reach the highest conversion efficiency, not the shortest pulse duration. At this level, we achieve an output XPW energy of 650 µJ and record internal efficiency of 33%. Similar spectral behavior is observed, compared to the previous experiment at 1.5 mJ. Pulse shortening from 30 fs down to 15.5 fs is confirmed after compression, together with a good spectral quality (Fig. 4a-b). An intensity transmission of 40% is attained at this energy level. Sub-10 fs pulse shortening is possible as well by moving the crystal closer to the waveguide thereby inducing SPM and carefully optimizing the spectral phase.

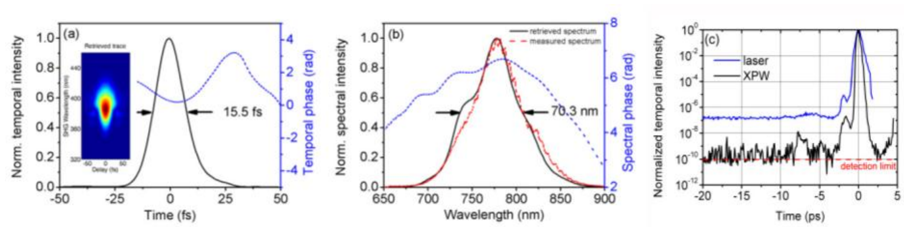

Fig. 4. (a) Temporal characterization of the high energy XPW pulse via FROG. Temporal profile and temporal phase with retrieved trace as inset (error = 0.14%) and (b) retrieved spectrum, measured spectrum and spectral phase. (c) Temporal contrast of the laser at 3.3 mJ and XPW pulse measured with a third-order cross-correlator.

Temporal contrast is measured with a homemade third-order high-dynamical cross-correlator [15]. The specific device has a 10-order of magnitude dynamic range when seeded with above 500 µJ. The cross-correlation is shown in Fig. 4c. The amplified spontaneous emission level of the laser is measured to be 10^{-7}. Consequently, XPW improves this by 3 orders of magnitude down to 10^{-10}, as determined by the extinction ratio of the Glan polarizer. The contrast could further be improved up to 10^{-12} with the use of high quality polarizers (extinction ratio 10^{-5}). As seen in Fig. 4c, two pre-pulses are found in the XPW pulse: one inherent in the laser at −2 ps and effectively suppressed down to 10^{-7} and one observed only in the XPW pulse at −7 ps, which may be an artifact since it disappeared in other measurements.

4. Conclusion

In conclusion, we present the highest ever reported efficiency for single crystal XPW generation at the multi-mJ level. High energy and intensity transmission is realized accordingly from efficient XPW conversion and pulse shortening. The suggested design is based on a novel spatial filtering configuration resulting in a compact and energy scalable setup. Furthermore, the effective spectral broadening due to the efficient XPW process, allows the compression of the input pulse to sub-10 fs. We believe that implementation of the device as an add-on to existing multi-mJ laser systems will directly result in high energy, contrast ratio enhanced, pulse shortened and CEP stable ultrashort laser sources. The maximum energy limitation of the setup is only imposed by the damage threshold of the waveguide. Moreover, in the point of view of industrial applications or for robust and reliable laser chains, the setup is very interesting because of its simplicity and compactness. Owing to its scalability, such a source could either be directly used for multi-mJ level high intensity experiments or as a broadband seed source for further amplification in laser chains.

Acknowledgments

The authors gratefully acknowledge financial support from the ILE 07-CPER 017-01 contract, the ANR-09-JCJC-0063 (UBICUIL) program and the Canadian National Research Council–Centre National de la Recherche Scientifique (CNRS) 2007 program.

#135890 - $15.00 USD Received 29 Sep 2010; revised 18 Nov 2010; accepted 18 Nov 2010; published 21 Dec 2010