October 2001 Progress Report on the Laboratory for Laser Energetics
Inertial Confinement Fusion Program Activities

Spectral Sculpting for IFE Lasers: Future high-repetition-rate, diode-pumped lasers for inertial fusion energy (IFE) applications need ~1 THz of frequency-modulated (FM) bandwidth in the ultraviolet. This translates into ~1/3 THz of FM bandwidth through the amplifier chain prior to frequency conversion. This bandwidth is comparable to the gain bandwidth of advanced crystalline materials such as Yb:SFAP developed specifically for IFE. Gain narrowing of an unmodified FM spectrum would result in potentially damaging amplitude modulation at the high-peak-power output of the laser system. Spectral sculpting[1] involves the modification of the FM spectrum at the input to the laser to compensate for the effects of gain narrowing. LLE scientists built and tested a spectral sculpting demonstration system in which the spectrum of a temporally flat, FM-modulated pulse is dispersed and focused onto a computer-controlled, liquid crystal light valve (LCLV) comprised of discrete elements (pixels) (see Fig. 1). The LCLV, in combination with an external polarizer, has the capability to individually control the transmission and optical phase of each pixel. The sculpted output pulse is then injected into a Nd:YLF-based multipass amplifier whose gain bandwidth is comparable to that of the original FM spectrum.

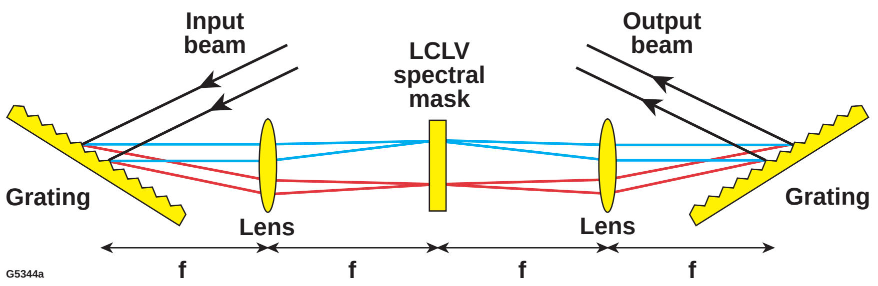

Figure 1. Diagram of the spectral sculptor. The FM spectrum is dispersed and focused onto a LCLV spectral mask. After sculpting, the input spectrum is re-imaged and recombined. The focal length of the re-imaging lenses is **f**.

For an FM spectral bandwidth of 8.3 Å, we have demonstrated compensation of gain narrowing in Nd:YLF (gain bandwidth ~13 Å) for small-signal gains in excess of 9000 (Fig. 2). A streak camera measurement of the original, unamplifed pulse intensity is shown in Fig. 2(a). After narrowband amplification, this pulse shape is significantly modified [see Fig. 2(b)], producing an amplified pulse with severe 20-GHz amplitude modulation. Based on spectral measurements, a spectral mask is calculated that, when applied to the input pulse, produces a pulse with the original FM spectrum at the output of the amplifier. The experimental pulse shape of a sculpted, amplified pulse is shown in Fig. 2(c). A comparison of Figs. 2(a) and 2(c) clearly shows that the spectral sculptor compensates the effects of gain narrowing in Nd:YLF. With repeated measurements of the amplified output spectrum, the applied spectral mask can be continuously updated to provide optimal compensation for changing conditions in the amplifier. Given the success of this initial work, LLE will continue to explore the limits of the spectral-sculpting technique and will begin to develop a system for application to a demonstration Yb:SFAP driver.

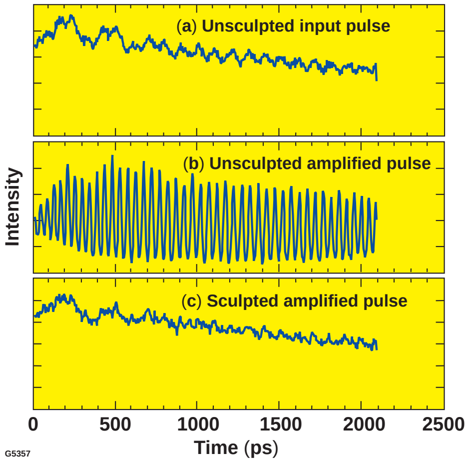

Figure 2. (a) Experimental intensity measurement of the input pulse. (b) Narrowband amplification of an unsculpted pulse shows significant intensity modulation. (c) Measurement of the intensity of a sculpted, amplified pulse shows that its time history matches that of the original unamplified pulse.

OMEGA Operations Summary: The first month of FY02 yielded a record number of 155 shots on target for the OMEGA facility. To meet the increased demand for target shots in FY02, LLE implemented a new schedule with extended target shot hours on a total of ten weeks during the year; the first week—8 to 12 October—included four shot days, one of which was 16 h long (compared to the normal 12-h-long shot days). LLNL, NLUF, and SNL used the extended shot week to accumulate 45 shots on six campaigns. The NLUF Ignition Diagnostics Campaign had four shots and Sandia National Labs had three shots. LLNL users also accumulated 34 shots during the week of 23 October, bringing the LLNL total for the month to 72 shots. LLE had 25 ISE shots, 42 SSP shots, and 9 RTI shots for an October total of 76 shots.

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[1] Originally proposed by Dr. Joshua Rothenberg, then at Lawrence Livermore National Laboratory.

Contact: Wolf Seka (716) 275-3815; fax: (716) 275-5960; e-mail: seka@lle.rochester.edu
John M. Soures (716) 275-3866; fax: (716) 256-2586; e-mail: jsou@lle.rochester.edu
http://www.lle.rochester.edu/