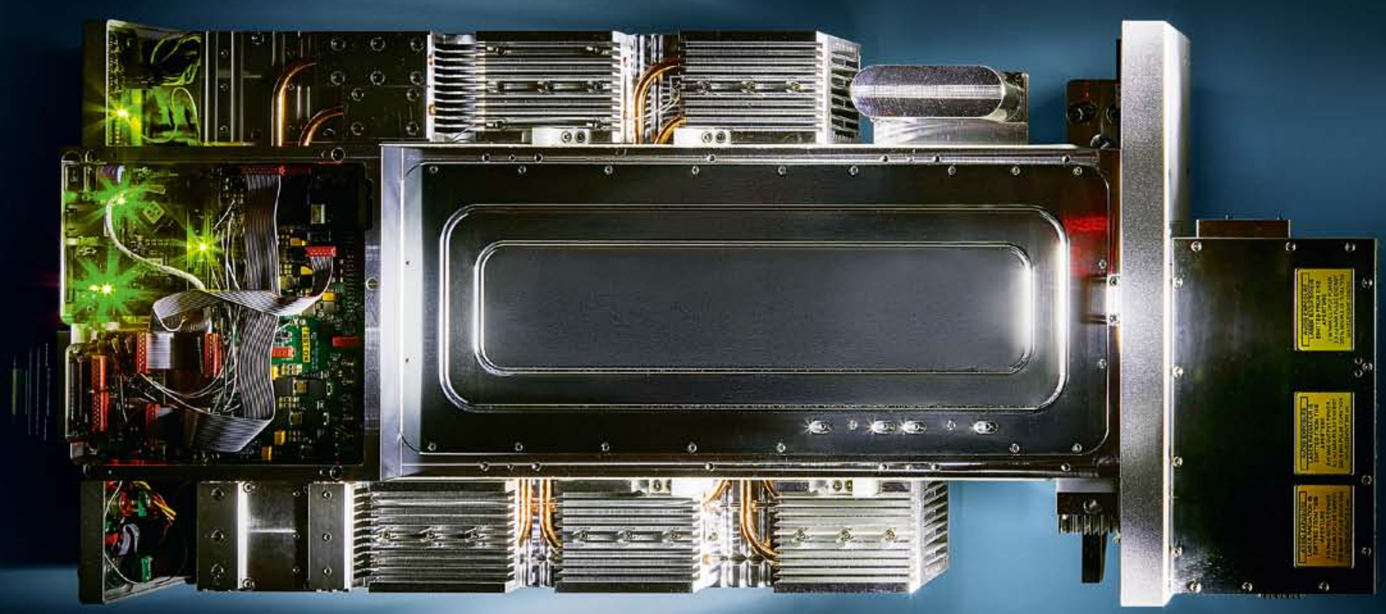
Excellence in Ultrafast

Industrial Femtosecond Lasers

2018



LIGHT CONVERSION

Industrial Femtosecond Lasers

2018 Product Catalogue

Revision 20180126

LIGHT CONVERSION

LIGHT CONVERSION

What we do

We are the world leading manufacturer of wavelength tunable ultrafast light sources based on TOPAS and ORPHEUS series of optical parametric amplifiers (OPA) as well as DPSS femtosecond lasers PHAROS and CARBIDE. PHAROS, the most versatile femtosecond laser amplifier on the market, and the ultra-compact and cost-efficient CARBIDE feature market-leading output parameters along with robust design attracting both industrial and scientific customers.

PHAROS reliability is proven by hundreds of systems operating in 24/7 production environment since it was introduced. Main applications include drilling and cutting of different metals, ceramics, sapphire, glass, material ablation for mass-spectrometry, etc. Among the customers are major manufacturers in display, automotive, LED, medical device industries and others.

Our laser amplifiers are complemented by a strong portfolio of ultrafast products: harmonics modules (provide femtosecond pulses at 515, 343, 257 and 206 nm), OPAs (produce continuous tuning output from ~190 nm up to ~20 μm), HARPIA and CHIMERA spectrometers, TiPA and GECO autocorrelators. All devices can be modified and fine-tuned to meet the most demanding applications.

Who we are

Light Conversion (official name UAB MGF "Šviesos konversija") is a privately owned company with >190 employees. We are based in Vilnius, the capital of Lithuania. Design, R&D and production are done in our state-of-the-art facility opened in 2014. We are the largest manufacturer of femtosecond Optical Parametric Amplifiers (OPAs) and Non-Collinear OPAs (NOPAs). Apart from sales through our distributors, we also provide our production as OEM devices for other major laser manufacturing companies.

With more than 3000 systems installed worldwide, Light Conversion has established itself as a reliable and innovative producer of ultrafast optical devices.

Contents

PHAROS

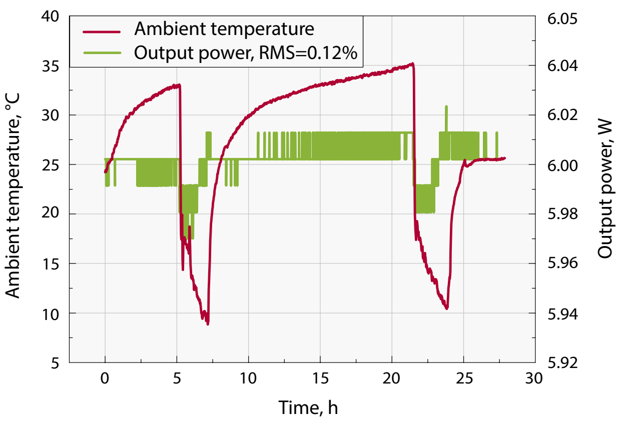
High Power and Energy Femtosecond Lasers

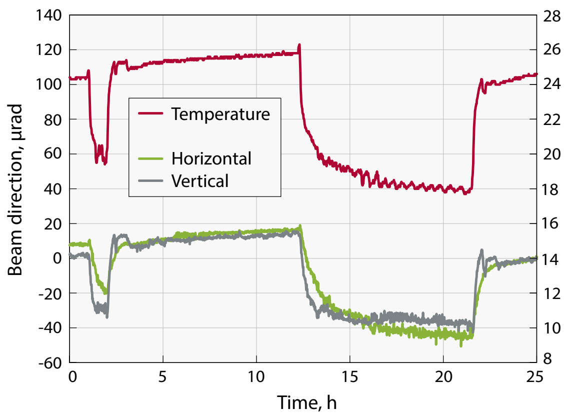
FEATURES

- 190 fs – 20 ps tunable pulse duration
- 2 mJ maximum pulse energy
- 20 W output power
- Single shot – 1 MHz tunable base repetition rate
- Pulse picker for pulse-on-demand operation
- Rugged, industrial grade mechanical design
- Automated harmonics generators (515 nm, 343 nm, 257 nm, 206 nm)

PHAROS is a single-unit integrated femtosecond laser system combining millijoule pulse energies and high average power. PHAROS features a mechanical and optical design optimized for industrial applications such as precise material processing. Compact size, integrated thermal stabilization system and sealed design allows PHAROS integration into machining work-stations. The use of solid state laser diodes for pumping of Yb medium significantly reduces maintenance cost and provides long laser lifetime.

Most of the PHAROS output parameters can be easily set via PC in seconds. Tunability of laser output parameters allows PHAROS system to cover applications normally requiring different classes of lasers. Tunable parameters include: pulse duration (190 fs – 20 ps), repetition rate (single pulse to 1 MHz), pulse energy (up to 2 mJ) and average power (up to 20 W). Its deliverable power is sufficient for most of material processing applications at high machining speeds. The built-in pulse picker allows convenient control of the laser output in pulse-on-demand mode. It comes along with an extensive external control interface dedicated for easy laser integration into larger setups and machining workstations. PHAROS compact and robust optomechanical design includes easy to replace modules with temperature stabilized and sealed housings ensuring stable laser operation across varying environments. PHAROS is equipped with an extensive software package, which ensures smooth hands-free operation.





