Developments in Target Fabrication for the U.S. ICF Program

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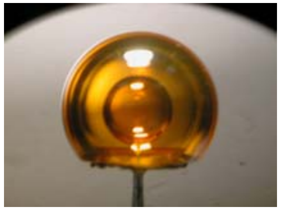
GENERAL ATOMICS

OUTLINE OF PRESENTATION

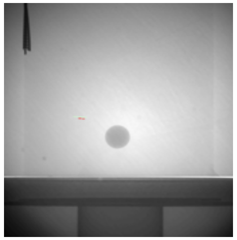
Developments in Target Fabrication for:

- **Glass Capsules from Si-GDP Precursors**

- **Double Shell Capsules**

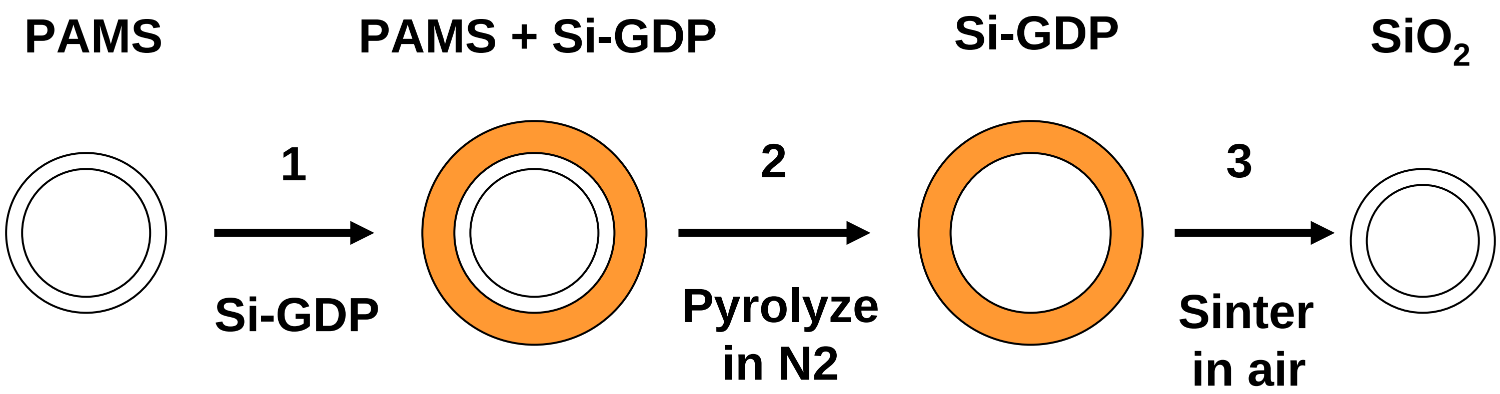


- **Innovative Foam Targets**



Production of Glass Shells from Si-GDP Conversion

Glass shell production involves pyrolysis of Si-GDP precursors to remove carbon and sintering to densify



