Advances in Diffraction Tomography: deep sub-micrometer resolution

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Introduction and Objectives

Performances and physical properties of high technology materials are influenced or even determined by their initial microstructure and by the behaviour of impurity phases. To characterize these impurities and understand their relations with the surrounding matrix, non-destructive techniques have to be used. Diffraction Tomography is a recent and powerful tool to analyze the 3D crystallographic composition of materials [1-3]. This technique was previously limited to samples giving a powder diffraction signal and had problems with coarse grained materials. Our developments overcame the granularity problem in order to reach sub-micron resolution when using an X-ray nanoprobe for diffraction tomography [4].

Results and Discussion

The sample was a powder composed of U-Mo alloy particles (about 25 µm in diameter) surrounded by a UO_2 protective layer [5]. A particle core is made up of several U-Mo alloy grains with an average diameter smaller than 3 µm. This core is covered by a 1 µm thick UO_2 protective layer (grains size ~10 nm). The grain map for a 2D slice of the particle is shown Fig. 1. Due to the high resolution of this technique, a minority U(C,O) phase (1 wt. %) with sub-micrometer sized grains was characterized inside the particle. The onset of U(C,O) grain crystallization can be described by a precipitation mechanism since a single U-Mo grain has direct orientation relationship with more than one of the surrounding U(C,O) grains.

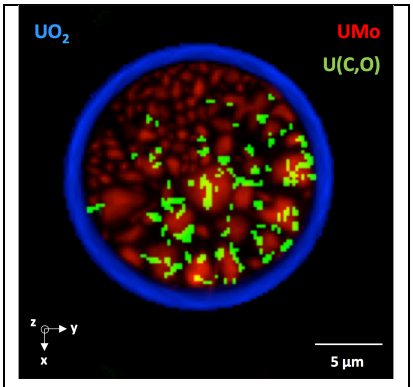

Fig.1: High resolution diffraction tomography slice of a U-Mo atomized particle.

Conclusions

Due to advanced reconstruction techniques and an adapted acquisition scheme, XRD-CT can now provide both powder diffraction and single crystal type X-ray structure analyses combined with tomographic imaging.

References

[1] Bleuet, P., Welcomme, E., Dooryhée, E., Susini, J., Hodeau, J.-L., Walter, P. Nature Mat. 2008, 468–473.

[2] Palancher H., Tucoulou R., Bleuet P., Bonnin A. and Cloetens P. Journal of Applied Crystallography, 2011, 44, 1111–1119.

[3] Poulsen H.F, Springer, 2004.

[4] Bonnin A., Wright J., Tucoulou R. and Palancher H. (2014) APL 105, 084103.

[5] Palancher H., Bonnin A., Honkimäki V., Cloetens P., Suhonnen H., Zweifel T. *et al.* (2012) J. Appl. Cryst. 45, 906–913.