SCSi Telescopes, SBIR Updates

Government Mirror Technology Days

Sept 18-20, 2006

Be Substitution Phase II

Methods of Attachment Phase I

McCarter Machine Inc.

Woman-owned Small Business

2002 - SBA Award of Excellence

2006 - Deer Park Texas Business of the Year

Acknowledgements

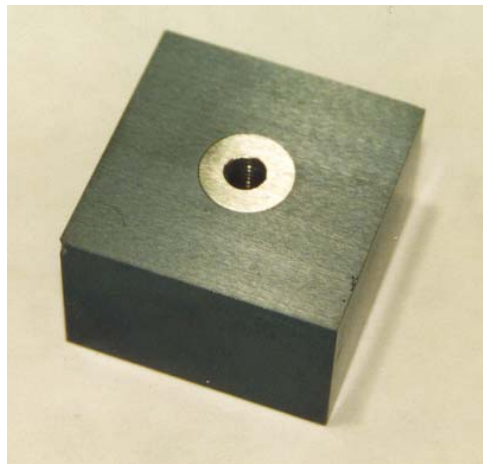
Presented by
Roger Paquin, Materials Stabilization Scientist
(Co-authored by Douglas R McCarter)

- **Be Substitute for GMD (Be-Sub II)**
- **COR: Dr. Doug Deason USASMC**
- **SBIR Phase II**
- **Manufacturing SCSi Test Samples & Telescope**
- **Methods of Attachments (MoA)**
- **COR: Mr Mark Pickens USASMC**
- **SBIR Phase I**
- **Bonding Techniques for Si/Metals**

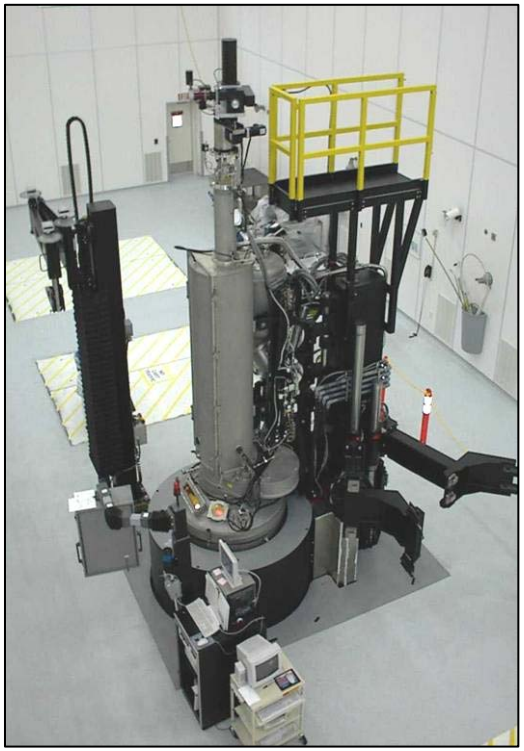
Special Thanks to Walt Wrigglesworth, Jim Dolan, Chris Theriault and Tony Lee at RMS

Leveraging McCarter's Cryostable Lightweight Silicon Technology for Larger and More Complex Silicon Components

- **Why Silicon?**
  - **Excellent Polishability**
  - **Excellent Quality Control of Material**
  - **Low Coefficient of Thermal Expansion**
  - **High Thermal Conductivity**
  - **Low Density**
  - **Moderately High Modulus of Elasticity**
- **Why Glass Frit Bonding?**
  - **Allows Scale-up to Larger Components than Existing Monolithic Material Technology**
  - **Allows Assembly of Efficient Configurations**
  - **Verified Suitability for Silicon to LN_2 Temperature**
  - **Implemented in an Air Atmospheric Furnace**

