In-depth analysis of the oxidation mechanism of Cr coated Zr-4 alloy under different high-temperature steam simulation conditions

Yun Wang[a,*], Yanfeng Wang[a], Shaopeng Wang[a], Juanjuan Geng[a], Changwei Zhang[a], Yongqing Zhao[a]

[a]*Northwest Institute for Non-ferrous Metal Research, Xi'an, 710016, China*

Abstract Chromium (Cr) coating is a potential candidate material for improving the oxidation resistance and efficiency of zirconium (Zr) alloys used in nuclear fuel cladding materials. This study investigates the effect of temperature on the effectiveness of Cr coating on a Zr-4 substrate deposited using arc ion plating, revealing the microstructure evolution mechanism of Cr coating in steam environments. The research results indicate that the oxidation of the Cr coating is slow at 900°C–1000°C and that the surface oxide layer, to some extent, hinders the diffusion of oxygen from the outside to the inside. However, at higher temperatures, the oxidation rate of the Cr coating is accelerated, and large bubbles and voids are formed at the interface between the Cr_2O_3 layer and the residual Cr layer, resulting in the fracture of the oxide layer. At this time, the protective performance of the Cr coating is completely lost. Note that the simultaneous inward diffusion of oxygen and outward diffusion of Zr trigger the occurrence of redox reactions, generating a ZrO_2 network. Changes in steam temperature significantly affect the oxidation behavior of Cr coatings. As a driving force, temperature accelerates the diffusion of oxygen to the substrate. Conversely, the formed zirconia network also promotes the failure of the Cr coating.