Use of Polyimide in IFE Target Components

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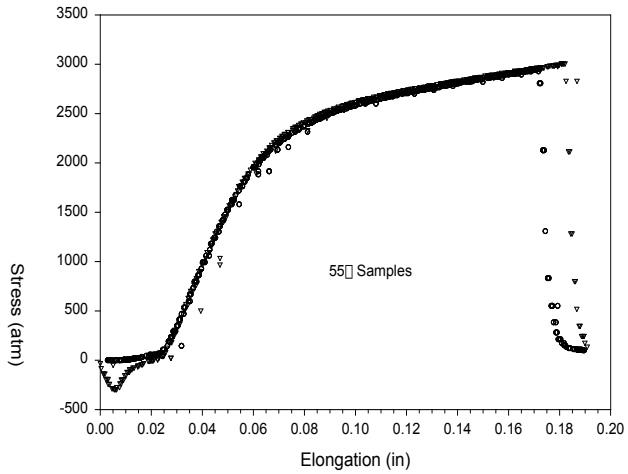
Polyimide Film

- **Polyimide consists of a large class of aromatic polymers**
  - Made by polymerizing a dianhydride and a diamine
  - $C_{22}H_{10}N_2O_4$
- **Commercially available polyimide:**
  - Films
    - Kapton® (Dupont)
    - Upilex® (UBE Industries)
    - Apical® (Kaneka (was Allied Signal))
  - Bulk
    - Vespel® (Dupont)

Advantages of Polyimide for IFE Targets

- **High Strength**
  - Luxel Polyimide — $\sigma_u \geq 310$ MPa
    - Dupont Kapton® Polyimide — $\sigma_u \geq 231$ Mpa
    - Mylar — $\sigma_u \geq 100$ MPa
    - Formvar — $\sigma_u \geq 60$ MPa
    - Polycarbonate (Lexan) — $\sigma_u \geq 60$ MPa
    - Parylene N — $\sigma_u \geq 60$ Mpa
  - Strength Measured by Mechanical and Burst Tests:



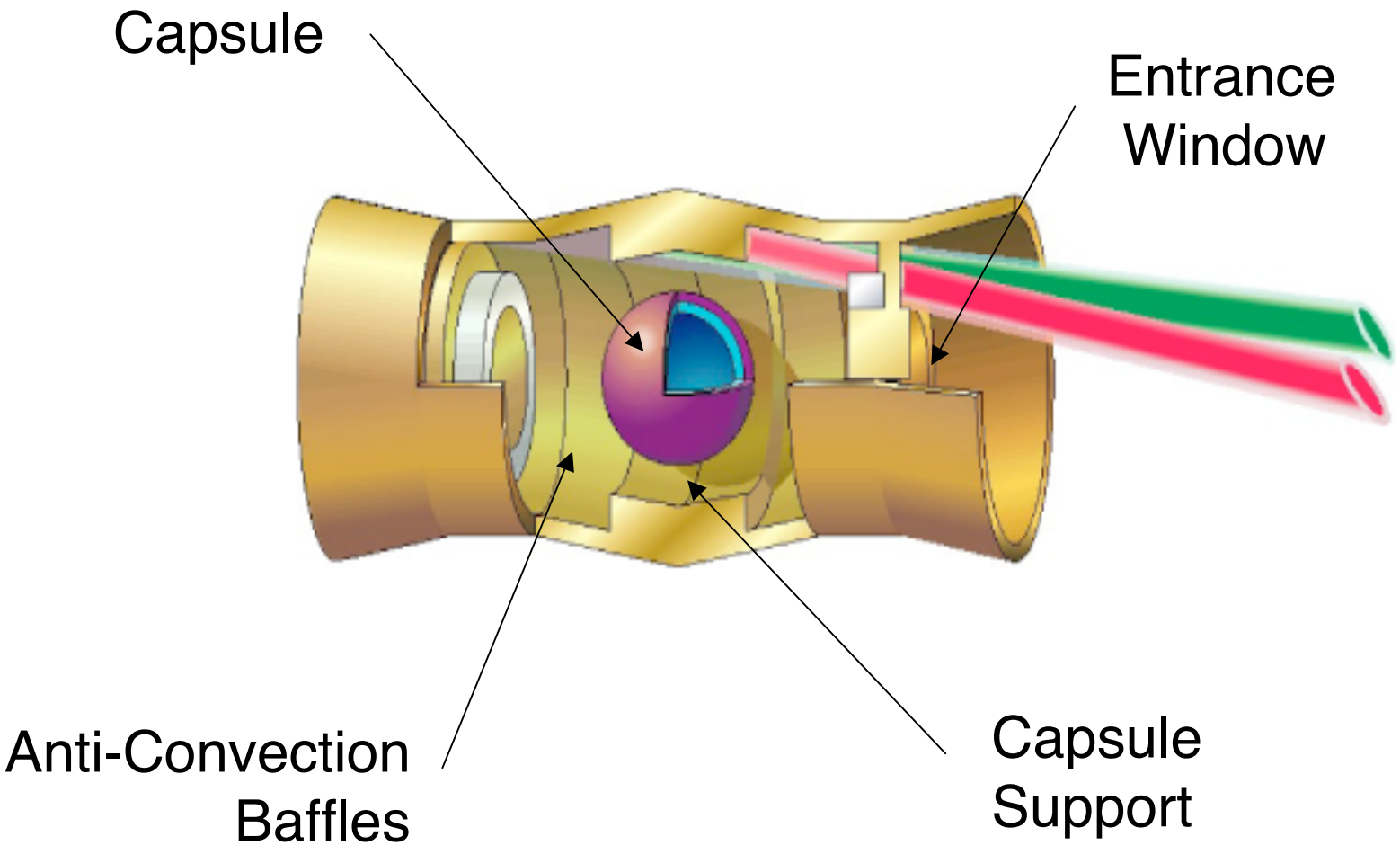
Advantages of Polyimide Film for Targets (con't)