PHAROS output power with power lock enabled under unstable environment

SPECIFICATIONS

Model	PHAROS-6W	PHAROS-10W	PHAROS-15W	PHAROS-20W	PHAROS SP	PHAROS SP 1.5	PHAROS 2mJ
Max. average power	6 W	10 W	15 W	20 W	6 W		6 W
Pulse duration (assuming Gaussian pulse shape)	< 290 fs				< 190 fs		< 300 fs
Pulse duration range	290 fs – 20 ps				190 fs – 10 ps		300 fs – 10 ps
Max. pulse energy	> 0.2 mJ / > 0.4 mJ				> 1.0 mJ	> 1.5 mJ	> 2 mJ
Beam quality	TEM_{00} ; $M^2 < 1.2$				TEM_{00} ; $M^2 < 1.3$		
Base repetition rate	1 kHz – 1 MHz [1]						
Pulse selection	Single-Shot, Pulse-on-Demand, any base repetition rate division						
Centre wavelength	1028 nm ± 5 nm						
Output pulse-to-pulse stability	< 0.5 % rms [2]						
Power stability	< 0.5 % rms over 100 h						
Pre-pulse contrast	< 1 : 1000						
Post-pulse contrast	< 1 : 200						
Polarization	Linear, horizontal						
Beam pointing stability	< 20 µrad/°C						
Oscillator output	Optional, please contact Light Conversion for specifications						

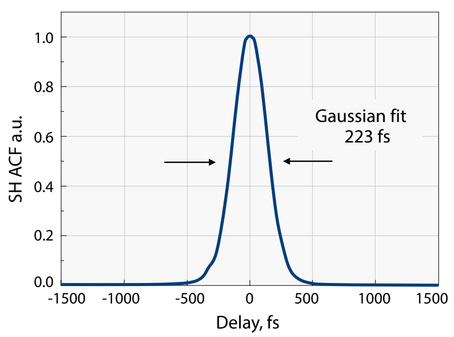
PHYSICAL DIMENSIONS

Laser head	670 (L) × 360 (W) × 212 (H) mm
Rack for power supply and chiller	640 (L) × 520 (W) × 660 (H) mm

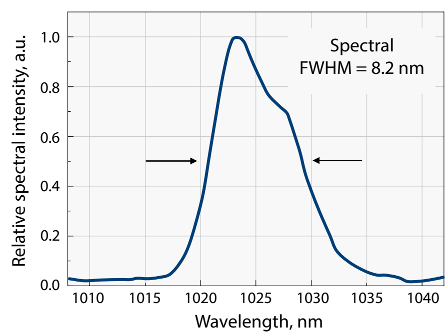
UTILITY REQUIREMENTS

Electric	110 V AC, 50 – 60 Hz, 20 A or 220 V AC, 50 – 60 Hz, 10 A
Operating temperature	15 – 30 °C (air conditioning recommended)
Relative humidity	20 – 80 % (non condensing)

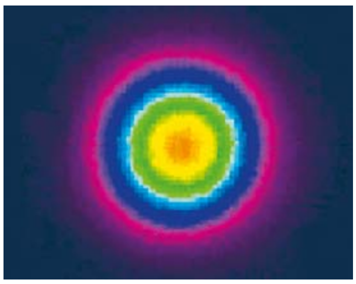
[1] Some particular repetition rates are software denied due to system design. *[2] Under stable environmental conditions.*

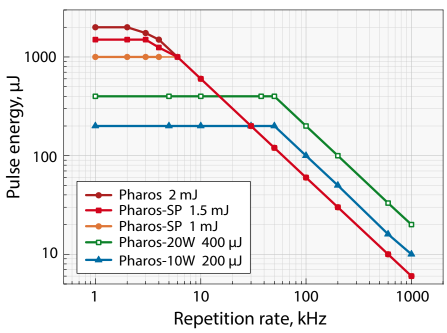


Pulse duration of PHAROS

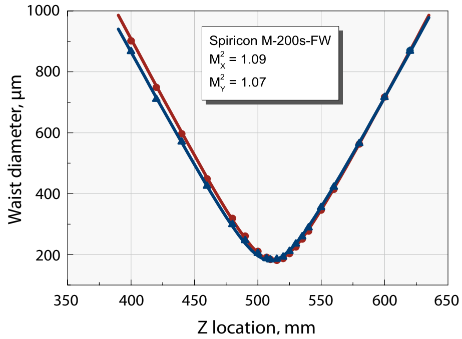


Spectrum of PHAROS

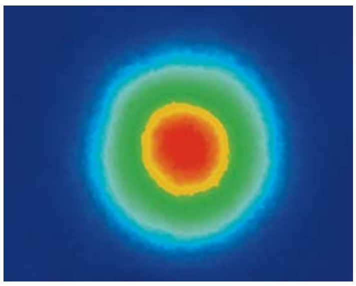

Typical PHAROS far field beam profile at 200 kHz

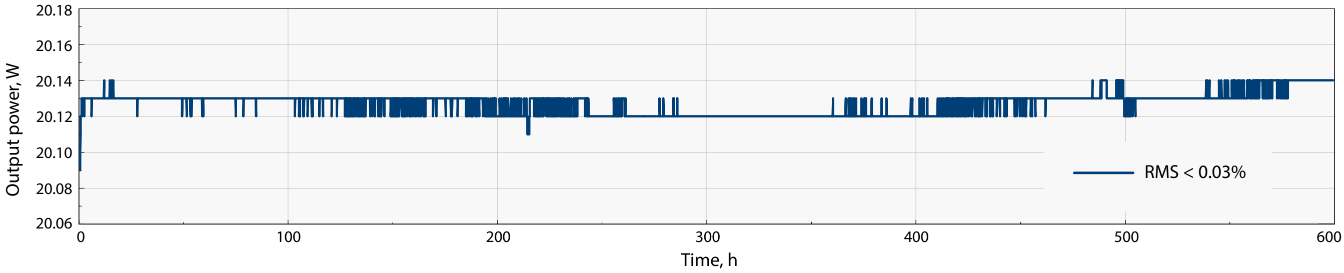


Pulse energy vs base repetition rate

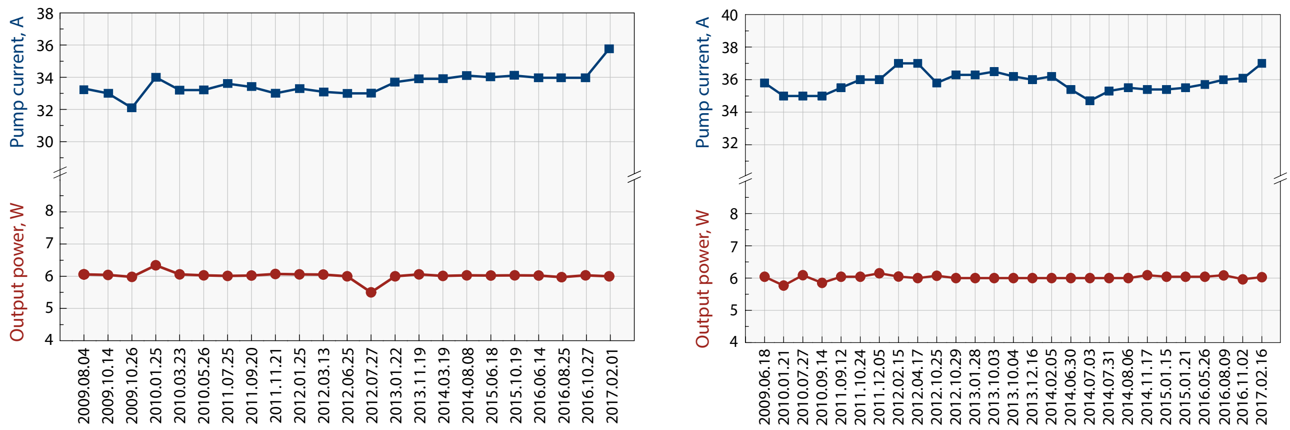


Typical PHAROS M^2 measurement data

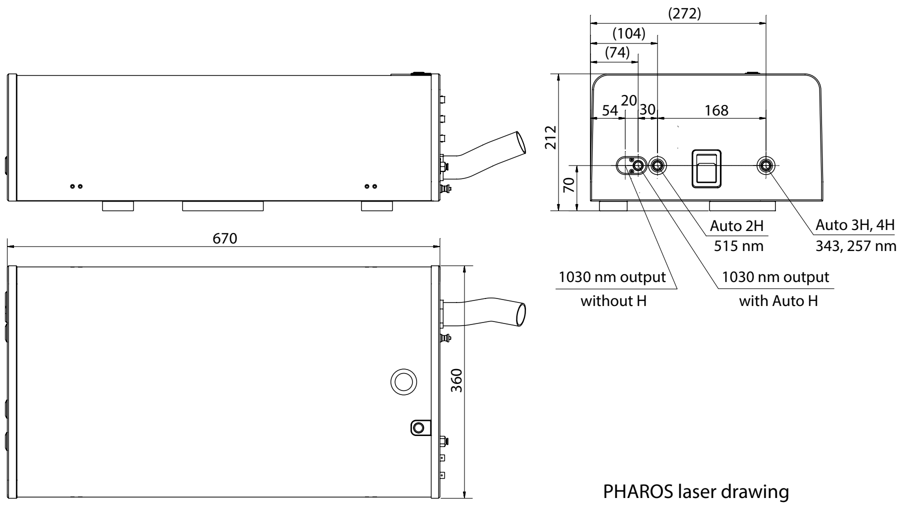

Typical PHAROS near field beam profile at 200 kHz



PHAROS long term stability graph



Output power of industrial PHAROS lasers operating 24/7 and current of pump diodes during the years



PHAROS laser drawing

PHAROS

Automated Harmonics Generators

FEATURES

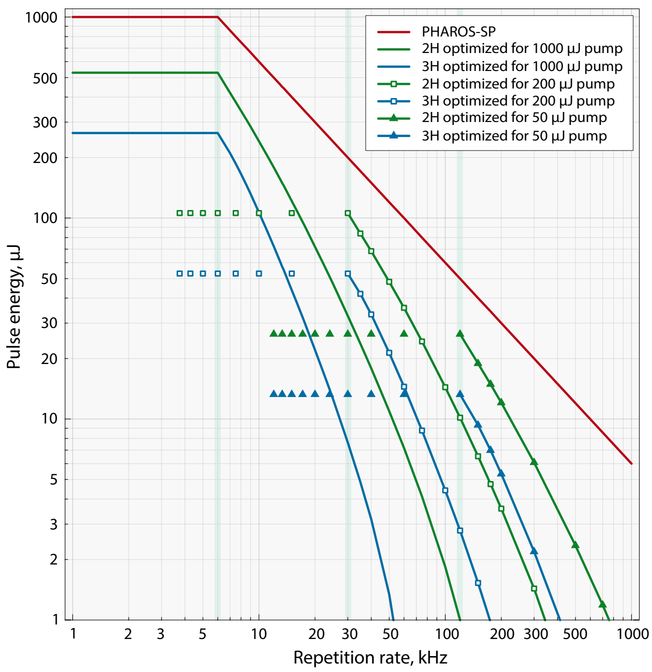
- 515 nm, 343 nm, 257 nm and 206 nm
- Output selection by software
- Mounts directly on laser head and integrated into the system
- Rugged, industrial grade mechanical design

PHAROS laser can be equipped with automated harmonics modules. Selection of fundamental (1030 nm), second (515 nm), third (343 nm), fourth (257 nm) or fifth (206 nm) harmonic output is available through software control. Harmonics generators are designed to be used in industrial applications where a single output wavelength is desired. Modules are mounted directly on the output of the laser and integrated into the system.

