APPENDIX E

TARGET FABRICATION

BY

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IFE - Target Fabrication Issues
or
Where Direct Drive Targets are Today

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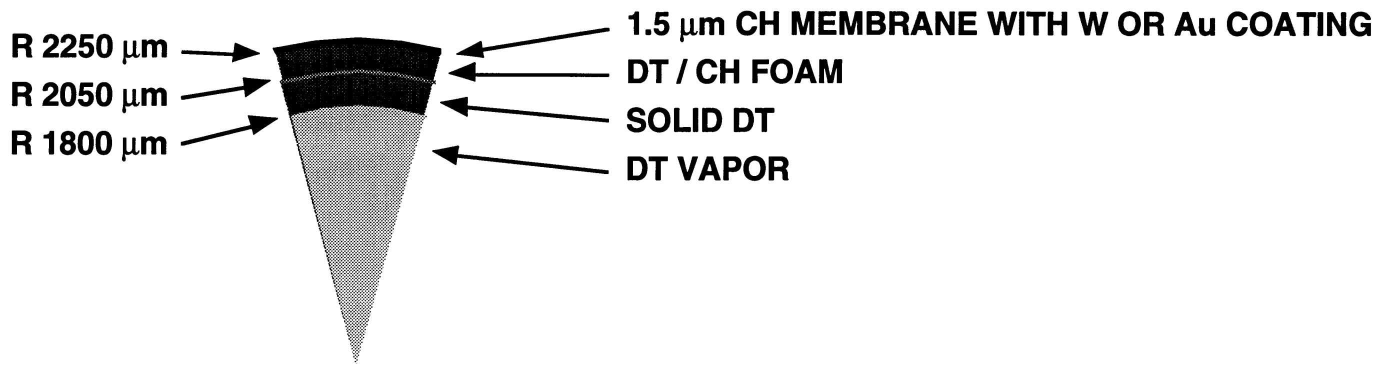
IFE Target Requirements

Specifications

- ~ 4.5 mm diameter foam shell with 200 μm wall
- 1.5 μm CH shell with Au overcoat
- Out-of-round: $d_{max} - d_{min} < 1\ \mu m$
- Wall thickness uniformity: $\Delta w < 0.5\ \mu m$
- Surface smoothness: < 200 Å RMS
- Surface power spectrum below NIF porfile
- Density: ~ 20 mg/cc
- Produce 10^8 targets per year
- Reduce cost to under 20¢ per target

Mechanical Performance of Foam Targets

NRL RADIATION HEATED ABLATOR TARGET

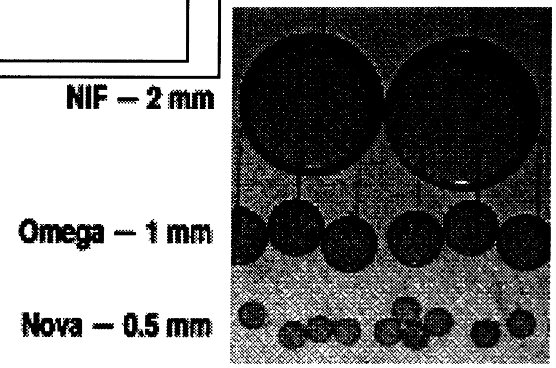


- Measure modulus and yield @ low temperature
- Measure transport properties (thermal expansion coefficient, thermal conductivity)
- Study tritium compatibility of capsule materials, e.g., foam
- Determine the equation of state of DT at the appropriate densities of interest to IFE capsules
- Observe behavior of solid DT below 10 K (i.e., can a DT solid layer be cooled below 10 K without forming cracks or without pulling away from the capsule inner wall)

