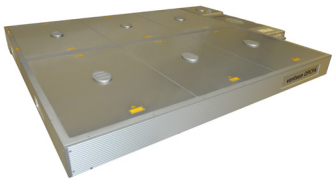
venteon OPCPA

Femtosecond amplifier system

- Optical Parametric Chirped Pulse Amplifier (OPCPA)
- Few-cycle, <8fs pulse duration
- High repetition rate 200kHz to 1MHz
- µJ level pulse energy
- Optional CEP stabilisation



Overview

Laser Quantum is proud to introduce 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 (Fig. 1 & 2). 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 below 1% (Fig. 3).

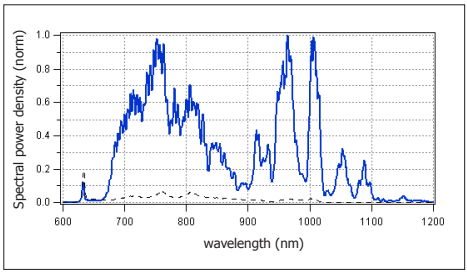


Fig. 1. Amplified output spectrum of the **venteon OPCPA** (blue) and initial signal seed spectrum of the broadband **venteon dual** seed oscillator (black). Due to the ultra-broadband gain characteristic of the parametric process, nearly the whole seeded bandwidth becomes amplified enabling pulse durations <8fs.

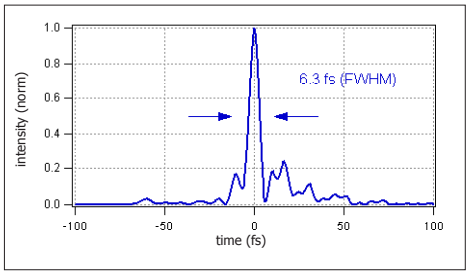


Fig. 2. Compressed output pulse of the **venteon OPCPA** system measured with **venteon SPIDER**. The few-cycle pulse duration together with the ability for a CEP stabilisation (see below) and pulse energies with µJ-levels, make this system ideally suited for e.g. attosecond science and nonlinear spectroscopy.

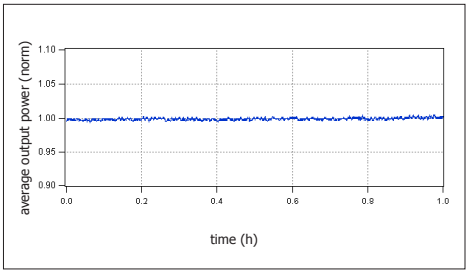


Fig. 3. rms noise of the **venteon OPCPA** output after system warm-up time. This exceptional low-noise output performance can be achieved even without an active power stabilisation e.g. controlling the delay stages within the NOPA process.

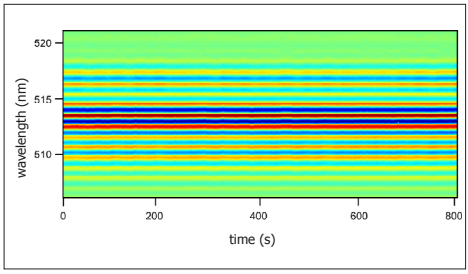


Fig. 4. Output CEP stability of the **venteon OPCPA** measured with an second f-to-2f interferometer for the compressed output. A slow feedback loop to the seed oscillator is used for the stabilisation. The system features an rms phase error smaller than 100 mrad (measured over more than 10 min @ 3ms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

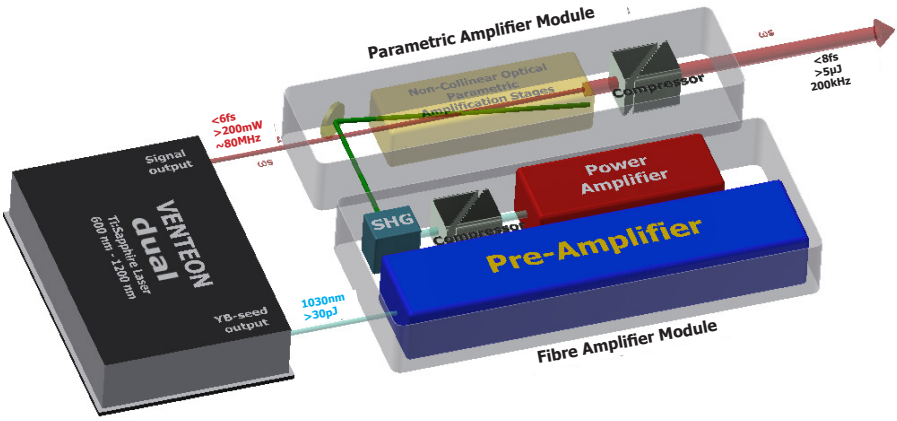
Innovative technology

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 @ 1030nm. 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 <6fs and a seed output at 1030nm and >30pJ 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 1030nm pump beam, the ultrabroad signal is simply amplified in two parametric amplification stages supporting an enormous bandwidth of 650 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 high order dispersion. The final amplified pulses therefore retain the ultra high spectral bandwidth >300nm (at -10dBc), short pulse durations of <8fs and high energies of >5µJ at high repetition rates of 200kHz. Higher powers and shorter pulses are also achievable with upgraded system configurations.