Developments in Glass Shell Production from Si-GDP

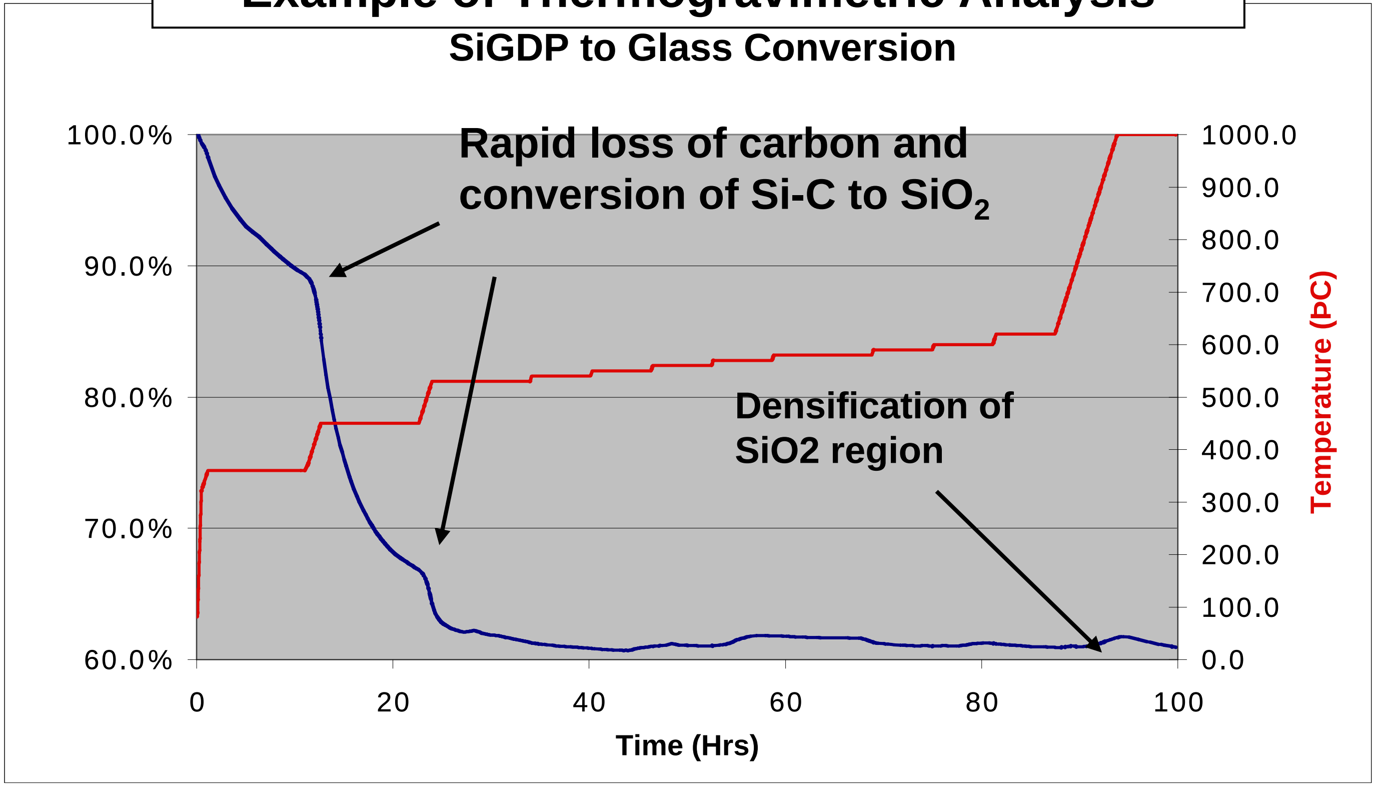
- Residual gases have been reduced to ~ 0.1 atm
- DD half-life can be made shorter when desired
- Thermogravimetric studies have revealed critical temperature regimes in the fabrication process
- Significant progress has been made fabricating colorless glass shells

M.L. Hoppe and D.A. Steinman, "New Developments in Glass Shells from SiGDP - Residual Gases, Gas Filling, and tailored Half-Lives," Fusion Sci. Technol. 51, 606 (2007).

Control of temperature profile for Pyrolysis and Sintering has enabled

- **Ability to adjust permeability for shells**
- **Reduction in trapped residual gases and carbon**
- **Ability to fill shells with Noble Gases (Ar, Kr, Xe), by using ~30% overpressure of Noble Gas throughout processing**

Example of Thermogravimetric Analysis



Residual Gas Pressures have been Minimized by Increasing the Hold Time at 450 C prior to High Temperature Sintering

Shell OD (µm)	Shell wall (µm)	Pyro Time at 450˚C (hrs)	Residual CO (atm)	Residual CO_2 (atm)	Residual Total (atm)
1082	5	60	.006	.182	.19
1123	5	60	.015	.168	.18
1126	5	60	.020	.150	.17
1106	5	100	.008	.035	.04
1115	5	100	.005	.036	.04

The DD Permeability of Glass Shells produced from Si-GDP can be controlled by varying the sintering temperature

Deuterium permeability for Glass Shells sintered at different temperatures

OD (µm)	Wall (µm)	K (mol · m)/ (m^2sPa)	Sintering Temp (C)	DD 1/2 Life (days)
250	8	2.3×10^{-20}	940	40
250	8	8.5×10^{-20}	920	11
250	8	5.2×10^{-19}	820	1.8

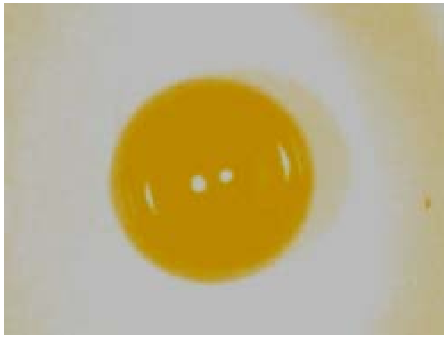
Literature value for K (DD through SiO_2) is 2.7×10^{-20}

