§3. Fabrication of Erbium Oxide Coatings by Arc-Source Plasma Deposition Device for Vanadium-Lithium Blanket System

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A self cooled vanadium-lithium blanket is one of the most attractive blanket concepts for its continuous operation, low neutron reactivity and high operation temperature. However, there is a serious issue called MHD (Magneto-hydrodynamics) pressure drop, which is Lorentz force towards the opposite direction of liquid lithium flow caused by interaction of magnetic field and lithium. This Lorentz force (***F***) is described as;

$$\vec{F} = \frac{(2b)^2}{R} \bullet \vec{v} \times \vec{B} \times \vec{B} \qquad (1)$$

Here, magnetic field (***B***), liquid lithium flow velocity (***v***) and length of pipe wall (*2b*) can not be reduced extremely because of the reactors operation. It is considered to enlarge resistance of the pipe wall (*R*) for reducing MHD pressure drop by establishing insulator coatings on inner pipe wall. Candidate materials of these insulator coatings are quite limited because liquid lithium has high reductivity and dissolves oxides or nitrides. From this viewopoint, candidates of the insulator coatings were chosen by means of exposure of bulk ceramics to liquid lithium. By the results of the experiment, erbium oxide (Er_2O_3) is considered as one of the best candidate material for the coatings [1]. In this report, the coatings of erbium oxide were fabricated and exposed to liquid lithium at up to 973 K for 100 hours, and observed their properties and corrosion behavior.

In this study, coated specimens were fabricated by arc source plasma deposition [2]. The coatings were fabricated on room temperature substrates or on high temperature (which is above 849 K) substrates. The specimens were put into molybdenum capsules with lithium and the capsules were welded in argon atmosphere. The molybdenum capsule was put into a stainless steel 316 capsule and the stainless capsule was welded in the argon atmosphere. The capsules were heated up to 773 K, 873 K and 973 K for 100 hours. After the exposure, the capsules were opened in argon atmosphere, liquid lithium was melted and the specimens were taken out. The specimens were put into vacuum chamber to evaporate the residual lithium on the surface of the specimens.

For the exposure, Er_2O_3 coated specimens fabricated with the substrate temperature of room temperature (room temperature specimen) and specimens fabricated with the substrate temperature of more than 850 K (high temperature specimen) were used. After the exposure, high temperature specimens showed better results, while the coatings of room temperature specimens were peeled off at 773 K and 873 K. Room temperature specimen exposed at 973 K had a good result as high temperature specimens. These results are shown in Fig. 1. From these results, it is considered that the crystal structure of room temperature specimens were unstable to liquid lithium. These crystal structures were changed after the exposure to be stable to liquid lithium. Figure 2 shows the X-ray diffraction pattern of the samples. The crystal structure of the coatings was changed from room temperature's one to high temperature's one, but these change were promoted when temperature of the exposure becomes higher. Thus the coatings exposed at 773 K had worst result.

References

[1] B. A. Pint, J.H. Devan and J.R. DiStefano, J. Nucl. Mater. 307 (2002) 1344.
[2] A. Suzuki, T. Muroga, H. Maier and F. Koch, NIFS Annual Report 2004

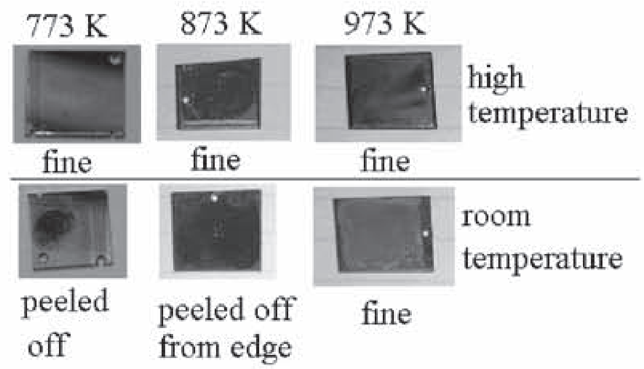

Fig. 1 Photos of specimens after 100 hours exposure

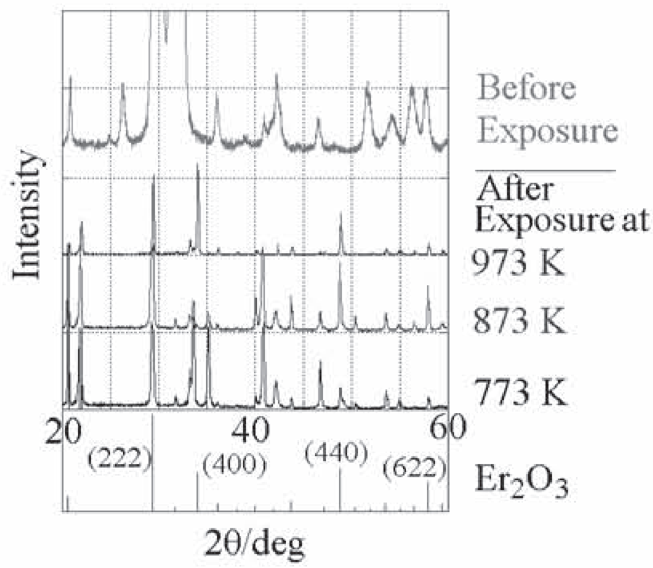

Fig. 2 Difference of crystal structure of the specimens after 100 hours exposure