Nanostructured surfaces

Nanohardness of Zr-2,5Nb alloy irradiated by deuterium at different temperatures: 100, 300 and 620 K

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The industrial importance of zirconium based alloys is mainly in the context of their nuclear applications. Zirconium alloys are used as cladding and structural material for the water cooled reactors. During in reactor operation under irradiation hydrogen (deuterium) and helium can accumulated in these materials and decreased their mechanical properties. Ion irradiation techniques using accelerators have many advantages to investigate the irradiation effects on the reactor materials: the short irradiation time, no induced-radioactivity, and high implantation doses of helium/hydrogen. For evaluate irradiation hardening in the ion-irradiated materials, a nanoindentation testing, has been used because the irradiation damage profile is limited in the surface up to hundreds nanometers.

In this work, the mechanical properties were investigated on polished Zr-2.5Nb disk samples pre-implanted with 12 keV deuterium ions at temperatures 100, 300 and 620 K. Nanoindentation performed on Nano Indenter G200 device using CSM option which controls the hardness and elastic modulus of the depth of indentation during the loading segment. The concentration of deuterium in the implanted layer was estimated by nuclear reactions in the process of ion implantation (product of d(d,T)p reaction).

Nanohardness of initial Zr-2.5Nb alloy is at 1.5 GPa, the presence of implanted deuterium at doses up to 1.5×10^{18} D/cm^2 results in increased nanohardness. At a temperature of 100 K in the implantation layer is mainly formed of zirconium hydride ZrD_2 with nanohardness ~2.5 GPa, at T=300 K – zirconium hydride $ZrD_{1.2}$ (nanohardness ~5 GPa) and at T= 620 K – solid solution of deuterium at Zr (nanohardness ~3.5 GPa).