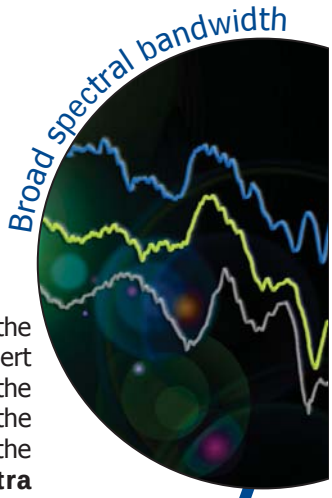
venteon OPCPA

The next generation ultrafast amplifier

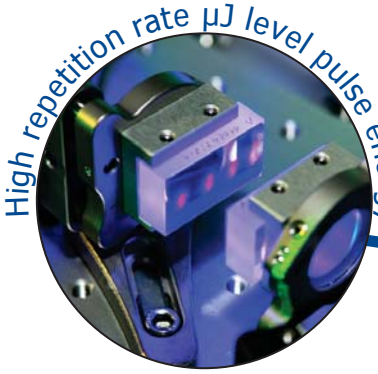
- Optical Parametric Chirped Pulse Amplifier (OPCPA)
- Few-cycle, <8 fs pulse duration
- High repetition rate 200 kHz to 4 MHz
- µJ level pulse energy
- Optional CEP stabilisation

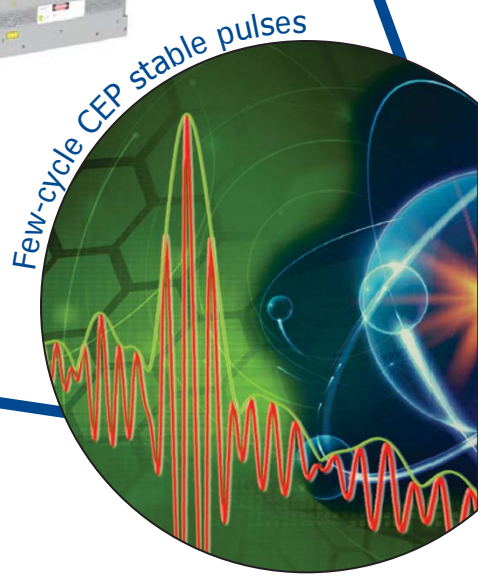


Overview

Laser Quantum is proud to introduce the newest generation of the first complete commercial OPCPA system worldwide! As an expert in ultrashort pulse generation, and having pioneered work in the field of parametric amplification, Laser Quantum now takes the next step with an innovative ultrafast amplifier that preserves the exceptional bandwidth and performance of the **venteon ultra** laser, delivering few-cycle, multi-µJ level pulses without additional nonlinear compression.

The **venteon OPCPA** system can provide the unique combination of few-cycle pulse durations together with a pulse energy within the µJ-regime and at high repetition rates. The excellent output stability and the ability for CEP stabilisation turns this amplifier system into the ideal source for nonlinear spectroscopy or High Harmonic Generation. Incorporating the **finesse pure** or **finesse pure CEP** pump laser, the **venteon OPCPA** has noise level specifications <1% (Fig. 3).





The applications of OPCPA

The **venteon OPCPA** is the only fully integrated ultrafast amplifier on the market that combines few-cycle pulse duration <8 fs , µJ level energy and a high repetition rate of 200 kHz or higher. Thereby, it is a unique light source for all applications benefitting from high photon flux, high intensity, broad bandwidth and ultrashort pulse duration.

A major application area is surface science, where two-photon photo-emission (2PPE) is one of the main techniques used to study the time-dependent interplay between electron, spin and phonon dynamics, as well as to study chemical reactivity at surfaces in real time.

With a peak power exceeding the GW level and peak intensities well beyond 10^{15} W/cm^2, the **venteon OPCPA** is an ideal tool for high repetition rate High Harmonic Generation and XUV spectroscopy. Correlation measurements benefit from the high repetition rate, so that data acquisition times can be reduced dramatically from several hours (with a 1 kHz amplifier) to only a few minutes with the **venteon OPCPA**. This also allows the study of unlikely events, as well as XUV spectroscopy, structure analysis and imaging techniques.

As another example, the **venteon OPCPA** allows new regimes of studying light-matter interaction in COLTRIMs by a dramatic improvement of statistics, so that e.g. coincidence measurements and double ionisation processes can be performed which are not possible with Ti:Sapphire amplifier systems.

