What we do

We are the world leading manufacturer of wavelength tunable femtosecond optical parametric amplifiers (OPA) based on TOPAS and ORPHEUS series as well as diode pumped solid state femtosecond lasers PHAROS and CARBIDE. Both 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 a robust design attractive both to industrial and scientific customers.

With major industrial customers operating in display, automotive, LED, medical device, and other industries, PHAROS and CARBIDE reliability has been proven by hundreds of systems operating in 24/7 production environment. The lasers are mainly used for drilling and cutting of various metals, ceramics, sapphire, glass, and material ablation for mass-spectrometry. However, customers are always finding new ways for PHAROS and CARBIDE to make existing manufacturing processes more efficient.

To complement our laser amplifiers we offer a strong portfolio of femtosecond products: harmonic modules (provide pulses at 515, 343, 257 and 206 nm), OPAs (produce continuous tuning output from ~190 nm up to ~20 μm), HARPIA spectrometers, TiPA and GECO autocorrelators. All our products can be customized and fine-tuned to meet the most demanding applications.

Who we are

Founded in 1994 in Vilnius, Light Conversion is a privately-owned company with > 200 employees. Our > 6500 m² facility accommodates design, R&D, and production teams so that all key manufacturing processes are managed in-house. With more than 3000 systems installed worldwide, Light Conversion has established itself as an innovative producer of ultrafast optical devices and the largest manufacturer of femtosecond optical parametric amplifiers (OPAs) and non-collinear OPAs. In addition to selling our products via a wide range of distributors, we also provide our OEM devices for other major laser manufacturing companies.
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- Industrial grade Optical Parametric Amplifier 8

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- Automated Harmonics Generators 13
- Applications Examples 14
  - Micromachining Applications Examples 14
  - Multi-photon Polymerization Examples 18

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PHAROS is a single-unit integrated femtosecond laser system combining millijoule pulse energies and high average powers. 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 allow PHAROS integration into machining workstations. 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. PHAROS compact and robust optomechanical design features stable laser operation across varying environments. PHAROS is equipped with an extensive software package which ensures smooth hands-free operation.
Industrial Lasers

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Product name</th>
<th>PH1-10</th>
<th>PH1-15</th>
<th>PH1-20</th>
<th>PH1-SP-1mJ</th>
<th>PH1-SP-1.5mJ</th>
<th>PH1-SP-10W</th>
<th>PH1-2mJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. average power</td>
<td>10 W</td>
<td>15 W</td>
<td>20 W</td>
<td>6 W</td>
<td>10 W</td>
<td>6 W</td>
<td></td>
</tr>
<tr>
<td>Pulse duration</td>
<td>&lt; 290 fs</td>
<td>&lt; 190 fs</td>
<td>&lt; 300 fs</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(assuming Gaussian pulse shape)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse duration range</td>
<td>290 fs – 10 ps (20 ps on request)</td>
<td>190 fs – 10 ps (20 ps on request)</td>
<td>300 fs – 10 ps</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. pulse energy</td>
<td>&gt; 0.2 mJ or &gt; 0.4 mJ</td>
<td>&gt; 1 mJ</td>
<td>&gt; 1.5 mJ</td>
<td>&gt; 1 mJ</td>
<td>&gt; 2 mJ</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beam quality</td>
<td>TEM₀₀ : M² &lt; 1.2</td>
<td>TEM₀₀ : M² &lt; 1.3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Base repetition rate</td>
<td>1 kHz – 1 MHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse selection</td>
<td>Single-Shot, Pulse-on-Demand, any base repetition rate division</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre wavelength</td>
<td>1028 nm ± 5 nm</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output pulse-to-pulse stability</td>
<td>&lt; 0.5 % rms over 24 hours</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power stability</td>
<td>&lt; 0.5 % rms over 100 h</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-pulse contrast</td>
<td>&lt; 1 : 1000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-pulse contrast</td>
<td>&lt; 1 : 200</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polarization</td>
<td>Linear, horizontal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beam pointing stability</td>
<td>&lt; 20 µrad/°C</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Oscillator output</td>
<td>Optional, please contact <a href="mailto:sales@lightcon.com">sales@lightcon.com</a> for specifications</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Burst mode</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PHYSICAL DIMENSIONS

- Laser head: 670 (L) × 360 (W) × 212 (H) mm
- Rack for power supply and chiller: 642 (L) × 553 (W) × 673 (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: < 80 % (non condensing)

Some particular repetition rates are software denied due to system design.
Under stable environmental conditions.
Dimensions might increase for non-standard laser specifications.

