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C/ORNL95-0351

Metals and Ceramics Division

CRADA Final Report
for
CRADA Number ORNL95-0351

# Optimization of Pseudo-Porous SiC Fiber Coatings for SiC/SiC Composites

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Oak Ridge National Laboratory

R. Shinavski
Hyper-Therm High Temperature
Composites, Inc.

Date Published – October 2000

Prepared by the
OAK RIDGE NATIONAL
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Oak Ridge, Tennessee 37831
Managed by
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[1] This work was supported through a CRADA with Hyper-Therm High-Temperature Composites, Inc., sponsored by the CFCC Program, Office of Industrial Technologies, U.S. Department of Energy, started under contract DE-AC05-96OR22464 with Oak Ridge National Laboratory, managed by Lockheed Martin Energy Research Corporation, and completed under contract DE-AC05-00OR22725, managed by UT-Battelle, LLC..

## Abstract

The objective of this Cooperative Research and Development Agreement between Lockheed Martin Energy Research Corporation and Hyper-Therm High-Temperature Composites, Inc. was the optimization of the microstructure of pseudo-porous SiC fiber coatings for SiC/SiC composites. Extensive interfacial test characterization was conducted through single-fiber push-out tests and analytical electron microscopy to assess the effect of various microstructural features of the fiber coating on the interfacial properties of the composite. The thermal stability of these coatings and their interfaces was also investigated after exposure to air at elevated temperatures.

## Objectives

The technical objective of the CRADA was:

- to identify the microstructural features of pseudo-porous SiC fiber coatings that provide conditions for fiber debonding and sliding in the wake of matrix cracks, particularly at elevated temperatures and provide guidance for the optimization of the microstructure of these coatings.

## Meeting Objectives

All tasks were completed.

## CRADA Benefit to DOE

The results from this study helped to develop an understanding of the role of various microstructural features of pseudo-porous fiber coatings on its functionality in ceramic matrix composites. This understanding has helped to provide insights in the development of a new generation of materials capable of meeting the very demanding conditions and requirements associated with the energy industries in the U.S.

## Technical Discussion

Introduction

Continuous fiber-reinforced ceramic matrix composites (CFCCs) constitute a relatively new class of materials with the potential for retaining strength and exhibiting tough behavior at elevated temperatures. The development of CFCCs has been driven to a great extent by the promise of substantial environmental and economic benefits if these materials are used in high-temperature industrial applications, particularly in the energy-related industries. The main attributes that make these materials attractive for these applications are their low density, their corrosion and wear resistance, and the potential for exhibiting dimensional stability and retention of strength at elevated temperatures. Most of the potential applications for these materials involve aggressive environments. For example, these materials are being considered for the fabrication of filters in coal-fired power plants that would be subjected to both oxidizing and reducing environments at elevated temperatures. These materials are also being considered for the manufacture of combustor liners for gas turbine engines. In this application stresses arise from thermal gradients through the wall of the component but the most severe conditions arise from being subjected to large heat fluxes, elevated temperature, and high pressure combustion environments. In most of these applications, these components are expected to last for tens of thousands of hours.

In general, the strength and toughness of CFCCs are controlled by the reinforcing fibers and by the fiber coatings. The roles of the fiber coating are: to allow for fiber debonding and fiber sliding in the wake of advancing cracks in the matrix; to protect the fibers during the synthesis of the matrix and from the service environment when this can ingress to the interior of the composite through matrix cracks.

Experimental

Single-fiber interfacial tests were conducted on materials densified by Hyper-Therm High Temperature Composites, Inc. Materials were synthesized with pseudo-porous SiC fiber coatings having various microstructures. The results from the single-fiber interfacial tests provide quantitative and qualitative information on the ability of fiber coatings and their interfaces to deflect cracks in the matrix. These results were complemented with transmission electron microscopy and other analytical techniques to determine the microstructure of the material and its changes after exposure to air at elevated temperatures.

Conclusions

The relationship between the microstructural features of pseudo-porous SiC fiber coatings and their ability to deflect cracks at the fiber/matrix interface of SiC/SiC composites was investigated. The ability of these fiber coatings to meet their functional requirements when SiC/SiC composites are exposed to air at elevated temperatures was determined.

## Report of Inventions

There were no inventions developed under this agreement.

## Commercialization Possibilities

Hyper-Therm High-Temperature Composites Inc., is offering variations of the materials investigated in this project on a commercial basis.

## Plans for Future Collaborations

Informal collaborations are maintained between the parties, but no plans have been made for future formal collaborations.

## INTERNAL DISTRIBUTION

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September 22, 2000

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Letter No. 000922-01

Subject: Approval for public release CRADA final report for CRADA ORNL 95-0351

Dear Edgar:

Hyper-Therm, Inc. High Temperature Composites (Hyper-Therm) has reviewed the subject document, and finds no information that is considered the proprietary data of Hyper-Therm.

Please continue to consider Hyper-Therm for any of your needs in fiber coatings or ceramic matrix composites.

Thank you for your patience in this matter.

Sincerely,

Wayne S. Steffier
President

WS/ct

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