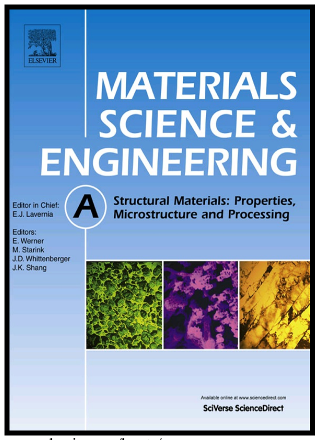

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Influence of microstructure on fatigue of biocompatible β-phase Ti-45Nb

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Abstract

Biocompatible β-phase Ti-45Nb (wt.%) alloy with a low elastic modulus of about 65 GPa has been proposed as suitable candidate for use in load bearing implants under fatigue conditions. In this work the influence of grain size on the mechanical properties and high cycle fatigue response of Ti-45Nb alloy has been studied. Severe plastic deformation was applied by using the high pressure torsion (HPT) technique in order to obtain an ultrafine grained (UFG) Ti-45Nb alloy with enhanced mechanical properties without increasing the elastic modulus. Due to limited size of the HPT processed samples, tensile and fatigue tests on the UFG and the initial conventional grained (CG) material were performed using small-scaled specimens and special testing set-up. Finite element simulations were conducted for calculation of the stress and strain conditions in the miniaturized samples subjected to dynamic loading. Grain refinement resulted in a mechanically stable structure with a considerable improvement of the tensile properties, however a significant improvement of the high cycle fatigue performance in comparison with the CG alloy was not observed. In order to explain this behavior, the changes in the nanohardness, subgrain size and dislocation density of the UFG material before and after SPD processing were evaluated and discussed. Microstructural investigations and fracture surface analyses were performed to gain information about the mechanisms of fatigue of the material at high cycle regime.

Keywords: β-phase Ti-45Nb Alloy, Ultrafine grained, biomaterial, high cycle fatigue, high pressure torsion

1. Introduction

Titanium alloys, stainless steels and Co-Cr alloys with biomechanical and biochemical compatibility are used for fabrication of a large variety of medical implants [1-3]. Especially α+β type titanium alloys such as Ti-6Al-4V with excellent combination of mechanical properties and biocompatibility have been recognized as suitable candidates for bone implants. Their Young's moduli (∼110 GPa) are, however, still greater comparing with that of the cortical bone (10-30 GPa) [4]. For structural