



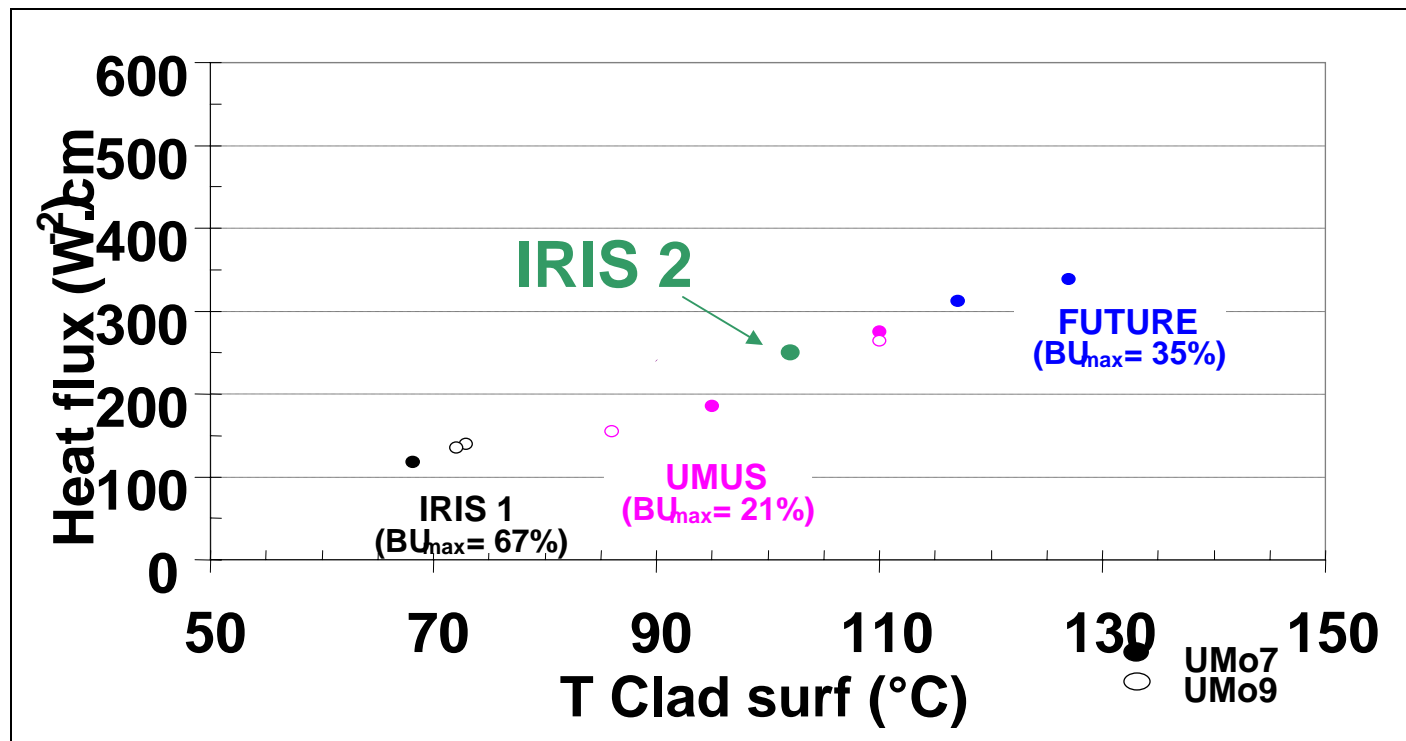
Post Irradiation Examination on UMo full-sized plates - IRIS 2 experiment -

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Introduction

- IRIS2 is a part of the French UMo Group qualification program



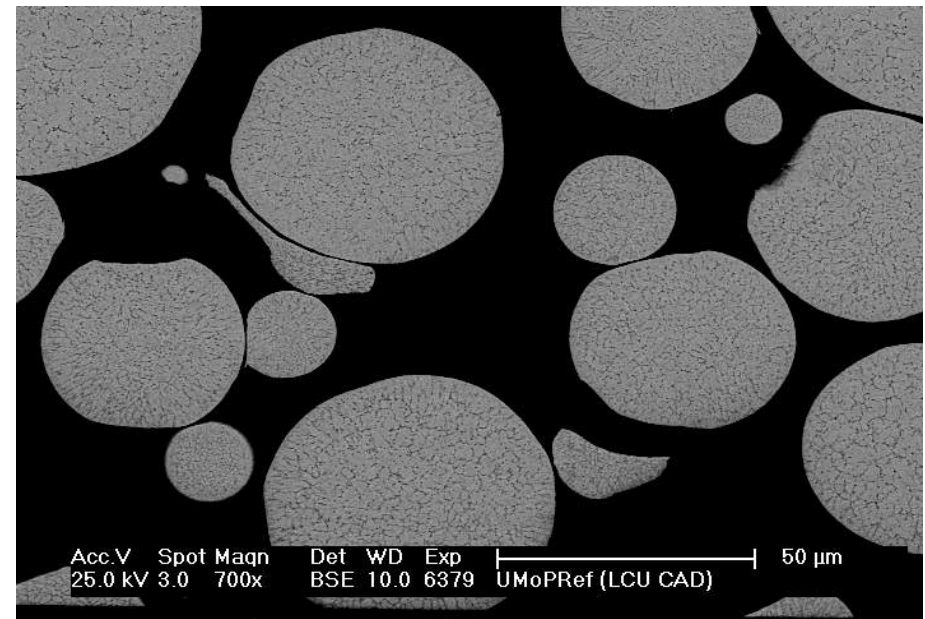
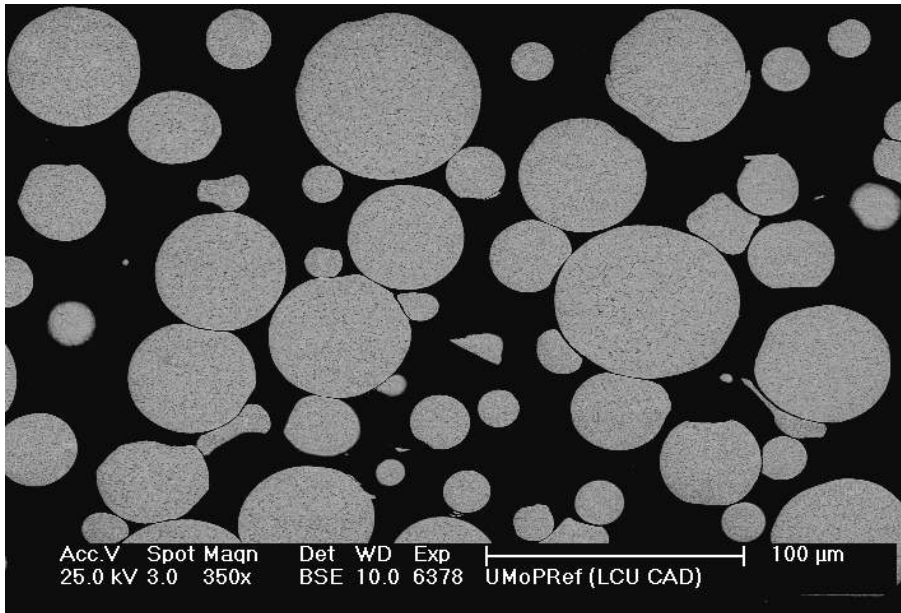
- 4 UMo plates were irradiated in OSIRIS reactor in IRIS device with the objectives to assess irradiation UMo dispersed fuel limits

