CARBIDE

Unibody-Design Femtosecond Lasers for Industry and Science

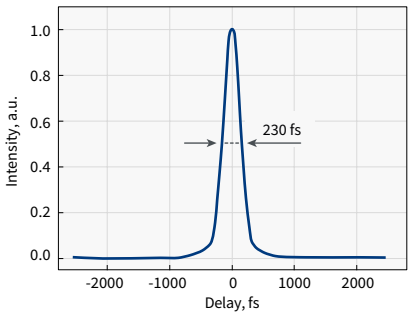
FEATURES

- 190 fs – 20 ps tunable pulse duration
- 2 mJ maximum pulse energy
- 80 W maximum output power
- Single-shot – 2 MHz repetition rate
- Pulse picker for pulse-on-demand mode
- Air-cooled version
- Automated harmonic generators
- Scientific interface module

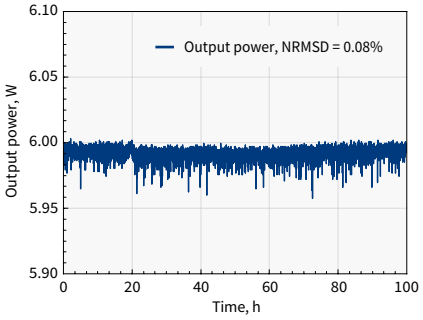
CARBIDE-CB3

CARBIDE is a series of femtosecond lasers combining high average power and excellent power stability. CARBIDE features market-leading output parameters without compromises to beam quality and stability. A compact and robust optomechanical CARBIDE design allows a variety of applications in top-class research centers, as well as display, automotive, LED, medical, and other industries. The reliability of CARBIDE has been proven by hundreds of systems operating 24/7 in the industrial environment.

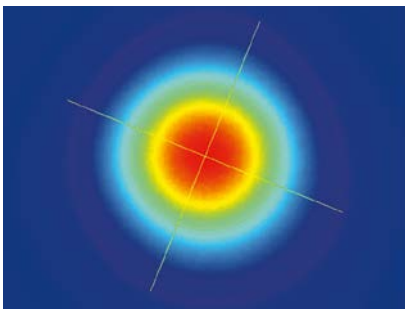
The tunability of CARBIDE lasers enables our customers to discover the most efficient manufacturing processes. Tunable parameters include pulse duration (190 fs – 20 ps), repetition rate (single-shot – 2 MHz), pulse energy (up to 2 mJ), and average power (up to 80 W). A pulse-on-demand mode is available using the built-in pulse picker. The CARBIDE lasers can be equipped with industrial-grade modules, including but not limited to high-power harmonic generators.