Pyrolysis with longer hold times produce colorless shells

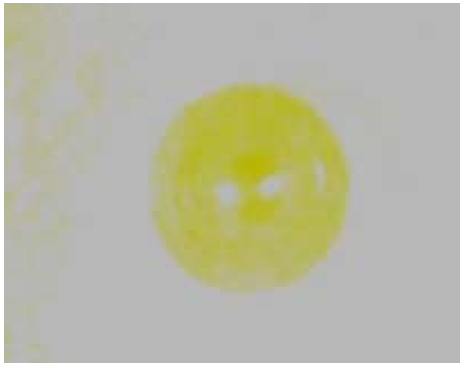
Long Pyrolysis hold times at 450-500 C allows removal of residual carbon and production of colorless glass shells

Pyrolysis hold time at 450 C and resulting shells

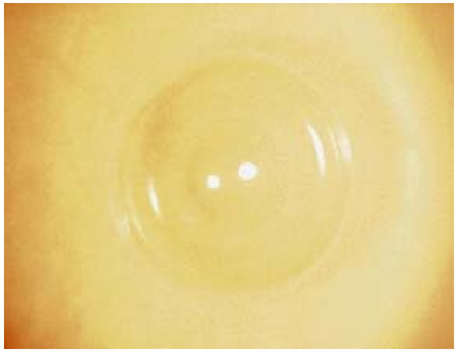
12 hrs



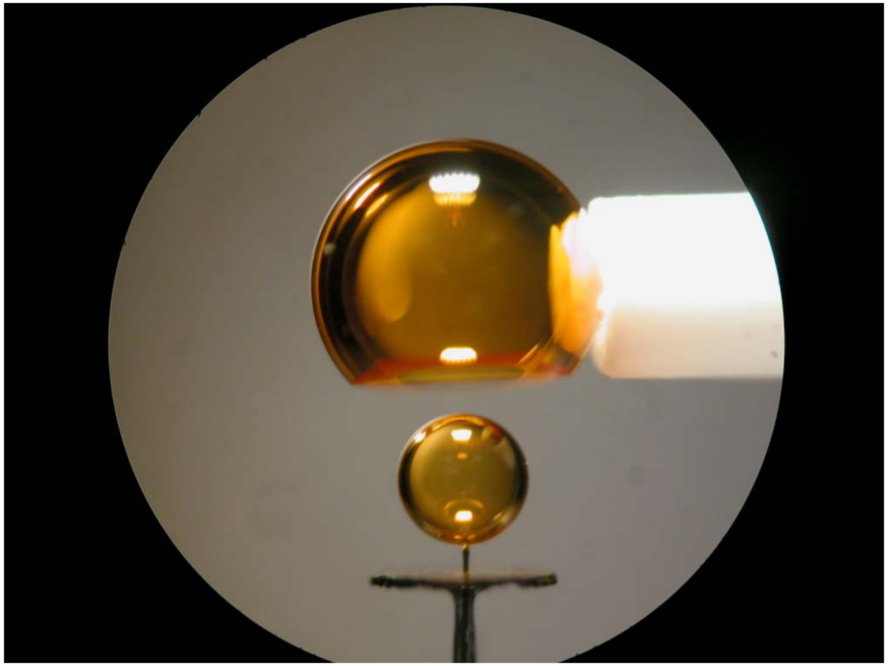
48 hrs

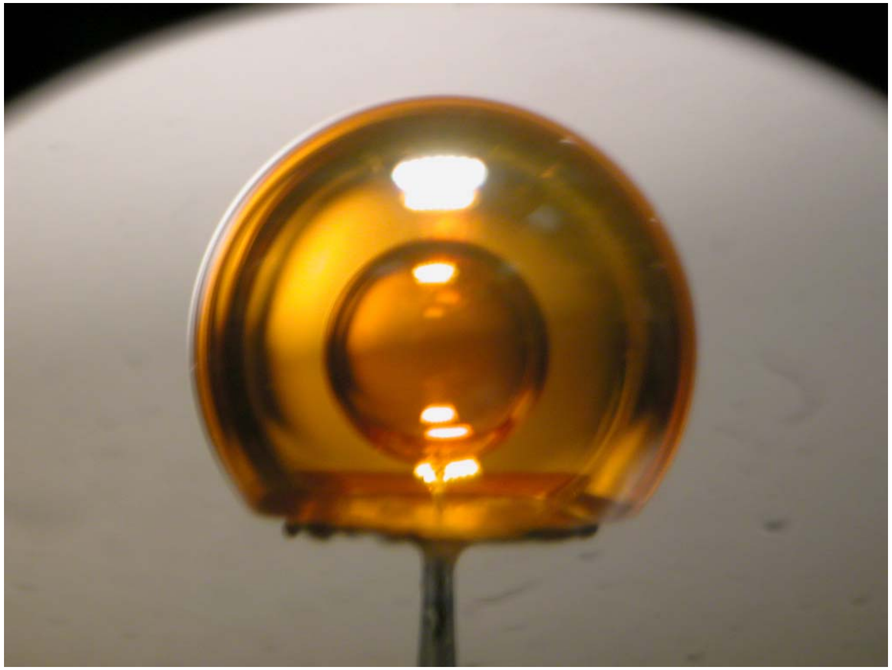


100 hrs



Double shell targets continue to be fabricated for use in Dynamic Hohlraum Experiments





Precision Assembly of a Double Shell Target

There are Many Challenges during the Fabrication of Dynamic Hohlraum - Double Shell Targets

Schematic of Double Shell Target

GDP outer shell

Xe or neopentane fill

Glass inner shell

DD fill

QuickTime™ and a
TIFF (Uncompressed) decompressor
are needed to see this picture.

PVA inner layer

Fill tube

Leak Tight Be Support Washer

Some Fabrication Challenges:

(1) Permeation barrier on inside of Outer GDP Shell

(2) Centering of Inner shell to +/- 10 µm

