Study of changes in melting behaviour of the UO_2-Zircaloy-2 system induced by addition of magnetite at temperatures 2000 and 2100 °C

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Abstract: Interactions in two systems UO_2-Zircaloy and UO_2-Zircaloy-magnetite were studied at temperatures 2000 and 2100 °C during 30 min in argon atmosphere. It was shown that presence of relatively small amount of magnetite in UO_2-Zircaloy system suppresses UO_2 dissolution in Zr melt and affects the composition of new-formed phases.

Keywords: fuel, cladding, interaction, corium, magnetite

Introduction

An interaction between UO_2 fuel and Zircaloy (Zry) cladding is a well-known process taking place during severe nuclear accident with core melting. In case of the 1F accident, due to considerable amount of stainless steel one could expect the influence of steel and steel oxidation products to the process of fuel debris formation [1]. This paper supposed to improve the understanding of UO_2-Zry-Fe_3O_4 system behavior during melting at temperatures 2000-2100 °C.

Results and discussion

A possibility of U diffusion from oxide phase to metallic melt was studied at temperatures 2000 and 2100 °C in argon atmosphere. The molar ratios UO_2 : Zry and UO_2 : Zry : Fe_3O_4 were 15 : 1 and 15 : 1 : 0.15, respectively. Despite the low molar ratio of Fe_3O_4/Zry, after 30 min of interaction the average bulk content of U dissolved in the melt was about 6 times lower for UO_2-Zry-Fe_3O_4 system than for UO_2-Zry. At both temperatures, 2000 and 2100 °C, main phases after UO_2-Zry-Fe_3O_4 interaction were Fe-Zr-O, ZrO_2, α-Zr(O), and Zr-Fe-U-O with U content varied from 1 at.% to 20 at.% (Figure 1). When Fe_3O_4 reacted together with Zry, the volume fraction of the typical corium phase $(U,Zr)O_2$ became almost negligible. Several minor inclusions of $(U,Zr)O_2$ phase were found in the local area of the sample. System UO_2-Zry at temperatures 2000 and 2100 °C showed formation of U-Zr-O solid solutions of various composition and α-Zr(O) phase which is in a good agreement with previously published data [2].

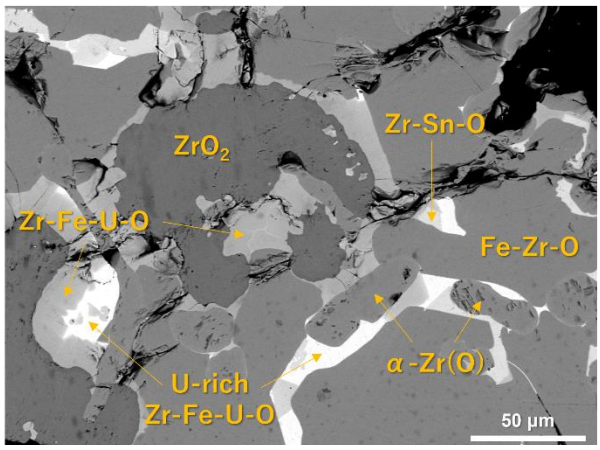

Figure 1. Components of the melt after reaction at 2100 °C.

Conclusion

The results obtained allow suggesting that presence of iron oxide may suppress the UO_2 dissolution in a Zry melt during severe accident progression and significantly affects the phase composition of new-formed fuel debris.

References

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