April 2000 Progress Report on the Laboratory for Laser Energetics
Inertial Confinement Fusion Program Activities

Determination of Preheat Due to Fast Electrons on OMEGA: The emission of hard x rays, coincident with $3\omega/2$ emission, was measured in laser-interaction experiments on OMEGA, indicating that fast electrons are caused by the two-plasmon-decay instability. The preheat due to these electrons was experimentally studied on 60-beam OMEGA implosions of CH shells (10^{15} W/cm^2, 1-ns square pulses), using the spectrum of hard x rays measured by a BaF scintillator array and the emission of MeV protons accelerated from the target surface measured by two magnetic charged-particle spectrometers. Both methods yield a fast-electron temperature of ~100 to 200 keV. The hard x-ray intensity indicates a preheat level of ~0.1% of the laser energy. To verify this preheat measurement, a high-Z planar-target experiment was performed (Fig. 1) at 10^{15} W/cm^2 (overlapped intensity, 1-ns square), where the hard x-ray results can be compared with Kα measurements. The target is designed such that the Ti-Kα line is excited mostly by radiation, whereas the V-Kα line is excited mostly by fast electrons. Measuring the preheat simultaneously by the hard x ray and Kα methods in high-Z planar targets substantiates the hard x-ray results for spherical CH target implosions.

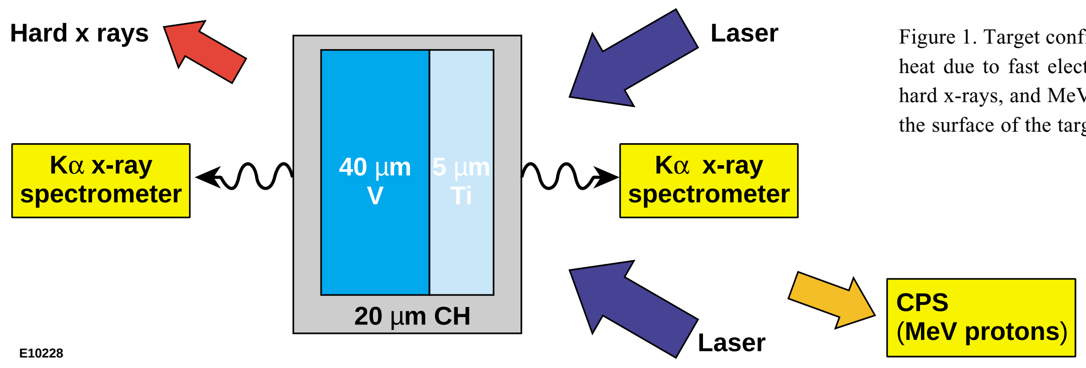

Figure 1. Target configuration for studying preheat due to fast electrons, using Kα emission, hard x-rays, and MeV protons accelerated from the surface of the target.

Imprint Reduction with Shaped Pulses: A novel technique for reducing laser imprint in OMEGA cryogenic targets has been developed. Standard ICF cryogenic targets consist of a shell of DT ice with an outer thin layer of CH (or polyimide). The presence of the CH layer gives rise to a brief period of early-time growth by the Rayleigh-Taylor instability, which effectively increases the amount of laser imprint by about a factor of 2. Two-dimensional *ORCHID* simulations show that by introducing a short, high-intensity spike at the start of the implosion, this early-time growth can be significantly reduced with only a small change to the calculated 1-D neutron yield. For instance, a spike of 100-ps duration and twice the intensity of the foot pulse reduces the imprint by a factor of 2, while lowering the total calculated 1-D neutron yield by only 20%. This spike also enhances thermal smoothing during the start of the pulse, providing further imprint reduction. The degree of imprint for a given simulation is characterized by the *equivalent surface finish*, the amplitude of surface roughness that would give rise to the same late-time target distortion. This is shown in Fig. 2, as a function of the spherical-harmonic mode number ℓ, for a target without a CH outer layer (black), a target with a 3-μm CH outer layer (blue), and a target with the same outer layer but with the initial intensity spike (red). As Fig. 2 shows, the high intensity spike reduces the imprint enough to eliminate, for this range of wavelengths, the penalty incurred by the plastic outer layer.

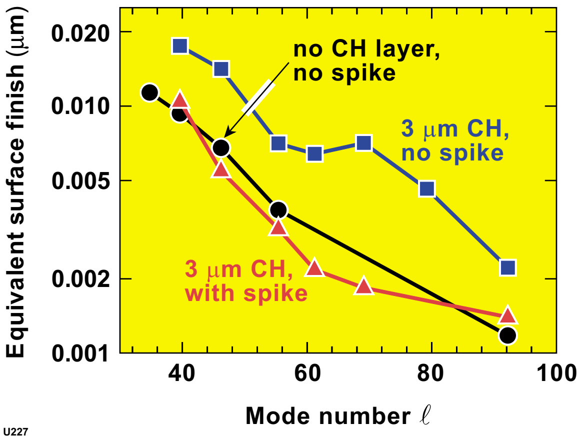

Figure 2. Calculated equivalent surface finish for different target and pulse conditions.

OMEGA Operations Summary: For the month of April 2000, OMEGA shots were allocated among LLNL (19), LLE integrated spherical (53), and NLUF campaigns (38) for a total of 110 target shots. Ten different experimental teams conducted experiments with a diverse variety of irradiation conditions over the 12 shot days. Additionally, several laser campaigns were executed including small-signal-gain scans, beam-balance scans, and energy diagnostic calibrations. The fourth P510 UV streak camera was installed allowing 40 of the 60 OMEGA beams to be sampled for pulse-shape characterization.

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