SYNTHESIS OF MO-ZR SURFACE ALLOY BY USING A LOW-ENERGY HIGH-CURRENT ELECTRON BEAM *

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Zirconium-based alloys have served the nuclear industry for several decades due to their unique set of properties [1]. During normal operation, zirconium alloys form a protective layer of zirconium oxide that protects against corrosion. However, at high temperatures, which can occur under accident conditions, zirconium alloys exhibit poor oxidation kinetics [2, 3]. The developing concept of accident tolerant fuel (ATF) defines a several areas of research and development aimed at improving the safety of nuclear fuel during normal operation, transients and possible accident [3-5]. One of the areas of ATF is the development of protective coatings on the surface of zirconium [4, 5]. Coatings based on chromium are the most promising, since they meet the basic requirements for ATF coating materials for Zr fuel cladding. Chromium has a high melting point, high corrosion resistance in water and steam due to protective chromium scale, and a coefficient of thermal expansion similar to zirconium alloys [4, 5]. However, interdiffusion at the interface between the protective coating and the substrate is a serious problem. In addition, interdiffusion can degrade the adhesive properties of the coating, leading to the destruction or bulging of the coating. The easiest way to limit diffusion between the Cr coating and the Zr substrate is to add a diffusion barrier between the coating and the Zr substrate. Molybdenum is considered one of the most promising interlayer materials, as it exhibits good barrier properties, CTE close to Cr, high thermal conductivity, high melting point, and acceptable neutron cross section. Moreover, the potential eutectic phase Mo-Zr has a higher melting point (1550°C) compared to Cr-Zr (1330°C) [6, 7].

The aim of present work was to synthesize of Mo-Zr surface alloy using magnetron deposition of Mo films and consequent irradiation with a low-energy, high-current electron beam (LEHCEB).

The electron-beam machine "RITM-SP" with an explosive-emission cathode and a plasma-filled diode generating the LEHCEB was employed in the work [8]. This machine is equipped with a magnetron sputtering system enabling formation of multicomponent surface alloys. The surface alloy was formed by repeating the operations of deposition of the Mo film on the Zr substrate and following LEHCEB irradiation. The surface alloy was formed at different NEEP energy densities, which resulted in different melt thicknesses and, consequently, different elemental and structural-phase compositions of the surface layer.

The surface morphology, phase and elemental composition of the Mo-Zr surface alloys were analyzed, the microhardness and wear resistance were measured. For its characterization different techniques like SEM, XRD and others have been used. The elemental composition of both the surface and cross sections of the samples was analyzed by EDS analysis. The structure and properties of the synthesized Mo-Zr surface alloy was compared with witness-specimens, which is coatings but without LEHCEB treatment.

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