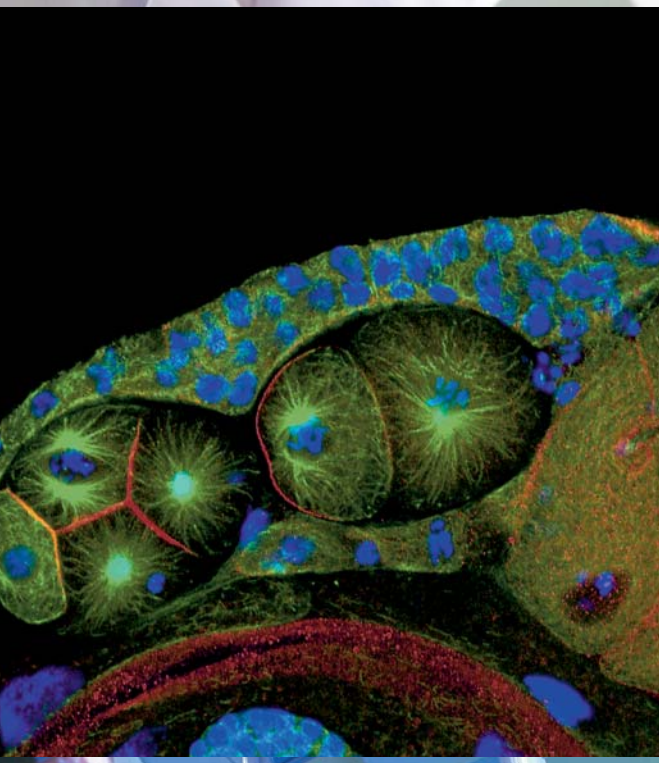
# Ultrafast Fiber Lasers

## The Next Generation – Reliable, Robust, Flexible

*A Passion for Precision.*

TOPTICA PHOTONICS



# FemtoFiber® Lasers — The Next Generation of Ultrafast Technology

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FemtoFiber pro

iChrome


FemtoFErb / PicoFYb


Ultrafast technology has seen an unpredictable success ever since it was introduced. Today physicists are still pushing the limits, e.g. the pulse duration down to a single optical cycle and the peak power up to tera- or even petawatt. On the other hand, many promising applications have emerged outside the laser laboratories. Mainly the high peak power and ultrashort pulse duration make ultrafast lasers very attractive. Both give rise to nonlinear effects and open new paths in engineering and scientific research.

Independent of the application, the key for successful integration of ultrafast lasers is the reduction of complexity. Many years ago, only laser experts could handle such sensitive devices. Today, one expects an ultrafast laser to work by pushing a single button. TOPTICA's answer to these expectations resulted in several matured products: The FemtoFiber pro series, iChrome, PicoFYb and the FemtoFErb.

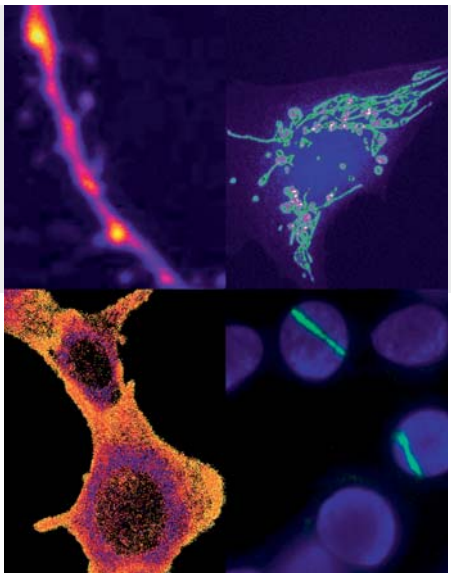
First of all, these fiber laser systems are based on polarization-maintaining fibers. Reliable mode-locking is achieved with a saturable absorber mirror (SAM). Only high quality components with extraordinary long lifetimes are built in. These comply with telcordia specifications and are suitable for 24/7 operation. The heart of each laser – namely the master oscillator and the amplifier – is completely fiber-based which makes alignment redundant and the systems extremely robust.

These and other advantages helped TOPTICA's ultrafast fiber lasers to become the source of choice for the following applications: Life sciences, time domain terahertz spectroscopy, attoscience and material processing among others.


# **Ultrafast Technology**
for Professional Applications

## Life sciences

Modern biomedical research often involves advanced laser microscopy. Tunable lasers account for the variety of fluorescent labels. Pulsed lasers enable fluorescent lifetime imaging microscopy (FLIM). Ultrafast lasers open the door for noninvasive methods relying on multiphoton excitation such as SHG, THG or CARS microscopy. While the techniques become more advanced, the



employed lasers should become easier to handle. That‘s why TOPTICA‘s fiber lasers are the product of choice.

Reliable and comfortable in handling, they allow the users to focus on their scientific task. Especially the iChrome is a fully automated and fiber coupled laser designed for confocal microscopy in the visible range (488 nm - 640 nm). On the other hand, the unique flexibility makes the FemtoFiber pro a versatile tool: Not only picosecond laser pulses that are tunable from 488 nm to 640 nm but also femtosecond pulses at 780 nm or tunable from 980 nm to 1400 nm can be combined in a single laser system.

## 2-photon polymerization

Miniaturized devices will change our life: Maybe someday micro-meter sized robots will travel through our blood circuit system and repair our cells. Today, nanotubes, nanowires, etc. are fabricated in nanotechnology centers around the world. For example, photonic crystals are produced by two-photon polymerization (2PP): The exciting property of such crystals is their photonic band gap which prohibits that light of certain wavelengths or polarizations can propagate through such a device. This band gap can be designed by the type and dimensions of the structure itself which enables the designer to directly access optical properties.

TOPTICA delivers the fiber laser with highest peak power at 780 nm that can be easily integrated in a commercial 2PP microscope. This enables the user to write structures with dimensions as big as 300 µm along the optical axis — the highest reported with fiber lasers.


## Time-domain terahertz

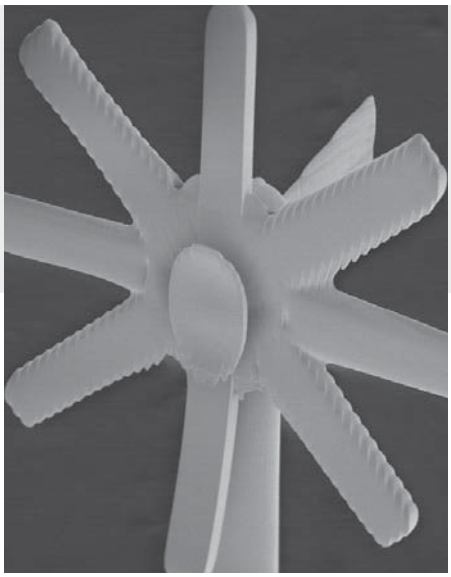
Terahertz technology features the chemical identification of substances through opaque materials such as cloth and synthetics, e.g for quality control and security tasks. Broadband terahertz radiation is generated with femtosecond laser pulses: Either they are focused on antenna devices such as photoconductive switches based on GaAs or InP, or they undergo optical rectification in nonlinear crystals, such as GaP, ZnTe or DAST. For high power and large bandwidth of the THz radiation peak power and pulse width of the laser are crucial.

TOPTICA offers two ideal laser sources for THz generation: The FemtoFiber pro and the FemtoFErb. Both systems provide outstanding peak power levels at pulse widths well below 100 fs. The FemtoFiber pro NIR is the ideal solution for research labs, thanks to its beneficial switching possibility between 780 and 1560 nm. Moreover, fast optical sampling of the THz signal can be accomplished without moving parts employing the ECOPS option. The FemtoFErb as an ultra-compact fiber-coupled system on the other hand is designed for easiest OEM integration.

## Material processing

The trend in laser micro-machining goes from nanosecond to picosecond laser pulses. Cold ablation without thermal load is the key for unprecedented precision. Furthermore, fiber lasers will replace solid state lasers in this market. Hands-off and maintenance-free operation, robustness and compactness, low running costs and better thermal properties are but only a few of the advantages over free-space, bulky laser resonators.

