Preliminary Study on the Phase Behavior of Rare Earth Doped Uranium Oxides using *In-Situ* High-Temperature X-ray Diffraction

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1. Introduction

The phase prediction of nuclear fuel is important to predict its behavior in severe accidents in nuclear power plants. Rare earth (RE) elements have a great influence on the physical and chemical property of the fuel [1]. Therefore, the prediction of ternary U-RE-O phase diagram is important to understand the fuel behavior but it is hard to predict because binary U-O phase diagram and RE-O phase diagram are different [2]. Furthermore, binary U-O phase diagram includes various uranium oxides such as U_4O_9, U_3O_7, U_3O_8, and UO_3.

In the present work, we investigated the phase behavior of rare earth doped uranium oxides by using *in-situ* high-temperature X-ray diffraction. The phase behavior was inferred from the crystallographic data.

2. Experimental

The mixture of uranium dioxide and rare earth dioxide powders were prepared. The powders was dispersed in ethanol and a drop of the dispersion was placed on the tungsten strip.

The *in-situ* X-ray diffraction patterns was obtained using a Bruker D8 Advance diffractometer equipped with a HTK 2000N (Anton Paar) heating chamber. Cu Kα radiation at a voltage of 40 kV and a current of 40 mA filtered through a nickel foil was used as X-ray source. X-ray diffraction patterns was recorded in the scan range 20-80º, scanning step of 0.02º, and step time of 0.1 s. The temperature ranges were 25 ºC – 2300 ºC by considering the embrittlement of the cladding occurs at 1975 ºC, in terms of severe accident [3].

The lattice parameter were refined and calculated based on the Pawely refinement.

3. Results and Discussion

The evolution of the lattice parameter of uranium oxide obtained by X-ray diffraction pattern refinement as a function of temperature represents in Fig. 1. The lattice parameter was expected to a linear increase with temperature due to the thermal expansion. However, a large lattice parameter decrease was observed between 300 K and 1800 K during heating. It seem to be because of the phase transition of U_4O_9 from UO_2. The phase transition is possible even at relatively low temperature because the structure of U_4O_9 are similar with that of UO_2. The large increase of lattice parameter above 1800 K indicates that the phase transition of UO_2 from U_4O_9.

On the other hand, a linear decrease of lattice parameter with temperature was observed during the entire cooling, indicating a monophasic uranium oxide. After the cooling, the lattice parameter of uranium oxide at room temperature was equal to that of UO_2. The linear increase and decrease of lattice parameter is due to the thermal expansion and thermal contraction of UO_2, respectively.

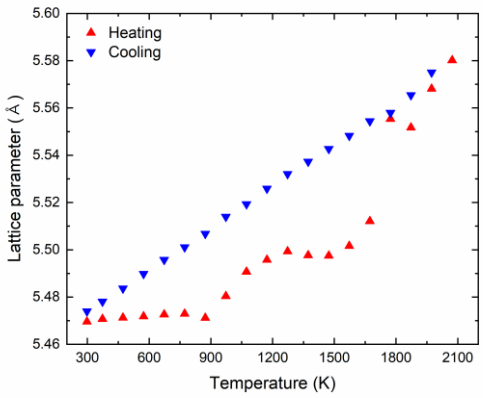

Fig. 1. Evolution of the lattice parameter of uranium oxide as a function of the temperature

4. Conclusions

The phase behavior of rare earth doped uranium oxides was investigated by in-situ high-temperature X-ray diffraction. The effects of rare earth element to uranium dioxide was inferred from the evolution of the lattice parameter. Further works will be carried out to measure the physical and chemical property of various rare earth doped uranium oxides.

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