As-Fabricated IRIS2 plates

- Plates supplied by CERCA with



- Low Enriched Uranium : $<20\%^{235}\text{U}/\text{U}$
- High uranium loading : $> 8.3 \text{ g.cm}^{-3}$
- U-7w%Mo alloy atomised powder
- Low Porosity in the meat : 1 - 1.5%



Irradiation test conditions

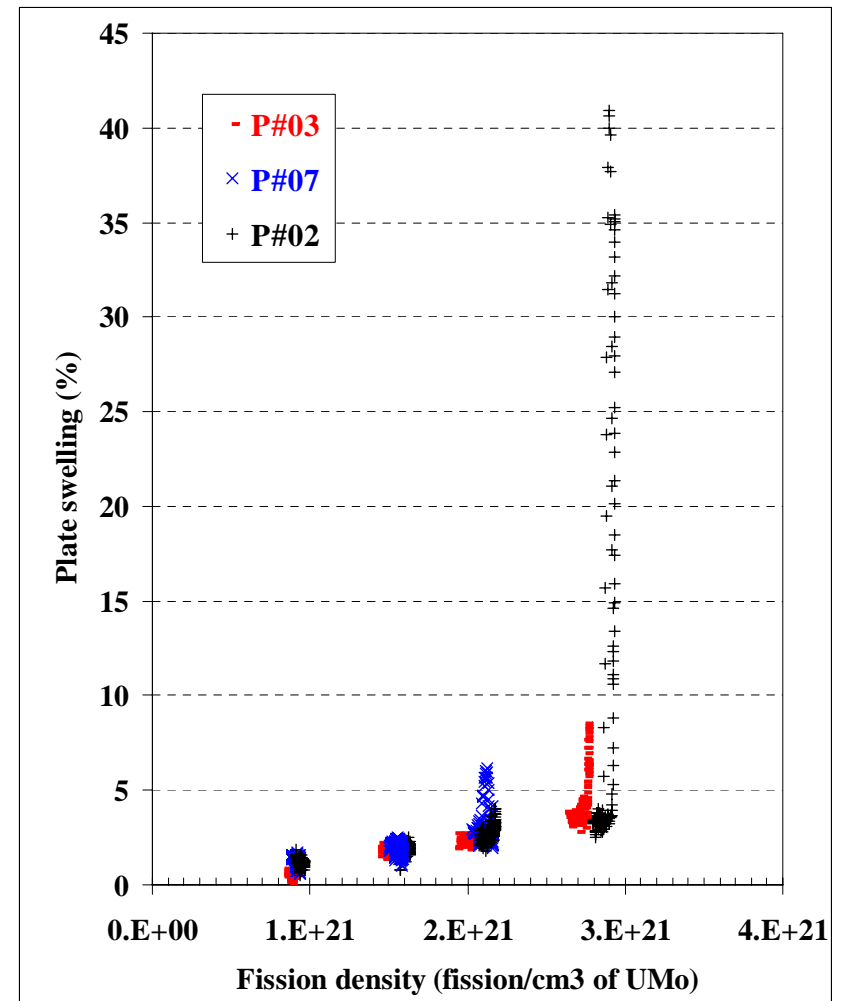
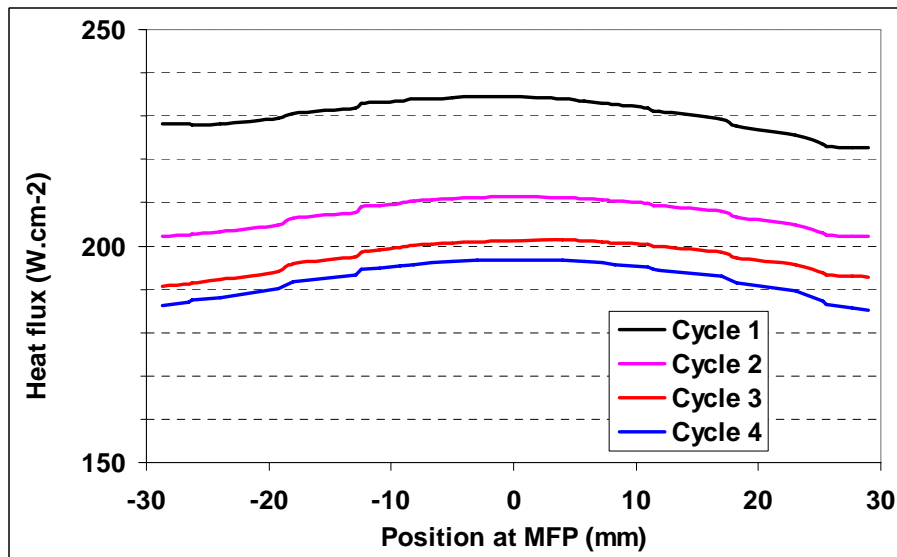
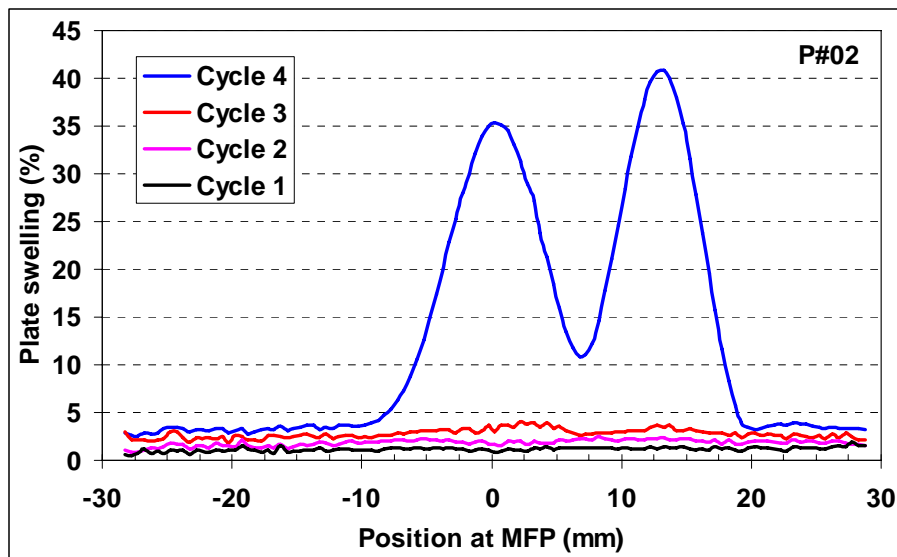
- **IRIS device of OSIRIS reactor**
 - 4 full sized plates : 641 x 73 x 1.27 mm³
 - Allows plates removal after each reactor cycle
 - Associated to a in-pool plate thickness measurements device