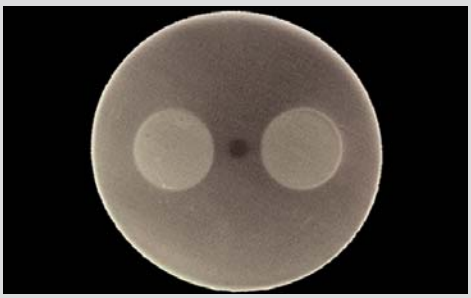
TOPTICA's PicoFYb is specially designed for OEM integration in laser amplifiers. Most stable laser operation is guaranteed in respect to amplitude noise, pulse duration, frequency jitter and reliable mode-locking. The compact laser head includes all driver electronics and delivers the laser pulses in a polarization-maintaining fiber. The typical wavelengths are 1030 nm and 1064 nm.



# Fiber Laser Technology
FemtoFiber pro

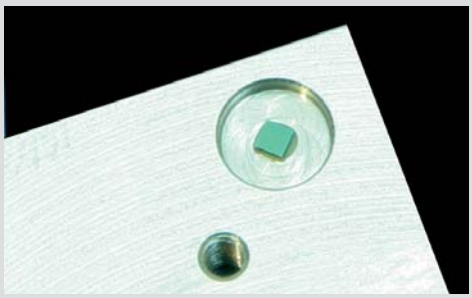
## Mode of operation

The engine of all TOPTICA's fiber lasers is a SAM mode-locked ring oscillator. This configuration – protected by an optical isolator – is known as most robust against back reflections of any kind. Running in the solitonic regime, the oscillator operates in a well defined state. Special TOPTICA design ensures full suppression of parasitic pedestals (Kelly-bands). The soliton pulses are carefully amplified to very high peak powers in a subsequent core-pumped fiber amplifier. This MOPA (master oscillator power amplifier) platform is all-fiber and based completely on polarization-maintaining fibers. In contrast to single-mode fiber compressors, the motorized silicon prism compressor preserves the smooth spectral shape. This results in nearly pedestal-free sub-100 fs pulse shapes in the time domain. Optional modules convert the center wavelength into supercontinua, tunable visible or NIR laser light.



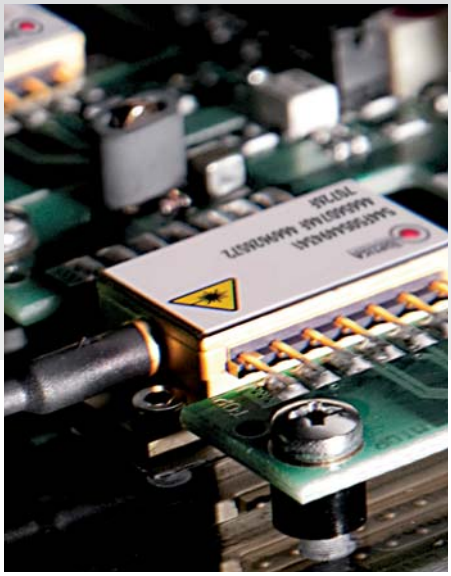
## PM fiber technology

Polarization-maintaining (PM) fibers preserve the linear state of polarization under all circumstances: Temperature, mechanical stress, humidity or other environmental influences can‘t disturb the stable laser operation.



## SAM mode-locking technology

The saturable absorber mirror (SAM) ensures self-starting and reliable cw-mode-locking. This passive device efficiently suppresses Q-switching operation. Only intense solitonic laser pulses are stabilized and supported by the SAM.



### Robust 24/7 operation

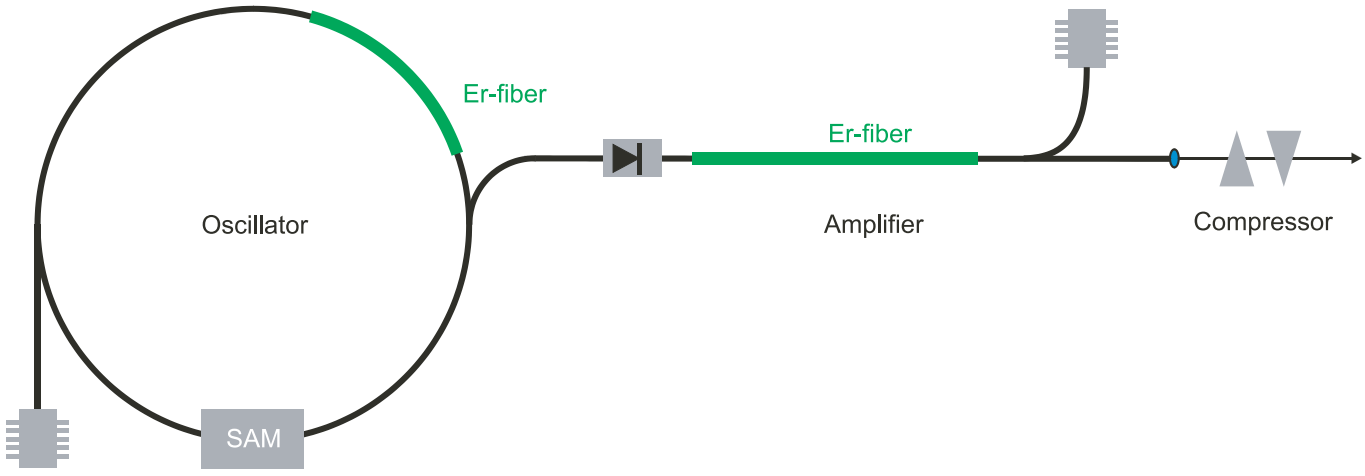
· PM fiber assembly
· All-fiber: Alignment free
· Telcordia proved components

### Turnkey

· Reliable SAM technology
· Self-starting mode-locking

### Price and system size

· Low cost of ownership & running costs
· Compact: Letter / A4 format footprint
· Neither air nor water cooling

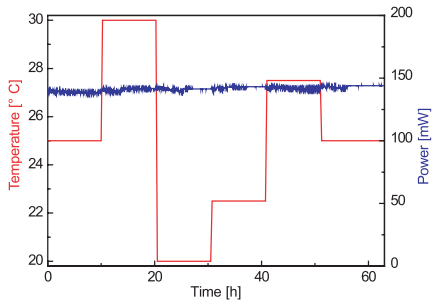


# Modularity
FemtoFiber pro

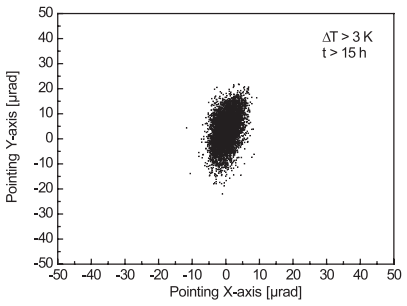
## Versatile laser system

An all-fiber master oscillator power amplifier (MOPA) concept is the basis for TOPTICA's ultrafast fiber lasers. Either Ytterbium or Erbium doped gain fibers support ultrashort laser pulses at 1030 nm, 1064 nm or 1560 nm. Depending on the application, femtosecond or picoseconds pulse widths are custom tailored. Optional modules extend the available wavelengths: Second harmonic generation adds 780 nm. Highly nonlinear fibers generate an octave spanning supercontinuum (980 nm - 2200 nm). Subsequent second harmonic generation results in tunable laser light in the visible range (488 nm - 640 nm). Fiber delivery makes integration easy. Finally, customization completes our idea of flexibility.

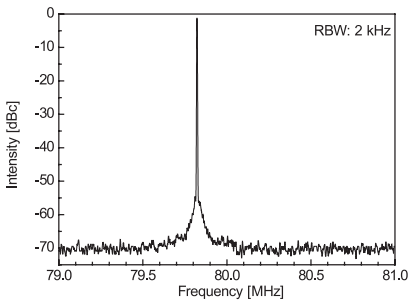
# Outstanding Performance




Excellent thermal power stability (e.g. NIR system).

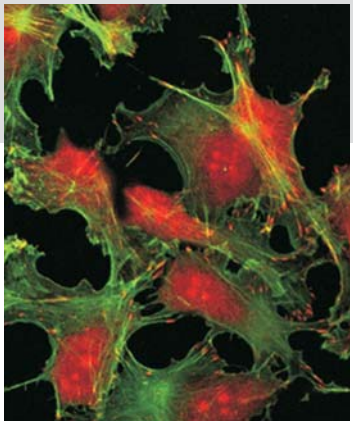


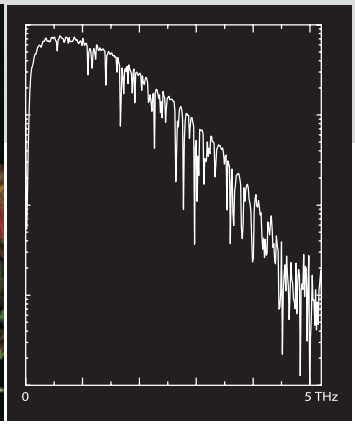

Superb pointing stability of the FemtoFiber pro output beam (NIR).

