

Abstract

Additively manufactured bulk metallic glass compliant mechanism for ankle joint orthoses

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Compliant mechanisms are a promising alternative to rigid systems because they reduce friction, avoid backlash, and require fewer components [1]. These advantages make them relevant for structural, biomedical, and micro-mechanical applications [2]. One application among biomedical engineering are orthoses which are especially important for providing functional support and can assist healing. Despite existing solutions to improve mobility, there is still a strong demand for orthotic devices that are lighter, more versatile, patient specific and more innovative. Better mobility improves comfort and everyday usability, and it can also support rehabilitation through controlled movement [3]. The performance of compliant mechanisms depends strongly on the elastic properties of the material. Bulk metallic glasses (BMGs) combine very high strength with elastic strain limits of up to about 2%, exceeding those of conventional crystalline metals [4]. This makes them well suited for elastic hinge elements and compact compliant structures [5]. For a long time, the wider use of BMGs was limited by processing constraints, since the high cooling rates needed to preserve the amorphous state restricted size and geometry. Additive manufacturing has opened new possibilities, especially through laser powder bed fusion (PBF-LB/M), which enables more complex and larger BMG components [6]. This is particularly relevant for ankle joint orthoses, where lightweight, patient-specific, and mechanically efficient structures are needed. In this study, we present the design and manufacturing of compliant mechanisms based on the alloy $Zr_{59.3}Cu_{28.8}Al_{10.4}Nb_{1.5}$. We show how the elastic behavior of BMGs can be combined with the design freedom of additive manufacturing. We also discuss other BMG alloys under investigation for additive manufacturing that may become relevant for future large-scale applications, including $Ni_{62}Nb_{38}$ [7], sulfur-containing Ti-based BMGs [8], and CuTi-based BMGs [9].

AUTHOR'S STATEMENT

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