The static Pb-Bi corrosion test of the coated austenitic 316L at 600^oC

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1. Introduction

Lead-Bismuth eutectic (LBE) alloy was determined as a spallation target and coolant material of the HYPER [1] (HYbrid Power Extraction Reactor) due to its high production rate of neutrons and effective heat removal. However, LBE has a great corrosion problem over more than 400℃ because the solubility of Fe, Cr and Ni is high[2]. Thus, the problem has been considered as an important design-factor that limits the operational temperature and flow velocity of the ADS system.

Therefore the main objective of this study is introduction of static corrosion test in LBE at 600℃. Static corrosion tests are useful to investigate the corrosion properties and modes of various kinds of materials to develop corrosion resistant materials for liquid metal.

Corrosion data have been obtained on as-received and active coating materials of 316L in stagnant lead-alloy containing reduced atmosphere of oxygen with the exposure time of 1500 hours at 600^oC. After the test, the specimens were analyzed metallurgically using a scanning electron microscopy (SEM) with energy dispersive X-ray analysis (EDX) on the cross section of the specimens In addition, X-ray diffraction(XRD) was performed to evaluate the phase composition of steels

2. Methods and Results

2.1 The static corrosion test facility

Fig. 1 shows the schematics of the static corrosion facility recently installed at KAERI. It is mainly composed of tube furnaces, a gas system and a glove box. The furnace discharges all the parts of the experiment, putting the specimen in Pb-Bi, which has a PID controller of a 3 Zone Type. It improves the reliability of the experiment by minimizing the temperature variation (±1℃) for each section along the test tube made of quartz with a 70mm inner diameter and 700mm length. The rail and tray inside of the Quartz Tube make it possible to control the movements. Also, six crucible holes on the tray make it possible to measure the oxygen concentration and temperature of the Pb-Bi in each crucible. Each crucible was designed to put maximum 4 samples at the same time, which has the advantage of obtaining reliable data. The dimension is 110 × 700(mm). The capacity is 10kw and the maximum operation temperature is 800℃. Because heated gas goes to the outlet during the experiment, a three stage heat filter was installed to prevent the O-ring part from being heated. In carrying out the corrosion experiment by controlling the oxygen, exposing to the specimen to air causes contamination by oxidation. This is the reason why we can not obtain reliable data. So a part of the furnace is linked to the glove box, which made it possible to start and finish the work in the glove box. The many intervals between them show why it is hard to control the oxygen concentration and humidity if the glove box is affected by the high temperature of the furnace link. By attaching a cooling pan between them, room temperature can be maintained during the experiment all the time.

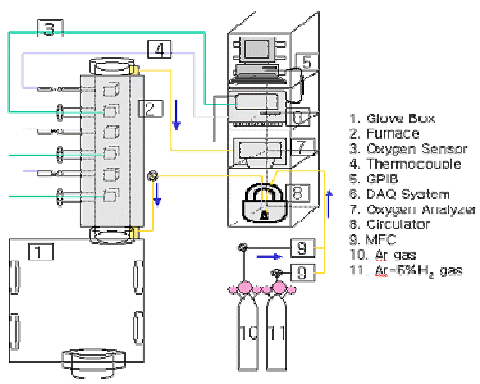

Fig. 1 Schematics of the static corrosion test facility

2.2 Active coating method

Nitrogen ion implantation is considered as a coating method that improves a chemical and mechanical property of material surface. Nitrogen ion implantations were performed using the 100keV ion beam generator operated by proton engineering frontier project of KAERI. The acceleration voltage of 75keV and a beam current of 0.8mA were employed for the investigation. The specimens were implanted at dose rate of 1×10^{17} ions/cm^2.

2.3 Experiment procedure

The static corrosion tests were performed with the exposure time of 1500 hours. The oxygen contents is to $<10^{-8}$ wt% at the temperature of 600℃. The sample surface is mechanically polished using SiC paper and to a 0.5 alumina finish, degreased ultrasonically in acetone and dried. X-ray diffraction measurements were carried out to characterize the surface phase composition after active coating. After corrosion tests, Energy dispersive X-ray analysis (EDX) was used to analyze the chemical composition of each specimens.

2.4 The result of active coating test

Fig. 2 shows the XRD analysis of the samples before and after ion implantation of 316L. These were employed with quite a few nano-depth, and analyzed using thin film attacher that fixed angle of incidence with the range of 1 to 3°. As-received material was performed with a normal analysis at 2θangle. Ion-implanted materials equally formed a new nitride of Fe_2N. Especially, a nearby 74° peak appeared to be a part of Cr_2N compound forming on ion-implanted 316L. Therefore we can certify that these play an important role in corrosion resistance at reduced oxygen concentration in high temperature

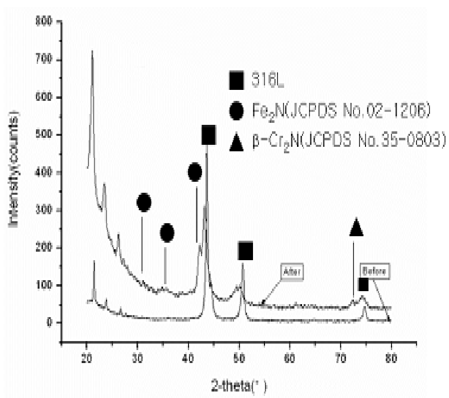

Fig. 2 XRD analysis compared with before and after ion implantation of 316L

3. Conclusion

Considering the above results, we can make a conclusion that compounds such as strong Cr_2N or Fe_2N defense in a reduced oxygen concentration and high temperature.

ACKNOWLEDGMENTS

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