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European Commission

Self-irradiation effects in UO_2 and $(\text{U,Pu})\text{O}_2$ accelerated by doping with ^{238}Pu

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Context

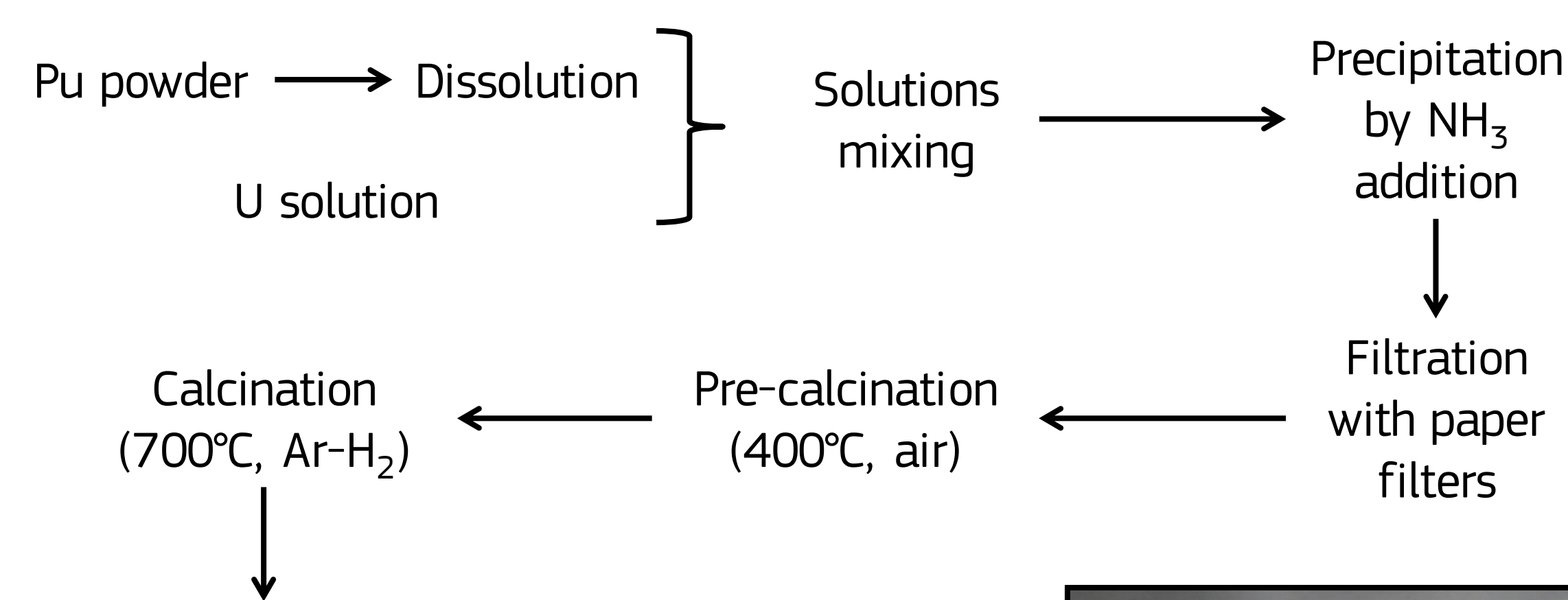
In order to tackle the issue of long term sustainability and safety of nuclear waste management, the new concept of Gen IV fast reactors (FR) has been designed. These new reactor types however require the design and development of completely new materials, including new nuclear fuels (NF), which will be also the component withstanding the most severe irradiation and temperature conditions. The present work aims at improving our knowledge about the behaviour of mixed oxides (MOX) fuels, which represent a crucial step towards the licensing process of those reactors. In particular, the focus of this work is on isolating and quantifying the effect of alpha-radiation damage on the thermal and physical properties of MOX fuels.

