Whitepaper

High energy few-cycle **OPCPA** system with variable repetition rate and tunable output

Abstract: *This whitepaper presents results from a compact Ti:Sapphire seeded* ***OPCPA*** *with high pulse energy >15 μJ, delivering few-cycle pulses of <8 fs at 200 kHz with a long active stabilisation and operation over several hours with low RMS noise of <1 %. The repetition rate of the* ***OPCPA*** *can be chosen between 0.1 and 4 MHz. Alternatively, we demonstrate the ability to use the* ***venteon OPCPA*** *in a narrow spectral output with tunability between 680 and 1050 nm and more than 15 μJ (at 100 kHz) pulse energy over the whole tuning range, from 720 to 920 nm.*

Introduction

The **OPCPA** uses a **venteon dual** as it presents an ideal **OPCPA** front-end, providing both ultrabroad signal pulses as well as a 1030 nm seed for the Yb-based amplifier. It exhibits extremely low jitter, as no nonlinearities are needed to achieve this broadband spectrum. The **venteon ultra** generates an octave-spanning spectral output, allowing for natural CEP locking without artificial band broadening. Using a specially designed dichroic mirror, the 1030 nm part is extracted from this output to be amplified and after frequency doubling form the pump pulse for the parametric stage. The remaining broadband beam forms the signal pulses. The parametric process allows for the broadband amplification if a non-collinear geometry is chosen and is thus ideally suited to amplify few-cycle pulses. High repetition rates are possible, as the parametric effect in the crystal is instantaneous and does not absorb any pump light. This also reduces heat management requirements.

Variable Repetition Rate

With a repetition rate that is changeable from 0.1 to 4 MHz, the **venteon OPCPA** can provide

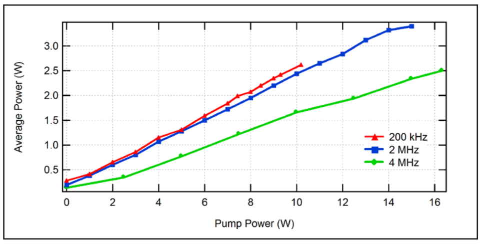

Figure 2: This shows the NOPA output at 200 kHz and 2 MHz levels with adapted focussing, as well as 4 MHz with non-adapted focus size.

the pulse characteristics to suit an application. At lower repetition rates (~200 kHz), the pulse energy of >15 μJ can be used for High Harmonic Generation which requires intensities in the order of 10^{14} W/cm^2. At the higher MHz repetition rates the **OPCPA** has high photon flux making it ideal for applications such as nonlinear conversion and spectroscopy, where averaging and statistical analysis benefit.

Figure 1a shows the spectral bandwidth of the **OPCPA** at three different repetitions, with Figure 1b showing the resulting pulse durations. Scaling the repetition rate from 200 kHz to 2 MHz requires the maintenance of the peak intensities at both the SHG and parametric amplifier crystal. Figure 2 shows the resulting NOPA output at the 200 kHz and 2 MHz levels, showing the parametric output power is unchanged over a range of pump powers due to the use of optimised focusing modules.

Scaling from 2 to 4 MHz can be achieved with the same optical setup, and reduces switching between the two to a simple button press. Figures 3a and 3b show the NOPA output versus pump power and the pulse duration as measured by a **SPIDER**. It can be seen that the amplification efficiency is maintained

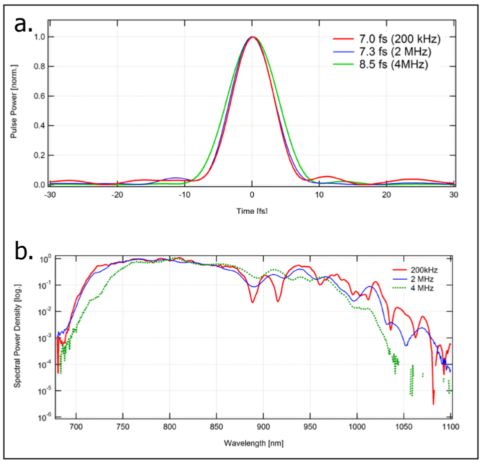

Figure 3a and 3b: These graphs show the NOPA output versus pump power and the pulse durations as measured by a **SPIDER**.

and with a slight narrowing of the bandwidth at 4 MHz, the pulse characteristics are maintained.

