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Microstructural refinement influence on the Ti-45Nb alloy properties in physiological conditions

Uticaj usitnjavanja mikrostrukture na svojstva Ti-45Nb legure u fiziološkim uslovima

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Abstract

The high-pressure torsion (HPT) post-processing treatment influence on the grain refinement, corrosion behavior, and biocompatible properties of the Ti-45Nb (mass%) alloy, as a promising new hard-tissue replacement material, was investigated in the present study. The HPT-induced microstructural alterations were experimentally analyzed by electron backscatter diffraction (EBSD), transmission electron microscopy (TEM), x-ray diffraction (XRD), and Vickers microhardness measurements, while additional theoretical investigations on the ab initio level were conducted to fully investigate the HPT influence on the alloy microstructural properties. Results showed that significant microstructural refinement was achieved through the HPT processing while a change in alloy phase composition was not detected. In both, unrefined and refined, microstructures the β-Ti and Ti4Nb phases were identified and confirmed by the ab initio modeling results. The microstructural alterations effect on the alloy corrosion behavior in simulated physiological conditions was examined through the potentiodynamic polarization measurements. In vitro tests were conducted to determine the grain refinement influence on the investigated alloy and live cells interaction. Attained results indicated that the HPT treatment can be successfully applied to improve the Ti-45Nb alloy bio-corrosive performance through an increase of the alloy hardness, corrosion resistance, and live cells viability during the alloy-cells interaction.
Keywords: *Ti-45Nb alloy; structural investigations; grain size; bio-corrosion resistance.*

Izvod

Tokom prezentovanog istraživanja ispitan je uticaj postupka uvijanja pod visokim pritiskom (UVP) na rafinaciju zrna, koroziono ponašanje i biokompatibilna svojstva Ti-45Nb (mas.%) legure, kao potencijalnog materijala za izradu kostnih implanata. Mikrostrukturne promene, uslovljene primenom UVP postupka, analizirane su elektronskom difrakcijom, transmisionom elektronskom mikroskopijom, difrakcijom x-zraka i određivanjem mikrotvrdoće, dok su teorijska istraživanja na ab initio nivou izvršena u cilju potpunog ispitivanja uticaja UVP metode na mikrostrukturna svojstva legure. Primenom UVP postupka postignuto je značajno usitnjavanje mikrostrukture bez promene faznog sastava legure. U nerafinisanoj i rafinisanoj mikrostrukturi identifikovane su β-Ti i Ti4Nb faze, što su potvrdili i rezultati ab initio modelovanja. Uticaj promene mikrostrukturnih svojstava na korozionu postojanost legure u simuliranim fiziološkim uslovima ispitan je potenciodinamičkom metodom. Uticaj rafinacije zrna na potencijalnu interakciju implantne legure sa živim ćelijama ispitan je primenom in vitro metoda. Potvrđeno je da se UVP obrada može uspešno primeniti za poboljšanje bio-korozionog ponašanja Ti-45Nb legure kroz povećanje tvrdoće i korozione otpornosti legure, kao i vijabilnosti ćelija tokom interakcije legure sa živim ćelijama.
Ključne reči: *Ti-45Nb legura; strukturna ispitivanja; veličina zrna; bio-koroziona postojanost.*