(3) Gas fill of neopentane which can condense on wall of Outer Shell

Double Shell Target Fabrication Challenges have been met by Various Methods

Schematic of Double Shell Target

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Xe or neopentane fill

Glass inner shell

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Leak Tight Be Support Washer

Fabrication Solutions:

(1) Use of PVA coated PAMS as Mandrel for GDP, removing PAMS, allows inner PVA coating for GDP

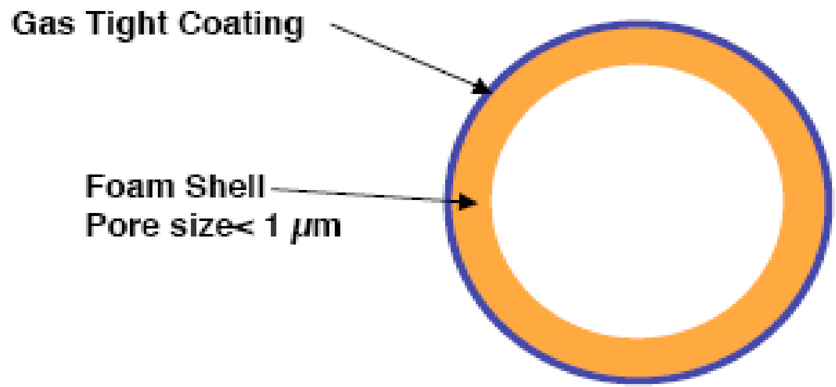
(2) Centering of Inner shell to +/- 10 µm has been achieved for 50% of targets using precision assembly stage

(3) neopentane which has b. point. of 18 C is prevented from condensing by its reservoir cooler than the target

Foam Shell Developments for Direct Drive Experiments

Direct Drive Capsule Requirements

- Cryogenic design (SDRF)
  - 100 mg/cc
  - 50-70 μm thick
  - Perm barrier ~ 3 μm
- Room temp surrogate (HDRF)
  - 200 mg/cc
  - 80-100 μm thick
  - Permeation barrier
- OMEGA laser ~ 850 μm dia
- NIF laser ~ 3 mm dia

