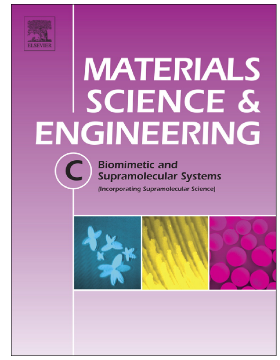

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Direct calciothermic reduction of porous calcium titanate to porous titanium

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ABSTRACT

A metallurgical material integration concept, using porous calcium titanate ($CaTiO_3$) as raw material, was put forward for preparation of metallic titanium powder and porous titanium by calciothermic reduction. Porous metallic titanium was prepared by calcium vapor reduction at 1273K for 6 h with two types of interconnected pores in titanium samples. The interconnected macropores about 50~300μm were inherited from porous $CaTiO_3$, and the micropores about 5~40μm were made by leaching removal of byproduct CaO in reduction products. Metallic porous titanium was fabricated in Ca-dissolved CaO-$CaCl_2$ molten salt mixtures by self-sintering and had a good interconnectivity inside with thickness about 155μm and the porosities of the porous titanium are 65-81%.

Keywords: Porous titanium; Calciothermic reduction; Titanium; Porous calcium titanate; Ca-dissolved CaO-$CaCl_2$ molten salt

1. Introduction

Titanium was first introduced into the medical field in 1940 with an article by Bothe, Beaton and Davenport [1].After B. Simancik adopted a method in which introduced pores into aluminium by adding mercury in the melt in 1943, investigation of porous materials has been actively paid much attention to [2]. With respect to the biomedical applications, the concept of using porous materials has been explored much later, one of the earlier ones reported to use porous metals for osseointegration is the work of Weber and White in 1972 [3]. Using porous structure for the purpose of fixing the skeletal by bone implant was investigated in the 1970s for the first time [4, 5]. At that time, instead of open porous structures, porous surface materials were extensively investigated as a way to achieve implant fixation [5, 6]. After that, porous titanium to which was used as biomaterial for medical applications was continuously paid attention due to its excellent mechanical properties, biocompatibility, high ratio of strength to weight as well as chemical stability [6-8], which can diminish the stress shielding phenomenon and enhance interfacial strength of the implant [9], and plenty of processes have been reported to fabricate porous titanium, comprehensively reviewed in past years [8, 10]. From morphology of products point of view, these processes can be distributed into two groups, namely open-cell and closed-cell.

In these methods, open porous titanium from titanium powder, the properties of pore walls are controlled by the bonding between the particles and their microstructure. Ultimately, the strength of the structure relies too much on the properties of pore walls [11]. Ample literature devoted to fabricate porous titanium is related to the space holder method. The pore size and shape can be determined by using this method to fabricate porous metal, having a potential to achieve good pore interconnectivity and uniformity [12-15]. Space holder method goes through some