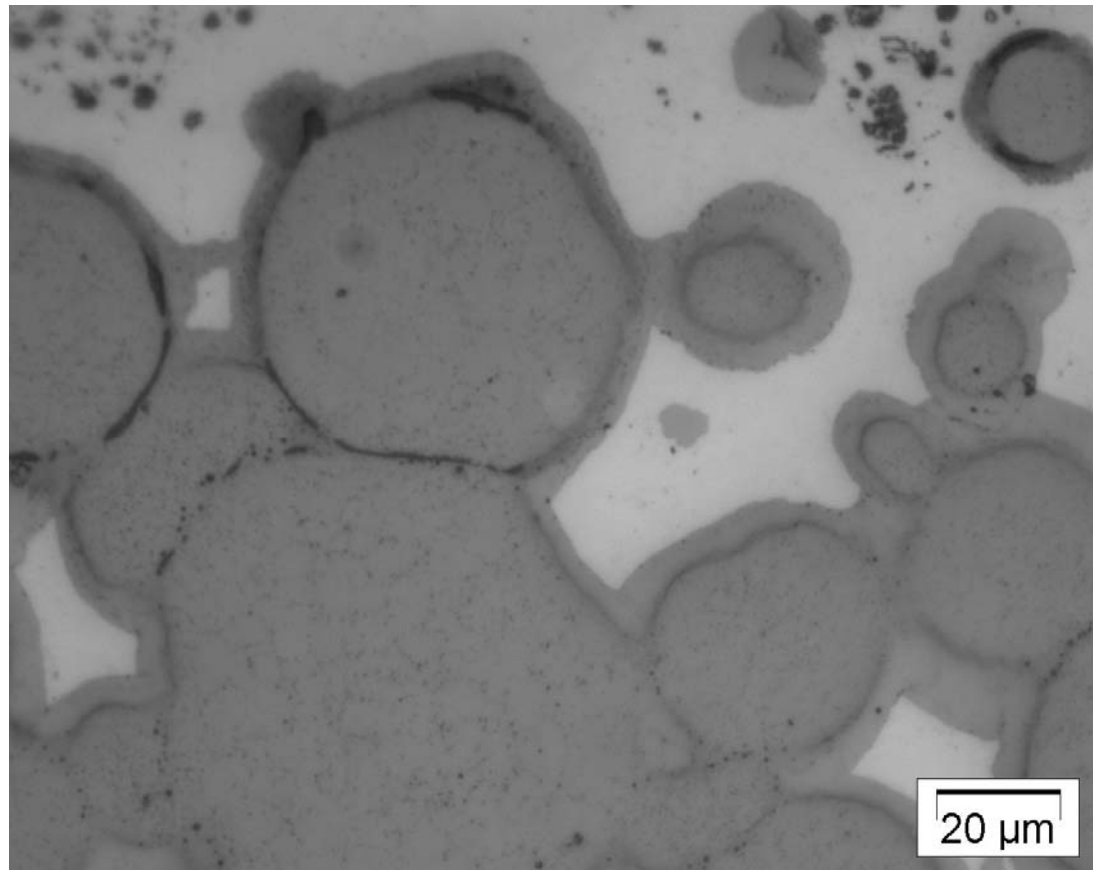
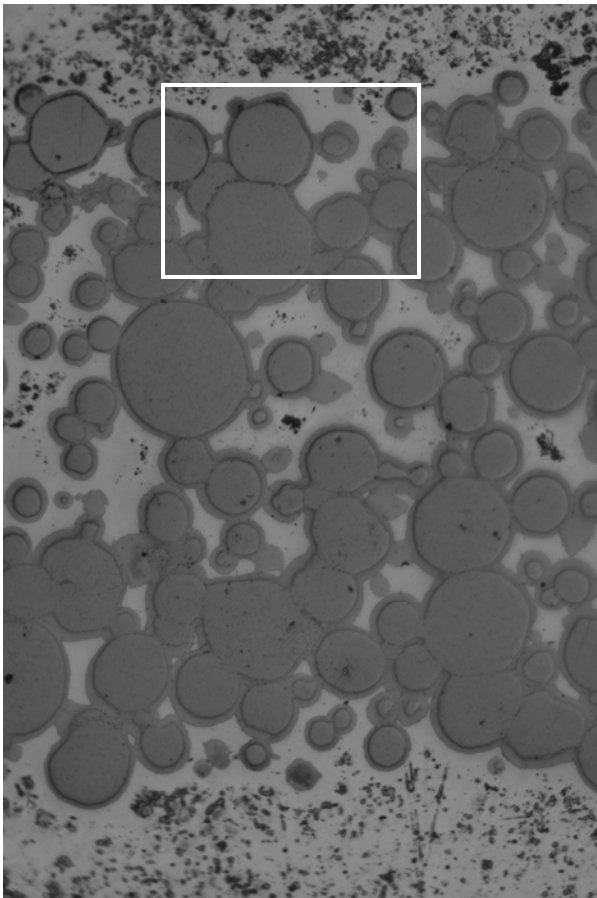
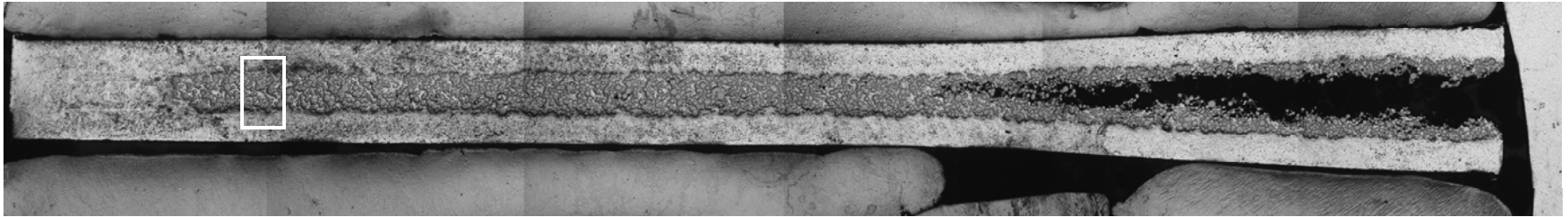
- **Irradiation conditions**

