A DR Technologies Company

EKV Composite Optical Sensor Mirrors and Support Structure

Aug 18, 2004

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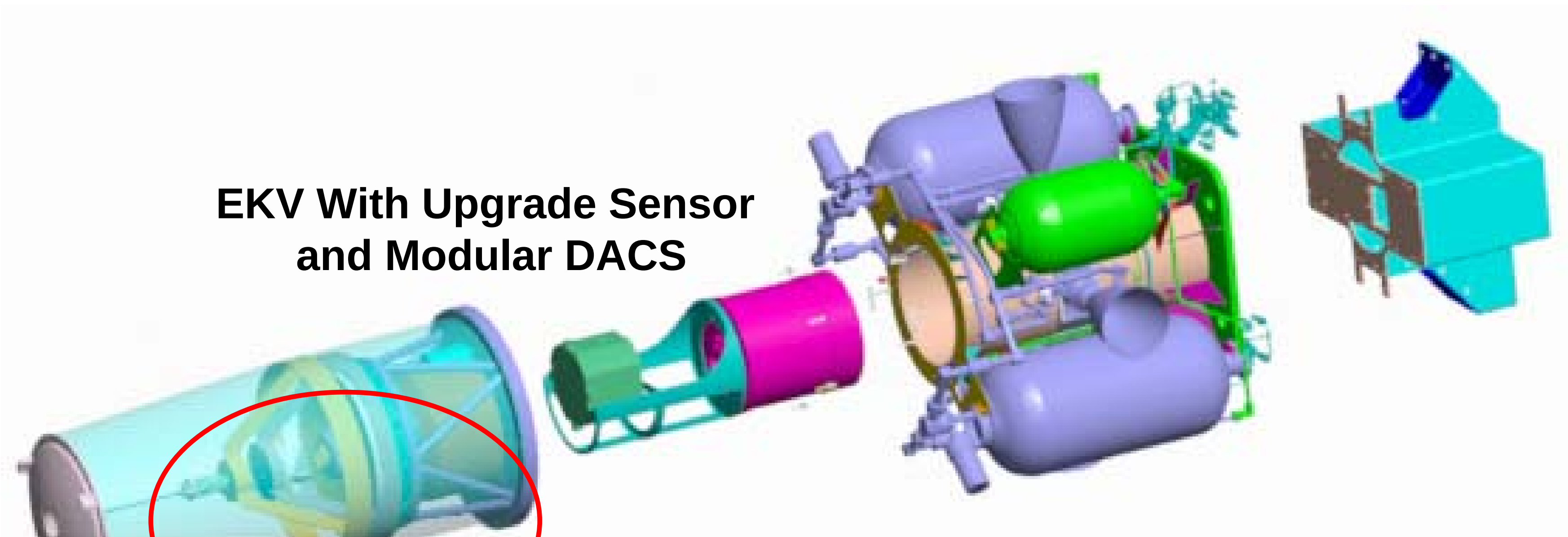
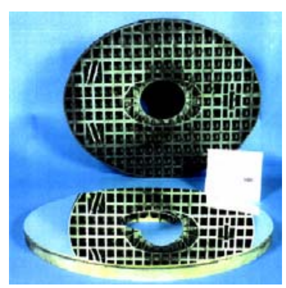
Overview

- Vanguard Funded by MDA AFRL SBIR to Develop and Demonstrate Composite Mirrors and Support Structure as an Alternative to Beryllium
  - Technical Monitor Dr. Arup Maji
- Vanguard Composite Dimensionally Stable Structures (OptiGraf) Teamed with Schafer, Albuquerque, NM, for Low Cost, High Performance Composite Structure and Composite Mirrors (SLMS and Cesic)
- Analyses Demonstrated Lower Weight and Higher Structural Performance of Lower Cost and More Producible OptiGraf-SLMS and OptiGraf-Cesic Composite Designs Compared to Beryllium
- Phase II SBIR to Address Concept Design and Demonstration for On-Axis Optical Sensor for kill vehicles
  - September ’04 - March ’06, $750K

