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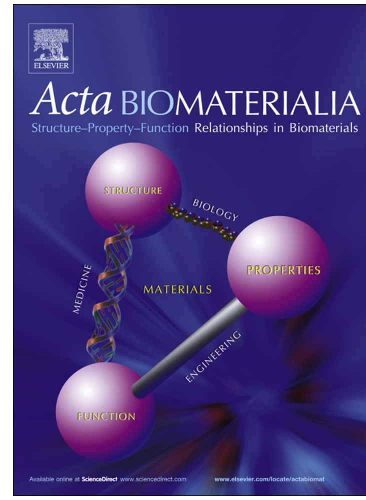

Full length article

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Research article

Improving the fatigue performance of porous metallic biomaterials produced by Selective Laser Melting

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ABSTRACT

This paper provides new insights into the fatigue properties of porous metallic biomaterials produced by additive manufacturing. Cylindrical porous samples with diamond unit cells were produced from Ti6Al4V powder using Selective Laser Melting (SLM). After measuring all morphological and quasi-static properties, compression-compression fatigue tests were performed to determine fatigue strength and to identify important fatigue influencing factors. In a next step, post-SLM treatments were used to improve the fatigue life of these biomaterials by changing the microstructure and by reducing stress concentrators and surface roughness. In particular, the influence of stress relieving, hot isostatic pressing and chemical etching was studied. Analytical and numerical techniques were developed to calculate the maximum local tensile stress in the struts as function of the strut diameter and load. With this method, the variability in the relative density between all samples was taken into account. The local stress in the struts was then used to quantify the exact influence of the applied post-SLM treatments on the fatigue life. A significant improvement of the fatigue life was achieved. Also, the post-SLM treatments, procedures and calculation methods can be applied to different types of porous metallic structures and hence this paper provides useful tools for improving fatigue performance of metallic biomaterials.

Keywords: biomaterials, Selective Laser Melting, orthopaedic implants, fatigue life

1. INTRODUCTION

Lattice structures are a particular type of porous structures that consists of a network of connected unit cells. A unit cell is defined as the smallest repeatable volume of a lattice structure, and is often constructed from beams or struts which form a three-dimensional framework. Widely used unit cell types include diamond, cubic, truncated cuboctahedron, etc., although currently also more complex types of unit cells are investigated, such as sheet gyroid and plane gyroid [1-3]. When a biocompatible material such as Ti6Al4V or CoCr is used to produce these porous structures, they can be considered porous metallic biomaterials.