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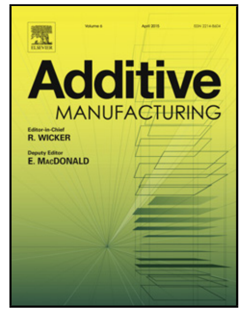

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Glass forming ability, flexural strength, and wear properties of additively manufactured Zr-based bulk metallic glasses produced through laser powder bed fusion

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Abstract

An evaluation of low-cost, high-oxygen content Zr-Cu-Al-Nb bulk metallic glasses (BMGs) produced through laser powder bed fusion (PBF) was performed. Four-point bending and wear resistance tests were used to compare the mechanical properties of the printed alloy with laboratory grade cast parts. It is shown that the laser PBF parts, while not being able to be cast as a bulk glass, can be printed amorphous up to at least several millimeters thick and yet still have reasonable mechanical properties.

Keywords

Additive manufacturing, Laser powder bed fusion, Bulk metallic glasses, Four-point bending, Wear testing

1. Introduction

Additive manufacturing (AM) or 3D printing of metals is a rapidly developing field that has attracted remarkable interest from both academia and industry [1–5]. In addition to the production of net-shaped parts and rapid prototyping, the allure of metal AM extends to the ability to fabricate parts with rapid solidification. Through the high cooling rates achievable with metal AM, parts made from bulk metallic glasses (BMGs), which are alloys with amorphous structures that possess outstanding mechanical properties, could be manufactured.

The vast majority of metal AM is done through powder bed fusion (PBF) and direct energy deposition (DED), which were extensively demonstrated to produce BMG parts [6–11]. AM of BMGs using non-powder feedstock, such as laser foil printing (LFP) [12–14], has also resulted in the fabrication of parts with dimensions that exceed the casting limits for glass formation. Currently, the literature demonstrates several important milestones related to the potential for manufacturing BMG through AM. These include demonstrations that (1) lasers are sufficient to fully melt Zr and Fe-based BMGs so that they can vitrified upon cooling, (2) the cooling rate of various AM processes is sufficient to form amorphous layers even with very weak glass-forming