doi:10.1017/S1431927618010784
Microsc. Microanal. 24 (Suppl 1), 2018

Electron Probe Microanalysis of Minor Actinide Bearing Fuels Studied within the FUTURIX-FTA International Collaboration: $(Pu_{0.8}Am_{0.2})O_2$ + 86 vol. % Mo and $(Pu_{0.23}Am_{0.25}Zr_{0.52})O_2$ + 60 vol. % Mo

Philipp Pöml[1], Jérôme Himbert[1], D. Freis[1], J. Somers[1]

[1.] European Commission, Joint Research Centre, Directorate G - Nuclear Safety and Security, JRC Karlsruhe Site, P.O. Box 2340, D-76125 Karlsruhe

The purpose of the FUTURIX-FTA (FUels for Transmutation of transURanium elements in phenIX) international irradiation program was to demonstrate the feasibility of burning minor actinides in dedicated reactors including Accelerator Driven Systems (ADS). The experiment also addressed the technical feasibility of transmuting minor actinides in fast neutron reactors from the fuel behaviour point of view. The study was carried out jointly by the US Department of Energy (DOE), the Joint Research Centre (JRC), the Japan Atomic Energy Agency (JAEA), and the Commissariat à l'énergie atomique et aux énergies alternatives (CEA). The advantage of this program was that eight different fuel compositions were irradiated at the same time under the same conditions in the Phénix reactor, France, and should have yielded comparable data.

In this paper we present electron probe microanalysis (EPMA) results of two fuel compositions $(Pu_{0.8},Am_{0.2})O_2$ + 86 vol% Mo and $(Pu_{0.23},Am_{0.25},Zr_{0.52})O_2$ + 60 vol% Mo. These two fuels were specifically designed for the transmutation of Am in ADS with a net zero Pu balance. The fuel consists of randomly dispersed and isolated actinide containing fuel particles of approx. 50 to 200 µm in diameter in an inert Mo matrix (Figure 1) [1].

The analyses were carried out using a shielded Cameca SX100R installed at JRC Karlsruhe, Germany. The operating conditions were 25 kV acceleration potential and 250 nA beam current. The analysed elements and lines were Zr Lα, Nd Lα, Np Mα, O Kα, Mo Lα, Cs Lβ, Pu Mα, Ru Lα, Am Mα, U Mα, and Xe Lα. As reference materials the metals Zr, Mo, and Ru were used for Zr, Mo, and Ru, $NpAl_2$ was used for Np, PuO_2 was used for Pu and O, UO_2 was used for U, and the mineral Pollucite was used for Cs. For Am and Xe virtual standards were used. Calibration factors were applied to relate the intensities of Am Mα and Xe Lα to Np Mα and Sb Lα, respectively [2, 3].

Figures 2 and 3 show absorbed current (Abs) electron images and quantitative X-ray maps for Am and Nd in weight %. Nd is usually taken as an indicator for the local burn-up in the fuel. For the fuel $(Pu_{0.8},Am_{0.2})O_2$ + 86 vol% Mo the mapped fuel grain shows a sharp interface to the Mo matrix. The interface between Am and Mo is sharp, no diffusion can be recognised. The Nd map shows high Nd concentrations in the centre of the fuel particle with a gradient of less Nd towards the grain edge. Nd is detected also in the Mo matrix. The Nd was probably implanted into the Mo by the fission recoil energy.

For the fuel $(Pu_{0.23},Am_{0.25},Zr_{0.52})O_2$ + 60 vol% Mo the results are similar. The maps show, however, two fuel particles with different Am concentrations, which shows that the fuel particles were not perfectly homogeneous in this fuel. In addition, for the lower particle in the maps, the interface between Am and the Mo matrix is not sharp and flat and shows some interaction between the fuel particle and the Mo matrix.

References:

[1] C Andrello *et al* 25th Int. Conf. on Nucl. Engin. Paper No. ICONE25-67252. (2017),
[2] X Ritter, Master thesis "Micro-analytical investigations on actinide reference materials" (2015), University of Münster, Germany.
[3] P Pöml *et al*, IOP Conf. Series: Materials Science and Engineering **7** (2010) 012025.

The irradiation of the fuels was performed within the framework of the FUTURIX-FTA international program and the support of CEA for the realisation of the experiment is greatly acknowledged.