EKV Composite Mirrors and Support Structures Development for EKV FY2008 Upgrade Program



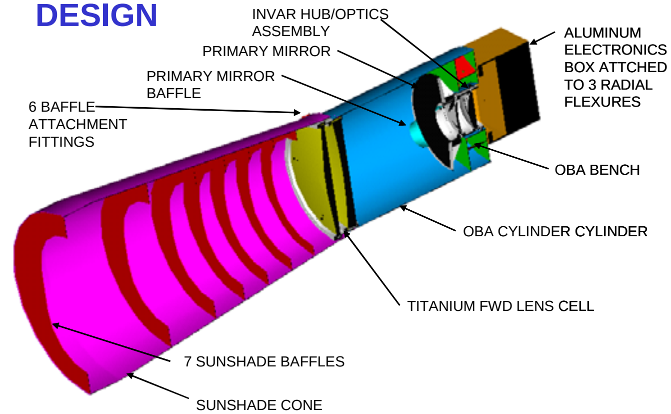


Composite Sensor Structure and Mirrors

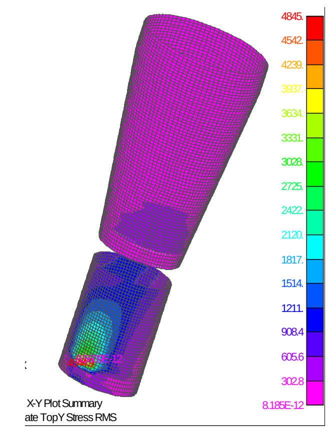
OptiGraf* Composite Structures Technology at Vanguard Composites Group

OptiGraf Example: Vanguard Contract for JPL Mars '05 Camera, Baffle, and Sunshade

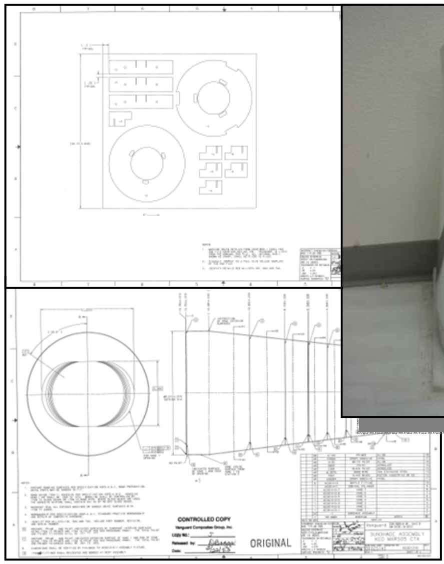
DESIGN



ANALYSIS



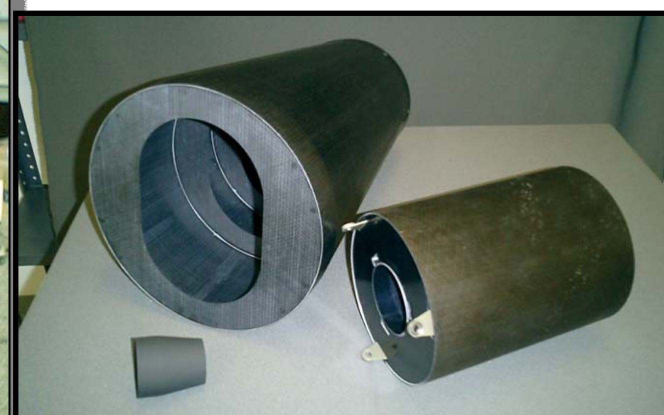
DETAIL DRAWINGS



TOOLING

ASSEMBLY

FLIGHT HARDWARE



*** OptiGraf- A Trademark of Vanguard Composites Group for Graphite Fiber Reinforced Composites (M55J-Cyanate Ester) for Optical Structures**

