Section 1
LASER SYSTEM REPORT

1.A GDL Facility Report

The glass development laser (GDL) system was used for LLE interaction experiments and National Laser Users Facility experiments. The system was also used for beam uniformity studies, the results of which are now being implemented on the 24-beam OMEGA system. In preparation of future experiments, GDL full system output tests at pulse lengths shorter than 1 ns were carried out.

A summary of GDL operations this quarter follows:

System Test Shots		89
Target Shots		49
Pointing, Activation Shots		14
	TOTAL	152

ACKNOWLEDGMENT

This work was supported by the U.S. Department of Energy Office of Inertial Fusion under agreement No. DE-FC08-85DP40200 and by the Laser Fusion Feasibility Project at the Laboratory for Laser Energetics, which has the following sponsors: Empire State Electric Energy Research Corporation, General Electric Company, New York State Energy Research and Development Authority, Ontario Hydro, Southern California Edison Company, and the University of Rochester. Such support does not imply endorsement of the content by any of the above parties.

1.B OMEGA Facility Report

During the first quarter of FY86 a number of improvements and modifications were made to the OMEGA laser system. A comprehensive upgrade of the laser front end took place. An actively mode-locked, Q-switched (AMQ) YLF oscillator, preamplifier, and a reconfigured predriver line were installed. Other activities included a cw system alignment, characterization of a new zoom in-air spatial filter, implementation of liquid-crystal-based polarization devices, and frequency-conversion crystal tuning.

Preparations making GDL a 25th beam of OMEGA for x-ray backlighting purposes are nearing completion. Optical as well as software integration of the two facilities will be completed by the beginning of the second quarter; the first, full-power shots of the GDL beam into the OMEGA target chamber are scheduled to begin in January 1986.

After completion of the system upgrade, OMEGA was used for two experimental programs. The first program, comprising beam uniformity studies, established a data base for beam intensity and phase profiles on selected beam lines. The second, a National Laser Users Facility program and a cooperative project with the Naval Research Laboratory, involved target experiments aimed at vacuum ultraviolet spectroscopy of selected elements.

A summary of OMEGA operations during this quarter follows:

Driver Test and Activation Shots	272
Beamline Test Shots	101
Target Shots	57
TOTAL	430

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1.C A Kilojoule-Scale Active Mirror System

One year ago LLE revived its interest in the large-aperture, active mirror laser amplifier as a booster for high-power neodymium laser systems. Progress in hardware development involving new mounting and sealing designs had resulted in the successful upgrade of GDL with four 21-cm, clear-aperture, active mirror amplifiers.[1] Lacking the proper front surface coatings on all four mirrors, multiple Fresnel-reflection losses limited the peak energy to just above 300 J at 1-ns pulse width for the single-pass case and precluded effective double-pass operation of the active mirrors. Furthermore, focusability suffered from the cumulative wave-front distortion caused by each of the mirrors.

Recent progress in fabrication and coating technologies and various assembly and testing techniques has resulted in the successful upgrade of GDL with four fully coated and distortion-free active mirror amplifiers. Interferometric analysis, applied to every stage of fabrication, coating, assembly, and system operation, was central to locating the sources of distortion and in defining effective solutions. Figure 25.1 shows interferograms that represent the optical quality of an active mirror disc at two different steps of the procedure. The interference pattern in Fig. 25.1(a) is generated by a Fizeau interferometer where the active mirror forms the end element in the test arm. The straight vertical fringes show that the unmounted active mirror creates less than a sixth of a wavelength ($\lambda/6$) wave-front distortion (λ = 633 nm) in its normal mode of double-pass reflection from its back surface. A Twyman-Green interferogram [Fig. 25.1(b)] of the same disc, following coating, mounting, and sealing, shows a distortion of less than $\lambda/4$ (λ = 1064 nm). This measurement is limited by the performance of the interferometer components. Interferometer normalization indeed shows that the distortion is kept below $\lambda/4$.