	P#08	P#07	P#02	P#03
Irradiation FPD	28.3	40.3	57.9	57.9
Peak Burnup (%)	19	28	39	37
Peak heat flux (W.cm⁻²)	218	232	238	219

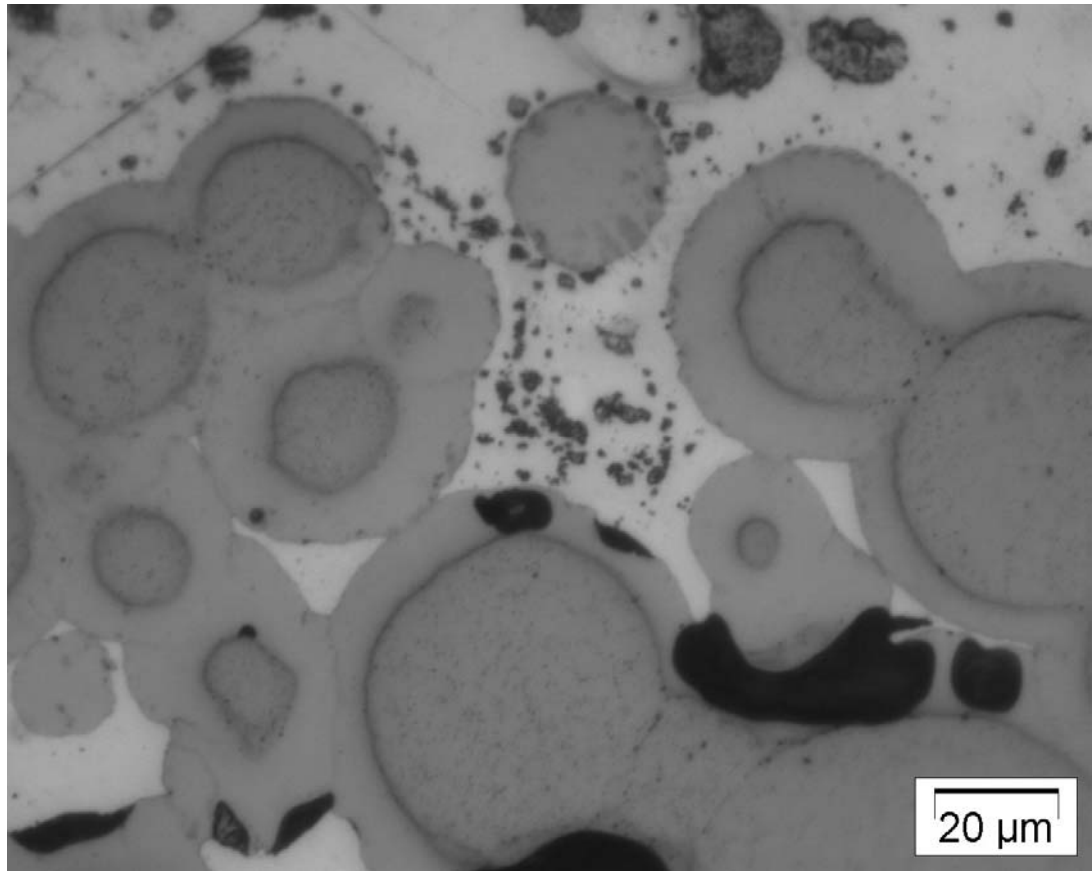
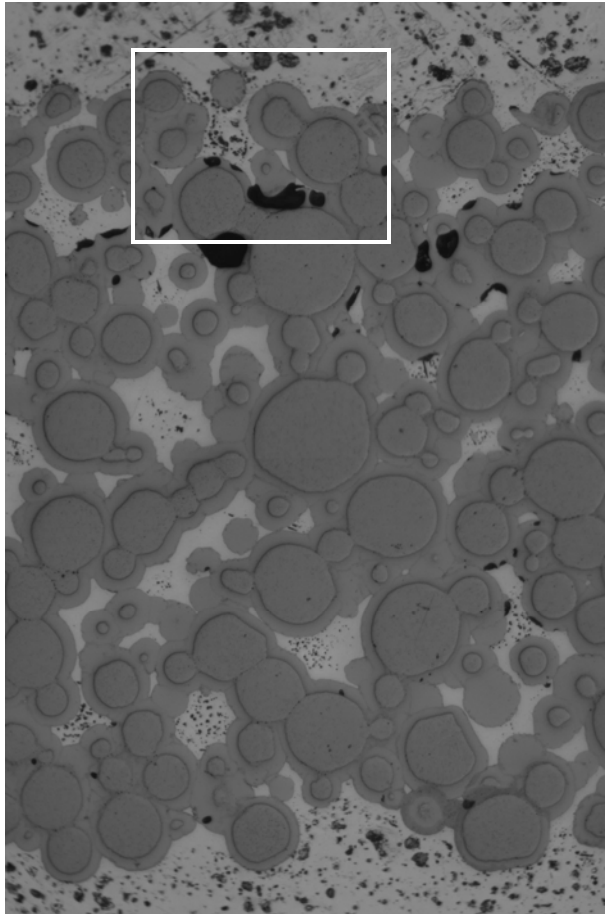
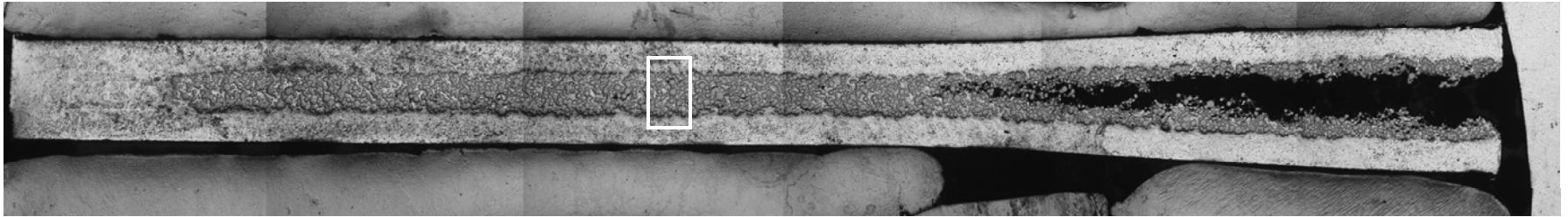
IRIS2 Plate swelling measurements