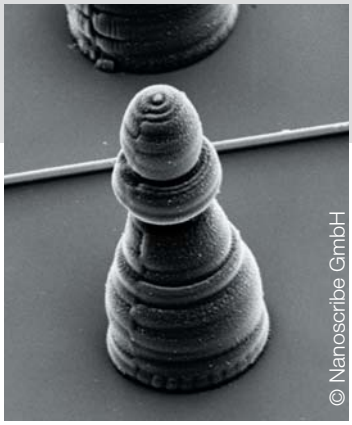


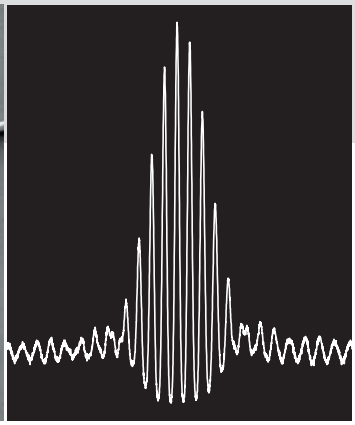

Excellent flat noise spectrum of the oscillator (typical).

# Challenging Applications





## Life sciences

**Laser requirements:**
- Tunability
- Ultrashort pulses
- Multi color

**Recommended products:**
- iChrome
- FemtoFiber pro TVIS
- FemtoFiber pro TNIR
- FemtoFiber pro NIR

## Time-domain terahertz

**Laser requirements:**
- < 100 fs pulse width
- 1560 nm or 780 nm

**Recommended products:**
- FemtoFiber pro IR
- FemtoFiber pro NIR
- FemtoFErb 1560

## 2-photon polymerisation

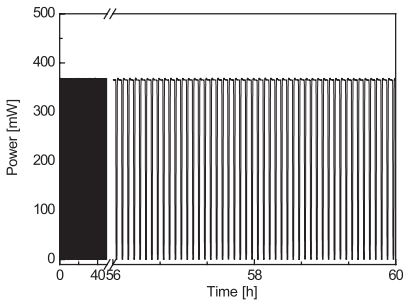
**Laser requirements:**
- High laser peak power
- Short pulses

**Recommended products:**
- FemtoFiber pro NIR

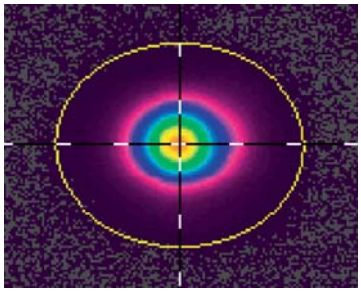
## Attoscience

**Laser requirements:**
- CEO-free laser pulses
- Mid-IR radiation for parametric amplification

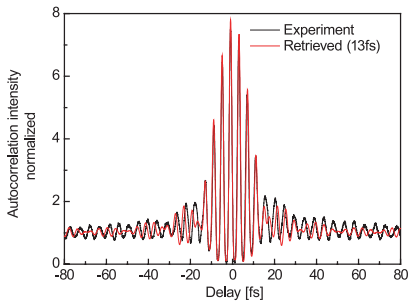
**Recommended products:**
- FemtoFiber pro IR + FemtoFiber pro SCIR
- FemtoFiber pro UCP



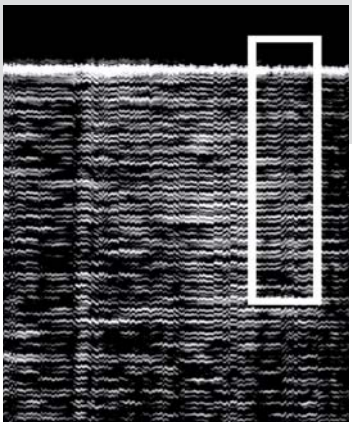

NIR system with on-off cycles shows 100 % starting probability.



Typical beam profile for e.g. NIR system.




Shortest pulses available with the UCP system.





## Optical coherence tomography

**Laser requirements:**
- Very broad spectrum
- Supercontinuum

**Recommended products:**
- FemtoFiber pro IR
- FemtoFiber pro SCIR

## Pump-probe spectroscopy

**Laser requirements:**
- Phase coherent dual beam system
- Independently configured outputs

**Recommended products:**
- FemtoFiber pro with multi beam option

## Material processing

**Laser requirements:**
- Picosecond pulses
- 1030 nm or 1064 nm

**Recommended products (seeders):**
- PicoFYb 1030 nm AMP
- PicoFYb 1064 nm AMP

## ECOPS

**Laser requirements:**
- Synchronization of the repetition rate
- Phase-locked loop electronics

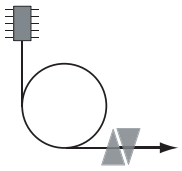
**Recommended products:**
- FemtoFiber pro with VAR option
- FemtoFiber pro laser repetition rate control (LRC)

| FemtoFiber pro specifications | | | | |
|---|---|---|---|---|
| **Models** | **Wavelength** | **Pulse width** | **Average power** | **Page** |
| FemtoFiber pro **IR** | 1560 nm | < 100 fs | > 350 mW | 12 |
| FemtoFiber pro **NIR** | 780 nm | < 100 fs | > 140 mW | 13 |
| FemtoFiber pro **SCIR** | 980 - 2200 nm | < 100 fs | > 150 mW | 14 |
| FemtoFiber pro **UCP** | 980 - 1400 nm | < 25 fs | > 30 mW | 15 |
| FemtoFiber pro **TVIS** | 488 - 640 nm | < 1 ps | 1 – 10 mW | 16 |
| FemtoFiber pro **TNIR** | 830 - 1100 nm | < 200 fs | 1 – 5 mW | 17 |

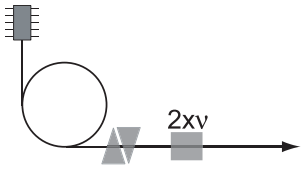
| Options | | |
|---|---|---|
| VAR | Modulation of the pulse repetition frequency<br>Piezo-transducer resonance frequency > 5 kHz<br>Repetition frequeny tuning range > 200 kHz | 18 |
| LRC | Phase-locked loop electronics<br>RMS jitter t.b.d.<br>Electronics rack with power supply<br>USB interface and control software | 18 |
| M40 | Oscillator design with 40 MHz repetition rate<br>(some specifications may change) | 18 |
| AMP | System without oscillator for multi beam systems<br>FC/APC fiber input | 18 |

| General specifications | |
|---|---|
| Repetition rate | 80 MHz standard |
| Output coupling | Free space |
| Beam shape | $TEM_{00}$ |
| Polarization | Linear, horizontal |
| Laser head dimensions (w x d x h) | **IR, NIR, SCIR**: 280 x 229 x 151 $mm^3$<br>**UCP, TVIS, TNIR**: 280 x 458 x 151 $mm^3$ |
| Control unit dimensions ( w x h x d) | 235 x 315 x 140 $mm^3$ |
| Line input | 90 – 260 VAC, 47 – 63 Hz |
| PC interface | Ethernet, USB, RS 232 |

Specifications are subject to change without further notice



FemtoFiber pro **IR** — System unit consisting of mode-locked Erbium fiber oscillator with integrated fiber amplifier and dispersion control module.




FemtoFiber pro **NIR** — System unit with additional second harmonic generation.

