Microstructure evolution and solid-state transformations of CP Ti and Ti-6Al-7Nb under high-pressure torsion (HPT)

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Severe plastic deformation (SPD) methods such as high-pressure torsion (HPT) have been shown to enhance the mechanical properties of bulk metallic materials, due to the significant refinement of the grain size of conventional pure metals and alloys down to a nanostructure [1,2]. In this research, microstructural modification of commercial purity (C.P.) Titanium and a Ti-6Al-7Nb alloy were accomplished by room temperature High-Pressure Torsion (HPT) at 6 GPa to produce a bulk nanostructure on discs of 10mm diameter and ~0.8mm thickness. Chemical composition analyses by Energy Dispersive Spectroscopy (EDS) were performed in both alloys prior to HPT processing, and phase analyses were performed by optical microscopy (OM) and scanning electron microscopy (SEM). After HPT, the samples were characterized by Vickers Microhardness measurements and X-Ray Diffraction (XRD) analyses, which showed that significant grain refinement was achieved, reflected on the XRD pattern as peak broadening of the fundamental phase peaks for both alloys, as well as an increase on the microhardness. Transmission electron microscopy (TEM) confirmed a grain size <100 nm after HPT for N=5 revolutions. The high pressure phase, ω-Ti has been observed during HPT processing of commercial purity Ti at pressures > 4 GPa [3] and in Ti-6Al-7Nb at 6 GPa [4]. The ω–Ti phase was detected on the XRD patterns for both the samples of C.P. Ti and Ti-6Al-7Nb as a result of the high pressure processing, which is not commonly found at room temperature, particularly for duplex Ti alloys such as Ti-6Al-7Nb, which is presumed to contribute significantly to the increase in microhardness.

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