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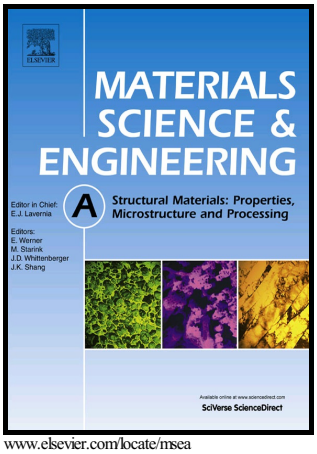

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Abstract

Freeze casting has been proven to be a versatile processing approach for the design of biomimetic composites that exhibit unique combinations of strength and toughness. However, to date, most studies have focused on polymer–ceramic composites, and very limited work has examined metal–ceramic composites, even though the latter possess much superior mechanical properties. In this work, we prepared nacre-like $Al/Al_2O_3–ZrO_2$ composites using freeze casting and pressure infiltration techniques and then investigated the influences of the ceramic lamellae compactness and interface reaction on the mechanical properties and fracture behavior of the composites. The results show that the compactness of the ceramic lamellae greatly influences the Al penetration and subsequent interfacial reaction with ZrO_2. The presence of Al_3Zr reaction product layers facilitates crack initiation and interface debonding, weakening the fracture toughness of the composites. The ceramic lamellae can be densified by using fine ceramic particles and increasing the ceramic loading and sintering temperature, thus greatly reducing the extent of the interfacial reaction and improving the strength and toughness of the materials.

Keywords:

freeze casting; infiltration; interface reaction; ceramic lamellae compactness; mechanical properties

1. Introduction

The development of structural materials that are lightweight, strong and tough has been an important topic of research for many decades. Unfortunately, in most materials, strength and toughness are mutually exclusive, and the achievement of one of these factors is invariably at the expense of the other [1].

To obtain optimal mechanical performance, an intriguing approach is to mimic the features of natural materials. Among numerous natural materials, a prime example is nacre, which consists of 95 vol.% $CaCO_3$ platelets bonded by thin layers of an organic material and exhibits a unique combination of strength and toughness [2]. Inspired by the fantastic microstructure and properties exhibited in nacre, many approaches, such as