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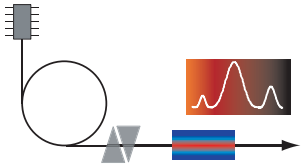
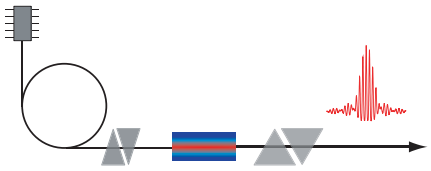
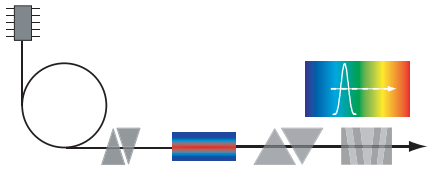


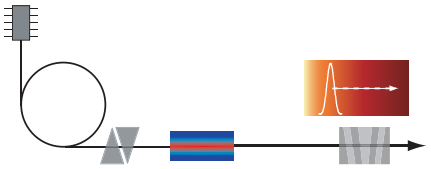
FemtoFiber pro **SCIR** — System unit with additional highly nonlinear fiber generating octave-spanning supercontinuum in the infrared.



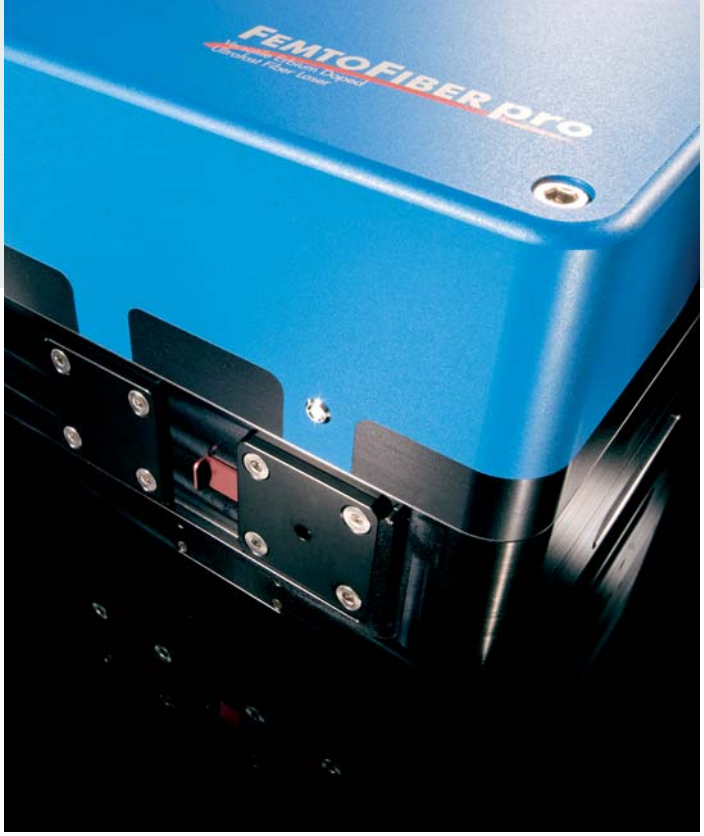
FemtoFiber pro **UCP** — Laser system generating < 25 fs pulses, continuously tunable from 980 – 1400 nm.



FemtoFiber pro **TVIS** — Laser system with ultrashort pulsed beam, continuously tunable from 488 – 640 nm.



FemtoFiber pro **TNIR** — Laser system with ultrashort pulsed beam, continuously tunable from 830 – 1100 nm.




# FemtoFiber pro IR

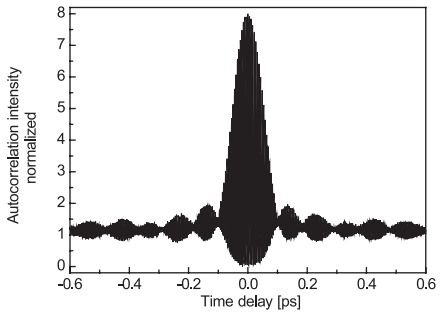
## InfraRed

### Key features

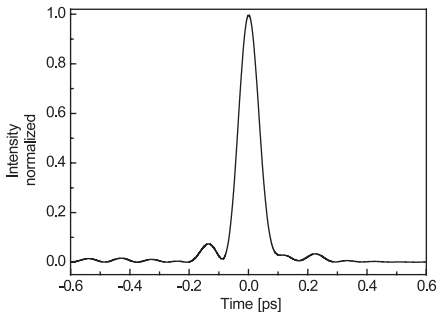
- Fiber laser system with SAM mode-locked oscillator and core-pumped high power amplifier in a single box
- Control unit with laser drivers, power PC control, communication interfaces and power supply
- Motorized prism compressor for pulse optimization
- Free-beam output
- Secondary oscillator fiber output (FC/APC connector)
- High bandwidth monitor output (SMA connector)

| Key specifications | |
|---|---|
| Center wavelength | **1560 nm** |
| Laser output power | > 350 mW |
| Pulse width | < 100 fs |
| Repetition rate | 80 MHz standard |
| Linear polarization | > 95 % (horizontal) |
| Beam shape | $TEM_{00}$, $M^2$ < 1.2 |
| Beam size ($1/e^2$) | Typ. Ø 3.5 mm |
| Beam divergence | < 2 mrad |
| Output coupling | Free space |
| Laser head dimensions | 280 x 229 x 151 $mm^3$ (w x d x h) |
| Laser head weight | < 10 kg |
| Control unit dimensions | 235 x 315 x 140 $mm^3$ (w x d x h) |
| Control unit weight | < 4.5 kg |
| Line input | 90 – 260 VAC, 47 – 63 Hz |
| PC interface | Ethernet, USB, RS 232 |

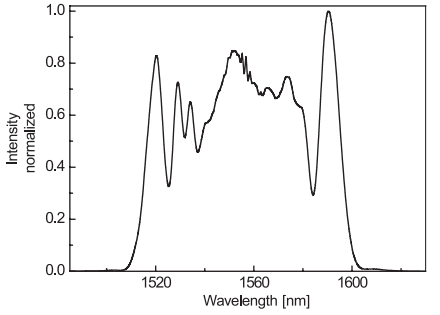
| Options |
|---|
| • Repetition rate 40 MHz (M40) or customized (some specifications may change) |
| • Further two oscillator outputs for seeding purposes (on total 3 FC/APC outputs) |
| • System without oscillator (AMP) for multiple beam extension systems (FC/APC input) |
| • Variable laser repetition rate VAR (for more information see options page) |
| • Phase-locked loop laser synchronization electronics LRC (see options page) |
| Contact TOPTICA for customized systems |




Autocorrelation pulse width < 100 fs at 1560 nm.




Retrieved pulse shape > 70 % of power in main peak.

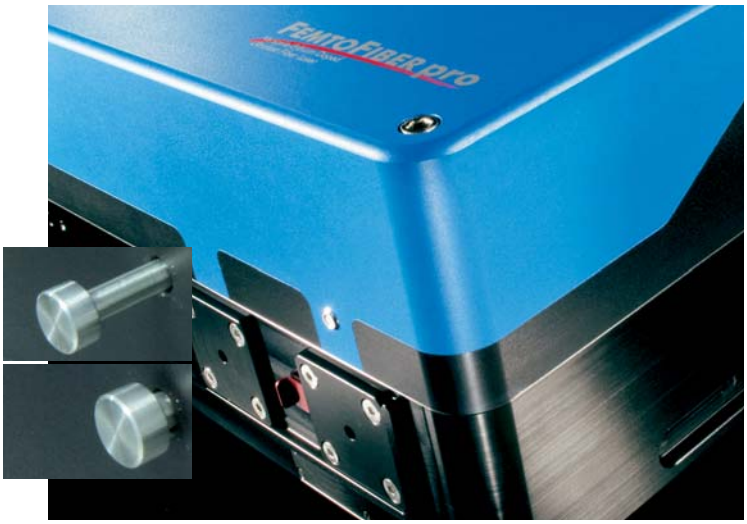


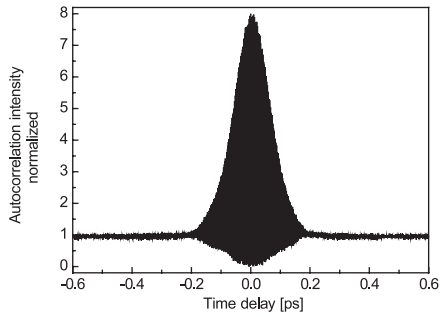

80 nm wide-ranging linear spectrum at 1560 nm.

