The corrosion Characteristics and Behaviors of the Ti-2.19Al-2.35Zr alloy

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1. Introduction

Ti-2.19Al-2.35Zr alloy is being considered as a steam generator tube material for the advanced pressurized water reactor (PWR) which is being developed by KAERI for the purpose of seawater desalination as well as a small-scale electricity production [1]. The main operational environment of SMART differs somewhat from that of a commercial PWR. That is, a heat-exchange tube is always exposed to a high temperature/pressure condition and an ammonia water chemistry is designed as a pH controlling agent without an addition of boric acid. The excellent mechanical and corrosion resistance properties are required for the steam generator tube material in SMART. Thus Ti-2.19Al-2.35Zr alloy was studied to investigate of the corrosion characteristics and behaviors of the Ti-2.19Al-2.35Zr alloy in a simulated-SMART loop [2].

2. Experimental

The Ti-2.19Al-2.35Zr alloy was annealed in a high vacuum at temperatures from 600 to 1050°C for 1h and then water quenched. Optical microscope (OM), scanning electron microscope (SEM), and transmission electron microscope (TEM) were used for the analysis of the microstructural characterization and the properties of oxides. For the preparation of TEM specimen, focused ion beam (FIB) system based on high-brightness gallium liquid-metal ion sources was used. The use of FIB systems made it possible to produce in-situ stress-free bulk cross-sections and precision cross sectional transmission electron microscopy specimens.

The Ti-2.19Al-2.35Zr alloys annealed with the different heat-treatments were evaluated in the SMART simulated loop in an ammonia aqueous solution adjusted to pH 9.98 at 360°C under a pressure of 18 MPa for 400 days using simulated loop systems. The water chemistries in the inlet of heating zone were constantly controlled and the corrosion kinetics was periodically determined by the weight gain method.

3. Results and Discussion

3.1 Observation of the Ti-2.19Al-2.35Zr alloy oxide

The cross sectional oxide layers grown in the Ti-2.19Al-2.35Zr alloy after corrosion in the simulated-SMART loop system were found through the OM and SEM observation. The cross sectional TEM images of the as-received Ti-2.19Al-2.35Zr alloy after 50-day corrosion test are shown in figure 1. A development of the oxide grown in the Ti-2.19Al-2.35Zr alloy with the corrosion time was observed. TEM/EDS showed the composition of the oxide determined to be 42.57Ti, 55.4O, 1.19Al, and 1.83Zr by at.%. As the corrosion proceeded, a further nucleation and development of the oxide grains occurred across the surface.

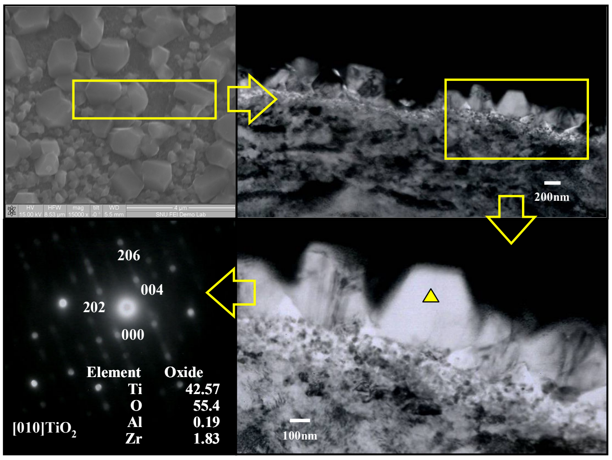

Fig. 1 TEM provided by FIB system for the Ti-2.19Al-2.35Zr alloy after 50 days corrosion test

3.2 Corrosion behaviors

Figure 2 shows the corrosion behavior of the Ti-2.19Al-2.35Zr alloy in the simulated-SMART loop system. The initial corrosion rate rapidly increased during the 150 days but decreased with a further corrosion time. This might be the result from a compact protective layer that formed on the surface of the Ti-2.19Al-2.35Zr alloy [3], and these results showed that the excellent corrosion resistance could be correlated with the thickness of the protective oxide layer [4].

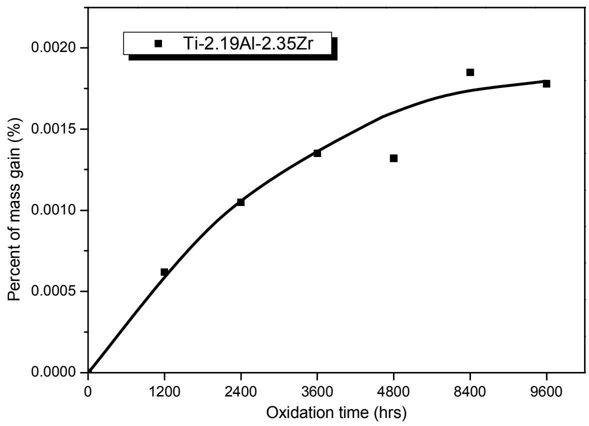

Fig 2. Corrosion behavior of the Ti-2.19Al-2.35Zr alloy in 360℃ simulated-SMART loop for the 400days

The thickness of the oxides and the metal-oxide interfaces were measured for the specimens which were oxidized for 50, 150, and 300 days respectively and the results are shown in figure 3. These results are well matched with the trends of percentage of mass gain with increasing corrosion time.

The oxides grown in the alloy were composed of a double layer structure, and the inner layer (interface layer) was covered by the outer layer of the outer oxide grains [5].

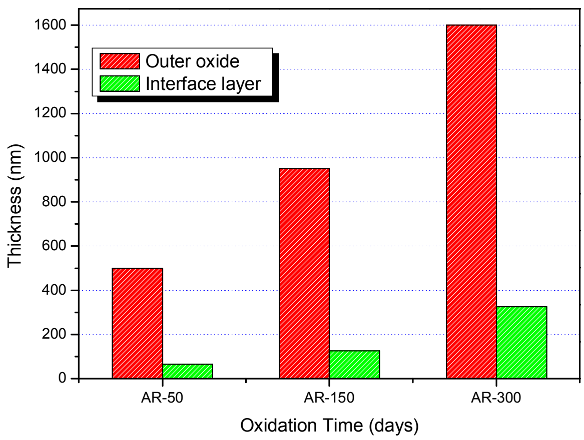

Figure 3. The growth of the oxide and interface thickness as the increase of the oxidation time

4. Conclusion

In this study, the corrosion characteristics and behavior of the Ti-2.19Al-2.35Zr alloy were evaluated. The TEM images for the oxide showed the growth of the oxide and oxide-metal interface as weight gain increases with an increase of the corrosion time. And the corrosion behaviors of the alloy showed that the corrosion rate would be decreased and saturated after 150 days and the transformation from a metal to titanium oxide is related with the weight gain.

ACKNOWLEDGEMENT

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