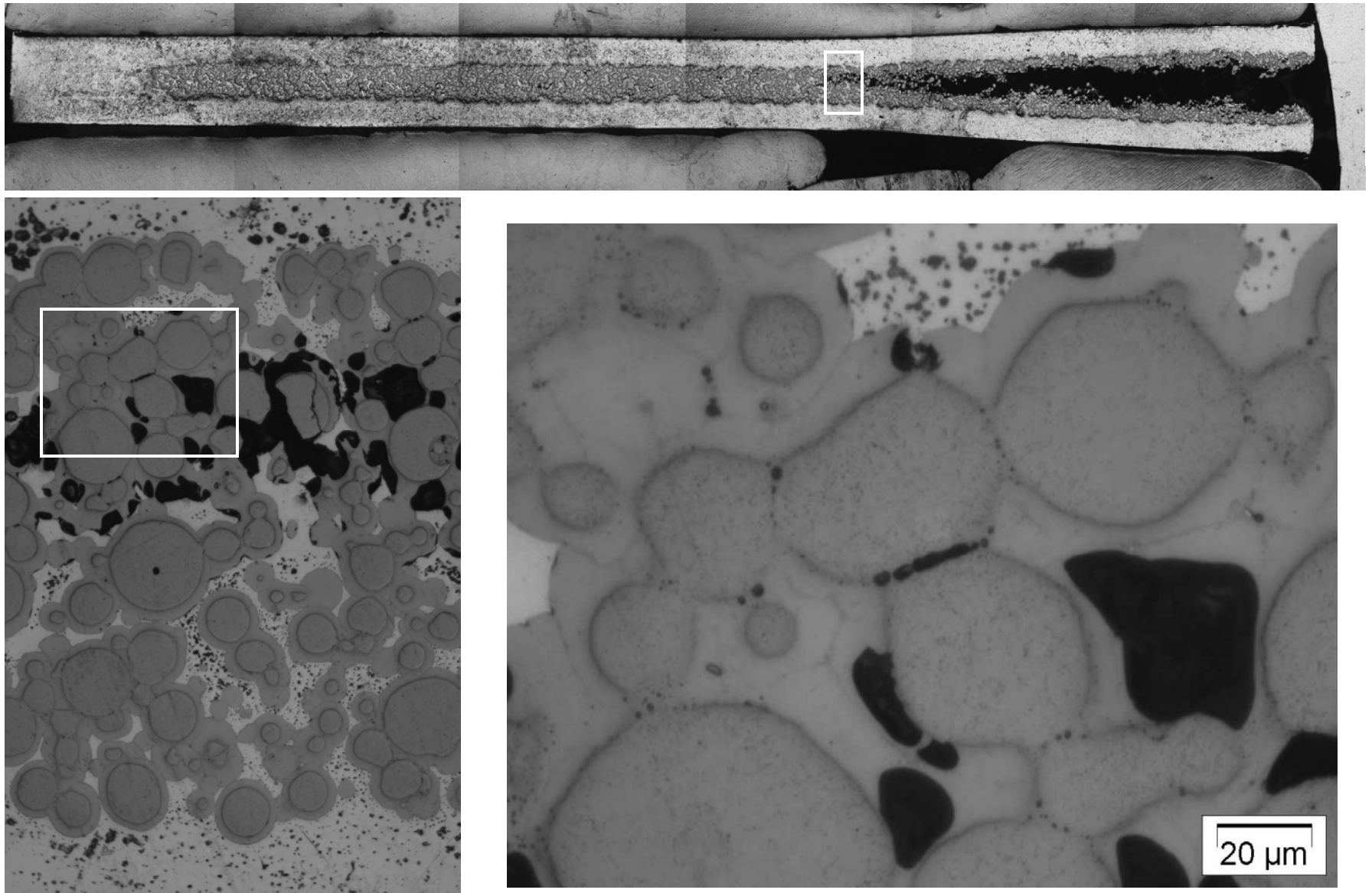
Metallographic examinations



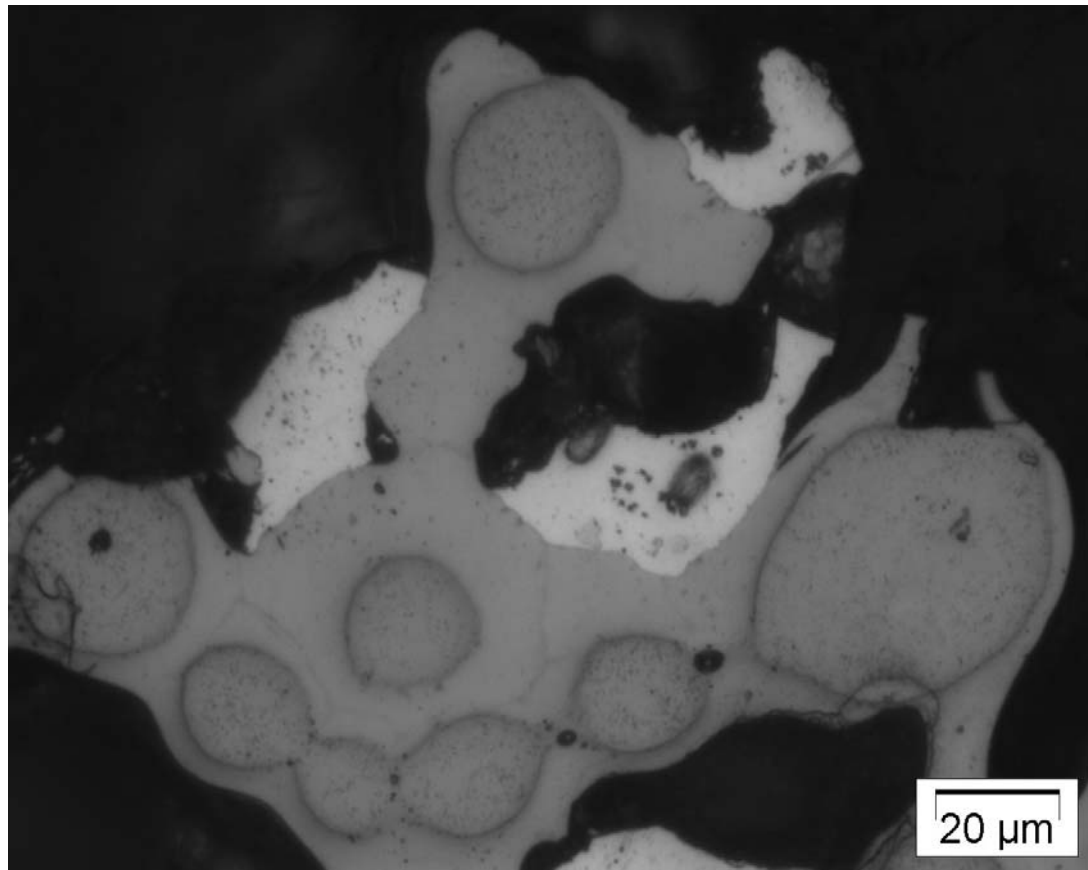
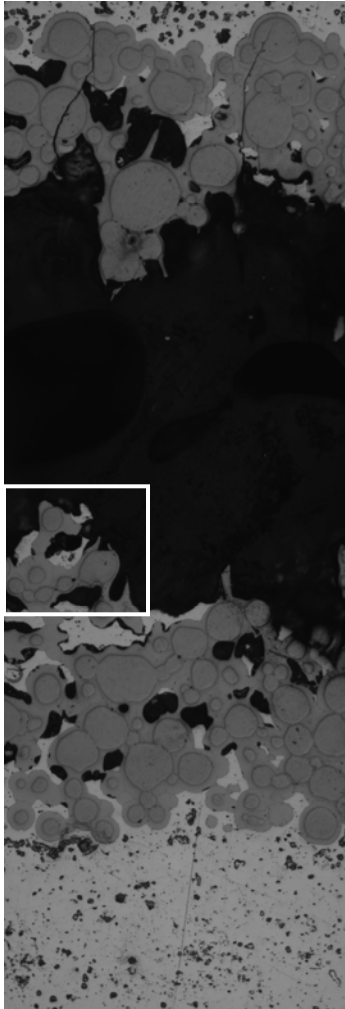
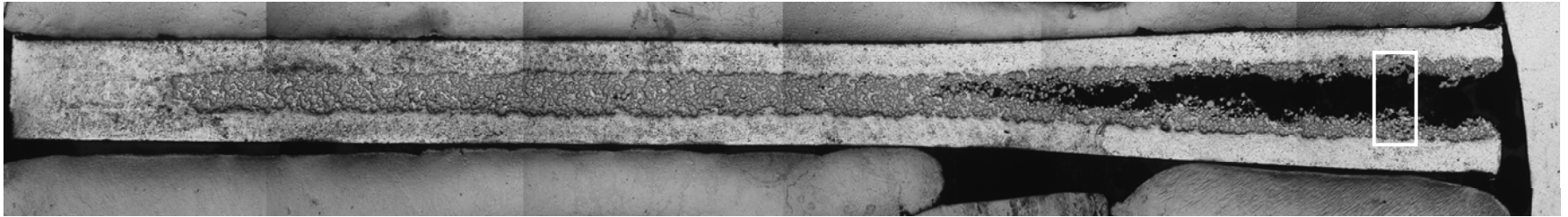
Metallographic examinations



Metallographic examinations



Metallographic examinations