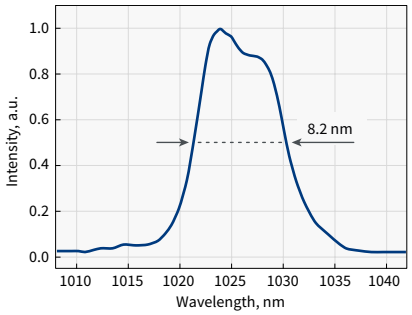


Typical pulse duration of CARBIDE laser

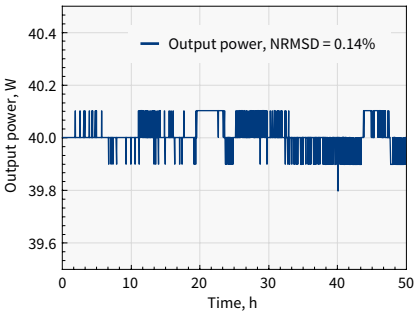


Long-term power stability of CARBIDE-CB5

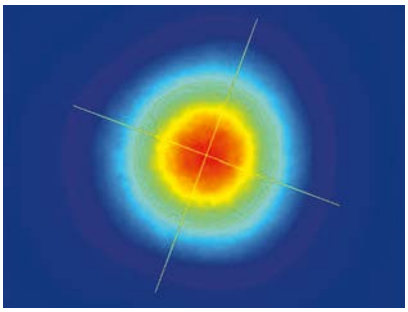

Typical beam profile of CARBIDE-CB5



Typical spectrum of CARBIDE laser



Long-term power stability of CARBIDE-CB3

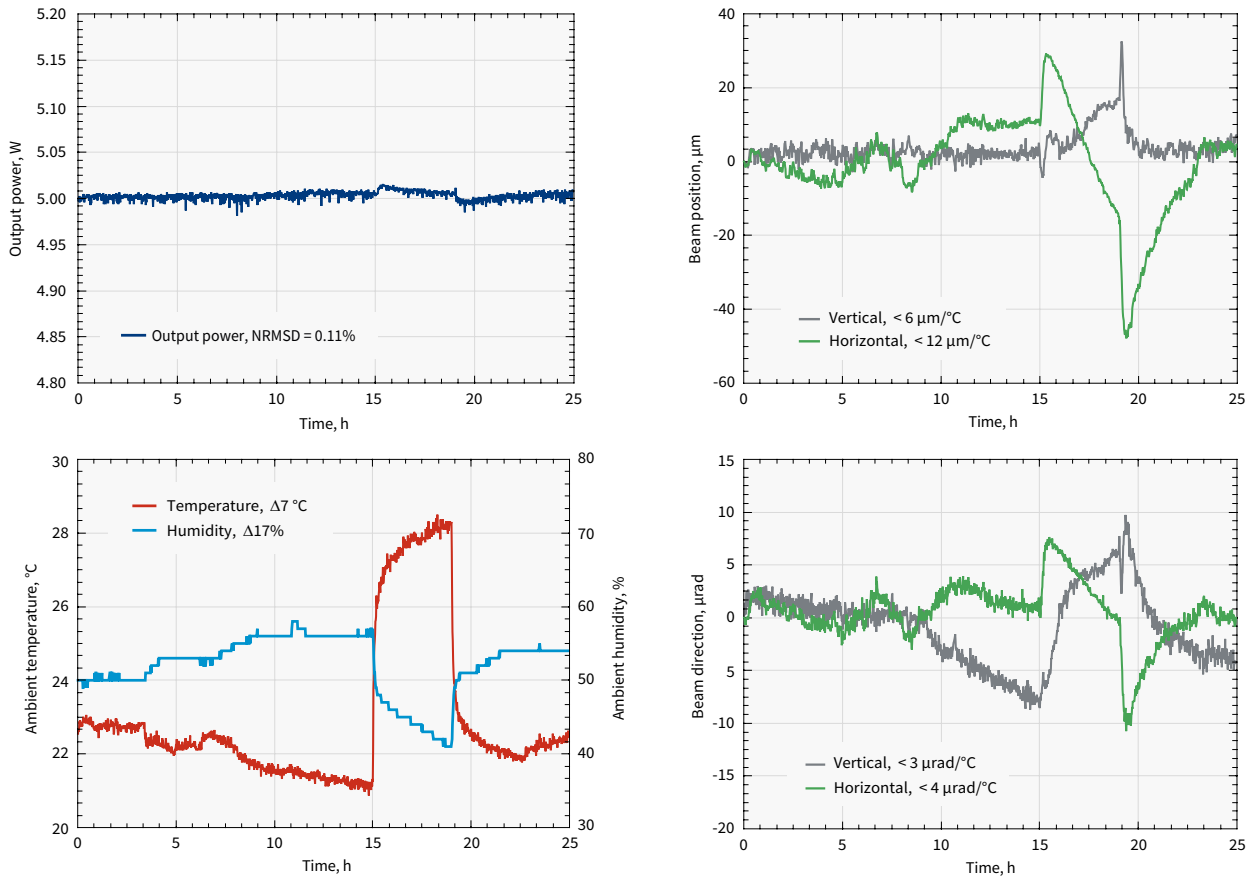

Typical beam profile of CARBIDE-CB3

SPECIFICATIONS

Model	CB3-20W	CB3-40W	CB3-80W NEW		CB5		CB5-SP
OUTPUT CHARACTERISTICS							
Cooling method	Water-cooled				Air-cooled [1]		
Maximum output power	20 W	40 W	80 W		6 W	5 W	
Pulse duration [2]	< 250 fs			< 350 fs [3]	< 290 fs		< 190 fs
Pulse duration tuning range	250 fs – 10 ps			350 fs – 10 ps	290 fs – 20 ps		190 fs – 20 ps
Maximum pulse energy	0.4 mJ		0.8 mJ	2 mJ	100 µJ	83 µJ	100 µJ
Repetition rate	Single-shot – 1 MHz	Single-shot – 1 MHz (2 MHz on request)	Single-shot – 2 MHz		Single-shot – 1 MHz		
Pulse selection	Single-shot, pulse-on-demand, any fundamental repetition rate division						
Center wavelength [4]	1030 ± 10 nm						
Polarization	Linear, vertical; 1 : 1000						
Beam quality, M^2	< 1.2						
Beam diameter [5]	4.3 mm		4.6 mm	5.6 mm	2.3 mm		
Beam pointing stability	< 20 µrad/°C						
Pulse picker	FEC [6]				included	included [7]	included
Pulse picker leakage	< 0.5%				< 2%	< 0.1%	< 2%
Pulse-to-pulse energy stability [8]	RMS deviation [9] < 0.5% over 24 h						
Long-term power stability [8]	RMS deviation [9] < 0.5% over 100 h						
OPTIONAL EXTENSIONS							
Harmonic generators	Integrated, optional *(see page 14)*						
Output wavelength	515 nm, 343 nm, or 257 nm						
Optical parametric amplifier	Integrated, optional *(see page 15)*						
Tuning range	320 – 10 000 nm						
BiBurst option	Tunable GHz and MHz burst with burst-in-burst capability, optional *(see page 9)*				n/a		
GHz-Burst							
Intra burst pulse period [10]	440 ± 40 ps						
Number of pulses, P [11]	1 – 10						
MHz-Burst							
Intra burst pulse period	≈ 15 ns						
Number of pulses, N	1 – 10						
PHYSICAL DIMENSIONS							
Laser head (L × W × H)	632 × 305 × 173 mm				631 × 324 × 167 mm		
Chiller (L × W × H)	680 × 484 × 307 mm				Not required		
24 V DC power supply (L × W × H)	280 × 144 × 49 mm		320 × 200 × 75 mm		220 × 95 × 46 mm		
ENVIRONMENTAL & UTILITY REQUIREMENTS							
Operating temperature	15 – 30 °C (59 – 86 °F)				17 – 27 °C (62 – 80 °F)		
Relative humidity	< 80% (non-condensing)						
Electrical requirements	100 V AC, 7 A – 240 V AC, 3 A; 50 – 60 Hz		100 V AC, 12 A – 240 V AC, 5 A; 50 – 60 Hz		100 V AC, 3 A – 240 V AC, 1.3 A; 50 – 60 Hz		
Rated power	600 W		1000 W		300 W		
Power consumption	500 W		700 W		150 W		
Electrical requirements (chiller)	100 – 230 V AC; 50 – 60 Hz		200 – 230 V AC; 50 – 60 Hz		Not required		
Rated power (chiller)	1400 W		2000 W				
Power consumption (chiller)	1000 W		1300 W				

