

100 kHz tunable mid-IR source for 2D-IR spectroscopy

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We present a 100-kHz parametric source delivering 40-fs pulses with an average output power of ~ 1 W. This source is tunable from 2.5 to 4.0 μm and delivers idler pulses in the 1.4-1.75 μm spectral range.

The ability to generate ultrashort pulses in the mid-infrared (MIR) region is of primary interest for coherent 2D infrared (2D-IR) spectroscopy. With the recent advent of 100-kHz-repetition-rate middle-infrared sources and high-speed pulse shaping techniques, time-domain 2D-IR spectra can be recorded within a fraction of a second [1]. This increase in repetition rate not only improves the consistency of the experimental data but also offers the unique capability to measure spatially resolved dynamics on molecular frame in condensed-phase matter and liquids.

In this talk we describe a 100-kHz middle-infrared parametric source delivering 40-fs pulses, with an energy per pulse of 10 μJ à 3 μm , and tunable from 2.5-4.0 μm . Additionally, the spectral width of the pulses can be switched instantly from ~ 13 cm^{-1} (1.2 ps FTL) to ~ 370 cm^{-1} (40 fs FTL) without any moving parts.

At the heart of the system is a white-light (WL) seeded optical parametric chirped-pulse amplifier. Both the WL and the OPCPA are pumped by a single industrial-grade Ytterbium laser system delivering 1.2 ps pulses at 1030 nm. An acousto-optic programmable dispersive filter selects a part of the seed bandwidth and matches the duration of the seed pulses to the pump-pulse duration by either adding dispersion (40-fs mode) or narrowing the bandwidth (1.2-ps mode). A difference frequency-generation (DFG) between the pump and the shaped pulses is achieved in a fan-out collinear MgO:PPLN resulting in an idler wave tunable from ~ 2.5 to $\sim 4.0/4.5$ μm (see Fig.1). The idler wave is then amplified in two successive collinear MgO:PPLN OPAs to ramp up the energy up the multi- μJ level (10 μJ at 3.0 μm). Eventually the pulses are compressed in a Silicon rod.

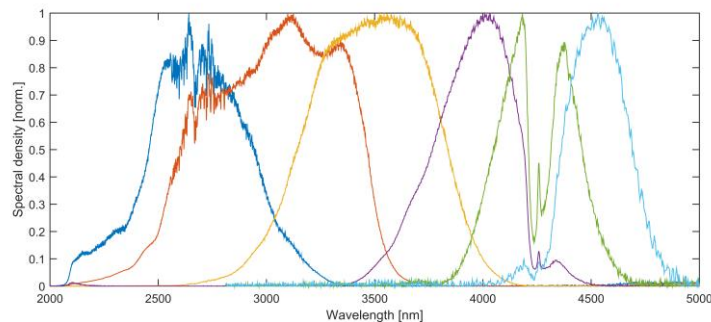


Fig. 1: Spectrum tunability from 2.6 to 4.5 μm .

As a by-product of the amplification process, the last OPA stage regenerates pulses at the wavelength of the shaped pulses (1.4-1.75 μm). Together with the 2.5-4.0 μm pulses, these pulses have the ideal properties to drive a tunable and/or ultrabroadband μJ -level infrared pulses in the 5-8 μm range through DFG in ZGP or AGS crystals.

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[1] B.M. Luther *et al.*, Opt. Express **24**, 4118 (2015)