Technology Opportunity
Glenn Research Center • Cleveland • Ohio
Technology Transfer & Partnership Office

TOP3–00173

High-Performance SiC/SiC Composite Systems

Technology

NASA Glenn Research Center researchers have developed two high-performance SiC/SiC composite systems with state-of-the-art thermostructural capability up to 1315 °C (2400 °F). These systems are based on advanced processes that significantly improve the performance of commercially available SiC fibers, boron nitride (BN) fiber coatings, and SiC matrices that are initially formed by conventional processes, such as chemical vapor infiltration (CVI).

Benefits

This technology can be used to improve the performance of ceramic composite structures by

- Increasing ultimate tensile strength, needed for component damage tolerance
- Increasing rupture strength after exposure to 800 °C, a temperature region where environmental attack of SiC/SiC composites is typically the greatest
- Increasing rupture life at 1315 °C, a temperature well above the thermal capability of metal alloys (~1100 °C)
- Increasing creep resistance, needed for high-temperature dimensional control and intrinsic strength retention

Commercial Applications

High-temperature structural components in aerospace, industrial, and military applications such as

- Engine hot-section components
- Heat exchangers
- Furnace components

Technology Description

Two SiC/SiC composite systems developed at Glenn, are based on a group of advanced constituent material and process technologies that significantly improve the performance of commercially available SiC fibers, architectural preforms formed from these fibers [1], BN fiber coatings, and SiC matrices that are formed by CVI and other matrix processes, see table A and B. These technologies all center on improving the microstructures and/or surface conditions of the composite constituents so that they can perform better at high temperatures.

Table 1 compares typical properties of oxide/oxide [2] and SiC/BN/SiC composite panels formed by the stacking of balanced 0/90 fabric pieces reinforced by the indicated ceramic fiber types. The Sylramic-iBN fabrics for the NASA systems were produced by thermal conversion of commercial Sylramic◆ fabric. For all SiC/SiC panels, the fabric stacks were formed by CVI of a BN fiber coating and a conventional SiC matrix. Panels with System B were then annealed, and remaining open porosity in the SiC matrix filled by silicon melt infiltration (MI). Panels with System A and the other SiC/SiC systems were not annealed and the remaining open porosity filled with SiC slurry and silicon MI.

Figure 1.—Combustor liner fabricated with the SiC/SiC systems of this technology.

◆*Sylramic SiC fiber is currently being produced by ATK COI-Ceramics, Inc.*

Table 1 shows that the panels with the SiC/SiC system A display the best performance in terms of such key properties as ultimate tensile strength, rupture strength and retained strength after burner rig exposure near 800 °C. The panels with SiC/SiC system B, display superior properties in terms of high temperature rupture life, creep resistance, and thermal conductivity.

Options for Commercialization

There are patent applications in process for this technology. NASA is seeking companies interested in applying this technology to commercial applications.

Composite Type	Oxide/Oxide	SiC/SiC	SiC/SiC	SiC/SiC (A)	SiC/SiC (B)
Fiber Type	Nextel 720*	Hi-Nicalon S	Sylramic	Sylramic-iBN	Sylramic-iBN
Fiber Coating (or Interphase)	None	BN	BN	Coated BN	Coated BN
Matrix Type	Oxide (PIP)	SiC-Si (CVI+slurry+Si)	SiC-Si (CVI+slurry+Si)	SiC-Si (CVI+slurry+Si)	SiC-Si
Ultimate Tensile Strength at 20°C, MPa	200	360	360	450	300
UTS at 20°C after 100-hr burner exposure at 800°C, MPa	200	170	360	450	300
100-hr Rupture Strength at 800°C in air, MPa	170	230	230	280	220
Ultimate Tensile Strength at 1315°C, MPa	<150	280	280	320	240
Rupture Life at 105 MPa, 1315°C, in air, Hours	<10	~500	~100	~500	>1000
Creep Strain for 100 hr, 1315°C, air, 105 MPa	>0.2%	0.05%	0.20%	0.05%	0.02%
Transverse Thermal. Conductivity at 20°C, W/m °C	1.2	16	25	23	36

* Total fiber fraction ~ 48%

Table 1.—Typical properties for 0/90 ceramic composite panels fabricated from various constituents with ~35–40 percent total fiber fraction.

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Key Words

SiC fibers
Sylramic fibers
Silicon carbide matrix composites
High-temperature composite products