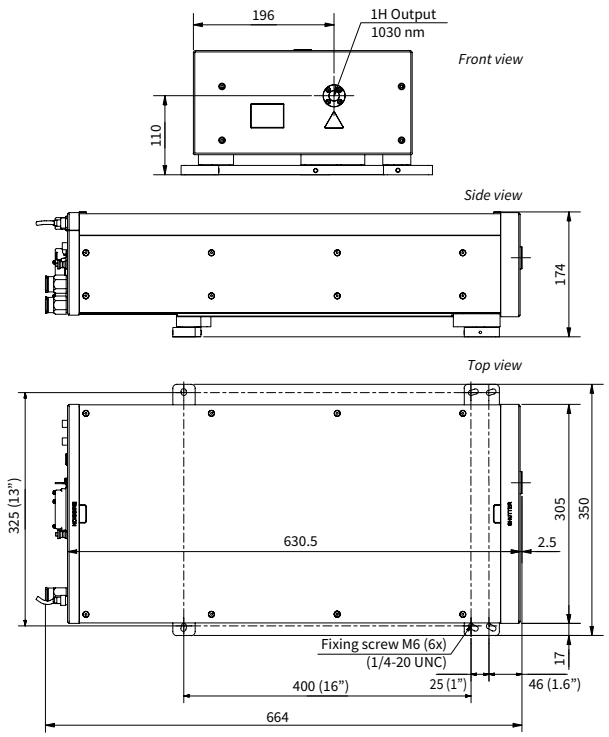
[1] *Water-cooled version available on request.*
[2] *Assuming Gaussian pulse shape.*
[3] *Pulse duration can be reduced to < 250 fs if pulse peak intensity of > 50 GW/cm² is tolerated by customer setup.*
[4] *Precise center wavelength for specific models available upon request.*
[5] *FW 1/e², using maximum pulse energy.*
[6] *Provides fast energy control; external analog control input available. Response time – next available RA pulse.*
[7] *Enhanced contrast AOM. Provides fast amplitude control of output pulse train.*
[8] *Under stable environmental conditions.*
[9] *Normalized to average pulse energy, NRMSD.*
[10] *Custom spacing is available on request.*
[11] *Maximum number of pulses in a burst depends on the laser repetition rate. Custom number of pulses is available on request.*

STABILITY MEASUREMENTS

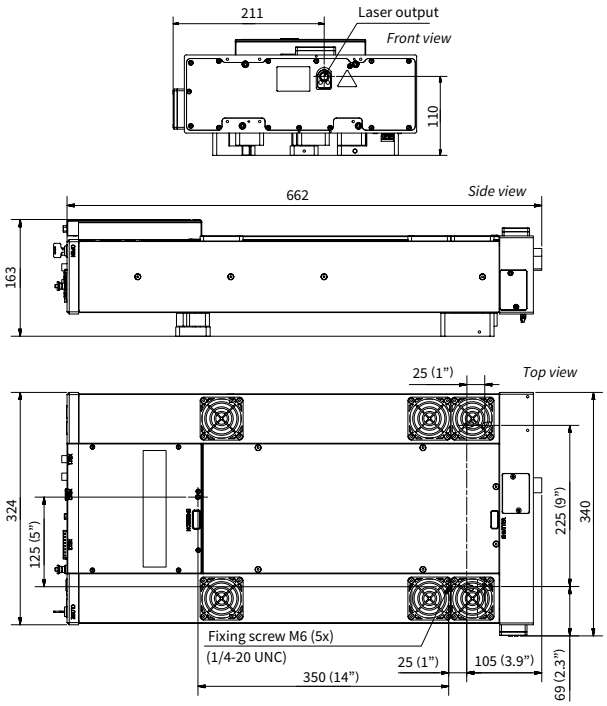


Output power, beam direction, and beam position of CARBIDE-CB5 under harsh environmental conditions

DRAWINGS



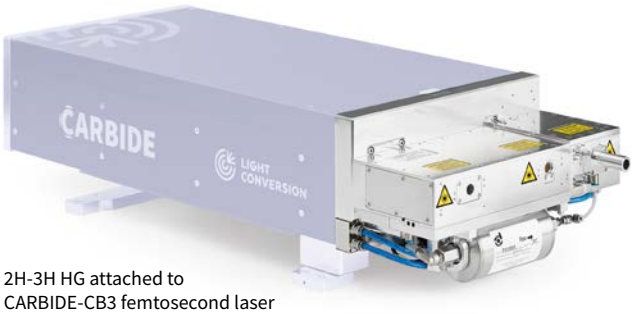
Drawing of CARBIDE-CB3



Drawing of air-cooled CARBIDE-CB5 with attenuator

HG | CARBIDE

Automated Harmonic Generators



2H-3H HG attached to
CARBIDE-CB3 femtosecond laser

FEATURES

- 515 nm, 343 nm, or 257 nm output
- Automated harmonic selection
- Mounted directly on the laser head
- Industrial-grade design
- 30 W UV model

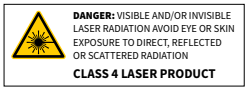
CARBIDE lasers equipped with automated harmonic generators (HGs) provide a selection of fundamental (1030 nm), second (515 nm), third (343 nm), or fourth (257 nm) harmonic outputs using software control.