In addition to these selected examples, with the high photon flux and unique combination of few-cycle pulse duration, high repetition rate and µJ level energy, the **venteon OPCPA** offers decisive advantages for a wide field of nonlinear application or spectroscopy methods. An example includes CARS, which will profit from a dramatic decrease of measurement time, enhanced statistics and the excellent CEP stability.

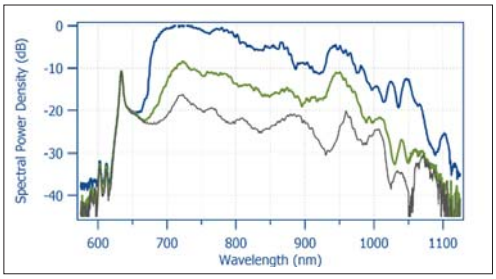


Fig. 1. Typical amplified output spectrum of the **venteon OPCPA** (blue) together with the broadband seed spectrum (black) and amplified spectrum of the first NOPA stage (green). Due to the ultra-broadband gain characteristic of the parametric process, nearly the whole seeded bandwidth becomes amplified enabling pulse durations <8 fs.

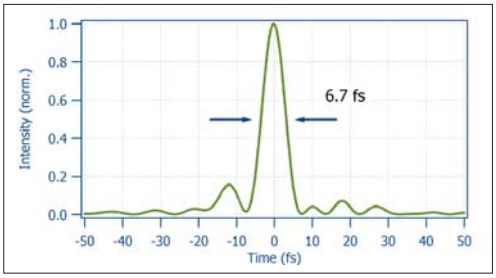


Fig. 2. Typical compressed output pulse of the **venteon OPCPA** system measured with **venteon SPIDER**. The few-cycle pulse duration together with the ability for a CEP stabilisation (see below) and pulse energies with µJ-levels, make this system ideally suited for e.g. attosecond science and nonlinear spectroscopy.

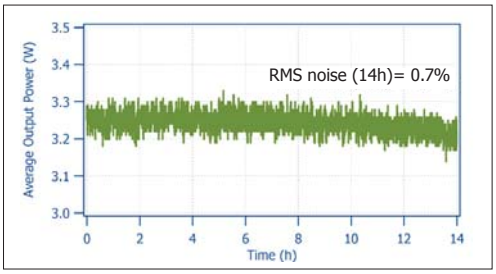


Fig. 3. Typical long term stability of the **venteon OPCPA** shown for 14 hours.

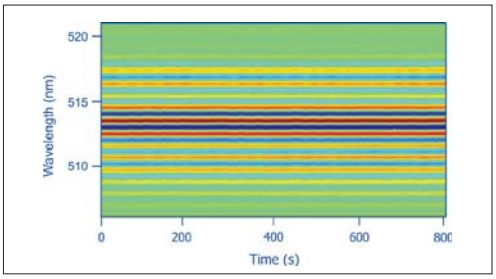


Fig. 4. Typical output CEP stability of the **venteon OPCPA** measured with a second f-to-2f interferometer for the compressed output. A slow feedback loop to the seed oscillator is used for the stabilisation. The system features an RMS phase error smaller than 100 mrad (measured over more than 10 min @ 3 ms integration time).

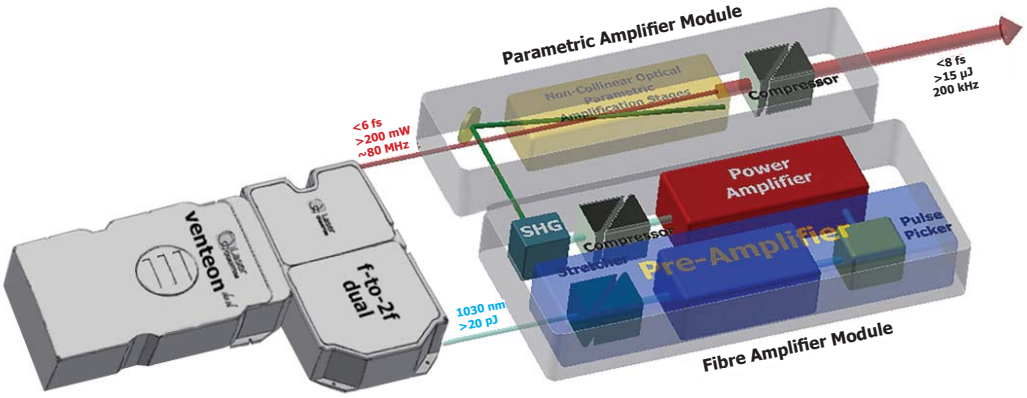
Innovative technology

In contrast to commonly used Ti:Sapphire-based multipass or regenerative amplifier systems, the parametric amplification process, the key technology of the **venteon OPCPA** system, features a much larger gain bandwidth, and thus is ideally suited to support the ultrabroad bandwidth and pulse duration generated by the **venteon** femtosecond oscillators.

