The Caesium Retention Phenomena Related to Oxidation of the Reactor Coolant Boundaries Materials

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Abstract: Cs retention/chemisorption mechanism onto Stainless Steel (SS) & Ni-based alloys on the various temperature are being identified. Besides the importance of Si solute element that is already known, Ti is also detected playing an important role, especially at temperatures below 1050°C.

Keywords: caesium, retention, chemisorption, coolant boundaries materials, solute elements, titanium

1. Introduction

Cs chemisorption behaviour is important for understanding severe accidents. Previous studies show that the minor elements, such as Mo, Si and B, have significant influence on the amount of absorbed Cs and their stability onto stainless steels (SS). Ni-based alloys are expected to show similar tendency to SS because they have similar oxide films on surface. However, solute Ti may change the Cs chemisorption behaviour forming different type of oxide film. This study intends to identify the effect of Ti for the Cs retention phenomena onto both SS and Ni-based alloys.

2. Experiment

The experiment is being conducted using fine polished SS 304, Inconel 600 & X-750 specimens those having different solute elements and pure Ti as the control material within CsOH as the precursor. Unoxidized and oxidized specimens were prepared. Oxide films have been growth under ambient air environment for 3 days at 300, 450, 600, 750, 900 & 1050°C. CsOH has been put on the surface of both oxide and unoxidized specimens then heated at CsOH melting point (272°C) for 1 hour to make sure the entire surface of the specimens is well-covered. Then the temperatures were increased at the respective values for 6 hours for oxidized specimens and 3 days for unoxidized specimens. Hereinafter, those specimens have been soaked on water and ethanol to remove the unstable structures on surface. Characterization has been done for each step using an optical microscope, XRD, SEM/EDX for surface and cross-section observation.

3. Results

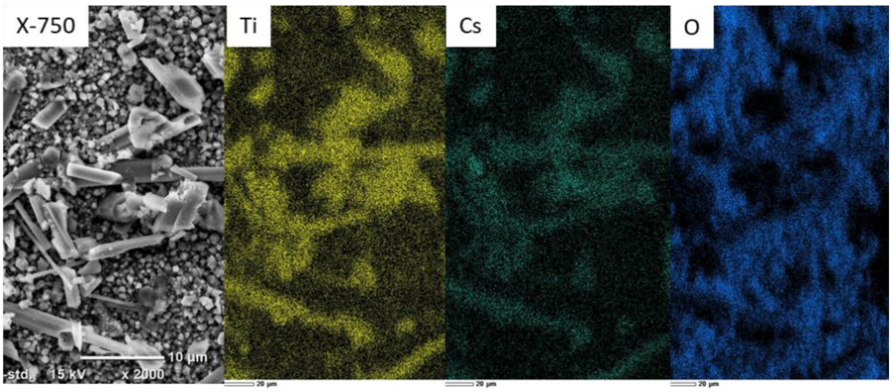

Fig. 1 – Oxidized X-750 + CsOH at 900°C after soaked by water

All samples surface at 300 & 450°C are hydrophilic indicating a large amount of CsOH are remain caused by slow reaction and evaporation rates. Interestingly, even if at 600°C SS 304 is still easy absorbing humidity, but in the opposite, both Inconel 600 & X-750 are dry, indicating CsOH is well reacted by forming more stable compounds such as Cs-Cr-O & Cs-Fe-O compounds. The small amount of Cs-Al-Si-O, and/or Cs-(Fe)-Si-O compounds are remaining after soaking within the higher amount on all oxidized specimens. Similar to the previous studies, Cs diffuse deeply onto SS304 at 750°C and higher temperature along the grain-boundary. Cs-Ti-O compounds was observed trapped by crack/explosive fracture on Inconel 600. In contrast, Cs-Ti-Si-O was found on the surface of X-750 at all temperature bellow 1050°C as shown in the Fig. 1.