OptiGraf for High Value Dimensionally Stable Structures

- Both Material Selection and Design are used to provide High Value Solutions for Dimensionally Stable Optical Structures
  - Typically stiffness driven as opposed to strength
  - Dimensionally Stable - Athermal due to Temperature Soaks and Gradients
    - Hygroscopic moisture effects
    - Long term stability
    - Mirror and optical component mounting, alignment of wide range of interfacing materials
    - Passive thermal control
  - Light Weight
  - Strength due to inertial and vibro-acoustic loads
    - Interface Loads
  - Contamination control
    - Outgassing
    - Moisture
    - Cleanability
  - Nuclear Hardness
  - light

Material and Design Solutions

- High Stiffness and Dimensionally Stable
  - Wide range of fibers available-stiffness, strength, thermal conductivity, and cost
  - Cyanate Ester Resin for low CME and Moisture uptake
  - Laminate Architecture is tailored
    - Ply Thickness, Orientation, Resin Content
  - High Degree of Design freedom to provide efficient and stiff load paths. By clever design can provide a stiffer structure than Be with lower modulus material
  - Stable Space Heritage and Near Zero and tunable CTE over a wide temperature range
  - Bonded Metallic interface fittings provide interface features for alignment and designed to minimize the effects their different CTE
- Lightweight of
  - High Specific Stiffness Material
  - Highly Tailorable Design for Efficient Load Paths

Material and Design Solutions

- Strength
  - Strength issues typically are localized at interface locations
  - Metallic fitting bonded to the composite provide precisely located high strength interfaces to distribute load into structure. Composite can be locally reinforced and is tailored for the specific forces and moments.

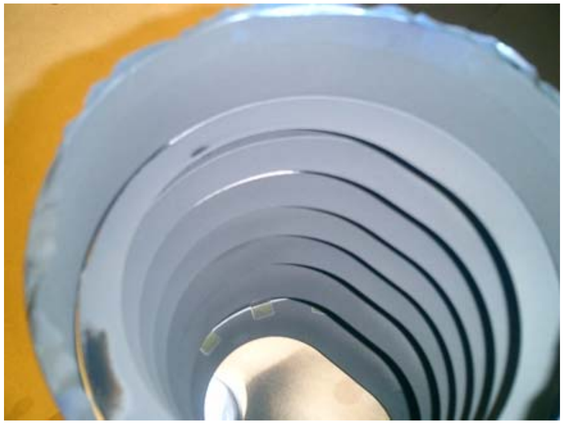
- Contamination Control and Cleanability
  - Cyanate Ester Resin
    - Low moisture uptake and CME
    - Meets NASA outgassing requirements
    - Surface finish and design for cleanability access provide a cleanable structure
    - Cladding with foils

- Nuclear Hardness
  - Inherant in materials
  - Nuclear shielding materials intergrated with the composite where various layers are used to provide a shielding system