# FemtoFiber pro
# NIR
## Near InfraRed

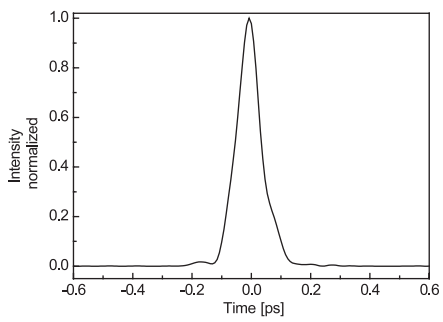
### Key features

- Fiber laser system with SAM mode-locked oscillator, core-pumped high power amplifier and second harmonic generation in a single box
- Control unit with laser drivers, power PC control, communication interfaces and power supply
- Motorized prism compressor for pulse optimization
- Free-beam output for 1560 nm and 780 nm, mechanically switchable
- Secondary oscillator fiber output (FC/APC connector)
- High bandwidth monitor output (SMA connector)

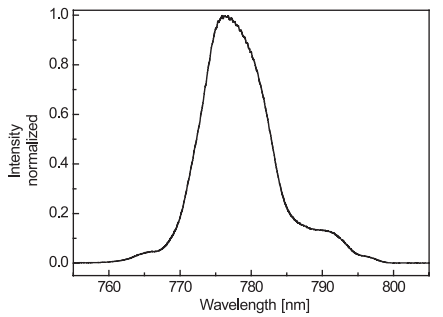



Autocorrelation pulse width < 100 fs at 780 nm.




Retrieved pulse shape > 70 % of power in main peak.




Linear emission spectrum at 780 nm.

| Key specifications | |
|---|---|
| Fundamental wavelength | **1560 nm** |
| Laser output power | > 350 mW |
| Pulse width | < 100 fs |
| Repetition rate | 80 MHz standard |
| Second-harmonic wavelength | **780 nm** |
| Laser output power | > 140 mW |
| Linear polarization | > 95 % (horizontal) |
| Beam shape | $TEM_{00}$, $M^2$ < 1.2 |
| Beam size ($1/e^2$) | Typ. Ø 1.2 mm (780 nm)<br>Typ. Ø 3.5 mm (1560 nm) |
| Beam divergence | < 1 mrad (780 nm)<br>< 2 mrad (1560 nm) |
| Output coupling | Free space |
| Laser head dimensions | 280 x 229 x 151 $mm^3$<br>(w x d x h) |
| Laser head weight | < 10 kg |
| Control unit dimensions | 235 x 315 x 140 $mm^3$<br>(w x d x h) |
| Control unit weight | < 4.5 kg |
| Line input | 90 – 260 VAC, 47 – 63 Hz |
| PC interface | Ethernet, USB, RS 232 |

| Options |
|---|
| • Repetition rate 40 MHz (M40) or customized (some specifications may change) |
| • Further two oscillator outputs for seeding purposes (on total 3 FC/APC outputs) |
| • System without oscillator (AMP) for multiple beam extension systems (FC/APC input) |
| • Variable laser repetition rate VAR (for more information see options page) |
| • Phase-locked loop laser synchronization electronics LRC (see options page) |
| Contact TOPTICA for customized systems |

# FemtoFiber pro SCIR

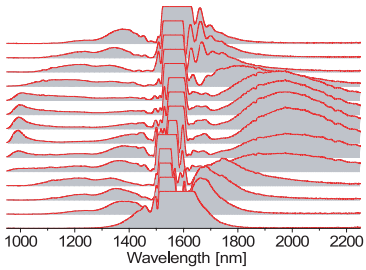
## SuperContinuum InfraRed

### Key features

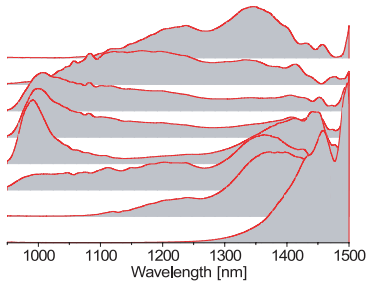
- Fiber laser system with SAM mode-locked oscillator, core-pumped high power amplifier and supercontinuum generation in a single box
- Supercontinuum generated by highly nonlinear fiber
- Control unit with laser drivers, power PC control, communication interfaces and power supply
- Motorized prism compressor for pulse optimization
- Free-beam output
- Secondary oscillator fiber output (FC/APC connector)
- High bandwidth monitor output (SMA connector)
- Motorized chirp adjustment

| Key specifications | |
|---|---|
| Wavelength range continuum | **980 – 2200 nm** |
| Laser output power | > 150 mW |
| Pulse width | < 100 fs |
| Repetition rate | 80 MHz standard |
| Linear polarization | > 95 % (horizontal) |
| Beam shape | $TEM_{00}$, $M^2$ < 1.2 |
| Beam size ($1/e^2$) | Typ. Ø 4 mm |
| Beam divergence | < 1 mrad |
| Output coupling | Free space |
| Laser head dimensions | 280 x 229 x 151 $mm^3$ (w x d x h) |
| Laser head weight | < 10 kg |
| Control unit dimensions | 235 x 315 x 140 $mm^3$ (w x d x h) |
| Control unit weight | < 4.5 kg |
| Line input | 90 – 260 VAC, 47 – 63 Hz |
| PC interface | Ethernet, USB, RS 232 |

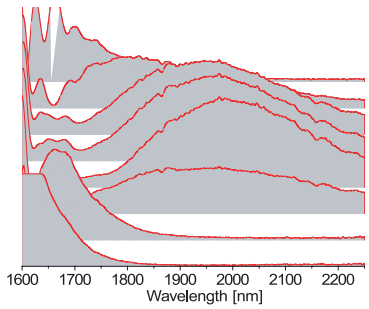
| Options |
|---|
| • Repetition rate 40 MHz (M40) or customized (some specifications may change) |
| • Further two oscillator outputs for seeding purposes (on total 3 FC/APC outputs) |
| • System without oscillator (AMP) for multiple beam extension systems (FC/APC input) |
| • Variable laser repetition rate VAR (for more information see options page) |
| • Phase-locked loop laser synchronization electronics LRC (see options page) |
| Contact TOPTICA for customized systems |




Supercontinuum spectrum (different initial pulse width).




Short wavelengths part (different initial pulse width).

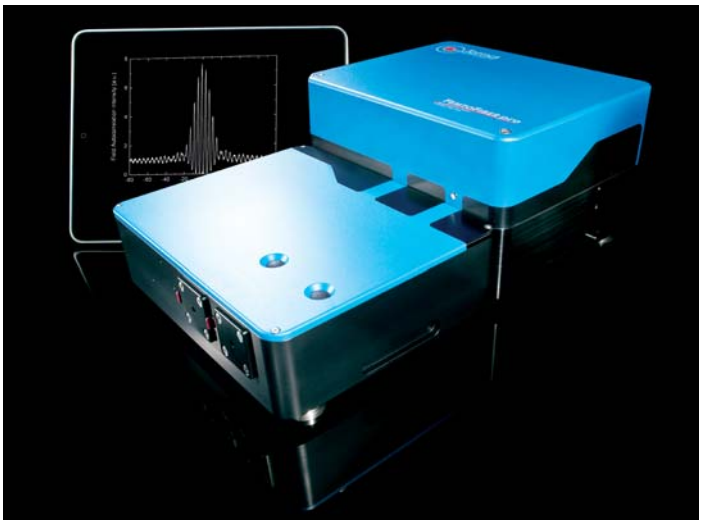


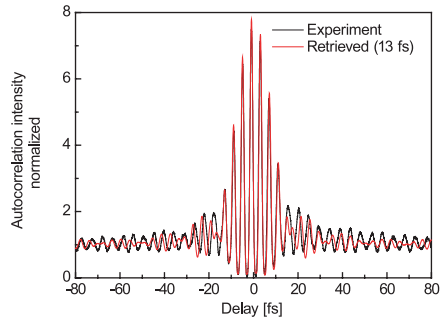

Long wavelengths part (different initial pulse width).

