

PROCEEDINGS

Fabrication of High-Performance Microchannel SiC Ceramics via Stereolithography-Assisted Freeze Casting

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ABSTRACT

Silicon carbide (SiC) ceramics are widely used in industries such as aerospace, nuclear reactors, heat exchangers, concentrated solar power, thermoelectric conversion, and gas turbines due to their superior resistance to high-temperature oxidation and corrosion, and outstanding chemical stability. The reaction melt infiltration (RMI) process achieves densification of microchannel SiC ceramics, which hold significant potential for heat exchanger applications. However, the diffusion and reaction behavior of molten silicon is significantly influenced by the pore structure of the green bodies, which can easily lead to residual silicon segregation and localized enrichment, thereby limiting improvements in the mechanical and thermal properties. Thus, this study combined stereolithography with freeze casting to control the pore structure of the green bodies by regulating the growth behavior of ice crystals at different freezing temperatures, thereby controlling the distribution of the silicon phase during the RMI process. Furthermore, numerical simulations were employed to elucidate the infiltration behavior of molten silicon during the RMI process. The results demonstrated that the SiC green bodies prepared using the optimized process exhibited uniformly distributed, discrete pores, which facilitated the homogeneous distribution of the residual silicon phase during the RMI process, resulting in a bending strength of 289 MPa and a thermal conductivity of 177.4 W/m·K for the SiC ceramics. Additionally, this technology was used to fabricate SiC ceramics with microchannels measuring 450 μm in size. The regulation of pore structures in ceramic green bodies is an effective strategy for optimizing the distribution of the silicon phase in microchannel SiC ceramics to achieve synergistic improvements in thermal and mechanical properties.

KEYWORDS

Stereolithography; freeze casting; microchannel SiC ceramics; thermal-mechanical properties

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