Metallographic examinations



- **UMo particles**

- No indications of break-away swelling in the pillowing area
- No indication of excessive fission gas release

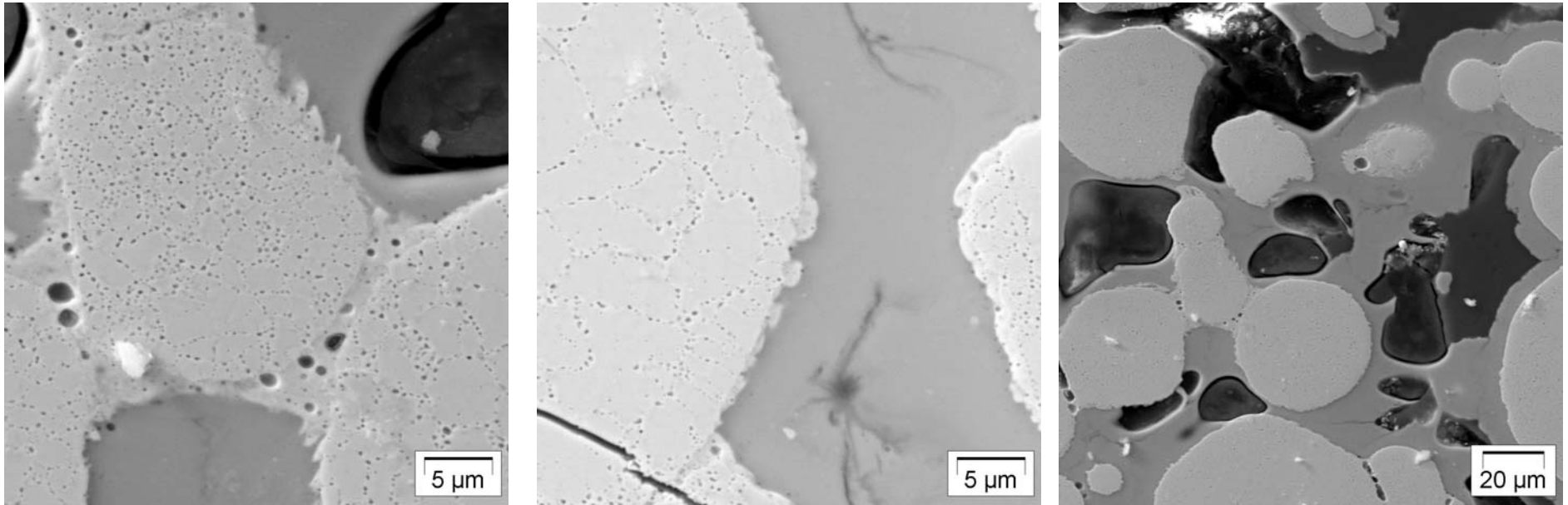
- **Interaction Layer**

- Thickness : 4 μm to 9 μm
- Indication of "plasticity"