<table>
<thead>
<tr>
<th>Amb</th>
<th>Output power, W</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5.96</td>
</tr>
<tr>
<td>5</td>
<td>5.98</td>
</tr>
<tr>
<td>10</td>
<td>6.00</td>
</tr>
<tr>
<td>15</td>
<td>6.02</td>
</tr>
<tr>
<td>20</td>
<td>6.04</td>
</tr>
<tr>
<td>25</td>
<td>6.06</td>
</tr>
<tr>
<td>30</td>
<td>6.08</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temp</th>
<th>Beam direction, µrad</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>-20</td>
</tr>
<tr>
<td>10</td>
<td>-40</td>
</tr>
<tr>
<td>15</td>
<td>-60</td>
</tr>
<tr>
<td>20</td>
<td>-80</td>
</tr>
<tr>
<td>25</td>
<td>-100</td>
</tr>
</tbody>
</table>

DANGER

VISIABLE AND/OR INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS IV LASER PRODUCT

PHAROS output power with power lock enabled under unstable environment

PHAROS laser outline drawing

PHAROS laser

1030 nm output
without H

1030 nm output
with Auto H

Auto 2H
315 nm

Auto 3H, 4H
343, 257 nm

168

54

72

168

74

272

374
Output power of industrial PHAROS lasers operating 24/7 and current of pump diodes during the years.

Carrier envelope phase (CEP) over the long period with active phase stabilization system.

Pharos CEP stability when laser is isolated from all noticeable noise sources – vibrations, acoustics, air circulation and electrical noise. System can achieve < 300 mrad std of CEP stability over a long time scale (> 8 hours) and < 200 mrad over a short time scale (< 5 min).
Industrial Lasers

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**

<table>
<thead>
<tr>
<th>Product name</th>
<th>2H</th>
<th>2H-3H</th>
<th>2H-4H</th>
<th>4H-5H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output wavelength (automated selection)</td>
<td>1030 nm</td>
<td>1030 nm</td>
<td>1030 nm</td>
<td>1030 nm</td>
</tr>
<tr>
<td></td>
<td>515 nm</td>
<td>515 nm</td>
<td>515 nm</td>
<td>257 nm</td>
</tr>
<tr>
<td>Input pulse energy</td>
<td>20 – 2000 μJ</td>
<td>50 – 1000 μJ</td>
<td>20 – 1000 μJ</td>
<td>200 – 1000 μJ</td>
</tr>
<tr>
<td>Pump pulse duration</td>
<td>190 – 300 fs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversion efficiency</td>
<td>&gt; 50 % (2H)</td>
<td>&gt; 50 % (2H)</td>
<td>&gt; 50 % (2H)</td>
<td>&gt;10 % (4H)</td>
</tr>
<tr>
<td>Beam quality (M²) ≤ 400 μJ pump</td>
<td>&lt; 1.3 (2H), typical &lt; 1.15</td>
<td>&lt; 1.3 (2H), typical &lt; 1.15</td>
<td>&lt; 1.3 (2H), typical &lt; 1.15</td>
<td>n/a</td>
</tr>
<tr>
<td>Beam quality (M²) &gt; 400 μJ pump</td>
<td>&lt; 1.4 (2H)</td>
<td>&lt; 1.4 (2H)</td>
<td>&lt; 1.4 (2H)</td>
<td>n/a</td>
</tr>
</tbody>
</table>

1) Max 1 W output. 2) Max 0.15 W output.

**FEATURES**

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

PHAROS-20W-400μJ
SH (400 μJ pump)
TH (400 μJ pump)
SH (200 μJ pump)
TH (200 μJ pump)
SH (50 μJ pump)
TH (50 μJ pump)

PHAROS harmonics energy vs pulse repetition rate

- RMS = 0.27%
- RMS = 0.23%

3H output stability

4H output stability
Industrial Lasers

PHAROS I-OPA is the first industrial grade optical parametric amplifier which features long-term stable output with a reliable hands-free operation. Manually tunable output wavelength extends application possibilities of a single laser source instead of requiring multiple lasers based on different technologies. In comparison to standard ORPHEUS line devices, the I-OPA lacks only a 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.