Carrier Envelope Phase stabilisation

The amplified output pulses of the **venteon OPCPA** system can be easily stabilised with respect to their carrier envelope phase (CEP), since the parametric amplification process conserves the CEP of the signal pulses. Due to the mechanical stability and sophisticated engineering of the whole amplifier system, the CEP performance of the seed laser system can be preserved and transferred to the amplified output with an ultra low rms phase noise.

The CEP stabilisation of the seed pulses is derived directly from the octave-spanning output spectrum of the front-end oscillator, realising the f-to-2f beating without any additional spectral broadening by either a PCF or PPLN device. Thus the amplifier system can benefit from this most natural, direct and reliable approach for a CEP stabilisation without affecting the laser output pulse and giving an excellent long-term locking performance with low drift and timing jitter (Fig. 4).

The applications of OPCPA

The **venteon OPCPA** is the only fully integrated ultrafast amplifier on the market that combines few-cycle <8fs pulse duration, µJ-level energy and high repetition rate of 200kHz 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. Apart from prominent examples such as high harmonic or attosecond pulse generation, a wide range of nonlinear techniques such as XUV spectroscopy, light-matter interaction in COLTRIMS or photoelectron emission microscopy (PEEM) are greatly profiting from dramatic decrease of measurement times, enhanced statistics or absence of space-charge effects.

Variants and upgrades

CEP ready: The **venteon OPCPA** can be supplied ready for future upgrade to a fully CEP locked laser. The CEP ready option includes the electronics, upgraded chiller unit and 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.

CEP upgrade: The **venteon OPCPA** can be supplied fully configured and CEP or CEP-Zero stabilised.

Related products

venteon dual: An ideal front end for the OPCPA amplification process, the **venteon dual** forms an integral part of the **venteon OPCPA** system, but is also available as a stand alone unit for other research applications.

venteon pre-amp1: Designed for the amplification of low energy pulses (~10pJ) to significantly higher power levels (~1nJ), it forms part of the **venteon OPCPA**, but can be used as a power amplifier for other applications.

venteon pre-amp2: Similar to the **venteon pre-amp1**, this system has an integrated pulse picker that can operate at between 80 and 0.3MHz.

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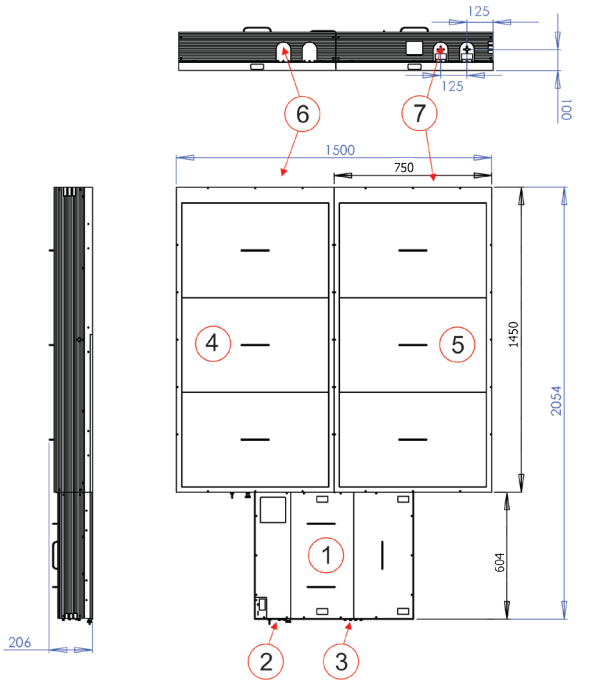

1. CEP stabilised Ti:Sapphire front-end oscillator
2. Pump laser / water/electrical connections
3. KLM starter / electrical connections
4. High Power amplifier unit
5. NOPA Unit
6. Output ports for OPCPA radiation
7. Auxilliary output ports

Dimensions in 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, or 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]	> 5µJ @200kHz >1µJ @1MHz
Average power output	>1W
Repetition rate	200kHz to 1MHz
Pulse duration	<8fs
Spectral bandwidth	>300nm (@-10dBc)
Noise	<1% rms
Power requirement	110 - 230V single phase 50-60Hz
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. See above.

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