High-temperature steam oxidation of 304 stainless steel in argon gas containing cesium molybdate

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Abstract
The oxidation behavior of 304 stainless steel (304 SS) in (argon + steam) mixture gas containing cesium molybdate will be examined over the range 530 to 1300°C from 1 to 9 hours. The surface and cross-section of SS304 will be analyzed by X-ray diffraction, micro-Raman and electron probe micro analyzer.

Keywords: cesium molybdate, 304 stainless steel, oxidation, severe accident

1. Introduction

After the Fukushima Daiichi nuclear accident, the reaction between cesium compounds such as cesium hydroxide (CsOH) and cesium molybdate (Cs_2MoO_4) with stainless steel has received great attention. In the previous study, Cs_2MoO_4 was supposed to decompose in the steam environment, both cesium (Cs) and molybdenum (Mo) oxides diffused into the oxide layers of stainless-steel [1]. In literature, it has been declared that Cs in the form of CsOH could react to silicon (Si) formed cesium silicate or cesium iron silicate [2]. Moreover, molybdenum has been detected in the iron oxides layer [1]. Besides the reaction that could form between Cs and Mo with components in stainless steel, it is important to evaluate how the depth of Cs or Mo has diffused as well as the location where Cs and Mo could exist inside the oxide layer.

2. Experiment method

SUS304 species with dimensions of 15×10×1 mm were polished by emery paper and buffing before the steam oxidation. Cs_2MoO_4 was placed at 1300 °C in a platinum (Pt) boat. From one side of the alumina tube, Ar gas containing H_2O which was kept at about 70°C was injected, flowed passing through the tube, and carried the Cs_2MoO_4 vapor which was generated at high temperature. On the other side of the tube, SUS304 specimens were placed at different positions where correspond to the temperature at 1300, 1200, 1000, 700, and 530°C. The oxidation time of interest were 1, 3, and 9 hrs. After heating, the surface of the specimens was analyzed by X-ray diffraction and micro-Raman. The elemental distribution was performed by the electron probe microanalyzer. The thickness of the oxide layer was estimated by the observation of cross-sections.

3. Results

Figure 1 shows the cross-section of SUS heated in Ar+H_2O for 9 hours at 1300°C. The surface layer was Fe_3O_4 and Fe_2O_3, which were identified by XRD. Cs was detected not only in the iron (Fe) oxide layer but also in the iron chromate ($FeCr_2O_4$) area where existed under the Fe oxide layer. This proved that Cs_2MoO_4 has been decomposed into cesium oxide (Cs_2O) and molybdenum oxide (MoO_3). From the BSE images, there were pores in the Fe oxide layer, these pores were supposed to be Cs_2MoO_4 or maybe cesium dimolybdate, but were removed during cutting and polishing the cross-section.

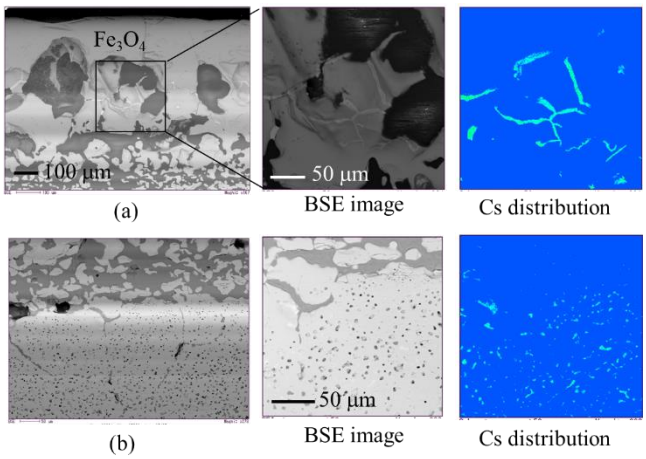

Figure 1. BSE image and Cs distribution in oxide layer of stainless steel heated for 9 hours in steam environment.
(a): upper part of oxide layer
(b) lower part of oxide layer

References

[1] Presentation at: The Annual meeting of the Atomic Energy Society of Japan; 2015, Mar 20-22; Ibaraki, Japan.
[2] M. Kobata, T. Okane, K. Nakajima, E. Suzuki, K. Ohwada, K. Kobayashi, H. Yamagami, M. Osaka, *J. Nucl. Mat.*, **498**, 387 (2018).