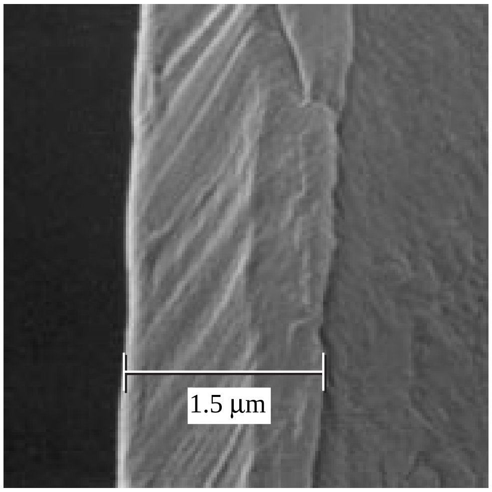
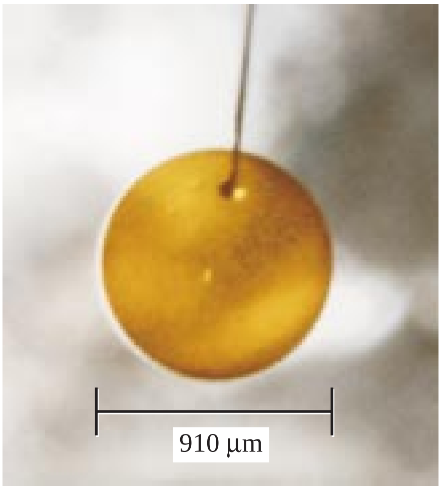
August 1998 Progress Report on the Laboratory for Laser Energetics Inertial Confinement Fusion Program Activities

Cryogenic Target Fabrication: We have successfully fabricated polyimide capsules with dimensions suitable for cryogenic experiments on OMEGA. The accompanying photographs show a 910-μm-diam shell and a cross-sectional view of its 1.5-μm wall. The film is transparent at the wavelengths needed to layer and characterize the DT ice. A capsule's outer surface had a rms roughness of ~300 nm for ℓ-modes 2 to 500 (measured courtesy of General Atomics). A capsule with a 6-μm wall was able to contain a 47-atm fill (the maximum pressure rating of our test apparatus and a value ~3× greater is achievable with a comparably sized plasma polymer capsule). These capsules possess a lower permeability than earlier polyimide shells made using a different procedure: the measured D_2 permeability was $K_p = 4 \times 10^{-16}$ mol·m/m^2·Pa·s. This permeability will allow polyimide capsules to be used in current experiments, but a greater permeability is desirable for cryogenic experiments. Future work will investigate how the processing conditions affect the capsules' permeability with the goal of controlling the permeability for the desired application.





Interpreting Results from the Charged-Particle Spectrometer: Early results from the charged-particle spectrometer show a strong acceleration of the ablator protons (up to ~1 MeV). This acceleration effect seems to have an intensity threshold at about 5×10^{13} W/cm^2. In addition, in DD shots the proton energy spectrum consistently shows a surprisingly regular discrete line structure. This structure does not appear in the majority of DT shots. The acceleration is most likely due to the electrostatic potential created when electrons in the corona are heated by the two-plasmon-decay instability; the threshold for this instability corresponds roughly to that of the acceleration effect. A small population of electrons at a temperature of 25 keV could charge the target to ~1 MV. Such a two-temperature corona tends to form a "rarefaction shock"—a sharp boundary between the rapid expansion driven by the hot electrons and the rest of the corona. Fluctuations in the return current through the ionized stalk, possibly caused by the pinching instability, would cause the potential of the target and the position of the rarefaction shock in the corona to oscillate. This would lead to ablator protons crossing the shock in bunches, with each bunch receiving a discrete increment in energy and velocity. Since the rate at which a proton acquires energy from the potential is proportional to its velocity, earlier bunches continue to acquire energy more rapidly than later ones throughout the pulse, maintaining a separation in the energies of the bunches as they are accelerated. Simple simulations show that this effect can give a line structure in the energy spectrum similar to that seen. Finally, in DT shots the expanding cloud of ablator protons is overtaken by the 3.5-MeV alpha fusion products, and calculations show that the two ion species can exchange energy through the two-stream instability. This would tend to smear out the line structure in the DT shots, consistent with the observations. It would also explain an anomalous broadening in the alpha energy spectrum, which has been observed to set in at an intensity of about 5×10^{13} W/cm^2. Further analysis of these effects should lead to a better understanding of coronal physics and more-accurate fusion product diagnostics.

OMEGA Operations Summary: During the month of August we carried out planned quarterly maintenance and calibration in addition to two weeks of target physics shots. There was a total of 75 target shots during the period: 21 for the S2 program, 9 for the integrated spherical experiments (ISE), 31 for the NLUF University of Wisconsin hohlraum physics experiments, 5 for diagnostic development, and 9 for beam focus characterization.

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