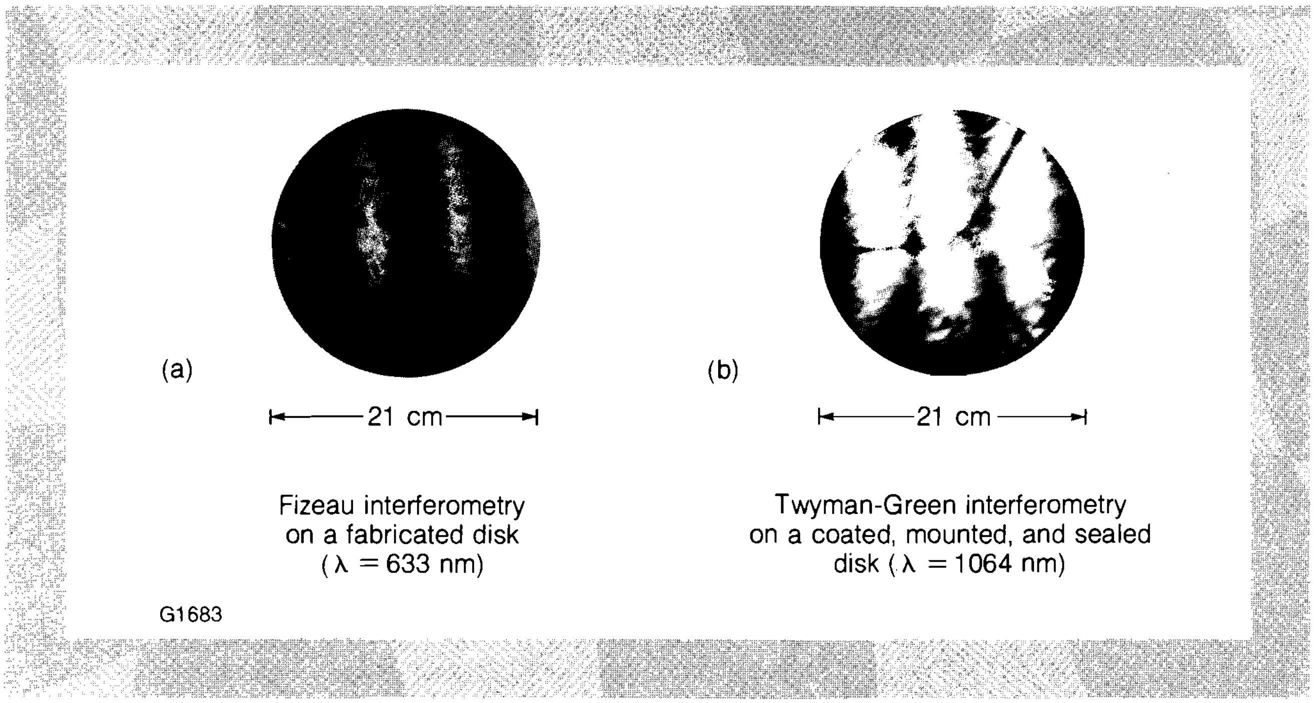

Fig. 25.1
Interferometric testing is an essential part of distortion-free mounting and sealing of the large aperture, active-mirror amplifier disc. The straight, vertical fringes in (a) are generated by a Fizeau interferometer and indicate that the unmounted active mirror creates less than $\lambda/6$ wave-front distortion (λ = 633 nm) in its normal mode of double pass reflection from the back surface. A Twyman-Green interferogram of the same disc (b), when coated, mounted, and sealed, shows an accuracy-limited distortion measurement of less than $\lambda/4$ (λ = 1064 nm).

During this GDL upgrade, three of the four active mirrors were reworked to remove old coatings and to repolish surfaces found inadequate because of excessive scratches and digs. Subsequently, each laser disc was coated with an in-house-developed, recently improved front-face dual-purpose coating. This coating simultaneously acts as an antireflection coating at 1054 nm for the front surface, and as a high reflector for the major neodymium pumpbands (Fig. 25.2). This method of returning pump light back into the amplifier increases the stored energy of a 25×3-cm, LHG-8 active mirror by more than 10%. Coatings of such complex design usually exhibit low damage threshold even at longer wavelengths (1054 nm). Recent tests demonstrate, however, that improved coatings repeatedly withstand irradiance levels higher than 5 GW/cm^2.

This observation supports the belief that removal of subspecification scratches and digs by fine polishing has increased coating adhesion and strength over the entire disk surface.

