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FILL-TUBE-FITTED SPHERES

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FILL-TUBE-FITTED SPHERES

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ABSTRACT

The high temperature diffusion technique for fuel filling of some future direct drive cryogenic ICF targets may be unacceptable. The following describes a technique of fitting a 1 mm diameter X 6 μ m thick glass microsphere with an $\sim 50 \mu$ m O.D. glass fill tube. The process of laser drilling a 50 μ m diameter hole in the microsphere wall, technique for making the epoxy joint between the sphere and fill tube, as well as the assembly procedure are also discussed.

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The high temperature diffusion technique for fuel filling of some future direct drive cryogenic ICF targets may be unacceptable. For this reason we are investigating attaching small tubes of glass to glass microspheres for cryogenic fill purposes. Initial studies on fill tube fitted spheres were done with "hand blown" spheres (Fig. 1) on the end of glass tubing pulled down into the small diameter our fill tube required. The inferior optical quality and nonuniform wall thicknesses of these assemblies led us to look into construction of two piece assemblies using higher quality spheres attached to vacuum chucks, which served as fill tubes.

We chose 1 mm diameter X 6 μ m wall thickness spheres made at LLNL using the dried gel techniques. These spheres had to be drilled to accept a 50 μ m O.D. vacuum chuck fill tube. Investigation into the process necessary for drilling included lapping a hole, pin burning, mechanical microdrilling, and laser drilling. The latter method was the most workable. After considerable experimenting with a pulsed ruby laser machining apparatus and consideration given to a CO₂ laser system, a Nd:Yag laser drilling system was used to success (Fig. 2).

Modification of the existing drilling facility was minimal and required only changing the final objective lens to a 10X power 0.25 mm numerical aperture. Once the maximum power spot was found a sphere was loaded into a vacuum chuck held in a Leitz micromanipulator for positioning. The table below shows the results of experiments aimed at drilling a 50 μm diameter hole.

Energy - Joules Aperture - in. Hole Diameter - μm

.12	.031	10
2.4	.103	40
2.4	.110	45
2.0	.125	40
1.0	.156	50

TABLE

The hole sizes obtained in this table are variable as much as $\pm 8 \mu\text{m}$ due to varying sphere wall thicknesses, however using the parameters listed for a 50 μm diameter

hole the results were quite reproducible (Fig. 3). Holes can be drilled in either the first or second wall surface by changing the focal point accordingly.

The fill tubes used were manufactured by pulling down the diameter of a blood capillary tube to the desired diameter about 45 μm . The ends of these tubes are ground flat and perpendicular. These tubes are commonly used as vacuum chucks for holding microspheres. These chucks are the proper size in diameter and length for our application. The glass used in manufacturing them has similar thermal contraction characteristics of the sphere glass.

The second phase of construction is to attach a fill tube to a sphere. The joint between the two had to be vacuum tight at ambient and cryogenic temperatures (4°K). Two avenues of approach to this joint were pursued (1) solder glass as a joint material (2) epoxy as a joint material. The solder glass joint could be done in two ways. One was to apply a solder glass solution to the sphere after the hole was drilled, and then to heat it with a laser or small local heater. Complex manipulation

of the solder glass solution over such a minute area made this very difficult. The second approach to solder joints was to place a small droplet of solder glass in a liquid vehicle on a sphere then drill the hole through the droplet leaving a ring of solid solder glass as a joint filler. The earlier mentioned heating techniques would be used to remelt the solder glass into a joint. The thickness of the droplets compounded the problem of wall thickness vs hole size, however.

Epoxy joints, on the other hand, offered several distinct advantages. One was the ease of epoxy manipulation, even in minute quantities. Another advantage to epoxy joints was the absence of the necessity for local heating to make the joint. Yet a third is epoxy's low thermal conductivity thus acting as a thermal standoff in the joint between sphere and fill tube.

We had planned to explore many epoxys before finding one that would maintain vacuum integrity during cryogenic excursions, but the first one we tried worked well. We found that Hardman Extra Fast Setting epoxy was still sealed well at 5.6⁰K. Although not tried, other epoxys

used in cryogenic work i.e. Stycast 1266, Bakelite 2774, and Epon 828 would most likely render similar results.

To assemble, we position the fill tube and sphere using Leitz micromanipulators so that the fill tube can enter the sphere with complete clearance (Fig. 4a and b). The epoxy, which is held in another small glass tube, is placed on the fill tube at the proper distance for insertion into the sphere, about 100 μm from the tip. The joint is allowed to cure with positions maintained. The assembly is then leak tested using a helium mass spectrometer and the apparatus shown in (Fig. 5). This apparatus allows us to cryogenically cycle the test assembly to 78⁰K while still being leak hunted with the helium mass spectrometer. All six assemblies made tested good at 78⁰K. The only failures were that of the operator not using proper handling procedures. One assembly has been used in a cryostat system to 5.6⁰K for 6 hrs. and successfully survived that cycle twice.

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FIGURE CAPTIONS

Figure 1. One piece "hand blown" sphere and fill tube.

Figure 2. ND:YAG Laser Machining Machine Facility.

Figure 3. 50 μm diameter laser drilled hole in glass microsphere.

Figure 4a. and 4b. Fill tube fitting assembly process.

Figure 5. Cryogenic leak detection fixture.

10X

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Fig. 1

ND:YAG MACHINING FACILITY

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Fig. 2

200X

Fig. 3

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Fig. 4a and 4b

CRYOGENIC LEAK DETECTION FIXTURE

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Fig. 5