A High-power (11 W), tunable (1.45 - 1.65 µm) OPCPA for THz generation in organic crystals

Ivanka Grguraš, Torsten Golz, Michael Schulz, Jan Heye Buss, Robert Riedel and Mark J. Prandolini

Class 5 Photonics GmbH, DESY Campus, Notkestrasse 85, 22607 Hamburg
Corresponding Author: robert.riedel@class5photonics.com Website: www.class5photonics.com

Abstract

Owing to their high second-order nonlinear susceptibility, organic crystals have gained tremendous interest as THz generators. Recently, high-field THz generation in several organic crystals , for example, OH1[1] [1], DSTMS[2] [2], and DAST[3] [3] have been demonstrated. The velocity phase matching condition is achieved using collinear propagating geometry. The phase matching condition is best fullfilled when the pump wavelength is in the IR range from 1400 nm to 1700 nm. The absorption of the pump light in the crystals is reduced in this wavelength region, leading to an increased damage threshold, which enables higher pump fluences and hence a higher conversion efficiency.

A compact, white-light generation (WLG) seeded, optical parametric chirped-pulse amplifier (OPCPA) [4] was extended to a tunable, high power laser system centered at a wavelength of 1.55 µm with a pulse duration of < 36 fs and a repetition rate of 350 kHz. In addition, an optically synchronized compressed probe pulse with a pulse duration of < 15 fs at 850 nm was made available as a second output channel.

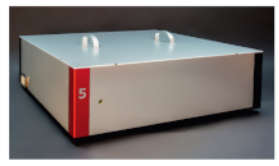
The customized WLG-module from Class 5 Photonics provides a stable and tunable platform to meet the application needs. Futhermore, this system can be pumped by a standard industrial Yb-dopped solid-state laser, for example, Yb:YAG Innoslab or thin-disk, or Yb-doped fiber laser system, and is scalable to hundreds of watts [5].

[1] 2-(3-(4-Hydroxystyryl)-5,5-dimethylcyclohex-2-enylidene)malononitrile
[2] 4-N,N-dimethylamino-4'-N'-methyl-stilbazolium 2,4,6-trimethlybenzenzesulfonate
[3] 4-N,N-dimethylamino-4'-N'-methyl-stilbazolium tosylate

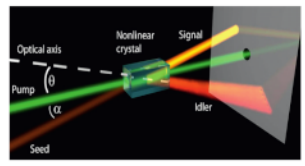
Optical-Parametric Chirped-Pulse Amplification

Industrial femtosecond laser (Yb:YAG, Yb:Fiber)

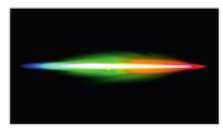
Femtosecond OPCPA module



Non-collinear phase-matching



High Average Power
200 W / 100 kHz



Few-Cycle Pulses
< 10 fs

Large Wavelength Range
350 - 3500 nm

1. Low absorption: Average power > 100 W possible
2. Broad bandwidth: Few-Cycle pulses and wavelength tuning
3. High single-pass gain: Compact Laser architecture
4. White-Light Generation: Long-term stability and low maintenance

Schematic Layout near- infrared pump-probe laser system

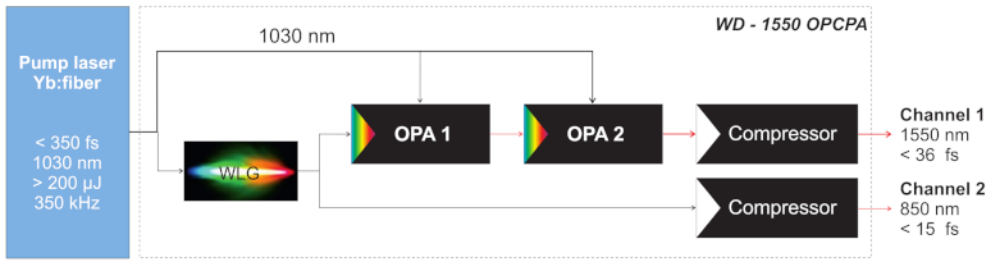


FIG. 1. Schematic setup of the high power near-infrared pump-probe laser system: WLG- white light generation, OPA - optical parametric amplifier.

