PHAROS

High-Power Femtosecond Laser System for OEM Applications

FEATURES

- <190 fs pulse duration
- Tunable pulse duration 190 fs – 10 ps
- Up to 1.5 mJ pulse energy
- Up to 15 W average power
- 1 kHz – 1 MHz tunable repetition rate
- Includes pulse picker for pulse-on-demand operation
- Rugged, industrial grade mechanical design
- Automatic harmonic generators (SH, TH, FH)

APPLICATIONS

- Micromachining
- Micro- and nano-structuring
- Writing of Bragg gratings and waveguides
- Multi-photon polymerization
- Biomedical applications
- Wafer dicing
- Transparent material processing
- Metal microprocessing

GENERAL DESCRIPTION

PHAROS is a single-unit integrated femtosecond laser system combining millijoule pulse energies and high average power. PHAROS features mechanical and optical design dedicated for industrial applications of precise material processing. Markets leading compact size, integrated thermal stabilization system, sealed design allow simple PHAROS integration into machining workstations. Use of a solid state laser diodes for pumping of Yb medium significantly reduce maintenance costs and provide long laser lifetime.

Most of PHAROS output parameters can be easily set via control pad or PC tuning the laser for particular application in seconds. Tunability of laser output parameters allows PHAROS system to cover applications normally requiring different class of lasers. Tunable parameters include: pulse duration (190 fs – 10 ps), repetition rate (1 kHz to 1 MHz), pulse energy (up to 1.5 mJ) and average power (up to 15 W). Its deliverable power is abundant for a most of material processing applications at high machining speeds. Built in pulse picker allows convenient control of laser output in pulse-on-demand and burst modes. It comes along with the 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 (oscillator, amplifier and stretcher/ compressor) with temperature stabilized and sealed housings ensuring stable laser operation within varying environments. Those features being of critical importance for OEM and industrial users. PHAROS is equipped with an extensive software package, which ensures its smooth hands-free operation as well as allows fast and easy integration into various processing devices.

OPERATION

PHAROS is built upon conventional chirped pulse amplification technique, employing the seed oscillator, regenerative amplifier and pulse stretcher/compressor modules. Kerr lens mode-locked oscillator delivers >700 mW output with sub-80 fs pulse duration. Regenerative amplifier is based on Yb:KGW lasing medium. Both oscillator and amplifier are non-collinearly pumped by one or two (respectively 4 W or 6-15 W PHAROS) Light Conversion proprietary design high brightness, solid state laser diode based pump modules. Low loss BBO Pockels cells support operation of amplifier and pulse picker at repetition rates up to 200 kHz (extendable to 1 MHz). The stretcher/compressor module is based on single transmission grating exhibiting high efficiency and excellent power handling capability. Operating parameters are adjustable from the remote control module or external PC connected via USB interface.

"Birefringent rose" image fabricated in bulk of quartz substrate. Dimensions 1×1 mm.

Courtesy of Prof. P. Kazansky, Optoelectronics Research Centre, University of Southampton

LIGHT CONVERSION

HARMONIC GENERATORS

PHAROS laser can be equipped with optional wavelength converters providing high power harmonics radiation at 515 nm, 343 nm and 257 nm wavelengths. Harmonic generators are designed to be used in industrial applications where single output wavelength is desired. Modules are mounted directly on the output of the laser and integrated into the system. Automatic harmonics modules providing computer selectable outputs of 1030 nm, 515 nm, 343 nm or 257 nm radiations are available for more demanding applications.

OPERATION

The principal of OEM harmonic generators operation is based on collinear generation of higher laser radiation harmonics in angle phase-matched nonlinear crystals. The optical layout of OEM harmonic generator also includes beam reduction and collimation optics that ensures highest harmonics conversion efficiencies. In a standard setup particular harmonic is produced in a single OEM harmonic generator module, different module is required for different order harmonics generation. Automatic harmonic modules are also available allowing selection of fundamental, second, third or fourth harmonic output by a control software. All the accessible harmonics exiting OEM harmonic generators are separated from the pump radiation by dichroic mirrors.