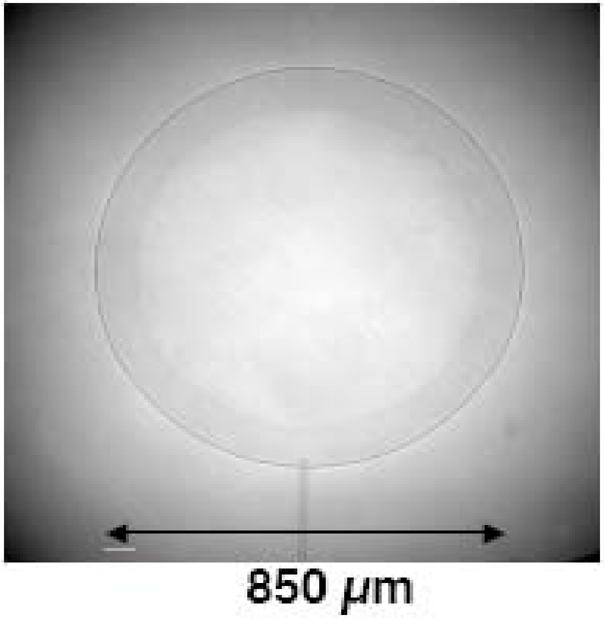


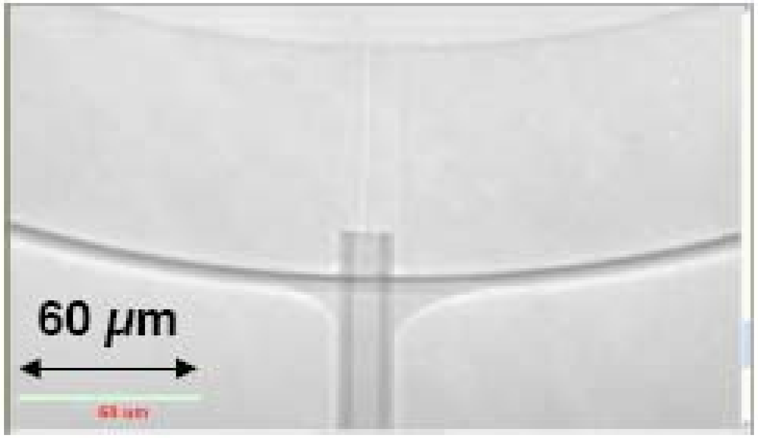
$$NC = \frac{\text{Offset}}{\text{Avg. Wall Thickness}} < 5\%$$

- Out-of-round < 5 μm
- Outer surface finish : given in terms of spatial frequency power spectrum

Our developments have enabled room temperature and cryogenic experiments at OMEGA

The OMEGA cryo direct drive target is permeation filled, but room temperature surrogates have been made with fill tubes

