3D-Printed Ceramic Preforms for Tailored Metal/Ceramic IPCs

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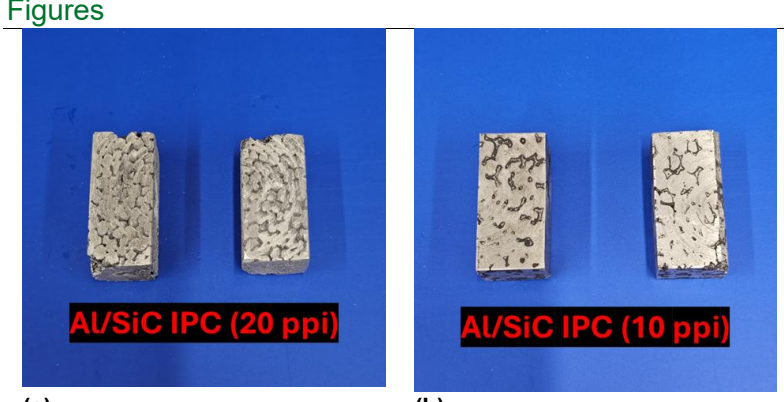
Abstract:

This work presents the development of metal/ceramic interpenetrating phase composites (IPCs) via melt infiltration of aluminum into commercially available silicon carbide (SiC) foams. The fabricated IPCs exhibited strong interfacial bonding and demonstrated notable compressive strength, confirming the viability of this approach for structural applications requiring high stiffness and damage tolerance. These findings underscore the potential of metal/ceramic IPCs in areas such as thermal management and lightweight structural components [1]. Building on these results, our current efforts focus on advancing the IPC design by employing 3D-printed ceramic preforms. Additive manufacturing offers precise control over the geometry and architecture of the ceramic phase, enabling the design of customized porous structures optimized for infiltration kinetics and application-specific performance. This transition from commercial foams to tailored architectures expands the potential for functional integration and allows for the implementation of novel testing methodologies, including localized mechanical analysis and anisotropic thermal characterization. The infiltration process for these 3D-printed preforms is currently being refined, with an emphasis on controlling wetting behavior, infiltration depth, and solidification conditions [2]. The optimized process will facilitate the scalable production of IPC specimens, which will undergo systematic mechanical, thermal, and microstructural evaluation to guide further material design and application development.

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] A. Singh, O. Al-Ketan, N. Karathanasopoulos, “Hybrid manufacturing and mechanical properties of architected interpenetrating phase metal-ceramic and metal-metal composite,” Materials Science & Engineering A, 2024.

Figures



(a) **(b)**

Figure 1: Metal/ceraic IPCs made of commercial ceramic foam using **(a)** 20 ppi SiC preform and **(b)** 10 ppi SiC preform

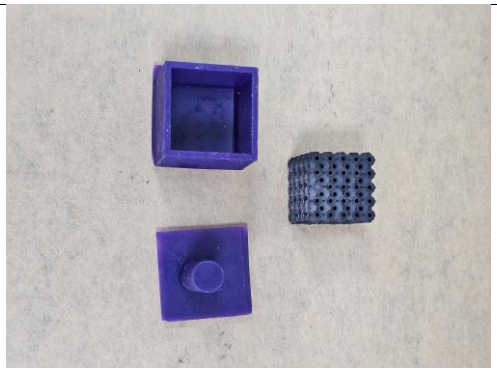


Figure 2: Preparation for investment casting to infiltrate 3D printed ceramic for customized metal/ceramic IPC