LBE corrosion resistant coatings: TiAlN coating and Al_3O_2/Fe-Al gradient coating

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Abstract The liquid lead-bismuth eutectic alloy (LBE) cooled reactor is considered as one of the most promising reactor types in the fourth-generation advanced nuclear energy system. The components in the reactor core will work over a long period of time under extreme environmental conditions such as intense neutron irradiation and high temperature liquid lead-bismuth corrosion. These will cause microstructural changes of component materials, thereby resulting in the deterioration in macroscopic properties of materials. Therefore, it is urgently needed to effectively improve the anti-corrosion and anti-irradiation properties of materials for meeting the service requirements in future reactors.

In this work, two kind of coatings were investigated. The TiAlN coating with nanocrystalline structure was prepared using cathodic arc technology. After being irradiated with N^{5+} ions, the coating was exposed to lead-bismuth eutectic (LBE) at 450 ^{o}C for 3000 h. The effect of irradiation on the corrosion resistance of the coating is investigated. There are no evidences of LBE corrosion attack observed in both irradiated and un-irradiated coatings. By Transmission Electron Microscope (TEM), the nano-scale oxide layer on surface of the coating should be the main barrier for the LBE corrosion. However, the un-irradiated coating has a single oxide layer, while the irradiated coating has a double-layer oxide. The Al_3O_2/Fe-Al gradient coating was prepared on the surface of stainless steel by using technology of ion liquid plating combined with heat treatment. The protective top layer of Al_2O_3 was about 100-140 nm thick, consisting of γ-Al_2O_3 and α-Al_2O_3. After exposure to LBE at 600 ^{o}C, the coating effectively protected the substrate material and exhibited excellent high-temperature LBE corrosion resistance.

Keywords LBE corrosion, Irradiation effects, TiAlN coating, Al_3O_2/Fe-Al coating