The basis of the **venteon OPCPA** system is a **venteon dual** laser that provides an ultra-broadband signal and an additional narrowband seed output @ 1030 nm. Since both laser outputs are filtered directly from the native laser spectrum and generated without any nonlinear broadening, a low timing jitter can be achieved resulting in minor residual noise in the final OPCPA output.

Due to the absence of thermal load problems within the amplifier stages, exceptional scaling performance and high repetition rates are possible. As a continuous upgrade program is maintained at Laser Quantum, specifications are subject to be improved without notification.

Principles of OPCPA

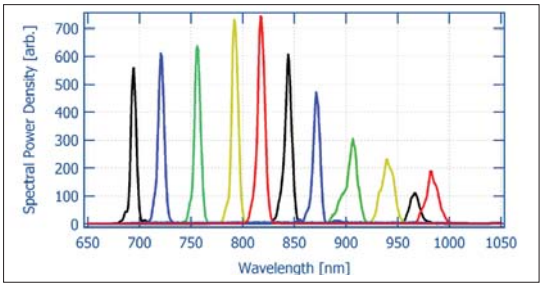


The **venteon dual** as an ideal front-end for OPCPA seeding since it offers two separate outputs. The ultrabroadband signal with a pulse duration of <6 fs and a seed output at 1030 nm and >20 pJ for subsequent power amplification. No nonlinear broadening of the Ti:Sapphire spectrum is needed, resulting in excellent stability and intrinsically low jitter between the two outputs.

After frequency doubling of the high power 1030 nm pump beam, the ultrabroad signal is simply amplified in two parametric amplification stages supporting an enormous bandwidth of 650 nm to 1100 nm. As this process is highly efficient, no complicated multi-pass arrangement is required. Due to the ultrashort pump pulses, the highly energetic signal pulses can be compressed in a mirror-based compressor with high throughput and well-matched order dispersion. The final amplified pulses therefore retain the ultra high spectral bandwidth >300 nm (@-10 dBc) , short pulsedurations of <8 fs and high energies >15 µJ@200 kHz repetition rate. Higher powers are also achievable with upgraded system configurations.

System versatility & customisation

In addition to the unique few-cycle specification, the **venteon OPCPA** is very versatile and can provide additional synchronous outputs at 515 nm or 1030 nm with high average power >25 W (515 nm) or >50 W (1030 nm) @ 200 kHz and less than 250 fs pulse duration. As an alternative to the broadband operation, an easy change to a tuneable output between 700 nm and 1000 nm is possible while maintaining the high µJ pulse energy. Available pulse duration and spectral bandwidth can be customised to a large extent in this mode of operation.