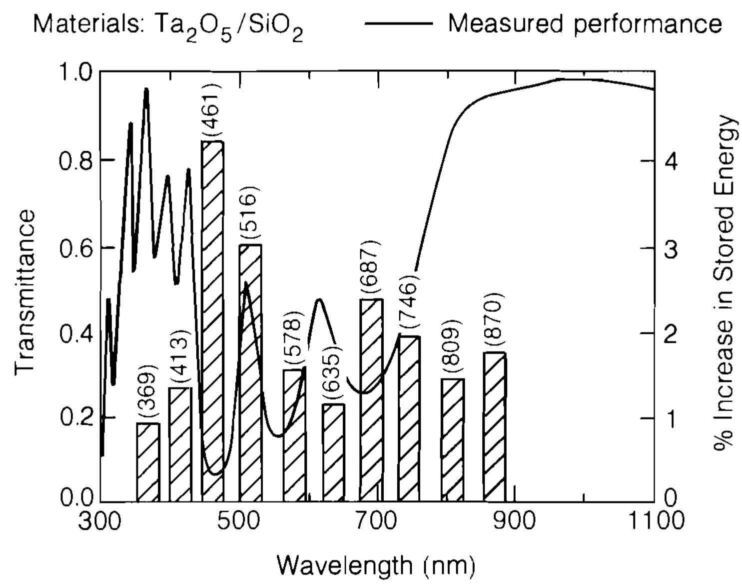

Fig. 25.2
Each active mirror amplifier is equipped with an improved front-surface coating designed to maximize the transmission of the 1053-nm laser beam at the front surface, while simultaneously reflecting the major neodymium pumpbands back into the amplifier. This in-house coating is capable of increasing the stored energy of a 25×3-cm, LHG-8 active mirror by more than 10%.

In an effort to achieve unprecedented high powers in GDL without the risk of damaging optical components, a dedicated effort was made to obtain a uniform-intensity distribution for propagation through the active mirror amplifiers. A thorough investigation of the new oscillator and predriver,[2] as well as of the driver line and remaining rod amplifiers, resulted in smooth spatial intensity profiles, as illustrated by the contour plots of Figs. 25.3 and 25.4. A smooth, Gaussian spatial profile with a slight, 45° orientation characterizes the new predriver in GDL (Fig. 25.3). After several rod amplification stages, which amplify the Gaussian-beam wings most prominently by the characteristic edge-gain profile, the energy distribution at the input to the active mirror booster remains smooth, center peaked, and at a slight, 45° orientation [Fig. 25.4(a)].

Accurate alignment techniques implemented throughout the laser chain have resulted in highly uniform active mirror intensity distributions [Fig. 25.4(b)] at very high-peak-power levels. Figure 25.5 shows the 500-ps performance of the single-passed active mirrors in GDL. The experimental results exceeded theoretical predictions by

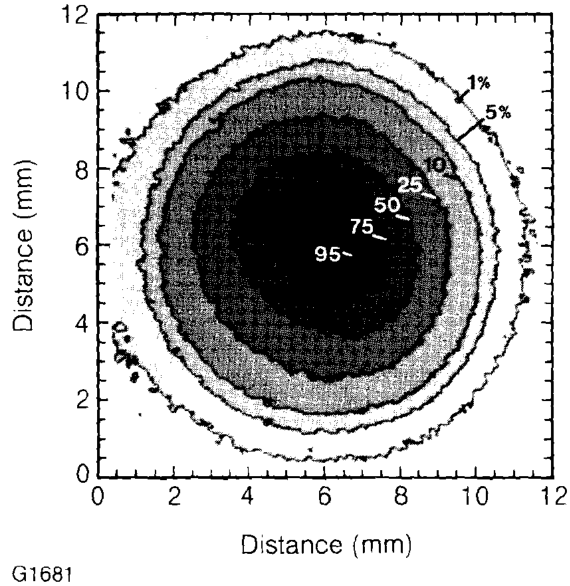

Fig. 25.3
Uniform spatial intensity distributions are essential for damage-free, high-power scaling of LLE laser systems. A smooth Gaussian spatial profile with a slight, 45° orientation characterizes the new predriver output in GDL.

