

ADVANCES IN TARGET FABRICATION

A Drill and Plug Technique for Filling Laser Fusion Targets

A new technique has been developed for filling hollow glass shell (microballoon) laser fusion targets with gases. Each microballoon is filled through a laser-drilled micron or submicron sized hole which is sealed using a single glass or plastic plug of comparable dimension. The seal is formed by melting a plug that was transferred onto the hole prior to filling. This technique was designed primarily to fill microballoons with Ar and other gases having low permeability through glass. The Ar targets for the intermediate density implosion experiments described on pages 25-30 were filled with this method.

Holes are drilled using 80 psec laser pulses of wavelength $1.06\mu\text{m}$. It has been found possible to produce high aspect ratio holes smaller than the diffraction limited laser spot size. Aspect ratios as high as 3:1 have been obtained, although typically the laser is configured to produce an aspect ratio of 1:1 which yields $0.5 - 2.5\mu\text{m}$ holes in the microballoons of interest.

Plug materials which have been used to seal holes include $1-5\mu\text{m}$ diameter polystyrene spheres and irregularly shaped pieces of low melting point glass of $\sim 2\mu\text{m}$ dimension. Since the plug is chosen from a material which can later be melted to form the seal, each plug can be transferred onto the hole at ambient atmospheric conditions.

Plugs are usually melted after the microballoons have been pressurized and flow in a manner such that the perturbation to the surface finish can be as small as 2000 \AA with a width of 2-4 μm . Figure 19 shows the surface of a microballoon which has been filled with 30 atm of Ar and sealed by melting a polystyrene sphere over the filling hole.

To certify the integrity of the seal, the optical path length through the balloon is interferometrically measured before and after filling. The change in optical path length is a direct measure of the gas pressure trapped inside a balloon. As expected, the pressure retention half life is dependent upon the interior volume of the balloon as well as the specific gas being trapped. For Ar trapped inside a 60 μm diameter microballoon, the pressure retention half-life is 12-30 hours when a polystyrene plug is used and well in excess of a month when sealed with a glass plug.

