March 1999 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

NIF Direct-Drive Target Designs: Progress has been made in understanding the sensitivity of NIF direct-drive target designs to laser pulse characteristics. The targets are 3 mm in diameter and consist of a 344-μm layer of DT ice enclosed by a 1- to 2-μm-thick plastic shell. The continuous laser pulse used to drive these targets [shown in Fig. 1(a)] consists of a low-power foot that sets the target in motion, followed by a fast rise to a high-power flat-top pulse that drives the target to high compression and ignition. The laser pulse creates two main shocks that set the isentrope in the DT-ice layer: (1) a first shock at time zero and (2) a stronger shock during the rise of the main part of the pulse. The highest gains are obtained when the second shock arrives at the inner surface of DT ice shortly after the first shock. The sensitivity of the target gain to the duration and intensity of the foot is shown in Fig. 1(b). The gain drops when the power of the foot pulse or its duration is changed from optimum conditions. Such changes lead either to a decompression of the inner part of the DT ice prior to the arrival of the second shock or to the coalescence of the two shocks prior to reaching the inner DT-ice surface. In all cases the gain decreases as indicated in the contour plot in Fig. 1(b); however, optimal timing between the two shocks can be maintained by trading the power of the foot with its duration. For foot-pulse durations between 3.5 ns and 6 ns, the gains increase from about 40 to a maximum value of 50. The isentrope parameter α—defined as the ratio of the fuel pressure to the Fermi-degenerate pressure—varies from 3.5 to 2.5 over that range. Lower α implosions are more unstable and therefore we have chosen our design point at $\alpha = 3$ corresponding to a foot-pulse duration of 4.4 ns and a foot power of 9.5 TW, resulting in a gain of 46.4 [black dot in Fig. 1(b)]. The black contour line in Fig. 1(b) indicates the 90% gain contour around the design point and demonstrates acceptable tolerances on the foot power (±10%) and in the foot-pulse duration (±350 ps).

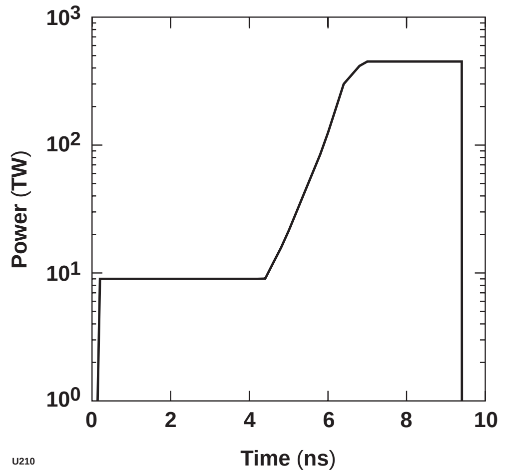

Fig. 1(a)

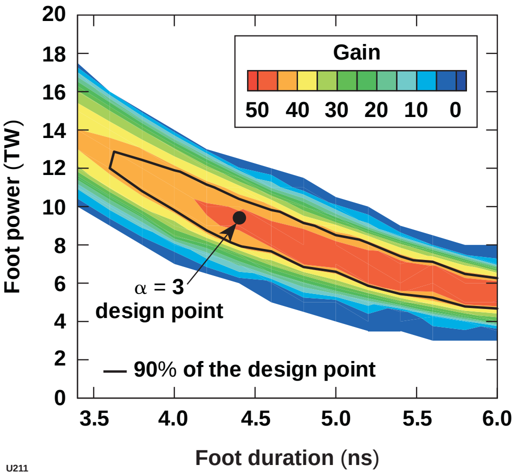

Fig. 1(b)

LLE/NRL Collaboration Experiments: In collaboration with the Naval Research Laboratory, planar burnthrough experiments were performed on the NIKE laser system to relate the onset of the characteristic line emission from a signature layer buried under a plastic ablator to the Rayleigh–Taylor (RT) instability growth of imprinted and preimposed modes. This collaboration extends the OMEGA planar burnthrough campaign to the irradiation uniformity of a KrF laser. CH/CHSi and CH/CHSi/parylene planar-foil targets were irradiated with the NIKE laser pulse, a 3.5-ns foot to a 4-ns flat-top with a 40:1 intensity contrast, having a peak intensity of 1×10^{14} W/cm^2. Time-resolved x-ray spectroscopy was used to determine the onset of the Si *K*-shell emission, and the burnthrough was imaged in Si He$_\alpha$ emission with a crystal imager coupled to a framing camera detector having a temporal resolution of 200 ps. The effects of ablator thickness (8 to 14 μm), preimposed surface mass modulations ($\lambda = 20$ μm with $a_{\text{p-v}} = 0.1$ μm, $\lambda = 30$ μm with $a_{\text{p-v}} = 0.25$ μm, $\lambda = 60$ μm with $a_{\text{p-v}} = 0.5$ μm), overall target thickness (20 μm, 40 μm, and 100 μm), and laser imprint on burnthrough were investigated.

OMEGA Operations Summary: During the reporting period, LLE hosted a variety of campaigns for LLNL, LANL, and NLUF in addition to an internal RTI series. LANL users had 24 shots of tetrahedral hohlraum configuration. LLNL campaigns were split between point backlighting of spheres in NIF-scale hohlraums and radiation-flow tests (28 shots). The third week of indirect-drive shots was split between high-*Z*, Rayleigh–Taylor LLNL experiments (9) and University of Wisconsin NLUF experiments to develop x-ray absorption spectroscopy for hohlraum targets (10). During the last two weeks of March, LLE RTI, backlit spherical implosions as well as planar-foil radiography experiments were conducted (56 shots). A total of 127 target sh ots were carried out in March. In addition several laser campaigns were supported including installation of broadband frequency converters on five beamlines as well as standard calibration and frequency-converter tuning (11 shots).

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