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# Sub-50 Femtosecond, Multiterwatt Ti: Sapphire Laser System

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We discuss a Ti:sapphire laser system based on chirped pulse amplification which produces over 750 mJ in sub-50 femtosecond pulses. We also describe a novel, all-reflective stretcher with a stretching ratio of 30,000.

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# Sub-50 femtosecond, multiterawatt Ti:sapphire laser system

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Recent advances in ultrashort (<100 fs) pulse lasers have made it possible to explore ultrahigh field physics using relatively compact laser systems. We report on the design and construction of a compact Nd:YLF/Ti:sapphire-based CPA system capable of producing over 750 mJ in pulses shorter than 50 fs at 1 Hz.

This system is composed of Kerr lens modelocked Ti:sapphire oscillator which produces sub-20 fs pulses centered at 820 nm in a 90 Mhz pulse train. As Perry et al.[1] have shown for systems based on chirped pulse amplification, high contrast in the temporal pulse shape after compression is limited by the B-integral accumulated in the system. To minimize this, a new, all-reflective stretcher design is used to stretch the pulse to 600 ps as shown in Figs. 1 and 2. Fig. 1 shows an interferometric autocorrelation trace of the oscillator output, corresponding to a pulse length of 22 fs FWHM. Using a fast avalanche photodiode with a sampling head, the stretched pulse length was measured at 600 ps FWHM as shown in Fig. 2. Finally, in addition to giving a stretching ratio of 30,000, the stretcher is aberration-free, is composed of only 4 elements, and has a bandpass of approximately 60 nm (as shown in Fig. 3).

Individual stretched pulses are injected at a 10 Hz repetition rate into a power amplifier chain comprised of 4 laser-pumped, Ti:sapphire stages. The first two of these are pumped at 10 Hz by the second harmonic output of a commercial Q-switched Nd:YAG laser. The third and fourth stages are pumped at 10 Hz and 1 Hz, respectively, by the doubled output of a Nd:YLF-based,

flashlamp-pumped, MOPA chain. This chain is seeded by a single longitudinal mode ring oscillator which produces 8 mJ in 15 ns pulses at 1053 nm and has smooth spatial and temporal profiles. The choice of Nd:YLF lasing at 1053 nm for this pump chain allows the option of adding large, Nd-phosphate glass amplifier heads to pump a fifth stage in the future.

The Ti:sapphire chain is composed of a regenerative amplifier which amplifies to 3 mJ followed by a series of three multi-pass amplifiers. The third amplifier stage produces pulse energies of 200 mJ which can be switched out directly to the compressor and compressed to under 50 fs—i.e. over 2 TW of peak power at 10 Hz. Finally, the fourth stage produces 750 mJ at 1 Hz compressed to less than 50 fs, providing a second beamline for higher power experiments with a peak power in excess of 15 TW.

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[1] M. D. Perry, T. Ditmire, B. C. Stuart, Opt. Lett. **19**, 2149 (1994).

# Captions:

Fig. 1: Interferometric autocorrelation trace of 22 fs pulses from Ti:sapphire oscillator.

Fig. 2: Sampled temporal profile of pulse after stretcher.

Fig. 3: Spectrum both before (solid line) and after (dashed line) stretcher.

