Abstract

In present study, the modifications in the elemental composition, phase changes, surface morphology and Field Emission (FE) properties of Tungsten (W) after Carbon (C) ion irradiation have been investigated. These characterizations are performed by using Fourier transformation Infrared Spectroscopy (FTIR), X-Ray Diffraction (XRD), Scanning Electron Microscopy (SEM) along with Optical microscopy analyses and field emission techniques. The study consists of two independent parts. The part A deals with irradiation of W with C ions generated by Pelletron linear Accelerator at different energies ranging from 350 KeV to 750 KeV at constant fluence of 1×10^{14} ions/cm^2. Whereas, part B deals with low energy of 6.4 KeV laser induced Carbon plasma ions irradiation of W. Nd:YAG (532 nm,10 ns) laser at irradiance of 1.75 GW/cm^2 was used to generate C plasma ions at various fluences ranging from 5.3×10^{15} ions/cm^2 to 2.1×10^{16} ions/cm^2. The energy and fluences of C ions are estimated by employing Faraday Cup (FC) technique.

It is observed that for Pelletron linear Accelerator generated Carbon ions irradiation at different energies ranging from 350 KeV to 750 KeV, the penetration depth in W varies from 1054 Å to 2283 Å. However, in the case of low energy ions of 6.4 KeV, the penetration depth comes out to be 105 Å. Fourier Transformation Infrared (FTIR) spectroscopy reveals the presence of (C=C), (CO-O-CO) and (O=C=O) bonds are identified in both cases. XRD analysis revealed that no new phase has been identified after C ion irradiation, however, a slight decrease in peak intensity and angular shifting is observed for both cases. Optical microscopy and Scanning Electron Microscopy analyses reveal the growth of ion induced surface structures in the form of pits, agglomers, craters, wrinkled protrusions and sputtered channels in the case of high energy accelerator ions. However, in the case of lower energy ions irradiated W the formation grains covered with particulates, sub-grains network along with rods like structures at different fluences is observed. These structures are explainable on the basis of Coulomb's explosion and thermal spike model. Field emission properties of ion-structured W are explored by measuring I-V characteristics of targets under UHV condition in diode configuration. The exponential behavior of the emission current density (J) verses applied electric field (E) curves and linearity of the Fowler-Nordheim (F-N) plots suggest the characteristics behavior of FE phenomenon. The turn on field, field enhancement factor β and maximum current density ranging from 6.5 V/μm to 8 V/μm, 104 to 537 and 9,090 nA/cm^2 to 58,520 nA/cm^2 respectively are obtained for the accelerator generatedion induced structured W at different incident ion energies depending upon emission sites density and geometrical configuration of surface structures. For the laser induced C plasma ion irradiated W at different fluences the turn on field, field enhancement factor β and maximum current density ranging from 6.5 V/μm to 8 V/μm, 20 to 196 and 17,045 nA/cm^2 to 25,568 nA/cm^2 is observed. The variation in the measured FE parameters were correlated with growth of surface structures on W.