



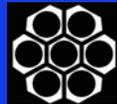
MSFC Tech Days 2004



Lightweight Gas-Fusion™ ULE® Mirrors

*Funded by HEL/JTO
Category: Beam Control*

Richard W. Wortley
Principal Investigator



HEXTEK Corporation

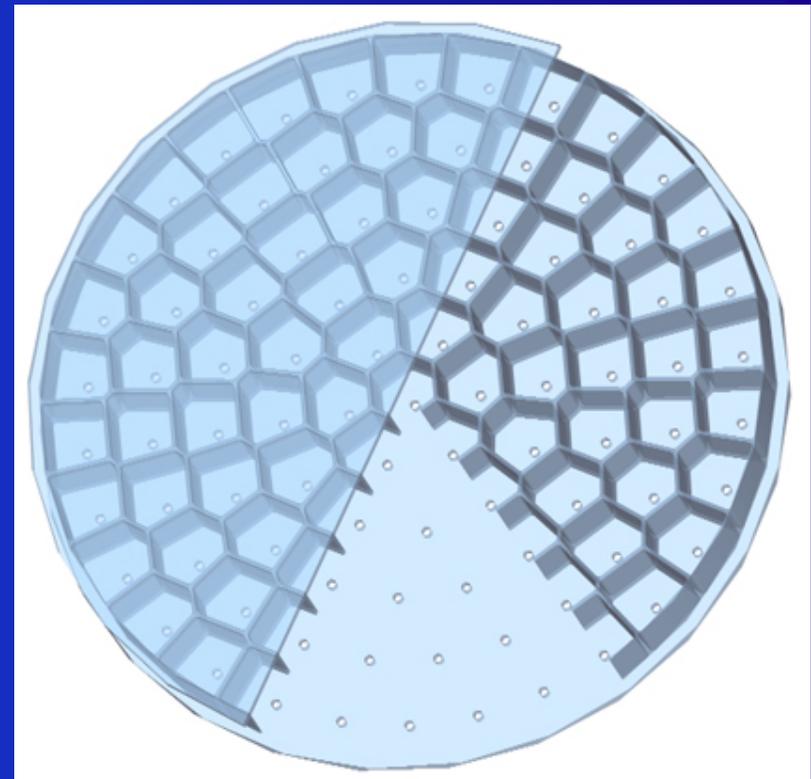
August 18, 2004



Gas-Fusion™ Substrate Features Match HEL Requirements



- Closed-back honeycomb structure.
- Mechanical stiffness: Behaves like a solid that is 40% thicker.
- Processed at high temperatures to create 100% fused cell structure.
- Radius corners at cell/faceplate intersection.
- Proven robust in demanding environments.
- Low thermal inertia.
- Flexible geometry designs.
- High degree of customization.
- Precision optical surface finishes $> \lambda/20$ p-v.
- Fabrication to 1.5 m diameter.
- Rapid manufacturing cycle times.
- Space heritage.
- Areal densities in the 15 kg/m² range.





JTO/HEL ULE[®] Gas-Fusion[™] Development Program



Objectives

- 1. Gas-Fusion[™] Application to ULE[®] Glass***
- 2. Produce Prototype 250 mm Ø Blank***
- 3. Evaluate Post-Processed ULE[®] Physical Characteristics***
- 4. Optically Polish & Test a Blank***

HEL/JTO Pay-Off

Develop a technology capability for high performance lightweight mirrors that can be manufactured in a fraction of the lead-time for existing technologies

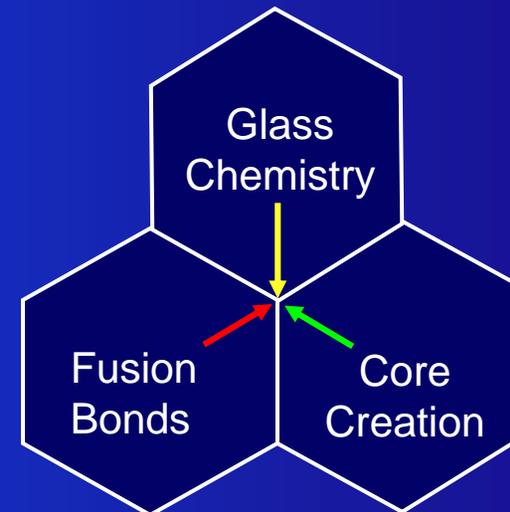




Key ULE[®] Gas-Fusion[™] Development - Challenges



- Technical Objectives Required for Successful Development
 - Glass Chemistry
 - Can we process the glass without changing its chemistry?
 - Fusion Bonding
 - Are we able to bond the core to the face and back plates?
 - Lightweight Cell Wall Formation
 - Can we control and create the core structure?