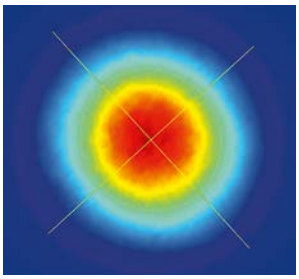
HGs are perfect for industrial applications that require a single-wavelength output. Modules, mounted directly at the output of the laser, are fully integrated into the system.

SPECIFICATIONS

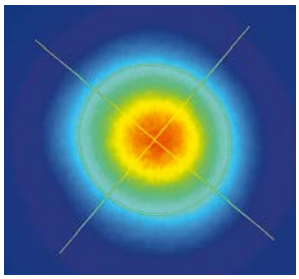
Model		2H	2H-3H	2H-4H	2H-3H (30W UV) [1]
Output wavelength [2] (automated selection)		1030 nm 515 nm	1030 nm 515 nm 343 nm	1030 nm 515 nm 257 nm	1030 nm 515 nm 343 nm
Pump pulse energy		20 – 2000 µJ	50 – 2000 µJ	20 – 2000 µJ	80 – 400 µJ
Pump pulse duration		< 300 fs			≈ 500 fs
Conversion efficiency / Output power		> 50% (2H)	> 50% (2H) > 25% (3H)	> 50% (2H) > 10% (4H) [3]	40 W (2H) 30 W (3H)
Beam quality (M^2) typical values	≤ 400 µJ pump	< 1.15 (2H)	< 1.15 (2H) < 1.2 (3H)	< 1.15 (2H) < n/a (4H)	< 1.2 (2H) < 1.3 (3H)
	> 400 µJ pump	< 1.2 (2H)	< 1.2 (2H) < 1.3 (3H)	< 1.2 (2H) < n/a (4H)	n/a

[1] Available only for CARBIDE-CB3-80W with maximum output power; 1 year lifetime.
[2] Depends on pump laser model. Up to 5th harmonic available; contact sales@lightcon.com for details.
[3] Maximum output power of 1 W.

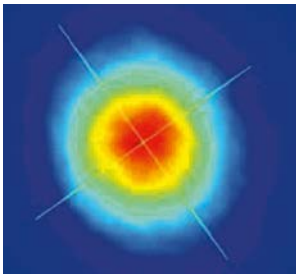




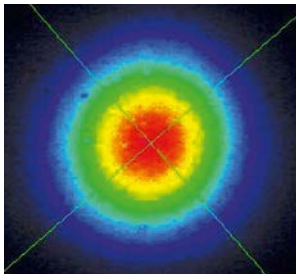
Typical 1H beam profile
of CARBIDE-CB5 (100 kHz, 6 W)



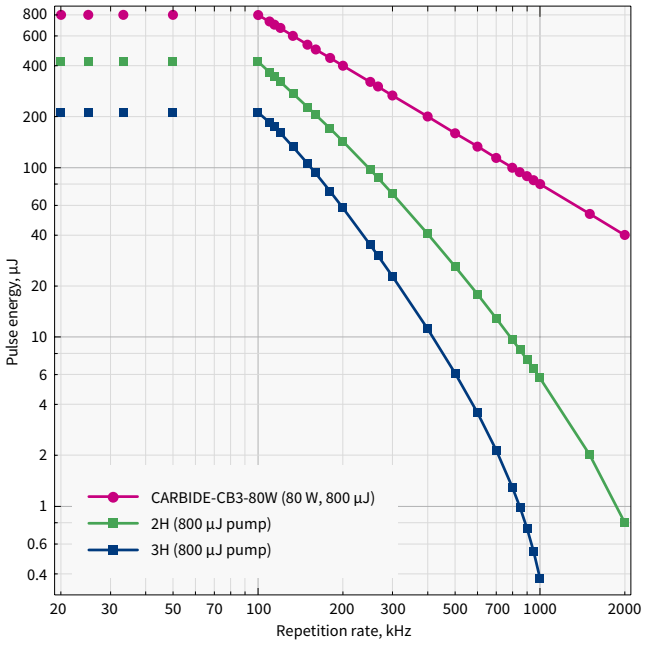
Typical 2H beam profile
of CARBIDE-CB5 (100 kHz, 3.4 W)



Typical 3H beam profile
of CARBIDE-CB5 (100 kHz, 2.2 W)



Typical 4H beam profile
of CARBIDE-CB5 (100 kHz, 100 mW)



Pulse energy vs repetition rate of CARBIDE-CB3-80W with HG

LIGHT CONVERSION
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BiBurst option

Tunable GHz and MHz Burst with Burst-in-Burst Capability

PHAROS and CARBIDE-CB3 lasers have an option for tunable GHz and MHz burst with burst-in-burst capability – called BiBurst.

In standard mode, a single pulse is emitted at some fixed frequency. In burst mode, the output consists of pulse packets instead of single pulses. Each packet consists of a certain number of equally separated pulses. MHz-Burst contains N pulses with a nanosecond period, GHz-Burst contains P pulses with a picosecond period. If both bursts are used, the equally separated pulse packets contain sub-packets of pulses (burst-in-burst, BiBurst).