# FemtoFiber pro
# UCP
## Ultra Compressed Pulse

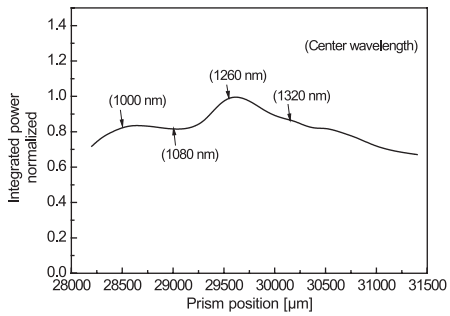
### Key features

- Fiber laser system with SAM mode-locked oscillator and core-pumped high power amplifier
- Supercontinuum generated by highly nonlinear fiber
- Two motorized prism compressors for supercontinuum and pulse optimization
- Free-beam output
- Control unit with laser drivers, power PC control, communication interfaces and power supply
- Secondary oscillator fiber output (FC/APC connector)
- Interlock capabilities
- High bandwidth monitor output (SMA connector)

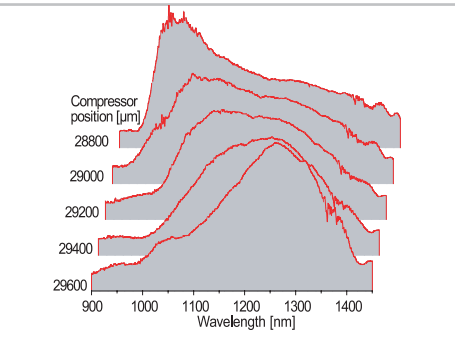





Autocorrelation intensity (typical, e.g. at 1235 nm).




Output power vs. prism compressor setting (typ.).




Typical spectral tunability of the UCP system.

| Key specifications | |
|---|---|
| Wavelength range continuum | **980 – 1400 nm** |
| Laser output power | 30 mW* |
| Pulse width | < 25 fs* |
| Repetition rate | 80 MHz standard |
| Linear polarization | > 95 % (horizontal) |
| Beam shape | $TEM_{00}$, $M^2$ < 1.2 |
| Beam size ($1/e^2$) | Typ. Ø 4 mm |
| Beam divergence | < 1 mrad |
| Output coupling | Free space |
| Laser head dimensions | 280 x 458 x 151 $mm^3$ (w x d x h) |
| Laser head weight | < 15 kg |
| Control unit dimensions | 235 x 315 x 140 $mm^3$ (w x d x h) |
| Control unit weight | < 4.5 kg |
| Line input | 90 – 260 VAC, 47 – 63 Hz |
| PC interface | Ethernet, USB, RS 232 |
| *) Dependent on center wavelength | |

| Options |
|---|
| • Repetition rate 40 MHz (M40) or customized (some specifications may change) |
| • Further two oscillator outputs for seeding purposes (on total 3 FC/APC outputs) |
| • System without oscillator (AMP) for multiple beam extension systems (FC/APC input) |
| • Can be combined with TNIR option (contact TOPTICA) |
| • Variable laser repetition rate VAR (for more information see options page) |
| • Phase-locked loop laser synchronization electronics LRC (see options page) |
| Contact TOPTICA for customized systems |

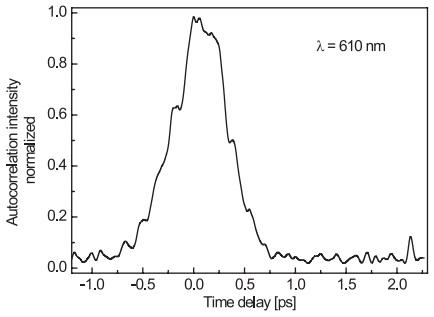
# FemtoFiber pro
# TVIS
## Tunable VISible

### Key features

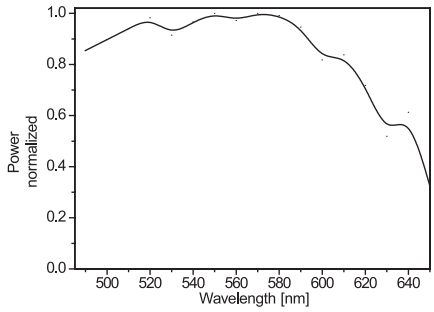
- Fiber laser system with SAM mode-locked oscillator and core-pumped high power amplifier
- Supercontinuum generated by highly nonlinear fiber
- Two motorized prism compressors for supercontinuum and pulse optimization
- Second harmonic generation by manually tunable crystal
- Free-beam output
- Control unit with laser drivers, power PC control, communication interfaces and power supply
- Secondary oscillator fiber output (FC/APC connector)
- High bandwidth monitor output (SMA connector)

| Key specifications | |
|---|---|
| Wavelength range continuum | **488 – 640 nm** |
| Laser output power | 1 – 10 mW |
| Pulse width | < 1 ps |
| Repetition rate | 80 MHz standard |
| Linear polarization | > 95 % (horizontal) |
| Beam shape | $TEM_{00}$, $M^2$ < 1.2 |
| Beam size ($1/e^2$) | t.b.d. |
| Beam divergence | < 1 mrad |
| Output coupling | Free space |
| Laser head dimensions | 280 x 458 x 151 $mm^3$ (w x d x h) |
| Laser head weight | < 15 kg |
| Control unit dimensions | 235 x 315 x 140 $mm^3$ (w x d x h) |
| Control unit weight | < 4.5 kg |
| Line input | 90 – 260 VAC, 47 – 63 Hz |
| PC interface | Ethernet, USB, RS 232 |

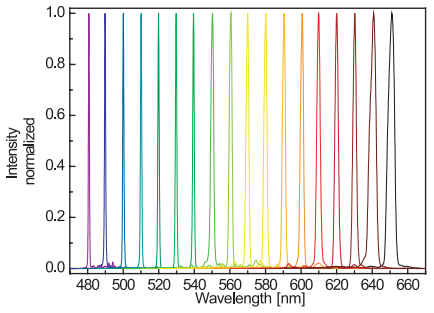
| Options |
|---|
| • Repetition rate 40 MHz (M40) or customized (some specifications may change) |
| • Further two oscillator outputs for seeding purposes (on total 3 FC/APC outputs) |
| • System without oscillator (AMP) for multiple beam extension systems (FC/APC input) |
| • Can be combined with TNIR option (contact TOPTICA) |
| • Variable laser repetition rate VAR (for more information see options page) |
| • Phase-locked loop laser synchronization electronics LRC (see options page) |
| Contact TOPTICA for customized systems |




Autocorrelation intensity (typical, e.g. at 610 nm).

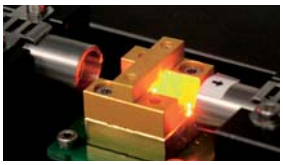



Typical spectral output power levels.



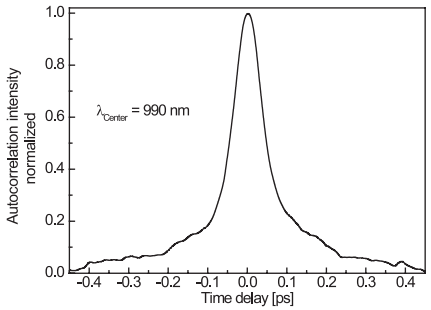

Spectral tunability between 485 and 650 nm.

# FemtoFiber pro
# TNIR
## Tunable Near InfraRed

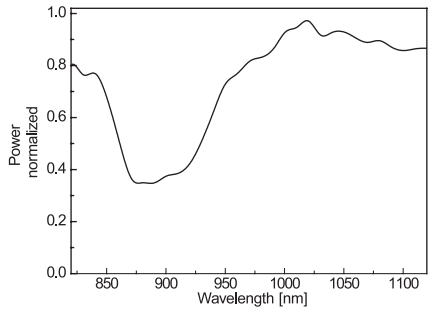


### Key features

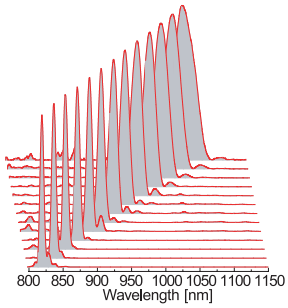
- Fiber laser system with SAM mode-locked oscillator and core-pumped high power amplifier
- Supercontinuum generated by highly nonlinear fiber
- Motorized prism compressor for pulse optimization
- Second harmonic generation by manually tunable crystal
- Free-beam output
- Control unit with laser drivers, power PC control, communication interfaces and power supply
- Secondary oscillator fiber output (FC/APC connector)
- High bandwidth monitor output (SMA connector)




Autocorrelation intensity (typical, e.g. at 990 nm).




Typical spectral output power levels.




