If, during the coating run, any of the process parameters deviate from threshold values or if critical components malfunction, appropriate alarms are sounded.

The parylene coater automation software was written in Forth.[5] Our system is "multi-tasked," meaning that the operator can change process parameters in the middle of a coating run.

The measurement and calculation functions of the automated system are affected by several sources of ambiguity. The index of refraction of parylene is known only to within 0.1%, which limits the resolution of the thickness associated with one complete reflectivity modulation cycle to 0.2 nm, assuming constant index of refraction as the film grows. The occasional variation in the reflectivity modulation amplitude from cycle to cycle has not been observed to exceed 5%, but this level of uncertainty gives an uncertainty in the modulation of 5% of the amplitude or 9° in phase. This phase uncertainty corresponds to a layer thickness uncertainty of 5 nm. Based on these estimates and estimates of other less important uncertainities, our best estimate of an achievable thickness specification is a tolerance of 10 nm. We have measured the thickness of target and witness-slide coatings with a Mach-Zehnder interferometer and have compared the results with reflectometer readings of target-coating thickness. The comparisons were completely consistent, to the precision of the Mach-Zehnder interferometer readings, which we also estimate to be near 10 nm.

Summary

The ablation-layer production facility has been automated. The new system performs a task virtually unattended that once required the constant attention of an operator for as much as eight hours per target. Thickness tolerances have been controlled to within 10 nm with the automated system.

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2.E Progress in Drill, Fill, and Plug Target Fabrication

The drill, fill, and plug technique was developed so that high-Z, slowly permeating diagnostic gases such as xenon and krypton could be contained inside glass microballoons (GMB's).[1,2] This fabrication procedure involves laser-drilling a hole approximately 1 μm in diameter through the GMB wall, placing a quantity of low-melting-temperature solder-glass plug material loosely over the hole, filling the target in a pressure chamber, and applying heat to melt the plug, thus sealing the gas inside the target. Several changes and improvements in these procedures have been made and are reported in this article. The changes affect target quality directly and improve the efficiency of the operation by reducing losses at various stages of production.

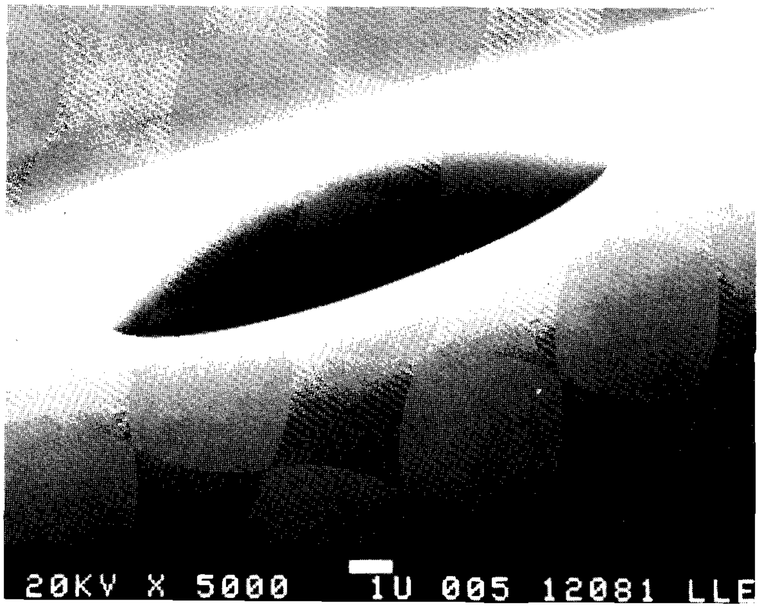
Because inertial-confinement fusion targets require a high degree of spherical uniformity for optimum implosion performance, steps have been taken to reduce the mass perturbation caused by the solder glass used to seal the laser-drilled hole. Until recently, a plug (Fig. 27) typically had dimensions of 10-14 μm in diameter and 1-2 μm in height.[3] Plugs of this size were produced by fracturing a bubble blown from bulk solder glass. Perturbations are often evident in x-ray images of implosions of targets having plugs of this size.[4] Reduction of plug sizes to smaller diameters had been limited by a lack of plug material fragments of the appropriate size.