Material and design Solutions

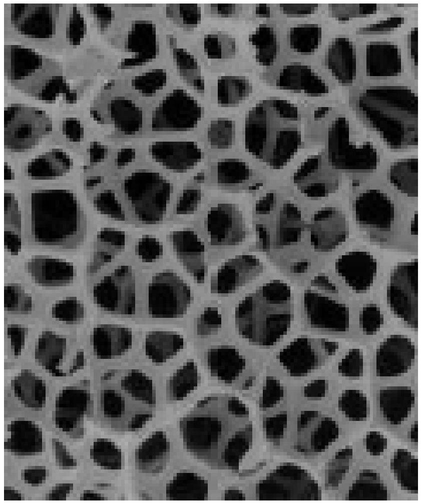
•Stray Light

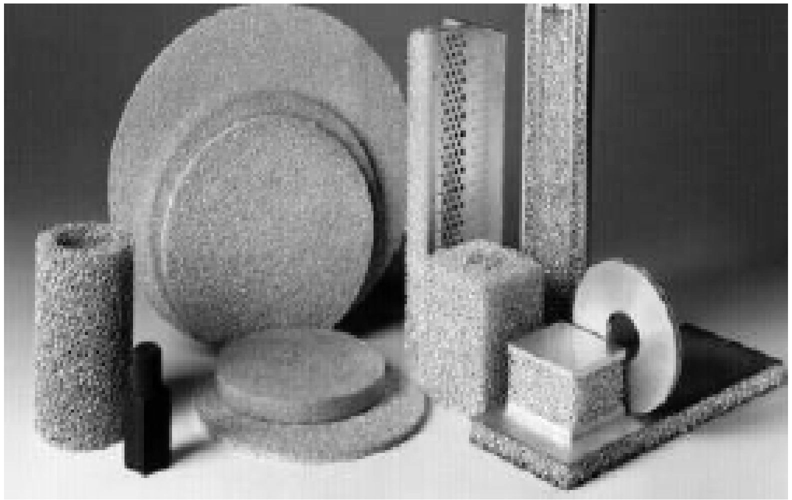
- Same Composite material can be used to provide very lightweight secondary structures such as light baffles and sunshades
- Baffles can be integrated into the structure or removable secondary structure.
- Optical coatings and paints or deposited metals or foil can be applied to achieve desired emmissivity and absorptivity.
- Coatings can also be used for thermal control
- Paints such as Z306 or Alion 6HN/LO can provide optically black surfaces that meet NASA outgassing specifications
- Inorganic coatings can also be applied for zero outgassing



SLMS* Mirror Technology at Schafer Corporation

- SLMS has a Silicon Foam Core (85%-95% Porosity) enclosed by a continuous CVD Polycrystalline Silicon Shell
- CVD Silicon can be Deposited to 2 Inch Thickness at 1 Meter Diameter
- Foam Core can be CNC Machined to Virtually any Shape to ±0.002
- Polishable and coating by standard methods

