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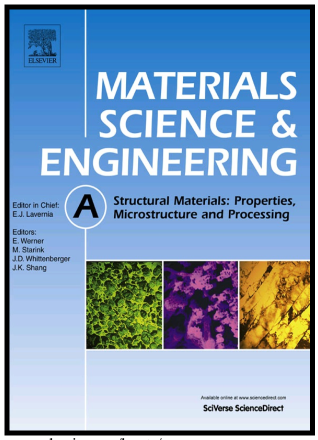

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A Multiscale Comparison of Stochastic Open-Cell Aluminum Foam Produced Via Conventional and Additive-Manufacturing Routes

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Abstract

With the exciting potential of additive manufacturing of metals to produce geometrically complex structures come many unknowns and uncertainties regarding the process-microstructure-property relationships of the additively manufactured (AM) parts, especially in comparison to their conventionally manufactured counterparts. This work attempts to elucidate some key differences between AM and cast parts by conducting a multiscale comparison of samples that are intended to be identical, except for the route by which each was manufactured. The samples of interest are open-cell foams of an Al-Mg-Si alloy (Al 6061). The baseline open-cell foam is conventionally produced via investment casting. Copies are produced using laser powder bed fusion. Full-field deformation is characterized under compressive loading using in-situ X-ray computed tomography. The foams are compared in terms of global load versus displacement response, local failure mechanisms, and characteristics of the grain structure.

Keywords: Casting, Rapid solidification, Mechanical characterization, EBSD, Tomography, Cellular materials

1. Introduction

Open-cell metallic foams are a class of structural-material systems that comprise a network of interconnected metallic ligaments, resulting in a hierarchical structure [1] − viz., the component scale of the engineered part, the topological scale of the foam, and the grain scale of individual ligaments or struts. The topology of open-cell foams can range from ordered (as in lattices) to stochastic. These low-density, hierarchical, structural-material systems have been recognized as being multifunctional [2, 3]. For example, in addition to serving as light-weight, load-bearing structures, open-cell metallic foams have the potential to serve concurrently as electrodes for energy-storage devices [4], as hosts for newly generated bone and blood vessels in biomedical implants [5], or as impact absorbers and noise insulators for advanced high-speed ground transportation [3], to name a few.

There has been a considerable amount of work done to investigate and describe various manufacturing

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