On the design of lattice structures by additive manufacturing

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Abstract

In this work, selective laser melting (SLM) is used to produce tailored open-cell scaffolds used in various applications, i.e., biomedical implants, miniaturised heat transfer systems and light-weight high-stiffness components. We developed and validated a framework to design lattices within a range of sizes and volume fractions prepared to suit the needs of the applications and at the same time accounting for the limitations of the AM process. The manufacturing challenges are addressed and embedded in the design process. We chose the titanium alloy Ti-6Al-4V due to its wide use in orthopaedics and space sector and known printability via powder bed fusion. Mechanical experiments under compression reveal the stiffness and the collapse load of the scaffold as a function of surface geometry and relative density. This combined with state-of-art 3D tomography allowed for the development of optimal lattice design spaces for each application combining both: geometrical design and manufacturability.

Introduction

Additive manufacturing (AM) is creating significant interest and excitement around the world. This is particularly the case for metallic alloys such titanium, used in many critical parts of spacecraft, heat-exchangers or implants. The use of AM on Ti alloys allows for the creation of new complex geometries, like latticing strategies (Fig. 1a), breaking the design limitations of conventional manufacturing (CM). These lattices will open the door to a whole new range of lightweight, functional and efficient Ti components that are called to revolutionise the fields of biomedicine, aerospace, transport or energy production[1-5]. For example, it can contribute to some of the current critical European challenges such as space exploration with lighter rockets and satellites[1,2] (ESA, ArianeSpace), more efficient lightweight airplanes[1] (Airbus), new generation of heat transfer components with breaking efficiency[3] applicable to engine industry (Reaction Engines, Rolls-Royce) or improved biocompatible implants with bone-like stiffness[4,5].

The mechanical performance and added functionality of these structures depends critically on the manufactured geometry[6-8]. This geometry can present deviations arising from the manufacturing