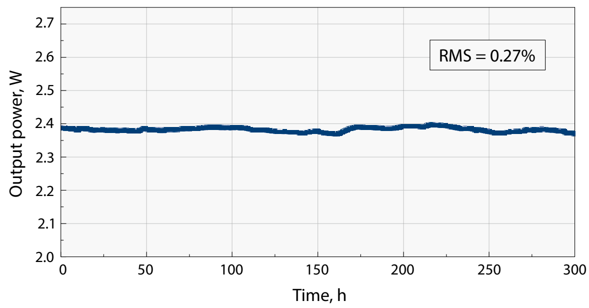
SPECIFICATIONS

Model	2H	2H-3H	2H-4H	4H-5H
Output wavelength (automated selection)	1030 nm 515 nm	1030 nm 515 nm 343 nm	1030 nm 515 nm 257 nm	1030 nm 257 nm 206 nm
Input pulse energy	20 – 2000 µJ	50 – 1000 µJ	20 – 1000 µJ	200 – 1000 µJ
Pump pulse duration	190 – 300 fs			
Conversion efficiency	> 50 % (2H)	> 50 % (2H) > 25 % (3H)	> 50 % (2H) > 10 % (4H) *	> 10 % (4H) * > 5 % (5H)
Pump laser beam quality (M^2)	< 1.2 / < 1.3 depends on a model			
Beam quality (M^2) ≤ 400 µJ pump	515 nm: M^2 (pump) + 0.1	515 nm: M^2 (pump) + 0.1 343 nm: M^2 (pump) + 0.2	515 nm: M^2 (pump) + 0.1 257 nm: n/a	n/a
Beam quality (M^2) > 400 µJ pump	515 nm: M^2 (pump) + 0.2	515 nm: M^2 (pump) + 0.2 343 nm: M^2 (pump) + 0.3	515 nm: M^2 (pump) + 0.2 257 nm: n/a	n/a

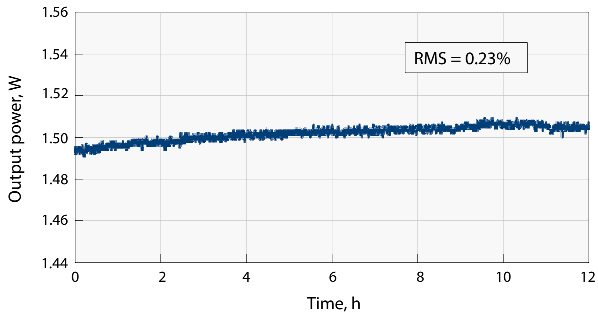
** Max 1 W output.*



Harmonics energy vs pulse repetition rate



3H output stability



4H output stability

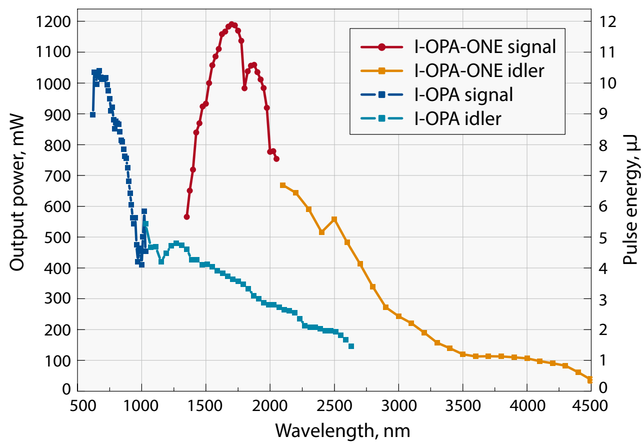
PHAROS

Industrial grade Optical Parametric Amplifier

FEATURES

- Based on experience with ORPHEUS line
- Manually tunable wavelength
- Industrial grade design provides excellent long-term stability
- Very small footprint
- Bandwidth limited or short-pulse configurations available
- CEP option

I-OPA is an optical parametric amplifier of white-light continuum pumped by the PHAROS laser. This OPA is focused on generating long-term stable output with reliable hands-free operation. Manually tunable output wavelength extends the application possibilities of a single laser source, instead of requiring multiple lasers based on different technologies.
In comparison to standard ORPHEUS line of devices, the I-OPA lacks only computer controlled wavelength selection. On the other hand, in-laser mounted design provides mechanical stability and eliminates the effects of air-turbulence, ensuring stable long-term performance and minimizing energy fluctuations.



I-OPA module energy conversion curves.
Pump: PHAROS-10W, 100 μJ, 100 kHz

PHAROS i-OPA MODEL COMPARISON TABLE

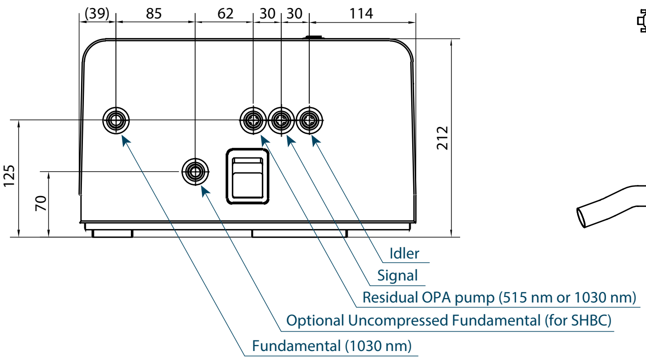
Model	I-OPA	I-OPA-F	I-OPA-ONE	I-OPA-CEP
Based on OPA	ORPHEUS	ORPHEUS-F	ORPHEUS-ONE	–
Pump pulse energy	10 – 500 μJ	10 – 400 μJ	20 – 500 μJ	150 – 500 μJ
Pulse repetition rate	Up to 1 MHz			Up to 100 kHz
Tuning range, signal	630 – 1030 nm	650 – 900 nm	1350 – 2060 nm	–
Tuning range, idler	1030 – 2600 nm	1200 – 2500 nm	2060 – 4500 nm	1400 – 2500 nm
Conversion efficiency signal+idler combined	> 12 %	> 10 %	> 14 %	> 10 %
Pulse energy stability < 2 % STD over 1 min. [1]	650 – 950 nm 1150 – 2000 nm	650 – 850 nm 1350 – 2000 nm	1500 – 3500 nm	1400 – 2000 nm
Pulse bandwidth [2]	100 – 150 cm^{-1}	200 – 600 cm^{-1}	80 – 200 cm^{-1}	~ 150 cm^{-1}
Pulse duration [3]	150 – 250 fs	30 – 80 fs	200 – 300 fs	< 200 fs
Applications	Micro-machining Microscopy Spectroscopy	Nonlinear microscopy Ultrafast spectroscopy	Micro-machining Mid-IR generation	OPCPA front-end

[1] *Better stability can be specified for a specific wavelength (e.g. < 1% STD at 800 nm).*
[2] *I-OPA-F outputs broad bandwidth pulses which are compressed externally.*
[3] *Output pulse duration depends on wavelength and pump laser pulse duration.*

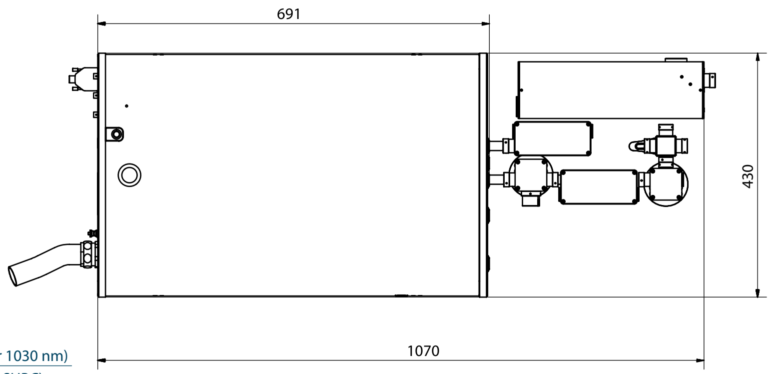
COMPARISON WITH OTHER FEMTOSECOND AND PICOSECOND LASERS

Laser technology	Our solution	HG or HIRO	I-OPA-F	I-OPA-ONE
		Pulse energy at 100 kHz, using PHAROS-10W laser		
Excimer laser (193 nm, 213 nm)	5H of PHAROS (205 nm)	5 µJ	–	–
TH of Ti:Sa (266 nm)	4H of PHAROS (257 nm)	10 µJ	–	–
TH of Nd:YAG (355 nm)	3H of PHAROS (343 nm)	25 µJ	–	–
SH of Nd:YAG (532 nm)	2H of PHAROS (515 nm)	50 µJ	35 µJ	–
Ti:Sapphire (800 nm)	OPA output (750 – 850 nm)	–	10 µJ	–
Nd:YAG (1064 nm)	PHAROS output (1030 nm)	100 µJ		
Cr:Forsterite (1240 nm)	OPA output (1200 – 1300 nm)	–	5 µJ	–
Erbium (1560 nm)	OPA output (1500 – 1600 nm)	–	3 µJ	15 µJ
Thulium / Holmium (1.95 – 2.15 µm)	OPA output (1900 – 2200 nm)	–	2 µJ	10 µJ
Other sources (2.5 – 4.0 µm)	OPA output	–	–	1 – 5 µJ

