Static Method of 3D EBSD Analysis of Ti64 Alloy

In this example a microstructure of the Ti-6Al-4V (Ti64) alloy prepared by direct metal deposition is studied by the three-dimensional electron backscattered diffraction (3D EBSD) technique using a focused ion beam equipped scanning electron microscope (FIB-SEM). An innovative static position 3D EBSD configuration was used for the acquisition.

Introduction

Novel techniques of net shape fabrication are low cost alternatives to the traditional Ti alloy preparation methods (casting+machining) see e.g. [1]. A process similar to 3D printer is used for fabrication of components from powder or rod substrates, avoiding the machining process.

A shaped metal deposition or electron beam freeform fabrication are examples of fabrication possibilities for small quantity production of components with complex shape see example in figure 1.

However, the microstructure and thus also mechanical properties may differ. Especially the porosity and anisotropy has to be studied carefully, as shown in [3].

The 3D EBSD analysis for precise description of the microstructure, phase distribution and grain formation in the material after annealing was introduced in [4].

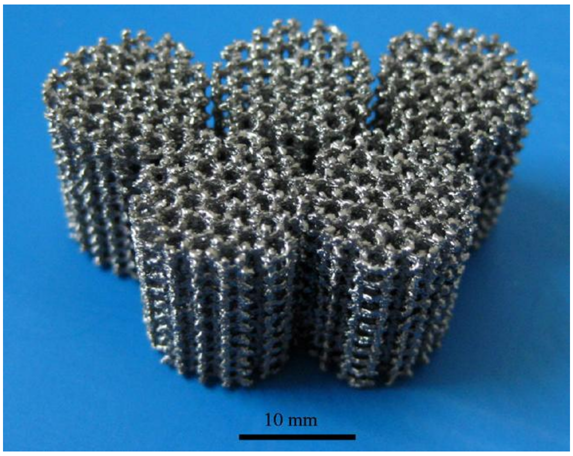

Fig. 1: Honeycomb-like structure with controlled porosity for biomedical applications, prepared by direct metal deposition of Ti64. [2]

3D EBSD

The 3D EBSD is one of the possible techniques from a broad range of FIB-SEM tomography techniques.

The repeated process of FIB cross sectioning is followed by orientation mapping by EBSD (2D) creating a three-dimensional orientation dataset of the selected volume – the 3D EBSD. An example of a 2D EBSD map on a cross section is shown in figure 2.

The conventional approach of 3D EBSD acquisition is using a sample movement between the FIB milling and EBSD acquisition position. This method has several serious drawbacks regarding the speed and precision of data acquisition process [5].

TESCAN FIB-SEM offers a *static setup* of 3D EBSD based on a special EBSD camera configuration developed within the FIBLYS project [6]. This configuration of the EBSD camera allows simultaneous EBSD acquisition and FIB milling in static sample position.

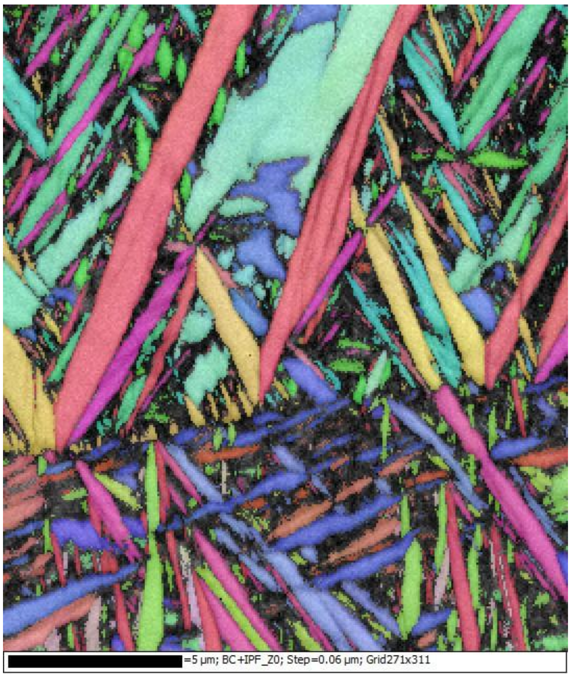

Fig. 2: 2D EBSD orientation map of the Ti64 microstructure.