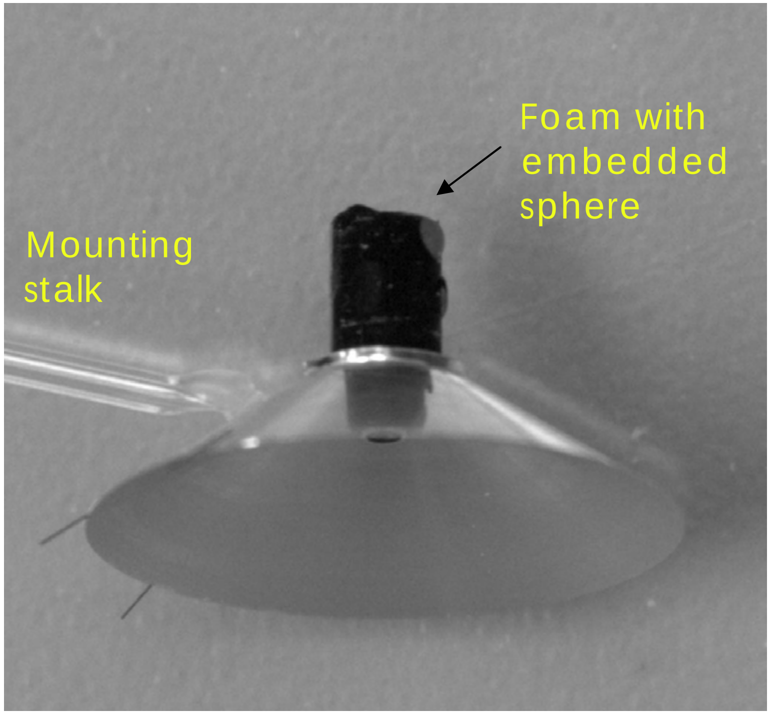


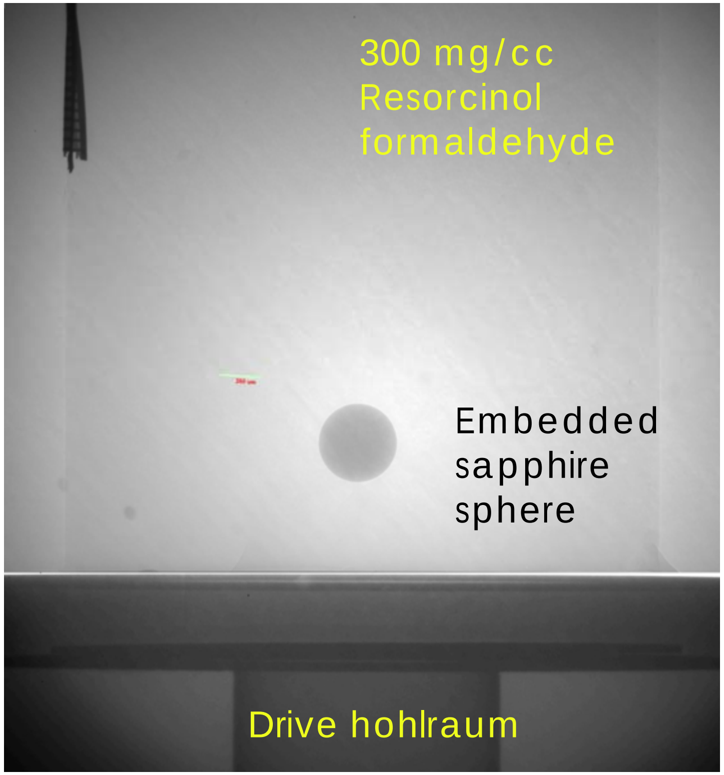


- **Fill tube foam shell (HDRF) with a large reservoir to maintain gas fill in porous foam shell was designed and fabricated in collaboration with LLE**

- **Reservoir volume was 5 cc. Holes were drilled with eximer laser, with precision of 12 +/- 2 µm, no back wall damage was observed**

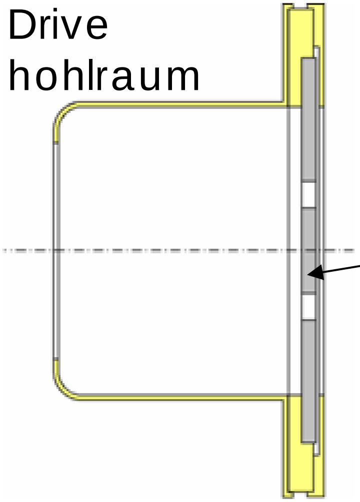
Aerogel Foams have been an essential component in experiments studying astrophysical jets and shocks

