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Annealing behavior of Ti-35Nb alloy deformed by cold rolling

A.O.F Hayama[1]*, J.F.S.C. Lopes[1] and R. Caram[1]

(1) DEMA, FEM, Universidade Estadual de Campinas, e-mail: alexandrah@fem.unicamp.br
* Corresponding author.

Abstract – This work describes the annealing behavior of Ti-35Nb alloy deformed by cold rolling followed by annealing. Vacuum annealing was performed at 600, 700 and 800°C during periods of time varying from 1 to 60 minutes. Microstructural characterization was performed in both cold rolled and annealed specimens using light optical microscopy (LOM), x-ray diffraction and Vickers hardness measurements. The results obtained show that shear bands are present in deformed state and there are recrystallized grains in these bands in annealed samples.

In the present work we report the main results of microstructural characterization of cold rolled and annealed β Ti-35Nb alloy to be applied in orthopedic implants. Application perspectives of titanium alloys in orthopedic implants and submitted to relatively high levels of mechanical stress show the existence of two main classes: α+β and β titanium alloys.[1] β titanium alloys present several advantages when compared to α+β alloys, including lower Young's modulus and can be produced with biocompatible metals as Ta, Nb, and Zr. These elements stabilize the β phase in titanium alloys and also improve their mechanical properties. Due to their interesting allotropic characteristics, titanium alloys can be processed by thermomechanical process, producing optimized microstructures in terms of type, morphology and distribution of phases.[2,3]

In this work, the starting material was obtained by electric arc melting, followed by solution heat treatment at 1000°C during 8 hours. The microstructure obtained is formed by β and orthorhombic martensite (α") phases. Samples were deformed by cold rolling to thickness reductions up to 85% and annealed at 600, 700 and 800°C during periods of time varying from 1 to 60 minutes. Using these temperatures and periods of time of annealing it was possible to obtain different fractions of grains recrystallized, allowing the study of the kinetics of recrystallization of this material.

The main results of the microstructural characterization of this alloy show the presence of shear bands in the deformed sample, as shown in Figure 1. These bands are deformation heterogeneities that tend to form an angle near to 35º with the rolling direction and they are preferential nucleation sites of the recrystallization, when the material is submitted to heat treatment after deformation. It was also observed that there is an orientation of the martensite phase in relation to the rolling direction. The softening behavior in annealed condition expressed by the hardness *versus* time isothermal plots (Figure 2) displays a classical behavior. It is noticeable that the material softens in a pronounced manner in the first 5 minutes; however, after 10 minutes hardness is leveled out remaining nearly unchanged for longer annealing times.

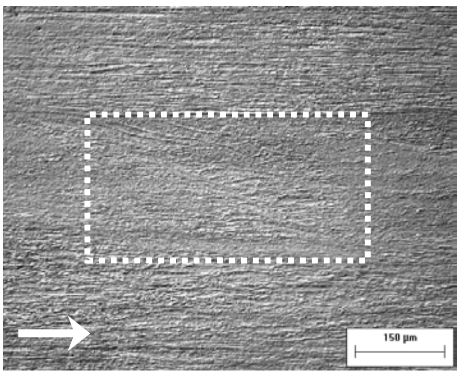

Figure 1. Micrograph showing the presence of a shear band in a sample cold rolled up to 85% (LOM, Nomarski contrast). The arrow indicates the rolling direction.

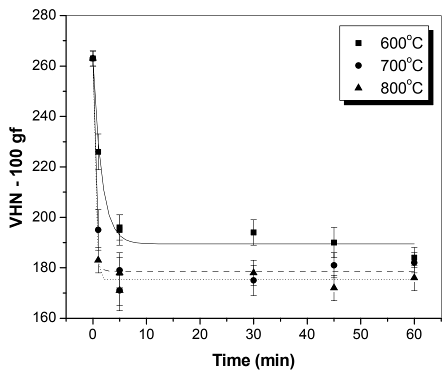

Figure 2. Softening kinetics for Ti-35Nb alloy deformed by cold rolling and annealed at 600, 700 and 800°C.

References

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