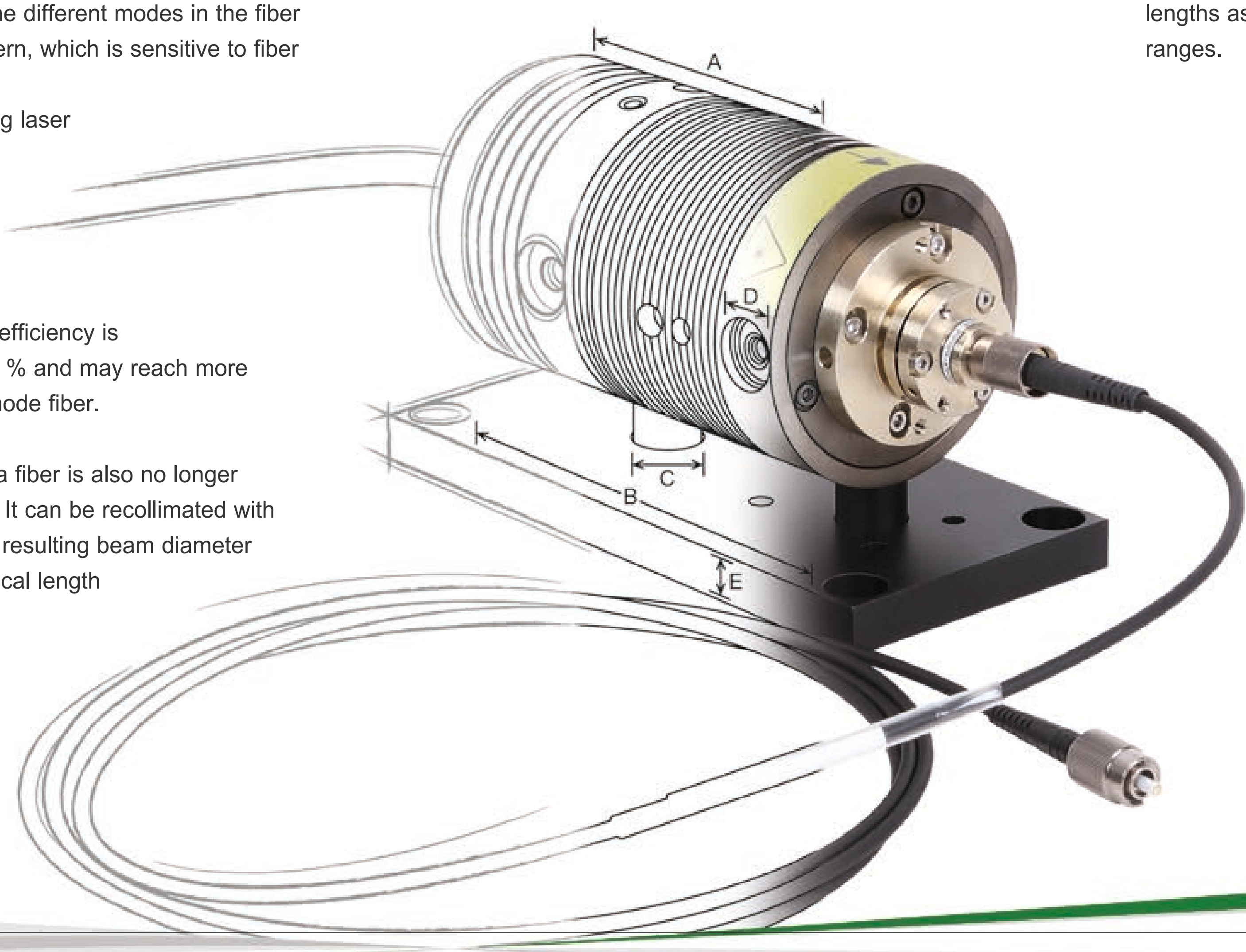
Single mode fibers are commonly used as they transform the elliptical beam shape into a diffraction limited gaussian beam profile. However, other beam characteristics are influenced by an optical fiber:

- Polarization – depending on fiber type, the linear polarization of the laser emission is either preserved or scrambled
- Interference – in case of multi-mode fibers, interference between the different modes in the fiber leads to a speckle pattern, which is sensitive to fiber movements
- Output power – coupling laser emission into an optical fiber always leads to a reduced output at the end of the fiber. The coupling efficiency is typically higher than 40 % and may reach more than 80 % for a multi-mode fiber.

The output at the end of a fiber is also no longer collimated, but divergent. It can be recollimated with a fiber collimator and the resulting beam diameter can be modified by the focal length of the lens type used.