Experiment

- $(\text{U},^{238}\text{Pu})\text{O}_2$ samples prepared to study the effect of uniform α -radiation damage on the MOX fuel matrix
- Extensive characterisation of the as-sintered material
- Periodic monitoring of the evolution of the samples properties
- Two compositions chosen, to study a broad dpa range and the effect of radiation damage kinetics

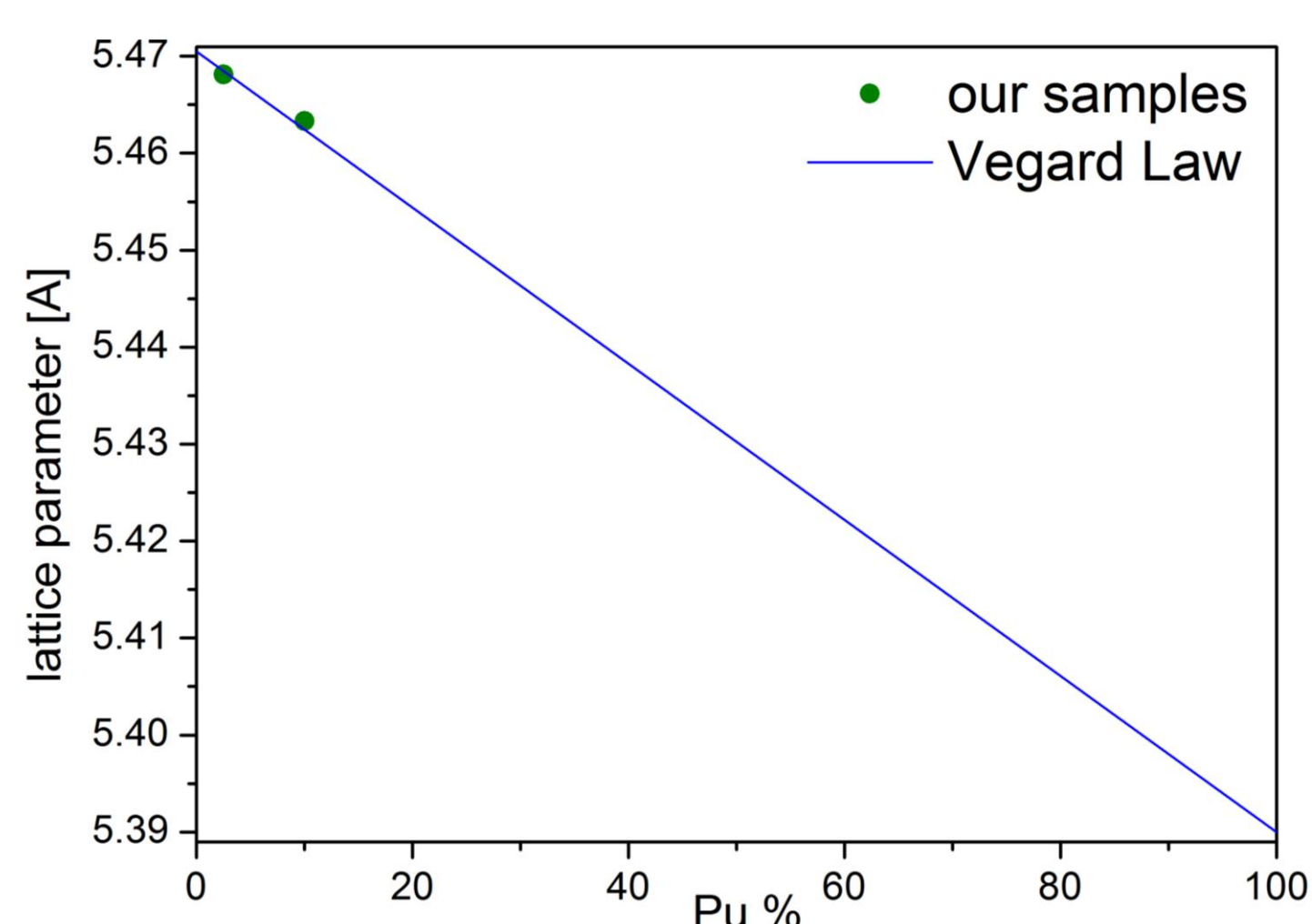
Samples preparation

Powder synthesis:

