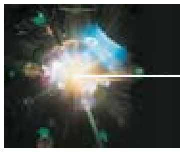

August 2007 Progress Report on the Laboratory for Laser Energetics

Inertial Confinement Fusion Program Activities

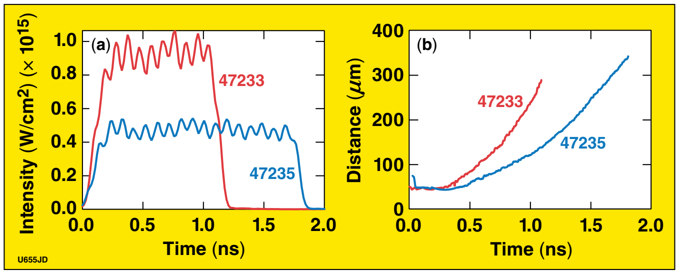

Figure 1. (a) Laser drive shapes of 1-ns (shot 47233) and 1.6-ns pulses (shot 47235). (b) Trajectories of the driven targets as measured by the side-on radiography.

Role of Preheat in the Stabilization of Rayleigh–Taylor Growth: One of the key parameters of the direct-drive-ignition designs is target compression. The compression is very sensitive to any preheat experienced by the driven target. The major sources of preheat in planar direct-drive targets include nonlocal-electron preheat (caused by electrons with energies of ~10 keV) and hot-electron preheat caused by laser–plasma instabilities (with electron energies of ~100 keV). The Rayleigh–Taylor (RT) growth of target modulation at the ablation surface is sensitive to preheat because the increased ablation velocity (caused by target decompression) reduces the RT growth. The preheat has a stronger effect on the growth of short-wavelength modulations relative to long-wavelength modulations. To observe this effect, it is therefore necessary to perform growth experiments at various wavelengths. The experiments were performed with 20-μm-thick targets, which had 2-D modulations at 20-, 30-, and 60-μm wavelengths with initial amplitudes of 0.05, 0.05, and 0.125 μm, respectively. The targets were driven with 1-ns square and 1.6-ns square pulses at peak intensities of ~1 × 10^{15} and ~5 × 10^{14} W/cm^2, respectively, as shown in Fig. 1(a). The intensities were varied because both nonlocal- and hot-electron preheat are sensitive to drive intensity. Figure 1(b) shows measured (with side-on radiography) target trajectories demonstrating that the target acceleration is higher at the higher intensity. The distances traveled by the targets at the end of the drive are similar. The foils were driven by 12 OMEGA laser beams that used standard smoothing techniques including distributed phase plates (DPP's), smoothing by spectral dispersion (SSD), and polarization smoothing (PS). The growth of the ablation-front modulations was measured with regular through-foil radiography using uranium backlighter x rays. Figure 2 shows the measured growth of optical-depth modulations with the 1-ns square [Figs. 2(a)–2(c)] and the 1.6-ns square pulse [Figs. 2(d)–2(f)]. The growth of the 60-μm modulation is shown in Figs. 2(a) and 2(d), the 30-μm modulation growth is shown in Figs. 2(b) and 2(e), and the 20-μm modulation growth is shown in Figs. 2(c) and 2(f). Since the 30-μm-wavelength modulation grows more slowly than the 60-μm modulation, its growth is strongly stabilized with a high-intensity drive. The growth of the 20-μm modulation is completely stabilized. At the lower intensity, both the 20- and 30-μm modulations grow more strongly than the 60-μm modulation, as expected with lower preheat. Because of the preheat, the modulations for all three wavelengths reach higher amplitudes at the end of the acceleration at the lower drive intensity, even though the targets travel approximately the same distance in both experiments. Upcoming experiments will study the relative contribution of nonlocal-electron preheat and hot-electron preheat to the stabilization of RT growth.

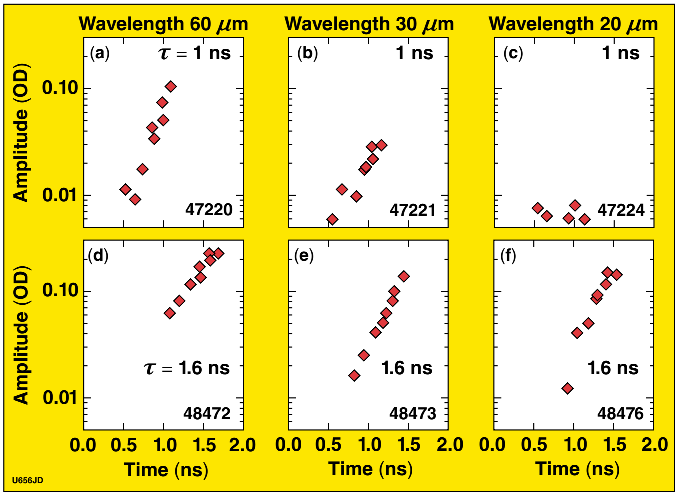

Figure 2. Measured growth of optical-depth modulation with 1-ns square [(a)–(c)] and 1.6-ns square pulses [(d)–(f)]. The growths of 60-μm modulations are shown in (a) and (d), 30-μm modulations are shown in (b) and (e), and 20-μm modulations are shown in (c) and (f).

OMEGA Operations Summary: The OMEGA facility produced a total of 169 target shots in August with an overall experimental effectiveness of 95.3% for experiments led by LLE (93 shots), LLNL (37), LANL (14), NLUF (20), and CEA (5) scientists. Of these shots, 107 were taken for the NIC campaign (30 for the IDI and 77 for the DDI campaigns). In addition, there were 62 target shots taken for various non-NIC programs including two NLUF experiments led by the University of California, Berkeley and Rice University, respectively.