- **"Porosity" generally start at**

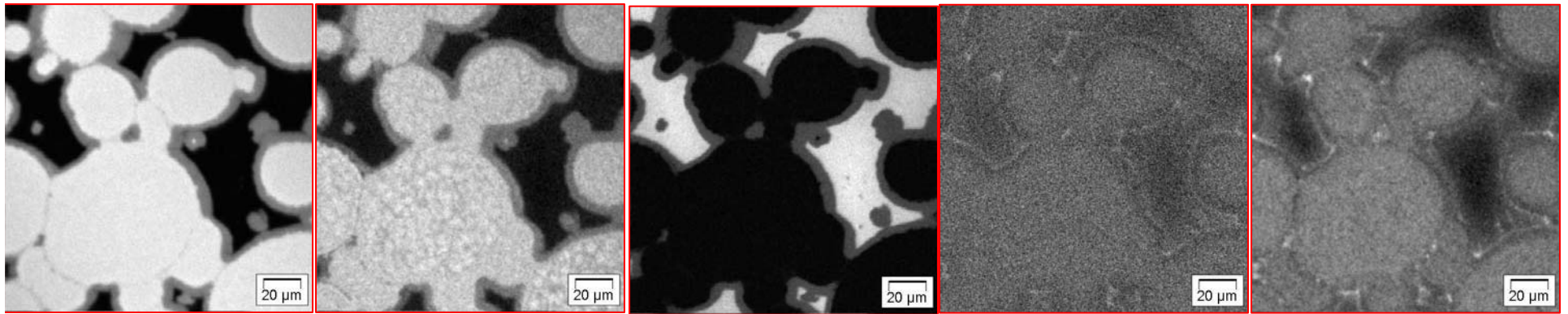
- Interaction / Aluminium matrix interface

SEM examinations



- **Fission gas bubbles :**
 - UMo particle grain boundaries
 - None in Interaction layer
- **Dark lines at the interaction edge**
- **"Sintering Neck" between narrow UMo particles.**
- **"plastic deformation" of the interaction product**

EPMA examination



U

Mo

Al

Zr

Xe



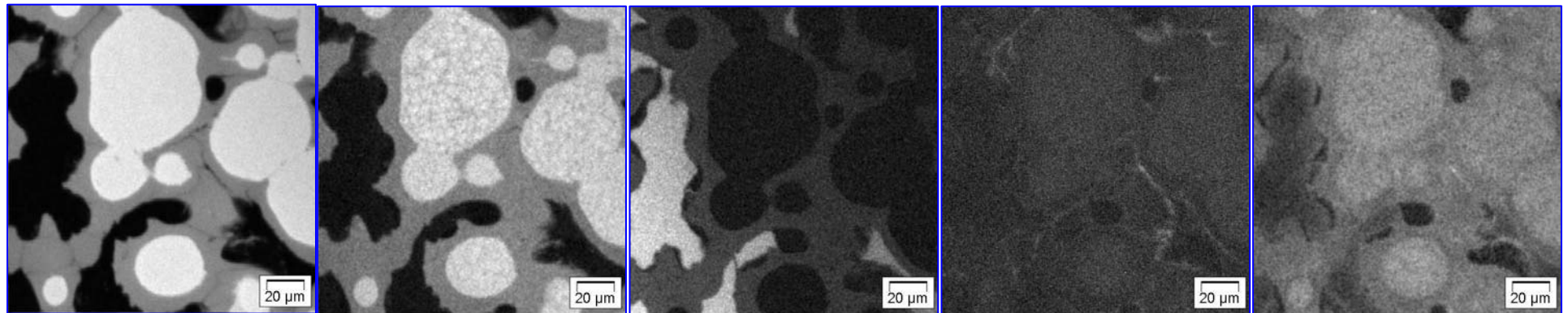
U

Mo

Al

Zr

Xe



EPMA : Quantitative analyses



- **Interaction Product global composition**

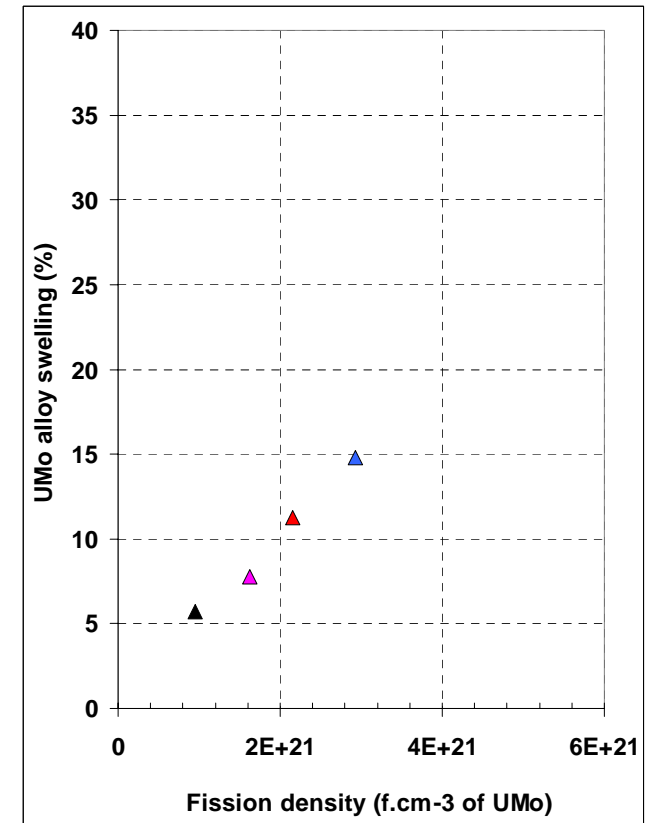
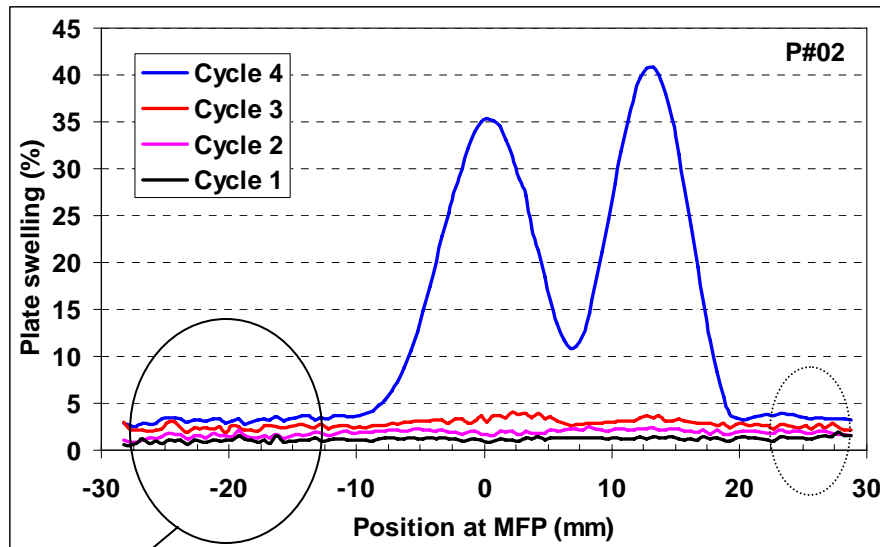
- "UMoAl_x"