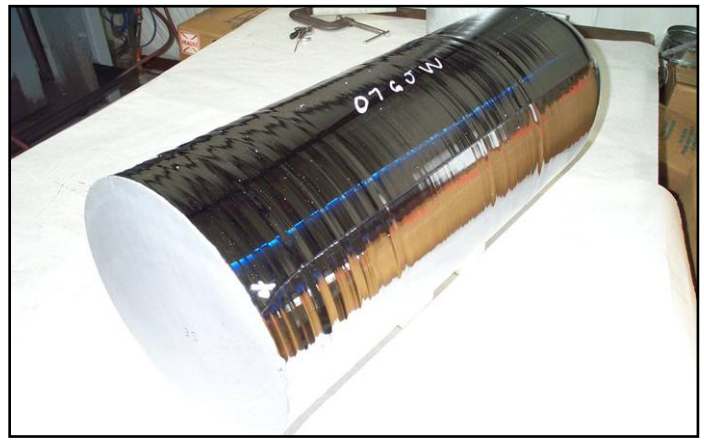


300 mm Diameter Zero-Defect Silicon Ingots



300mm Crystal Puller at St. Peters, MO Site

300mm diameter Silicon Crystal

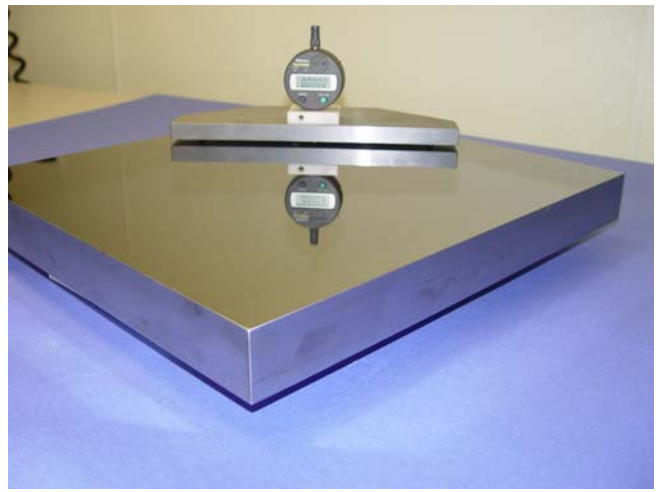


MEMC Supplied Boule to McCarter with Both Ends Cropped

MEMC
TECHNOLOGY IS BUILT ON US

Producibility

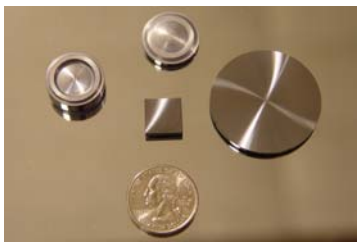
McCarter Superfinish

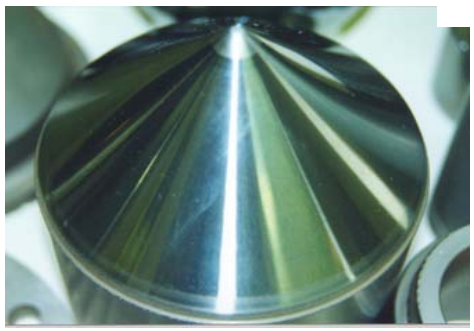


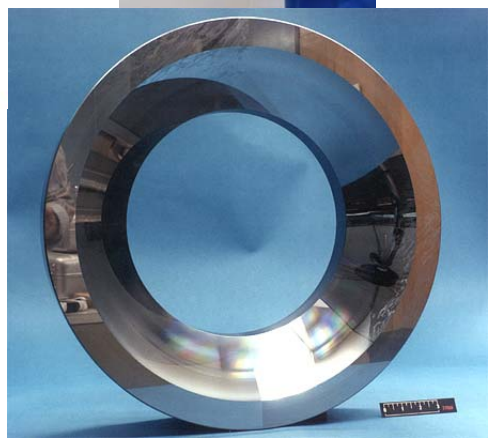
Awarded US Patent 6,443,817 for Superfinishing Method

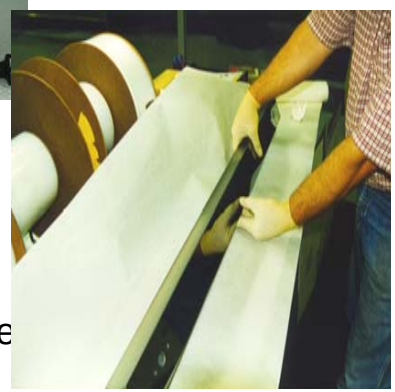
- Allows near net shaping
- Improved Surface finish lowers optical lapping cost and reduces schedule
- An integral part of frit bonding

