Effect of Titanium on the Cs Chemisorption of Stainless Steel

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Abstract: The effect of Ti and oxidation on the Cs chemisorption of stainless steel (SS) on various temperatures had been identified. Ti was found to effectively suppress the Cs to be chemisorbed between the inner and outer oxide layer.

Keywords: cesium, chemisorption, retention, oxidation, stainless steel, titanium

1. Introduction

Previous studies show that the minor elements, such as Mo, Si, and B significantly influence the Cs chemisorption and their stability onto stainless steels (SS). Another element such as Ti is also common to be used to improve SS oxidation resistance. Ti as well as the oxide film transformation may change the Cs chemisorption behavior. This study intends to identify the effect of Ti for the Cs retention phenomena onto SS.

2. Experiment

The experiment had been conducted using finely polished (10 mm x 10 mm x 0.5 mm) SS 304 and 321 with almost similar element concentrations except for the existence of Ti for ~0.7wt.%. Different pre-oxide films were grown under ambient air environment at 300, 450, 600, 750, 900 & 1050°C temperatures for 3 days. The thin layer of ~0.5 g CsOH was formed on those specimens at its melting temperature (272°C) for 1 hour. Then the temperatures were increased at the respective values for 6 hours. Hereinafter, those specimens were soaked in water and ethanol using the ultrasonic cleaner for 180 s respectively then dipped on acetone for 2 s. Characterization has been done for each step using an optical microscope, XRD, SEM/EDX for surface and cross-section observation.

3. Results

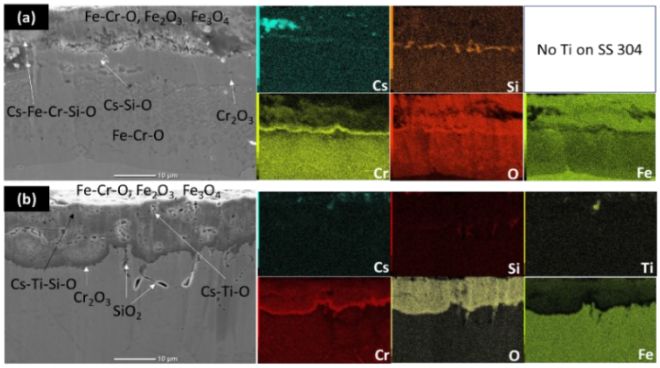

Fig. 1 – Cs can be found between inner and outer oxide layer of (a) SS 304, and only retain on/in the outer oxide layer of (b) SS 321 specimens treated at 900 °C.

Ti was found to gives insignificant impacts to the Cs concentration on the surface of 300°C & 450°C treated specimens. Nevertheless, small sticky particles related to the Cs-Al-Ti-Si-O chemical systems on the outer oxide layer of SS 304 and 321 were observed. The significant impact of Ti was identified at elevated temperatures when the oxide layers grow thicker. As shown by Fig. 1, instead of forming Cs-Si-O as happen between the inner and outer oxide layer of SS 304, Ti can be observed to interact with Cs by forming Cs-Ti-O only on/in the outer oxide layer of SS 321. Relatively high Cs concentration still can be observed on SS 304 specimen treated at 1050°C, but could not be observed in the case of SS 321. The different chemisorption characteristics of those materials can be postulated by assuming; (1) Cs formations that were found between the inner and outer oxide layer of SS 304 are not caused by Cs diffusion. Cs may firstly be chemisorbed on the pre-existing oxide layer then be overlapped by the growth of iron oxide as the outer layer. (2) Cs that only could be observed on/in the outer oxide layer of SS 321 treated at 900°C specimen and completely disappear at 1050°C are influenced by Ti. Ti strongly reacts with Cs forming higher evaporation rate compounds then keeps its compounds on/in the outer oxide layer as well as makes them easily disappear especially at 1050°C.