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Application Example

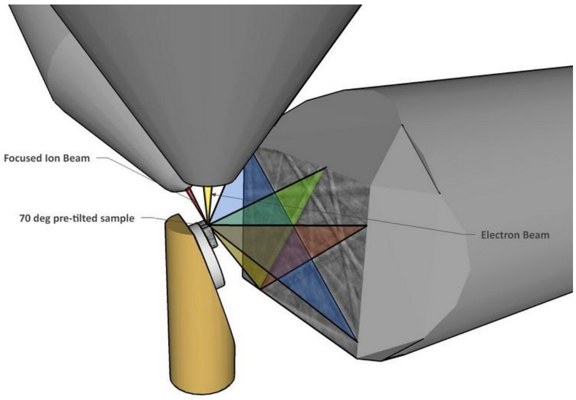

Fig. 3: Static position 3D EBSD configuration on TESCAN FIB-SEM

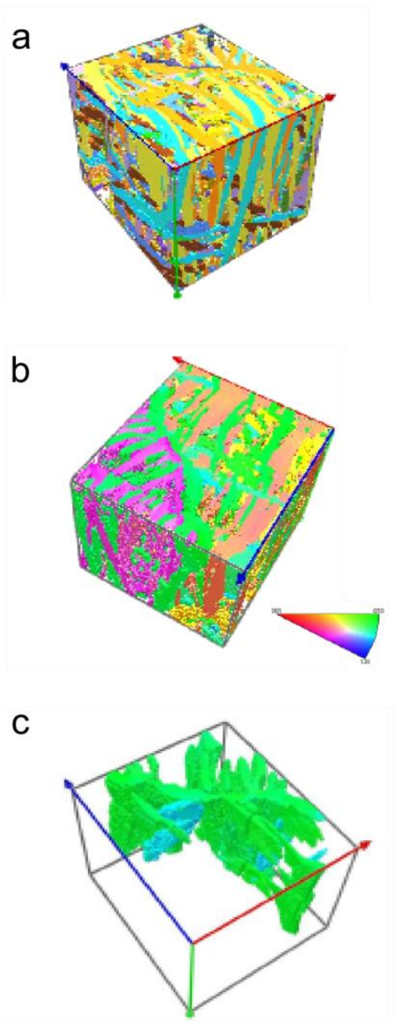

Fig. 4 3D EBSD visualization after post processing in **a)** Euler angles as RGB color, **b)** inverse pole figure (IPF-Z) with color legend, **c)** visualization of a single grain after grain segmentation using misoreintation limit > 2 deg.

Static 3D EBSD Method

The key idea of the "static 3D EBSD" approach was proposed and also firstly realized within the FIBLYS project [5]. This static set-up allows acquisition of 3D EBSD without sample movement during the whole acquisition process. The configuration is shown schematically in figure 3.

There are several advantages of the static configuration against the conventional movable 3D EBSD setups:

- **Highest possible acquisition accuracy**
  – no correction for stage inaccuracies required (tilt, rotation, shift).
- **Highest possible acquisition speed**
  – no stage movement time.
- **Highest possible EBSD resolution**
  – EBSD can be as close as possible to the sample without risk of screen damage during the sample movement.
- **Easy process setup**

Experiment and Results

The acquisition was done on a LYRA 3 FIB-SEM equipped with Oxford Instruments EBSD NordlysNano.
The post processing and visualization of the acquired 3D EBSD dataset done using Oxford Instruments 3D Viewer.

Acknowledgements

This experiment was realized in cooperation between TESCAN and Oxford Instruments application laboratories.

References

[1] G.P. Dinda, L. Song, and J. Mazumder, Fabrication of Ti-6Al-4V Scaffolds by Direct Metal Deposition, Metallurgical and Materials Transactions A, vol. 39A,Springer 2008, p. 2914-2922,

[2] Xiang Li, Chengtao Wang, Wenguang Zhang, Yuanchao Li, (2010) "Fabrication and compressive properties of Ti6Al4V implant with honeycomb-like structure for biomedical applications", Rapid Prototyping Journal, Vol. 16 Iss: 1, pp.44 - 49

[3] B. Baufeld and O. Biest, "Mechanical properties of Ti-6Al-4V specimens produced by shaped metal deposition", Sci. Technol. Adv. Mater. 10 (2009)

[4] R. E. A. Williams, M. Uchic, D. Dimiduk and H. L. Fraser (2005). Three-Dimensional Reconstruction of Alpha Laths in Alpha/beta Titanium Alloys …, Microscopy and Microanalysis, 11 (Suppl. 02) , pp 836-837.

[5] S. Zaefferer, "3-Dimensional Orientation microscopy Using FIB-EBSD Tomography: An overview on Techniques, Applications and limits", Book of abstracts p. 123-136, EMAS Workshop 2009

[6] Description of a new 3D EBSD method without the additional sample movement, FIBLYS - Building an Analyzing Focused Ion Beam (FIB) for Nanotechnology, 2009, www.fiblys.eu