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AM of NiTi for medical applications

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Additive manufacturing (AM) of superelastic Nitinol represents a promising field of research, as its freeform capabilities and potential for customization may enable the development of a new generation of medical implants and devices [1]. However, the use of additive processes for fabricating Nitinol components presents several challenges due to the functional nature of NiTi as a material.

Processes such as laser powder bed fusion (LPBF) can lead to preferential evaporation of nickel or oxidation of titanium. These effects are particularly critical because the material is highly sensitive to compositional variations; even a loss of 0.1 at.% Ni can shift transformation temperatures by approximately 10 °C. Furthermore, if oxygen levels exceeding 500 ppm, oxide formation can significantly reduce fatigue life and lead to premature failure [2]. Therefore, it is essential to use high-purity feedstock powders with tightly controlled chemical composition.

In this work, we present our experience and approach to the preparation and processing of NiTi powders for LPBF. Powders produced via electrode induction melting gas atomization (EIGA) and vacuum induction melting gas atomization (VIGA) are characterized, and both technologies are evaluated in terms of their suitability for AM processing. Key aspects of these processes are discussed.

In the second part of the study, multiple powder batches were prepared in-house using EIGA. These powders were characterized through microscopy, chemical analysis, differential scanning calorimetry (DSC) to determine transformation temperatures, and X-ray diffraction (XRD) to verify phase composition. Results from fabricated parts are presented in the as-built condition and after heat treatment, and are compared with the transformation behavior of the original powders. The parts were manufactured via LPBF, their functional properties were evaluated and compared to previously reported results [3, 4]. Finally, key considerations for the application of AM-processed NiTi in the medical field are discussed.

Author's statement

Conflict of interest: Authors are employees of BioActiveMetals S.r.l, Legnano, Italy. Animal models: No animal experiments have been carried out. Informed consent: Informed consent has been obtained from all individuals included in this study. Ethical approval: The research related to human use complies with all the relevant national regulations, institutional policies and was performed in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee. Acknowledgments: The authors state no funding involved.

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