**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 available

**PHAROS I-OPA MODEL COMPARISON TABLE**

<table>
<thead>
<tr>
<th>Product name</th>
<th>Based on ORPHEUS model</th>
<th>Pump pulse energy</th>
<th>Pulse repetition rate</th>
<th>Tuning range of signal</th>
<th>Tuning range of idler</th>
<th>Conversion efficiency at peak, signal+idler combined</th>
<th>Pulse bandwidth</th>
<th>Pulse duration</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>I-OPA</td>
<td>ORPHEUS</td>
<td>10 – 500 µJ</td>
<td>Up to 1 MHz</td>
<td>630 – 1030 nm</td>
<td>1030 – 2600 nm</td>
<td>&gt; 12 % when pump energy 20 – 500 µJ, &gt; 6 % when pump energy 10 – 20 µJ</td>
<td>60 – 150 cm⁻¹ @ 1450 – 2000 nm</td>
<td>130 – 290 fs when pumped by Pharos-SP</td>
<td>Micro-machining, Microscopy, Spectroscopy</td>
</tr>
<tr>
<td>I-OPA-F</td>
<td>ORPHEUS-F</td>
<td>10 – 500 µJ</td>
<td></td>
<td>650 – 900 nm</td>
<td>1200 – 2500 nm</td>
<td>&gt; 10 %</td>
<td>200 – 750 cm⁻¹ @ 650 – 900 nm, 150 – 500 cm⁻¹ @ 1200 – 2000 nm</td>
<td>&lt; 55 fs @ 800 – 900 nm, &lt; 70 fs @ 650 – 800 nm, &lt; 100 fs @ 1200 – 2000 nm</td>
<td>Nonlinear microscopy, Ultrafast spectroscopy</td>
</tr>
<tr>
<td>I-OPA-ONE</td>
<td>ORPHEUS-ONE</td>
<td>20 – 1000 µJ</td>
<td></td>
<td>1350 – 2060 nm</td>
<td>2060 – 4500 nm</td>
<td>&gt; 14 % when pump energy 30 – 1000 µJ, &gt; 10 % when pump energy 20 – 30 µJ</td>
<td>60 – 150 cm⁻¹ @ 1450 – 2000 nm</td>
<td>130 – 190 fs when pumped by Pharos-SP</td>
<td>Micro-machining, Mid-IR generation</td>
</tr>
</tbody>
</table>

1) I-OPA-F outputs broad bandwidth pulses which are compressed externally.
2) Output pulse duration depends on wavelength and pump laser pulse duration.
COMPARISON WITH OTHER FEMTOSECOND AND PICOSECOND LASERS

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

Note that the pulse energy scales linearly in a broad range of pump parameters. For example, a PHAROS PH1-20 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.

I-OPA beam pointing and output power measurements under harsh environment conditions (humidity and temperature cycling)

Pharos with I-OPA output ports

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

VISIBLE AND/OR INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS IV LASER PRODUCT
DANGER
CARBIDE industrial femtosecond laser features an output power of >40 W at 1028 nm wavelength. The laser emits single pure temporal contrast (>1:200) and up to 400 μJ energy pulses without any compromises to the beam quality, industrial grade reliability and beam stability regardless of the environment it is put in. Continuously tunable base repetition rate in a range of 60 – 1000 kHz is combined with an in-built pulse picker for convenient output pulse control. Software adjustable pulse duration can be easily set in a range of 290 fs – 10 ps in seconds. Excellent power stability of < 0.5 % RMS is standard.

