ABSTRACT

Zr-Sn alloy (Zircaloy-4) is extensively used in nuclear industry as fuel cladding and structural material due to its fascinating properties such as good corrosion resistance, low neutron absorption cross section and good mechanical stability under irradiation. In nuclear reactor, interaction of energetic neutrons with the reactor core, made up of Zr-Sn alloy, produces helium ions during (n, α) reaction that can strongly affect the structural performance of the alloy. In this work, structural and surface modification of Zr-Sn alloy after helium ions irradiation has been presented at different fluences. Zr-Sn alloy samples were irradiated with helium ions of fluences of 1×10^{13}, 1×10^{15} and 1×10^{16} ions/cm^2 while maintaining the energy constant at 300 keV by Pelletron Accelerator. The ion range inside the alloy was noticed to be 0.84 μm as found through the SRIM software. The structural properties of unirradiated and helium ions irradiated alloy were studied by using x-ray diffraction (XRD) technique. From the XRD analysis, Zr peaks along various planes were observed whose width, intensity and positions were changed after helium ions irradiation. The Williamson-Hall analysis was conducted for the calculation of crystallite size and strain. The results revealed a decrease in the alloy crystallinity when exposed to helium ions at 1×10^{15} ions/cm^2. However, the crystallinity was improved by increasing the ions fluence to 1×10^{16} ions/cm^2. The surface morphology of Zr-Sn alloy was investigated through field emission scanning electron microscope which demonstrated the formation of irradiation induced defects such as cavities, pits and bubbles. The helium ions induced defects in Zr-Sn alloy were explained using the thermal spike model. The electrochemical corrosion testing of unirradiated and irradiated samples was studied in 0.1% NaCl solution. The potentiondynamic polarization tests were performed for the determination of corrosion parameters such as corrosion current density and corrosion rate. The results showed a significant decrease in the corrosion rate at lower irradiation fluence (1×10^{13} ions/cm^2). By further increasing the fluence, the corrosion current density and corrosion rate were increased. At higher irradiation fluence of 1×10^{16} ions/cm^2, the corrosion rate was again reduced indicating an improvement in the corrosion resistance of the sample. These variations in corrosion rate were explained on the basis of lattice defects generated in Zr-Sn alloy due to helium ions irradiation. The SEM images of electrochemically tested samples

revealed lower pitting corrosion in the sample irradiated with helium ions at 1×10^{13} ions/cm^2 as compared to higher irradiation fluences.