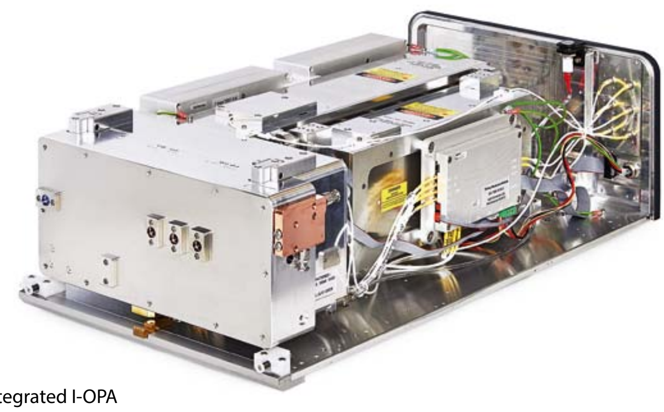
Note that the pulse energy scales linearly in a broad range of pump parameters. For example, a PHAROS-20W laser at 50 kHz (400 µJ energy) will increase the output power twice, and the pulse energy – 4 times compared to the reference table above. The pulse duration at the output is <300 fs in all cases. The OPA output is not limited to these particular ranges of operation, it is continuously tunable as shown in energy conversion curves.



Pharos with I-OPA output ports



PHAROS with I-OPA-F and compressors for signal and ilder



Pharos with integrated I-OPA

CARBIDE

new

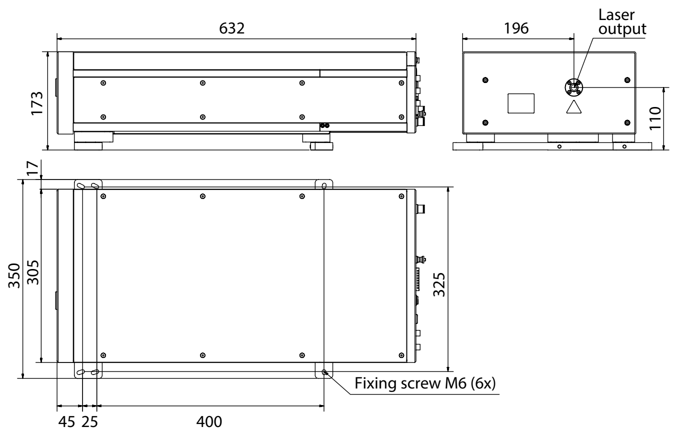
Femtosecond Lasers for Industrial and Medical Applications

FEATURES

- <290 fs – 10 ps tunable pulse duration
- >400 μJ pulse energies
- >40 W output power
- 60 – 1000 kHz tunable base repetition rate
- Includes pulse picker for pulse-on-demand operation
- Rugged, industrial grade mechanical design
- Air or water cooling
- Automated harmonics generators (515 nm, 343 nm, 257 nm)

CARBIDE industrial femtosecond lasers feature output power of >40 W at 1028 nm wavelength, with >400 μJ highest pulse energies, it maintains all the best features of its predecessor PHAROS: variable pulse repetition rate in the range of 60–1000 kHz (amplifier internal clock) with the built-in pulse picker feature for pulse-on-demand control, computer controllable pulse duration 290 fs – 10 ps. In addition to usual parameters CARBIDE brings in a few new technologies. One of the most important being a few times higher output average power to wall plug efficiency. It also features novel approach to a cavity design where oscillator, stretcher/compressor and amplifier are integrated into a single housing, this way optimized for volume production. It also allows fast warm-up (important for medical applications), easy access to pump LD modules for replacement. Intra-cavity pulse picker allows reduction of cost and power consumption. Highly integrated LD driver and control electronics, along with embedded control computer now provide less electromagnetic noise emission and allow faster assembly during production stage. However, one of the most impressive features of CARBIDE is its size of 631×324×167 mm air-cooled version and 632×305×173 mm water-cooled version including integrated power supply and air cooling unit. Water-cooled version has external chiller. This represents about 7 times reduction in system volume as compared to PHAROS, already one of the most compact ultrafast lasers on the market.

CARBIDE features number of optional components complementing different application requirements: certified safety shutter, beam conditioning unit (beam expander with optional spatial filter), automated attenuator, harmonics unit, additional pulse picker for enhanced contrast. CARBIDE is primarily targeted to the industrial market where relatively low average power cost effective solution with ultrafast pulses is needed. In largest part this is biomedical application with a direct biological tissue processing or biomedical device manufacturing. In addition output parameters of CARBIDE are sufficient to support different wavelength converters starting with harmonic generators to parametric amplifiers.

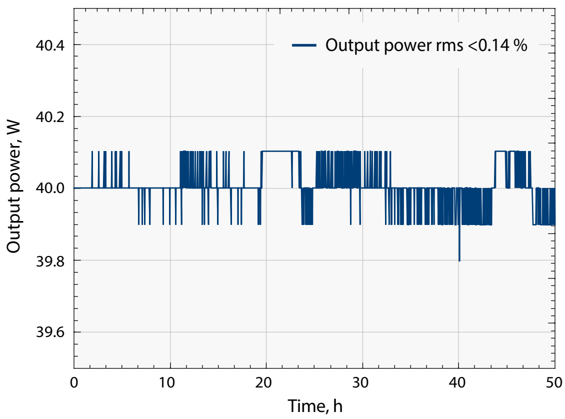


Outline drawing of water-cooled CARBIDE

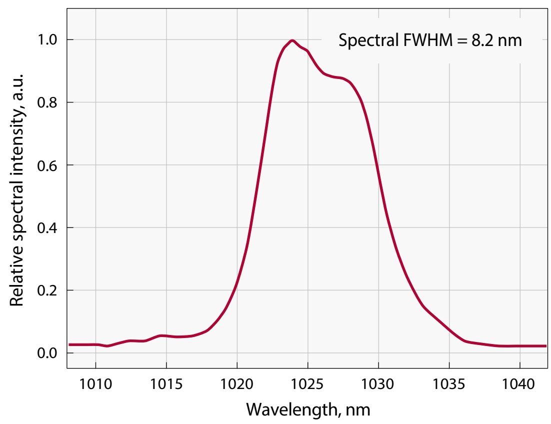
SPECIFICATIONS

Cooling method	Air-cooled [1]		Water-cooled	
Max. average power	>5 W	>4 W	>40 W	
Pulse duration (assuming Gaussian pulse shape)	<290 fs			
Pulse duration adjustment range	290 fs – 10 ps			
Max. pulse energy	>85 μJ	>65 μJ	>200 μJ	>400 μJ
Base repetition rate [2]	60 – 1000 kHz		200 – 1000 kHz	100 – 1000 kHz
Pulse selection	Single-Shot, Pulse-on-Demand, any base repetition rate division			
Centre wavelength [3]	1028±5 nm			
Beam quality	TEM$_{00}$; M^2 < 1.2			
Pulse picker	included	included, enhanced contrast AOM [4]	included	
Pulse picker leakage	<2 %	<0.1 %	<0.5 %	
Output power stability	<0.5% rms over 24 hours [5]			
PHYSICAL DIMENSIONS				
Laser head	631(L) × 324(W) × 167(H) mm		632(L) × 305(W) × 173(H) mm	
Power supply	220(L) × 95(W) × 45(H) mm			
UTILITY REQUIREMENTS				
Electric	110 – 220 V AC, 50 – 60 Hz, up to 300 W			
Operating temperature	17–27 °C (62–80 °F)			
Relative humidity	< 65 % (non-condensing)			

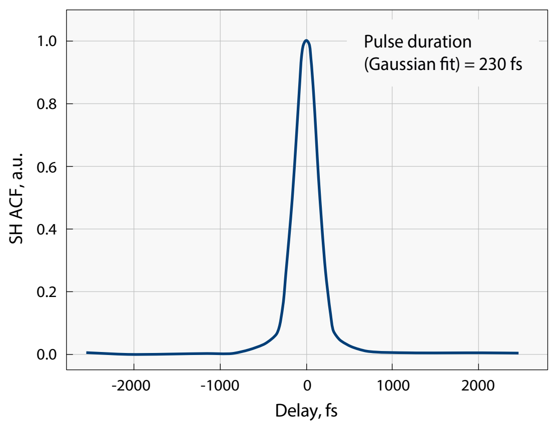
1) *Water-cooled version available on request.*
2) *Lower repetition rates are available by controlling pulse picker.*
3) *2nd (515 nm) and 3ed (343 nm) harmonic output also available.*
4) *Provides fast amplitude control of output pulse train.*
5) *Under stable environmental conditions.*