Materials Compatibility



Examples of 125 mm Ø test samples processed through Gas-Fusion™ cycle.



No obvious chemistry change to pristine areas of the glass.



Some tooling materials dramatically attacked the glass.



Most materials reacted with the glass through direct contact.





250 mm \emptyset Gas-Fusion™ Mirror Fabrication



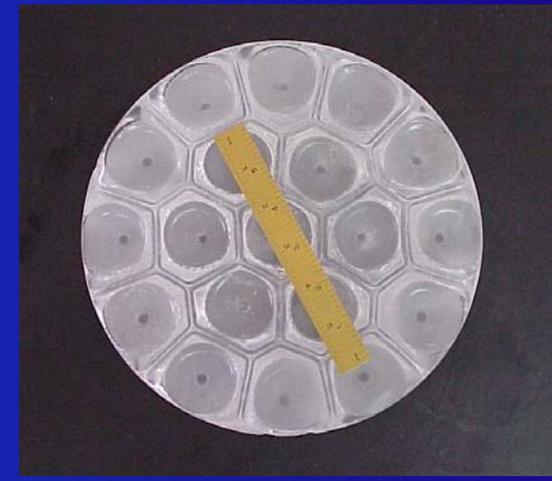
Blank as removed from furnace.



Blank after edging and fine grinding.



Blank with specular polish.



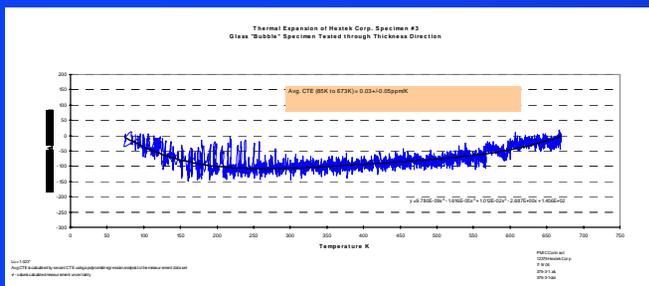
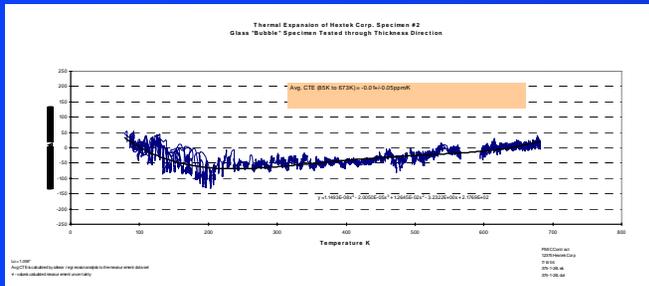
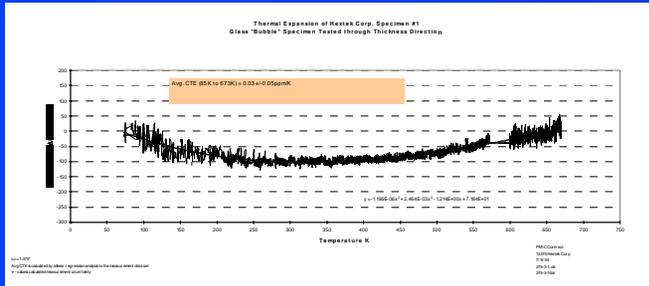
Substrate processed by Tucson Optical Research Corp.