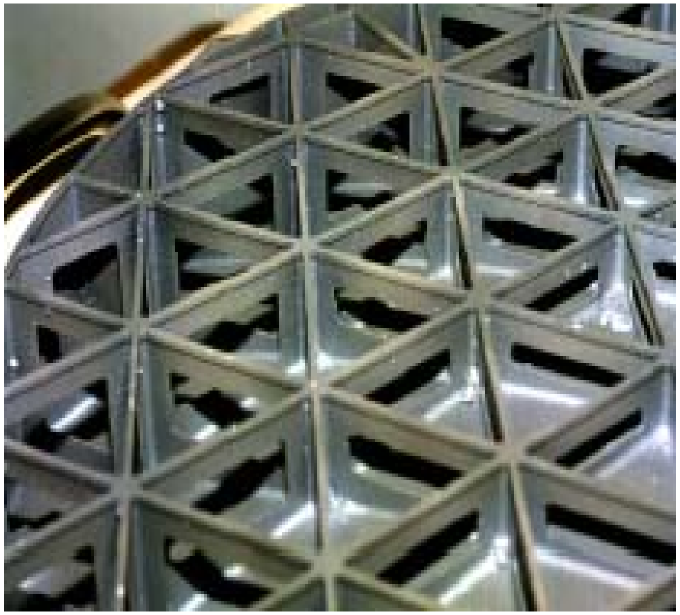


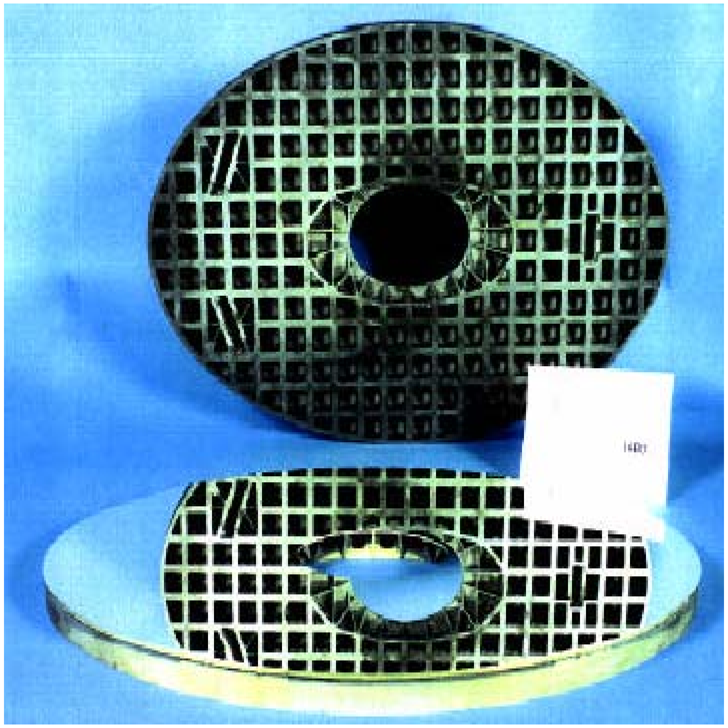


*** Silicon Lightweight Mirror System, SLMS, A Trademark of Schafer Corporation**

Cesic® * Mirror and Structures Technology at Schafer Corporation

- In Filtration Processing of Porous C/C-Structures with Molten Silicon by Capillary Forces in High Temperature Vacuum Process
- Densification and Partial Reaction of Carbon Matrix With Silicon to Silicon Carbide (SiC)

