Micro X-ray Diffraction Analysis for Spent Fuel of Burn-up 41,000 MWd/tU

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1. Introduction

With the development of high burn-up fuels, the microstructural changes like as the formation of the many pores and the small grains and the change of the UO_2 lattice size in a periphery of a fuel pellet have been observed [1-4]. Even though a periphery (rim) of a fuel pellet has thin layer within a few hundred micrometers in thickness, affects the thermal conductivity of the nuclear fuel. Therefore, the microstructural characters in a rim have investigated by many researchers.

In this study, the lattice parameter change was investigated for a spent nuclear fuel pellet of average burn-up 41,000 MWd/tU involving a rim and the diffraction pattern was measured for a pellet/clad interface by a radiation shielded micro-XRD.

2. Experimental methods

The sample for the diffraction analysis was a spent fuel of the average burn-up 41,000 MWd/tU discharged from Yeonggwang-2 nuclear power plant. The spent fuel specimen was prepared by cutting in the size of 5 x 3 x 0.5 mm including the core, rim and a clad, molding with the epoxy resin and then polishing on the surface (Fig.1).

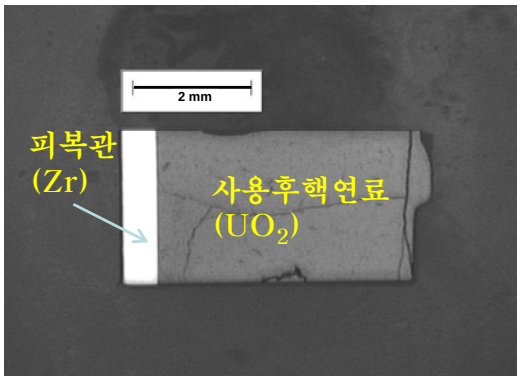

Figure 1. Spent fuel of average burn-up 41,000 MWd/tU discharged from Yeonggwang-2 nuclear reactor.

The radial analysis of UO_2 lattice parameter for the spent fuels was done with a micro x-ray diffraction system modified and lead shielded in our laboratory [5].

3. Results

Fig. 2 shows the lattice parameter change of UO_2 with cubic phase (a=b=c) in about 3.5 mm range from a interface of a pellet and a clad to the core of a spent fuel of average burn-up 41,000 MWd/tU by micro-XRD. The lattice parameter values decreased from about 150 um position to 0 position of the interface of a UO_2 pellet and Zry-4 clad due to the recrystallization of UO_2 by the high burn-up structure (HBS). And, the lattice parameter values also decreased from about 150 um position to 300 um position inside of a rim and showed constant values to the core due to the thermal healing by high temperature in the center of a fuel.

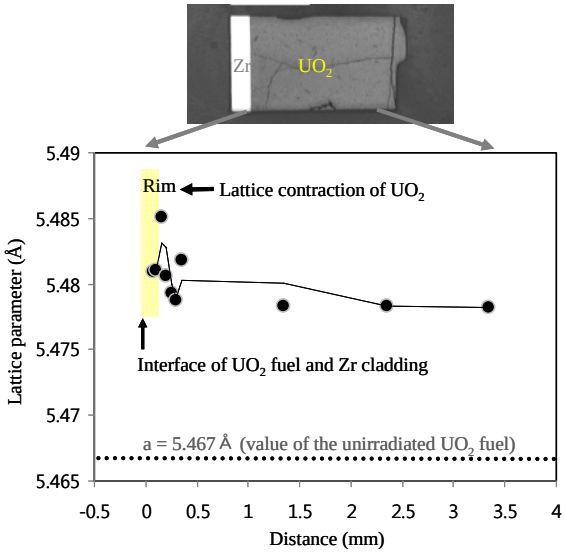

Figure 2. Changes in lattice parameter of UO_2 (cubic) from a rim to the core of a spent fuel of average burn-up 41,000 MWd/tU discharged from Yeonggwang-2 nuclear reactor.

Fig. 3 shows the XRD spectra obtained for a Zry-4 clad from the interface of a UO_2 pellet and a Zry-4 clad to the region inside a clad at intervals of 50 um. In the interface of a UO_2 pellet and a Zry-4 clad, zirconium oxide predicted as a product by the chemical reaction between a pellet and a clad was not detected. This result may be the reaction layer is too thin as a few micrometers in thickness to be detected.

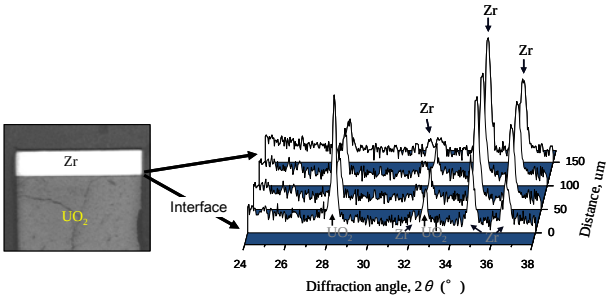

Figure 3. XRD Spectra for the Zry-4 cladding of a spent fuel of the average burn-up 41,000 MWd/tU.

3. Conclusions

Micro X-ray diffraction analysis for a spent fuel of average burn-up 41,000 MWd/tU was carried out. For a UO_2 pellet, the lattice contraction by the high burn-up structure formation in a rim and the lattice recovery by the thermal healing in a core were identified. For the clad, the oxide layer by the chemical interaction between a pellet and a clad was not identified due to very thin thickness.

Acknowledgements

We acknowledge the financial support of Nuclear Development Fund from Korean Ministry of Education, Science and Technology.

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