Directly mounted fiber couplers

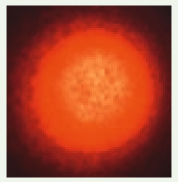
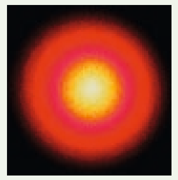
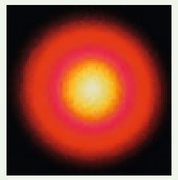
Fiber coupling is achieved by adding suitable coupling optics as well as a corresponding fiber. The fiber coupler is always directly mounted to the laser head and optimized for its emission wavelength range as well as its mechanical design. The output connector of the fiber couplers is usually angled in order to avoid laser back reflections into the head, which can influence its stability and distort the output.



Depending on the desired output qualities, different fiber types can be attached to the coupler. These include multi-mode, single-mode, and polarization maintaining single-mode fibers. They can be supplied with different lengths as well as optimized for different wavelength ranges.

Pre-aligned and optimized

All fiber coupled laser heads are pre-aligned for maximum performance before delivery. Although fiber and coupler can be unmounted from the laser head, this is not recommended, since remounting always requires a realignment of the coupling. This is a complex task requiring great experience, especially for single-mode fibers which have a core diameter of only a few micrometers.

Fiber type	Multi-mode	Single-mode	Polarization maintaining
Beam shape	"Top hat profile" with speckles	Gaussian	Gaussian
			
Polarization	Scrambled	Partly scrambled	Linear
Typical coupling efficiency	> 80 %	> 40 %	> 40 %

Quality Control

It is more than just a diode…

Highest quality and reliability are two fundamental characteristics of all PicoQuant products. These are achieved by applying high quality standards at every step going from first development to final assembly. Each laser diode undergoes thorough testing before being finally used in one of our products.

Characterization of each single diode

Each diode is fully characterized with respect to its pulse shape, energies, and spectral output before being added to our stock. This ensures that low quality diodes will be excluded and only the best are used in our products. Our stocks usually holds several hundred individual laser diodes along with fully assembled and characterized laser heads. This stocking strategy not only allows for quick delivery, but also enables short reaction times to special requirements, like the selection of a special emission wavelength or pulse power.