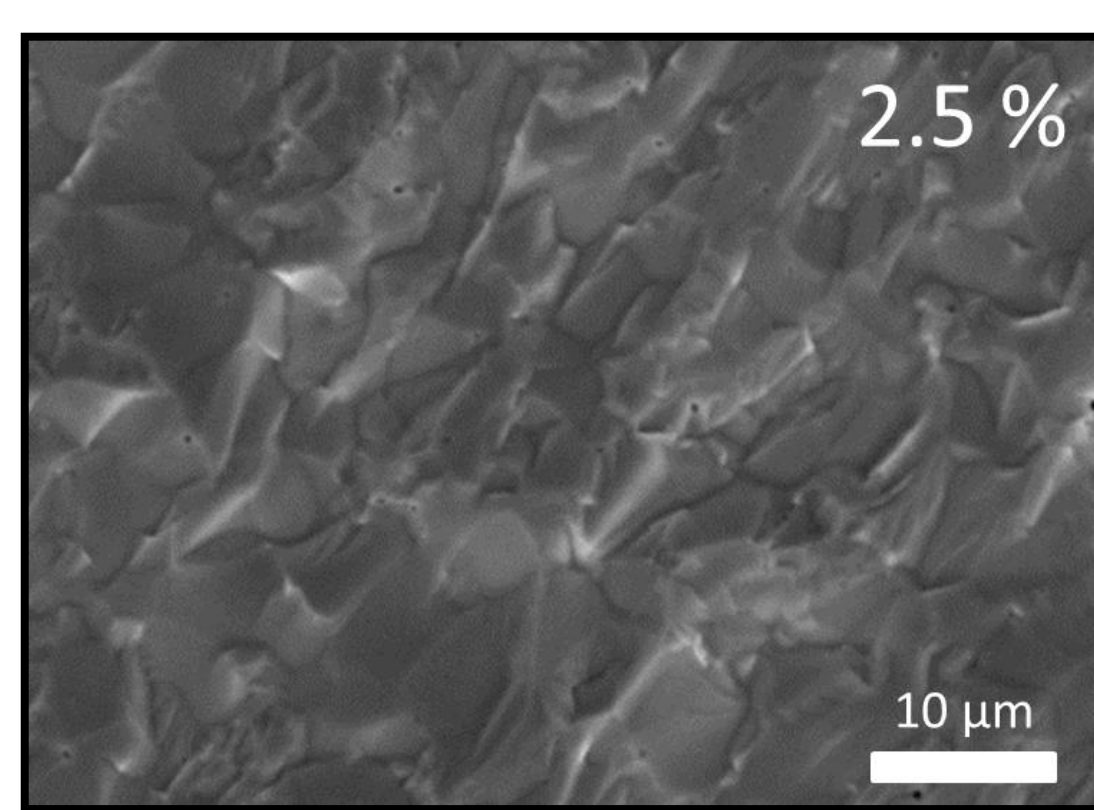
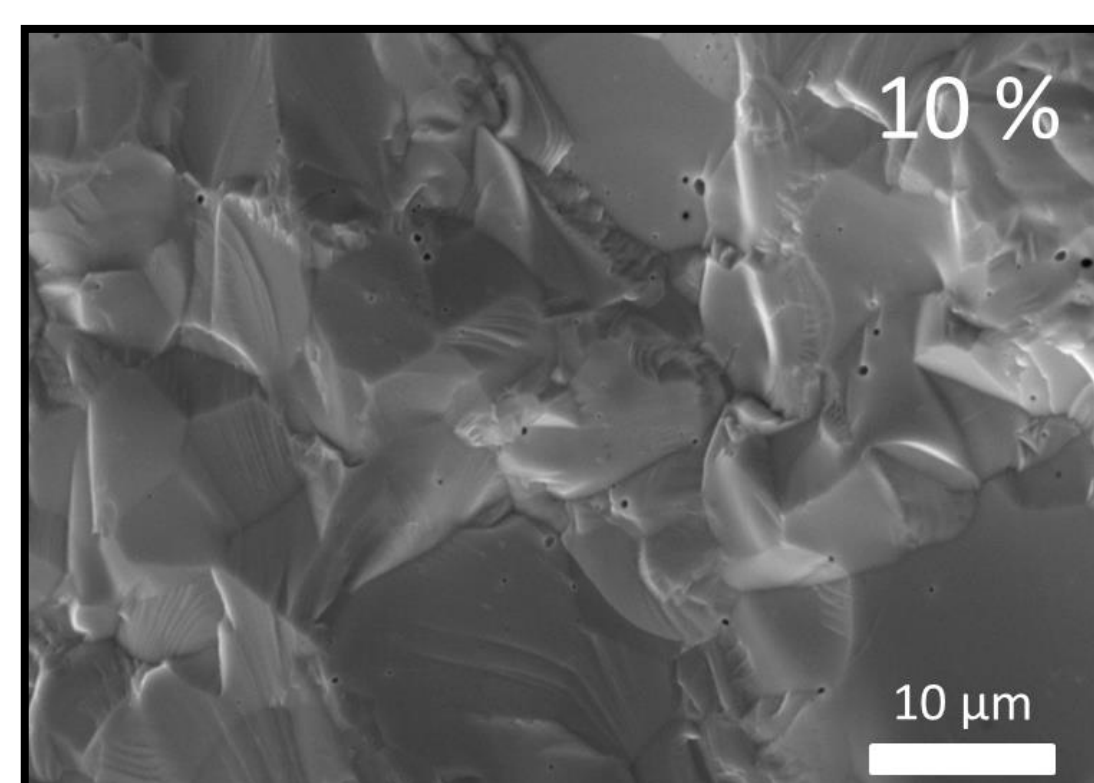