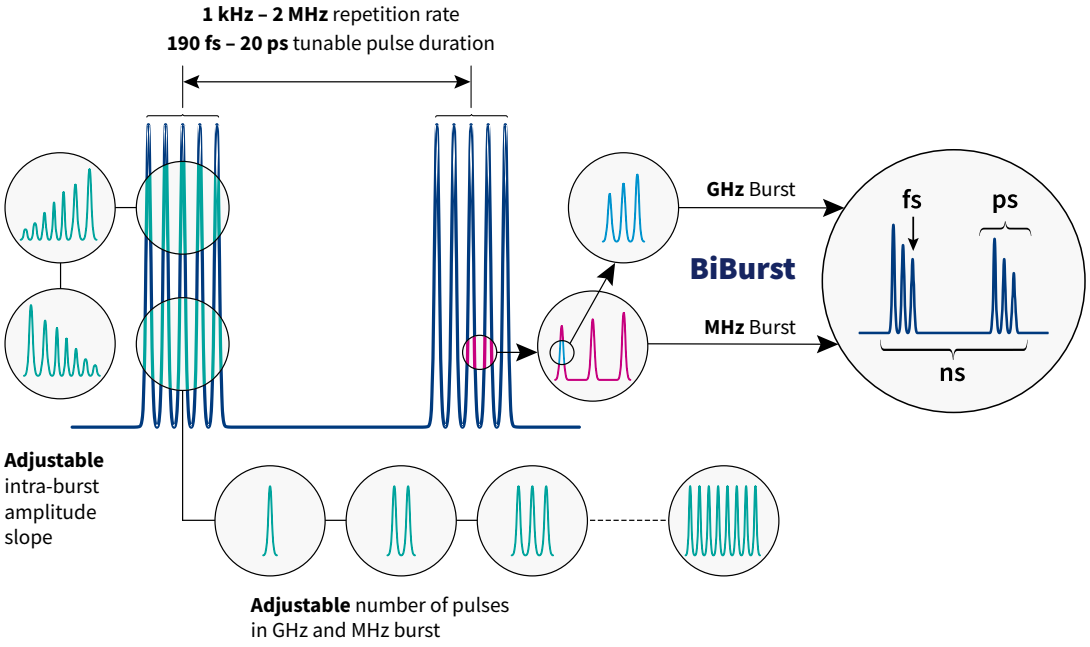
PHAROS and CARBIDE lasers with the BiBurst option bring new capabilities to high-tech manufacturing industries such as consumer electronics, integrated photonic chip manufacturing, future display manufacturing, and quantum technologies. The applications include:

- brittle material drilling and cutting
- deep engraving
- selective ablation
- volume modification of transparent materials
- hidden marking
- surface polishing
- surface functionalization

SPECIFICATIONS

Model		CARBIDE-CB3	PHAROS
GHz Burst	Intra burst pulse period [1]	440 ± 40 ps	200 ± 40 ps
	Number of pulses, P [2]	1 – 10	1 – 25
MHz Burst	Intra burst pulse period	≈ 15 ns	
	Number of pulses, N	1 – 10	1 – 9 (7 with FEC)

[1] *Custom spacing is available on request.*
[2] *Maximum number of pulses in a burst depends on the laser repetition rate. Custom number of pulses is available on request.*



I-OPA

Industrial-Grade Optical Parametric Amplifier

FEATURES

- Tunable or fixed-wavelength models
- Industrial-grade design
- Plug-and-play installation and user-friendly operation
- Single-shot – 2 MHz repetition rate
- Up to 40 W pump power
- < 100 fs pulse duration

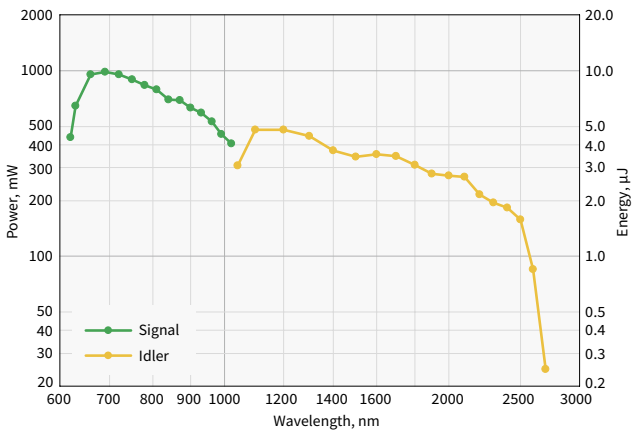
I-OPA-TW attached to air-cooled CARBIDE-CB5

The industrial-grade optical parametric amplifier I-OPA series marks a new era of simplicity in the world of wavelength-tunable femtosecond light sources. Based on over 10 years of experience producing the ORPHEUS series of optical parametric amplifiers, this solution brings together the tunability of wavelength with the robust industrial-grade design. The I-OPA is a rugged module attachable to our PHAROS and CARBIDE lasers, providing long-term stability comparable to that of the industrial-grade harmonic generators.

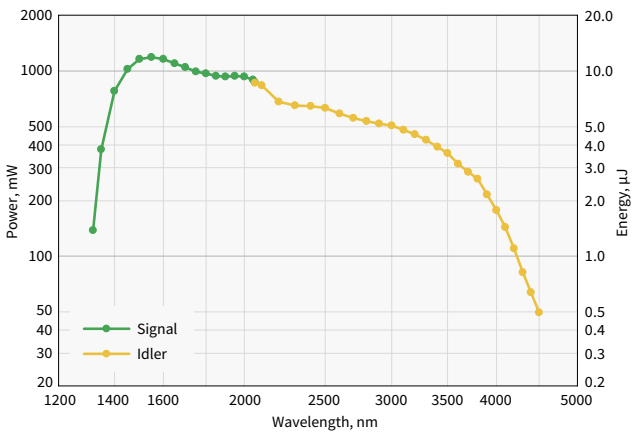
The tunable-wavelength I-OPA (I-OPA-TW) provides a wide tuning range and is primarily intended for spectroscopy and microscopy applications. In particular, the -HP model is targeted to be coupled with our HARPIA spectroscopy system as a pump beam source for ultrafast pump-probe spectroscopy. The -F model is primarily designed as a light source for multiphoton microscopy, the -ONE model – for IR spectroscopy and other applications where high energy MIR pulses are desired. All of the models can also be used for micromachining and other industrial applications.