AN ARGON-FILLED MICROBALLOON PREPARED BY THE DRILL AND PLUG TECHNIQUE

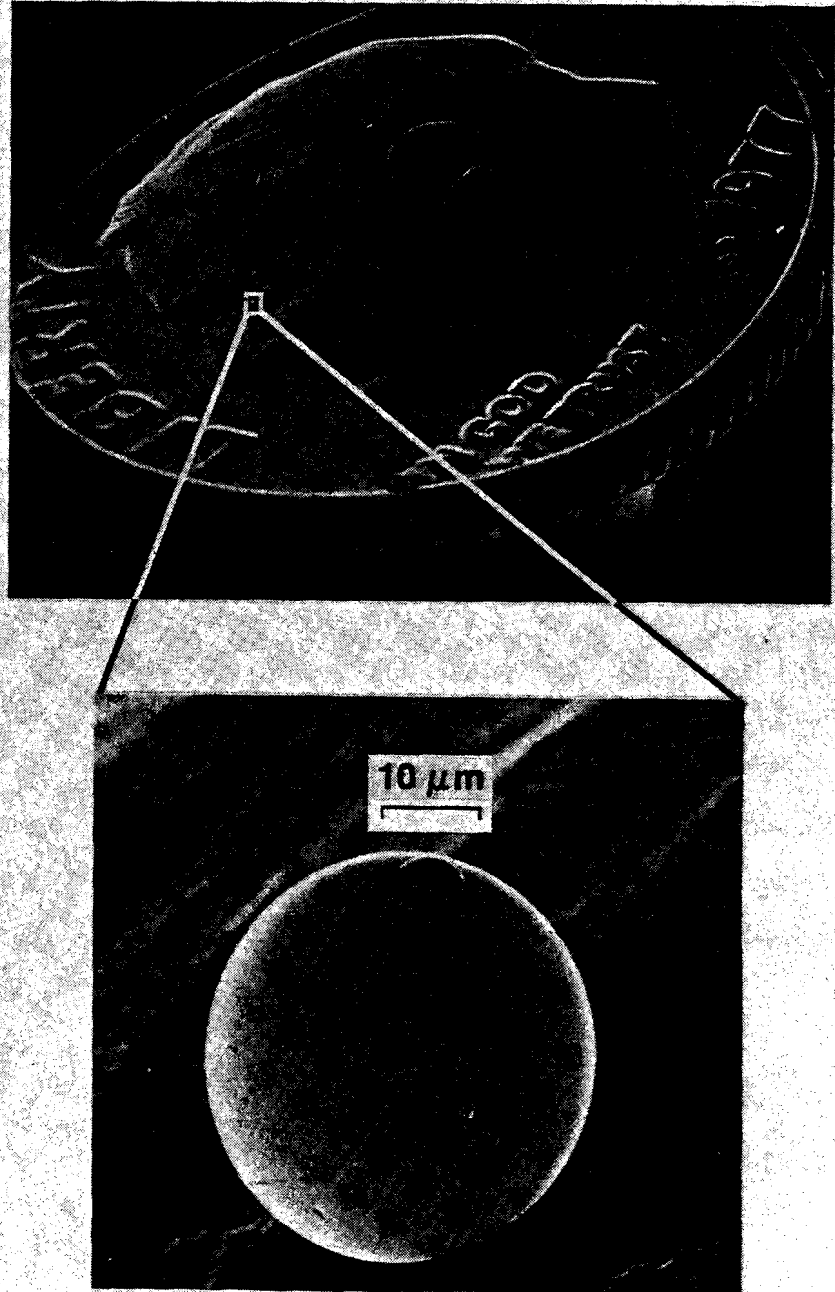


Figure 19

Self-Consistent, Non Destructive Measurement of Tritium Content and Wall Thickness of Glass Microballoon Laser Fusion Targets

In laser fusion experiments employing gas filled microballoons, it is essential that the fill pressure and glass wall thickness be known for each target prior to its use. While most targets retain their original fill pressure "indefinitely" when stored at liquid nitrogen temperature, some leakage has been found to occur in random samples. Previously, we have reported¹ a method for determining the tritium content of microballoon targets by measuring the flux of beta particles from the decay of tritium which emerge from the target wall. Since it was found that tritium and deuterium leak from glass microballoons at the same rate, a measurement of only the tritium content is sufficient to completely characterize the target fill. In order to relate beta particle count to tritium pressure, an accurate knowledge of the shell wall thickness is required. Optical interference methods^{2,3} are useful for wall measurements; however, corrections must be applied to account for the optical path length contributions from the gas within the target. Furthermore, the measured beta flux is reduced due to interactions with the fill gas; and a significant correction is required for high pressures and large microballoon diameters.

Because the wall thickness and pressure measurements are interdependent, an iterative technique has been developed to determine self-consistent parameters from the basic experimental input data. Required in the analysis, which relates measured beta flux to tritium fill pressure, is a quantitative modeling of the transmission of the

betas through the fill gas and glass walls. This model was developed using the Monte Carlo code, SANDYL, which calculates the net transmission probability for betas created uniformly within a spherical microsphere with the appropriate distribution of initial energies. Each code run follows the trajectories of 100,000 betas which are initially distributed according to the well-known energy spectrum of tritium beta decay. The particles are transported through the gas fill region and the glass wall accounting for such physical processes as slowing down due to inelastic collisions and the tracking of secondary electrons.

In the present application, the sample trajectories are used to calculate the fraction of source particles which emerge from the target as a function of total gas pressure p (atm), microballoon outer diameter D (μm) and wall thickness t (μm). For equi-molar deuterium-tritium fills and glass walls (density = 2.5 g/cm^3) the transmitted fraction is accurately represented by the expression: $f = 1.007 \exp(-2.717 \times 10^{-5} p D) \exp(-2.769 t)$ for $0 < p < 100 \text{ atm}$, $50 < D < 200 \mu\text{m}$ and $.4 < t < 2 \mu\text{m}$. This expression agrees well with previous estimates^{1,4} of the transmission fraction.

Using an assumed pressure p_0 (e.g., the permeation pressure), a wall thickness t_0 is calculated from: $t_0 = x\lambda - 1.30 \times 10^{-4} p_0 D$; where x is the measured fringe shift. This expression includes a correction for the refractive index of deuterium and tritium based upon the estimates of Briggs et. al.⁵. Using t_0 and the measured beta count rate C , a corrected pressure p_1 is calculated using the method of Reference 1. This new value of p_1 is then used to calculate a

corrected thickness t_1 . Typically 6-8 iterations yield convergence in p and t to 5% or better.

This technique has proven quite useful in providing a self-consistent measurement of the pressure content and wall thickness of deuterium- tritium filled glass microballoons.

1. H. W. Deckman, G. M. Halpern, J. Appl. Phys. 50, 132 (1979).
2. B. W. Weinstein, J. Appl. Phys. 46, 5305 (1975).
3. G. M. Halpern, J. Varon, D. C. Leiner, D. T. Moore, J. Appl. Phys. 48, 1223 (1977).
4. M. Mueller, Los Alamos Laboratories (private communication).
5. C. K. Briggs, R. T. Tsugawa, C. D. Hendricks, P.C. Souers, UCRL-51921.