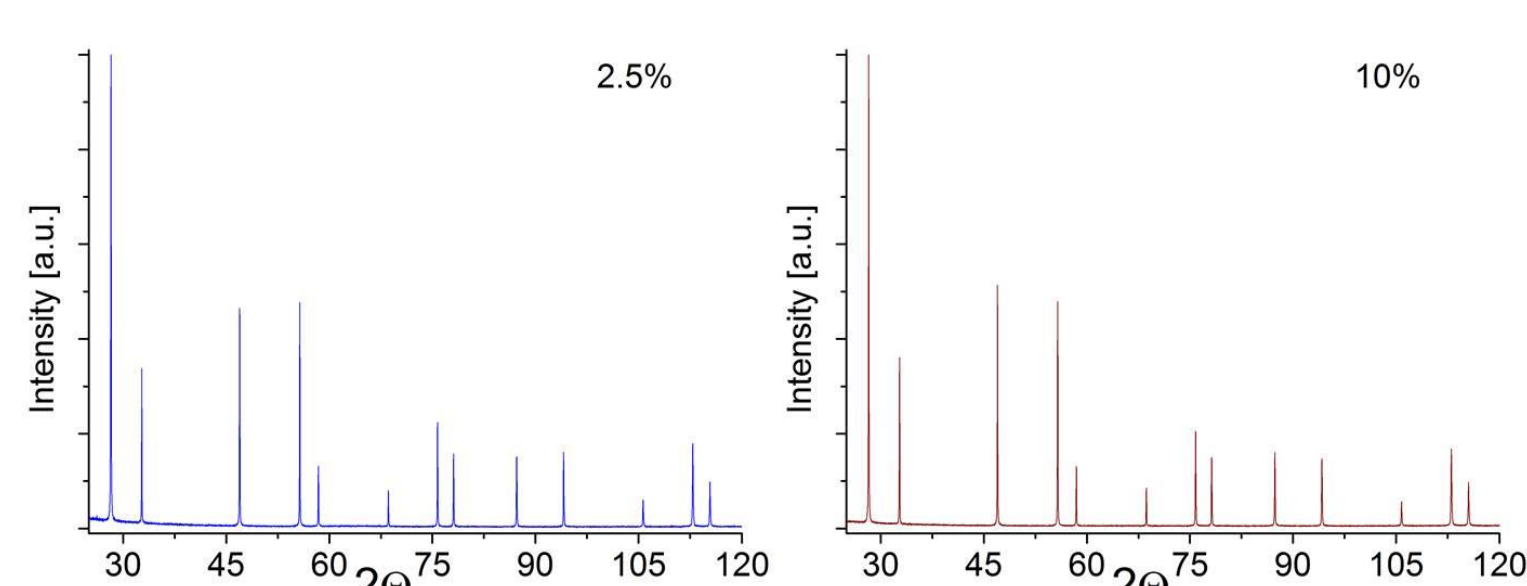