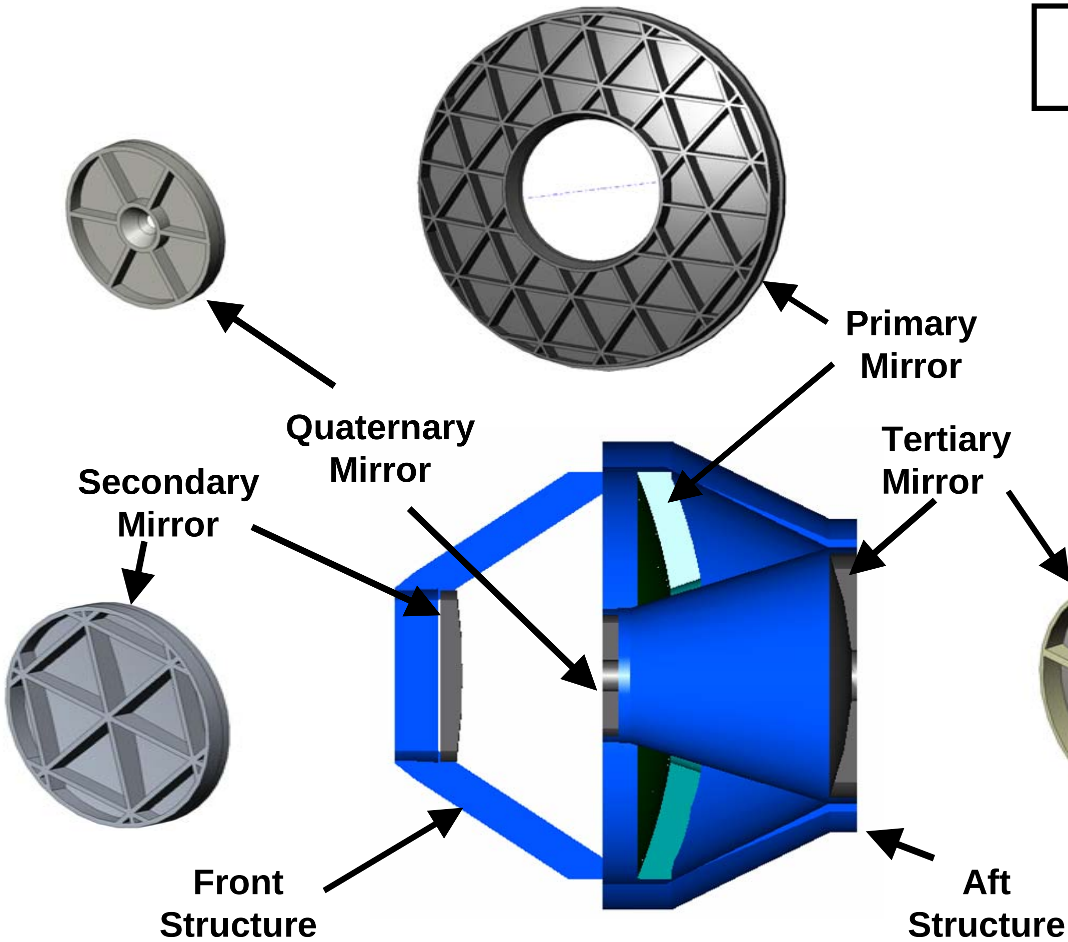




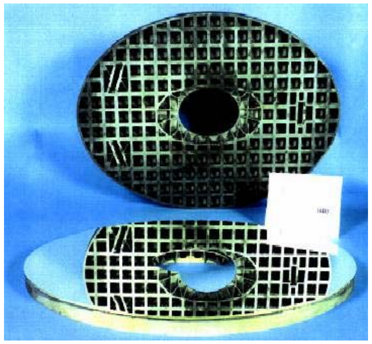
*** Carbon/Silicon Carbide Composites, Cesic® , a Trademark