Corrosion Behavior of Al-alloying High Cr-ODS Steels in Lead-Bismuth Eutectic


*Advanced Nuclear System R&D Directorate, Japan Atomic Energy Agency, 4002, Narita, Oarai, 311-1393 Ibaraki, Japan
Japan Aerospace Exploration Agency, Mitaka, Tokyo, Japan
Institute for Pulsed Power and Microwave Technology, Forschungszentrum Karlsruhe GmbH, P. O. Box 3640, D-76021 Karlsruhe, Germany
Kobelco Research Institute, 1-5-5 Takatsukadai, Nishi-ku, Kobe, 651-2271 Hyogo, Japan
Structural Metals Center, National Institute for Materials Science, 1-2-1 Sengen, Tsukuba, 305-0047 Ibaraki, Japan
Graduate School of Engineering, Hokkaido University, N13, W8, Kita-ku, 060-8628 Sapporo, Japan
EcoTopia Science Institute, Nagoya University, Furo-cho, Chikusa, 464-8603 Nagoya, Japan
Institute of Advanced Energy, Kyoto University, 1 Gokasho, Uji, 611-0011 Kyoto, Japan
takaya.shigeru@jaea.go.jp

Development of high corrosion resistant fuel cladding materials is very important for enhancement of the efficiency of a Lead-Bismuth Eutectic (LBE) cooled fusion reactor and a fast breeder reactor. Concerning an Oxide Dispersion Strengthened (ODS) steel, which is one of the promising candidate materials, recently, the authors’ group has reported that Al-alloying high Cr-ODS steels have much higher corrosion resistance in LBE than a 9Cr-ODS steel without Al. Addition of Al, however, may cause coarsening of ODS particles and decrease in high-temperature strength. Too much higher Cr content also has a problem of aging embrittlement. Therefore, it is needed to reveal the effect of Al and Cr on formation of protective scales on the material surface and find optimal amount of Al and Cr to balance corrosion resistance and high-temperature strength.

In this study, the corrosion tests were performed for the ODS steels with various Al and Cr contents, from 0 wt% to 3.5 wt% and from 13.7 wt% to 17.3 wt%, respectively, in stagnant LBE containing $10^{-6}$ wt% and $10^{-8}$ wt% oxygen at temperature of 823 K and 923 K for 1000 h and 3000 h. Before and after the corrosion tests, the scanning electron microscopy observation and energy-dispersive X-ray spectroscopy analysis were done.

While the ODS steel containing 16.0 wt% Cr and no Al suffered from dissolution attack just after 1000 h in all the cases, the ODS steels containing Al showed relatively good corrosion resistance even after 3000 h. For example, in the case of the ODS steel alloyed with 17.3 wt% Cr and 3.5 wt% Al exposed in LBE with $10^{-8}$ wt% oxygen at 923 K for 3000 h, the whole surface was protected by around 1 mm-thick alumina scale, and there is no oxygen diffusion zone. Among the ODS steels containing the same level of Al, there is tendency that less internal oxidation is formed in higher Cr-ODS steels. In the presentation, the effect of Cr will be discussed further in comparison with the 12Cr steel.