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Study of precipitation and recrystallization in Ti-Nb-Ta biomedical alloy during heat treatment

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Materials for bioapplications (especially beta-titanium alloys) are nowadays intensively studied because of increasing demand on implants and other surgical devices [1,2]. Beta titanium alloys moreover posses low Young's modulus which is very important to avoid stress shielding effect [3-5]. In this work the effect of heat treatment on microstructure of Ti-35Nb-6Ta beta-titanium alloy was studied. The alloy was prepared via powder metallurgy (cold isostatic pressing and sintering). As sintered specimens were hot forged, solution treated and subsequently cold swaged into wires of a 5 mm diameter. Cold swaged specimens were subjected to annealing for various periods (0.5; 1; 2; 4; 8 and 16 hours) at different temperatures (i.e. 500; 550; 600; 650 and 700°C). The changes in microstructure were studied by using transmission electron microscopy (TEM) and electron back scattered diffraction (EBSD).

Precipitation of α-Ti (hcp) phase occurred in all annealed specimens at temperatures used for annealing α-phase instead of ω-phase (usually precipitates at lower temperatures) precipitates [6,7]. Changes in size and morphology of these precipitates depending on annealing conditions can be observed. In general there are two types of precipitates in specimens annealed at lower temperatures. Almost equiaxed precipitates with diameter about 1 micrometer especially placed along grain boundaries (Fig.1). These precipitates were probably present in microstructure before annealing and coarsened during annealing. Finer needle like (with size of few hundreds nm) precipitates can be observed (Fig.2). These are inside grains and were formed during annealing. Their size increases with increasing annealing time and temperature.

After cold swaging the microstructure is highly deformed and EBSD measurements are quite difficult. The deformation is in general localized along grain boundaries and in these areas the image quality (IQ) of EBSD is poor – see Fig.3. Recrystallization processes take place during annealing, but the effect is strongly depended on temperature used for annealing. At temperatures 500 or 550°C no recrystallization can be observed. On the other hand recovery takes place, because the areas along grain boundaries where EBSD image quality pattern was poor decreased in comparison with cold swaged specimen. After annealing 600°C/8h newly formed grains can be observed in formely highly deformed areas. The fraction of recrystallized areas increases with increasing temperature and longer time it can be seen (Fig.4) that after annealing at 700°C the microstructure consist mainly of newly formed fine grains. On the other hand after 0,5h annealing at 700°C only few recrystallized grains are present. As mentioned above precipitation takes place along with recrystallization, but needle – like precipitates are present only in original grains, but not in newly formed fine grains.

1. M. Niinomi, M. Nakai, J. Hieda; Acta Biomaterialia; 8; 2012; p. 3888.
2. M. Geetha, A.K. Singh, R. Asokamani, A.K. Gogia; Progress in Materials science; 54; 2009; p. 397.
3. X. Zhao, M. Niinomi, M. Nakai, C. Myiamoto, T. Furuhara; Acta Biomaterialia; 7; 2011; p. 3230.
4. Y.L. Hao, S.J. Li, S.Y. Sun, R. Yang; Materials Science and Engineering A; 441; 2006; p. 112.
5. M. Niinomi; J. Artif Organs; 11; 2008; p. 105.
6. J.I. Qazi, B. Marquardt, L. F. Allard, H.J. Rack; Materials Science and Engineering C; 25; 2005; p. 389.
7. Y. L. Zhou, M. Niinomi; Journal of Alloys and compounds; 466; 2008; p. 535.

