

**MASTER**

PREPRINT UCRL-83395

CONF-800208--10

# **Lawrence Livermore Laboratory**

**FABRICATION OF GLASS SPHERES FOR LASER FUSION TARGETS**

**R. L. Woerner, V. F. Draper, J. C. Koo and C. D. Hendricks**

**September 21, 1979**

This paper was prepared for submission to the  
Topical Meeting on Inertial Confinement Fusion  
San Diego, California  
February 26-28, 1980

This is a preprint of a paper intended for publication in a journal or proceedings. Since changes may be made before publication, this preprint is made available with the understanding that it will not be cited or reproduced without the permission of the author.



**DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED**

## FABRICATION OF GLASS SPHERES FOR LASER FUSION TARGETS\*

R. L. Woerner, V. F. Draper, J. C. Koo and C. D. Hendricks

University of California  
Lawrence Livermore Laboratory  
P. O. Box 5508, L-482  
Livermore, California 94550  
(415) 422-5954


### ABSTRACT

We have developed processes for mass producing the quality glass microspheres required for current laser fusion experiments. We describe the advances in the methods and materials used in our liquid droplet and dried gel systems.

#### DISCLAIMER

This book was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

-----  
\*This work performed under the auspices of the U.S. Department of Energy by the Lawrence Livermore Laboratory under contract number W-7405-ENG-48.

REPRODUCTION OF THIS DOCUMENT IS UNLIMITED 

The glass-microsphere specifications for laser fusion experiments are very stringent. Acceptable shells must meet a diameter tolerance of  $\pm 5 \mu\text{m}$ , a thickness tolerance of  $\pm 500 \text{ nm}$ , a wall thickness uniformity of  $200 \text{ nm}$ , and a surface smoothness of better than  $50 \text{ nm}$ . Because the glass microspheres undergo several additional processing steps, such as coating, we also need batches in which 80% of the spheres meet all of the requirements. Successful production of high quality glass microspheres requires understanding and control of both the physics of sphere formation and the chemistry of glass. Our processes give us the required control over glass composition, microsphere mass, and formation sequence.

In our liquid droplet process,<sup>(1)</sup> we produce uniform droplets of an aqueous solution of glass-forming compounds by acoustic disintegration of a liquid jet and then pass them through a long vertical furnace where they blow and fuse into hollow glass microspheres. The percentage of solids in the solution, the size of the jet orifice, and the acoustic driving frequency determine the size of the liquid drops and the mass of the resulting microspheres. The furnace temperature profile and air flow, in conjunction with the drop size, determine the diameter, wall thickness, and uniformity of the spheres. When properly tuned our systems produce batches of spheres in which more than 90% of the spheres have the same diameter and wall thickness within  $\pm 10\%$ . In addition, more than 90% of the spheres within a batch satisfy the exacting surface and symmetry specifications.

To expand our range of compositions and available sizes we use a dried-gel process in addition to the liquid-droplet method to make hollow glass microspheres. In the dried-gel process<sup>(2, 3)</sup> a solution containing glass-forming oxides is dried and ground into fine particles. The powder, after sieve cutting for the appropriate size granules, is dropped through a furnace. The water of hydration in the gel is encapsulated and the oxide particles blow and fuse into hollow glass shells. Unlike the droplet system a wide distribution of spheres is produced due to the varying initial particle size. When necessary we diameter and density sieve cut to narrow the size distribution. By adding urea to the gel which acts as an additional blowing agent we can produce large-diameter, thin-walled spheres ( $\sim 500 \mu\text{m}$  O.D.  $\times .5$  to  $1 \mu\text{m}$  thick).

We recently succeeded in filling spheres made in the dried gel system with argon as was done in the past with spheres made in the liquid-droplet system.<sup>(4)</sup> We are now in the processes of filling the spheres with bromine.

In both processes we use low melting point glass compositions that give us uniform spheres and smooth surfaces. Currently our glass consists of 70.6 wt. % silicon dioxide, 21.0 wt. % sodium oxide, 2.0 wt. % boron oxide, 5.4 wt. % potassium oxide, and 1.0 wt. % lithium oxide. For future applications we are experimenting with lead glass compositions.

Once the glass microspheres are formed, it is vital to remove all of the reactive alkali and to passivate the surface to prevent its rapid deterioration on exposure to humid air. We developed a special acid wash procedure that yields surfaces much smoother than the required 50 nm.

#### REFERENCES

- 1) A. Rosencwaig, J. L. Dressler, J. C. Koo and C. D. Hendricks, Lawrence Livermore Laboratory Report UCRL-81421 (1978).
- 2) C. D. Hendricks, A. Rosencwaig, R. L. Woerner, J. C. Koo, J. L. Dressler, J. W. Sherohman, S. L. Weinland and M. Jeffries, Lawrence Livermore Laboratory Report UCRL-82530 (1979)
- 3) R. L. Nott, Jr., R. L. Downs, W. J. Miller, M. A. Elmer, N. E. Dolitzky and D. E. Solomon, Paper TuE1-1 in the Technical Digest of the Topical Meeting on Inertial Confinement Fusion, February 7-9, 1978.
- 4) J. C. Koo, J. L. Dressler, C. D. Hendricks, "Low Pressure Gas Filling of Laser Fusion Microspheres," Proceedings of the First Topical Meeting on Fusion Reactor Materials Paper K-12 (1979).

#### NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the United States Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately-owned rights.

Reference to a company or product name does not imply approval or recommendation of the product by the University of California or the U.S. Department of Energy to the exclusion of others that may be suitable.