Single monolithic housing allows fast warm-up times. Laser is maintenance free. Electronical and most optical components in the laser are field accessible and upgradeable. Carbide ships with an integrated shutter fulfilling performance level d requirements according to EN 13849-1 by default. Due to an in-built computer laser control is smooth via the provided extensive software package. Multiple custom laser control options are also available; they are convenient when lasers are being integrated in medical or industrial processing applications. CARBIDE can be equipped with a growing number of optional features: a beam expansion unit, an automated attenuator, harmonics or can be used as a seed source for parametric amplifiers and OPCPA systems.
**SPECIFICATIONS**

<table>
<thead>
<tr>
<th>Product name</th>
<th>CB5-05</th>
<th>CB5-04</th>
<th>CB3-40-200</th>
<th>CB3-40-400</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OUTPUT CHARACTERISTICS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooling method</td>
<td>Air-cooled ¹</td>
<td></td>
<td>Water-cooled</td>
<td></td>
</tr>
<tr>
<td>Max. average power</td>
<td>&gt; 5 W</td>
<td>&gt; 4 W</td>
<td>&gt; 40 W</td>
<td></td>
</tr>
<tr>
<td>Pulse duration (assuming Gaussian pulse shape)</td>
<td>&lt; 290 fs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse duration adjustment range</td>
<td>290 fs – 10 ps</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. pulse energy</td>
<td>&gt; 85 µJ</td>
<td>&gt; 65 µJ</td>
<td>&gt; 200 µJ</td>
<td>&gt; 400 µJ</td>
</tr>
<tr>
<td>Base repetition rate ²</td>
<td>60 – 1000 kHz</td>
<td>200 – 1000 kHz</td>
<td>100 – 1000 kHz</td>
<td></td>
</tr>
<tr>
<td>Pulse selection</td>
<td>Single-shot, any base repetition rate division</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Centre wavelength ³</td>
<td>1028 ± 5 nm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output pulse-to-pulse stability</td>
<td>&lt; 0.5 % rms over 24 hours ⁴</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Output power stability</td>
<td>&lt; 0.5 % rms over 100 hours</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Beam quality</td>
<td>TEM₀₀, M² &lt; 1.2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pulse picker</td>
<td>included</td>
<td>included, enhanced contrast AOM ⁵</td>
<td>included</td>
<td></td>
</tr>
<tr>
<td>Pulse picker leakage</td>
<td>&lt; 2 %</td>
<td>&lt; 0.1 %</td>
<td>&lt; 0.5 %</td>
<td></td>
</tr>
<tr>
<td>Beam pointing stability</td>
<td></td>
<td></td>
<td>&lt; 20 µrad/°C</td>
<td></td>
</tr>
<tr>
<td><strong>ENVIRONMENTAL &amp; UTILITY REQUIREMENTS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relative humidity</td>
<td>&lt; 65 % (non condensing)</td>
<td>&lt; 80 % (non condensing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electric</td>
<td>110 – 220 VAC, 50 – 60 Hz</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power consumption</td>
<td>100 W</td>
<td></td>
<td>1.5 kW</td>
<td></td>
</tr>
<tr>
<td><strong>DIMENSIONS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Laser head</td>
<td>631 (L) × 324 (W) × 167 (H) mm</td>
<td>632 (L) × 305 (W) × 173 (H) mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Power supply</td>
<td>220 (L) × 95 (W) × 45 (H) mm</td>
<td>280 (L) × 144 (W) × 49 (H) mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chiller</td>
<td>–</td>
<td>590 (L) × 484 (W) × 267 (H) mm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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

![Long term power stability (water-cooled version)](image1)

![Typical CARBIDE beam profile (water-cooled version)](image2)

![Pulse duration of CARBIDE (water-cooled version)](image3)

![Spectrum of CARBIDE (water-cooled version)](image4)
AIR-COOLED CARBIDE STABILITY MEASUREMENTS

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)

WATER-COOLED CARBIDE WITH A SCIENTIFIC INTERFACE

Port 1: Simultaneous uncompressed laser output with/without attenuator

Port 2: All options of oscillator output

Port 3: Uncompressed laser output – after PP divider

Port 4: Main (standard) laser output

Port 5: Main laser output after attenuator

Port 6: Main laser output (reflected) or “leftover” after attenuator, transmitted through

Fixing screw M6 (6x)

Drawings of CARBIDE with scientific interface
Industrial Lasers

CARBIDE
Automated Harmonics Generators

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

CARBIDE laser can be equipped with automated harmonics modules. Selection of fundamental (1030 nm), second (515 nm), third (343 nm) or fourth (257 nm) harmonics outputs are available by software control. Harmonics generators are designed to be used in industrial applications where a single output wavelength is desired.