SCSi Mirrors Manufactured by McCarter









Small (.20”)

Tertiary

Simplistic Lightweight

Conical

Cooled

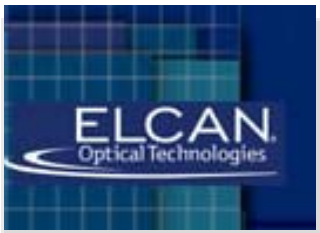
Annular (60.00”)

Advanced Lightweight

Synchrotron

Programs Using Our Unique Approach

Raytheon Elcan Sensor and Surveillance

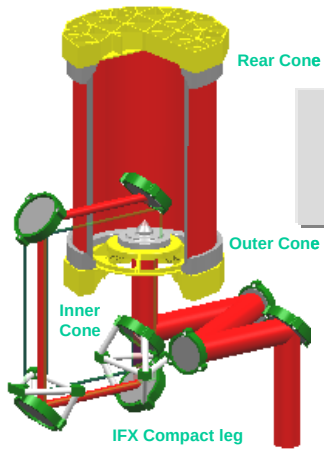


Northrop Grumman THEL Program

NASA Goddard Space Flight Center

Northrop Grumman ABL Program

Raytheon's Strawman Program



Team Member SBL-IFX TRW/McCarter

CapestronoTest Facility

SCSi Material Properties versus Beryllium

Selected Room Temperature Material Properties

Reference: R.A. Paquin, "material for Mirror Systems: An Overview", SPIE Proceedings Vol 23543, p2-11, July 1995.							Distortion Coefficient	
Preferred	**Density** ρ g/cm^3 **Small**	**Young's Modulus** E Gpa **Large**	**Specific Stiffness** E/ρ $Gpa/g/cm^3$ **Large**	**Thermal Expansion** α $10^{-6}/K$ **Small**	**Thermal Conductivity** k W/mK **Large**	**Thermal Diffusivity** D $10^{-6} m^2/s$ **Large**	**Steady State** α/k µm/W **Small**	**Transient** α/D s/m^2-k **Small**
BerylliumI-70	1.85	303	163.78	11.4	216	57.2	0.05	0.20
Silicon	2.33	131	56.2	2.6	156	89.2	0.02	0.03

SCSi as a Beryllium replacement optic

- Will increase thermal and transient stability
- Does not creep or jitter
- Will improve cost and schedule