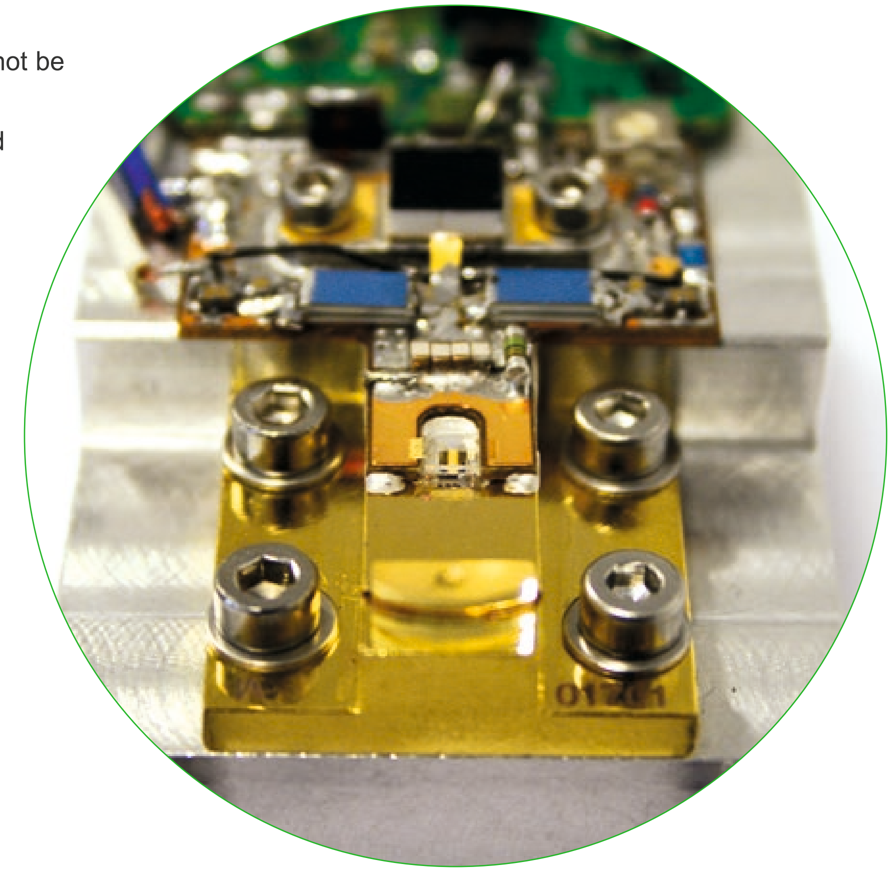
Long term stability tests

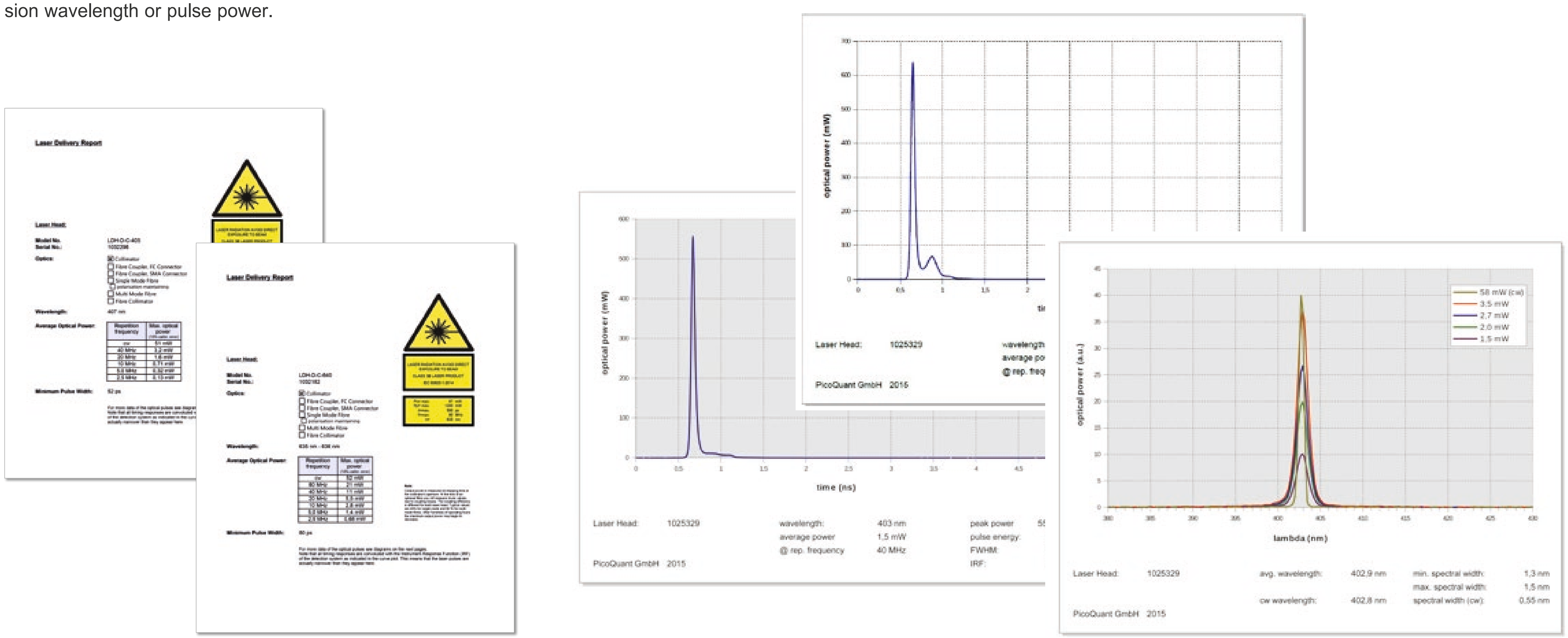
All laser heads are tested in a burn-in procedure for at least 36 hours before they are finally delivered to the customer. This allows judging short and long term laser stability as well as sorting out laser diodes with a short predicted lifetime. Lifetime in this context does not mean that the laser stops emitting, but that the average output power drops to 50% of its initial value.

The exact lifetime of each laser diode can not be predicted. However, more than 20 years of experience with data from several thousand laser diodes allow deriving the following typical values:

- > 2000 working hours for UV/blue laser heads and LEDs
- > 6000 working hours for red laser heads

Both values refer to conditions where the laser head is operated with appropriate maximum settings for repetition rate and output power. Running the laser head at lower repetition rate and output power increases their lifetime accordingly.





An extensive set of test data sheets is delivered with each laser and LED head.

Extensive test data sheet

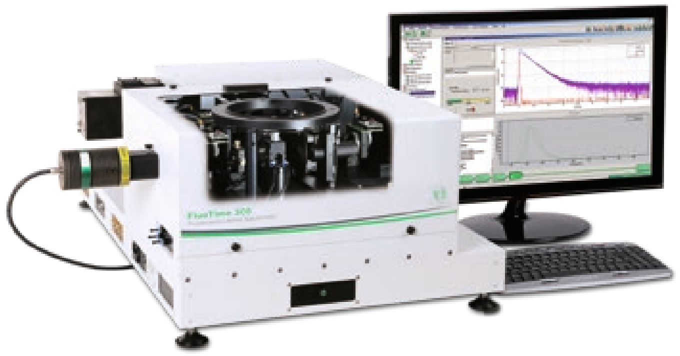
All laser and LED heads are shipped with an extensive set of test data sheets. These data sheets document pulse profiles, power values, and corresponding spectral emission profiles at different intensity settings. All data sheets are also stored in our database for future reference. Our database currently contains more than 20 years worth of measurement data.

