From Microstructure to Mechanical Integrity: SiC/Al IPCs for Demanding Industrial Applications

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Abstract

Interpenetrating Phase Composites (IPCs) represent an innovative class of materials that combine the advantages of ceramics and metals by offering high-temperature stability, wear resistance, and enhanced ductility and toughness. The unique interlinked microstructure of IPCs, which is formed by integrating two or more continuous phases, develops properties that surpass those of conventional composites, thus making IPCs suitable for high-performance applications in fields such as medical tools, grinding instruments, defense, aerospace, and components exposed to extreme environments. In this study, silicon carbide (SiC) IPCs were fabricated through the infiltration of aluminum alloy to further enhance their mechanical performance. A pressureless infiltration method was utilized in an atmospheric furnace, with aluminum blocks introduced into SiC foams (10 ppi and 20 ppi) placed in graphite molds. The furnace was filled with N2 gas and heated gradually to 1100 ◦C over four hours, then maintained at this temperature for an additional three hours, and subsequently allowed to cool. Optical microscopy of the fabricated Al-SiC IPC samples revealed a well-connected structure, free of voids or cracks, indicating a robust metal-ceramic bond. SEM/EDS analyses and mechanical assessments of the developed SiC-Al IPCs have shown promising results that demonstrate the material structural integrity and potential for implementation in extreme environments and demanding applications. Subsequently, further in-depth SEM/EBSD analyses and impact testing are planned to comprehensively evaluate the microstructural cohesion and mechanical robustness of the IPCs. These investigations will validate the suitability of SiC-Al IPCs for applications involving high wear, stress, and thermal fluctuations, thus emphasizing their role as high-performance materials for challenging operational conditions.

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