

# I-OPA

## Industrial-grade Optical Parametric Amplifier



### FEATURES

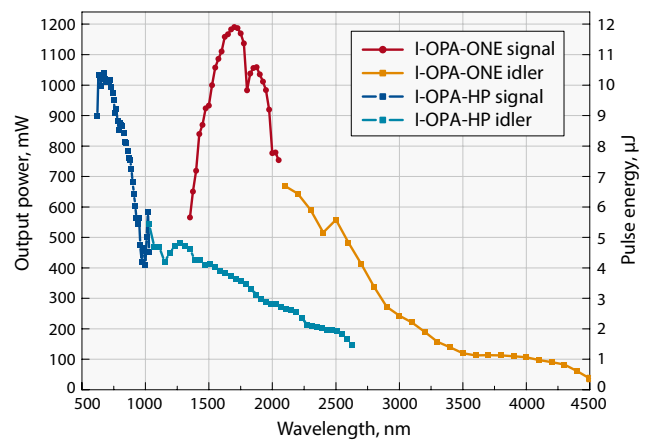
- Automatically tunable or fixed wavelength options
- Robust, integrated mechanical design
- Plug and play installation
- User friendly operation
- Up to 2 MHz repetition rate, down to single shot operation
- Up to 40 W pump power
- Short pulse duration option (< 100 fs)
- Integrated tunable beam splitter for pump laser beam



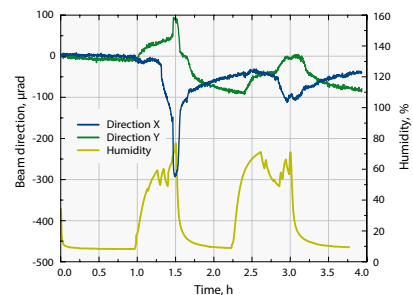
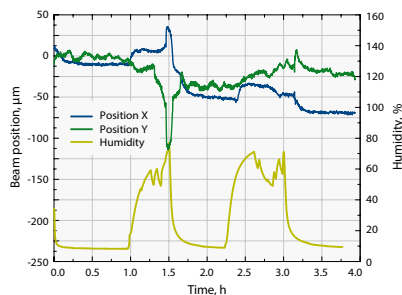
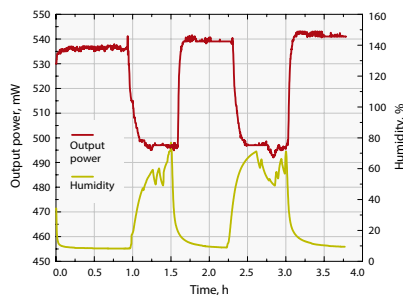
Tunable I-OPA-TW module attached to air-cooled CARBIDE-CB5

I-OPA series of optical parametric amplifiers marks a new era of simplicity in the world of tunable wavelength femtosecond light sources. Based on 10 years of experience producing the ORPHEUS series of optical parametric amplifiers, this solution brings together the flexibility of tunable wavelength with robust industrial-grade design. The original I-OPA is a rugged module attached to our PHAROS laser, providing long term stability comparable to that of the industrial harmonics modules. The new and improved tunable version is designed to be coupled with our PHAROS and CARBIDE series femtosecond lasers and primarily intended to be used with spectroscopy or microscopy applications that demand high stability. The -HP model is targeted to be coupled with our HARPIA series as a pump beam source for ultrafast pump-probe spectroscopy. The -F model is primarily designed to be used as a light source in multiphoton microscopy devices. The -ONE model will be useful in the field of mid-IR spectroscopy, as well as other applications where higher pulse energy is required in the infrared part of the spectrum. All of these models can be used for micromachining and other

industrial applications; the tunable version suited to be the ideal R&D system, while the fixed wavelength I-OPA would be the cost-effective solution for large scale production.



