3D grain mapping by X-ray diffraction contrast tomography

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X-ray diffraction contrast tomography (DCT) [1,2,3] combines the principles of X-ray diffraction imaging, three-dimensional X-ray diffraction microscopy (3DXRD) and image reconstruction from projections. DCT provides simultaneous access to 3D grain shape, crystallographic orientation and local attenuation coefficient distribution. The technique applies to plastically undeformed, polycrystalline mono-phase materials, fulfilling some conditions on grain size and texture. The straightforward combination with high-resolution microtomography opens interesting new possibilities for the observation of microstructure related damage and deformation mechanisms in these materials [4]. The analysis of Friedel pairs of diffraction spots (hkl and -h-k-l reflections, observed 180° apart in rotation) increases the accuracy with which the diffraction vectors are determined and allows the use of improved algorithms for grain indexing and 3D shape reconstruction. The accuracy of the resulting grain maps is quantified with reference to synchrotron microtomography data for a specimen made from a beta titanium alloy in which a second phase can be precipitated at grain boundaries, thereby revealing the grain shapes in phase sensitive tomographic imaging mode.

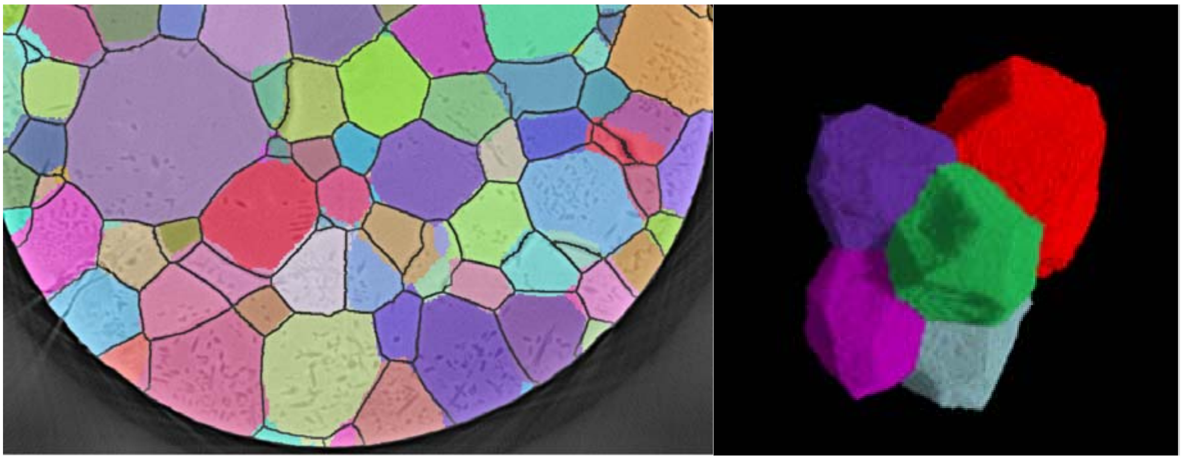

Figure 1 a) Overlay of grain reconstruction in Ti alloy (TIMET β21S) produced by DCT (coloured outlines) with the real microstructure as determined from phase contrast tomography (black lines) b) 3D rendition of a small grain cluster (DCT data).

References

[1] W. Ludwig, S. Schmidt, E.M. Lauridsen, H.F. Poulsen, J. Appl. Cryst. 41, 302-309 (2008).
[2] G. Johnson, A. King, M.G. Honnicke, J. Marrow, W. Ludwig, J. Appl. Cryst. 41, 310-318 (2008).
[3] W. Ludwig, P. Reischig, A. King, M. Herbig, E.M. Lauridsen, T.J. Marrow, J.Y. Buffière, Rev. Sci. Instrum., accepted
[4] A. King, G. Johnson, D. Engelberg, W. Ludwig, J. Marrow, Science 321, 382-385 (2008).