Powder pressing and sintering:

Pressing: $\phi = 5 \text{ mm}$; $p = 738 \text{ Mpa}$
Sintering: $1650 \text{ }^\circ\text{C}$, 6 h, under Ar-H_2

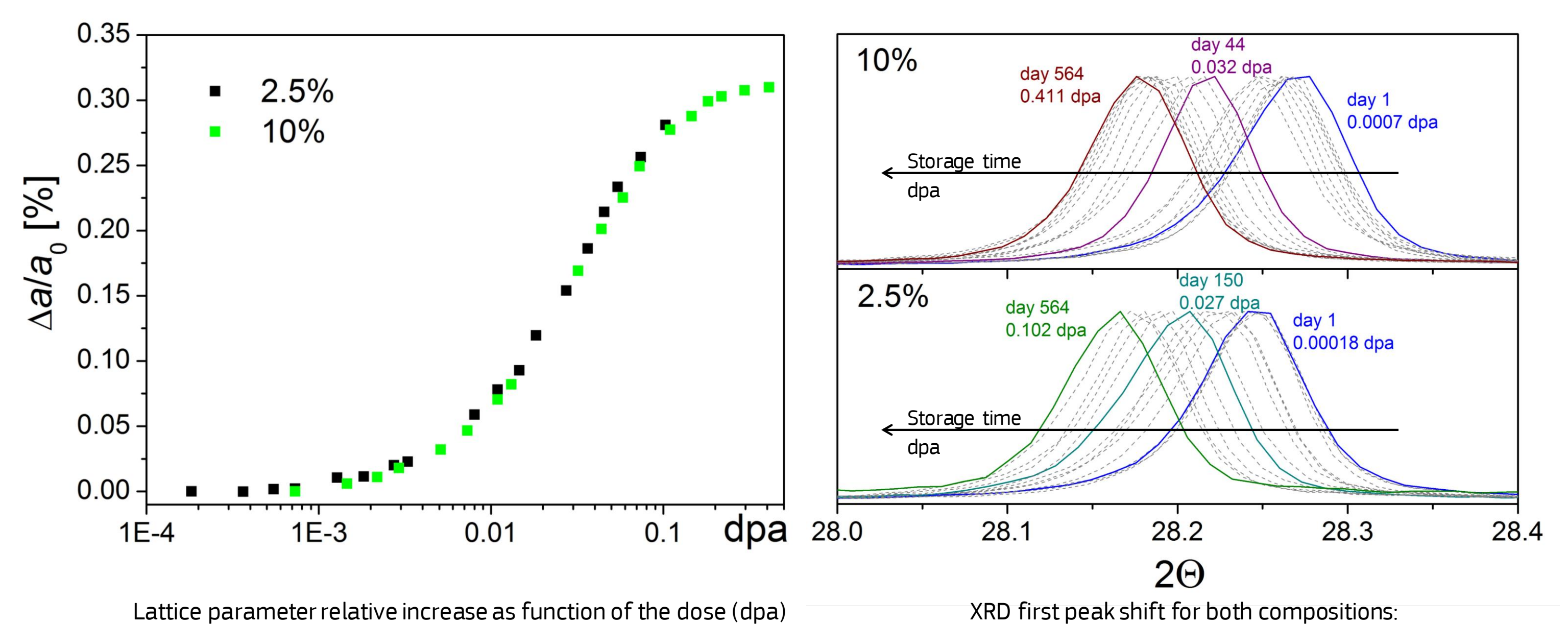


$(\text{U,Pu})\text{O}_2$ solid solution achieved, lattice parameter in good agreement with Vegard Law