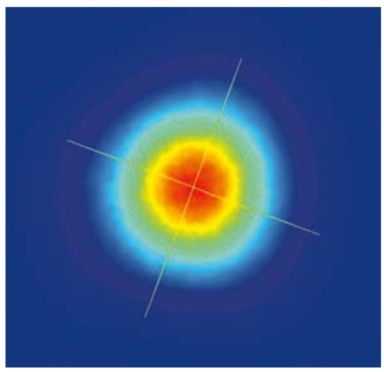
Long term power stability (water-cooled version)



Spectrum of CARBIDE (water-cooled version)



Pulse duration of CARBIDE (water-cooled version)

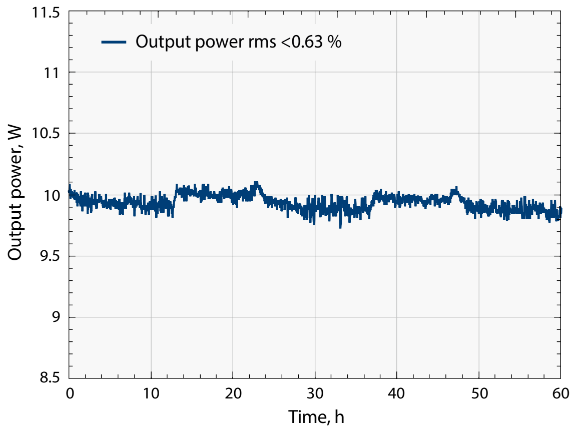


Typical CARBIDE beam profile (water-cooled version)

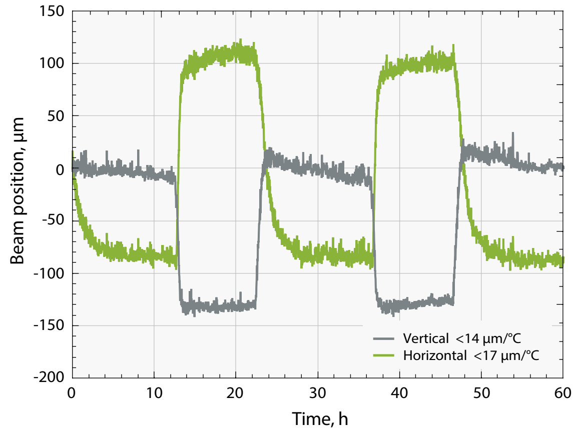
Air-cooled version of CARBIDE

FEATURES

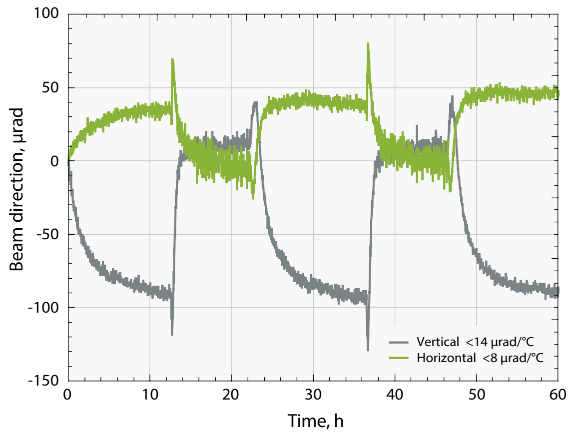
- <290 fs – 10 ps tunable pulse duration
- >85 μJ pulse energies
- >5 W output power
- Air or water cooling



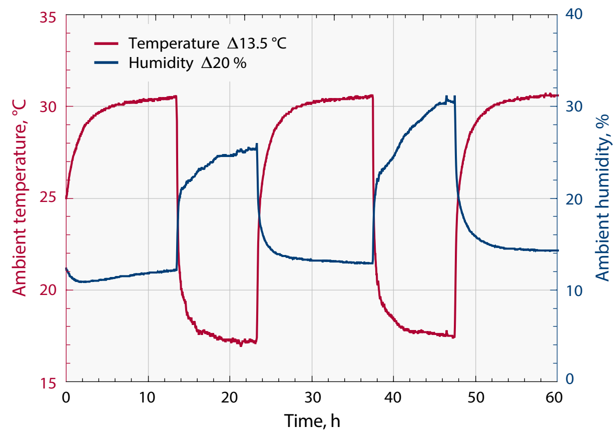
Output power under harsh environment conditions (air-cooled version)



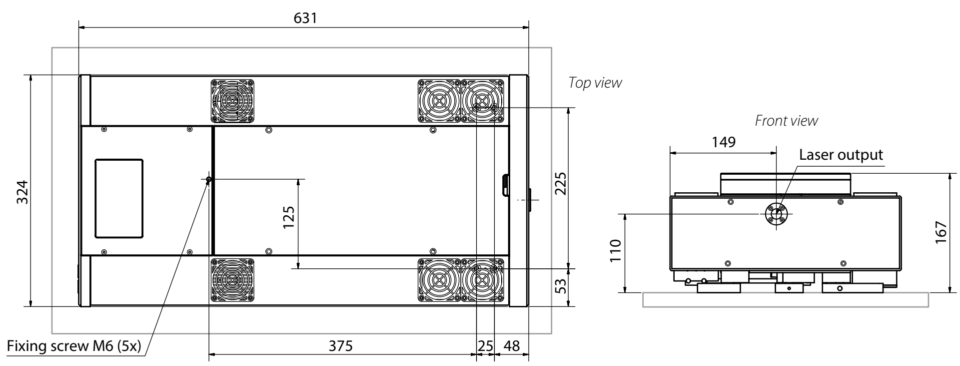
Beam position under harsh environment conditions (air-cooled version)



Beam direction under harsh environment conditions (air-cooled version)



Harsh environment conditions (air-cooled version)



Outline drawing of air-cooled CARBIDE

CARBIDE

Automated Harmonics Generators

Air-cooled CARBIDE with harmonics generator module

FEATURES

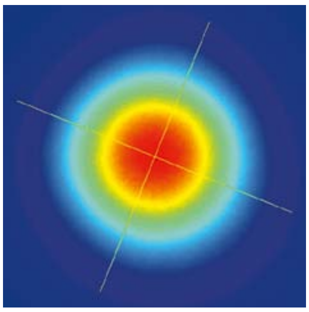
- 515 nm, 343 nm and 257 nm
- Output selection by software
- Mounts directly on laser head and integrated into the system
- Rugged, industrial grade mechanical design

CARBIDE laser can be equipped with automated harmonics module. Selection of fundamental (1030 nm), second (515 nm), third (343 nm) or fouth (257 nm) harmonic output is available by software control.

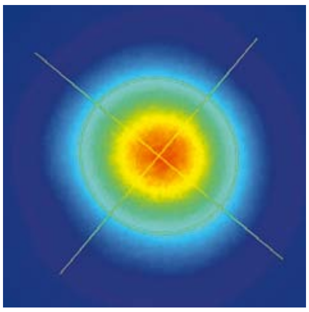
Harmonic generators are designed to be used in industrial applications where a single output wavelength is desired. Modules are mounted directly on the output of the laser and integrated into the system.

SPECIFICATIONS

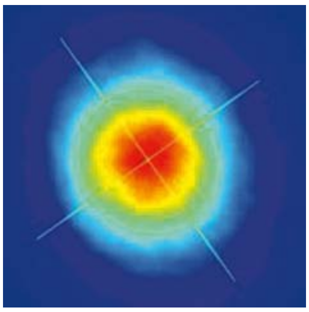
Model	CHM02-1H-2H	CHM01-1H-2H-3H	CHM01-1H-4H
Output wavelength (automated selection)	1030 nm 515 nm	1030 nm 515 nm 343 nm	1030 nm 257nm
Input pulse energy	20 – 85 μJ		
Pump pulse duration	>300 fs		
Conversion efficiency	> 60 % (2H)	> 60 % (2H) > 30 % (3H)	>15% (4H)
Beam quality (M^2)	< 1.3 (2H)	< 1.3 (2H) < 1.4 (3H)	<1.4 (4H)
PHYSICAL DIMENSIONS			
Laser head with harmonics module	751 (L) × 324 (W) × 167 (H) mm		



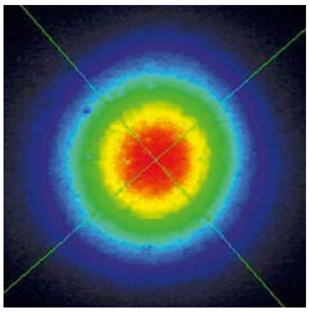
Typical CARBIDE 1H beam profile.
60 kHz, 5W