- **Large Temperature Range**
  - Used in applications from 1.8K to 400ºC
- **High Radiation Resistance**
  - Gamma Radiation at Savannah River
    - Tests performed on Dupont Kapton®

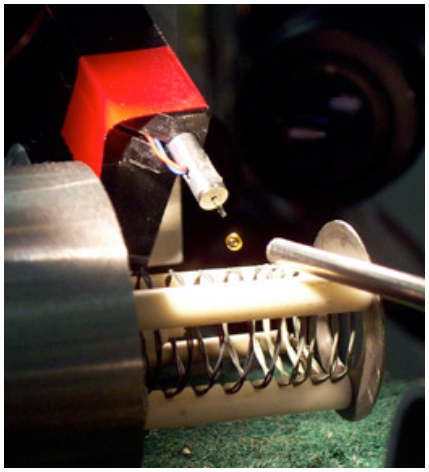
	0 Gy	10^5 Gy	10^6 Gy	10^7 Gy	10^8 Gy
Tensile (MPa)	207	207	214	214	152
Elongation (%)	80	78	78	79	42
Modulus (MPa)	3170	3280	3380	3280	2900

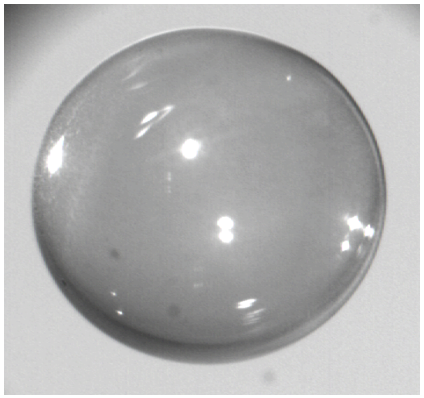
  - Similar Results for Neutron, Electron, and UV Radiation