of Schafer Corporation**

Cesic® Mirrors

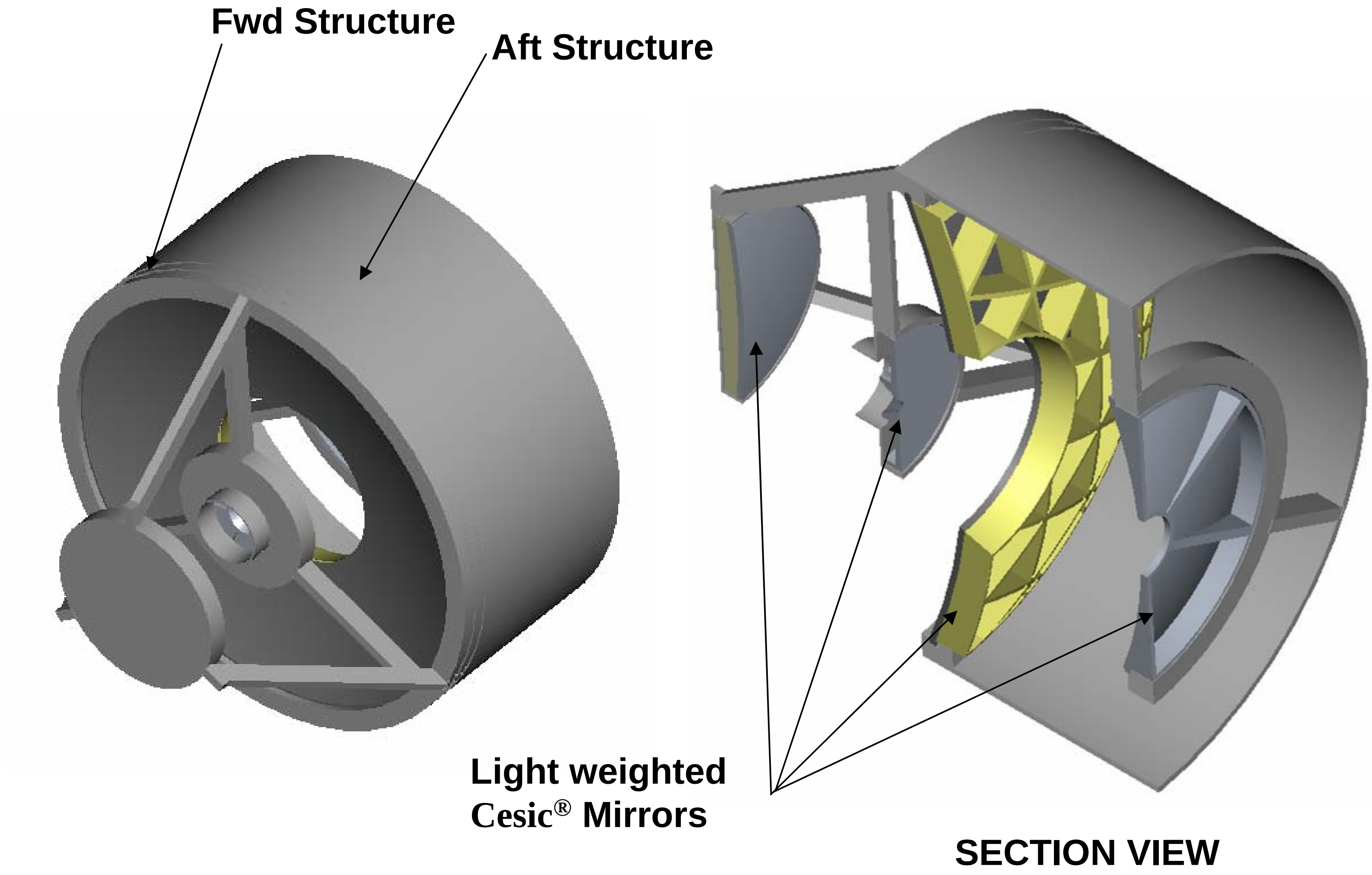
- Phase I Mirror Lightweighted Cesic® Mirror Designs



