

# X-RAY DIFFRACTION NANO-TOMOGRAPHY: APPLICATION TO THE LOW ENRICHED NUCLEAR FUELS.

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Material Test Reactors (MTR), in particular the highest power ones, currently use a fuel type whose <sup>235</sup>U enrichment can reach 93%. To comply with the international treaty of non-proliferation - which calls for an enrichment below 20 at % - a new low-enriched uranium fuel (LEU) must be developed. To compensate the decrease in enrichment, high-density uranium fuels have been proposed by different teams: the most promising of them is based on an uranium-molybdenum alloy. This fuel is a plate, in which the fissile phase is pressed by hot rolling between two sheets of aluminium that act as cladding. UMo fuel elements usually consist of UMo particles (15 to 120 microns in average diameter) dispersed in an aluminium matrix (cf Fig.1).

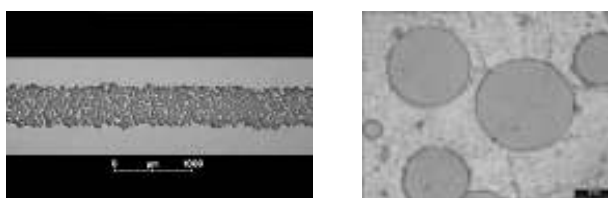


Figure 1. UMo atomized powder dispersed in an aluminium matrix.

However their in-pile behaviour has not been totally satisfactory during a long time because of the growth under irradiation of a large Interaction Layer (IL) at the UMo/Al interface, leading to a degradation of the fuel plate. UMo fuel development is thus now essentially geared towards stabilizing and minimizing (or avoiding) this interaction. One remedy consists in slightly modifying the composition of the Al matrix by adding limited concentration of Si to the Al: the size of the IL has been significantly reduced. This solution is now under validation for the low and intermediate power reactors and needs further optimisation for the most powerful ones (such as the Jules Horowitz reactor in Cadarache).

In parallel with the development of UMo/Al-Si nuclear fuels, the growth mechanisms of the UMo/Al IL have to be studied. For simulating the influence of the in-pile irradiation or manufacturing conditions, thermal annealing methods are usually performed. A method using high energy X-ray beams has been developed to identify the components of this IL at a macroscopic scale [1], but local analyses combining diffraction and 3D imaging techniques have to be undertaken for better describing this IL growth and its thickness (estimated below 2  $\mu\text{m}$ ).

We report in this paper the first attempts to perform X-ray diffraction computed tomography (XRD-CT) measurements [2-4] on the ID22NI hard X-ray nanoprobe of the ESRF with a beam size of 150 $\times$ 220 nm [5]. The studied sample is a small spherical (about 50  $\mu\text{m}$  in diameter) annealed UMo particle. A multiphases interface buried about 5  $\mu\text{m}$  under the surface has been especially characterized [6]. Moreover the interest of the Rietveld method for analyzing the XRD-CT data is evaluated and the possibility to derive from such an approach the weight fraction of the various phases inside each voxel is discussed. Finally, the advances provided by this experiment on our understanding of the UMo/Al system are presented.

## References

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