Thermal Radiative Properties of Refractory Ceramics Materials

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Refractory ceramics materials are widely applied in industry because they are capable of maintaining physical and chemical stability at high temperatures. Thermal radiative properties of ceramics, especially in the near- to mid-infrared region, play an important role in heat transfer analysis and temperature measurement. There is a lack of systematic study of the thermal radiative properties of ceramic materials, due to the complexity of their intrinsic and extrinsic structures. Here, intrinsic structures refer to the crystal structure and chemical composition while extrinsic structures refer to the grain size, porosity, surface roughness, etc. The objective of this study is to correlate the radiative properties of ceramics with their chemical compositions, porosity, grain size, and surface roughness. The ceramics samples considered here include alumina (Al_2O_3), silicon carbide (SiC), and silicon nitride (Si_3N_4). The directional-hemispherical reflectance spectra of selected ceramics samples are obtained at room temperature using Fourier transform infrared spectroscopy (FTIR) and monochromator combined with integrating spheres. The measured wavelengths range from 0.4 μm to 15 μm. In the theoretical analysis, refractive indices of highly dense and porous ceramics are obtained based on the effective medium approximation (EMA). Combined with the Mie scattering theory, the radiative transfer equation (RTE) can be solved using a Monte Carlo ray tracing algorithm, which enables the spectral reflectance prediction. This study will help the understanding of the effects of intrinsic and extrinsic structures on the spectral radiative properties of ceramics.