Cryogenic Target Fabrication: OMEGA cryogenic capsules make use of a thin (a few microns thick) polyimide shell that contains the fusion fuel. New OMEGA-size polyimide shells with a different chemical formulation than the earlier polyimide shells have demonstrated a 50-fold increase in room-temperature permeability. This decreases the time required to fill the targets, and because the greater permeability continues to lower temperatures (Fig. 1), thinner-wall targets will more likely survive pressure gradients that develop within the permeation cell when the targets are cooled.

This improved performance was achieved by adding a fluorine-based linkage [~10% (atomic) fluorine] within the backbone of the polyimide chain, which improves the flexibility of the material. The measured mechanical properties were marginally reduced: the elastic modulus and tensile strength decreased by ~20% to 2.6 GPa and 220 MPa, respectively. The improvement in the permeability is considerably more important, however, for the processing and survivability of this type of target in cryogenic ICF applications.

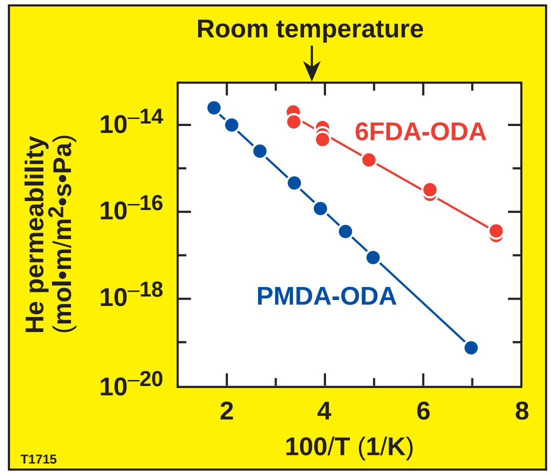

Figure 1. The temperature-dependent helium permeability of two polyimide shells with different chemical formulations is provided. The PMDA-ODA polyimide is the standard vapor-deposited polyimide shell. The 6FDA-ODA polyimide is the newly developed material with enhanced permeability.

First Shaped-Pulse Cryogenic Target Implosion: A low-adiabat pulse shape (ALPHA501) with a foot-to-drive contrast ratio of approximately 10:1 has been used to implode a cryogenic D_2-filled capsule on OMEGA. The 907-μm-diam, 3.9-μm-thick CD shell contained a 100.8-μm-thick D_2-ice layer with an inner-surface roughness of ~4.6 μm averaged over two orthogonal views. The calculated capsule adiabat with the shaped pulse was ~4. The implosion produced 1.51×10^{10} primary neutrons; the yield-over-clean 1-D was 14%. The average capsule ρR from this implosion was ~50 mg/cm^2; the highest value inferred from earlier measurements for a cryogenic implosion using higher-adiabat square pulses was ~30 to 36 mg/cm^2. Figure 2 shows one of the four measured secondary proton spectra used to infer the capsule ρR, which is 85% of the calculated, clean, 1-D, predicted ρR. In addition, the secondary-to-primary neutron ratio was 1.25%, significantly larger than any previous cryogenic implosion, while the ion temperature was only 2.2 keV. This is the lowest ion temperature measured to date on any cryogenic implosion and very close to the 1-D prediction of 2.1 keV.

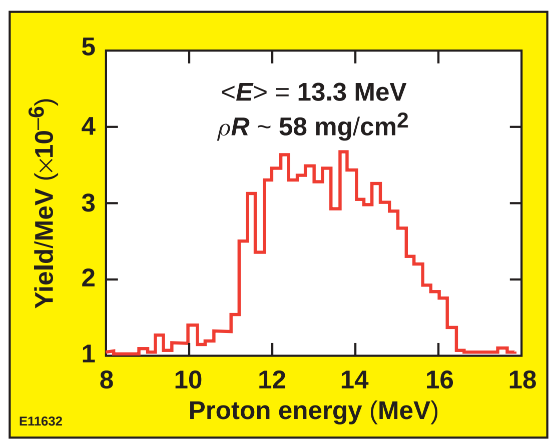

Figure 2. The measured secondary proton spectrum shows an average energy loss of over 1.6 MeV that corresponds to a total fuel ρR of approximately 58 mg/cm^2. The average ρR of all four similar measurements using wedged-range-filter detectors is 50 mg/cm^2. These measurements are carried out in collaboration with the MIT Plasma Science and Fusion Center.

OMEGA Operations Summary: During May 2002, a total of 123 target shots were taken for campaigns led by Los Alamos National Laboratory (LANL), Lawrence Livermore National Laboratory (LLNL), and LLE. The 32 LANL target shots included hohlraum radiography experiments, spectroscopic measurements, and joint astrophysical jet experiments with LLNL, LLE, and scientists from the United Kingdom Atomic Weapons Establishment (AWE). The 16 LLNL experiments included double-shell-capsule implosions, development of asymmetric-capsule-implosion areal-density measurements, and the development of x-ray backlighting for dynamic hohlraum experiments. The 75 LLE shots included 20 Stockpile Stewardship Program (SSP) shots, 48 integrated spherical experiments (ISE), 3 cryogenic target campaign (cryo) shots, and 4 Rayleigh–Taylor Instability (RTI) experiments.

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