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Oxidation of cladding for spent $(U,Gd)O_2$ fuel

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1. Introduction

The understanding of corrosion of the fuel cladding under the primary circuits, and under the dry storage is very important. It is well known that a corrosion layer of a cladding under the primary circuits is produced by the oxygen and the hydrogen diffusion from the cooling water into the cladding during the operation of a nuclear reactor [1, 2]. In addition, a fuel pellet swells and contacts with its cladding during irradiation, leading to a chemical reaction in the interface [3]. The oxidation results in a thinning of a cladding which affects the safety of fuel pins. Therefore, there have been a lot of studies for the pellet/cladding chemical interaction and the corrosion of a fuel cladding.

In this study, the structural change of a cladding for spent $(U,Gd)O_2$ fuel was investigated by a radiation shielded micro-XRD system. Gd is used as a burnable absorber to extend cycle length [4].

2. Experimental methods

A spent UO_2 fuel containing Gd as a burnable absorber was chosen as a test specimen (average discharged burnup ca. 40GWd/tU). Axial slice of the fuel with 3 mm height was cut along the diameter from cladding to the fuel center into the small piece of 3 mm length as shown in Fig. 1. The slice of test specimen was embedded in the epoxy resin, and then was polished for the analysis. The contact of a $(U,Gd)O_2$ fuel pellet with its cladding was observed as shown in Fig. 1.

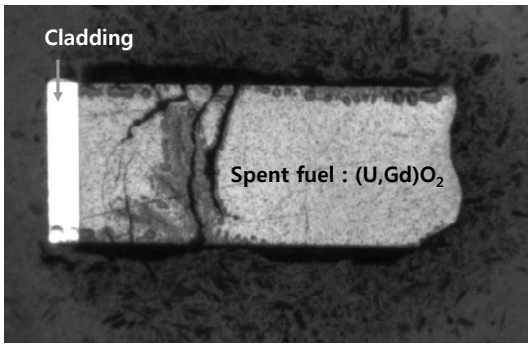

Figure 1. Prepared spent $(U,Gd)O_2$ fuel specimen.

The phase analysis of the cladding was performed by a micro-XRD system consisted of a Cu target and NaI(Tl) scintillation counter detector. The XRD spectra were obtained on the measuring condition of 40 kV-40 mA power, 50 μm(w)× 4 mm(l) exit slit, 1 mm/Ni filter/0.6 mm detector slit and 250 sec./0.04° step measuring time.

3. Results

The structural change of a cladding for spent $(U,Gd)O_2$ fuel was investigated. Zirlo was used as a cladding material for this fuel.

Fig.2 shows an X-ray diffraction spectrum of the inner layer (a) and outer layer (b) of the irradiated cladding. The peaks of uranium dioxide and zirconium metal were observed in the inner layer, while small peaks of zirconium oxide were observed in the outer layer.

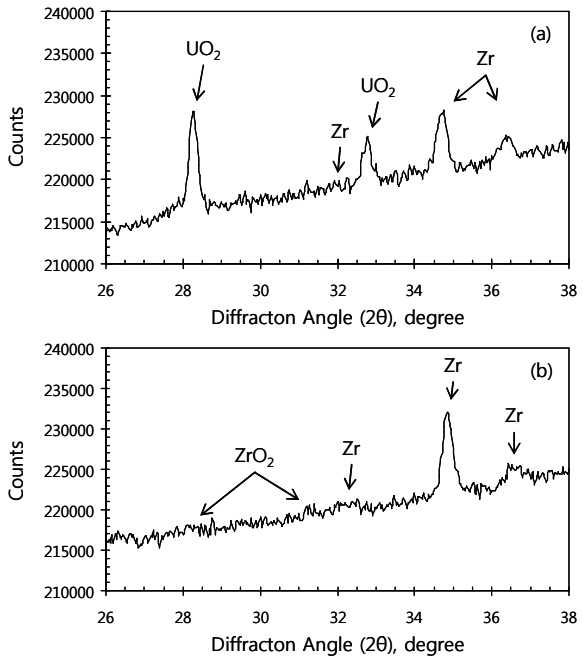

Figure 2. XRD Spectrum of a zirlo cladding: (a) the inner layer, (b) the outer layer.

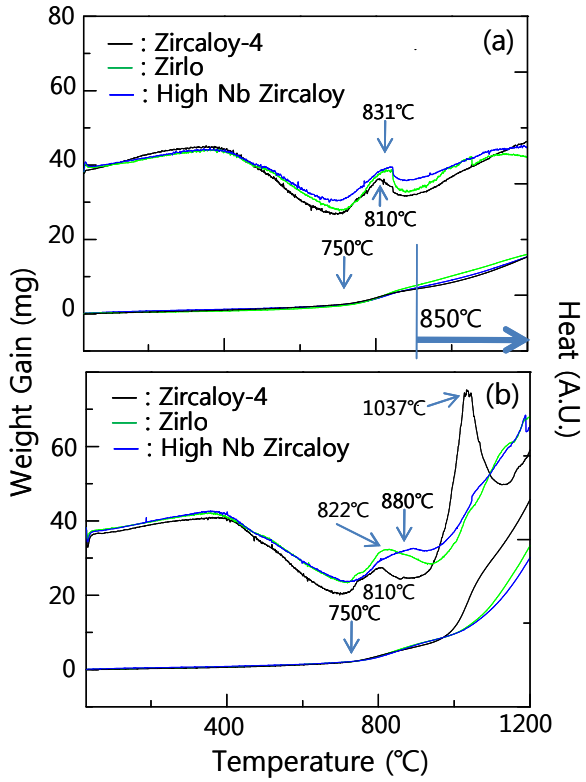

Figure 3. TG-DTA curves for the Zircaloy oxidation under oxygen. [stay 5 hours at 850℃ (a); continue to 1200℃ (b)]

The oxidation-kinetic curve of zirlo was obtained to understand oxidation behavior of the cladding material, and it was compared to that of zircaloy-4 and high Nb zircaloy as shown in Fig. 3. The oxidation-kinetic curve showed that Zr alloy is expected to be comparatively stable against oxygen at the cladding temperature under the PWR operation condition.

3. Conclusions

The changes of micro structure for a fuel cladding involving the interaction layer with the fuel and also cladding outer surface were measured by a micro-XRD. The Zr oxidation in the inner layer was not observed in the inner layer of fuel cladding (40GWd/tU) by micro XRD-system, while small peaks of zirconium oxide were observed in the outer layer. The oxidation-kinetic curve also showed that the cladding is expected to be stable against oxygen under the PWR operation condition.

Acknowledgements

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