Post Processed ULE[®] CTE Results

Tests Conducted by PMIC with an LVDT dilatometer system based on ASTM standard E 228-85 Modified



Specimen #	Specimen ID	Avg. CTE (ppm/K) (85K to 673K)
#1	glass specimen	0.03 +/- 0.05
#2	glass specimen	-0.01 +/- 0.05
#3	glass specimen	0.03 +/- 0.05

The reported average CTE is calculated as a secant CTE using a polynomial regression fit to the measurement data set.



Cell samples in dilatometer.

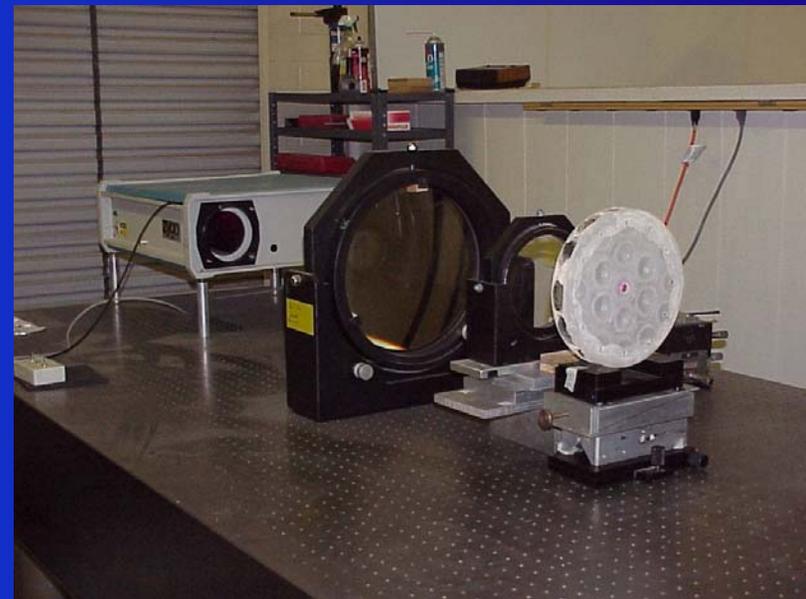
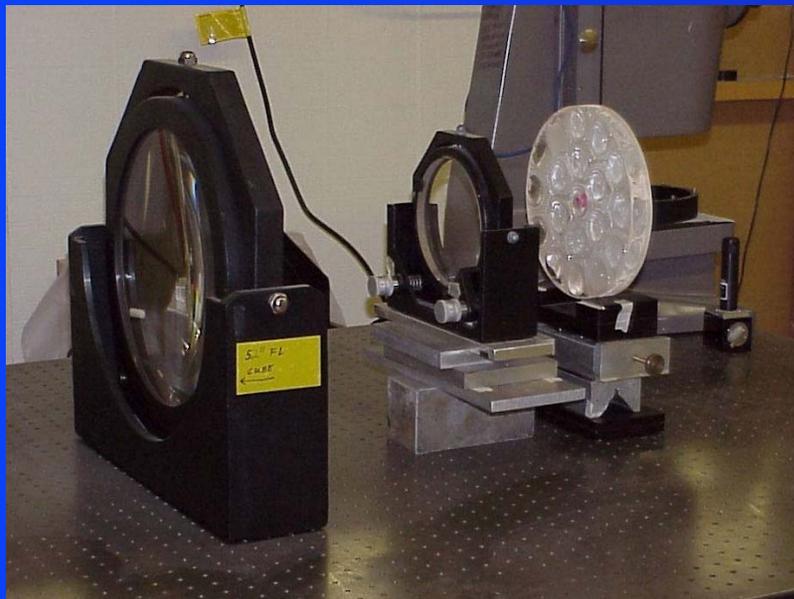
Parent blank.



Optical Finishing and Stability Verification



Shack Cube Interferometer Setup at Tucson Optical Research Corp.