Spectral tunability between 800 and 1150 nm.

| Key specifications | |
|---|---|
| Wavelength range continuum | **830 – 1100 nm** |
| Laser output power | 1 – 5 mW |
| Pulse width | < 200 fs |
| Repetition rate | 80 MHz standard |
| Linear polarization | > 95 % (horizontal) |
| Beam shape | $TEM_{00}$, $M^2$ < 1.2 |
| Beam size ($1/e^2$) | t.b.d. |
| Beam divergence | < 1 mrad |
| Output coupling | Free space |
| Laser head dimensions | 280 x 458 x 151 $mm^3$ (w x d x h) |
| Laser head weight | < 15 kg |
| Control unit dimensions | 235 x 315 x 140 $mm^3$ (w x d x h) |
| Control unit weight | < 4.5 kg |
| Line input | 90 – 260 VAC, 47 – 63 Hz |
| PC interface | Ethernet, USB, RS 232 |

| Options |
|---|
| • Repetition rate 40 MHz (M40) or customized (some specifications may change) |
| • Further two oscillator outputs for seeding purposes (on total 3 FC/APC outputs) |
| • System without oscillator (AMP) for multiple beam extension systems (FC/APC input) |
| • Can be combined with TVIS or UCP option (contact TOPTICA) |
| • Variable laser repetition rate VAR (for more information see options page) |
| • Phase-locked loop laser synchronization electronics LRC (see options page) |
| Contact TOPTICA for customized systems |

# FemtoFiber pro
# Options

## Option: VAR — VAriable laser Repetition rate

- Adaptation to the oscillator unit, enabling modulation of the repetition rate
- Adjustable resonator length by Piezo transducer and translation stage
- Piezo resonance frequency > 5 kHz
- Repetition rate tuning range > 200 kHz

## Option: LRC — Laser Repetition rate Control

- Phase-locked loop electronics for synchronization of the laser pulse train to external reference signal
- RMS jitter t.b.d.
- Electronics rack with power supply
- USB interface and control software
- ECOPS capability

## Option: M40 — 40 MHz repetition rate

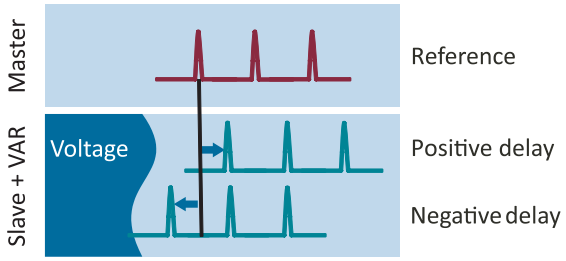
- Oscillator design with 40 MHz repetition rate

Some specifications may change

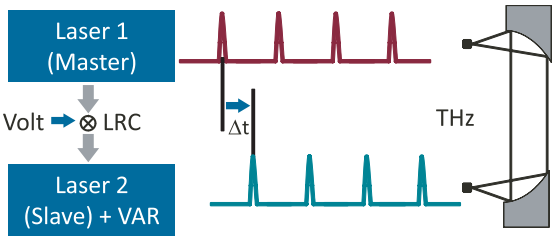
## Option: AMP — Multi beam configuration

- System without oscillator for multi beam systems
- FC/APC fiber input

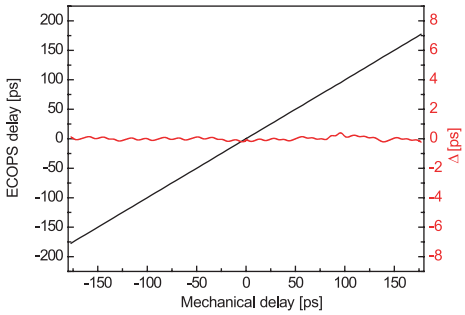
## Electronically controlled optical sampling — ECOPS




ECOPS: Mode of operation.

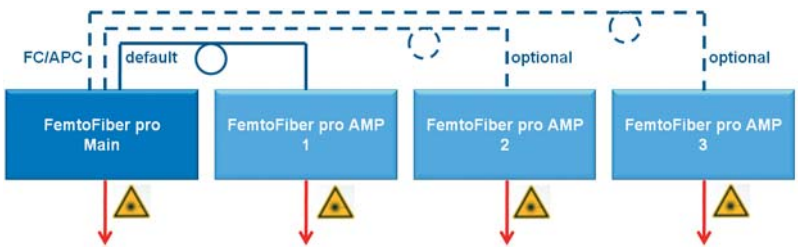


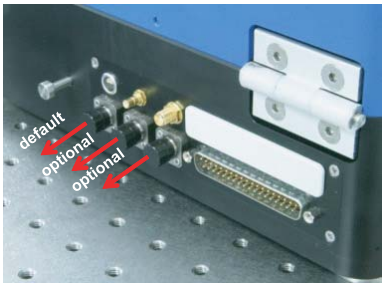

ECOPS: Example implementation for THz.




Perfect linearity of the ECOPS tuning and the difference between electronic and mechanical delay.

## Fiber coupling to other units



# FemtoFiber pro
# Control Unit

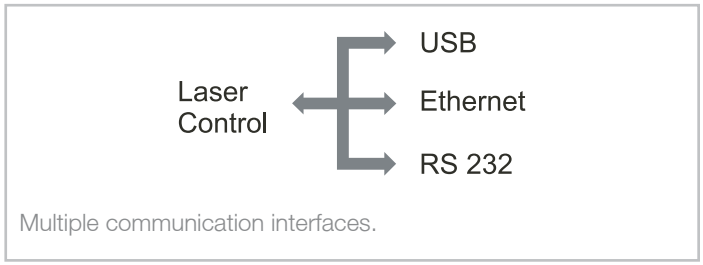
## Key features

- Built-in power PC for system control
- Easy communication through web browser
- Access to motorized controls, such as variable pulse compression
- LabVIEW™ routines available for system integration
- Manual interface: Push ON/OFF button only
- Key lock switch
- Interlock capabilities
- 12 inch rack housing including interfaces, driver electronics for pump diodes and power supplies

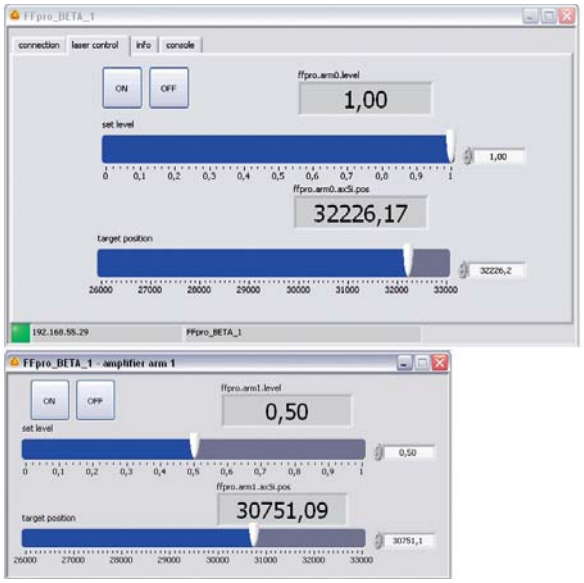

FemtoFiber pro control unit.

The laser control unit includes a power PC that controls all laser parameters. This ensures turnkey and hands-off operation with a single ON/OFF button for the user. Standard communication interfaces (Ethernet, USB and RS 232) give access to all relevant parameters for an easy integration in complex setups.

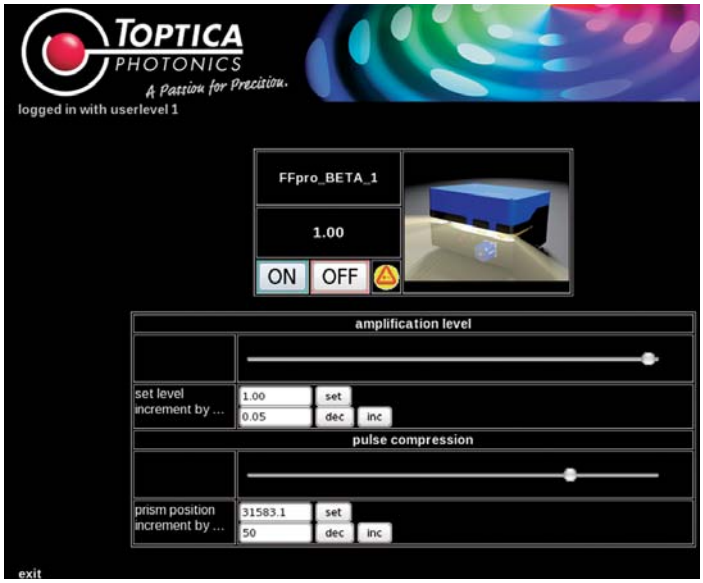
The user can choose between three alternatives. Simplest way is to login via any web browser already installed on the user's computer. Another way is employing the LabVIEW™ routine that is included free of charge. The most sophisticated way is to use self-written scripts with a pool of pre-defined commands.




