Fabrication and Microstructural Analysis of SiC-Al IPCs for Enhanced Mechanical Properties

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Abstract

Interpenetrating Phase Composites (IPCs) represent a groundbreaking class of materials that combine the benefits of ceramics and metals by deploying both high-temperature stability and wear resistance with enhanced ductility and toughness. IPCs integrate two or more continuous phases that contribute to unique interlinked microstructure design that imparts superior properties beyond those of conventional composites. This makes IPCs ideal for demanding applications such as surgical instruments, grinding tools, defense, aerospace, and components in extreme environments [1]. Recent advancements have introduced IPCs with tailored porosities and novel structures, such as 3D interconnected porous matrices and layered configurations [2]. In this study, silicon carbide (SiC) IPCs was fabricated by infiltration with aluminum alloy to further optimize their mechanical performance. Using a pressureless infiltration method in an atmospheric furnace, aluminum blocks were introduced into SiC foams (10 ppi and 20 ppi) contained within graphite molds. The furnace was filled with N_2 gas and gradually heated to 1100 °C over four hours, then held at this temperature for an additional three hours, and subsequently cooled. Optical microscopy confirmed a well-interconnected Al-SiC structure that revealed an absence of voids or cracks, thus indicating robust metal-ceramic interconnection.

References

[1] N. Kota, M. S. Charan, T. Laha and S. Roy, "Review on development of metal/ceramic interpenetrating phase composites and critical analysis of their properties," Ceramics International, 2022.
[2] P. Kozera, A. Boczkowska, K. Perkowski, M. Małek and J. Kluczyński, "Influence of Fabrication Method and Surface Modification of Alumina Ceramic on the Microstructure and Mechanical Properties of Ceramic–Elastomer Interpenetrating Phase Composites (IPCs)," Materials, 2022.

Figures

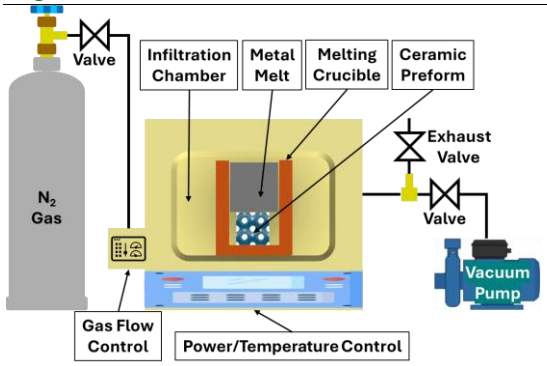
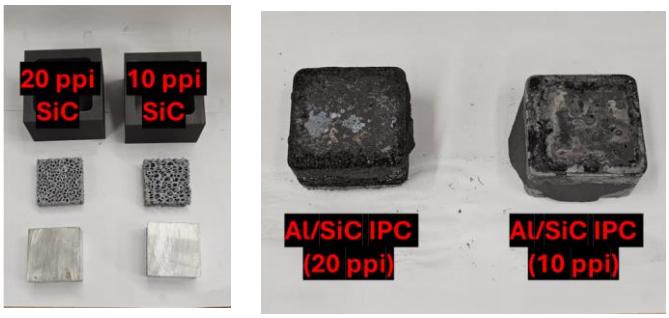
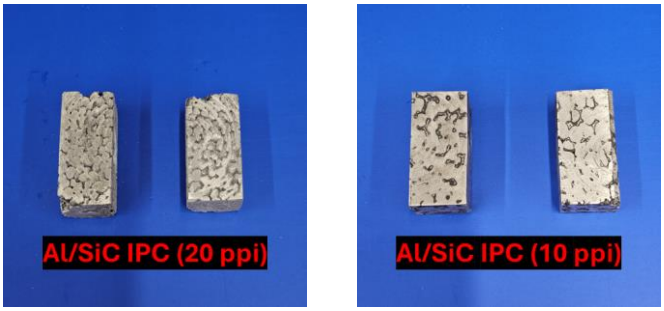


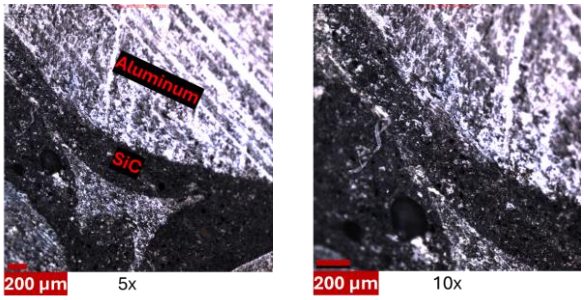
Figure 1: Schematic illustrating the metal infiltration process



(a) **(b)**
Figure 2: Photographic Images showing **(a)** Infiltration tools and **(b)** IPCs after infiltration



(a) **(b)**
Figure 3: Post-machining of IPCs using **(a)** 20 ppi SiC preform and **(b)** 10 ppi SiC preform



(a) **(b)**
Figure 4: Optical microscopy images of Al/SiC interface at magnifications of **(a)** 5× and **(b)** 10×