The production of plugs roughly 1.5 μm in diameter and 0.25 μm in height (Fig. 28) involves grinding solder glass fragments down to sizes that are only slightly larger than the laser-drilled hole in the GMB wall. Typically, reduced-size plugs have 300-600 times less volume than those produced using the fractured bubble technique. This results in a correspondingly smaller mass perturbation on an initially uniform shell. By this technique, about 50% of the GMB's are plugged successfully in any given heating cycle. This efficiency should improve as process capabilities are optimized for specific target parameters.

Improvements in the fabrication process include a variation of the salt-crystal bonding technique used to secure the target to a glass-slide substrate where it is held during the drilling, filling, and sealing steps. Previously, the target was secured to the glass slide with salt (NaCl) that was applied in solution with water. This method produced crystals which were ~ 25 to 50 μm in size. Crystals of this size worked well in securing GMB's up to ~ 200 μm in diameter.[3] For larger targets, however, the bond proved too weak to keep the targets secured during the heating stage of the process.

Successful bonding of 400-μm targets has been accomplished by sieving NaCl crystals to specific sizes and manipulating them into a tripod support configuration on the glass slide. The moisture necessary to initiate the bond is supplied by very light breathing through a plastic tube onto the crystals. Characterized GMB's are then secured by placement on a set of re-moistened crystals that bond the target to the slide once the evaporation of the applied water is complete.

Improvements in the gas handling system have also been attained by implementation of a reduced-volume gas manifold and valves. The system now requires approximately one-tenth of the gas previously necessary for operation. Also, pump-down and pressurization are more carefully controlled by a reduced flow rate through the system.



T440

Fig. 27
Scanning electron micrograph of a large plug, 14 μm in diameter, applied to a microballoon using the original technique.[3]

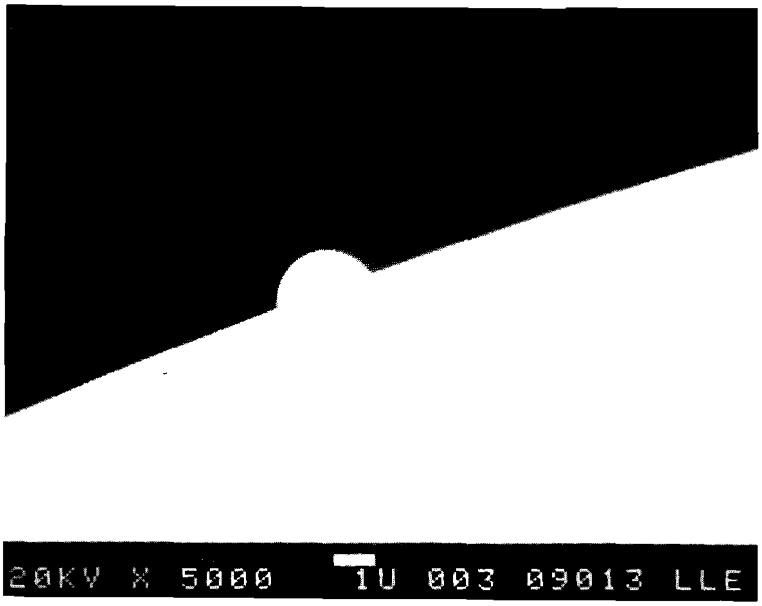


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Fig. 28
Smaller plug, 1.5 μm in diameter, applied to an identical microballoon using the improved technique (same length scale as in Fig. 27).

The main significance of our progress thus far is that we have passed out of the regime of gross shell nonuniformities. The implications for high-compression target implosions of the plug-mass and size reductions we have achieved are encouraging. The plug-mass reduction from approximately 0.4-1 ng to 2 pg and the corresponding reduction in areal density from approximately 4-8 pg/μm^2 to 1 pg/μm^2 is an important step. The plug masses are now sufficiently small that they are comparable to the mass lost in drilling through the shell.

Summary

The drill, fill, and plug target fabrication capability has been improved so that the fill-gas consumed is reduced by an order of magnitude, and the mass perturbation of the plug has been reduced by at least two orders of magnitude. This increased target uniformity should contribute significantly to the success of high-compression implosion experiments.

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