C3-P-017602

IMPROVEMENT PROPERTIES OF PROTECTIVE COATINGS ON ZIRCONIUM ALLOYS AND AUSTENITIC STAINLESS STEELS BY PRE-TREATMENT WITH HIGH-INTENSE PULSED ION BEAMS*

V.A. TARBOKOV[1], *M.S. SLOBODYAN*[2], *S.K. PAVLOV*[1], *E.A. SMOLYANSKIY*[1], *D.G. KROTKEVICH*[1], *V.A. RYZHKOV*[1], *V.V. UGLOV*[3], *G.E. REMNEV*[1]

[1]*Tomsk Polytehcnic University, Tomsk, Russia*
[2] *Tomsk Scientific Center of the Siberian Branch of the Russian Academy of Sciences, Tomsk, Russia*
[3]*Belarusian State University, Minsk, Belarus*

We have investigated the effect of pre-treatment of metal substrates with a high-intense pulsed ion beam (HIPIB) on functional properties of subsequently deposited protective coatings. Austenitic stainless steel and the Zr-1%Nb alloy have been studied, which are widely used in the nuclear industry as a structural material for fuel assemblies. The following irradiation parameters have been applied: the accelerating voltage of 200kV, pulse duration of 90ns, and the energy density per pulse of 1.5J/cm^2. After irradiation, coatings of both Fe-Cr-Al and Al-Si-N systems have been deposited by magnetron sputtering. Then, both normal and loss-of-coolant accident (LOCA) conditions for water-cooled nuclear reactors are simulated. In the first way, radiation damage was modeled using protons accelerated to 400keV at a current density of 0.667μA/cm^2 and a fluence of $2.25 \cdot 10^{16}$ proton/cm^2. The second modeling method was the hydrogenation of samples in hydrogen (purity 99.999%) at a temperature of 360°C and a pressure of 2 atm. for 80 minutes. After irradiating the coatings with protons or saturating them with hydrogen, high-temperature oxidation of the samples was carried out in air and steam at a temperature of 1000ºC for 180 seconds. Finally, the oxidized samples have been studied by scratch tests and subsequent investigations using scanning electron microscopy in order to understand the effect of the pre-treatment procedure.

The results of testing samples for resistance to high-temperature oxidation have showed that the HIPIB treatment of the surfaces of both stainless steel and zirconium alloy has reduced their weight gain. In addition, the HIPIB pre-treatment of the stainless-steel surface has enhanced adhesion of both Fe-Cr-Al and Al-Si-N coatings under the simulated normal and LOCA conditions.

* The work was supported by RFBR and ROSATOM, project number 20-21-00025.

The research was carried out using the equipment of the Centers for Sharing Use ‘Nanotech’ of the ISPMS SB RAS and the ‘Nanomaterials and Nanotechnologies’ of Tomsk Polytechnic University