Thermal Conductivity of Biomorphic Porous SiC Based Ceramics

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Biomorphic porous SiC based ceramics were produced by chemical vapor infiltration and reaction (CVI-R) technique using paper preforms as templates. The thermal conductivity of three samples with similar porosity (40 – 50 %) but different composition and microstructure was investigated: i) pure SiC, ii) SiC-Si_3N_4 (9:1) composite, and iii) SiC coated with a thin layer of TiO_2. The composite ceramics (SiC-Si_3N_4 and SiC-TiO_2) show enhanced oxidation resistance compared to single phase SiC. However, a key property for the application of these materials at high temperatures, e.g., in a pore burner, is their thermal conductivity. The latter was determined experimentally at defined temperatures around ambient both with a stationary guarded parallel plate instrument and with a laser flash apparatus. While for the first method, the thermal conductivity was determined directly, the quantity accessible with the latter is rather the thermal diffusivity. For comparison purposes, the specific heat of all samples was determined in the flash device employing a comparative graphite sample, while the density was measured according to Archimedes' principle. The results for the thermal conductivity from both methods were found to be clearly below 1 W/mK and in good agreement within the combined uncertainties, which could be estimated to be less than 3 % to 5 % for the flash method and 10 % for the parallel plate instrument. With respect to SiC for the composite with 10 % Si_3N_4, an increase in the thermal conductivity by a factor of about two could be observed. At first, this seems to be astonishingly high taking into account that the thermal conductivity of solid SiC is about one order of magnitude larger than that of solid Si_3N_4. Yet, a closer insight into the samples using scanning electron microscopy (SEM) reveals a mixed phase microstructure for the composite material with Si_3N_4, which may explain the differences. For the SiC sample coated with a thin TiO_2 layer, the results may also be explained through a change in microstructure. The experimental macroscopic and microscopic effects observed within the scope of this work at a given porosity were used to model the thermal conductivity of ceramics as a function of porosity.