Corrosion behaviors of ODS-FeCrAl exposed to oxygen-saturated lead-bismuth eutectic at 550 °C: Effects of grain boundary

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Abstract The corrosion of fuel cladding in high-temperature liquid lead-bismuth eutectic (LBE) is the key issue restricting the development of lead-cooled fast reactors. The long-term corrosion behaviors (0-8000 h) and damage mechanism of ODS-FeCrAl tube was investigated in oxygen-saturated liquid LBE at 550 °C. It was found that a double-layer oxide film mainly composed of Fe_3O_4 layer and Fe-Cr-Al spinel layer was formed on the surface of ODS-FeCrAl. The thickness of the oxide film first increased (0-500 h) and then tended to be stable (500-8000 h) with time, which was attributed to the formation of a continuous Al_2O_3 layer at the oxide/matrix interface at 500 h. In addition, different densities of grain boundary lead to different corrosion behaviors of ODS-FeCrAl. An oxide film with a thickness of about 100 nm, consisting of a Cr&Al-rich Fe-Cr-Al spinel layer and a continuous Al_2O_3 layer, was formed on the ODS-FeCrAl surface with a higher density of grain boundary. It is worth noting that there is a synergistic effect between grain boundary and active elements (Al and Cr). Grain boundaries provide fast diffusion channels for Cr and Al, accelerate the formation of Cr-rich and Al-rich spinel layers, thereby promoting the formation of Al_2O_3 layer. The higher grain boundary density are conducive to the formation of a compact protective oxide film on the surface of ODS-FeCrAl in a very short time, significantly improving the corrosion resistance of ODS-FeCrAl.

Keywords: ODS steel, liquid metal corrosion, high temperature oxidation, grain boundary