The fixed-wavelength I-OPA (I-OPA-FW) is primarily intended for applications that desire a single-wavelength output. The industrial-grade design provides mechanical stability and eliminates the effects of air-turbulence, minimizing energy fluctuations and ensuring stable long-term performance.

The I-OPA-TW is best suited for R&D systems, while the I-OPA-FW is a cost-effective solution for large-scale production.



Typical I-OPA-TW-HP tuning curves.
Pump: 10 W, 100 µJ, 100 kHz

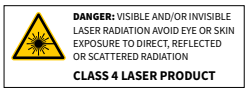


Typical I-OPA-TW-ONE tuning curves.
Pump: 10 W, 100 µJ, 100 kHz

SPECIFICATIONS OF TUNABLE I-OPA

Model	I-OPA-TW-HP	I-OPA-TW-F	I-OPA-TW-ONE
Configuration	ORPHEUS	ORPHEUS-F	ORPHEUS-ONE
Pump power	Up to 40 W		
Pump pulse energy	10 – 400 µJ		20 – 400 µJ
Repetition rate	Up to 2 MHz		
Tuning range	640 – 1010 nm (Signal) 1050 – 2600 nm (Idler)	650 – 900 nm (Signal) 1200 – 2500 nm (Idler)	1350 – 2000 nm (Signal) 2100 – 4500 nm (Idler)
Conversion efficiency at peak	> 7% @ 700 nm (40 – 400 µJ pump; up to 1 MHz)		> 9% @ 1550 nm (40 – 400 µJ pump; up to 1 MHz)
	> 3.5% @ 700 nm (10 – 40 µJ pump; up to 2 MHz)		> 6% @ 1550 nm (20 – 40 µJ pump; up to 2 MHz)
Spectral bandwidth [1]	80 – 220 cm^{-1} @ 700 – 960 nm	200 – 1000 cm^{-1} @ 650 – 900 nm 150 – 1000 cm^{-1} @ 1200 – 2000 nm	60 – 150 cm^{-1} @ 1450 – 2000 nm
Pulse duration [1] [2]	120 – 250 fs	< 55 fs @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	100 – 300 fs
Long-term power stability, 8 h	< 1% @ 800 nm		< 1% @ 1550 nm
Pulse-to-pulse energy stability, 1 min	< 1% @ 800 nm		< 1% @ 1550 nm
Wavelength extension options	320 – 505 nm (SHS) [3] 525 – 640 nm (SHI) [3]	Contact sales@lightcon.com	4500 – 10000 nm (DFG) [4]
Pulse compression options [1]	–	SCMP (Signal pulse compressor) ICMP (Idler pulse compressor) GDD-CMP (Compressor with GDD control)	–

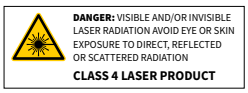
[1] I-OPA-TW-F broad-bandwidth pulses are compressed externally. Typical pulse duration before compression: 120 – 250 fs, after compression: 25 – 70 fs @ 650 – 900 nm, 40 – 100 fs @ 1200 – 2000 nm.
[2] Output pulse duration depends on the selected wavelength and pump laser pulse duration.
[3] Conversion efficiency is 1.2% at peak; specified as the percentage of pump power.
[4] Up to 16 µm tuning range is accessible with an external difference frequency generator.

