March 2002 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

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OMEGA Cryogenic Target Experiments: OMEGA cryogenic target experiments focus on imploding D_2-filled capsules with reduced levels of ice roughness. In one of the experiments carried out this month, a cryogenic target with an inner-ice-surface roughness of 3.0±0.9 μm (see Fig. 1) was imploded with a 1-ns, 23.4-kJ laser pulse. A record (for a 100-μm-thick, D_2-ice capsule) neutron yield of 3.2×10^{10} (32% of 1-D predicted yield) was achieved on this shot. Neutron time-of-flight detectors recorded a temperature of 2.6 keV, and secondary proton slowing-down measurements (using wedged range filters*) indicate an average capsule areal density of ~36 mg/cm^2. The clean 1-D calculations predicted a temperature of 2.3 keV and a capsule areal density of 37 mg/cm^2, respectively, for this implosion. Further improvements in ice-layer uniformity are expected for future OMEGA cryogenic capsule experiments.

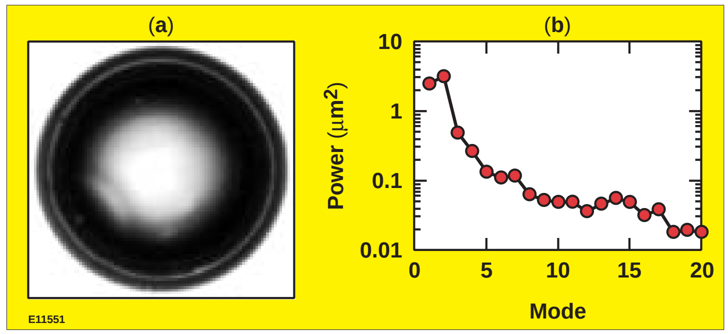

Figure 1. (a) Shadowgraph of the cryogenic target for OMEGA shot 26477. The target was a 907.6-μm-diam, 3.3-μm-thick CD shell containing a 100-μm-thick D_2-ice layer. (b) The average inner ice power spectrum (taken along nine independent views) shows a σ_{rms} = 3.0±0.9 μm.

Picket-Pulse Implosion Experiments: Last year, the use of a picket pulse to control the growth of the Rayleigh–Taylor instability (RTI) at the ablation surface was demonstrated in planar target experiments on OMEGA (March 2001 Progress Report). Recently, these experiments were extended to spherical implosions. A single picket pulse (see Fig. 2) was added to the front of a shaped pulse designed to implode a spherical target on an $\alpha = 5$ isentrope (α is defined as the ratio of the fluid pressure to the Fermi pressure). Four types of CH shell targets (with diameters ranging from 901 to 923 μm) were used to assess the effect of the picket pulse on the capsule implosion performance: 33-μm-thick shells filled with either 3 or 15 atm of D_2 or 12 atm of ^{3}He and 6 atm of D_2; and 27-μm-thick shells filled with 15 atm of D_2. All capsules were driven with 18 to 20 kJ of UV laser energy. The shot data (Table I) show significant increases in both absolute fusion yield and the ratio of the experimental/simulation yield [yield over clean (YOC)] when the picket pulse was added to the $\alpha = 5$ implosion pulse shape. For 33-μm shells, the YOC increased from 4% to ~19%. These results increase our confidence that the use of a picket pulse will help mitigate the effects of RTI in future cryogenic capsule implosions on OMEGA and eventually on the NIF.

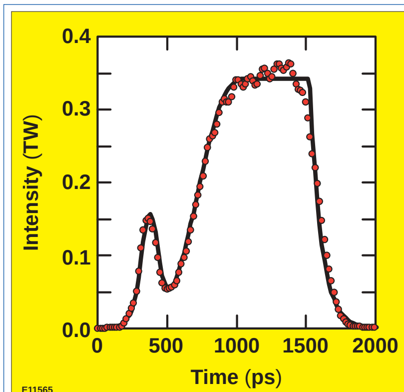

Figure 2. Pulse shape used to test the effect of a picket pulse added to the front of an $\alpha = 5$ implosion pulse shape; specified pulse shape (blue solid line); actual pulse shape (red dots). The picket intensity is 40% of the peak intensity, and its peak precedes the time of the half-maximum intensity of the $\alpha = 5$ pulse by 340 ps.

Table I: Summary of picket-pulse implosion experiment results.

	Without Picket (Alpha 501)		With Picket (Alpha 501P)	
Capsule Type	Neutron Yield	YOC	Neutron Yield	YOC
D_2(15)CH[33]	4.77×10^9	3.7%	1.27×10^{10}	19.2%
D_2(3)CH[33]	1.03×10^9	3.0%	1.83×10^9	15.3%
$D_2(6)^3$He(12)CH[33]	8.22×10^8	5.5%	1.37×10^9	16.7%
D_2(15)CH[27]	1.86×10^{10}	6.8%	3.35×10^{10}	16.8%

OMEGA Operations Summary: During March 2002, one week of scheduled maintenance was conducted on the system, and a total of 97 target shots were taken, including 32 shots for two LANL campaigns (asymmetric direct-drive implosions and direct-drive cylindrical implosions) and 65 shots for four LLE campaigns (Stockpile Stewardship Program, laboratory astrophysics, integrated spherical experiments, and cryogenic target implosions). In the first half of FY02, a total of 751 target shots were taken on OMEGA. This increase of 16% in the shot rate over that of FY01 is attributed to the extended shot schedule implemented at the start of FY02.

*Charged-particle spectroscopy was carried out in collaboration with the MIT Plasma Science and Fusion Center.

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