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Mechanical Behavior of Beta-Type Titanium Alloy Lattice Structures Fabricated by Additive Manufacturing

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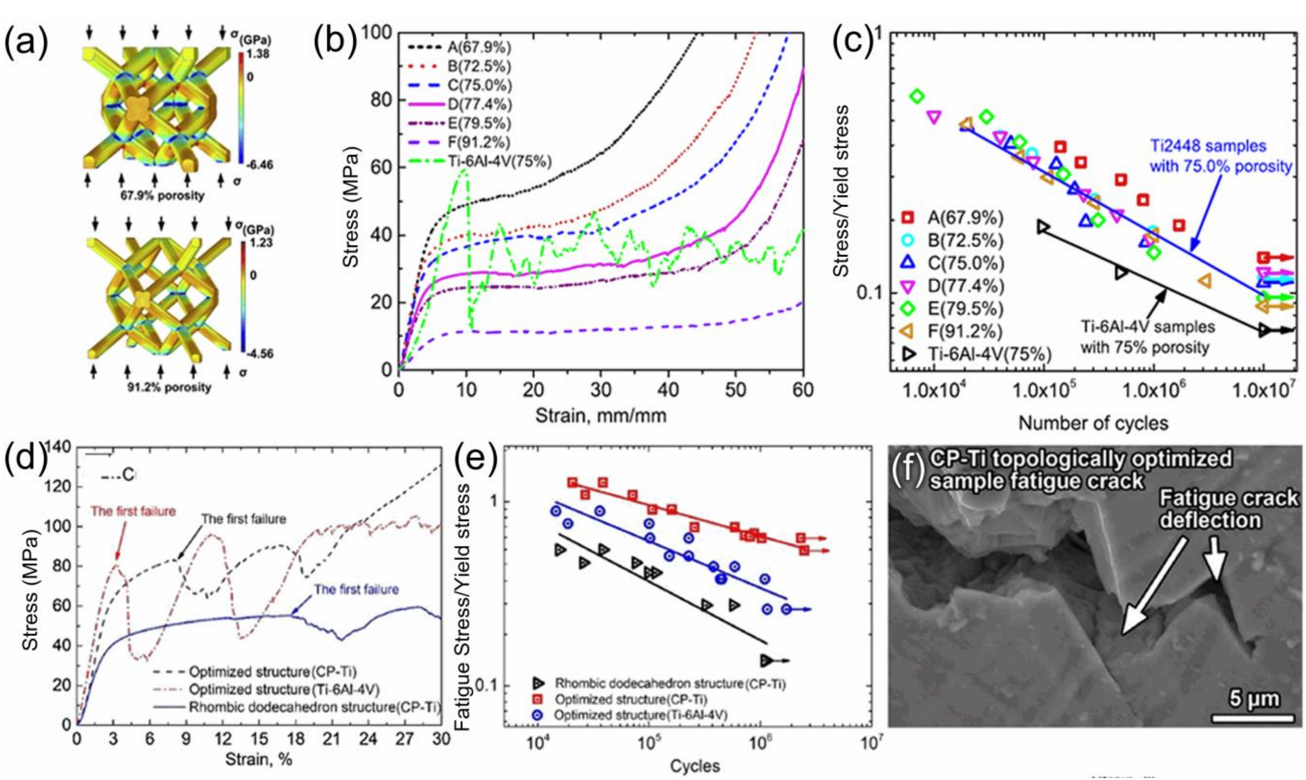
Graphical Abstract

The decreased porosity EBM (electron beam melting) produced beta-type Ti-24Nb-4Zr-8Sn lattice structures would increase the materials used (relative density) in a unit cell and therefore the strength of the lattice structure. For the identical porosity (75%), beta-type Ti-24Nb-4Zr-8Sn lattice structures exhibit higher compressive and fatigue strength compared with the (α+β)-type Ti-6Al-4V counterpart with the same porosity built from the same unit shape.



Abstract

Beta-type titanium porous structures are a new class of solution for implants because they offer excellent combination of high strength and low Young's modulus. This presentation studies the influence of porosity variation in 3D printing (via electron beam melting (EBM)-produced and selective laser melting (SLM)) produced beta-type titanium alloy samples on the mechanical properties including super-elastic property, Young's modulus, compression strength, energy absorption and fatigue properties. Compared with Ti-6Al-4V samples, the beta-type titanium porous samples exhibit a higher normalized fatigue strength owing to super-elastic property, greater plastic zone ahead of the fatigue crack tip and the crack deflection behaviour. Stress distribution results, obtained by finite element methods, coupled with the investigation of the slip bands generated have been used to reveal the plasticity mechanism and local stress concentrations for each structure. The topology optimized structure exhibits the best balance of bending and buckling stress with a high elastic energy absorption, a low Young's modulus and a high compression strength.

Keywords: Additive manufacturing; titanium alloys; lattice structure; mechanical behavior; mechanical properties.

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