Multiple communication interfaces.




Graphical user interface based on LabVIEW™.



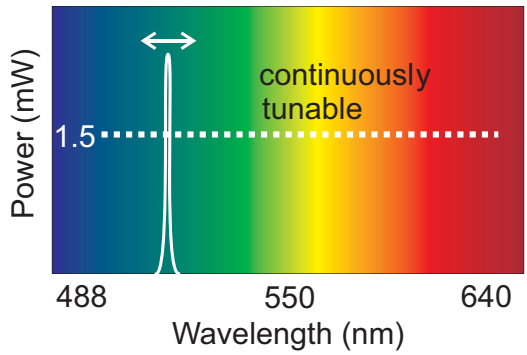

Web browser based GUI.


# All-Color Fiber Laser
# iChrome

## Applications

- Pump probe spectroscopy
- Fluorescence life time measurement
- Excitation spectra measurement
- Confocal microscopy

| Key specifications | |
|---|---|
| Wavelength range | **488 – 640 nm** |
| Average fiber output power | > 1.5 mW |
| Repetition rate | 40 MHz ± 1 MHz |
| Bandwidth (FWHM) | < 3 nm |
| Pulse width | 3.5 ps ± 1 ps |
| Polarization | Linear, 100 : 1 |
| Trigger output | Typ. - 300 mV, 1 ns |
| Spatial mode | $TEM_{00}$ |
| Fiber delivery | PM SM fiber, 2 m length<br>MFD 4 µm @ 480 nm |
| Accuracy | ± 1 nm |
| Speed | ≥ 50 nm/s |
| Line-up time | ≤ 500 ms |
| Warm-up time | 2 h |
| Operating temperature | 22°C ± 3°C |
| Air humidity | < 70 % non-condensing |
| Power consumption | < 75 W |
| Dimensions | 450 x 570 x 230 $mm^3$<br>(w x d x h) |
| Weight | 21.5 kg |




**Flexible fiber laser**
The newly introduced iChrome is a fiber laser with the flexibility to set automatically the laser output to any wavelength in the visible – from 488 nm to 640 nm. In contrast to conventional white light sources, the narrow bandwidth laser pulses are not filtered out from an intrinsically noisy supercontinuum. Moreover, even the coherence of the fundamental laser is preserved during the frequency conversion processes. This ensures that the visible light exhibits the best intensity noise performance. Additionally all optical components are polarization-maintaining. This results in a stable linear polarization of the output beam.

**Fiber coupled output**
The laser output of the iChrome is delivered by a single-mode and polarization-maintaining fiber. Independent from the chosen wavelength the fiber output exhibits a smooth $TEM_{00}$ profile, an excellent beam product with $M^2$ < 1.1 and a linear polarization with a PER* > 1:100. The fiber makes the connection between the high quality light source and the experiment as simple as possible. Pointing stability is guaranteed and all colors are delivered by the same fiber.

**Fully automated operation**
The entire laser system is extremely user friendly: No alignment procedures of any optical components distract the user from the main task – to produce results. Besides the fiber delivery also the full automation of the premium light source helps to avoid wasting time. The built-in power PC controls all necessary parameters to ensure smooth operation every minute, hour, day, week and month. The power PC also hosts a webserver and is equipped with an ethernet connection. Therefore, all user commands can be sent from an ordinary web browser to the laser system.

*PER = Polarization Extinction Ratio

# Industrial-Grade Fiber Lasers
# PicoFYb 1030 nm, 1064 nm / FemtoFErb 1560 nm

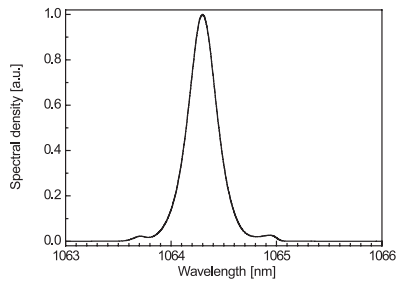
## Applications

- Micro material processing
- Time-domain Terahertz generation
- Light source for microscopy
- Medical surgery / examination
- Ophthalmology

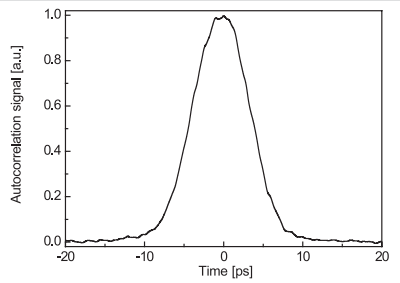

**Ultrafast, ultra stable, turnkey**
The PicoFYb / FemtoFErb laser systems are turnkey fiber-based picosecond and femtosecond mode-locked fiber oscillators. The PicoFYb is ideally suited for seeding industrial laser systems. The FemtoFErb is the most compact and cost-effective source for Terahertz generation.

**Key features**
The PicoFYb / FemtoFErb laser pulses exhibit excellent amplitude and frequency jitter parameters. The PicoFYb is typically amplified to multi-Watt levels in the MOPA (master oscillator, power amplifier) laser systems of our customers.
The FemtoFErb has an output power of more than 100 mW and fits perfect to applications such as Terahertz generation or metrology.
Based on state-of-the-art FemtoFiber technology, the PicoFYb / FemtoFErb lasers set the benchmark for the new generation of ultrafast lasers satisfying the most advanced industrial requirements.
Applications benefit from the most stable, compact and cost effective laser design, but in particular from the unique fiber output coupling, a key to a modular customer integration.

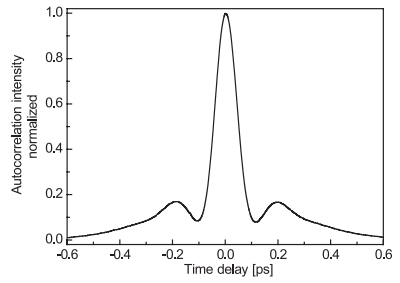
The specifications are derived from our current OEM developments. Further customization (wavelength, pulse duration, footprint, interfacing, etc.) is possible under usual OEM conditions.




PicoFYb 1064 AMP: Linear spectrum with less than 0.5 mm linewidth.




PicoFYb 1064 AMP: Autocorrelation data with less than 10 ps pulse width.

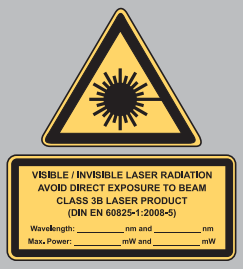



FemtoFErb 1560 AMP: Autocorrelation data.

| Key specifications | | | |
|---|---|---|---|
| | PicoFYb | | FemtoFErb |
| Model | **1030 nm AMP** | **1064 nm AMP** | **1560 nm AMP** |
| Wavelength | 1030.5 ± 0.5 nm | 1064.3 ± 0.5 nm | 1560 |
| Average power | > 10 mW*/** | 10 mW*/** | > 100 mW*/** |
| Repetition rate | 20 MHz ± 0.5 MHz | 20 MHz ± 0.5 MHz | 50 MHz / 100 MHz |
| Pulse duration (FWHM) | < 10 ps** | 6 ± 2 ps** | < 150 fs** |
| Spectral width | < 0.5 (0.3) nm | < 0.5 (0.3) nm | < 40 nm |
| TBP | Typ. 0.5 | Typ. 0.5 | tbd |
| RF side mode suppression | < -60 dBC | < -60 dBC | tbd |
| P-p-noise | < 3 % | < 3 % | tbd |
| Output | SM PM fiber (narrow key FC/APC receptacle) | | |
| Dimensions | 122 x 202 x 69 $mm^3$ (w x d x h) | | |

*) Fixed output power, not adjustable **) After fiber delivery

# Distributors




LGA InterCert
Zertifiziertes QM-System
ISO 9001:2008

BR-043 B 2010-09

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