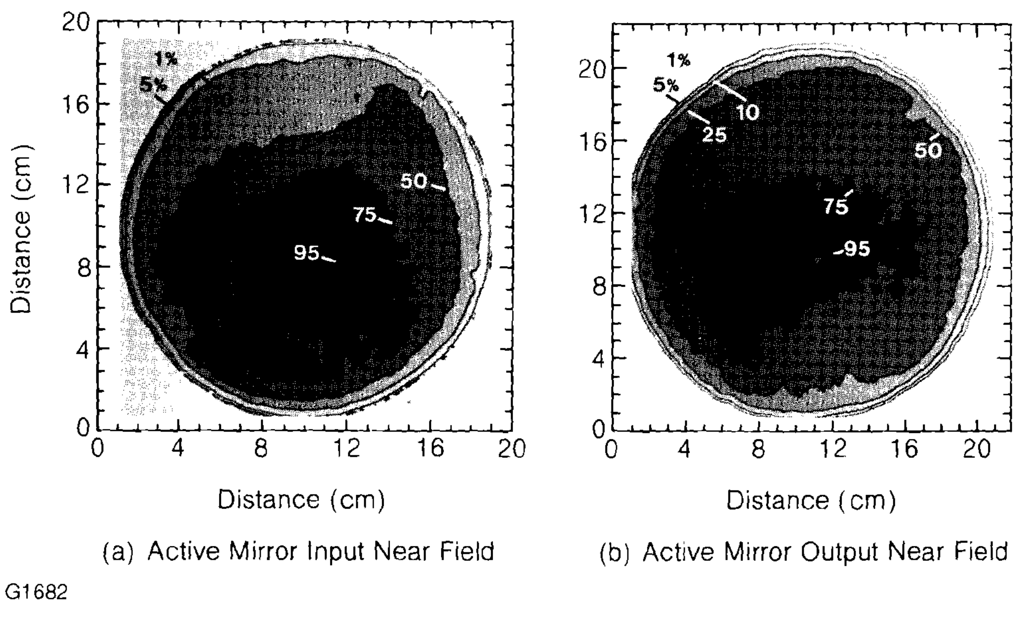

Fig. 25.4
After several rod amplification stages, the energy distribution at the input to the active mirror booster remains smooth, center peaked, and at a slight, 45° orientation (a). Accurate alignment techniques used throughout the laser chain result in highly uniform active mirror outputs (b).

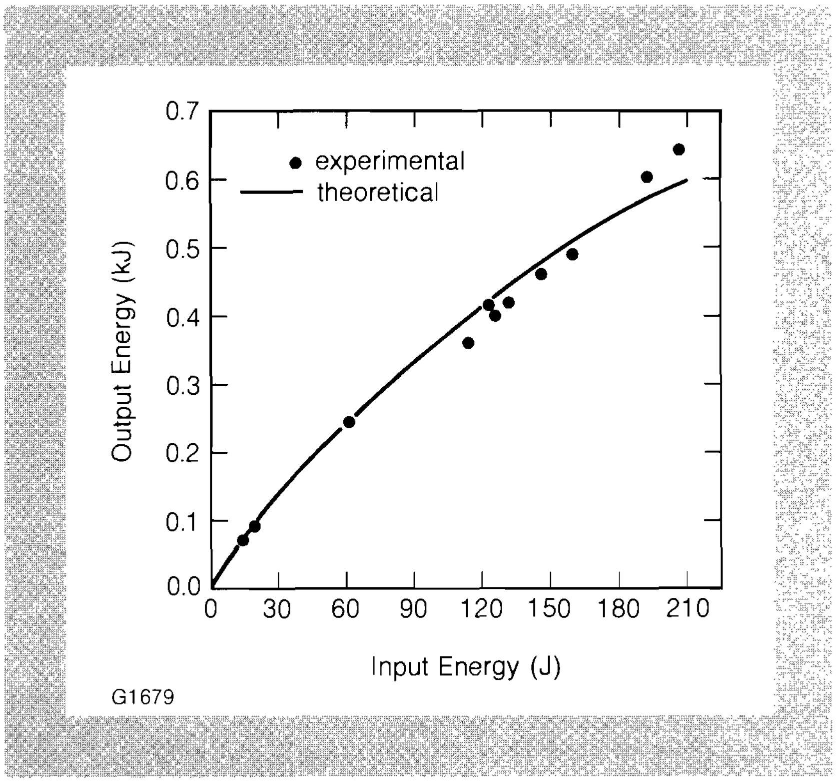

Fig. 25.5
Performance of a four-unit, single-passed active mirror booster to the glass development laser (GDL) at 500 ps. Experimental results exceeded theoretical predictions to produce more than 1 TW of focusable power.

the code *RAINBOW* and yielded more than 1 TW of focusable power. Higher powers can only be obtained in a double-pass configuration, since the system is clearly driver limited at this point.

The active-mirror-boosted GDL facility is currently scheduled for more extensive beam characterization, as it delivers 100-ps pulses for short-pulse frequency tripling in x-ray backlighting experiments and 500-ps to 1-ns pulses for frequency-doubled interaction experiments.

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REFERENCES

1. LLE Review **21**, 3–7 (1984).
2. LLE Review **20**, 143–149 (1984).