TW-class high-power femtosecond infrared laser source based on dual-chirped optical parametric amplification

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High-order harmonics generation [1] is a promising method to generate coherent ultrafast soft x-ray pulses from a tabletop fs laser. Longer-wavelength intense laser allows generating higher photon energy high harmonics (HH) [1, 2]. Now using ultrafast IR fs laser is recognized the best way to efficiently extend photon energy of HH. But current IR fs laser pulse energy is mostly several mJ class. Even it is possible to increase a pulse energy by OPCPA, the increased complexity makes it very difficult to develop such a laser system [3].

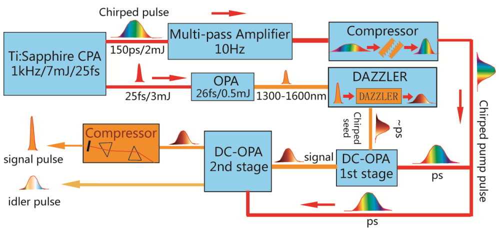

Fig. 1. Experimental setup of DC-OPA.

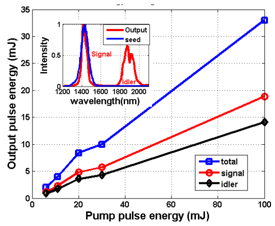

Fig. 2. Energy scalability of DC-OPA.

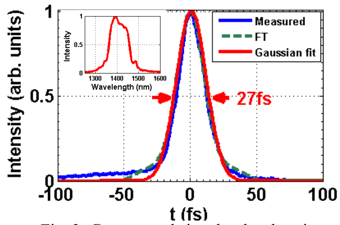

Fig. 3. Compressed signal pulse duration.

In this work, we demonstrate a simple and robust method to generate energy scalable high power IR fs pulses by Dual-Chirped Optical Parametric Amplification (DC-OPA) [4]. The experimental setup is shown in Fig. 1. To increase pumping energy without damage to BBO crystals, the pump pulse is temporally stretched to keep intensity well below damage threshold. Simultaneously a seed pulse is temporally stretched to well overlap with pump pulses in temporal domain. The seed pulse is formed in the first OPA stage (Coherent Inc. TOPAS Prime). Meanwhile, the high-energy output pulse from a 10 Hz-multi-pass amplifier (~ 100 mJ) is used to pump DC-OPA. Fig. 2 shows the energy scaling ability of this DC-OPA technique. For this demonstration, central wavelength of the seed pulse is fixed at ~1.4 μm. Under optimized dispersion condition, OPA energy linearly increases with pumping energy at conversion efficiency of 30% ~ 40%. When pump energy is increased to 100mJ, ~20mJ/1.4μm/signal and ~13mJ/1.9μm/idler pulses are generated. The inset figure shows the typical spectrum. This result clearly shows good energy scalability of DC-OPA. Signal pulses compression is demonstrated by a fused silica prism compressor. The signal spectrum is shown in the inset figure of Fig. 3. By carefully tuning the seed dispersion by DAZZLER and optimizing the prism compressor, the signal pulse duration is compressed to 27fs, as is shown in Fig. 3. This technique achieves the highest power infrared femtosecond source using OPA technique up to now. This DC-OPA technique will be a powerful tool for obtaining high power coherent soft X-ray pulses (e.g. "water window") by HHG, and for high laser field physics research.

References: [1] F. Krausz and M. Ivanov, Rev. Mod. Phys. **81**, 163 (2009); [2] E. J. Takahashi *et. al.*, Phys. Rev. Lett. **101**, 253901(2008); [3] Giedrius *et. al.*, Opt. Lett. **36**, 2755 (2011); [4] Q. Zhang *et. al.*, Opt. Express **19**, 7190 (2011)