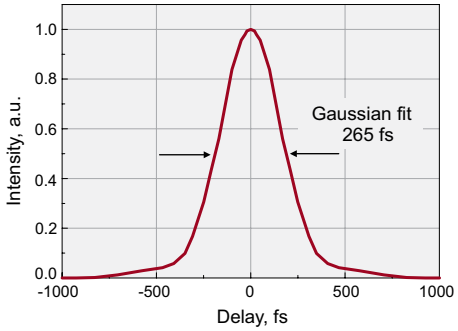
PHAROS LASERS SPECIFICATIONS

PHAROS model	PHAROS-4W	PHAROS-6W	PHAROS-10W	PHAROS-15W	PHAROS SP	PHAROS SP 1.5	PHAROS LP
Max. average power	4 W	6 W	10 W	15 W	6 W		18 W
Pulse duration (assuming Gaussian pulse shape)	290 fs				190 fs		10 ps
Pulse duration range	290 fs – 10 ps				190 fs – 10 ps		10 ps
Max. pulse energy	> 0.2 mJ				> 1.0 mJ	> 1.5 mJ	> 30 µJ
Beam quality	TEM_{00}; M^2 < 1.2			TEM_{00}; M^2 < 1.3			TEM_{00}; M^2 < 1.2
Repetition rate	Single pulse – 200 kHz (extendable to 1 MHz)						600 kHz
Centre wavelength	1028 nm ± 5 nm						
Output pulse stability	< 0.5 % rms over 24 hours *						
Pre-pulse contrast	> 1000 : 1 **						
Post-pulse contrast	> 200 : 1						
Polarization	Linear, horizontal						
Beam pointing stability	< 20 µrad/°C						
Beam divergence	1.1x diffraction limited (of M^2< 1.2 beam)						
Burst output	Pulse burst output on trigger signal. Every n^{th} pulse continuous or trigger controlled output (pulse temporal spacing in burst corresponds to amplifier repetition rate)						
Oscillator output	Optional, typical output 0.5–1 W, 76 MHz, < 100 fs						

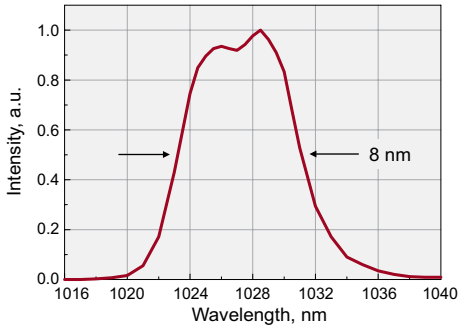
* Under stable environmental conditions ** With the pulse picker installed

PERFORMANCE SPECIFICATIONS OF HARMONIC GENERATORS

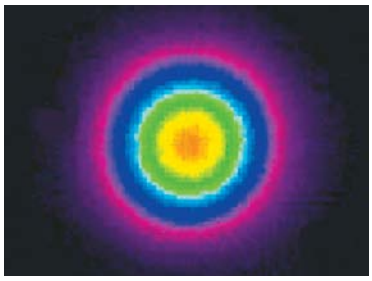
Model	G2	G3	G4	GA
Generated harmonics	SH	TH	FH	Fundamental, SH, TH (or FH) (automated harmonic selection)
Output wavelength	515 nm	343 nm	257 nm	1030 nm, 515 nm, 343 nm (257 nm)
Supported repetition rates	Single pulse – 1 MHz			
Supported pump pulse durations	200 fs - 10 ps	200 - 300 fs	200 - 300 fs	200 - 300 fs
Conversion efficiency	>50 %	>25 %	>10 %	>50 % SH, >25 % TH (or >10 % FH)
Beam quality	M^2 < 1.4	M^2 < 1.7	–	M^2 <1.4 SH, <1.7 TH



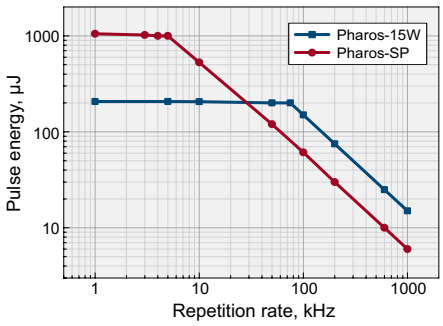
Pulse duration of PHAROS



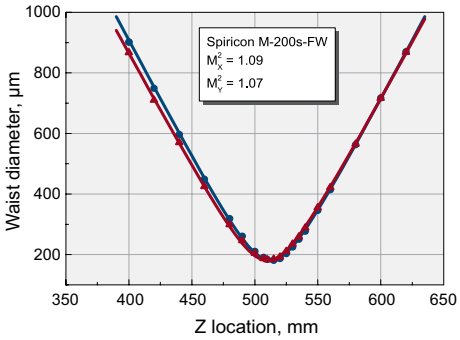
Spectrum of PHAROS



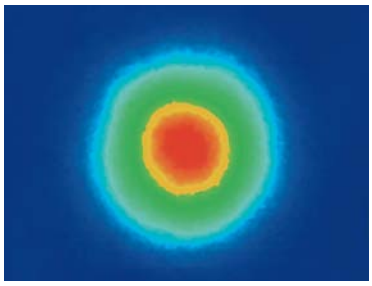
Typical PHAROS far field beam profile at 200 kHz