Full Density Polymers

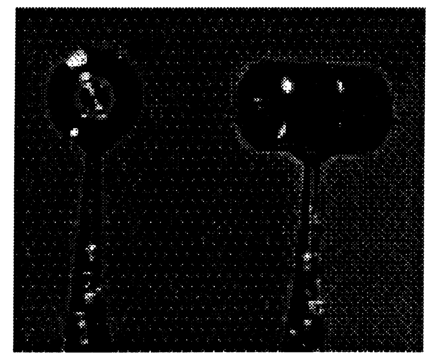
Shells

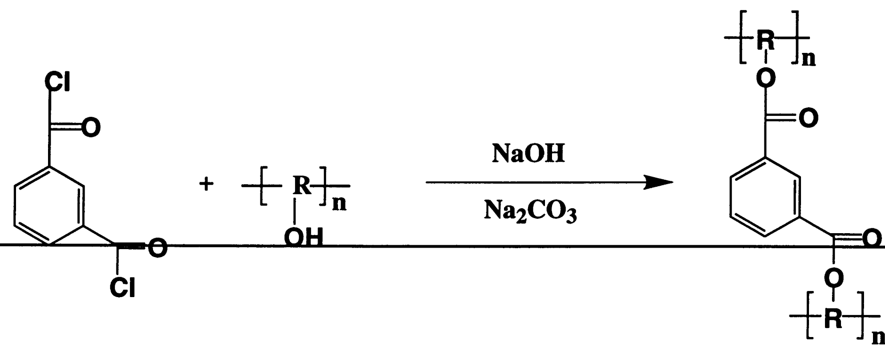
- **Kapton**
- **Polystyrene**
- **PAMS**
- **Glass**



Microencapsulation

- **Polystyrene**
- **Polyvinyl phenol/alcohol**



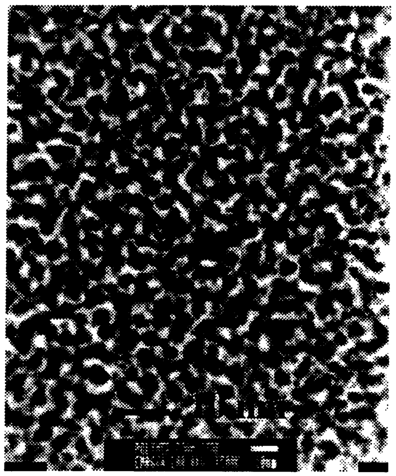


Foams Currently Used in Targets

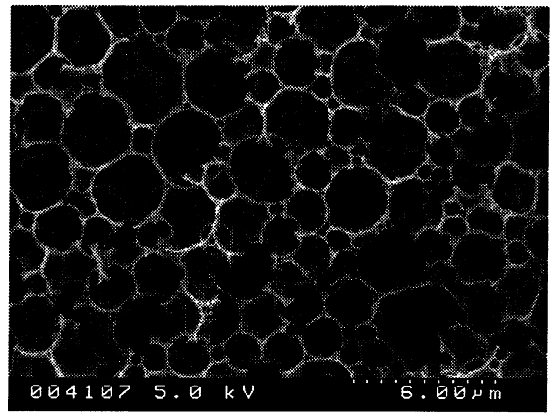
Foam	Density Range (mg/cc)	Pore Size	Dopants	Production Features
Acrylate TMPTA	10-700	1-3 µm	Halogens Physical dispersions Embedded objects	Microfabrication (in situ) ~10/day Supercritical extraction
HIPE Polystyrene	15-700	1-10 µm	Halogens Chemical modification Physical dispersions	Bulk production >0.15m^3 Machined targets
RF	20-850	5-50 nm	Chemical modification Physical dispersions	Bulk production <250cc Supercritical extraction Machined targets
Hypercrosslinked	125-900	10-750 nm	Chemical modification Physical dispersions	Bulk production <250cc Supercritical extraction Machined targets

