ABSTRACT

This work deals with the investigation of proton irradiation effects on the structural, surface and mechanical properties of pure Zirconium at different energies. Zirconium samples (99.98 %) were irradiated with proton beams in the energy range 1-2.5 MeV using Pelletron Accelerator at $1 \times 10^{14} p/cm^2$ dose rate. The structural and surface morphological studies of the samples before and after irradiation were conducted using the X-ray diffraction (XRD) and scanning electron microscope (SEM) respectively. XRD results revealed a polycrystalline Zirconium structure with preferred orientation along (002) plane both in the unirradiated and irradiated specimens. The changes in the peak positions and intensities were observed after the irradiation which indicated the presence of lattice strain and stresses inside the irradiated specimens. The crystallite size, lattice strain and stresses were evaluated using Williamson-Hall analysis and were found to be anomalous with increase of the irradiation energies. The SEM results showed the presence of black spots and cracks on the specimens surface after irradiation which became more pronounced at 2.5 MeV. Electrochemical testing of the samples was carried out using potentiodynamic polarization technique to explore the effects of proton irradiation on the corrosion rate of the polycrystalline Zirconium. The results showed a decrease in the corrosion rate with increase of the irradiation energy. The tensile testing of the specimens before and after proton irradiation was carried out using Universal Testing Machine (UTM) at room temperature. The results showed an increase in the yield stress, ultimate tensile stress and decrease in the percentage elongation of the Zirconium after irradiation, however, these changes remained insignificant with increase of the irradiation energies. These changes in the surface and mechanical properties of proton beam irradiated Zirconium at different energies were attributed to a competition between the generations of radiation induced defects and their thermal recovery during the course of irradiation.