

Nondestructive Materials Characterization in 3D by Laboratory Diffraction Contrast Tomography – Applications and Future Directions

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The majority of metallic and ceramic engineering materials of interest are polycrystalline. The properties of these materials can be significantly affected by behaviour at the length scale of the crystalline grain structure. The ability to characterise this crystallographic microstructure, non-destructively and in three-dimensions, is thus a powerful tool for understanding many facets of materials performance.

The introduction of diffraction contrast tomography as an additional imaging modality on the ZEISS Xradia Versa laboratory X-ray microscope has opened up a whole new range of possibilities for studies of the effect of 3D crystallography on materials performance. The non-destructive 3D crystallographic imaging capabilities of the laboratory diffraction contrast tomography technique (LabDCT) [1, 2], complements the structural data obtained by traditional absorption-based tomography and together they provide an unprecedented insight into materials structure [3].

Here we will present a selection of results of LabDCT with particularly emphasis on its non-destructive operation, demonstrated through 4D evolutionary studies obtained by repeating the imaging procedure numerous times on the same sample. We will discuss the boundary conditions of the current implementation, point to the future of the technique and discuss ways in which this can be correlatively coupled to related techniques for a better understanding of materials structure evolution in 3D.

References:

- [1] McDonald, S.A. *et al.* Non-destructive mapping of grain orientations in 3D by laboratory X-ray microscopy. *Scientific Reports* **5**, 14665 (2015). doi: [10.1038/srep14665](https://doi.org/10.1038/srep14665)
- [2] Feser, M., Holzner, C. & Lauridsen, E.M. US Patent 9,110,004 (2012).
- [3] Technology Note, *Contrast with Submicron 3D X-ray Imaging for Difficult to Image Materials* (Pleasanton, CA: Carl Zeiss X-ray Microscopy [2015]) link to: http://pages.zeiss.com/rs/270-LXH-014/images/TechNote_Contrast_digital.pdf

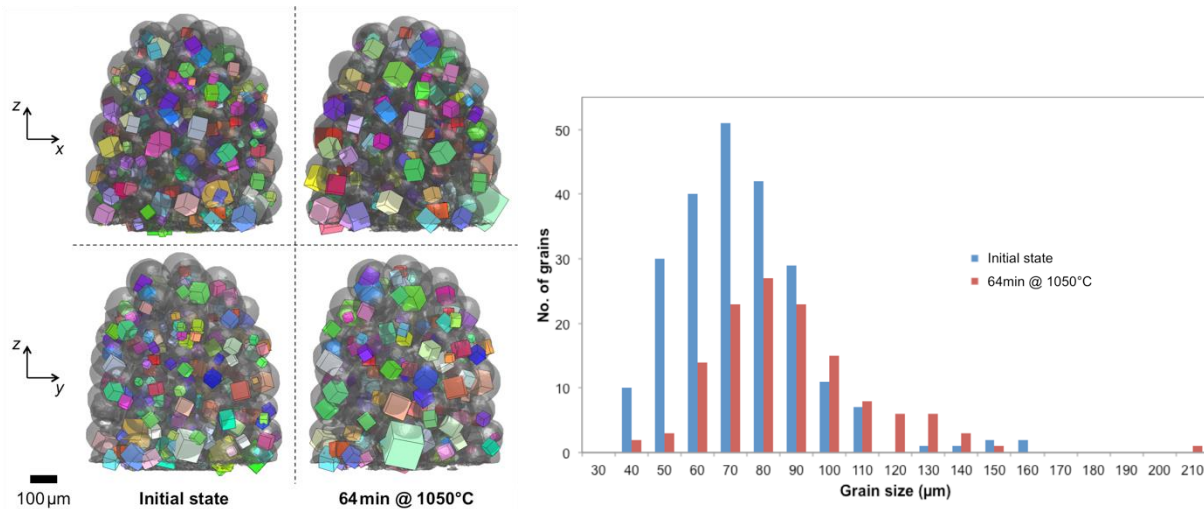


Figure 1. Left: Reconstructed grain maps from two different time steps of a sintering experiment with Cu. The grains are plotted as cubes at their measured positions within the absorption mask of the sample, which is shown transparent, revealing their (relative) size and crystallographic orientation (by color). Right : Comparing the grain size distributions for the two time steps.