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Phase Transformations during Aging Heat Treatments in Ti-30Nb alloy

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Abstract – Effects of aging heat treatment of Ti alloys were investigated. Ti alloy ingots were prepared, homogenized and hot-rolled. Samples were submitted to solubilization and water quenched (WQ). A subsequent two-step aging was performed and resulting microstructures were examined. Hardness testing was performed to evaluate hardness behavior. Orthorhombic martensite decomposition associated with ω phase (omega) precipitation was observed in short aging times by using Vickers microhardness measurements. In the second step of the heat treatment, kinetics of aging allowed the β phase transformation into α” during air quenching (AQ).

Biomedical β titanium alloys have interesting characteristics such as low elastic modulus (*E*), high corrosion resistance and superior biocompatibility. Aging heat treatments are an important way to improve mechanical properties and tailor microstructure and phase’s behavior of β Ti alloys [1-3]. Microstructure evolution during aging heat treatments of the β Ti-30Nb alloy was investigated.

Ti alloy ingots were melted using pure Ti (99.81%) and Nb (99.99%) in a non-consumable arc-melting furnace under argon protection, then sealed into quartz tube and homogenized at 1000°C for 8 h. Following, ingots were hot-rolled with a reduction of 80% in thickness. Samples with 15 X 15 X 1.5 mm were subjected to solution heat treatment at 1000°C for 1 h, followed by water quenching. A subsequent two-step aging was performed during periods of time of 1 min, 2 h and 4 h at 260°C and 1 min, 10 min, 20 min, 30 min, 1 h, 2 h, 4 h, 8 h, 12 h, 18 h and 24 h at 400°C, followed by air quenching (AQ). Microstructures were examined using transmission electron microscopy (Jeol JEM 2100) and X-ray diffraction (Panalytical X’Pert PRO). Vickers microhardness was measured through a Buehler 2100 equipment, with a load of 200 gf applied for 15 s to evaluate the mechanical response. Elastic modulus (E) was determined by ultrasonic methods by measuring longitudinal and transversal wave velocities by using pulser/receiver emission and piezoelectric transducer (10 MHz) (Panametrics).

Orthorhombic martensite decomposition associated with ω_{iso} phase precipitation was observed after short aging period of time at 260°C. In the second step of the aging heat treatment, at 400°C for 2 h, kinetics of aging process led to decrease of hardness and elastic modulus, as presented by Fig.1. That decrease was, probably, connected with the formation of softer phases, like α”. Results of X-ray diffraction confirmed such a formation. However, the amount of ω phase in the microstructure remained considerable, as shown in Fig.2. The formation of α” in aged structure may be due to partial transformation of the β → α” existing at 400°C upon AQ [4]. The results obtained allow one to conclude that aging heat treatment of Ti alloys is essential when control of mechanical behavior is necessary.

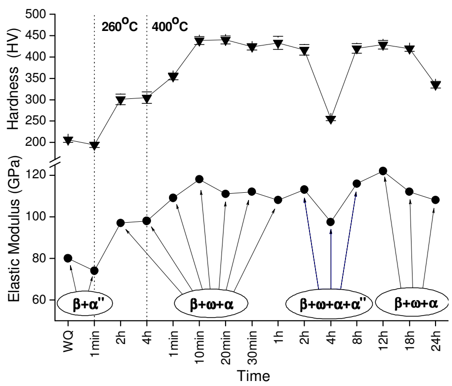

Figure 1: Vickers microhardness e elastic modulus behavior during two-step aging heat treatment.

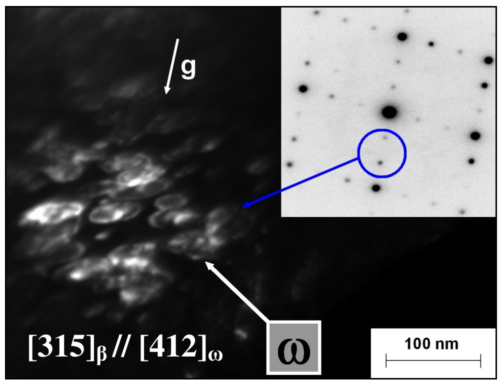

Figure 2: Dark field (DF) TEM of Ti-30Nb aged 400ºC/4h AQ.

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