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



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

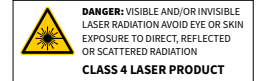
## SPECIFICATIONS OF TUNABLE I-OPA

Model	I-OPA-TW-HP	I-OPA-TW-F	I-OPA-TW-ONE
Based on ORPHEUS model	ORPHEUS	ORPHEUS-F	ORPHEUS-ONE
Pump power	Up to 40 W		
Pump pulse energy	10 – 400 $\mu$ J		20 – 400 $\mu$ J
Pulse repetition rate	Up to 2 MHz		
Tuning range, signal	640 – 1010 nm	650 – 900 nm	1350 – 2060 nm
Tuning range, idler	1050 – 2600 nm	1200 – 2500 nm	2060 – 4500 nm
Conversion efficiency at peak, signal wavelength	> 7 % @ 700 nm		> 9 % @ 1550 nm
Additional options	n/a	SCMP: Signal pulse compressor ICMP: Idler pulse compressor PCMP: pre-chirp dispersion compensator	n/a
Pulse bandwidth <sup>1)</sup>	80 – 220 $\text{cm}^{-1}$ @ 700 – 960 nm	200 – 750 $\text{cm}^{-1}$ @ 650 – 900 nm 150 – 500 $\text{cm}^{-1}$ @ 1200 – 2000 nm	60 – 150 $\text{cm}^{-1}$ @ 1450 – 2000 nm
Pulse duration <sup>2)</sup>	120 – 250 fs	< 55 fs @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	100 – 300 fs
Wavelength extension options	SHS: 320 – 505 nm SHI: 525 – 640 nm Conversion efficiency 1.2% at peak	Contact sales@lightcon.com	DFG: 4500 – 10000 nm <sup>3)</sup>
Applications	Micro-machining Microscopy Spectroscopy	Nonlinear microscopy Ultrafast spectroscopy	Mid-IR spectroscopy AFM microscopy

<sup>1)</sup> I-OPA-F outputs broad bandwidth pulses which are compressed externally.

<sup>2)</sup> Output pulse duration depends on wavelength and pump laser pulse duration.  
I-OPA-F requires pulse compressors to achieve short pulse duration.

<sup>3)</sup> Up to 16  $\mu$ m tuning range is accessible with external Difference Frequency Generator.



Fixed wavelength I-OPA in comparison to tunable version or standard ORPHEUS line devices 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.



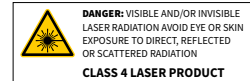
Fixed wavelength I-OPA-FW module attached to PHAROS

## SPECIFICATIONS OF FIXED WAVELENGTH I-OPA

Model	I-OPA-FW-HP	I-OPA-FW-F	I-OPA-FW-ONE
Pump power		Up to 40 W	
Pump pulse energy	10 – 500 $\mu$ J	10 – 500 $\mu$ J	20 – 1000 $\mu$ J
Pulse repetition rate		Up to 2 MHz	
Wavelength range, signal	640 – 1010 nm	650 – 900 nm	1350 – 2060 nm
Wavelength range, idler	1050 – 2600 nm	1200 – 2500 nm	2060 – 4500 nm
Conversion efficiency at peak, signal wavelength	>7 % @ 700 nm	>7 % @ 700 nm	> 9 % @ 1550 nm
Pulse bandwidth <sup>1)</sup>	80 – 220 $\text{cm}^{-1}$ @ 700 – 960 nm	200 – 750 $\text{cm}^{-1}$ @ 650 – 900 nm 150 – 500 $\text{cm}^{-1}$ @ 1200 – 2000 nm	60 – 150 $\text{cm}^{-1}$ @ 1450 – 2000 nm
Pulse duration <sup>2)</sup>	120 – 250 fs	< 55 fs @ 800 – 900 nm < 70 fs @ 650 – 800 nm < 100 fs @ 1200 – 2000 nm	150 – 300 fs
Applications	Micro-machining Microscopy Spectroscopy	Nonlinear microscopy Ultrafast spectroscopy	Micro-machining Mid-IR generation

<sup>1)</sup> I-OPA-F outputs broad bandwidth pulses which are compressed externally.

<sup>2)</sup> Output pulse duration depends on wavelength and pump laser pulse duration. I-OPA-F requires external pulse compressors to achieve short pulse duration.

