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Three-Dimensional Reconstruction of Alpha Laths in α/β Titanium Alloys by Serial Sectioning with a FEI NOVA

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Titanium alloys have a wide range of applications in industry, and thermo-mechanical processing of these alloys significantly influences their microstructure and mechanical properties. In order to develop accurate, predictive models a three-dimensional understanding of the microstructure is necessary, however the microstructure is complex and involves features spanning a wide range of scales. One such microstructural feature that has been identified as impacting mechanical properties is alpha lath aspect ratio obtained from two-dimensional SEM images[1]. Due to the complex nature of titanium microstructure two-dimensional images provide very limited information regarding the three-dimensional nature of the microstructure. In order to gain a better understanding and accurately quantify the complex microstructures found in titanium alloys a FEI NOVA microscope was used to serial section through alpha laths for digital reconstruction.

The serial sectioning procedure provides the process for acquiring digital images of the microstructures at successive depths into the material. For this research, a FEI/Philips NOVA Focused Ion Beam was used in conjunction with Slice and View™ software. The specimen was an alpha/beta titanium alloy that was heat treated to produce □n alphạlath structure within a □eta matrix. The ion beam was used normal to the specimen surface to mill out a protruding rectangle from the bulk material so as to provide for fast removal of material and optimum imaging conditions during serial sectioning. The imaging surface of the rectangle is tilted 38° from the vertical axis of the electron column. The milled surface was then imaged using the SFEG SEM column in backscattered mode, at a scan rate of 160 seconds, to provide an image with optimal contrast between the alpha/beta microstructure and reduce noise content in the digital image. After each successive slice, a backscattered image was taken to produce a serial sectioning data set of images The previous version of FEI DBFIB in conjunction with Slice and View™ was only able to section through 8 μm of material at 50 nm slices, which made sectioning through various alpha laths virtually impossible due to their size. The emergence of the NOVA has made it possible to section though much larger sections which in turn has allowed serial sectioning through complete alpha laths.

It is also possible to store data from additional detectors including an orientation imaging detector that scans the surface to provide crystallographic information and an EDS detector that can provide chemical analysis. The orientation imaging may be indexed for each layer of material and then recombined to provide a three dimensional mapping of the texture within the sample as well. The resulting digital images from the backscatter detector were processed using Photoshop version 7.0 and Fovea Pro to provide thresholded images with clearly defined □lphạanḍ□etạregions. The program IMOD, from University of Colorado-Boulder, was used to cross-correlate and align the images from the acquisition process and also to reconstruct the microstructure such that rendered surfaces produced a three dimensional reconstruction of the alpha laths for visualization and analysis[2].

References

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[2] Kremer J.R., D.N. Mastronarde and J.R. McIntosh, J. Struct. Biol. 116 (1996) 71-76.
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