§6. Corrosion Characteristics of Ferritic Steel JLF-1 in Candidate Breeder Material Pb-17%Li for Liquid Blanket

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Lithium-lead alloy has been one of candidate tritium breeder materials for the liquid blanket of the fusion reactor. One of key issues for the use of the lithium-lead as a breeder material is the compatibility of structural materials with the lithium-lead. In the present study, the corrosion characteristics of a ferritic steel with a low activation property JLF-1 in a static liquid lithium-lead alloy was investigated experimentally.

In order to evaluate the possibility of oxidation corrosion of steel elements in lithium-lead, the Gibbs free energies for oxide formation are compared with oxygen potential in lithium-lead. By assuming the activity of lithium as the weight ratio a,tThe oxygen saturation potential in lithium-lead Φ is given by

$$\Phi = a \times \Delta G^0_{Li2O} + (1-a)\Delta G^0_{PbO} + RT \ln \frac{C}{C_s} \cdot \qquad (1)$$

The calculated result is shown in Fig. 1. It is suggested that Fe and Cr oxides can be formed stably in Pb-17%Li when oxygen is saturated.

A corrosion test of the ferritic steel JLF-1 (8.92Cr-2W) was conducted by immersing specimens in a static Pb-17%Li at the temperature of 600ºC for 250 h. The crucible for the test section was made of JLF-1 to avoid the effect of the other material on the corrosion. Two specimens were tested, i.e., one of them was for measurement of weight loss, and another was used for observation of a steel surface with adhered Pb-Li and corrosion products. The specimen for the measurement of weight loss was rinsed in acetic acid to remove adhered Pb-Li and corrosion products from the specimen surface.

At first, the specimen was rinsed in the acetic acid with concentration of 50% at the room temperature. In this process, acetic lead is formed in the following chemical reaction:

$$2Pb+O_2+4CH_3COOH \rightarrow 2Pb(CH_3COO)_2+2H_2O. \qquad (2)$$

Lithium in Pb-Li dissolved in the acid reacts with water as

$$Li+H_2O=LiOH+1/2H_2, \qquad (3)$$

which forms LiOH. It was found that it took too long time to remove all the lead from the surface because of low temperature of the acetic acid. It may be necessary to increase the temperature of the acetic acid for improvement of the rinse.

Fig. 2 shows the result for the SEM/EDX analysis of the cross section of the specimen surface after the corrosion test. It is found that the contents of Fe and Cr reduced near the interface between the steel and the adhered Pb-Li. There was observed no oxide layer on the surface. This is possibly caused by lower oxygen potential in the Pb-Li than expected. The content of tungsten W is detected in the adhered Pb-Li by the EDX analysis. The adhered Pb-Li was analyzed by ICP-MS. As a result, chromium Cr and tungsten W were detected in the adhered Pb-Li. This suggests the dissolution of Cr and W from the steel into the Pb-Li.

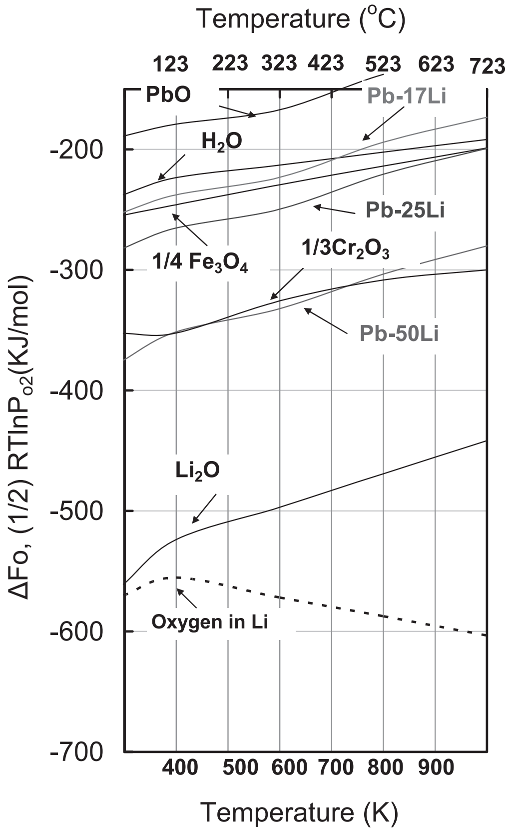

Fig. 1 Comparison of oxygen potentials in Pb-Li and Li with Gibbs free energies of oxide formation

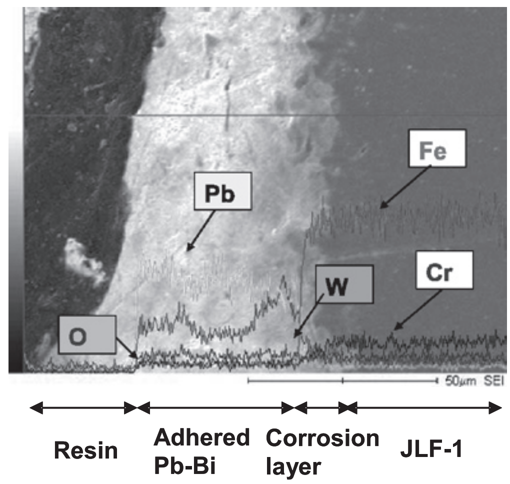

Fig. 2 Cross section of JLF-1 after corrosion test in Pb-17%Li at 600ºC for 250 h