N1-P-025205

COMPUTER SIMULATION OF THERMAL FIELDS OF THE MO-ZR SYSTEM FOR COATING FORMATION USING A LOW-ENERGY HIGH-CURRENT ELECTRON BEAM*

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Currently an important task is to achieve a more accident tolerant fuel (ATF) cladding that by virtue of its higher oxidation resistance would allow for increased coping times under a loss of coolant accident (LOCA) scenario [1]. One of the many ways to create ATF is to apply chromium-containing coatings using a low-energy high-current electron beam [2, 3]. Molybdenum is used as a barrier layer between zirconium and chrome-containing coatings [4]. For example, the FeCrAl alloy provides excellent oxidation resistance, but Fe forms eutectics with Zr at temperatures up to 1201 K, which leads to mutual diffusion and associated melting. Molybdenum is used as an interlayer coating due to its high melting point (2893 °C), low diffusion rate of Cr, Fe and Zr into Mo, and high eutectic points with Fe and Zr [5-8].

The report presents the results of computer calculations of the thermal fields of the Mo-Zr system for the formation of protective coatings. Melting thresholds for pure metals were calculated: Mo - 7.02 J/cm^2, Zr - 1.83 J/cm^2. The dependences of melting thresholds for the Mo-Zr system as a function of film thickness were calculated. For film thicknesses from 0.1 to 8 μm, the film melting threshold is higher than the substrate melting threshold. In this case, the Zr substrate melts first, followed by the Mo film. For film thicknesses above 8 μm, the film melting threshold is below the substrate melting threshold. In this case, the Mo film begins to melt first, then the Zr substrate. The threshold of Mo melting with increasing film thickness increases from 2.9 J/cm^2 (Mo film thickness is 0.1 μm) to 7.02 J/cm^2 according to the law close to the polynomial of the second degree. The Zr substrate melting threshold increases from 1.83 J/cm^2 (Mo film thickness is 0.1 μm) to infinity according to the law also close to the polynomial of the second degree. The dependences of the melt thickness on the NSEP energy density for the systems Mo(0.1)/Zr, Mo(0.25)/Zr, Mo(0.5)/Zr, Mo(1.0)/Zr are calculated. The dependences of the lifetime of the film and substrate melts on the NSEP energy density for the systems Mo(0.1)/Zr, Mo(0.25)/Zr, Mo(0.5)/Zr, Mo(1.0)/Zr are calculated. The optimum conditions for the synthesis of the surface Mo-Zr alloy have been determined.

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* The work was supported by the Ministry of Science and Higher Education of the Russian Federation (project № FWRF-2021-0001).