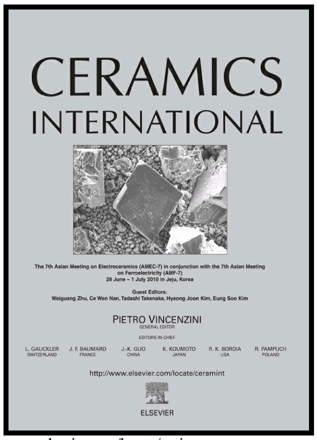

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J. Moradgholi, A. Monshi, K. Farmanesh

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An investigation in to the mechanical properties of CP Ti/TiO_2 nanocomposite ceramic manufactured by the accumulative roll bonding (ARB) process

J.Moradgholi[a*], A.Monshi[a], K.Farmanesh[b]

[a]Department of Materials Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran

[b]Department of Materials Engineering, Malek Ashtar University of Technology, Isfahan, Shahin-Shahr, Iran

Abstract

In this study, a commercially pure titanium (CP Ti) sheet was produced by the ARB process. Then, the mechanical properties of monolithic and nanocomposites specimens manufactured using 0.1, 0.3, and 0.5 wt.% TiO_2 nanoparticles as the reinforcement were investigated at different ARB cycles. The results showed improvement in the mechanical properties of specimens with the addition of TiO_2 nanoparticles, as their yield strength and ultimate tensile strength were increased by increasing the TiO_2 nanoparticles percent. In this regard, the ultimate tensile strength of the monolithic specimen reached to 810 MPa, while it was 980 MPa, 1040 MPa, and 1085 MPa after applying 8 ARB cycles for 0.1 wt.%, 0.3 wt.% and 0.5 wt.% nanocomposite specimens, respectively. However, the ultimate tensile strength of the as-received CP Ti sheet was 285 MPa. Moreover, the yield strength and the ultimate tensile strength were increased by increasing the number of ARB cycles and the total elongation; on the other hand, in the monolithic and nanocomposite specimens, it was decreased by increasing the number of ARB cycles. Grain refinements due to severe strain, work hardening and TiO_2 nanoparticles reinforcements were the main causes accounting for the improved mechanical properties. Recovery and dynamic recrystallization were two phenomena observed via TEM studies in the ARB process, leading to the development of equiaxed grains in the final ARB cycles.

Keywords: CP/Ti nanocomposite; mechanical properties; TiO_2 nanoparticles reinforcement; accumulative roll bonding (ARB).

Introduction

Titanium and its alloys are well-known materials with widespread applications. In the recent decade, the focus of studies on these strategic alloys has been on their mechanical properties [1–7], corrosion [8] and creep [9–11] behaviors.

Recently, severe plastic deformation (SPD) processes have been applied as powerful techniques for achieving high strength metals by mechanical working and grain refinements, as these methods allow manufacturing bulky metals to nanostructure bulky specimens. The objective of SPD techniques is to develop severe strains within the metals, resulting in detectable dislocation structures forming cells, subgrains and high-angle grain boundaries (HAGB) that cause progressive grain refinement [12]. Typical SPD techniques conventionally used include equal channel angular pressing (ECAP) [13–20], high-pressure torsion (HPT)[21–24] and accumulative roll bonding [25–31]. ARB process, which is the