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Report:

Experimental data and results have been published in the Thesis work citing:

Thönnessen, Lisa, *Influence of heat treatment parameters on phase transformations in the near-beta titanium alloy Ti-1Al-8V-5Fe*, Doctor of Philosophy thesis, School of Mechanical, Materials, Mechatronic and Biomedical Engineering, University of Wollongong, 2017. http://ro.uow.edu.au/theses1/153

Abstract

This research aims to combine in-situ diffraction techniques with transmission electron microscopy to answer open questions with respect to phase transformations in near-β titanium alloys. The exact mechanism of the β- to ω-phase transformation was determined in a Ti-1Al-8V-5Fe alloy. Specific attention was paid to the role the ω-phase plays in subsequent α-phase precipitation.

Specimens were heated to α-precipitation temperatures between 763 and 823 K at rates of 1 to 100 K/min in-situ in high-energy X-ray, neutron and electron diffraction facilities. In addition, an isothermal holding time at 623 K was imposed in some experiments. These in-situ techniques provided insights into the exact sequence of phase transformations as well as the kinetics of transformation as influenced by the selected heat treatments. Selected specimens were prepared for ex-situ electron microscopy investigations, which shed further light on the mechanisms of the pertaining phase transformation at atomic level.

These investigations revealed that the extent of solute diffusion plays a major role in determining the phase transformation sequence and hence, α-nucleation kinetics and morphology.

Experimental conditions that promote a high degree of solute diffusion, such as heating rates of less than 5 K/min or holding at 623 K, lead to full β- to ω-phase transition. The ω-phase precipitates as small, homogeneously distributed particles and of hexagonal crystal structure. Such a microstructure provides the ideal conditions for α-phase formation at elevated temperatures by enhancing α-phase nucleation kinetics. Under these conditions α-phase nucleation will initiate below 700 K. The α-precipitates nucleate on ω-

precipitates and grow to consume them, thereby producing a microstructure that consists of fine α-precipitates, homogeneously distributed through the β-matrix and of a composition close to equilibrium.

Conversely, heating cycles that significantly limit the extent of solute diffusion, such as heating at a rate of 100 K/min, lead to incomplete β- to ω-phase transition. In this instance the ω-phase precipitates are not of hexagonal crystal structure and in addition, only a small fraction of these ω-precipitates form. Such heat treatments lead to a delay in the subsequent α-phase precipitation kinetics, to the extent that α- phase nucleation only occurs at 823 K. The primary α-precipitates formed under these conditions are coarse, but small secondary α-precipitates also form and hence, an inhomogeneous microstructure results.

The improved understanding of microstructural development, specifically the link between thermo-mechanical parameters and the resulting microstructure of a Ti-1Al- 8V-5Fe alloy, gained through this study should lead to an improved ability to tailor the mechanical properties of products in industrial practice. The findings outlined in this thesis contribute to a better understanding of the scientific principles underpinning the phase transformation mechanisms in near-β titanium alloys. Moreover, in addition to making a contribution to science it is envisaged that a better foundation for an improved design of products manufactures from Ti-10V-2Fe-3Al and related alloys have been laid.

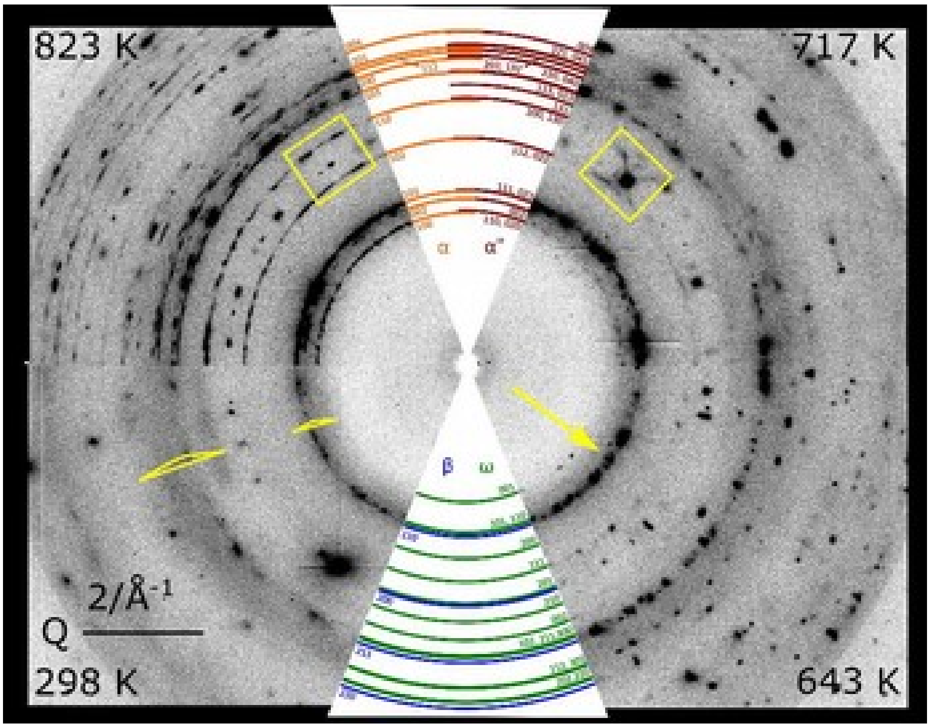

Figure 1: Experimental high-energy X-ray diffraction data compiled at various temperatures. The morphology of the rings is evaluated, revealing orienation correlationship upon transformation, particularly emphasized in the encadred areas. (Figure 36 of Thesis)

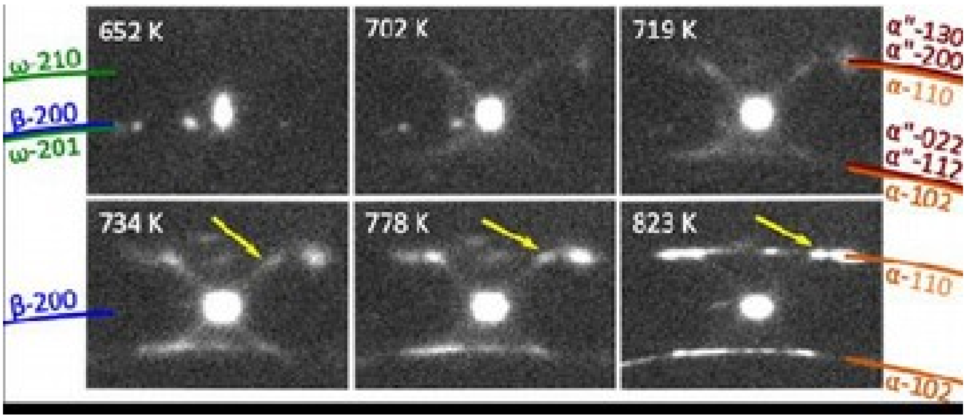

Figure 2: Emphasized areas from Figure 1. Diffuse streaks evolve upon the phase transformation, revealing its mechanism and orientation correlation. (Figure 38 of Thesis)