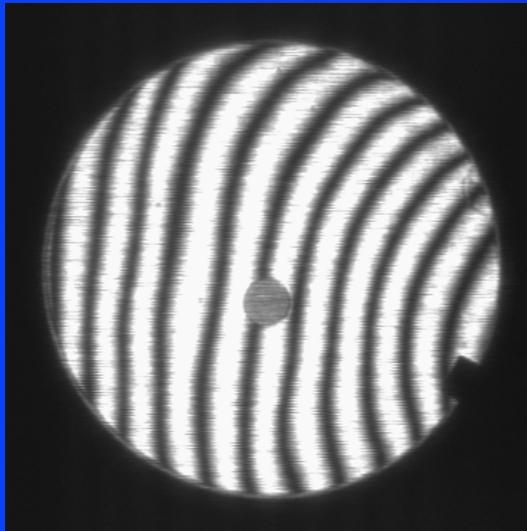




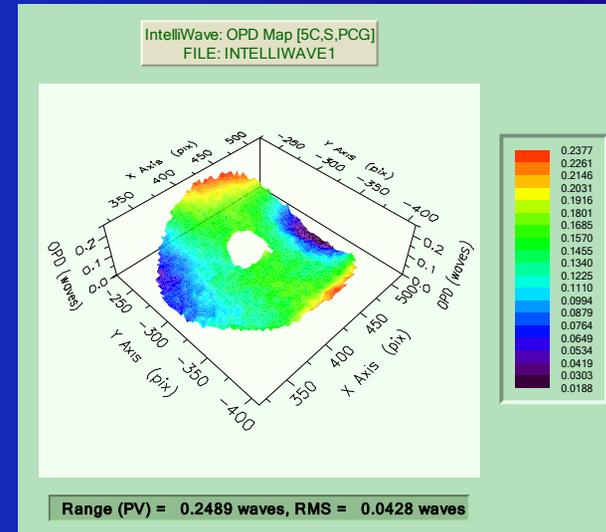
Optical Testing Results



- Room Temperature Test ($\sim 20^{\circ}\text{C}$)
- Instrument accuracy $\pm \lambda/15$ ($.067\lambda$) p-v.



Overall mirror size ~ 250 mm \varnothing .
– Figure of $\lambda/2$ p-v due to turned down edge.



Central tested aperture ~ 100 mm \varnothing .
– Typical figure $\lambda/4$ p-v.



Optical Stability Results



Test #	Temperature Front Face °C	Temperature Back Face °C	Flatness λ p-v	Flatness λ rms
1	20	20	0.2544	0.0469
2	20	20	0.2489	0.0428
3	27	40-60	0.2647	0.0494
4	33-36	40-75	0.2673	0.0537
5	32-40	31-50	0.2674	0.0472

Aperture size ~ 100 mm. Accuracy $\pm 0.067\lambda$ p-v



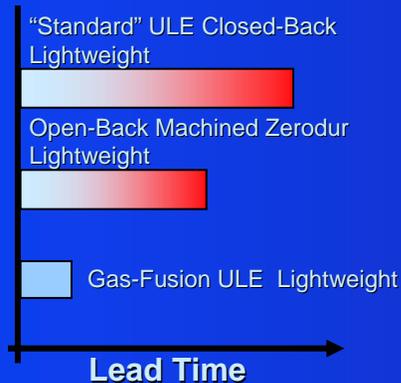


Lightweight Gas-Fusion™ ULE® Mirrors

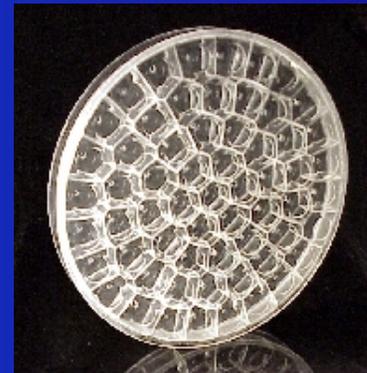


Objective

Produce high performance closed-back mirror substrates in a fraction of existing lead times.



Lightweight Mirror Blank Fabrication



Program Accomplishments

1. Successful application of ULE® to the Gas-Fusion™ Process.
2. Preliminary validation of glass cte integrity.
3. Substrate is proven to be finished to precision optical tolerances.

Information

- Company: HEXTEK Corporation
- PI & Contact: Richard W. Wortley
- Email: rwortley@hextek.com
- Phone: 520-623-7647

- Principal Investigator: Richard W. Wortley
- Funding Agency: HEL/JTO



HEXTEK Corporation