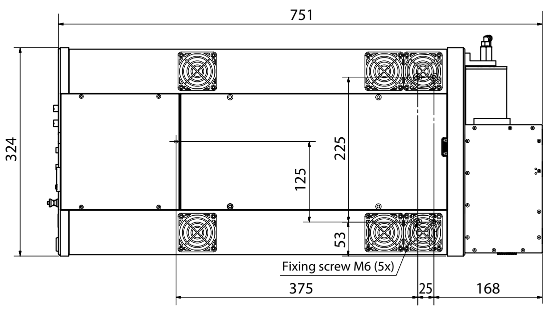
Typical CARBIDE 2H beam profile.
100 kHz, 3.4 W

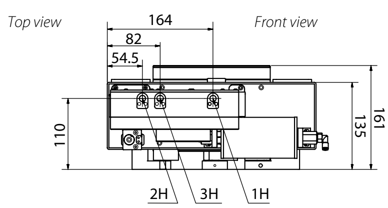


Typical CARBIDE 3H beam profile.
100 kHz, 2.2 W



Typical CARBIDE 4H beam profile.
100 kHz, 100 mW





Outline drawing of
air-cooled CARBIDE with harmonics generator module

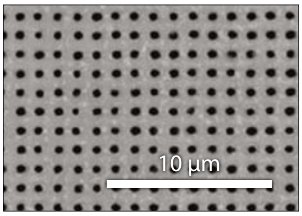
EXAMPLES OF INDUSTRIAL APPLICATIONS

STEEL FOIL M-DRILLING

- No melting
- Micron diameter

Applications:

- Filters
- Functional surfaces

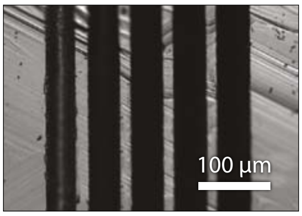


DIAMOND CUTTING

- Low carbonization
- No HAZ
- Low material loss

Applications:

- Diamond sheet cutting
- Chip breaker formation
- Diamond texturing/patterning

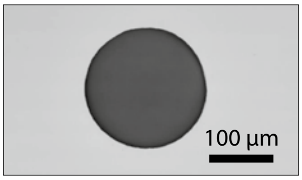


GLASS HOLES

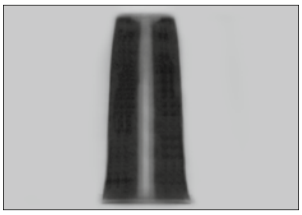
- Various hole sizes with routine tapper angle better than 5 deg
- Minimal debris around the edges of holes

Application:

- Microfluidics
- VIAs



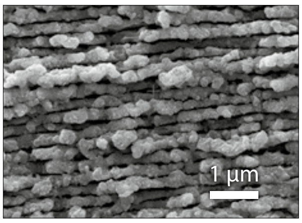
Top view



Cross-section

NANO RIPPLES

- Up to 200 nm ripple period fabricated using ultra-short laser pulses
- Individual nano-feature size on ripples: 10 – 50 nm
- Controlled period, duty cycle and aspect ratio of the ripples



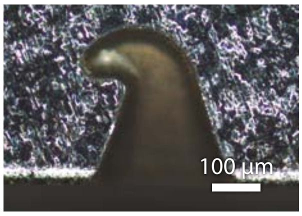
Developed in cooperation with Swinburne University, Australia

Application:

- Detection of materials with increased sensitivity using surface-enhanced Raman scattering (SERS)
- Bio-sensing, water contamination monitoring, explosive detection etc.

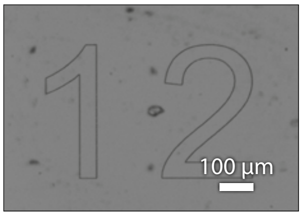
METAL MICROMACHINING

- 3D structures formed on steel surface
- High precision and surface smoothness achieved



MARKING OF CONTACT LENS

- Marking made inside the bulk of contact lens, preserving surface of lens and distortions
- Exact positioning of markings – 3D text format



Application:

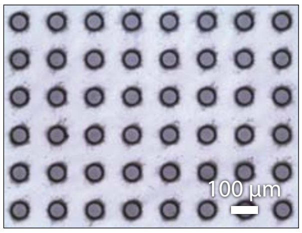
- Product counterfeit protection
- Serial number and customer identification

THIN GLASS DRILLING

- Taper angle control
- Low heat affect
- No cracking or chipping around holes

Applications:

- VIAs

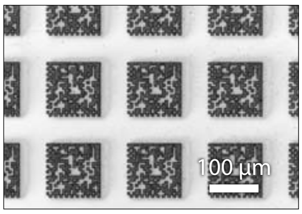


DATAMATRIX

- Data inscribed on a glass surface or inside bulk
- Extremely small elements, down to 5 µm in size

Application:

- Product marking

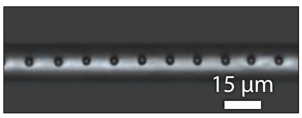


GLASS TUBE DRILLING

- Controlled damage and depth
- Hole diameter of few microns

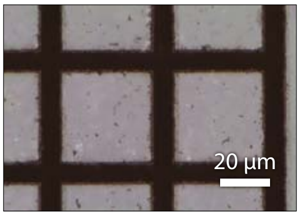
Applications:

- Medical applications
- Biopsy equipment



FERROELECTRIC CERAMICS ETCHING

- No or low melting and HAZ
- Easily removable debris
- Good structuring quality

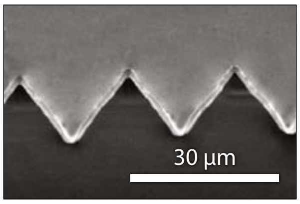


Applications:

- Infrared sensors for cameras
- Memory chips

SILICON LASER ASSISTED ETCHING

- No HAZ
- No melting

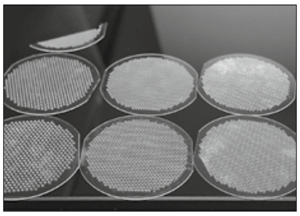


Applications:

- Solar cell production
- Semiconductor industry

MASK FOR BEAM SPLITTER PATTERN DEPOSITION

- Borosillicate glass
- 150 um thickness
- ~900 holes per mask
- Mask diameter 25.4 mm

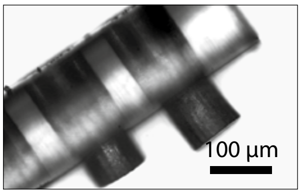


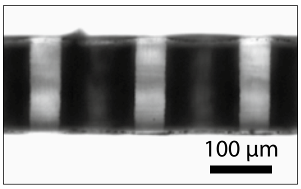
Appplication:

- Selective coating

STENT CUTTING

- Holes in stent wall, cross-section view
- Polymer stent
- No heat effect, no debris
- Minimal taper effect



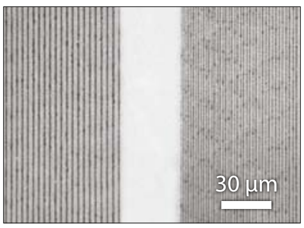


Application:

- Vascular surgery

TEXTURIZED SAPPHIRE SURFACE

- Micron resolution
- Large area processing
- Single pulses used to form craters on the surface



Application:

- Better light extraction in LED
- Semiconductor structure growth

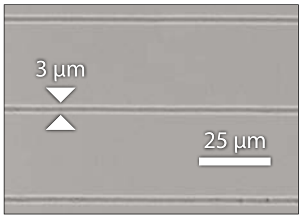
MARKING AND PATTERNING

- Smallest spots down to 3 µm in width
- Micron level positioning
- No heat effect

Metal

MICRO CHANNEL FORMATION

- Wide range of materials – from fused silica to polymers
- Controllable channel shape
- Low debris
- Smooth surface

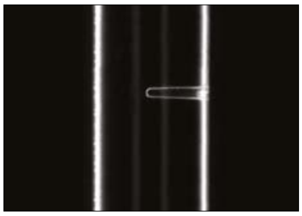


Applications:

- Microfluidic sensors
- Waveguides

OPTICAL FIBER DRILLED TO THE CORE

- Diameter from <10 µm
- Various hole profiles possible
- Depth and angle control

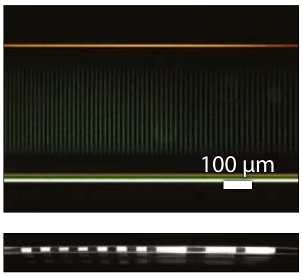


Applications:

- Optical fiber sensors
- Material science

OPTICAL FIBER SCATTERING

- No impact on fiber strength
- No surface damage
- Even light dispersion

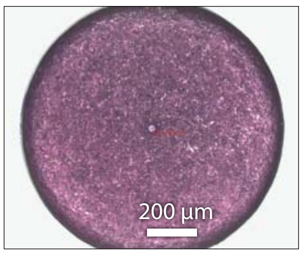


Applications:

- Medical fibers
- Oncology

SYNTHETIC RUBY DRILLING

- No cracks after drilling
- Taper angle control



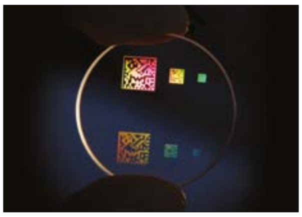
Application:

- High precision mechanical parts

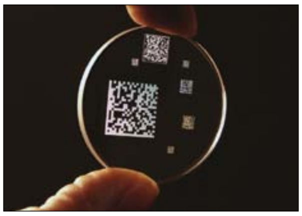
GLASS BULK PROCESSING

- Refractive index volume modification
- Bragg gratings with 99% diffraction efficiency
- Birefringent gratings/elements
- Low influence on strength of the substrate

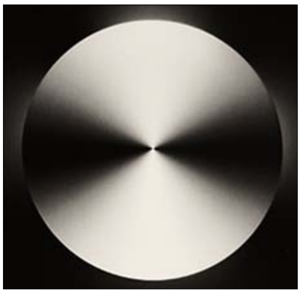
Birefringence modification inside fused silica. Photo in crossed polarized light



Sapphire



Glass

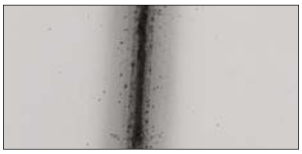


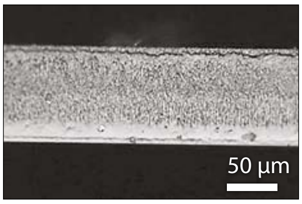
S-waveplate *

* M. Beresna, M. Gecevičius, P. G. Kazansky and T. Gertus, Radially polarized optical vortex converter created by femtosecond laser nanostructuring of glass, Appl. Phys. Lett. 98, 201101 (2011).