Improvements in Parylene Coating of Fusion Targets by Molecular Structure Changes

Deposition of polymer coatings on glass microballoons is a convenient method for obtaining thick shell targets for laser fusion experiments. Since surface perturbations in the coating will cause the symmetry of the implosion to deteriorate, it is essential to be able to place extremely uniform polymer coatings onto the surface of a target, preferably at fast deposition rates. We have found that uniform plastic coatings can be made by using the Parylene process¹ of Union Carbide if molecular structure changes are made to the commercial material Parylene N (Poly (p-xylylene)). These coatings are applied without special cooling or heating arrangements, i.e., at 25 °C.

Problems with Parylene N coatings were noted by Liepins et al.² Unacceptable surface finish is obtained with too high a deposition rate, while slow rates of deposition produce surfaces relatively free of non-uniformities. This is due to the fact that the polymer coating typically has a high degree of crystallinity (60%) and is therefore quite susceptible to nucleation on a highly nucleating surface such as glass. On a very clean surface at room temperature, the deposition rate of parylene N is about 0.5 $\mu\text{m}/\text{hour}$ in order to obtain an acceptable surface finish. If the surface were not clean, the deposition rate would have to be even lower. This is illustrated in Figure 20(a), which shows the surface finish of a parylene N (Poly(p-xylylene)) coating applied to an uncleaned surface at 1 $\mu\text{m}/\text{hour}$. The regular molecular structure (shown to the right) leads to

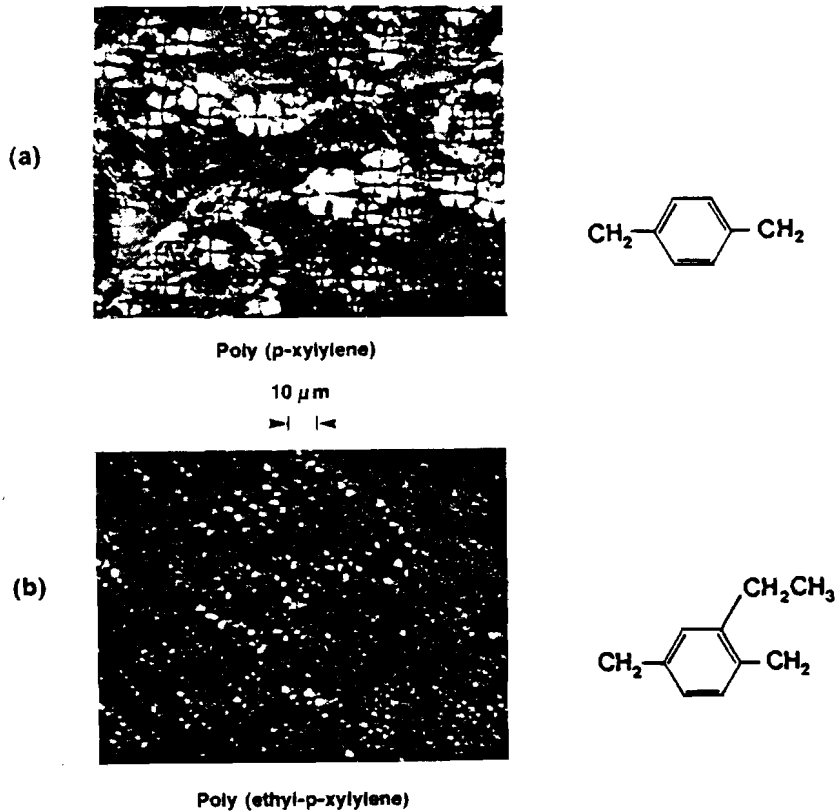


Figure 20 Improvements in surface finish and deposition rate for Parylene coated targets is obtained by making molecular structure changes to Parylene N: (a) surface finish for Parylene N; (b) surface finish with modified structure

the growth of crystalline formations and an unacceptable surface finish results. It has been found that by modifying the molecular structure of parylene N as shown in Figure 20(b), the tendency to nucleate is much reduced. The coating in Figure 20(b) was also applied to an uncleaned surface but at 2 μ m/hour. With appropriately prepared surfaces, target quality coatings (structure size \leq 0.1 μ m) are obtained at 2 μ m/hour deposition rates with Poly(ethyl-p-xylylene).

1. W. F. Gorham, J. Polymer Sci., A-1, 4 3027 (1966).
2. R. Liepins, M. Campbell, and R. J. Fries, ACS Polymer Preprints (Organic Coating and Plastic Chem.), Vol. 40, 175 (1979).