Possible Polyimide Components Heavy Ion Driven Target



Polyimide Capsules

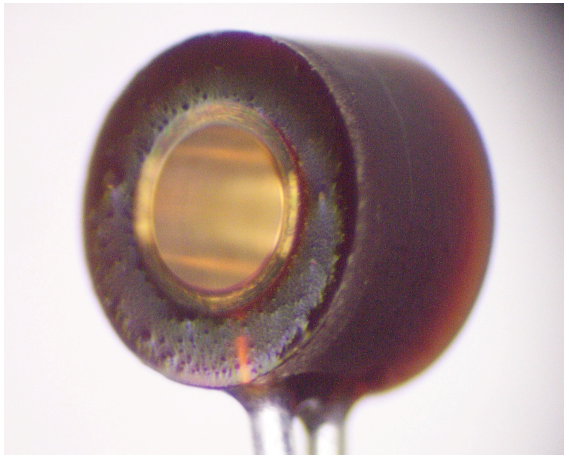


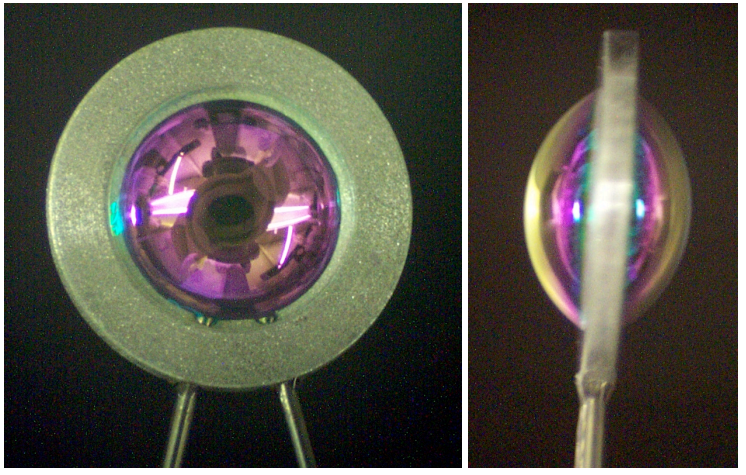


- **Various Fabrication Methods**
  - Vapor Deposited on Mandrels
    - Lawrence Livermore National Lab
    - University of Rochester
    - General Atomics
  - Solution Deposited on Mandrel (Thick Wall)
    - Luxel
    - Solution Deposited Using Ink-Jet
  - Direct Formation Using Bubble (Thin Wall)
    - Luxel
    - Bubble Cured while Acoustically Levitated

Entrance Windows

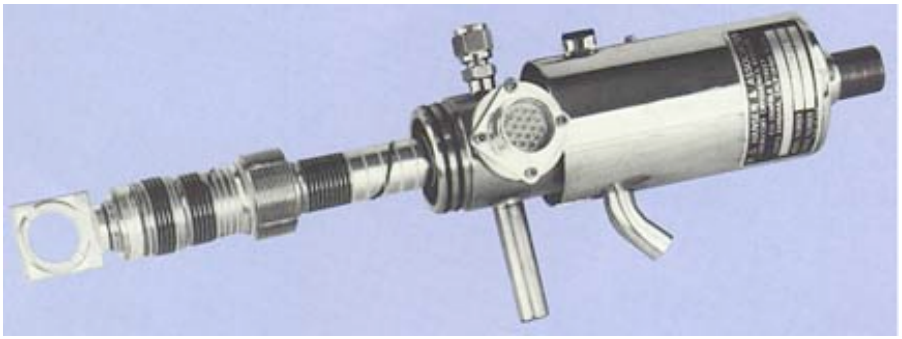
- **Polyimide is Currently used for ICF Hohlraum Entrance Windows**
  - NOVA
  - NIF
  - CEA
- **Gas Bags Use Polyimide Windows**
  - Film is 3500Å Thick
  - 1atm Internal Pressure
- **Luxel Routinely Spin-Casts Polyimide Film from 300 to 20,000Å**

