NASA SBIR/STTR Technologies

T12.02-9894 - In-situ EBCs for High Performance Composite Propulsion Components

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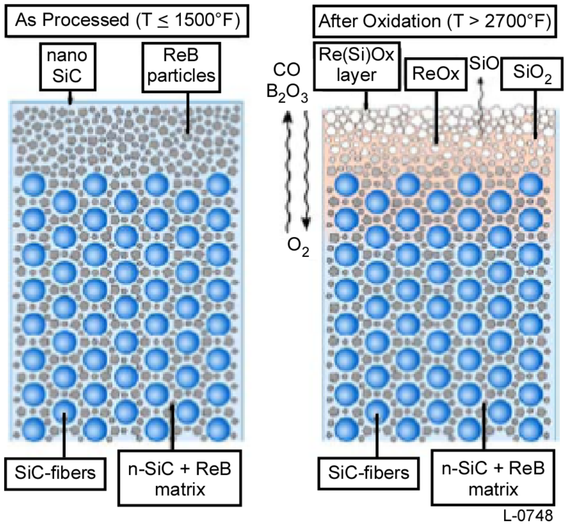
Identification and Significance of Innovation

Silicon Carbide based ceramic matrix composites (CMCs) offer the potential to fundamentally change the design and manufacture of aeronautical and space propulsion systems to significantly increase performance and fuel efficiency over current metal-based designs. Physical Sciences Inc. (PSI) and our team members at the University of California Santa Barbara (UCSB) will develop, design and fabricate enhanced SiC-based matrices capable of long term operation at 2750oF to 3000oF in the combustion environment. We will build upon our previously successful work in incorporating refractory and rare earth species into the SiC matrix to increase the CMC use temperatures and life-time capabilities by improving the protective oxide passivation layer that forms during use. As part of this work we will create physics based-materials and process models that qualitatively define methods of improving matrix properties and the interaction of the fibers, interphases and matrix with each other.

Estimated TRL at beginning and end of contract: (Begin: 2 End: 5)



Technical Objectives and Work Plan

By the end of the Phase I program, we will have reached the following 5 (five) technical objectives. 1. Produced CMC with advanced matrices that demonstrate oxidation rates less than ½ those of pure SiC matrix CMCs at 2700oF in flowing air or oxygen; 2.Validated that CMC strengths exceed 28 KSI after oxidizing to a combination of 1800oF for 16 hours and 1500oF for 50 hours; 3. Demonstrated non-brittle failure of the CMC and fracture toughness of greater than 15 KSI-in.^1/2 at room temperature while the oxide surface retains coherent, undisturbed attachment; 4. Defined physical differences in oxidized microstructure and morphology between rapid (1000oF/min) and slow heating; 5. Defined a physics based model for oxidation of specific matrix compositions and descried how this will enable development of specific matrix and CMC improvements.
Work Plan
Task 1: Kickoff Meeting and Reporting; Task 2: Design of Robust CMC Matrix - We will build upon our prior work and methodology to optimize matrix compositions that demonstrate enhanced oxidation at 2700oF; Task 3: CMC Fabrication; Task 4: Oxidation Testing and Controlled Laser Forming of Passivation Layer - At UCSB we will perform oxidation and phase evolution tests on the CMCs; Task 5: Passivating Oxide Characteristics and CMC Thermo-mechanical Testing - We will characterize the oxidized materials and perform thermo-mechanical tests; Task 6: Technical and Economic Trade Study

NASA Applications

Use of 2700oF CMC-based components such as combustor liners, turbine shrouds, and turbine vanes will enable higher temperature operation of turbine engines in subsonic, supersonic, and hypersonic aircraft. The lighter weight of the CMC components will reduce fuel consumption and their higher temperature operation will reduce air cooling requirements, decrease NOx emissions, and improve overall engine efficiency.

Non-NASA Applications

Commercial aircraft engines, both large and small, will benefit from low-cost, technically superior CMCs that enable higher temperature operation of CMC-based components. In addition, CMCs are currently being tested in ground-based gas turbines for power generation, where long-life high temperature survival is of particular importance.

Firm Contacts

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NON-PROPRIETARY DATA