

Study on Design, Fabrication and Properties of Biomedical Porous Titanium



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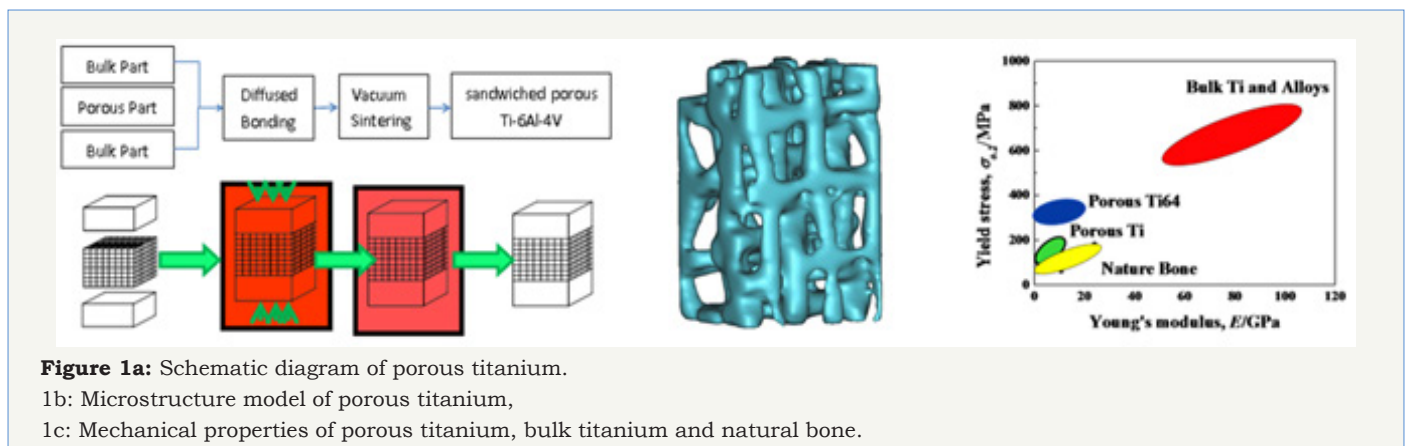
Mini Review

It has been shown that introducing porous structure in titanium and its alloys implant material is an effective way to reduce the “stress shielding” effect [1,2]. Interconnected pores in titanium and its alloys not only can decrease Young’s modulus through tailoring porosity but also can enhance bone ingrowth and improve fixation [3,4]. Therefore, design, fabrication, mechanical behavior and biocompatibility of porous titanium and its alloys have become a research focus in this field. Development of fabrication methods, together with studies of mechanical behavior and biocompatibility is beneficial to improve the performance of porous titanium and its alloys for implant applications.

First, effect of pore size, pore shape, pore topology and strut material on mechanical properties of porous titanium and its alloys has been studied by using computer simulation methods. The results show that porosity increases as the pore size increases from 200 μm to 500 μm , which also leads to the decrease in Young’s modulus and yield strength of porous titanium. Porous titanium with square pores has a low Young’s modulus and relatively high yield strength compared with the circle and hexagonal pores. Porous titanium has a good match of elastic modulus and high yield strength when pore topology is changed from regular array to staggered array. In addition, yield strength increases as the strut

material changed from CP-Ti to Ti-6Al-4V alloy. Therefore, Young’s modulus and yield stress of porous titanium and its alloys can be adjusted through designing pore size, pore shape, pore topological arrangement and strut material.

Based on the results of the above simulation, porous titanium is prepared by titanium mesh stacked-forced-sintering method (TMSS) [5]. Structure and mechanical properties of the prepared porous titanium are studied by tailoring pore structure parameters, strut material and process parameters [6,7]. The results show that porous titanium fabricated by TMSS has square pore structure. There are no cracks and inclusions on the strut. Mechanical behavior of porous titanium is anisotropic and sensitive to strain rate. The flow curves are smooth, stable and no obvious serration yield process. The strain for plastic platform region reaches up to 64%. It can obtain a fine match of low elastic modulus and high yield strength by regulating the pore topology at the same porosity [8]. Porous titanium prepared by Ti-6Al-4V alloys owns Young’s modulus and tensile strength in the range of 9.5~12.2GPa and 360~505MPa, respectively. Fatigue fracture intensity level is about 40MPa at the testing condition of $R = -1$, $f = 10\text{Hz}$ and $N = 5 \times 10^6$. Heat treatment has much more influence in the tensile stress but minor influence in the Young’s modulus [9] (Figure 1).



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