Chemical interaction between Sr compounds and Zircaloy

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Abstract

In the accident of Fukushima Daiichi nuclear power station, release of Sr from fuel would be enhanced by formation of volatile $SrCl_2$, and thus chemical reaction of Sr onto reactor structural material such as Zircaloy (Zry) would occur. Chemical interaction between Sr related compounds and Zry were therefore investigated to elucidate such a chemical behavior. As a result, $SrCl_2$ vapor does not directly react with Zry.

Keywords: Chemisorption, Strontium, Zircaloy

1. Introduction

Strontium (Sr) source term is one of the most important issues for the decommissioning and dismantling of Fukushima Dai-ichi Nuclear Power Station (1F-NPS) in views of its abundance and lasting radioactivity. The accident of 1F-NPS shows the possibility of Sr release from the fuel, although Sr is categorized to non-volatile fission product under steam atmosphere [1]. One of the possible reason is the changes in volatility of Sr compounds in fuel pellet to a high volatility by specific conditions in 1F-NPS: reduction of Sr oxide to Sr metal in steam-starvation atmosphere [2], and/or the formation of $SrCl_2$ by a reaction with sea water [3]. However, if these Sr vapor species released from fuel pellets react with Zircaloy (Zry) cladding to form stable compound such as strontium zirconate, the Sr release behavior into Reactor Pressure Vessel (RPV) should be altered. In this study, we therefore carried out two kinds of basic interaction tests between Sr compounds (SrO, $SrCl_2$ and $Sr(OH)_2$) and Zry.

2. Experimental

The materials used for Sr compounds/vapor species were powders of $SrCl_2$ (99.5%), SrO (98%) and $Sr(OH)_2$ (99%). For the vapor-solid reaction test, $SrCl_2$ vapor was reacted with the Zr-liner Zry-2 tube at 1273 K for 2h under H_2/H_2O/Ar atmosphere. On the other hand, solid phase reaction tests were carried out using SrO and $Sr(OH)_2$ with the Zry-2 tube. Thermogravimetric (TG) and differential thermal analysis (DTA) analysis was carried out at 1373 K under Ar/4.5%O_2 and Ar/4.5%O_2/H_2O for the solid phase reaction test. The reacted Sr compounds onto Zry were characterized by using XRD and SEM/EDX to identify the chemical form.

3. Results and discussion

SEM/EDX analysis for the surface of Zry specimen of the vapor-solid test was shown in the Figure 1. The mapping analysis shows Sr and Cl rich region onto the matrix phase. This result indicates that $SrCl_2$ vapor did not react directly with Zry at this temperature. On the other hand, according to the thermodynamic calculation, SrO/$Sr(OH)_2$ solid will react with Zry. These solid reaction results will be discussed in the presentation.

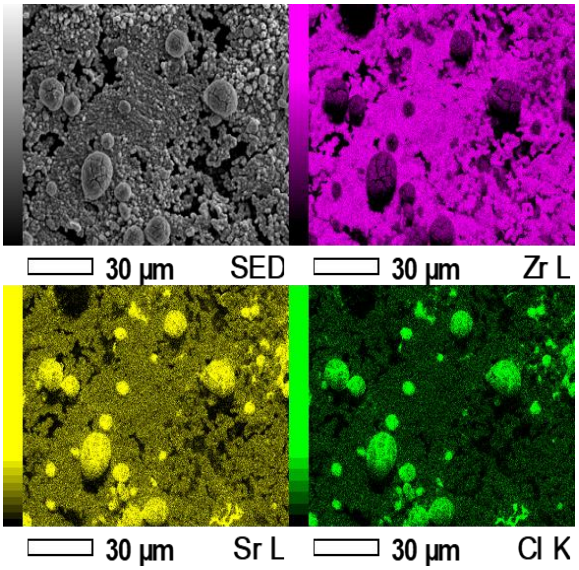

Figure 1 SEM/EDX analysis of $SrCl_2$ deposited onto Zry surface specimen.

References

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