NON TEMPERED GLASS CUTTING

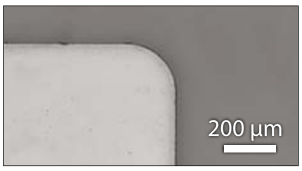
- Thickness: 0.03 – 0.3 mm
- Mechanical or heat assisted break after scribing
- Speed: up to 800 mm/s
- Any shape
- Round corners
- Surface quality: Ra ≤ 2µm





SAPPHIRE CUTTING

- Thickness: 100 – 900 µm
- Easy to break
- Circle shapes diameter: 3 – 15 mm
- Corner radius: from 0.5 mm
- Speed: up to 800 mm/s
- Cut quality: Ra ≤ 2 µm
- No surface cracks
- No or low chipping
- Non ablating process



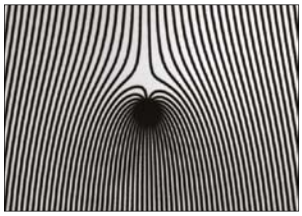
Thickness: 420 µm, clear sapphire

SELECTIVE METAL COATING ABLATION (REMOVAL)

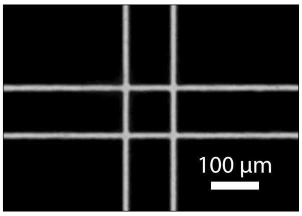
- Selective ablation of metal coatings from various surfaces
- Depth and geometry of ablation may vary

Application:

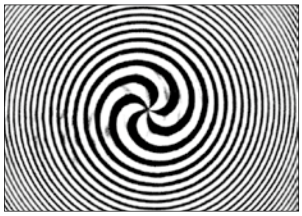
- Lithography mask production
- Beam shaping elements
- Optical apertures
- Other



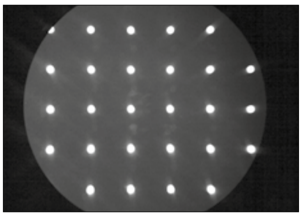
Amplitude grating formation



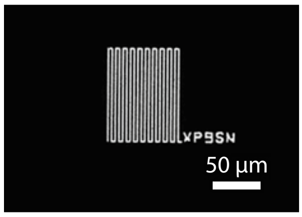
Titan coating selective ablation



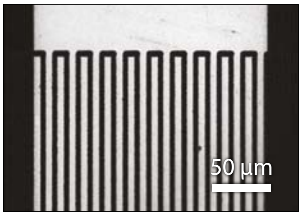
Chrome ablation for beam shaping



Apperture array fabrication



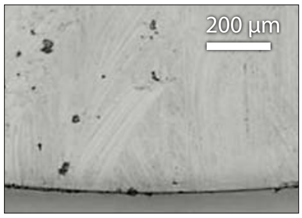
Gold layer removal without damage to MgO substrate – Au layer removal without damaging

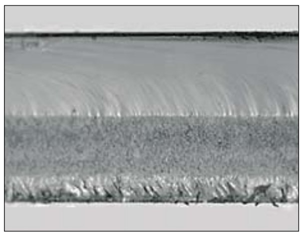


Chrome ablation from glass substrate

TEMPERED GLASS CUTTING

- Single pass process
- In bulk damage (closed cut), surface remains intact, practically no debris
- Homogeneous cut surface

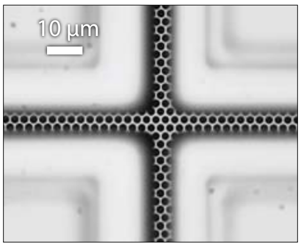


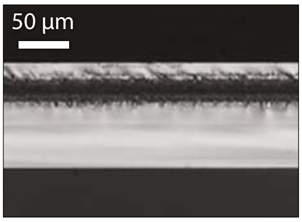


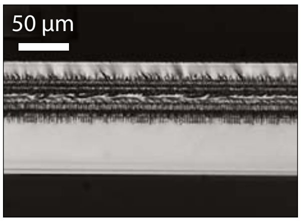
Samples provided by
Workshop of Photonics
www.wophotonics.com

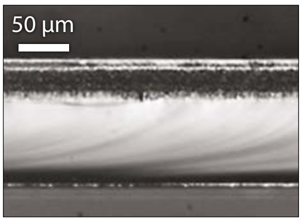
SAPPHIRE DICING FOR LED INDUSTRY

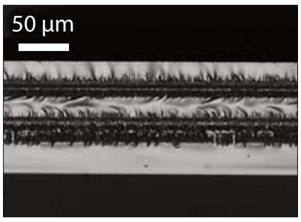
- Wafer thickness 50 to 330 µm
- Narrow street width up to ~10 µm
- Bending strength (650–900 MPa)
- High light extraction efficiency
- Controllable damage length
- Easy breaking
- Scribing with DBR coated backside of sapphire

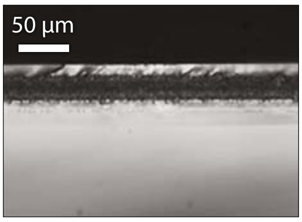


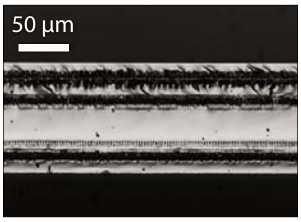










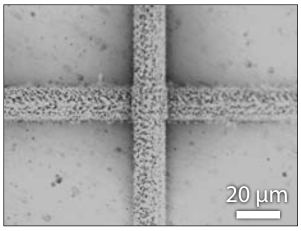


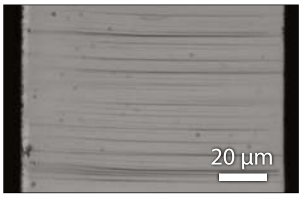
SILICON CARBIDE DICING

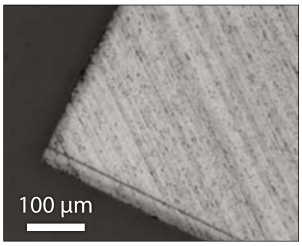
- No chipping on the edges
- Cleaved-surface roughness <1 µm
- Easy breaking

Applications:

- High power, high frequency electronics







EVANA TECHNOLOGIES

Samples provided by
Evana Technologies
www.evanatech.com

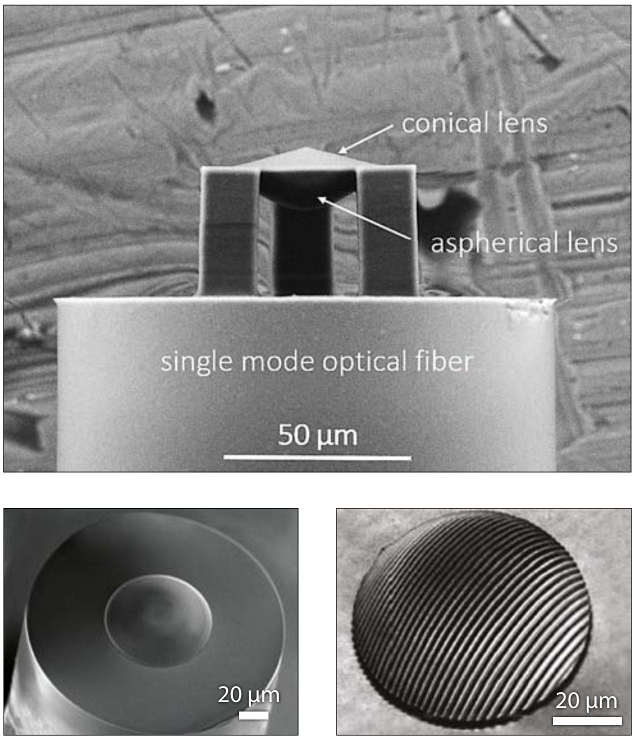
MULTI-PHOTON POLYMERIZATION

Multi-photon polymerization (MPP) is a unique method allowing the fabrication of 3D microstructures with a spatial resolution of the order of 100 nm. MPP technology is based on non-linear absorption at the focal spot of a tightly focused femtosecond laser beam, which induces well confined photopolymerization reactions. <290 fs pulses at >100 kHz repetition rates are advantageous for material modification via avalanche ionization – enabling fabrication of materials ranging from hybrid composites to pure proteins.