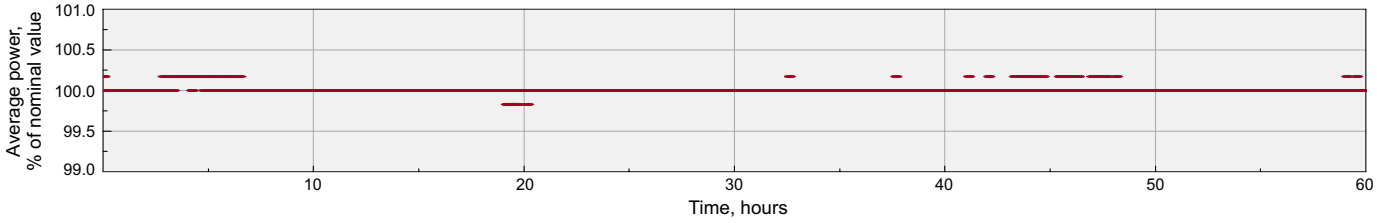
Pulse energy vs PRR



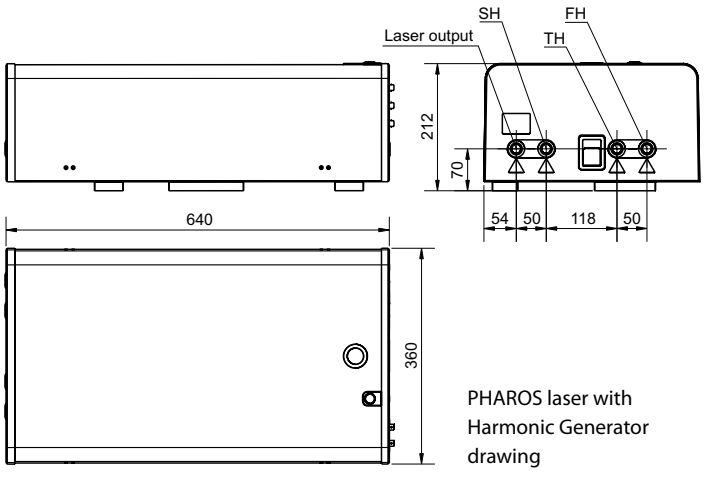
Typical PHAROS M^2 measurement data



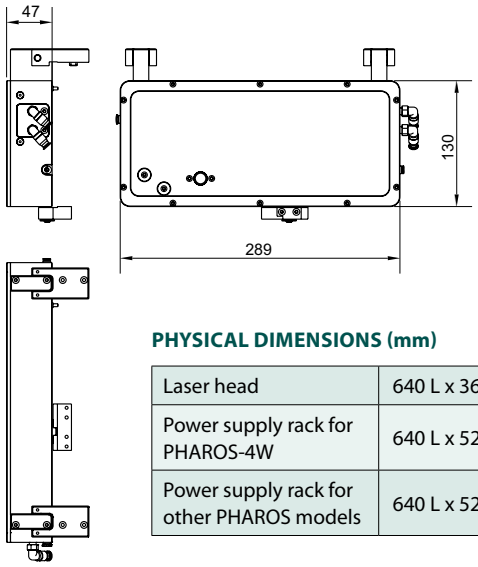
Typical PHAROS near field beam profile at 200 kHz



PHAROS long term stability graph, 0.4 % RMS



PHAROS laser with Harmonic Generator drawing



Harmonic Generator drawing

PHYSICAL DIMENSIONS (mm)

Laser head	640 L x 360 W x 212 H
Power supply rack for PHAROS-4W	640 L x 520 W x 420 H
Power supply rack for other PHAROS models	640 L x 520 W x 553 H

UTILITY REQUIREMENTS

Electric	110 VAC, 50-60 Hz, 20 A or 220 VAC, 50-60 Hz, 10 A
Room temperature	15-30 °C (air conditioning recommended)
Relative humidity	20-80 % (non condensing)

LIGHT CONVERSION

APPLICATION EXAMPLES

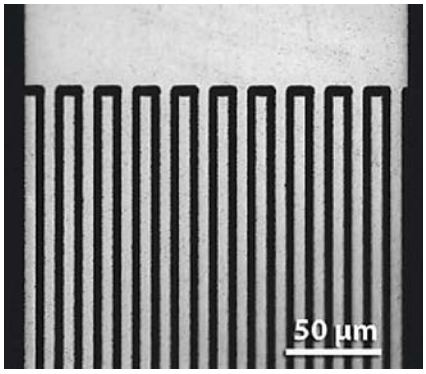


Fig. 1. Selective thin chromium layer ablation from $LiNbO_3$ crystal surface (Pharos-10W laser, 1030 nm fundamental output).
Courtesy of Workshop of Photonics, Altechna R&D Ltd.

