Toward a Multi-kHz, Multi-mJ, Few Cycle, Phase Stabilized Laser System

Michaël Hemmer, Andreas Vaupel and Martin Richardson

CREOL, Townes Laser Institute, University of Central Florida, Orlando, FL, 32826, USA

Synopsis: The progress toward the completion of a multi-kHz, multi mJ few cycle OPCPA laser system is shown. The current and expected performances of the MOPA system generating the OPA pump beam are presented. Energies up to 0.5 mJ in a Gaussian spatial beam profile and high signal to noise ratio are currently obtained. The design and performances of the stretcher/compressor assembly are also discussed. The system is expected to provide up to 2 mJ at repetition rates in the 5 to 10 kHz range with pulse durations ~8 fs.

The emergence of attoscience has been made possible by the availability of table top laser systems generating pulses with durations approaching one cycle of electric field. Increasing the repetition rate and the energy of such laser systems while maintaining limited footprint and quasi turnkey operation is one of the current challenges in the laser development field. In this paper, we describe the current state and the expected performances of the multi-kHz, multi-mJ few cycle phase stabilized OPCPA system under development at the Townes Laser Institute.

The main Ti:Sapphire oscillator is a commercial system (Menlo Systems Inc.) generating an octave spanning spectrum centered at 850 nm, resulting in pulses as short as 4.7 fs. A feedback loop ensures carrier-envelope phase stabilization. The pump beam and signal beam are optically synchronized by splitting the pulse at the output of the main oscillator. The 1064 nm line of the main oscillator is seeds the MOPA that generates the pump beam while the rest of the pulse is carefully stretched and sent into the OPA.

The MOPA is a hybrid system combining fiber and solid state technology. A saturated two stage Yb fiber preamplifier is used to amplify the weak 1064 nm spectral line sampled from the main oscillator. The design ensures low ASE at 1064 nm, TEM_{00} spatial profile and buffering of the expected day to day fluctuations in seed energy. The preamplifiers can provide up to 5 nJ of energy in ~10 nm bandwidth at 85 MHz, the repetition rate of the main oscillator. The preamplifiers seed a $Nd:YVO_4$ regenerative amplifier that can operate at repetition rates up to 20 kHz. In the current state, the regenerative amplifier produces up to 0.5 mJ at 1 kHz and is limited by ASE. Thermal lensing issues are addressed by the cavity design, leading to a Gaussian output profile. Current improvements will lead to energies up to 0.3 mJ at 20 kHz from the regenerative amplifier. A $Nd:YVO_4$ double pass amplifier and a Nd:YAG four pass amplifier will complete the MOPA system allowing energies up to 15 mJ in the 5-10 kHz repetition rate range.

Before seeding the OPA, the ultrabroad band pulse from the main oscillator is down chirped by a grism pair and stretched to ~30 ps [1]. Fine adjustment of the chirp is performed by an Acousto-Optic Programmable Dispersion Filter (Dazzler, Fastlite). Measures are currently undertaken to remove the excess negative third order dispersion provided by the grism pair. Compression will be achieved by passing the amplified pulse through dispersive glass. The parametric amplification is expected to be performed in three type-I BBO crystals in a non-collinear geometry. Simulations show a 300 nm gain bandwidth for a noncollinear angle $\alpha = 2.39°$ and a phase matching angle $\beta = 23.8°$ [2].

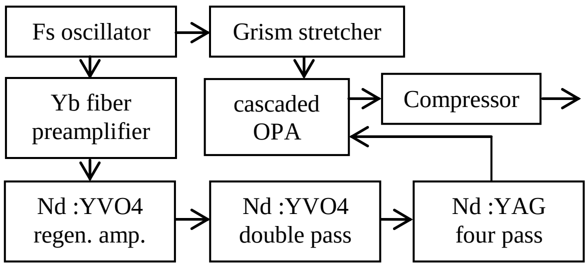

Fig.1. Layout of the laser system

The laser system is expected to provide energies up 2 mJ in the 5 to 10 kHz repetition rate. Further energy scalability is currently being investigated.

References

[1] Eikema et al., *Appl. Phys. B* **87**, 677-684 (2007)
[2] Tavella et al., *Opt. Letters* **32**, 2227-2229 (2007)

E-mail: hemmer@creol.ucf.edu