10.3.8 Ceramic Matrix Composites (Continuous Fiber Reinforced) Thermal Protection Systems by Salvatore R. Riccitiello, NASA ARC

# NVSV

National Aeronautics and Space Adminstration

# SPACE TRANSPORTATION MATERIALS AND STRUCTURES TECHNOLOGY WORKSHOP

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# CERAMIC MATRIX COMPOSITES [CONTINUOUS FIBER REINFORCED] THERMAL PROTECTION SYSTEMS

#### **BACKGROUND**

- Initiated program with American Inc. to develop continuous fiber reinforced CMC thermal protection materials based on silicon carbide
- Reticulated low density ceramic foam core panel structures, based on silicon carbide, were fabricated and evaluated
- o Reticulated silicon carbide low density foam susceptible to thermal shock
- o "TOPHAT" thermal protection system utilizing a continuous fiber reinforced CMC and reusable surface insulation developed
- Single-ply/multi-ply continuous fiber reinforced silicon carbide CMC successfully evaluated, in the "TOPHAT" thermal protection system, to 3100° F

#### **BACKGROUND** cont.

- The carbon reinforced CMC material showed little degradation after a 100 minute exposure to surface temperatures of 2000° F and 2700° F
  - ★ The carbon reinforced CMC material showed little change in physical property after 100 minutes exposure to surface temperatures of 2000° F and 2700° F

# **CERAMIC MATRIX COMPOSITES** [CONTINUOUS FIBER REINFORCED] THERMAL PROTECTION SYSTEMS

### **TECHNOLOGY NEEDS**

- o Fabrication Methods / Processes (silicon carbide based systems)
  - \* Large Components
  - \* Architecture
  - \* Costs
- o Material Property Data Base \* Fatigue (loaded, unloaded, thermal, isothermal)
  - \* Baseline Thermal/ Mechanical Properties
  - \* Environmental Effects
    - Aero-acoustic (with/without shock impingement)
      - sound levels in excess of 170 db
      - oscillating pressure (1-5 psi peak to peak)
    - Particle Impact
    - Water Adsorption/Absorption

- o Attachment Techniques
  - \* Integral Structure / TPS
  - \* Hot Structure
  - \* Warm Structure
  - \* Seals
- o Non-Destructive Evaluation
  - ⋆ Quality Assurance
  - \* Flaw / Separation Detection

# CERAMIC MATRIX COMPOSITES [CONTINUOUS FIBER REINFORCED] THERMAL PROTECTION SYSTEMS

## **TECHNOLOGY GAPS**

- o High Temperature Continuous Fiber Reinforced CMC Materials
  - ★ Temperatures > 3500° F
    - o High Strength / High Temperature Fibers
      - ★ Property Retention At Temperatures > 2200° F
    - o High Temperature / High strength Matrices
      - \* Property Retention At Temperatures > 2200° F
- o Process Developments
  - **★ New Processes**
  - \* Shorter Fabrication Times

### **HIGHEST PAYOFF AREAS**

- o High Temperature / High Strength Continuous Fiber Reinforcements
  - ★ Temperatures > 3500° F
  - ★ Strength Retention > 3500° F
    - High Temperature Strengths Comparable To RT Strengths of present State-of-the-Art Fibers

10.3.9 Thermal Protection Systems for Space Transportation Vehicles by Howard Goldstein, NASA ARC