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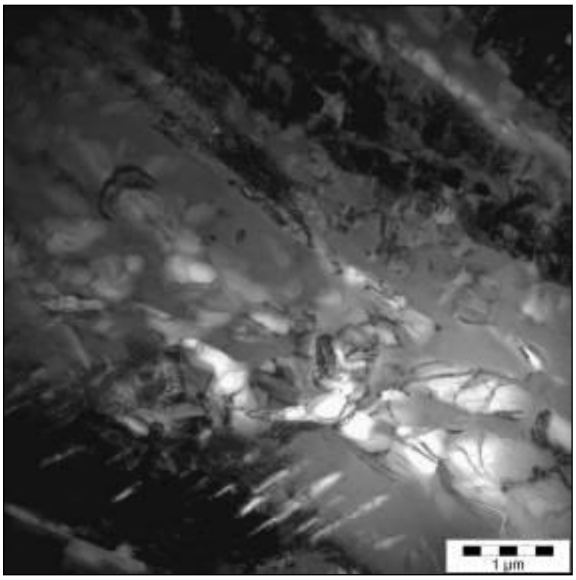

Figure 1: TEM image of coarse α-precipitates in specimen annealed at 600°C for 8 hours

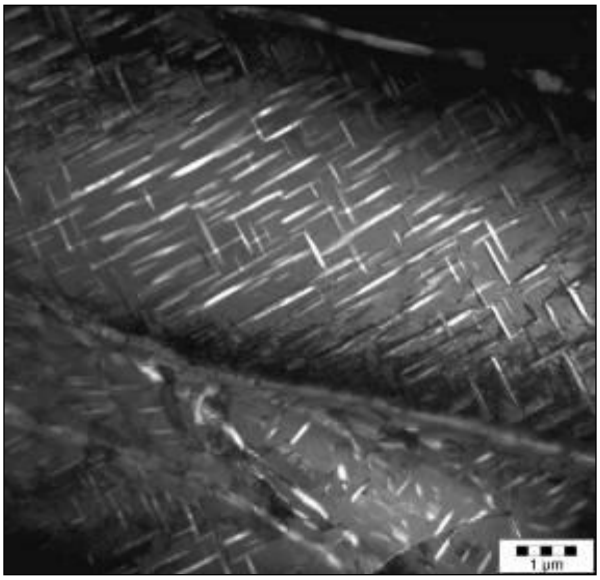

Figure 2: TEM image of fine needle-like α-precipitates in specimen annealed at 600°C for 8 hours

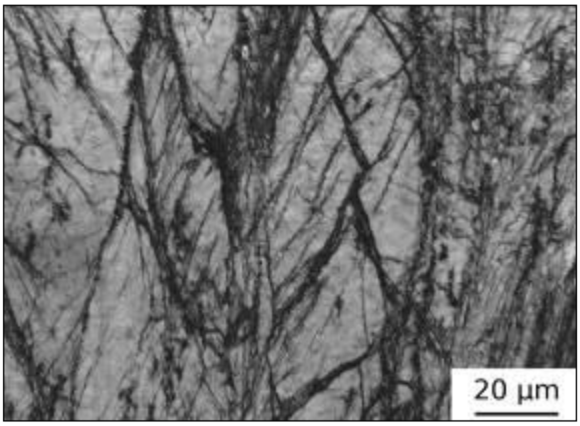

Figure 3. Map of Kikuchi band contrast (image quality) in cold swaged specimen

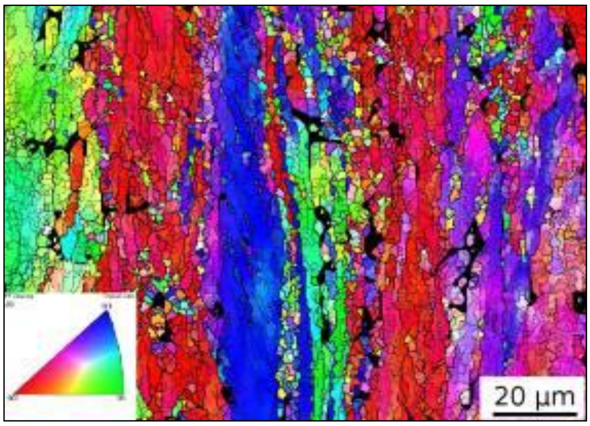

Figure 4: Inverse pole figure map of specimen annealed at 700°C for 4 hours