X	5.8	5.5	5.5	4.8	4.4
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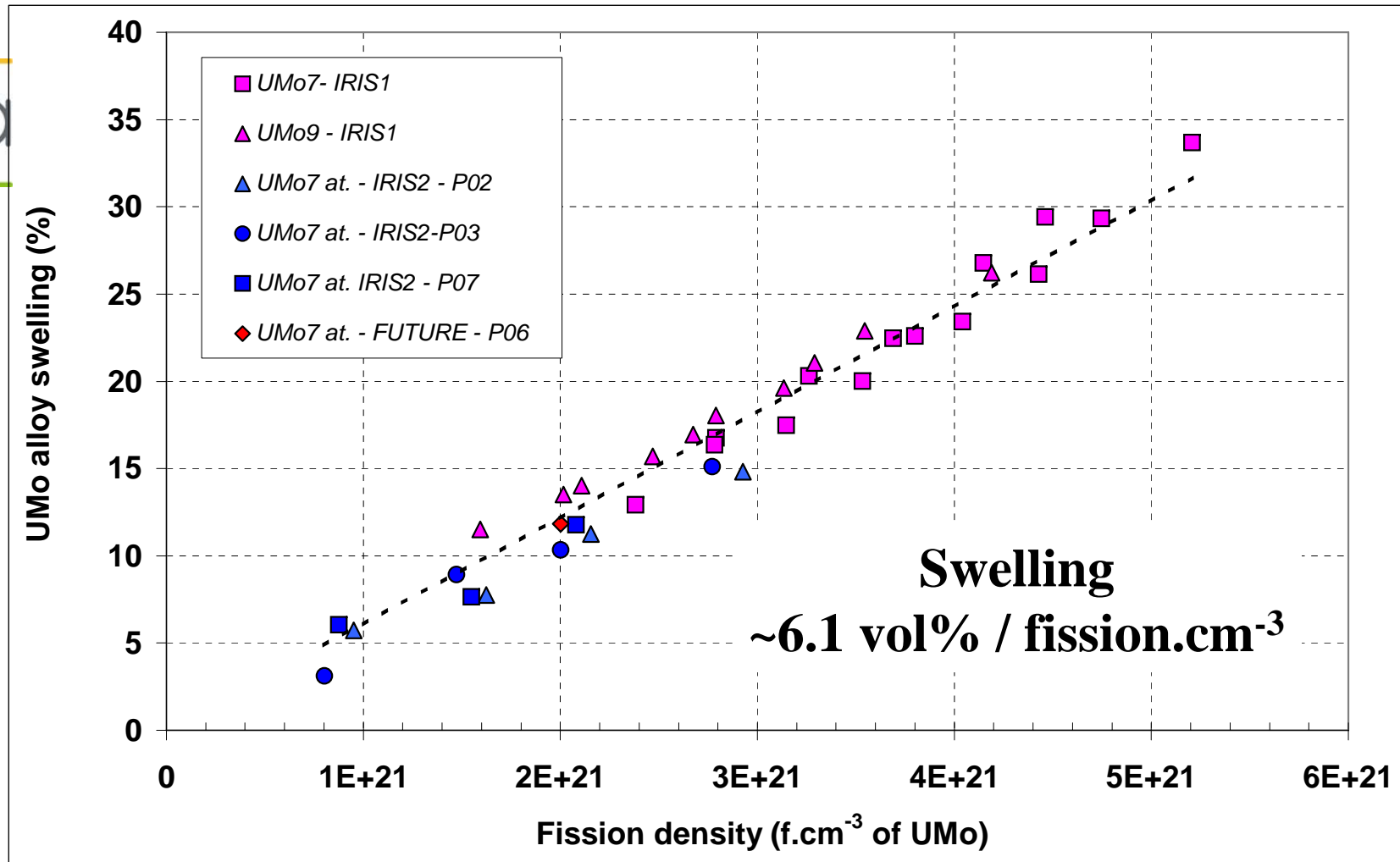
- (U+Mo) content in the interaction product increases with
 - Temperature, pillowing porosity, interaction product amount

Plate Swelling -> meat swelling -> UMo swelling



- Boehmite growth
- Meat porosity evolution
- Fission products in UMo alloy (and interaction)
- Density of the interaction product

UMo Alloy Swelling



Conclusions



IRIS2 experiment confirm

- ❑ that the dispersed fuel as initially designed can't be used without improvement

- ❑ UMo Alloy exhibits a good swelling behaviour :
 - ❑ No evidence of Break away swelling
 - ❑ Constant swelling rate of :
6,1 vol% / 10²¹ fission.cm⁻³UMo

Conclusions

Origine for the pillowing



- ❑ Fission products (gas) accumulation at the interaction / aluminium matrix interface
 - ❑ "Pushed" during Interaction layer growth
 - Low solubility of FP in the interaction layer
 - High diffusion rate of FP (and vacancy) in the interaction zone



UMo particles

CE