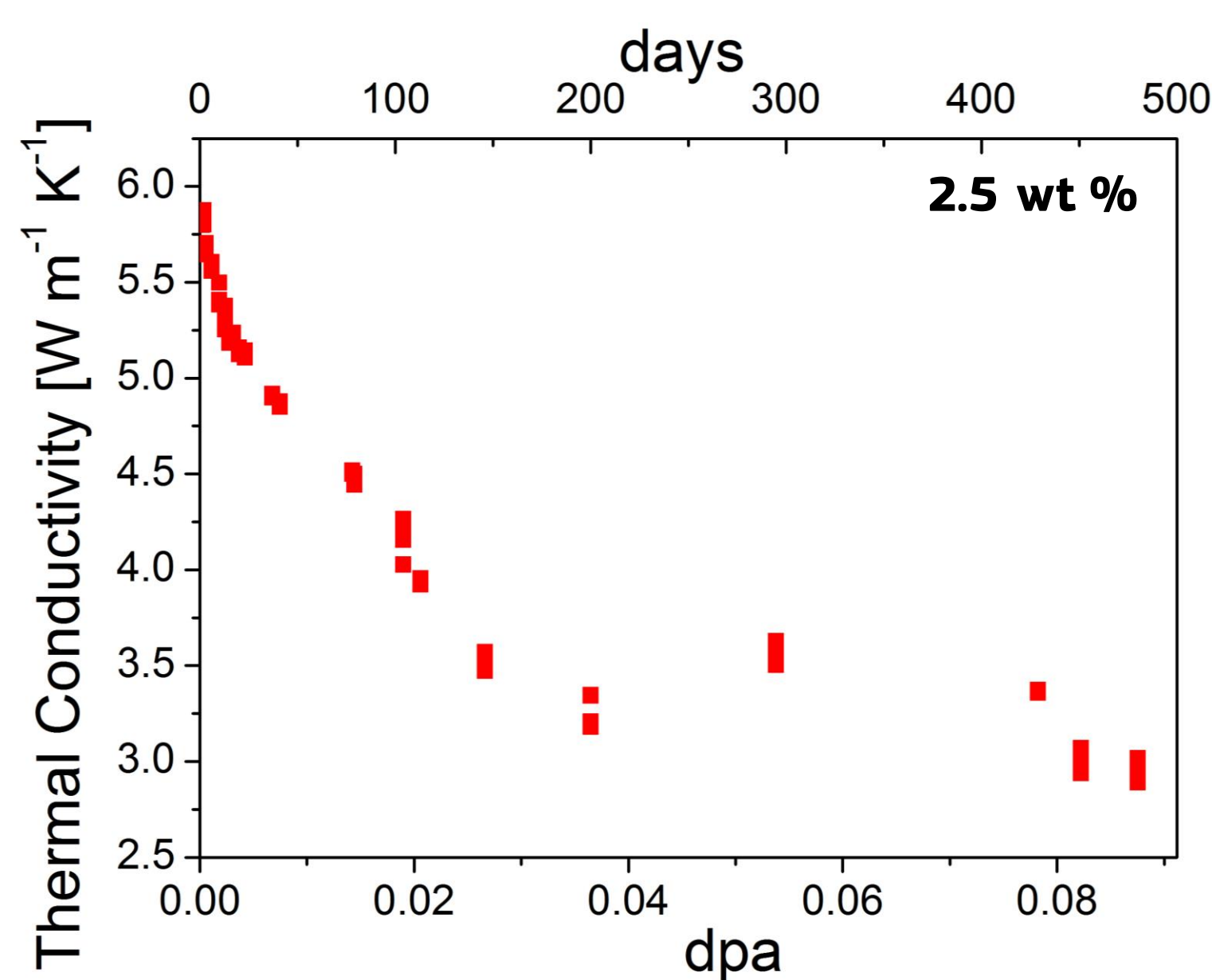


Periodic characterization

Day 0 = thermal treatment at $1250 \text{ }^\circ\text{C}$ to anneal all the defects