SPECIFICATIONS

<table>
<thead>
<tr>
<th>Product name</th>
<th>2H</th>
<th>2H-3H</th>
<th>2H-4H</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output wavelength</td>
<td>1030 nm</td>
<td>1030 nm</td>
<td>1030 nm</td>
</tr>
<tr>
<td>(automated selection)</td>
<td>515 nm</td>
<td>515 nm</td>
<td>515 nm</td>
</tr>
<tr>
<td></td>
<td>343 nm</td>
<td>343 nm</td>
<td>257 nm</td>
</tr>
<tr>
<td>Input pulse energy</td>
<td>20 – 400 μJ</td>
<td>&lt; 300 fs</td>
<td>&lt; 300 fs</td>
</tr>
<tr>
<td>Pump pulse duration</td>
<td></td>
<td></td>
<td>&gt; 50 % (2H)</td>
</tr>
<tr>
<td>Conversion efficiency</td>
<td>&gt; 50 % (2H)</td>
<td>&gt; 25 % (3H)</td>
<td>&gt; 50 % (2H)</td>
</tr>
<tr>
<td>Beam quality (M²)</td>
<td>&lt; 1.3 (2H), typical &lt; 1.15</td>
<td>&lt; 1.3 (2H), typical &lt; 1.15</td>
<td>&lt; 1.3 (2H), typical &lt; 1.15</td>
</tr>
<tr>
<td></td>
<td>&lt; 1.4 (3H), typical &lt; 1.2</td>
<td>&lt; 1.4 (3H), typical &lt; 1.2</td>
<td>n/a (4H)</td>
</tr>
</tbody>
</table>

1) Maximum output power 1 W.

Air-cooled CARBIDE with harmonics generator module

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

VISIBLE AND/OR INVISIBLE LASER RADIATION
AVOID EYE OR SKIN EXPOSURE TO DIRECT, REFLECTED OR SCATTERED RADIATION
CLASS IV LASER PRODUCT
DANGER
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

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

APPLICATIONS OF INDUSTRIAL APPLICATIONS

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
**Application Examples**

**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**
- Borosilicate glass
- 150 μm thickness
- ~900 holes per mask
- Mask diameter 25.4 mm

Application:
- 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

**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

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

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

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

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

**Application Examples**

**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

**SAPPHIRE DICING**
- No chipping on the edges
- Cleaved-surface roughness <1 μm
- Easy breaking
- Applications:
  - High power, high frequency electronics

**SILICON CARBIDE DICING**
- Applications:
  - High power, high frequency electronics
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.

**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.

**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.


Hybrid microfabrication

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⁾


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.

ETCHING AND POLYMERIZATION

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

LASER ASSISTED SELECTIVE ETCHING

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

LASER ABLATION

For Scientific Inquiries
mangirdas.malinauskas@ff.vu.lt
www.lasercenter.vu.lt

For Production Tool Inquiries
info@femtika.lt
www.femtika.lt
## List of Local Distributors

### AUSTRALIA
- **Lastek Pty Ltd**
  - Thebarton, Australia
  - Tel: +61 8 84 438 668
  - alex.stanco@lastek.com.au
  - www.lastek.com.au

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  - Vinkeveen, Netherlands
  - Tel: +32 11 75 79 87
  - dloos@laser2000.nl
  - www.laser2000.nl

### BRAZIL
- **Photonics**
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  - Phone: +55 11 2839-3209
  - info@photonics.com.br
  - www.photonics.com.br

### CZECH REPUBLIC
- **Femtonika s.r.o.**
  - Zbiroh, Czech Republic
  - Phone: +420 792 417 400
  - jan.hubert@femtonika.cz
  - www.femtonika.cz

### CHINA
- **Genuine Optronics Limited**
  - Shanghai, China
  - Tel: +86 21 64 325 169
  - jye@gen-opt.com
  - www.gen-opt.com

### FRANCE
- **Optoprim SAS Paris**
  - Paris, France
  - Phone: +33 1 41 90 33 77
  - fbeck@optoprim.com
  - www.optoprim.com

### FRANCE and SWITZERLAND
- **Marc Watremez**
  - Industrial Market Development Manager
  - Phone: +33 609 16 9538
  - marc.w@lighticon.com

