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Short Communication

Radiative properties characterization of ZrB_2–SiC-based ultrahigh temperature ceramic at high temperature

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ABSTRACT

Experimental investigations of radiative property on pre-oxidized ZrB_2–SiC–15 vol.%–C ultrahigh temperature ceramic (ZSC UHTC) at high temperature range of 1100–1800 °C were performed. By Fourier transform infrared radiant (FT-IR) spectrometer, spectral emissivity was measured in the wavelength region between 3 and 18 μm. Total normal emissivity was calculated using spectral emissivity data via theoretical formula. It has been found that high emissivity for all the testing specimens was presented, and the total normal emissivity is between 0.65 and 0.92 with temperature range from 1100 to 1800 °C. Moreover, the total normal emissivity of pre-oxidized ZSC ceramic decreased non-monotonously as the temperature increased. The total normal emissivity decreased as the testing temperature increased from 1100 to 1800 °C, whereas the total normal emissivity at the testing temperature of 1600 °C was higher than that of 1400 and 1800 °C. Macroscopical surface morphology and microstructure were carried out before and after the testing.

1. Introduction

Zirconium diboride (ZrB_2) has high melting point (3250 °C), high hardness, high electrical conductivity, excellent corrosion resistance against molten metal and superb thermal shock resistance [1–3,5–8]. The materials have been commonly referred as ultrahigh temperature ceramic and have been as the most promising candidate materials for using in extreme space thermal protection system applications such as sharp leading edges or nose cap on the next generation hypersonic reentry vehicles [1,6–9]. Although this kind of material has many excellent capabilities, their intrinsic characteristics such as low fracture toughness and resistance to oxidation at high temperature are still obstacles for them to be used widely [10]. A method to overcome these deficiencies has been applied by tailoring microstructure and composition to produce ZrB_2-based ceramics which are engineered to enhance densification while maintaining load-bearing capability, such as incorporating SiC into the ZrB_2 ceramics [11,12] . However, unsatisfactory fracture toughness of the ZrB_2–SiC ceramics is still the obstacle for applications in extreme environment [13]. Wang et al. [14] have confirmed that the fracture toughness of the ZrB_2–SiC ceramics was further improved by addition of the graphite flake with a high aspect ratio. Since a quite long time, the research for ZrB_2-based UHTC has been focused on the characterization in their mechanical and oxidation resistance properties [5]. So far, little or no data at all of the material radiative properties is available, especially at high temperature. Emissivity is a key parameter for the eligibility of UHTC materials in hot structures, since the radiation is the main way to dissipate aeroheating so that reduces the surface temperature. High emissivity improves the materials performance in hypersonic reentry conditions by reducing temperature gradients and thermal stress of the components, which is favorable for the vehicle to operate under higher heat flux conditions. A reliable experimental evaluation of the parameters is required to feed aero-heating computations and structure response [1,5]. In absence of experimental data, extreme conservative theoretical values are used in the design of thermal protection system so that making the vehicle redundancy. Moreover, the most important feature for our work is that the radiative properties of ZrB_2–SiC-based UHTCs during the true service status were characterized, which is most significant to engineering design and engineering application.

In the present work, the spectral emissivity and total normal emissivity of the ZSC ceramic were measured by the FT-IR spectrometer. The main purpose of this paper is to report the results of an experimental investigation on radiative properties for pre-oxidized ZSC ceramic in the temperature range of 1100–1800 °C. The macroscopical morphologies, surface microstructure and compositions were observed before and after the testing. Moreover, the

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