Output Parameters

Parameter	NIR channel (Ch. 1)	WLG channel (Ch. 2)
Output power (W)	11	> 3.5 mW
Repetition Rate (MHz)	0.35	0.35
Power fluctuation (rms)	0.4%	-
Center wavelength (nm)	1550	850
Pulse duration (fs)	36	< 15 fs
Tunability	1.45 - 1.65 µm	not tunable
Pulse Energy (µJ)	up to 31	> 10 nJ

FROG characterization of the NIR pulse

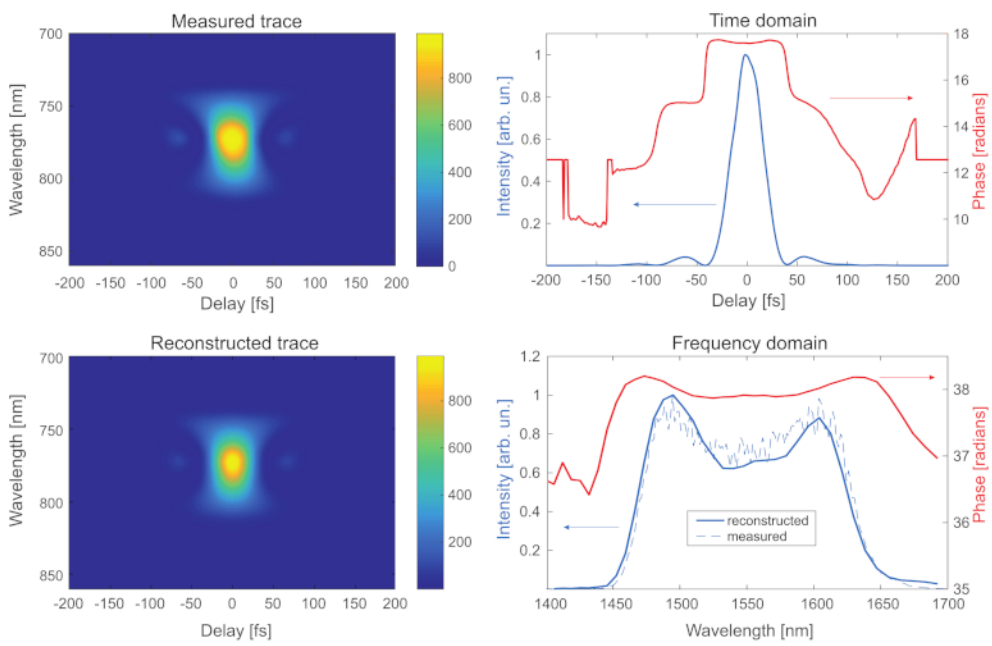


FIG. 2. Second-Harmonic Frequency-resolved optical gating (FROG) characterization of the 36 fs NIR pulse.

Power Stability

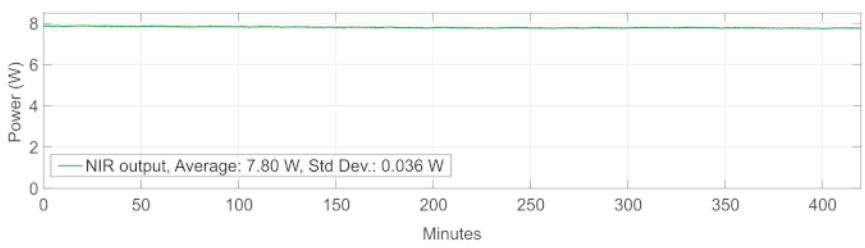


FIG. 3. Power stability of the NIR output.

References

1. M. Savoini, L. Huber, H. Cuppen, E. Abreu, M. Kubli, M. J. Neugebauer, Y. Duan, P. Beaud, J. Xu, and T. Rasing, "THz Generation and Detection by Fluorenone Based Organic Crystals," ACS Photonics **5**, 671–677 (2018).
2. A. Curcio, V. Dolci, S. Lupi, and M. Petrarca, "Terahertz-based retrieval of the spectral phase and amplitude of ultrashort laser pulses," Opt. Lett. **43**, 783 (2018).
3. C. Vicario, B. Monszlai, G. Arisholm, and C.P. Hauri, "Generation of 1.5-octave intense infrared pulses by nonlinear interactions in DAST crystal," J. Opt. **17**, 094005 (2015).
4. R. Riedel, A. Stephanides, M. J. Prandolini, B. Gronloh, B. Jungbluth, T. Mans and F. Tavella, "Power scaling of supercontinuum seeded megahertz-repetion rate optical parametric chirped pulse amplifiers," Opt. Lett. **39**, 1422–1424 (2014).
5. K. Mecseki, H. T. Olgun, M. Windeler, M. Schulz, R. Riedel, F. Tavella, and M. J. Prandolini, "Investigation of the critical parameters for CEP stabilized high power 1.5 m OPCPA," Proceedings Vol. 10082, Solid State Lasers XXVI: Technology and Devices; 100821C (2017).