### GERMANY
- **TOPAG Lasertechnik GmbH**
  - Darmstadt, Germany
  - Phone: +49 6151 4259 78
  - info@topag.de
  - www.topag.de

### GERMANY, AUSTRIA and SWITZERLAND
- **Ulrich Hoechner**
  - Industrial Market Development Manager
  - Phone: +49 157 8202 5058
  - U.Hoechner@lightcon.com

### HUNGARY
- **RK Tech Ltd.**
  - Budapest, Hungary
  - Tel: +36 1 40 20 721
  - rktech@rktech.hu
  - www.rktech.hu

### INDIA
- **Anatech Instruments**
  - Mumbai, India
  - Tel: +91 22 2673 0463
  - anatech@mtnl.net.in
  - www.anatechinstruments.in

### ISRAEL
- **IL Photonics BSD Ltd.**
  - Beit Shemesh, Israel
  - Tel: +972 2 992 1480
  - moshe@ILPhotonics.com
  - www.ILPhotonics.com

### ITALY
- **Optoprim S.r.l.**
  - Monza, Italy
  - Phone: +39 039 834 977
  - info@optoprim.it
  - www.optoprim.it/

### JAPAN
- **Phototechnica Corp.**
  - Saitama, Japan
  - Phone: +81 48 871 0067
  - kkakuta@phototechnica.co.jp
  - www.phototechnica.co.jp

### KOREA
- **L2K (Laser Leader Of Korea) Co., Ltd**
  - Daejeon, Korea
  - Phone: +82 42 934 7744 ~ 6
  - sales@L2K.kr
  - www.l2k.kr

- **MJL Crystek Inc.**
  - Daejeon, Korea
  - Phone: +82 42 471 8070 ~ 2
  - mj@mjcrystek.com
  - www.mjcrystek.com

### POLAND
- **Amecam**
  - Warszawa, Poland
  - Phone: +48 22 207 2278
  - amecam@amecam.pl
  - www.amecam.pl

### RUSSIA
- **OOO “Плазменная”**
  - Moscow, Russia
  - Phone: +7 495 22 11 208
  - info@cml.ru
  - www.cml.ru

### SINGAPORE
- **Aexcon Technologies Pte Ltd**
  - Singapore
  - Tel: +65 6565 7300
  - sales@aexcon.com
  - www.aexcon.com

### SPAIN
- **INNOVA Scientific S.L.**
  - Las Rozas de Madrid, Spain
  - Tel.: +34 91 710 56 50
  - rafael.pereira@innovasci.com
  - www.innovasci.com

### SWITZERLAND
- **Dyneos AG**
  - Effretikon, Switzerland
  - Tel: +052 355 12 40
  - info@dyneos.ch
  - www.dyneos.ch

### TAIWAN
- **Alaser**
  - Taipei, Taiwan
  - Tel: +886 2 3551 5560
  - alexfu@alaser.com.tw
  - www.alaser.com.tw

### UNITED KINGDOM
- **Photonic Solutions**
  - Edinburgh, UK
  - Phone: +44 0 131 664 8122
  - ben.agate@photonicssolutions.co.uk
  - www.photonicssolutions.co.uk

### USA and CANADA
- **Altos Photonics Inc.**
  - Bozeman, MT, USA
  - Phone: +1 866 658 5404
  - Fax: +1 866 658 7357
  - sales@altosphotonics.com
  - www.altosphotonics.com
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LIGHT CONVERSION, UAB
Keramiku 2B, LT-10233 Vilnius
Lithuania
Tel.: +370 5 2491830
Website: www.lightcon.com
Sales: sales@lightcon.com
OPA support: support@lightcon.com
Lasers support: lasers@lightcon.com

LIGHT CONVERSION CHINA
Room 1106, Gongyuan Dao building B,
Nanshan, Shenzhen, Guangdong, 518054
China
Phone: +86 138 2376 0064
E-mail: yiliping@cn.lightcon.com

LIGHT CONVERSION KOREA Co. Ltd.
No. 510, Hanshin S-meca, 65, Techno 3-ro
Yuseong-Gu, Daejeon, 34016
Korea
Phone: +82 42 368 1010
E-mail: jungsik.seo@lightcon.com