On-Orbit Performance

Based on Our SCSi Validation Study Results and Open Literature

Orbit Phase:
Cryostability

Boost Phase:
Transient Stability

Reentry:
Thermal Stress Stability
Rad Hard

Awaiting Depolyment:
Temporal stability

Launch Phase:
Dynamic Stability

End of cycle:
High microyield
Optical stability

Be-Sub II Program

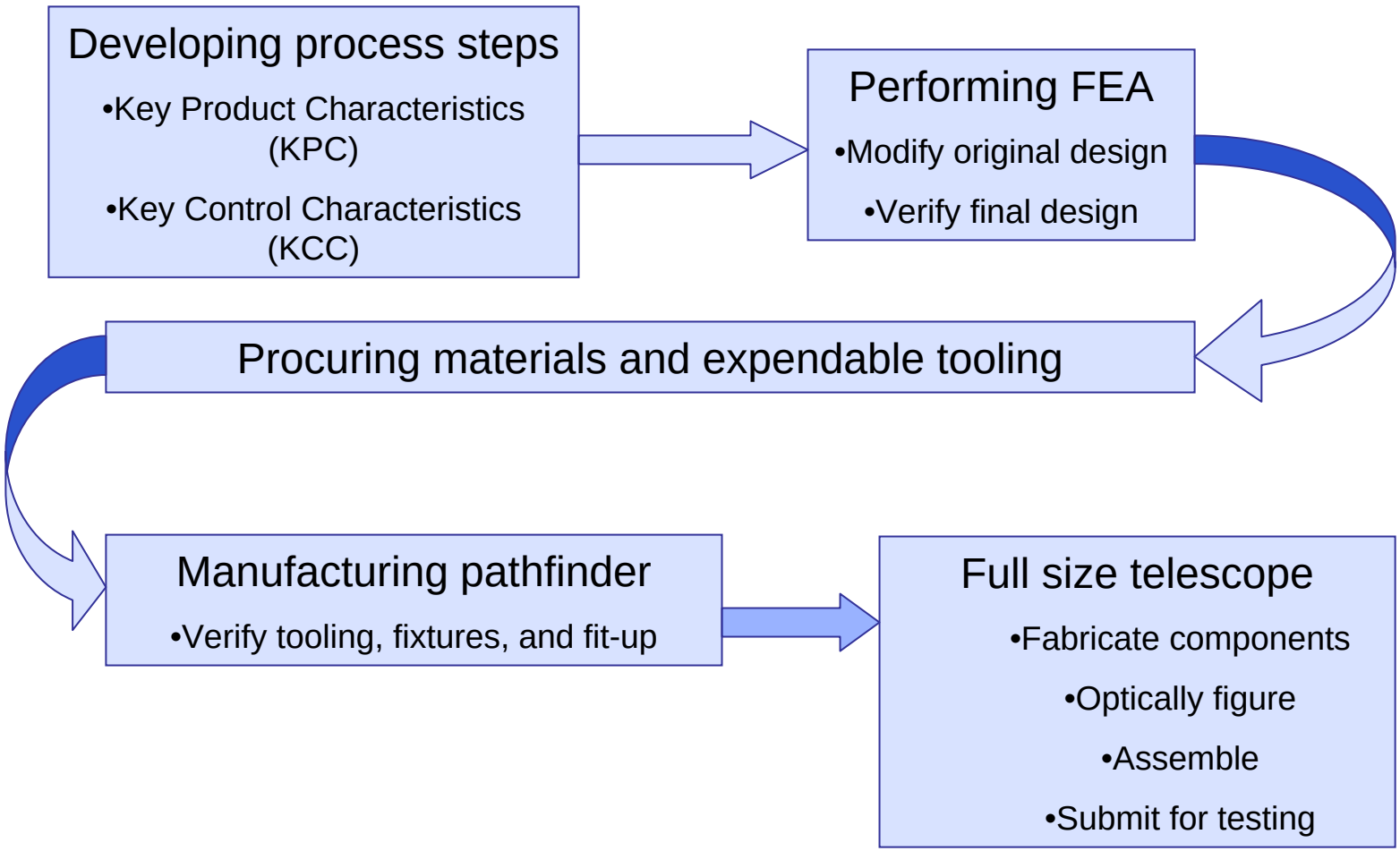
- Significance of Problem:
  - Cost/schedule reduction
  - Eliminate health liabilities
  - Improve stability/performance

- Program Plan
  - Testing manufacturing processes to optimize cost:performance
  - Fabricate 5-inch prototype telescope for performance evaluation

Be-Sub II Testing/Samples

- Testing manufacturing process effects on SCSi for thermal & dimensional stability and strength
- Testing dimensional stability of mirror surface from effects of fritted inserts

Be-Sub II Telescope Status



MoA Program

Methods of Attachment

- Significance of the Problem:
  - Provide methods of attaching Si to metals
  - Minimize stress concentration & risk
  - Minimize complexity to control cost
- Program Plan
  - Evaluate 4 bonding techniques
    - Glass frit, solder, thin film, hybrid
  - Develop minimum contact designs
    - 4 bond pad configurations

MoA Status

- Researching literature (public/private)
- Established test plan
  - FEA of metal insert design
  - Solid Works modeling of test assemblies
- Procured materials
- Fabricating samples for testing
- Evaluating sealability & joint strength
- Testing as funds permit

Future Possibilities Using Single Crystal Silicon

- Lightweight Mirrors
- Optical Benches
- Cooled Mirrors
- Cornercubes
- Substructures
- Housings and Shields
- Mechanical Apparatus
- Metal/Silicon Assemblies
- Spacecraft Instrumentation