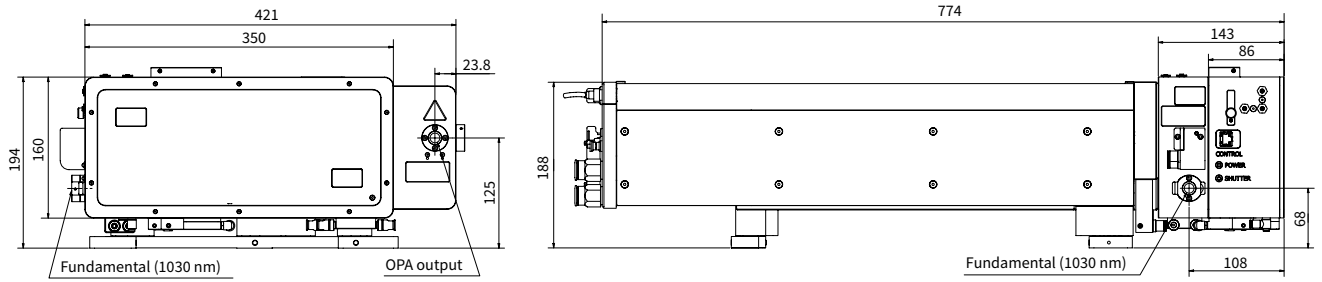


## COMPARISON WITH OTHER FEMTOSECOND AND PICOSECOND LASERS

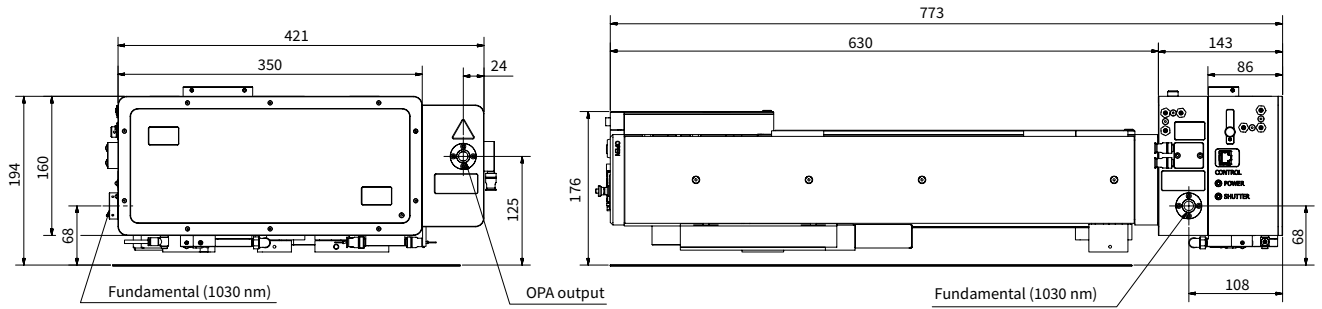
Laser technology	Our solution	HG or HIRO	I-OPA-FW-F	I-OPA-FW-ONE
Pulse energy at 100 kHz, using PHAROS-10W laser				
Excimer laser (193 nm, 213 nm)	5H of PHAROS (205 nm)	5 $\mu$ J	n/a	n/a
TH of Ti:Sa (266 nm)	4H of PHAROS (257 nm)	10 $\mu$ J		
TH of Nd:YAG (355 nm)	3H of PHAROS (343 nm)	25 $\mu$ J		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

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  $\mu$ J 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.

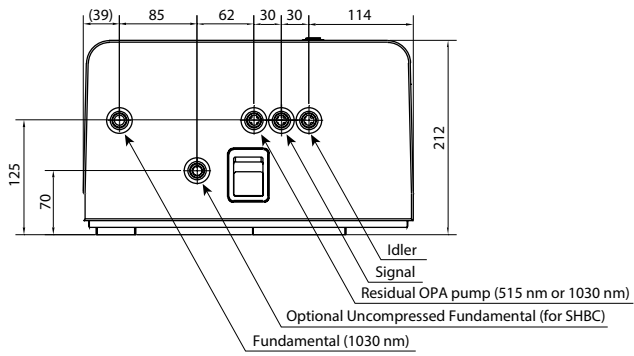
## OUTLINE DRAWINGS



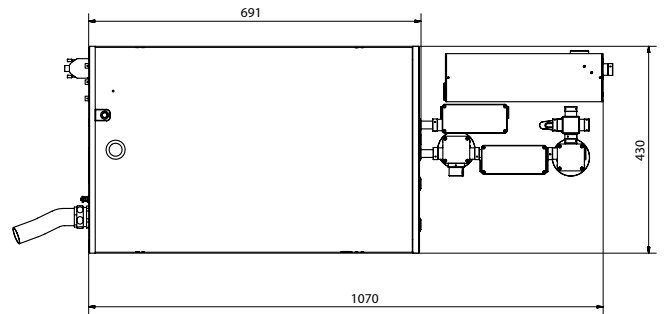
Outline drawing and output ports of CARBIDE-CB3 with tunable I-OPA-TW-HP



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



Output ports of PHAROS with fixed wavelength I-OPA-FW



PHAROS with fixed wavelength I-OPA-FW-F and compressors for signal and idler