Conf-930586--6

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UCRL-JC-113579
PREPRINT

Multi-Terrawatt. 100 fsec Laser System Using Flashlamp-Pumped, Dye-Converted Ti:Sapphire as an Amplifier

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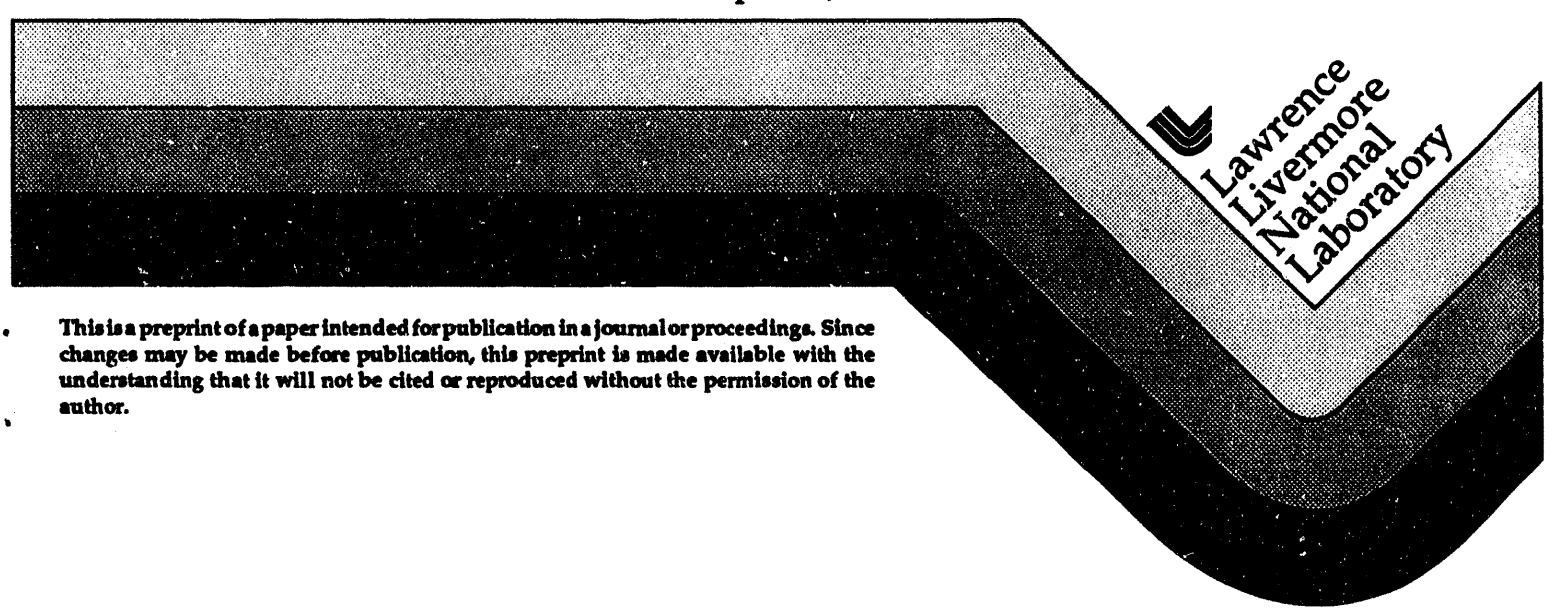
This paper was prepared for submittal to the
CLEO, Baltimore, Maryland
May 2–7, 1993

April 14, 1993



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Abstract

We report on amplification of 100 fsec laser pulses to 250 mJ using flashlamp-pumped, dye converted Ti:Sapphire. The resulting 5 Hz beam is focused to irradiances in excess of 5×10^{18} W/cm^2.

§ Work performed under the auspices of the U.S. Department of Energy by Lawrence Livermore Laboratory under Contract No. W-7405-Eng-48.

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Terrawatt level 100 fsec chirped pulse amplification[1] (CPA) systems have previously been reported using laser pumped Ti:Sapphire[2] and flashlamp pumped Cr:LiSAF[3] as final amplifiers. We have recently produced 2.5 TW pulses using a compact flashlamp pumped, dye-converted Ti:Sapphire amplifier. The availability of high quality Ti:Sapphire rods for this type of amplifier allows amplification with no significant spatial beam degradation. This amplifier exhibits many of the best characteristics of both types of systems: The high repetition rate and good spatial beam fidelity of laser pumped Ti:Sapphire as well as the convenience of a flashlamp pumped system.

