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HRTEM analysis related to the microstructure of Ti6Al4V alloy biomaterial

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Abstract – Ti6Al4V alloy microstructure was investigated based on High Resolution Electron Microscopy (HRTEM) analysis to identify the structure components. The mechanical properties of the alloy show a strong dependence on the size and morphology of α and β phases present in the microstructure. Metallic biomaterials as titanium alloys are used for implants in living body.

The evaluation of the mechanical properties such as toughness, fatigue and wear resistance of titanium alloys used as biomaterial aiming to improve its production requires the analysis and characterization of the material microstructure. The microstructures in metallic structural biomaterials change according to the processing and heat treatment employed in their fabrication [1]. Increased use of titanium alloys as biomaterials is occurring due to their lower modulus, superior biocompatibility and enhanced corrosion resistance when compared to more conventional stainless steels and cobalt-based alloys. These attractive properties were a driving force for the early introduction of α (cp Ti) and α+β (Ti-6Al-4V) alloys as well as for the more recent development of new Ti-alloy compositions and orthopaedic metastable β titanium alloys [2]. In the present work the microstructure and nanostructure of the alloy is characterized by scanning electron microscopy (SEM), high-resolution transmission electron microscopy (HRTEM) and X-ray diffraction (XRD). Electron microscopy investigations are performed on plan-view and cross-section thin foils, prepared by conventional methods [3].

The as-received Ti-6Al-4V sample was submitted to thermal treatment (1000 °C/1 h and water quenched).

HRTEM micrograph in figure 1a shows a typical lamellar structure and dislocations present in the specimen and some evidence of fine grains can be seen in figure 1b. Figure 2 shows an interfacial dislocation pile up. The appearance of a fringe contrast trailing along the interface and dislocation lines was observed. The wavy appearance of those dislocation lines suggests that they were severely dragged during the quenching heat treatment, presumably by lattice imperfections such as solute atoms.

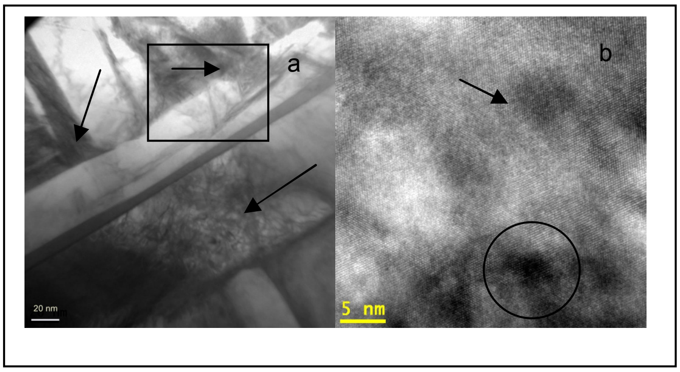

Figure 1: HRTEM images of the Ti6Al4V alloy show (a) typical lamellar structure and (b) fine grains present in the nanostructure.

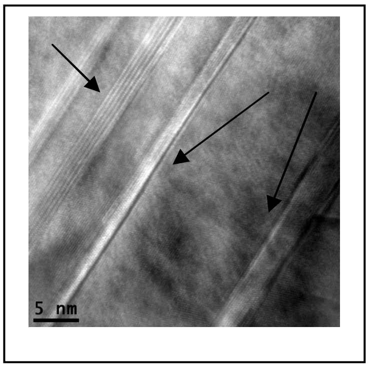

Figure 2: HRTEM image of the Ti6Al4V alloy showing the fringe contrast and dislocation lines.

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