Transactions on Additive Manufacturing Meets Medicine
Trans. AMMM, 2023, Vol. 5, No 1, Suppl. 1, Article ID 821, 1 Page

Infinite Science Publishing

Abstract

Functional performance of NiTi shape memory architected structures produced by laser powder bed fusion (LPBF)

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NiTi shape memory alloys have gained significant attention in various medical applications due to their exceptional superelastic and shape memory properties, allowing them to recover their original shape after deformation [1, 2]. The integration of additive manufacturing technology has revolutionized the design possibilities for NiTi alloys, enabling the fabrication of intricately designed medical devices with precise geometries and tailored functionalities [3-5]. This study investigates the functional performance of NiTi architected structures fabricated using laser powder bed fusion (LPBF) technology. Spherical Ni-rich NiTi powder with functional properties at body temperature (37°C) was carefully selected as the material. The LPBF process parameters were optimized to achieve nearly full density, reaching up to 99.5%. To assess the quality of the lattice samples, micro-Computed Tomography (micro-CT) was employed to evaluate potential residual defects. To enhance the functional properties of the printed samples, a specific low-temperature heat treatment process was applied. The samples were annealed at 500°C for 5 minutes, followed by water quenching. Differential scanning calorimetry (DSC) analysis was performed to determine the transformation temperature of both the as-built and heat-treated samples. Cycling mechanical testing was conducted through compression at room temperature to evaluate the pseudo-elastic behavior of the lattice structures. A limited number of loading/unloading cycles (10 cycles) were applied to assess the mechanical response of the NiTi lattices. The resulting NiTi metamaterials exhibited notable recoverable deformation strains, spanning from 1.5% to 3.8%, attained through an applied force of up to 12 kN. This firmly emphasizes the design's capacity to amplify structural functionality and deformability, rendering it exceptionally well-suited for versatile and adaptive applications. The findings strongly emphasize the remarkable potential of these structures for use as bone implants, showcasing their suitability for medical applications. Thanks to 3D printing technology, there is also a unique capability to fine-tune the implant's mechanical characteristics to match the specific parameters of individual bones.

Author's statement

Conflict of interest: Authors state no conflict of interest.

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DOI: 10.18416/AMMM.2023.2309821