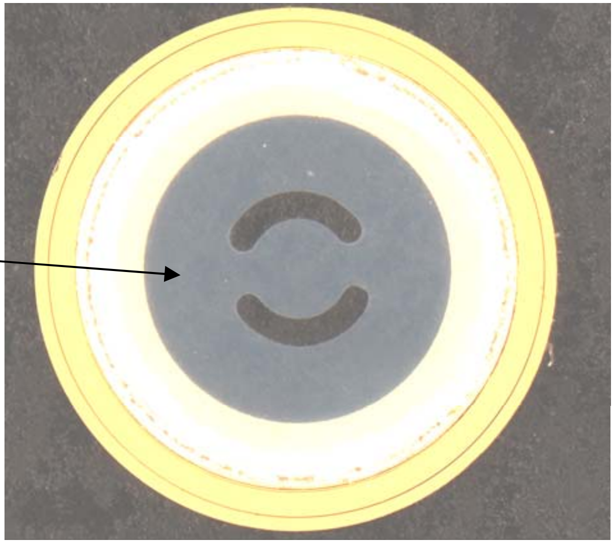


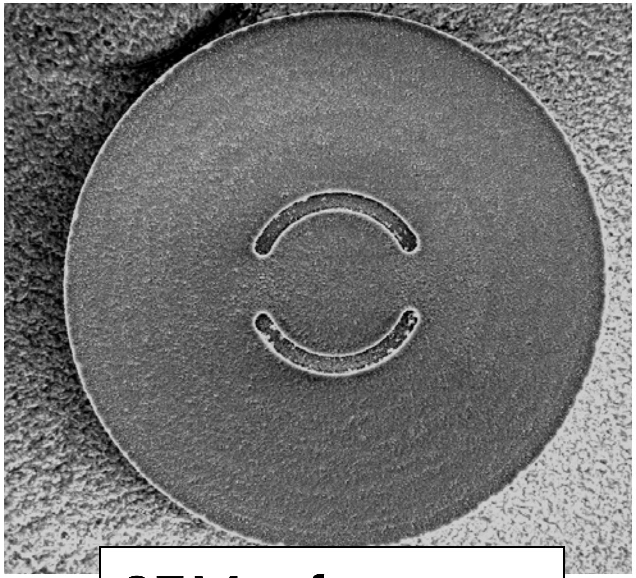


We have developed a technique needed to embed objects in aerogel foam without supporting stalks or fibers

Tantalum oxide aerogel disks have been made for use in high energy density experiments







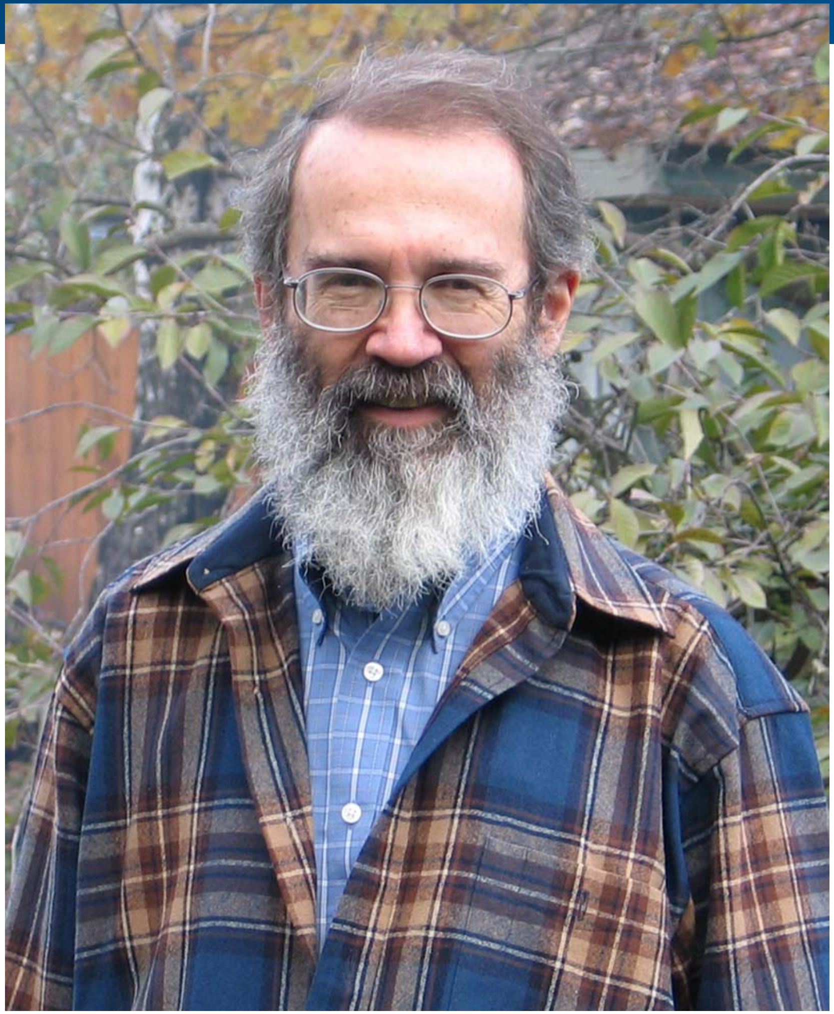
SEM of target

- **Recent work has focused on improving the areal density of the foam by making more homogeneous foam material.**

- **Reducing density nonuniformities in the foam and improving the surface roughness has been achieved by better cross-linking which has lowered the void content.**

Summary/Conclusions

- Development Studies for the Si-GDP to Glass Capsule Fabrication Process has allowed control of DD half-lives, decreased residual gases, and routine production of colorless capsules.
- Challenging Double Shell Targets continue to be developed for Dynamic Hohlraum Experiments
- Aerogel Foam Target Development has enabled room temperature and cryogenic experiments. Novel Foam Targets have been developed for experiments used to study astrophysical jets and shocks.



R.C. Cook