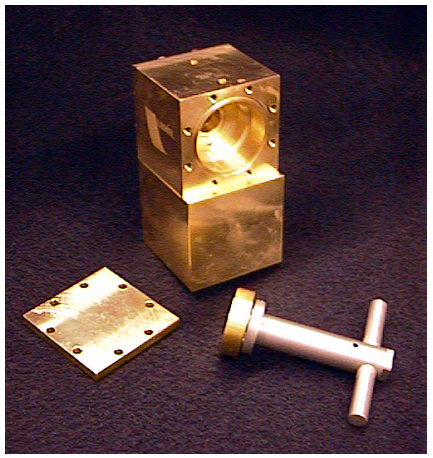




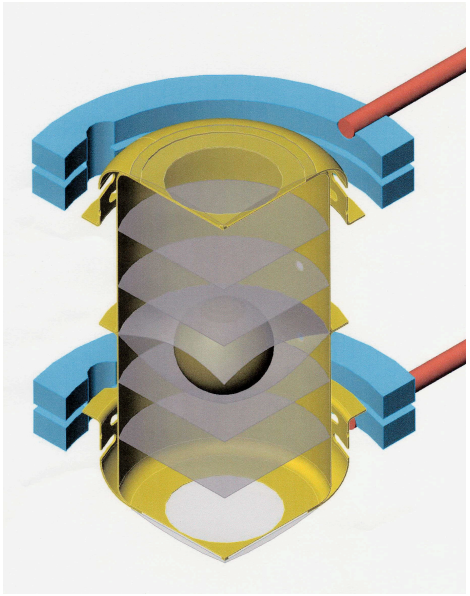
Optimization of Strength at Cryogenic Temps

- **Recently Completed a Project to Optimize the Burst Strength of Polyimide Windows at Cryogenic Temperature**
  - Windows From 450 to 9115Å thick
  - Testing at 300K, 77K and 4.2K
  - Optimized Cure Cycle Resulted in Average Burst Strength Increase of 36%
  - Allows Thinner Windows or Higher Internal Pressure





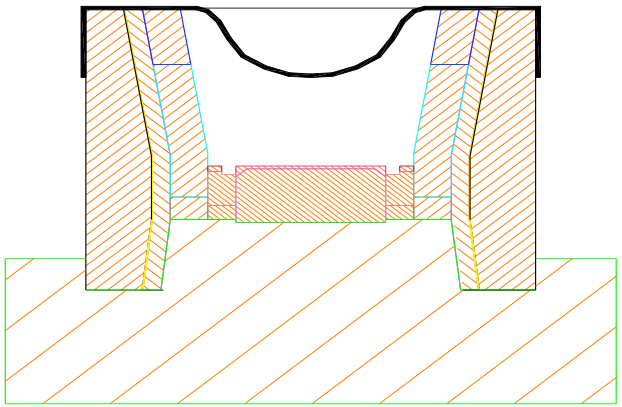
Anti-Convection Baffles

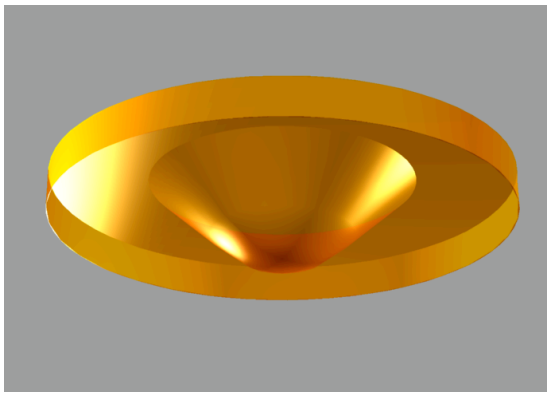


- **IFE Hohlraums May Require Anti-Convection Baffles**
  - Convection Cells Set Up in Gas
  - Destroy Symmetry Required for Beta Layering
- **Current NIF Design Includes Four 1000Å thick Polyimide Baffles**

