Nanostructured surfaces

Effect of surface treatment on the nanohardness of zirconium alloys E110 and E125

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Working characteristics of zirconium alloys in nuclear reactors determined by the state of their surface. The purpose of this work is determination of the effects of treatment on the surface nanohardness of zirconium alloys. The investigations were performed on flat samples of E110 and E125 alloys after mechanical polishing, electropolishing, chemical etching, and ion implantation Al (E = 20 keV, dose - 1×10^{18} ions/cm^2) on the device Nano Indenter G200 using CSM console.

From the data presented in Fig. 1 shows that the smallest value of nanohardness ~ 1.7 GPa observed for E125 alloy after chemical etching, and does not depend on the depth of the indentation (curve 1). Mechanically polished without etching leads to surface hardening to 3,5 GPa (curve 4), which remains to a depth of 600nm. For comparison, from [2], presented data of Zircaloy-4 alloy nanohardness after mechanical polishing (curve 2), which is ~ 2 GPa. Nanohardness of E110 alloy after electropolishing is at about 2,5 GPa and not dependent on the depth of penetration of the indenter (curve 3). Implantation of the Al ions in E110 alloy increases the nanohardness up to 11 GPa at a depth from 20 to 50 nm and a depth > 150 nm decreased to the initial values of hardness.

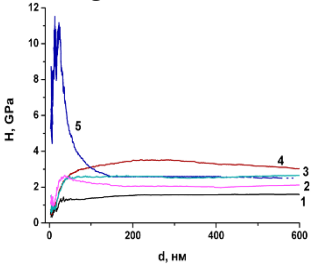

Fig.1. Nanohardness of Zr alloys: 1 - E125 chemical etching; 2 - Zircaloy-4 [1]; 3 - E110 electropolishing; 4-E125 mech. polishing; 5 - E110 electropolishing + Al ion implantation.

Thus, this study shows dependence of the degree of the surface hardening of zirconium alloys by the type of treatment: mechanical polishing increases the nanohardness more than 2 times to the depth exceeding 600 nm, and the implantation of aluminum ions to 8 times to a depth of 100 nm.

1. *P. Dayal, D. Bhattacharyya, W.M. Mook et all.* Effect of double ion implantation and irradiation by Ar and He ions on nano-indentation hardness of metallic alloys // Journal of Nuclear Materials **438** (2013) p. 108–115.