Measuring phase transitions of a new candidate fuel material

INTRODUCTION

In a nuclear reactor, the initiation and control of a self-sustained nuclear fuel reaction (fission) take place. As the fission reaction progresses over time, various fission products emerge, leading to a change in the fuel's composition. Therefore, it is crucial to establish the phase diagram of the nuclear fuel in advance to assess the potential risk of phase transformation in the reactor caused by this compositional change.
A phase diagram serves as a valuable tool for determining the temperatures at which phase transitions (such as melting, crystallization, and solid-solid transitions) occur in any candidate new fuel material, based on its composition. Hence, phase diagrams provide crucial insights into the potential risks of phase transformation within the reactor. High-temperature techniques such as DTA (differential thermal analysis), DSC (differential scanning calorimetry), or drop calorimetry directly measure the temperatures associated with these phase transitions in materials.

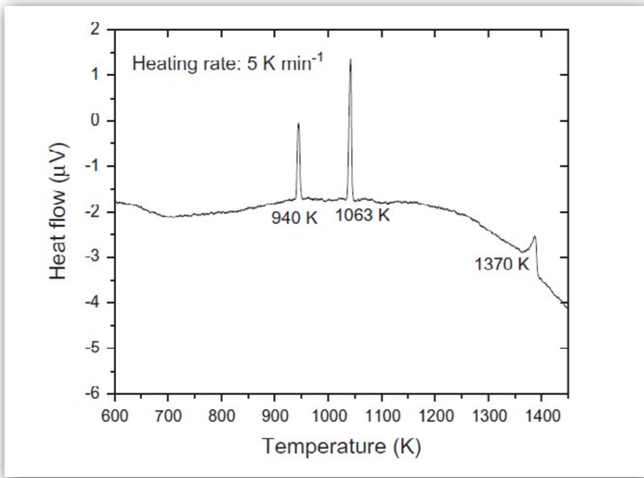

Figure 1 – DTA curve showing the peak corresponding to the detected phase transitions.

EXPERIMENT

- Sample: 200mg of U-15wt%UO_2 sintered cermet, a candidate fuel for fast reactor technologies.
- Instrument: THEMYS STA, with a tricouple DTA rod
- Crucible: alumina
- Temperature: from room temperature to 1200°C at 5K/min
- Atmosphere: argon flow at 2l/h

RESULTS AND CONCLUSION

As seen on Figure 1, the test helps determining three phase transitions over the tested temperature range:
- a solid-solid phase transition (α → β) at 940K
- a second solid-solid phase transition (β→ γ) at 1063K
- melting, or solidus at 1370K

As far as the cermet's application in fast reactors is concerned, the high solidus temperature of the candidate fuel provides a good margin between the reactor's operating temperature and the fuel's solidus.

Reference : S. Mishra et al., Journal of Nuclear Materials 442 (2013) 400–407.

INSTRUMENT

THEMYS STA

ACCURATE AND SENSITIVE ULTRA-HIGH TEMPERATURE
heat flow measurement with Tri- Couple DTA technology

ULTRA-HIGH TEMPERATURE CAPABILITY
to 2400°C with a single furnace.

MODULAR ADAPTIONS ALLOWING
TGA only, DTA only, TG-DTA, and TMA up to 2400°C, DSC only and TG-DSC up to 1600°C all in one instrument

EXTERNAL COUPLING CAPABILITY
designed for evolved gas analyzers (FTIR, MS, GCMS, MSFTIR, or FTIR-GCMS)