Going Beyond Diode Lasers

PicoQuant is not only known for manufacturing state-of-the-art diode lasers, but also as a leader in the field of single photon counting and timing as well as fluorescence lifetime systems. Our portfolio includes a large selection of components or complete systems, which are individually tailored to the user's requirements.

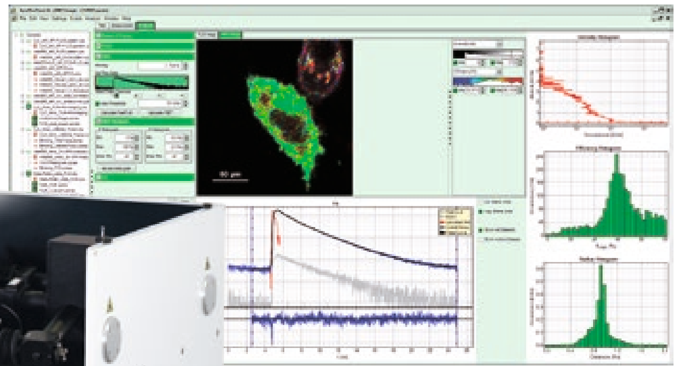
Photon counting and timing

Timing with high accuracy and fast photon counting are key areas of PicoQuant's technological competence. Notably, the HydraHarp, PicoHarp, and TimeHarp Series of Time-Correlated Single Photon Counting (TCSPC) and Multichannel Scaling (MCS) units have become a brand known world-wide. These versatile instruments for event timing and TCSPC are ideally suited for sophisticated applications such as single molecule spectroscopy, correlation spectroscopy, quantum optics, and imaging. The product range is completed by high speed photon counting detectors, specialized analysis software, and various accessories.



Fluorescence lifetime systems

PicoQuant offers compact or fully automated, modular time-resolved fluorescence spectrometers, time-resolved upgrade kits for laser scanning microscopes, and complete time-resolved confocal microscopes with 3D scanning and super-resolution imaging capabilities using Stimulated Emission Depletion (STED). These can be used for applications like Fluorescence Lifetime Imaging (FLIM), Fluorescence (Lifetime) Correlation Spectroscopy (F(L)CS), or Förster Resonance Energy Transfer (FRET). All systems are available in various configurations that can meet the requirements of even the most demanding analytical applications such as single molecule spectroscopy. Individual set-ups detect fluorescence lifetimes down to 10 ps or up to several hundred milliseconds. All kinds of samples can be analyzed including liquids in standard cuvettes, membranes, cells, or even semiconductor wafers for in-line quality control.



PicoQuant

PicoQuant was founded in 1996 with the goal to develop robust, compact, and easy to use time-resolved instrumentation. Since April 2008 sales and support in North America is handled by PicoQuant Photonics North America Inc.

Today, PicoQuant is known as a leading company in the field of pulsed diode lasers, time-resolved data acquisition, single photon counting, and fluorescence instrumentation.

Our instruments are present all over the world. They are used in the laboratories of Nobel Laureates as well as for carrying out routine quality control in production processes of global industry players. Starting from traditional time-resolved fluorescence detection, the range of covered applications continuously grew to include semiconductor quality control, diffuse optical imaging, materials research, quantum information processing, optical detector testing, and telecommunications. Due to the ease of use of our products, researchers can focus on their scientific questions in biology, medicine, environmental science, quantum optics, or chemistry without needing a large background in physics, electronics, or optics.

We offer state-of-the-art technology

Our goal is to offer state-of-the-art technology that has been co-developed and tested by renowned researchers, at an affordable price for both scientists and price conscious industry.

We have successfully teamed up with major confocal microscopy companies to develop dedicated equipment that permits carrying out time-resolved fluorescence studies on their laser scanning microscopes. Following this philosophy, we are always looking for new challenges. PicoQuant especially encourages OEM inquiries for its products, notably for applications where implementing time-resolved techniques were considered too expensive or cumbersome.

More than 20 years of R & D work

The combination of more than 20 years of R & D work, several thousand units sold, and cooperation with international experts forms the basis for new outstanding developments which are always driven by our customers' needs and inspirations. Visit our website or contact our product and application specialists directly to discuss your needs. Of course, you are always welcome to visit our application labs during your travels to Germany.

PicoQuant GmbH
Rudower Chaussee 29 (IGZ)
12489 Berlin
Germany
Phone: +49 30 1208820-0
info@picoquant.com
www.picoquant.com

Published by: PicoQuant GmbH
January 2019
Editorial and production: Pink Lemon Werbeagentur
Tina Stundner, Berlin
Photos: PicoQuant GmbH