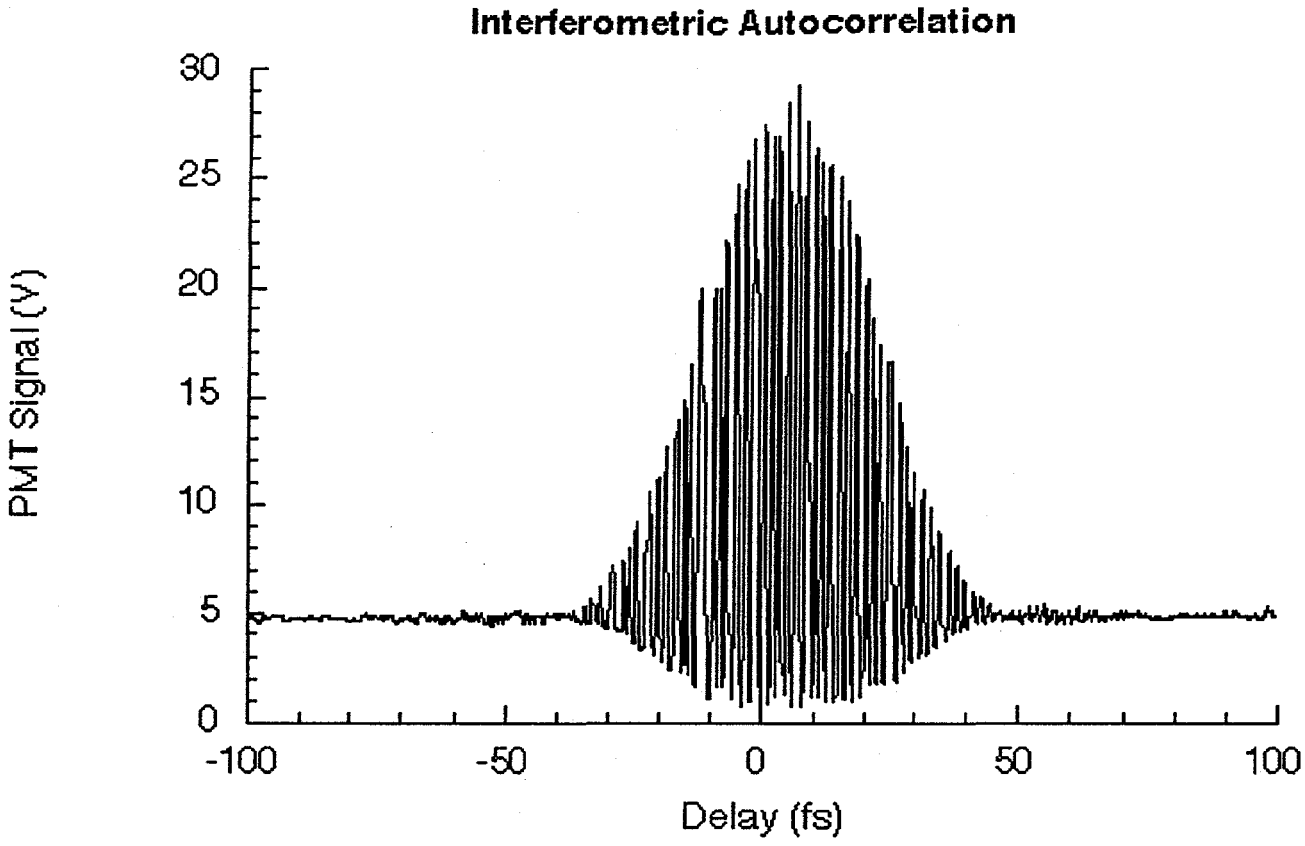


Figure 1

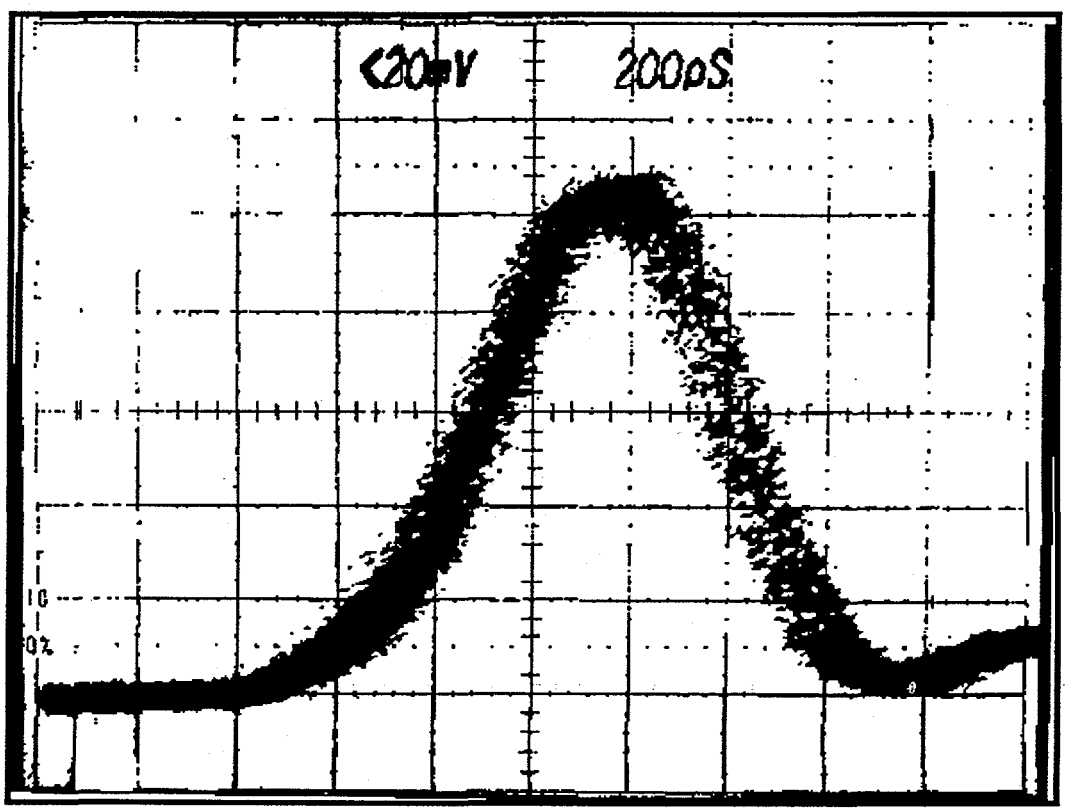


Figure 2

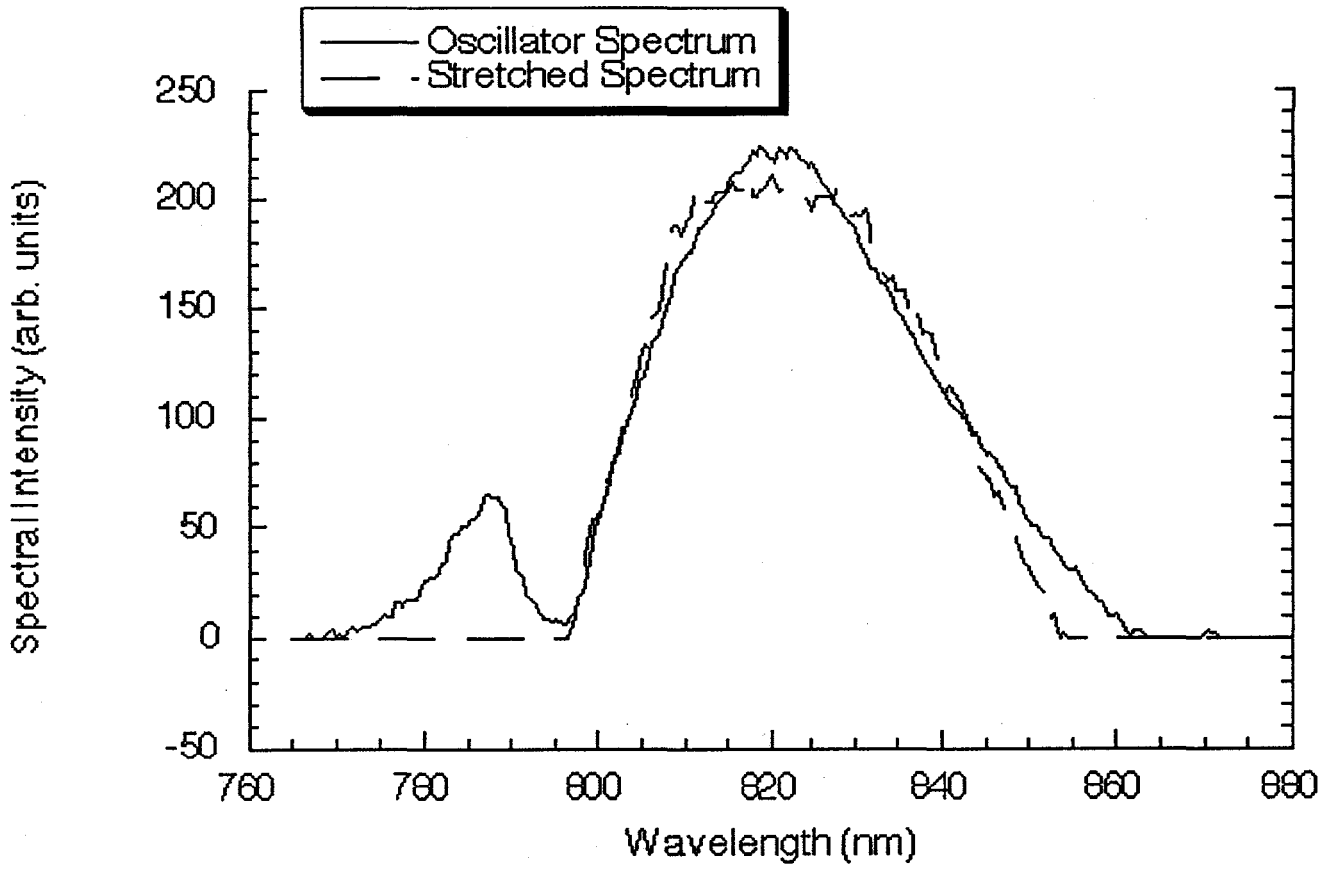
Oscillator Spectrum
Stretched Spectrum
250
200
150
100
50
0
-50
760
780
800
820
840
860
880
Spectral Intensity (arb. units)
Wavelength (nm)

Figure 3

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