Radiative and Optical Properties of Plasma Sprayed Thermal Barrier Coatings: a Porosity Estimation Technique

Leire del Campo [C, S], Domingos De Sousa Meneses and Patrick Echegut
CNRS - Centre National de la Recherche Scientifique, CEMHTI - Conditions Extrêmes et Matériaux : Haute Température et Irradiation, Orléans, France
leire.del-campo@cnrs-orleans.fr

Antoine Bacciochini and Alain Denoirjean
CNRS - Centre National de la Recherche Scientifique, SPCTS - Science des Procédés Ceramiques et de Traitement de Surface, Limoges, France

Normal spectral emittance of plasma sprayed ceramic films with varying porosity is reported between ambient temperature and 850 K, for wave numbers between 40 and 5000 cm^{-1}. Two coupled Fourier transform infrared (FT-IR) spectrometers are used to compare the spectral radiance of the sample to that of a blackbody radiator so as to obtain the emittance. 50-150 µm thick oxide films are deposited on a metallic substrate by suspension plasma spraying (SPS), the suspension being a mixture of nanometric (*f* 50 nm) oxide powder and ethanol. The porosity of the ceramic films is measured by ultra-small-angle X-ray scattering (USAXS), environmental scanning electron microscope (ESEM) analysis is performed to characterize the microstructure of the films, and an optical microscope is employed to measure the thickness of the film. Theoretical models of radiative and optical properties are combined to develop a simulation tool that predicts the radiative behavior of smooth nano- and meso-porous ceramic films. The change in the optical properties of the monocrystalline oxyde matrix due to the meso-pores is described in the frame of the effective medium theories (EMT), and this result is combined to the radiative effect of thin films which accounts for interferential oscillations. The experimentally measured spectral emittance cannot be thoroughly reproduced using this model in the whole spectral range because diffusion due to micrometric heterogeneities is not taken into account; however, the thickness and the porosity of the film can be adjusted to reproduce the periodicity of the radiative interferences in the far infrared domain. The adjusted values are compared to the measured values obtained by ESEM and USAXS, and it is concluded that infrared spectroscopy is a valuable and sensitive enough technique to estimate the porosity of meso-porous ceramic films whenever the thickness is accurately known, and vice versa.