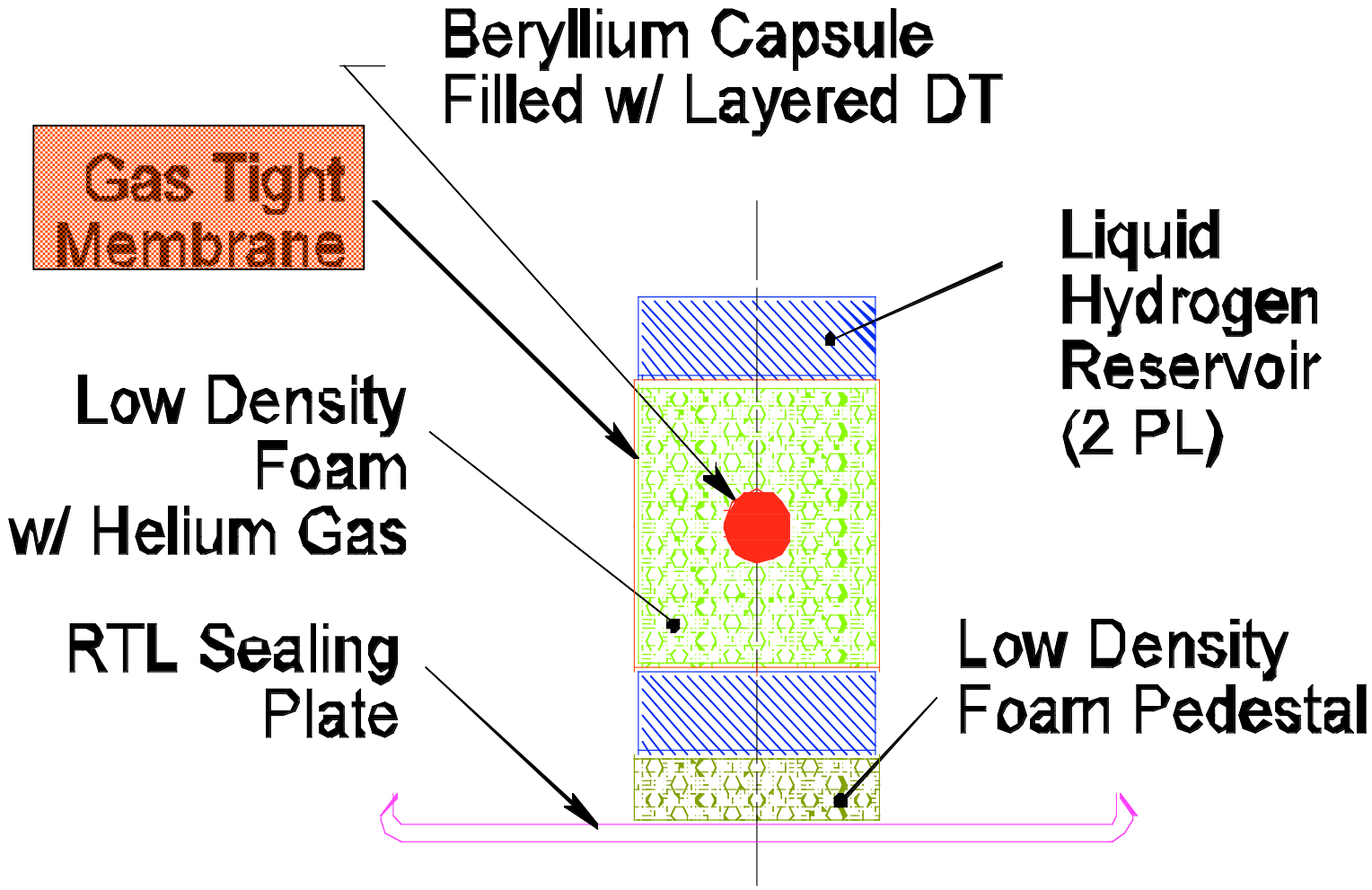
Capsule Supports

- **Current NIF Capsule Supports use Formvar Films**
  - However, DT Filled Capsules Cause the Films to Fail
  - Polyimide is Very Radiation Resistant
- **Heavy Ion Driven Target Capsule Supports**
  - Baseline Assembly Technique is Cryogenic Assembly
  - Shape Required is Too Severe for Flat Film
  - Luxel has Submitted a SBIR Proposal to Develop IFE Capsule Support Mass-Production Methods





Possible Polyimide Components Z-Pinch Driven Target



Gas Tight Membrane

- **Z-Pinch IFE Target Membrane Requirements:**
  - Right Circular Cylinder
  - Ultra Thin
  - Leak Tight
  - Low Emissivity
  - High Thermal Conductivity
- **Luxel Currently has SBIR Grant to Develop Mass-Production Methods**

Summary

- **Polyimide's Unique Properties Offer Many Advantages to IFE Target Designers:**
  - Ultra Thin Films
  - High Strength
  - High Radiation Resistance
  - Excellent Cryogenic Properties
- **Polyimide Is Available in Many Forms:**
  - Thin Films
  - Shapes(spheres, hemis, cylinders)
  - Conformal Coatings