

Study on crystal structure of $U_{1-y}Ln_yO_{2-x}$ ($Ln=Gd, Er$) solid solution $U_{1-y}Ln_yO_{2-x}$ ($Ln=Gd, Er$) 固溶体の結晶構造に関する研究

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The crystal structure of $U_{1-y}Ln_yO_{2-x}$ ($Ln=Gd, Er$; $y=0-0.4$) samples sintered at 1700 °C for 4 hours under reduction conditions is investigated by XRD and XAFS measurements.

Keywords: UO_2 , burnable poison, crystal structure, XRD, XAFS

1. Introduction

Burnable poison fuels ($UO_2-LnO_{1.5}$; $Ln=Gd, Er$) are widely used in LWR to control the initial reactivity. In this study, the effect of $LnO_{1.5}$ doping on the crystal properties of $UO_2-LnO_{1.5}$ samples was evaluated by XRD and XAFS measurements because it gives a change in thermo-physical properties such as thermal conductivity and melting point.

2. Experimental

2-1. Sample preparation: The disk-shaped $UO_2-LnO_{1.5}$ samples were sintered at 1700 °C for 4 hr in an Ar gas flow. The sintered samples were observed by SEM, and their chemical compositions and element distributions were analyzed by the EDS.

2-2. Phase identification: The XRD measurements were performed at room temperature to determine the lattice parameter of the fluorite structure for above $UO_2-LnO_{1.5}$ solid-solution samples.

2-3. X-ray Absorption Fine Structure (XAFS): The X-ray absorption measurements near U L_3 , Gd L_3 , and Er L_3 -edges were carried out at room temperature with synchrotron radiation (KEK-PF). Based on the EXAFS function $k^3\chi(k)$ and Fourier transform magnitude $|FT(k^3\chi(k))|$, the structural parameters such as oxidation state, coordination number, interatomic distance of the first peak corresponding to the nearest cation-oxygen pair were obtained.

3. Results and discussion

The lattice parameter of $UO_2-LnO_{1.5}$ decreased with increasing $LnO_{1.5}$ content (Fig. 1). The interatomic distances of U-O and Ln-O in $U_{1-y}Ln_yO_{2-x}$ decreased with a very small change when $LnO_{1.5}$ is added (Fig. 2). The change of crystal structure for such solid solutions results from (1) doping of $LnO_{1.5}$ and (2) oxidation U^{4+} to U^{5+} ion. In the case (1), oxygen vacancies are simultaneously generated. On the other hand, the ionic radius increases in the order: $U^{5+} < U^{4+} \leq Ln^{3+}$. Thus, the case (2) caused these results in the present study.

References

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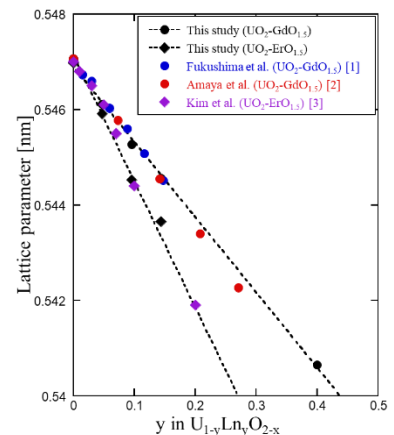


Fig. 1. The lattice parameter of $UO_2-LnO_{1.5}$ samples as a function of $LnO_{1.5}$ content.

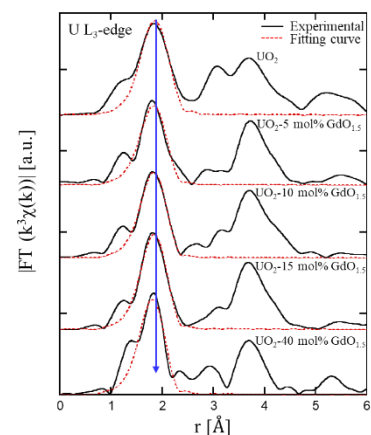


Fig. 2. U L_3 -edge FT magnitude function of $UO_2-GdO_{1.5}$ solid solution.