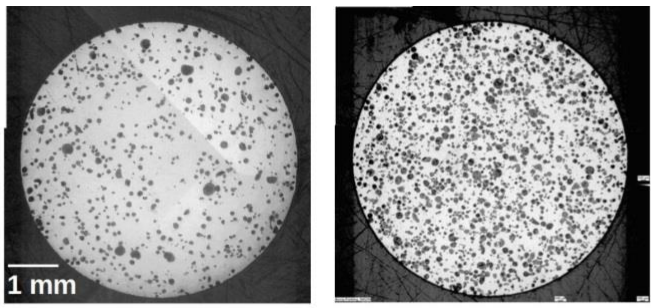

Figure 1. Optical images of fuel $(Pu_{0.8},Am_{0.2})O_2$ + 86 vol% Mo (left) and fuel $Pu_{0.23},Am_{0.25},Zr_{0.52})O_2$ + 60 vol% Mo (right) before irradiation.

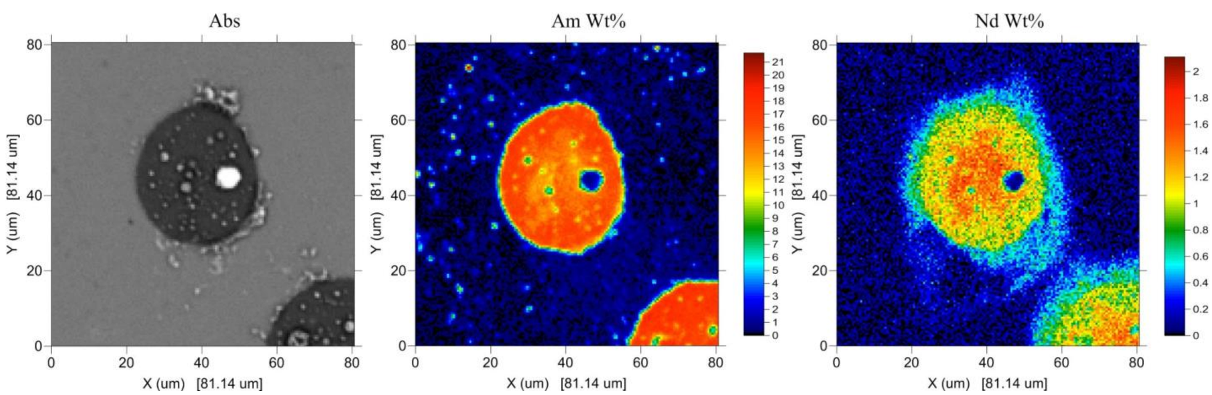

Figure 2. Absorbed current (Abs) and Am and Nd quantitative maps of fuel $(Pu_{0.8},Am_{0.2})O_2$ + 86 vol% Mo.

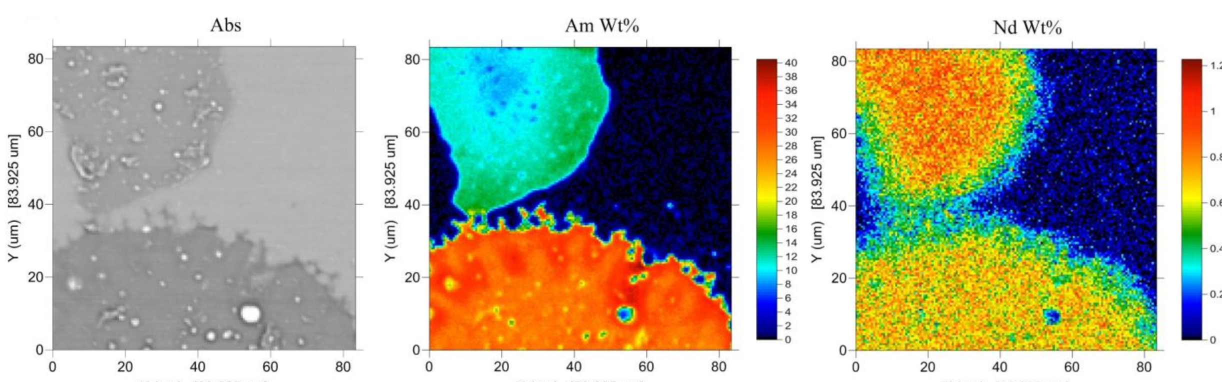

Figure 3. Absorbed current (Abs) and Am and Nd quantitative maps of fuel $(Pu_{0.23},Am_{0.25},Zr_{0.52})O_2$ + 60 vol% Mo.