Our system begins with 100 fsec transform limited laser pulses at 800 nm from a commercial Ti:Sapphire oscillator. These pulses are stretched to 400 ps in a grating pulse stretcher and amplified to 10 mJ in a Ti:Sapphire regenerative amplifier pumped by 60 mJ, 532 nm pulses from a doubled, Q-switched, Nd:YAG laser. Output from this amplifier is temporally cleaned in a Pockels cell pulse slicer and further amplified to 100 mJ in a double pass Ti:Sapphire amplifier pumped by 600 mJ, from another doubled, Q-switched, Nd:YAG laser. Output pulses from this amplifier are then amplified to 500 mJ in the flashlamp pumped amplifier. As shown in figure 1, compression of the output of this amplifier results in <100 fs pulses with >250 mJ of energy. In

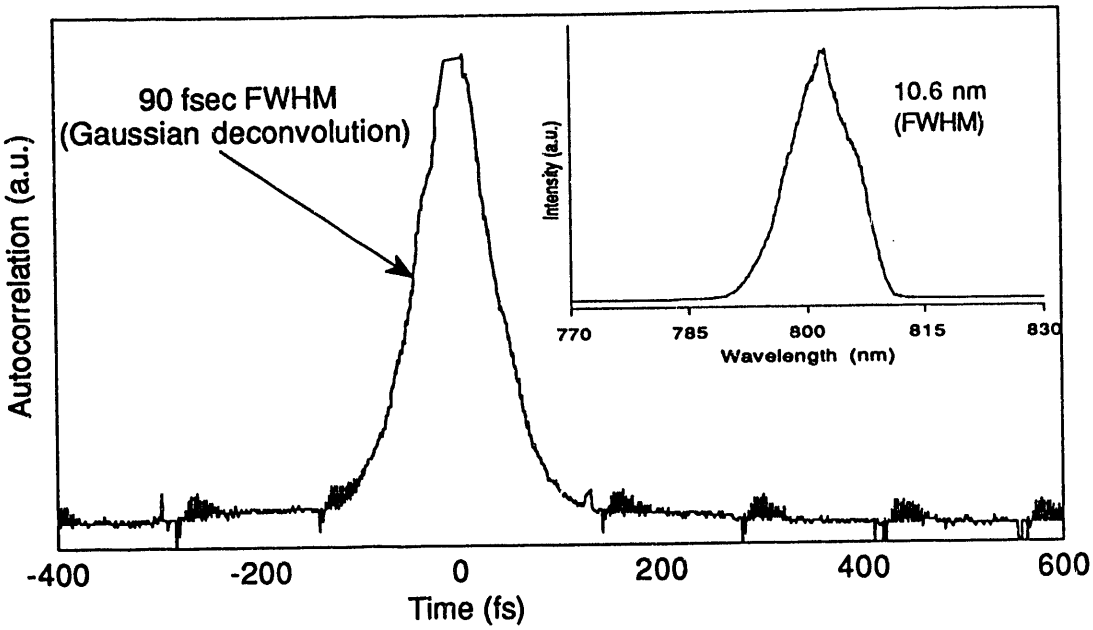

Figure 1. Single-shot autocorrelation and spectrum of a 250 mJ compressed output pulse from the laser system.

order to avoid non-linear beam degradation in air or a chamber window, the pulse compressor is entirely contained in a vacuum chamber allowing the compressed pulse to be focused on target with no transmissive optics after compression. In our case, the amplified compressed pulses are focused with an off-axis parabaloid to a near diffraction limited 5 μm FWHM spot resulting in irradiances in excess of 5×10^{18} W/cm2. The excellent thermal properties of Ti:Sapphire allow this amplifier to be operated at high repetition rates. Our present amplifier is limited to 5 Hz by the power supply but higher repetition rates would be possible.

This work was performed for the U.S. Department of Energy under the auspices of contract W-7405-Eng-48.

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9/24/93