Heavy Ion Irradiation of U–Mo/Al Dispersion Fuel

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1. Introduction

The international community has decided to use — whenever possible — Low Enriched Uranium (LEU) instead of High Enriched Uranium (HEU) fuel for research and test reactors. In order to achieve this goal high density fuels are required. One of the most promising candidates is the metallic U–Mo/Al dispersion fuel. This fuel allows a uranium density of around 8.5 gU/cm^3 and is currently under worldwide development [1].

However, some concerns have appeared due to the anomalous swelling of full size plates during in–pile irradiation. Post irradiation examinations of these plates revealed an Al–rich interdiffusion layer building up at the interface between U–Mo grains and the Al–Matrix with a thickness of some 10 μm. Furthermore, cracks which are regarded as the reason of the anomalous swelling have been observed between the interdiffusion layer and the matrix [2].

Here we show an approach to generate an interdiffusion layer by out–of–pile irradiations with heavy ions thereby simulating the radiation damage created by fission fragments during reactor irradiation without the drawback of creating highly radioactive samples.

2. Experimental set-up

Fuel plates containing spherical U–6wt% Mo and U–10wt% Mo dispersed in Al were provided by Argonne National Laboratory free of charge. The samples were cut ($5 \times 5\,mm^2$) and polished in order to make the meat layer accessible for irradiation with heavy ions. The irradiation experiment has been carried out at the Munich 14 MV tandem accelerator with a heavy ion beam of ^{127}I at 120 MeV. The penetration depth depends on the target material, but is always in the range of the thickness of the interdiffusion layer (see Fig. 1). The flux was set in order to not exceed a sample temperature of 200 °C. The final fluence was 10^{17} ions/cm^2, which corresponds to a low burn–up.

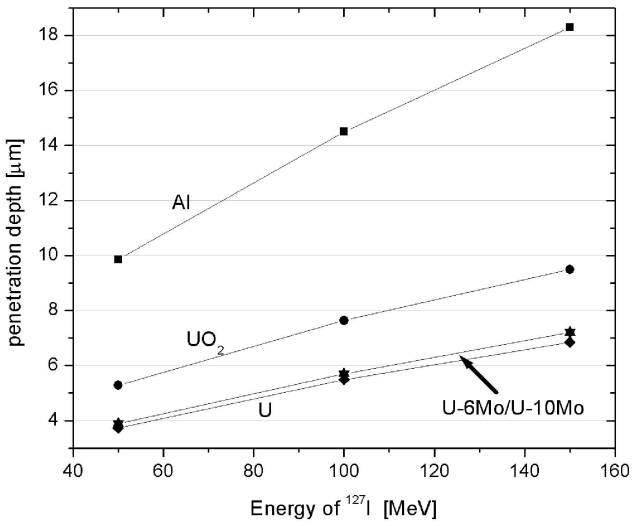

Fig. 1: Penetration depth of ^{127}I into different materials [3].

3. Post Irradiation Examinations

Fig. 2 shows a partly heavy ion irradiated U–Mo sample. The part on the left hand side was not irradiated and therefore looks like fresh fuel, while the part on the right hand side has been irradiated. Here a new phase between the fuel and the matrix is visible. This new phase has sharp borders and a light blue colour. The blue colour could be due to the irradiation with iodine. The thickness of the new phase depends on many parameters but is always in the range of some 10 μm. These optical properties fit with the interdiffusion layer, which has been observed after in–pile irradiation.

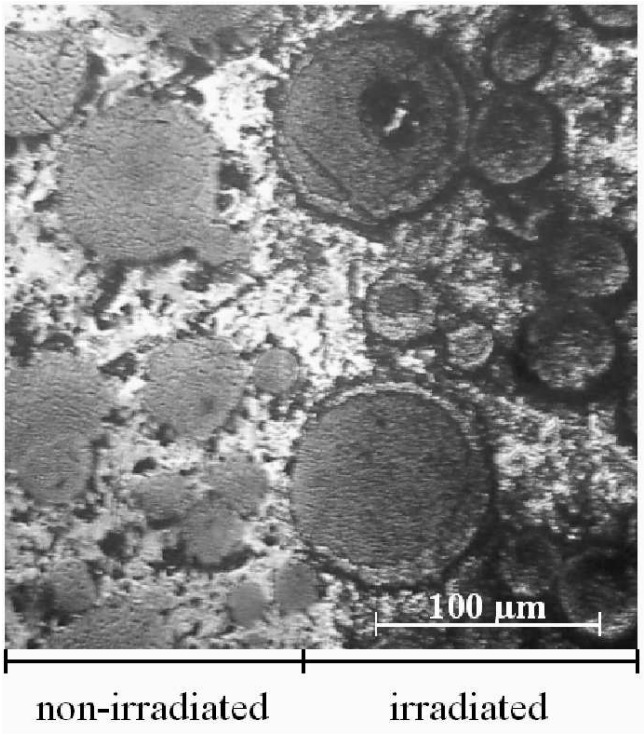

Fig. 2: Optical microscopy of a partly irradiated U–6Mo sample.

Furthermore, we accomplished to file a patent (reference no. DE 10 2005 055 692) in 2005, which is dealing with a manufacturing technique for U-Mo monolithic.

References

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