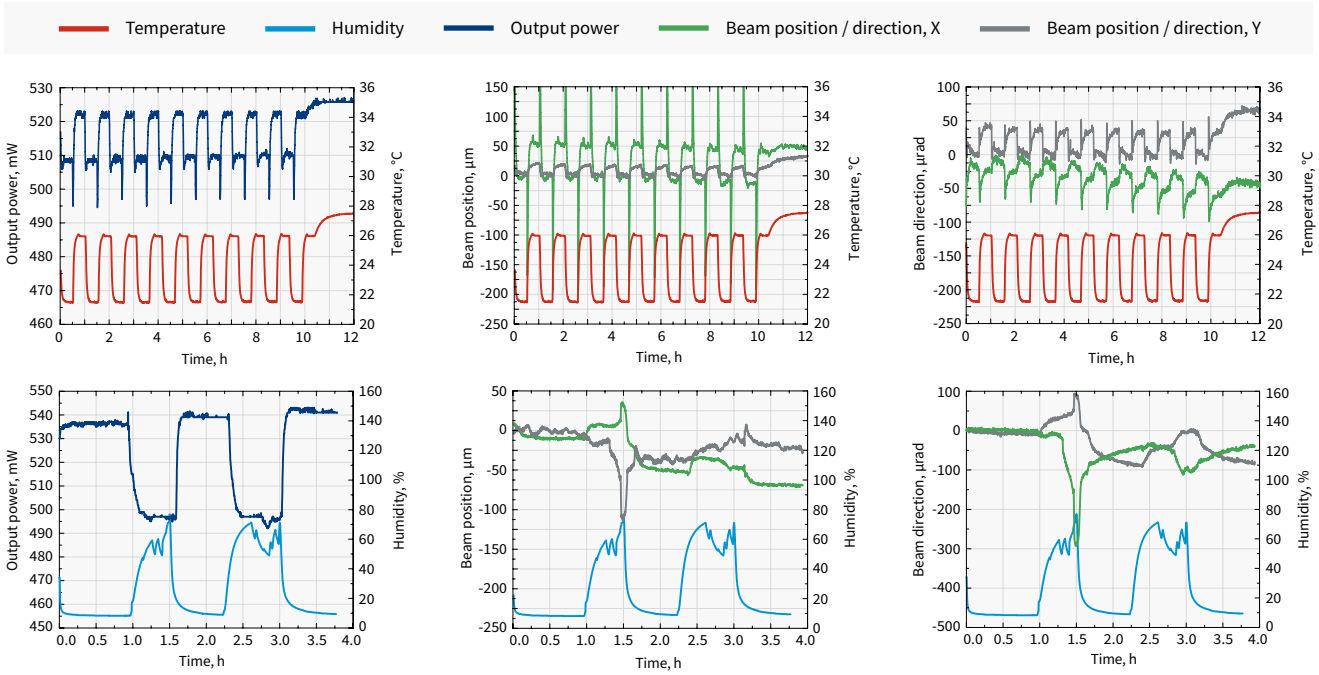


SPECIFICATIONS OF FIXED WAVELENGTH I-OPA

Model	I-OPA-FW-HP	I-OPA-FW-F	I-OPA-FW-ONE
Configuration	ORPHEUS	ORPHEUS-F	ORPHEUS-ONE
Pump power	Up to 40 W		
Pump pulse energy	10 – 500 µJ		20 – 1000 µJ
Repetition rate	Up to 2 MHz		
Wavelength selection range [1]	640 – 1010 nm (Signal) 1050 – 2600 nm (Idler)	650 – 900 nm (Signal) 1200 – 2500 nm (Idler)	1350 – 2000 nm (Signal) 2100 – 4500 nm (Idler)
Conversion efficiency at peak	> 7% @ 700 nm (40 – 500 µJ pump; up to 1 MHz)		> 9% @ 1550 nm (40 – 1000 µJ pump; up to 1 MHz)
	> 3.5% @ 700 nm (10 – 40 µJ pump; up to 2 MHz)		> 6% @ 1550 nm (10 – 40 µJ pump; up to 2 MHz)
Spectral bandwidth [2]	80 – 220 cm^{-1} @ 700 – 960 nm	200 – 1000 cm^{-1} @ 650 – 900 nm 150 – 1000 cm^{-1} @ 1200 – 2000 nm	60 – 150 cm^{-1} @ 1450 – 2000 nm
Pulse duration [2] [3]	120 – 250 fs	< 55 fs @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	150 – 300 fs
Long-term power stability, 8 h	< 1% @ 800 nm		< 1% @ 1550 nm
Pulse-to-pulse energy stability, 1 min	< 1% @ 800 nm		< 1% @ 1550 nm

[1] A fixed wavelength can be selected from the Signal or Idler range. Signal may have accessible Idler pair, and vice versa.
[2] I-OPA-FW-F outputs broad-bandwidth pulses which are compressed externally. Typical pulse duration before compression: 120 – 250 fs, after compression: 25 – 70 fs @ 650 – 900 nm, 40 – 100 fs @ 1200 – 2000 nm.
[3] Output pulse duration depends on the selected wavelength and pump laser pulse duration.





I-OPA-FW output power, beam position, and beam direction under harsh environmental conditions

COMPARISON WITH OTHER FEMTOSECOND AND PICOSECOND LASERS

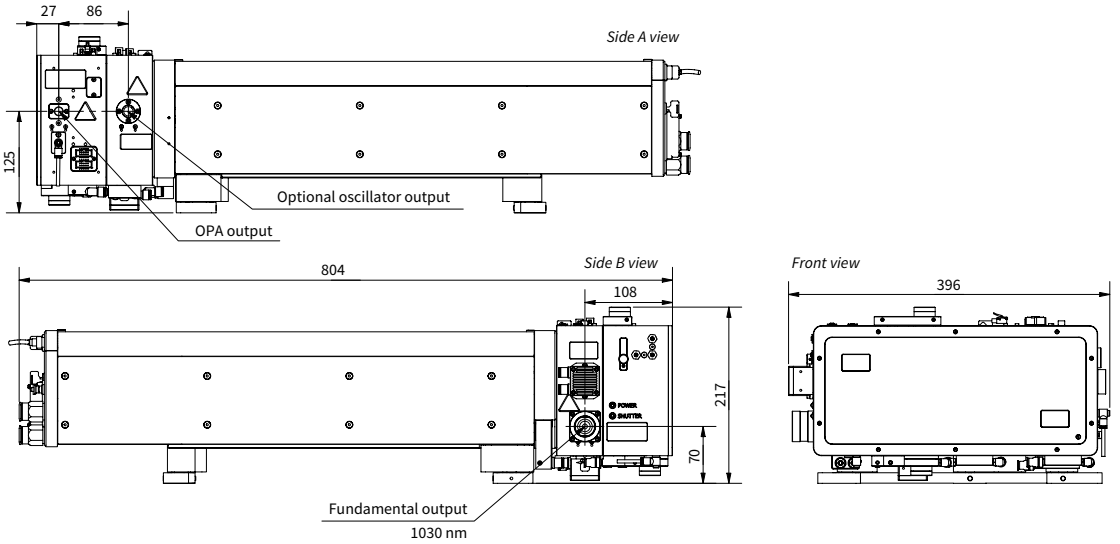
Laser technology	Our solution [1]	Typical performance [2]			
		HG or HIRO	I-OPA-FW-HP	I-OPA-FW-F [3]	I-OPA-FW-ONE
Excimer (193 nm, 213 nm)	5H of laser (205 nm)	> 20 µJ	–	–	–
3H of Ti:Sapphire (266 nm)	4H of laser (257 nm)	> 40 µJ			
3H of Nd:YAG (355 nm)	3H of laser (343 nm)	> 100 µJ	> 10 µJ		
2H of Nd:YAG (532 nm)	2H of laser (515 nm)	> 200 µJ	> 140 µJ		
Ti:Sapphire (800 nm)	OPA (750 – 850 nm)	–	> 25 µJ		
Nd:YAG (1064 nm)	Laser (1030 nm)	400 µJ			
Cr:Forsterite (1240 nm)	OPA (1200 – 1300 nm)	–	> 14 µJ		–
Erbium (1560 nm)	OPA (1500 – 1600 nm)		> 10 µJ		> 40 µJ
Thulium / Holmium (1950 – 2150 nm)	OPA (1900 – 2200 nm)		> 7 µJ		> 25 µJ
MIR sources (2500 – 4000 nm)	OPA (2500 – 4000 nm)		–		> 5 µJ

