Paper ID: 50232
oral
student

IAF MATERIALS AND STRUCTURES SYMPOSIUM (C2)
Advanced Materials and Structures for High Temperature Applications (4)

Author: Mr. Stefano Mungiguerra
Università degli Studi di Napoli “Federico II”, Italy

Dr. Giuseppe Di Martino
University of Naples ”Federico II”, Italy
Dr. Anselmo Cecere
Università degli Studi di Napoli “Federico II”, Italy
Prof. Raffaele Savino
University of Naples ”Federico II”, Italy
Dr. Frederic Monteverde
CNR-ISTEC, Italy

EFFECT OF SIC CONCENTRATION ON AERO-THERMAL BEHAVIOR OF ZRB2-BASED CERAMICS IN HYPERSONIC ENVIRONMENT

Abstract

The extremely demanding aero-thermo-dynamic conditions encountered by hypersonic vehicles during atmospheric re-entry make the design of proper Thermal Protection Systems (TPS) a topic of utmost importance, requiring continuous improvement of materials and technologies. The environment of re-entry includes hypersonic Mach numbers, temperatures above 2000°C, the activation of gas dissociation/recombination reactions at extremely low oxygen partial pressures, which can substantially enhance the heat flux on the exposed surface of the spacecraft.

Ultra-High-Temperature Ceramics (UHTCs) and Ultra-High-Temperature Ceramic Matrix Composites (UHT-CMCs), based on transition metals carbides and diborides and silicon carbide, are actively studied as candidates for these applications, especially in light of their high melting temperatures, strength and oxidation resistance at temperatures over 2000°C. The dispersion of SiC in the form of particles, short fibers or whiskers, in the main ultra-refractory ceramic matrix is frequently used to improve damage tolerance and oxidation resistance thanks to the formation of an oxide protective scale, performing a self-healing function at ultra-high temperatures.

In this framework, University of Naples “Federico II” (UNINA) and the Institute of Science and Technology for Ceramics (ISTEC) are involved in the Horizon 2020 European C^3HARME research project, focused on a new class of UHT-CMCs for near zero-ablation thermal protection systems. Among the experimental activities, specific tests were carried out to study the effect of increasing amount of SiC into a ZrB_2 UHTC matrix. Lab-scale samples with different SiC amount (5-15% vol.) were tested in the high-enthalpy arc-jet wind tunnel available at UNINA, where atmospheric re-entry conditions are reproduced at maximum flow total enthalpies higher than 20 MJ/kg, supersonic Mach number and temperatures over 2000°C in a gas atmosphere with high concentration of atomic oxygen. Non-intrusive diagnostic equipment, including two-color pyrometers and an infrared thermo-camera, was employed to monitor the surface temperature of the samples. Results are discussed primarily addressing the effect of SiC content on the material behavior, in terms of oxidation resistance, maximum equilibrium temperature, thermal conductivity, surface emissivity and the occurence of a spontaneous temperature jump, a sudden temperature overshoot in the order of 400-500 K occurring at constant flow total enthalpy. Such phenomenon, closely related to the overall thermal stability of the material, seems favoured by lower SiC amount, but it appears also in case of larger SiC content, for prolonged exposure time.