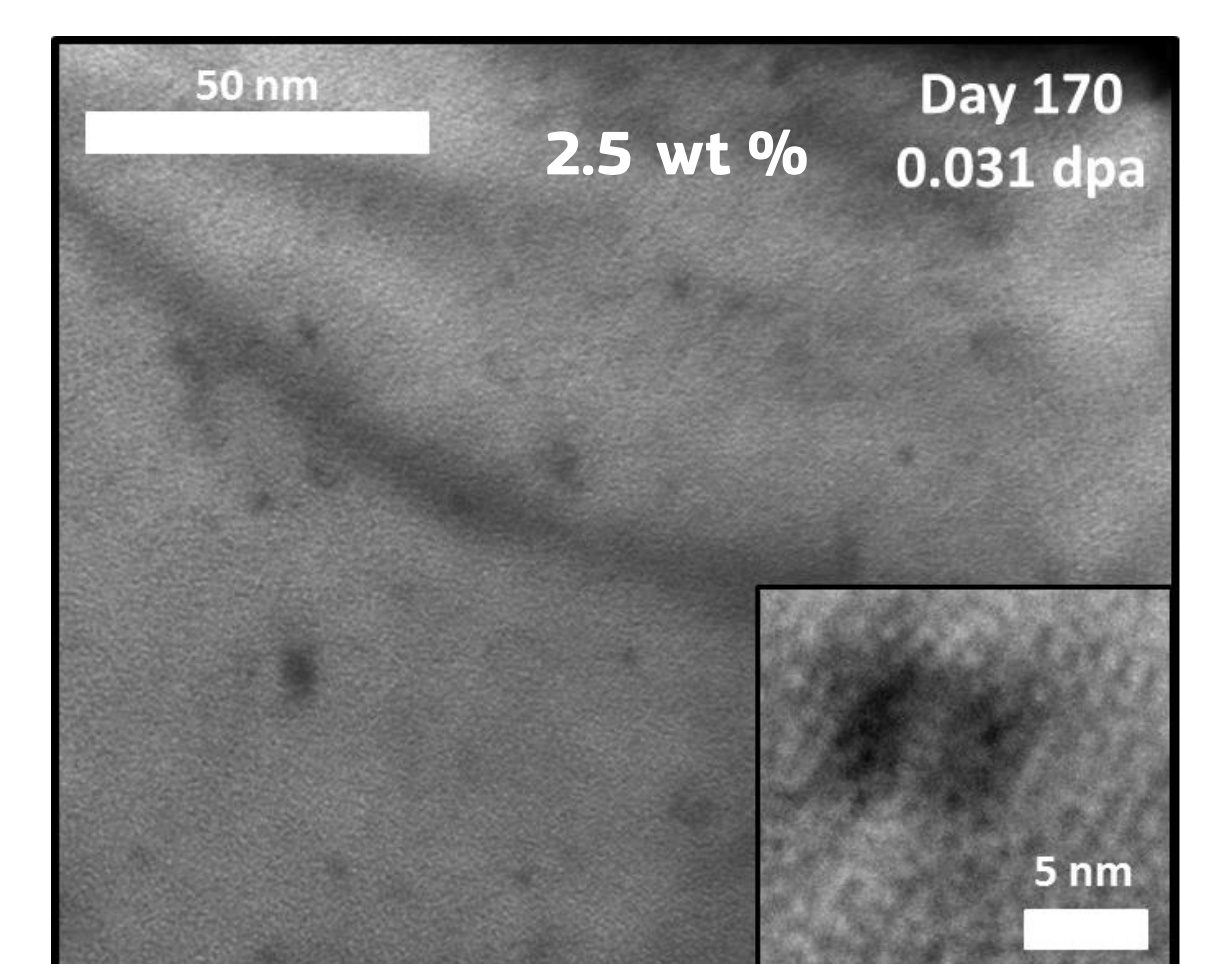


Damage-induced lattice swelling does not depend on the nominal sample activities.

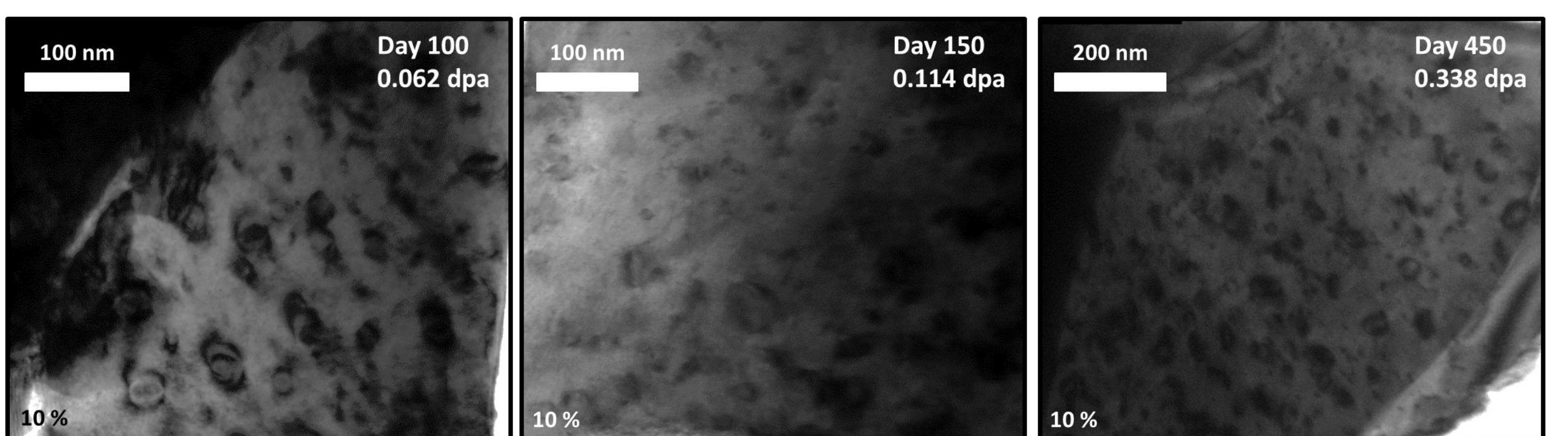


Thermal conductivity (measured at 550 K and corrected for 95 % TD) on a 2.5 wt % sample.

Thermal conductivity is very sensitive to point defects, reaching a floor value when they start to cluster.



TEM picture of a 2.5 wt % sample. At this dpa level, thermal conductivity has already completely degraded.



TEM pictures of 10 wt % samples with increasing dpa. Dislocation loops grow in number and dimension, but do not form tangles at 0.338 dpa yet.

Summary

- Preparation of $(\text{U},^{238}\text{Pu})\text{O}_2$ samples with 2 different compositions allows to study the effect of α -self-irradiation on the thermomechanical properties of nuclear fuel
- Periodic monitoring of lattice parameter (XRD), thermal conductivity (LAF) and microstructure (TEM) shows α -damage effects having radically different evolutions

Outlook

- Correlate these observations with other characterization techniques (RAMAN, DSC, KEMS) and (tentative of) defect quantification
- Compare and contrast these results with He-implanted UO_2

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