[1] OPA output is not limited to the given spectral ranges; see the full ranges in the specifications above.

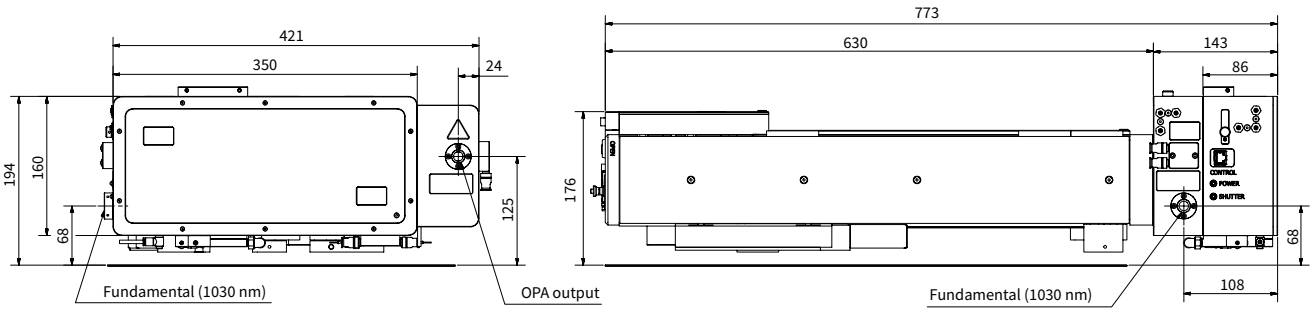
[2] Typical pulse energy when using 400 µJ pump from CARBIDE/PHAROS laser. Output scales linearly in a broad range of pump parameters. For exact specifications, contact sales@lightcon.com.

[3] I-OPA-FW-F broad-bandwidth pulses are compressed externally. For compression options, see specifications above.

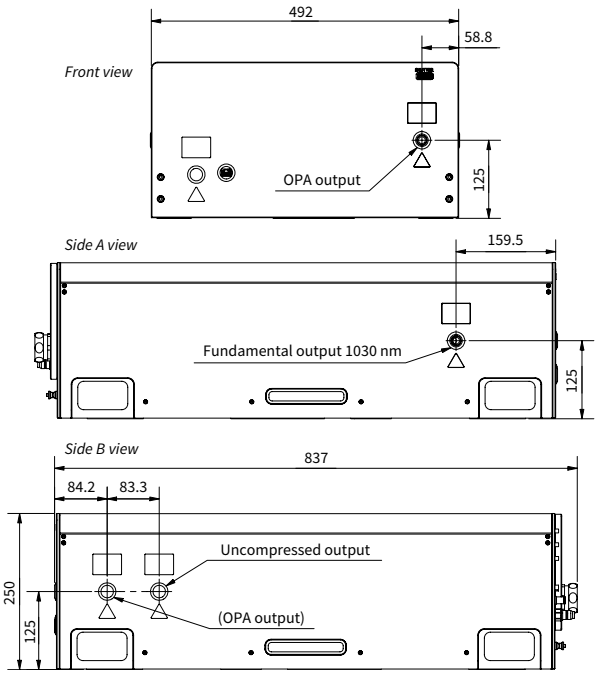
DRAWINGS



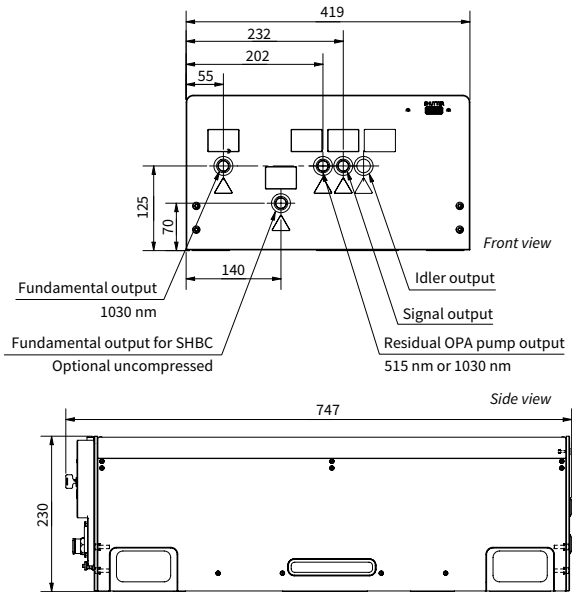
Drawing and output ports of CARBIDE-CB3 with tunable I-OPA-TW-HP



Drawing and output ports of CARBIDE-CB5 with tunable I-OPA-TW-HP



Drawing and output ports of PHAROS-PH2
with tunable I-OPA-TW-HP



Drawing and output ports of PHAROS-PH2
with fixed-wavelength I-OPA-FW-HP