Current Technology & Things to Come

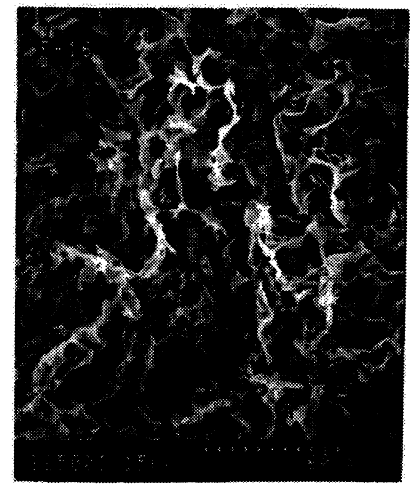
Hyper



HIPE



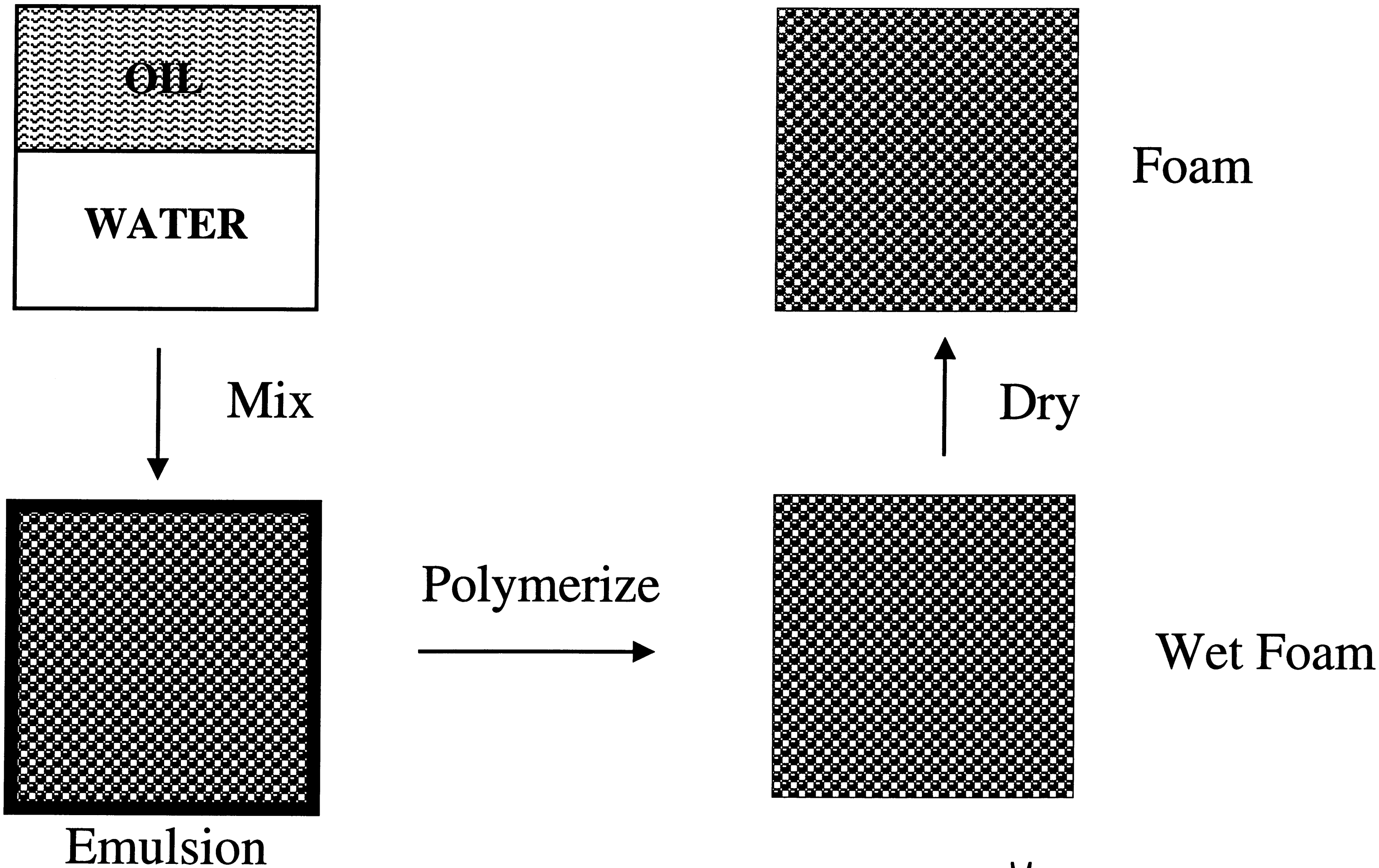
PMP



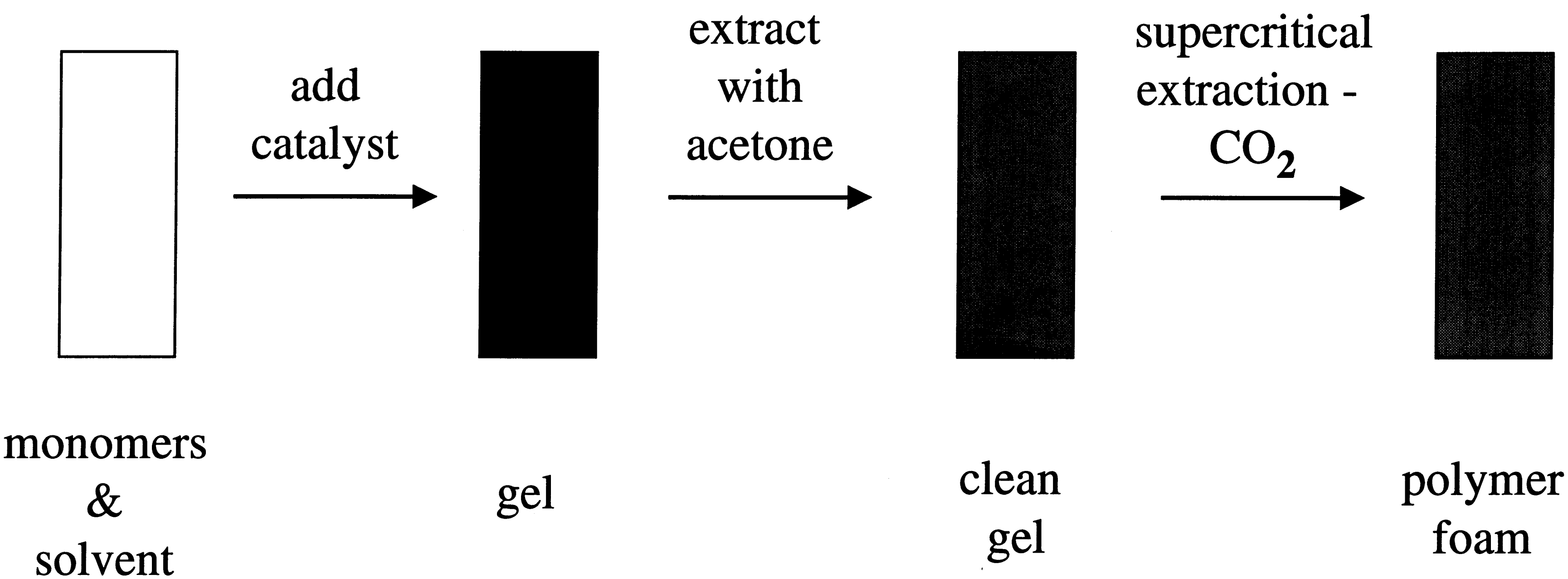
- Foam materials: aerogels, RF/aerogels[1], hypercrosslinked[2], nanotemplating[3-4]
- Barrier layer formation: interfacial polymerization, shell manufacture - micro-encapsulation, GDP/polyimide
- High Z coatings processes: chemical and physical vapor deposition

1.) Lambert, S. M., *et al.* *J. App. Poly. Sci.*, 1997, **65**, 2111.
2.) Steckle, W. P., Apen, P. G., Mitchell, M. A. US Pat. 5,629,353 and 5,710,187, 1998.
3.) Jacoby, M. *C&EN* Nov. 1998, **38**.
4.) van Blaaderen, A. *Science* 1998, **282**, 887.