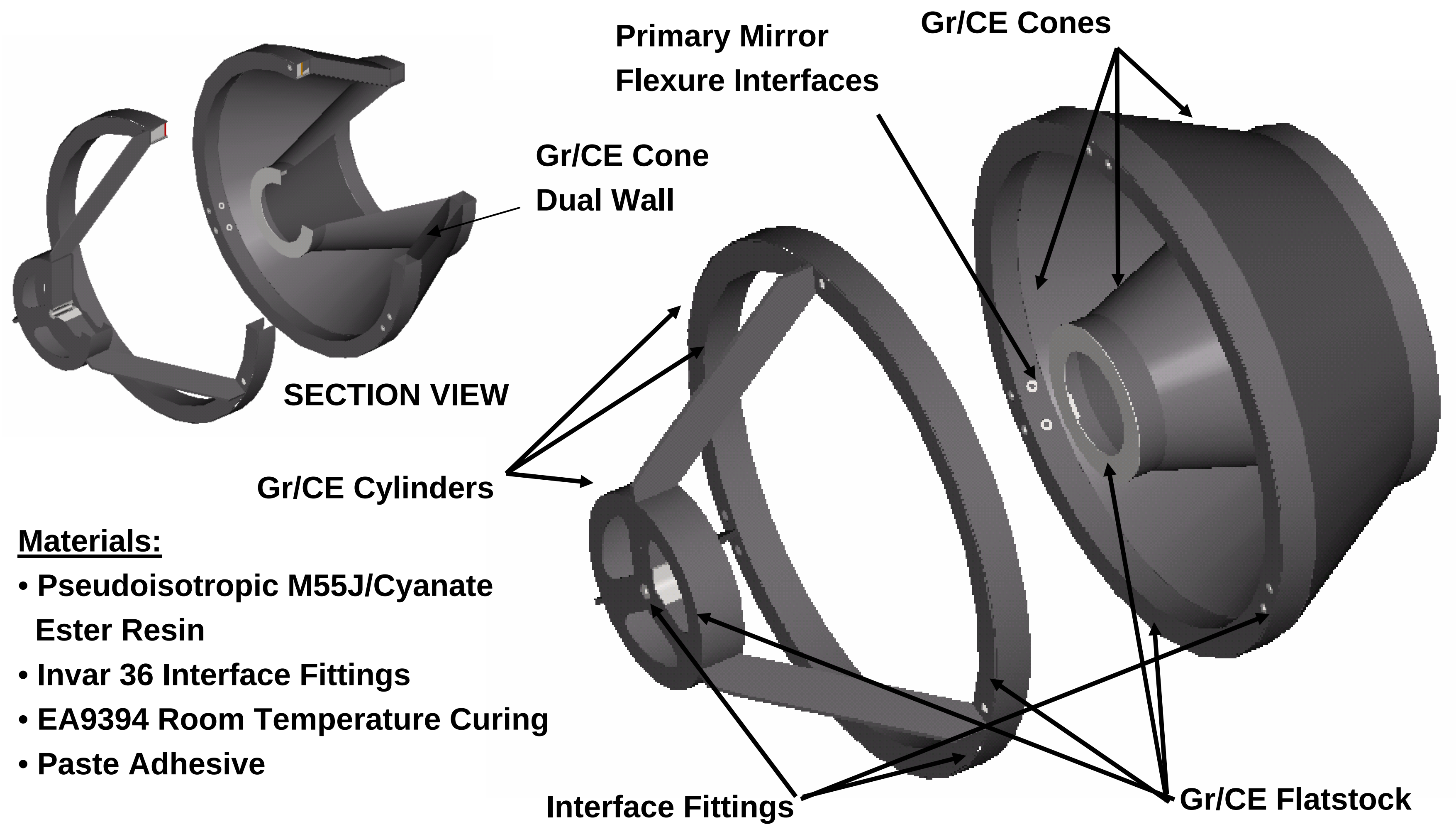
C/SiC Cesic Mirror Prototype



Cesic® Structure and Cesic® Mirrors



OptiGraf Structure Design Description



Materials:

- Pseudoisotropic M55J/Cyanate Ester Resin
- Invar 36 Interface Fittings
- EA9394 Room Temperature Curing
- Paste Adhesive

Simple, Well Behaved Flat, Cylindrical, and Conical Shaped Gr/CE Details Bonded into a Unitized, Stable Structure

EKV Composite Mirrors/Structure-
Concept Trade Study Results from Phase I

Structure Material	Structure Design Concept Number	Mirror Material	Mass (lb)	G-load Displ. (inches)	Nat. Freq. (Hz) 1st 2nd 3rd	Temp. Soak Displ. over Half Struct. (inches)
BE	-	BE*	6.4	5.12E-06	373.35 849.85 849.86	6.16E-03
GR/CE (.125" Thick Vanes)	5	SLMS	2.55	7.09E-06	565.61 569.71 580.79	1.60E-04
GR/CE (.25" Thick Vanes)	5a	C/SiC*	5.52	1.32E-05	424.95 424.96 473.53	5.75E-04
C/SiC	3	C/SiC	6.52	1.69E-05	462.09 463.42 633.47	1.53E-03

EKV Composite Mirrors/Structures- Summary of Phase I Results

- EKV Optical Sensor Mirror and Support Structure Requirements were Obtained from Raytheon for 4-Mirror, On-Axis System for EKV FY2008 Upgrade Program
- Defined SLMS and Cesic Mirrors and OptiGraf and Cesic Structures as Alternative Composite Materials and Designs to Replace Beryllium Components for the EKV Optical Sensor
- Trade Studies were Performed for 3 Concepts- SLMS-OptiGraf, Cesic-OptiGraf, and Cesic-Cesic Concepts and Performance, Cost, and Producibility Estimated Compared to Beryllium
- SLMS Mirror Technology with OptiGraf Composite Structure Projected as the Lowest Cost, Shortest Schedule, and Lightest Alternative with Improved Dimensional Stability versus Beryllium
- Radiation Hardness as well as Contamination Control, and Storage Life Stability are important requirements to be addressed in Phase II

EKV SLMS-OptiGraf Composite Mirrors/Structures - Phase II Program Plan

Objective: Develop and demonstrate lower cost SLMS mirror and OptiGraf structure composite materials and design concepts as alternatives to beryllium for the EKV optical sensor mirrors and support structures

Proposed Ph II Technical Approach:

- **Use Ph I Analytical Design and Analysis Results to Focus on High Performance SLMS Mirror Concept with OptiGraf Structure**
- **Obtain EKV Design and EKV FY2008 Upgrade Program Technology Insertion Requirements for 4-Mirror, On-Axis Optical Sensor from Raytheon**
- **Develop SLMS-OptiGraf Engineering Design for Full-Scale Concept including RadHard Concepts**
- **Generate Materials and Design Database for SLMS-OptiGraf Concept**
- **Develop Manufacturing Process for SLMS-OptiGraf Concept**
- **Fabricate & Assemble One(1) Full-Scale SLMS-OptiGraf Test Article Consisting of Four(4) Mirrors & Support Structure**
- **No Structure, Optical, Alignment of Other Full-Scale Testing**

Schedule and Funding: 18 Months, September, 2004-February, 2006, $750K