High-energy mid-infrared femtosecond pulses generated by DC-OPA

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Development of high-energy infrared (IR) fs pulses currently have become important for strong-field laser sciences [1-3]. To break a bottleneck of energy scaling in the standard optical parametric amplification (OPA) scheme, we have proposed [4] and demonstrated [5-7] a dual chirped optical parametric amplification (DC-OPA) method. For the first time in literatures, we have obtained fs pulses with100-mJ-class energy and multi-TW peak power in 1-2 μm region by DC-OPA [8]. Moreover, DC-OPA is capable to generate high-energy mid-infrared (MIR) [9] and far-infrared (FIR) [7] fs pulses. In this work, we experimentally obtained 31 mJ pulses in the MIR wavelength region at 3.3 μm.

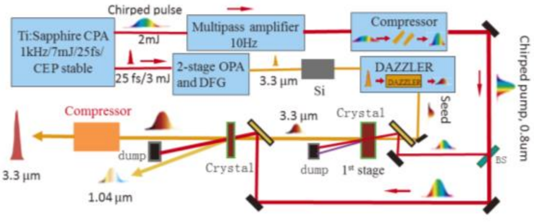

Fig. 1. Experimental setup of MIR DC-OPA.

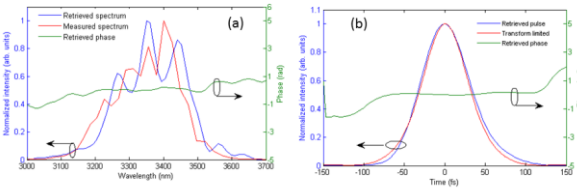

Fig. 2. (a) Measured spectrum (red solid), and retrieved spectrum (blue solid) and phase (green solid) by FROG. (b) Retrieved pulse (blue solid) and phase (green solid). Transform-limited pulse is shown by the red solid curve.

The experimental setup is shown in Fig. 1. The pump for DC-OPA was a Ti:sapphire laser (640 mJ/10 Hz/810 nm), with its duration stretched to ~ 5.2 ps. The seed (3.3 μm) for DC-OPA was provided by the difference frequency generation (DFG) between a signal and idler pulses after a two-stage OPA (TOPAS, Prime). Its pulse was stretched to ~ 4.1 ps by a silicon bulk and an AOPDF (dazzler, Fastlite). Type-I MgO: $LiNbO_3$ crystals were employed in the 2-stage DC-OPA system. Both stages were constructed in a noncollinear configuration. After the second stage, the seed pulse (3.3 μm) was amplified to ~ 31 mJ. The energy of pulses at 1.04 μm (DFG between pump and seed) was ~ 85 mJ. The total conversion efficiency after the second stage reached ~ 21%. Then, the high-energy MIR pulses at 3.3 μm were compressed by a CaF_2 bulk compressor. Fig. 2 (a) shows the retrieved spectrum and phase (FROG method) as well as the spectrum measured by a spectrometer (Mozza, Fastlite). The temporal pulse and phase were reconstructed as shown in Fig. 2 (b). The pulse duration was 70 fs (6.4 cycles) which was close to its TL duration of 66 fs.

Inclusion, we generated 31 mJ pulses near 3.3 μm using DC-OPA, which proves that DC-OPA is a superior technique for obtaining IR fs pulses with great energy scaling ability and wavelength tunability. The MIR pulse was compressed to 70 fs which consists of 6.4 optical cycles. In the following work, we will increase its peak power to TW-class by shorten the pulse duration to two-cycles [9] and by further increasing its pulse energy.

References

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