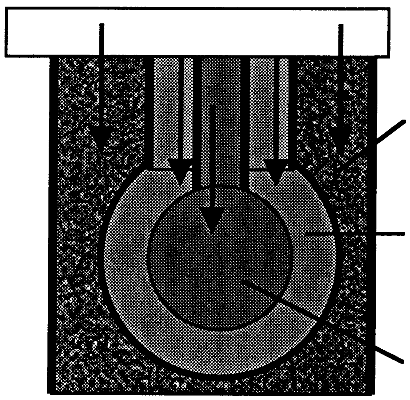
HIPE Foams

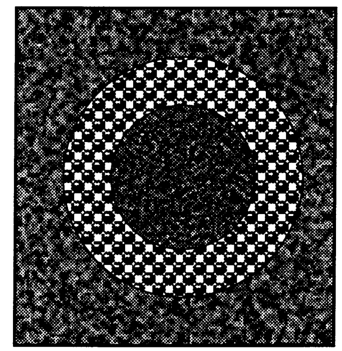


Hypercosslinked Foams

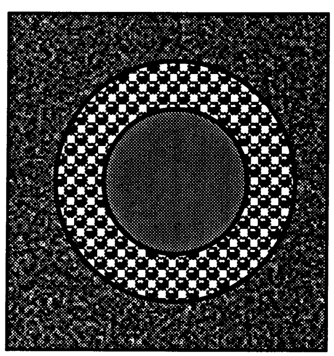


RF Foam Shell Process

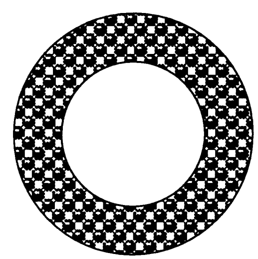




After curing,
oil and aqueous
phases are exchanged
with isopropanol

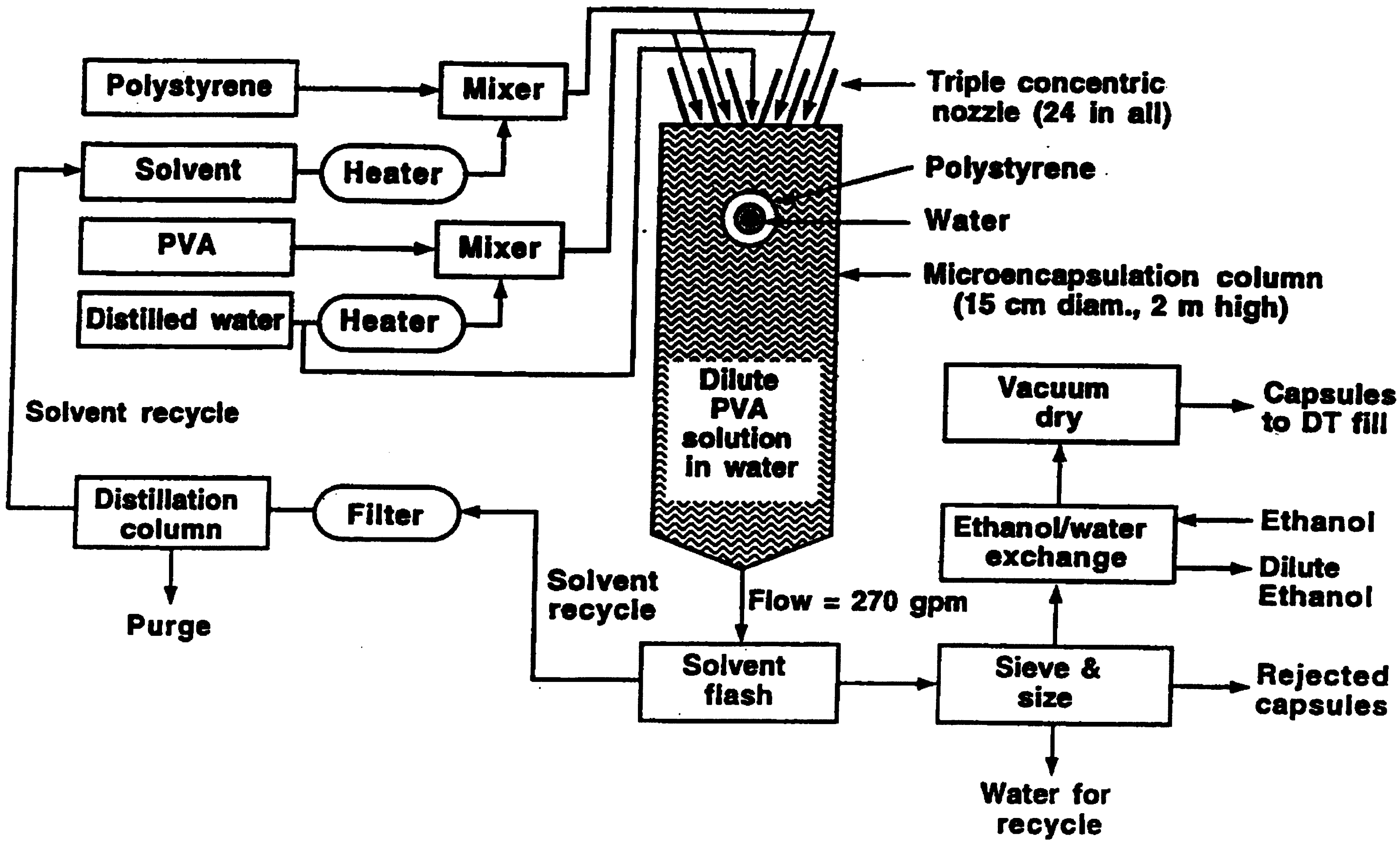


Heat activates
crosslinking and
stiffening of
aqueous gel



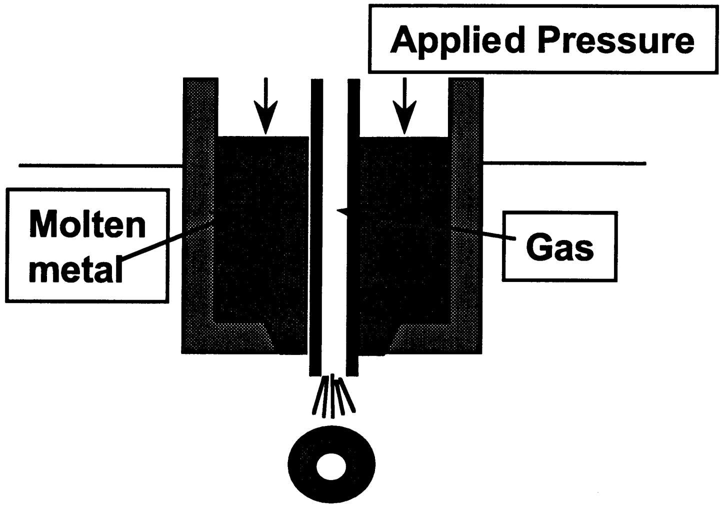
Isopropanol is
exchanged with
liquid CO_2 which
is removed as a
supercritical fluid

Drop Tower



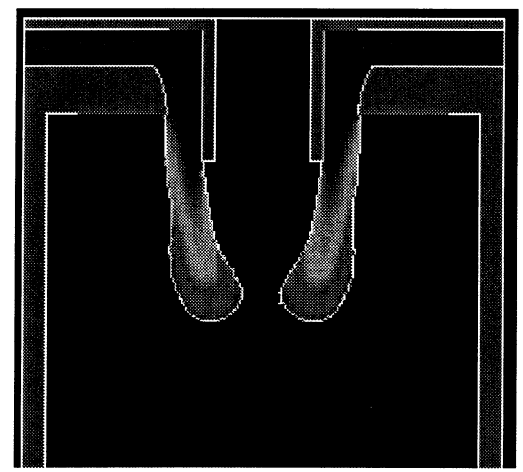
Schematic of possible IFE capsule fabrication process using microencapsulation. (UCRL-ID-117396)

Be Droplet Formation for Shells



- **Advantages of new process**
- Faster production time: 10-100 / second
- Better remote handling of materials: less exposure to hazardous materials

- **Computer Simulations**
- Help engineers understand the process
- Determine the ideal process parameters
- Hundreds of simulations can be run and only a few experiments will be needed.
- Initial computer simulations have been performed FLOW-3D - a commercial code



FLOW-3D simulation of balloon process (Color indicates temperature)