OPCPA Tuning

Due to the short 515 nm pump pulses at <250 fs, the **venteon OPCPA** can easily be operated in tunable mode. By chirping the signal pulse, only a short (but controllable) part of the pulse is amplified in the parametric crystal (Figure 4). The amplified bandwidth and pulse duration are only determined by the applied chirp and the wavelength selection is adjusted by altering the time delay between signal and pump pulse, via a simple delay translation stage arrangement. Since the parametric process is instantaneous, the speed of output tuning is therefore only limited by the speed of movement of the translation stage.

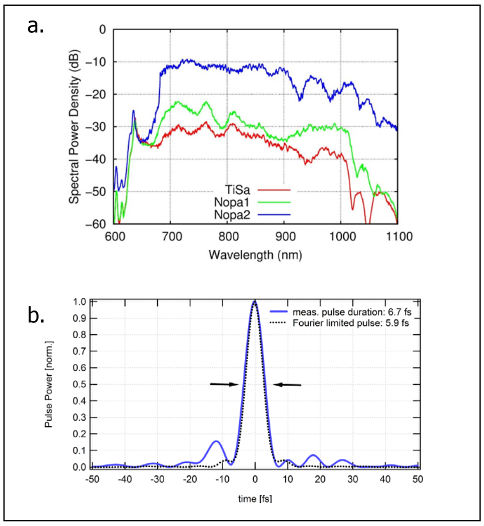

Figure 1a: The spectral bandwidth of the **OPCPA** at different repetition rates. 1b: The resulting pulse durations from the different repetition rates.

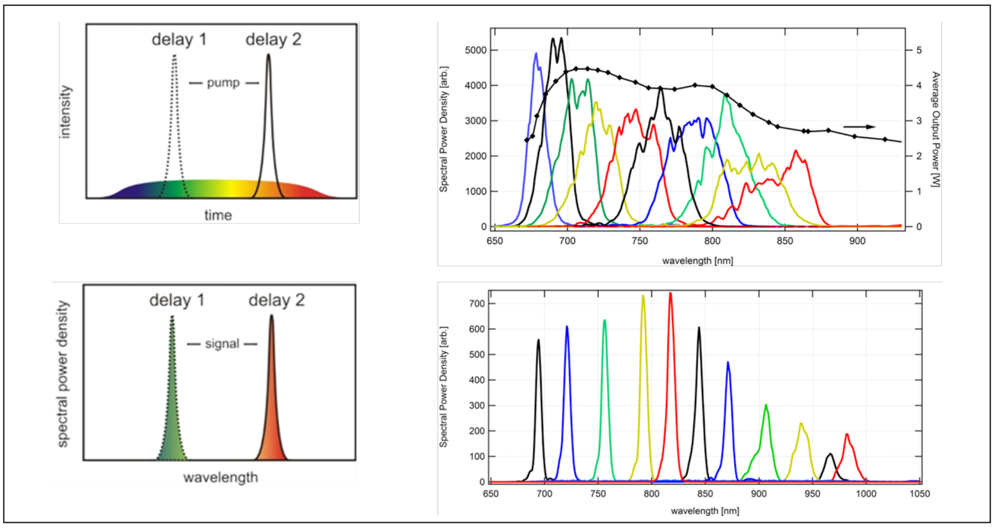

Figure 4: This shows a short but controllable part of the pulse being amplified in the parametric crystal after the signal pulse has been chirped.

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