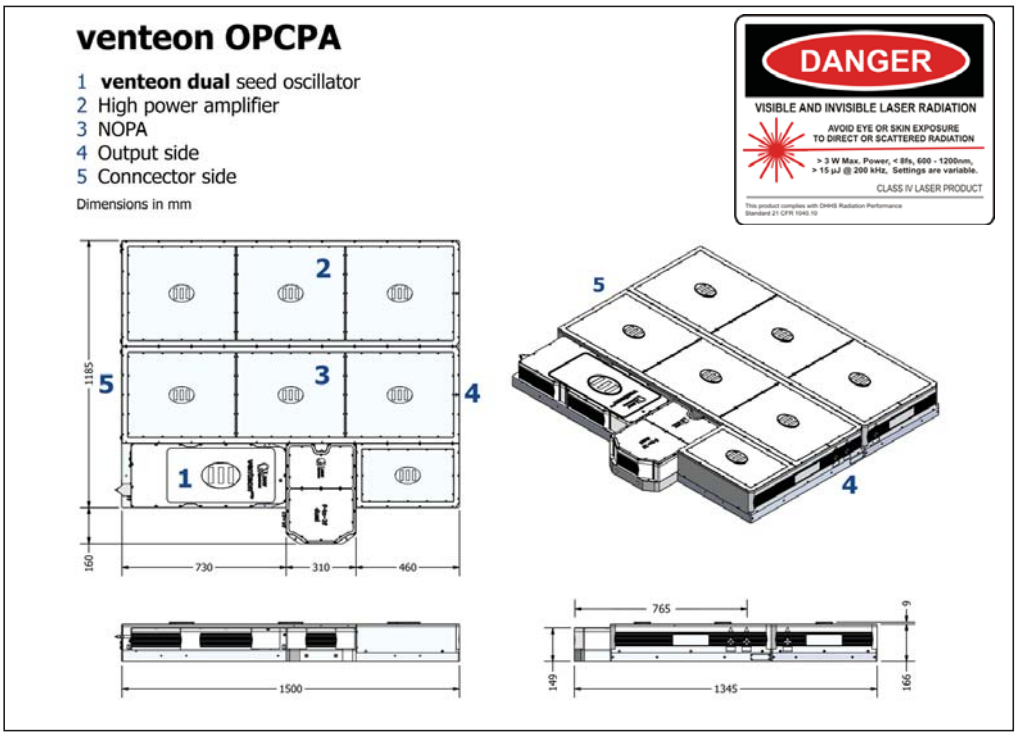


The combination of additional laser pulses delivered at 515 nm or 1030 nm, together with the broadband or tunable OPCPA output, furthermore allows efficient frequency conversion from the UV to MID-IR, thus making the **venteon OPCPA** a multi-functional light source which provides intense ultrashort pulses at µJ level and MHz repetition rate.

Related products		**Variants and upgrades**	
venteon dual	Ideal front end for the OPCPA amplification process, available as a stand alone unit for other research applications.	**CEP ready**	The **venteon OPCPA** can be supplied ready for future upgrade to a fully CEP locked amplifier system. This option includes the **finesse pure CEP** pump laser that features CEPLoQ™ technology. CEPLoQ™ allows direct pump modulation leading to faster and more stable responses than traditional methods.
venteon pre-amp1	Designed for the amplification of low energy pulses (~10 pJ) to significantly higher power levels (~1 nJ).		
venteon pre-amp2	Integrated pulse picker that can operate between 80 and 0.3 MHz.	**CEP upgrade**	The **venteon OPCPA** can be supplied fully configured and CEP or CEP-Zero stabilised.

venteon OPCPA

Dimensions (mm)



Drawings are for illustrative purposes only. Please contact Laser Quantum for complete engineer's drawings.

System configurations

OPCPA is a fast developing technique and Laser Quantum is at the forefront of this advance. As our mission is to make this technology available for a wide range of applications, we are keen to collaborate with scientists to configure the **venteon OPCPA** amplifier to fulfil their demands. Additional amplifier stages can generate higher power, optic alignments can provide access to other beams, and pulse parameters can be adjusted. As the world-leader in OPCPA, Laser Quantum is ideally positioned to continue the technological advance and the benefits it brings.

Specifications*

	venteon OPCPA		
Pulse energy[1,2]	>15 µJ	>3 µJ	>0.75 µJ
Repetition rate[3]	200 kHz	1 MHz	4 MHz
Average output power	>3 W		
Pulse duration (measured)	<8 fs		
Spectral bandwidth	>300 nm (@-10 dBc)		
Noise (RMS)	<1%		
Power requirement	110 - 230 V single phase 50-60 Hz		
Additional outputs	Multi-colour outputs at 1030 nm, 515 nm are available on request		

* Laser Quantum operates a continuous improvement programme which can result in specifications being improved without notice.
[1] Higher amplified power is available with development system configurations.
[2] System will be manufactured to achieve the target repetition rate with the corresponding pulse energy. Only one set of repetition rate / pulse energy is specified. Operation at other repetition rates using the same layout can be discussed.
[3] Other target repetition rates can be discussed.

LASER QUANTUM LTD
tel: +44 (0) 161 975 5300
email: info@laserquantum.com
web: www.laserquantum.com

LASER QUANTUM INC
tel: +1 408 501 0079
email: info@laserquantum.com
web: www.laserquantum.com

LASER QUANTUM GmbH
tel: +49 7531 368371
email: info@laserquantum.com
web: www.laserquantum.com

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