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Abstract

Tailoring mechanical properties and fatigue strength by varying gyroid unit cell sizes on electron beam manufactured scaffolds

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Triply periodic minimal surface structures (TPMS) possess unique properties in terms of open porosity, large surface area, and surface curvature, which are considered to have bone mimicking properties. However, the structural mechanical influence of design parameters such as the pore or unit cell size of additively manufactured TPMS structures has not yet been thoroughly investigated. Here, Ti6Al4V scaffolds of differently sized gyroid unit cells were manufactured by electron beam melting. The scaffolds were analyzed by micro-computed tomography to determine morphological characteristics [1]. To establish a relationship between structure and mechanical properties, the scaffolds were subsequently investigated in terms of their quasi-static and fatigue properties. By selectively adjusting the unit cell sizes, it was possible to fabricate scaffolds that continued to exhibit fatigue strength of 35% to 45% of their offset stress at 106 load cycles. For additively manufactured scaffolds with a high porosity, this represents a comparably good result and shows that the mechanical properties of implants can be tailored explicitly through targeted design adaptation of TPMS unit cells to allow better integration of implants into the bone and to avoid effects such as stress shielding.

AUTHOR'S STATEMENT

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