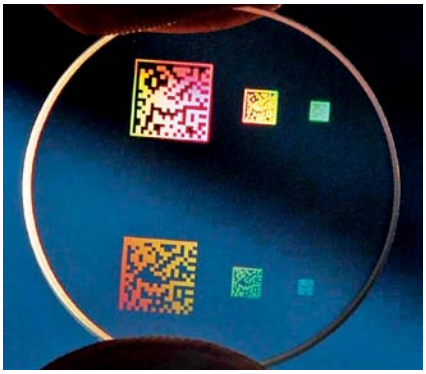


Fig. 2. Sapphire bulk marking Colors produced by diffraction from printed microscopic structures.
Courtesy of Workshop of Photonics, Altechna R&D Ltd.

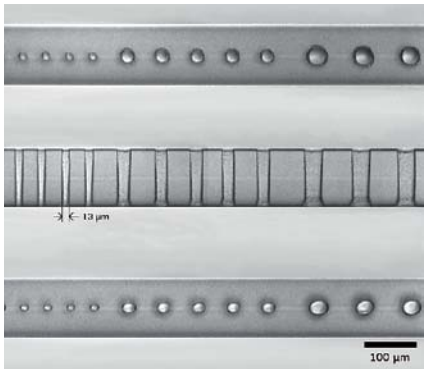


Fig. 3. Example of single mode fibre drilling (Pharos-10W laser, 343 nm third harmonic output).
Courtesy of Workshop of Photonics, Altechna R&D Ltd.

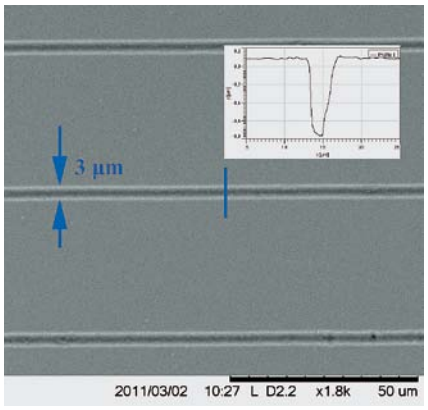


Fig. 4. Machining of grooves in fused silica for micro fluidic applications (Pharos-10W laser, 257 nm).
Courtesy of Workshop of Photonics, Altechna R&D Ltd.

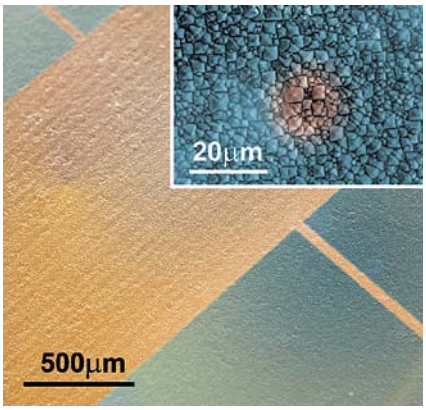


Fig. 5. Contact pathways opened by Pharos laser beam in dielectric SiN_x coated cSi solar cell. Inset – SiN_x layer selectively removed from the front surface of cSi wafer for subsequent Ni deposition.
Courtesy of Workshop of Photonics, Altechna R&D Ltd.

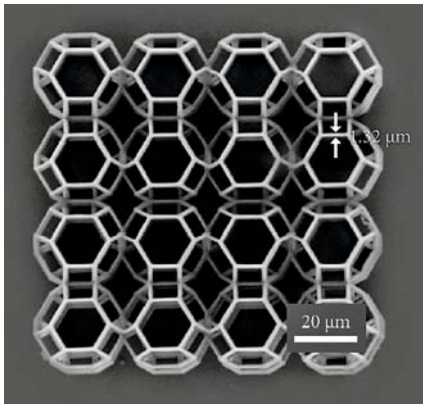
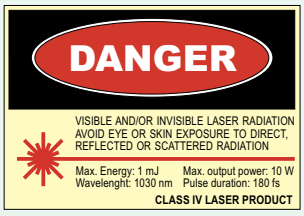


Fig. 6. Cell 3D scaffolding of biocompatible polymer produced by two photon photopolymerisation.
Courtesy of Vilnius University, Laser Research Center.



Specifications are subject to change without notice.

Local distributor list available at
www.lightcon.com

LIGHT CONVERSION

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