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Coated Chromium Thin Film on Zirconium for Corrosion Resistance of Nuclear Fuel Rods by Plasma Focus Device

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Abstract : Improvement of zirconium properties by chromium coating and nitrogen implantation is ideal to protect the nuclear fuel rods against corrosion and secondary hydrogenation. Metallic chromium (Cr) has attracted attention as a potential coating material on zirconium alloys, to limit external cladding corrosion. In this research, high energy plasma focus device was used to coat the chromium and implant the nitrogen ions in the zirconium substrate. This device emits high-energy nitrogen ions of 10 keV-1 MeV and with a flux of 10^16 ions/cm^2 in each shot toward the target so it is attractive for implantation on the substrate materials at the room temperature. Six zirconium samples in 2cm×2cm dimensions with 1mm thickness were located at a distance of 20cm from the place where the pinch is formed. The experiments are carried out in 0.5 mbar of the nitrogen gas pressure and 15 kV of the charging voltage. Pure Cr disc was installed on the anode head for sputtering of the chromium and deposition on zirconium substrate. When the pinch plasma column decays due to various instabilities, intense and high-energy N2 ions are accelerated towards the zirconium substrate also sputtered Cr is deposited on the zirconium substrate. XRD and XRF analysis were used to study the structural properties of the samples. XRF analysis indicates 77.1% of Zr and 11.1% of Cr in the surface of the sample. XRD spectra shows the formation of ZrN, CrN and CrZr composites after nitrogen implantation and chromium coating. XRD spectra shows the chromium peak height equal to 152.80 a.u. for the major sample (θ=0□) and 92.99 a.u. for the minor sample (θ=6□), so implantation and coating along the main axis of the device is significantly more than other directions.

Keywords : ZrN and CrN and CrZr composites, angular distribution for Cr deposition rate, zirconium corrosion resistance, nuclear fuel rods, plasma focus device
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