APPLICATION IN MICRO-OPTICS

Most of the photopolymers used in MPP technology are transparent in the visible range and could be directly applied in various micro-optical applications. Various mechanical as well as optical properties can be tuned.

Examples: prisms, aspherical lenses, lenses on the tip of an optical fiber, multi-lens arrays, vortex beam generators, diffractive optical elements, etc.



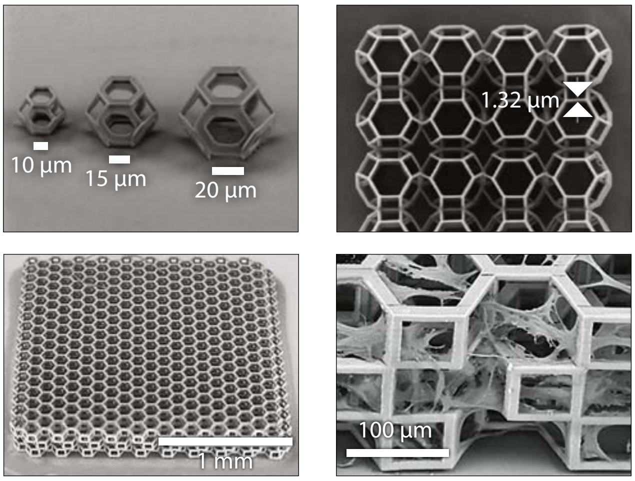
M. Malinauskas et al. Femtosecond laser polymerization of hybrid/integrated micro-optical elements and their characterization. J. Opt. 12, 124010 (2010).

M. Oubaha et al. Novel tantalum based photocurable hybrid sol-gel material employed inthe fabrication of channel optical waveguides and three-dimensionalstructures, Appl. Surf. Sci. 257(7), 2995–2999 (2011).

APPLICATION IN BIOTECHNOLOGY AND REGENERATIVE MEDICINE

MPP technique can be realized in biocompatible and even biodegradable materials, thus it is a perfect platform for regenerative medicine research and applications.

Examples: 3D polymeric scaffolds for cell growth and tissue engineering, drug delivery devices, micro-fluidic devices, cytotoxic elements.

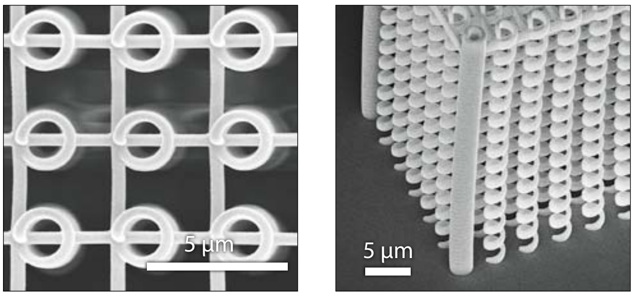


M. Malinauskas et al. 3D artificial polymeric scaffolds for stem cell growth fabricated by femtosecond laser. Lithuanian J. Phys., 50 (1), 75-82, (2010).

APPLICATION IN PHOTONICS

Highly repeatable and stable technological process enables the fabrication of various photonic crystal devices for controlling spatial and temporal properties of light at micrometer distances.

Examples: photonic crystal spatial filters, supercollimators, structural colours, etc.



L. Maigyte et al. Flat lensing in the visible frequency range by woodpile photonic crystals, Opt. Lett.38(14), 2376 (2013).

V. Purlys et al. Spatial filtering by chirped photonic crystals, Phys. Rev. A 87(3), 033805 (2013).

V. Purlys et al. Super-collimation by axisymmetric photonic crystals,Appl. Phys. Lett. 104(22), 221108 (2014).

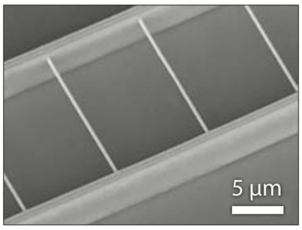
V. Mizeikis et al. Realization of Structural Colour by Direct Laser Write Technique in Photoresist, J. Laser Micro Nanoen. 9(1), 42 (2014).

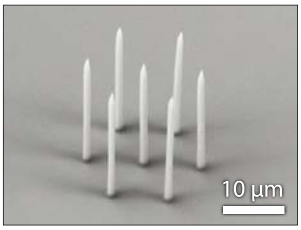
LIGHT CONVERSION

APPLICATION IN MICROMECHANICS

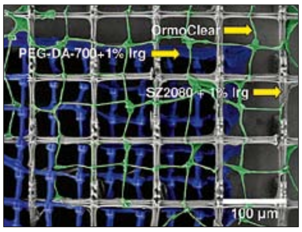
MPP technology gives the user ability to create multiscale and multimaterial 3D objects out of substances with various physical, chemical, and biological properties.

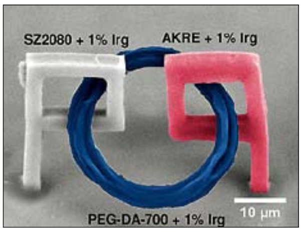
Examples: cantilevers, valves, micro-pore filters with controllable pore sizes, mechanical switches. [1)]





Examples of multicomponent structures. [2)]



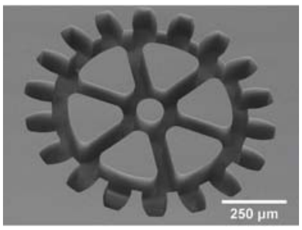


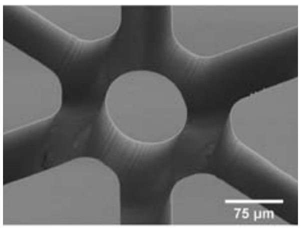
[1)] V. Purlys, Three-dimensional photonic crystals: fabrication and applications for controlof chromatic and spatial light properties, Ph.D. Thesis. Vilnius University: Lithuania (2015).

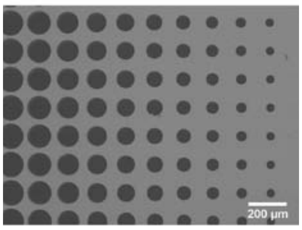
[2)] M. Malinauskas et al. Ultrafast laser processing of materials: from science to industry, Light: Sci. Appl., to be published, (2015).

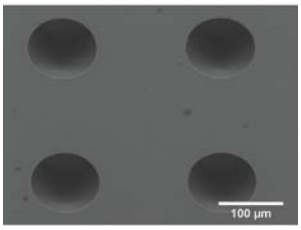
LASER ASSISTED SELECTIVE ETCHING

Can be applied in microoptics, micromechanics, medical engineering, etc.

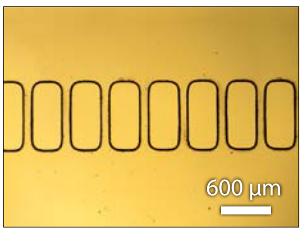


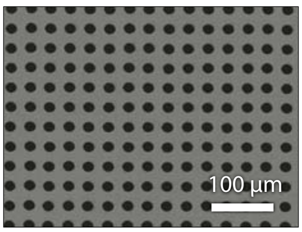






LASER ABLATION

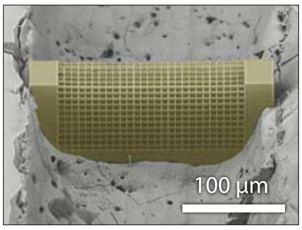


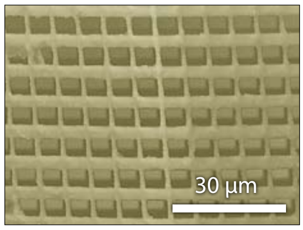


Hybrid microfabrication

ABLATION AND LITHOGRAPHY

Laser ablation allows a rapid production of glass channels while 3D laser lithography is used to integrate fine-mesh filters inside the channels. Then whole system is then sealed by laser welding.

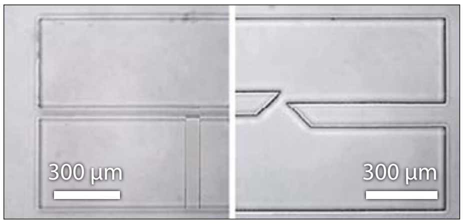


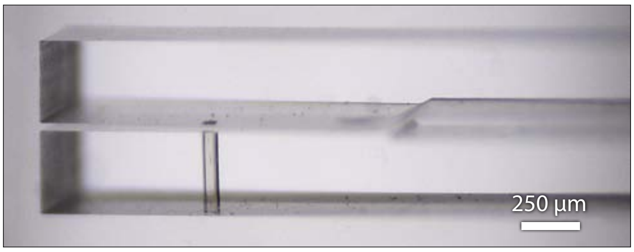


Jonušauskas et al., Opt. Eng. 56(9), 094108 (2017).

ETCHING AND POLYMERIZATION

Combining selective laser etching and photopolymerization allows manufacturing of cantilevers for sensing applications.





Tičkūnas et al., Opt. Express, 25(21), 26280-26288 (2017).

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