Abstract

Laser and ion-induced modifications of brass in terms of surface morphology, elemental composition, phase changes, field emission properties and electrical conductivity have been investigated. Brass targets are irradiated at various laser fluences ranging from 38 J/cm^2 to 150 J/cm^2 by employing using Nd:YAG laser (1064 nm, 10 Hz, 10 ns). Similarly, brass targets are also irradiated by proton beam at constant energy of 3 MeV for various ion doses ranges from 1×10^{12} ions/cm^2 to 1.5×10^{14} ions/cm^2 using Pelletron Linear Accelerator. Scanning electron microscope (SEM) analysis performed to reveal the surface morphology of laser irradiated brass targets. Occurrence of distinct features such as cavities, pores, droplets, micro-cones, pinholes, cracks, ridges and wave type structures are observed at central as well as peripheral ablated region. Laser induce heating, localized melting, explosive boiling and exfoliational sputtering are different phenomena which are responsible for the growth of such kind of structure at central region. Whereas, splashed melt, hydro-dynamic instabilities, and thermal expansion are the few mechanisms that are involved in peripheral ablation. Likewise, Field Emission Scanning Electron Microscope (FESEM) analysis reveals the formation of randomly distributed clusters, particulates, droplets and agglomers for lower ion doses which are explainable on the basis of cascade collisional process and thermal spike model. Whereas at moderate ion doses, fiber like structures are formed due to incomplete melting. The formation of cellular like structure is observed at the maximum ion dose and is attributed to intense heating, melting and re-solidification. SRIM software analysis reveals that the penetration depth of 3 MeV protons in brass comes out to be 38 μm, whereas electronic and nuclear energy losses come out to be 5×10^{-1} and 3.1×10^{-4} eV/Å respectively. The analytical evaluation shows that average surface temperature rise of brass after 3 MeV protons irradiation is 2250 K. The evaluated values of energy deposited per atom vary from 0.01 to 1.5 eV with the variation of ion dozes from 1×10^{12} ions/cm^2 to 1.5×10^{14} ions/cm^2. Field emission properties of laser and ion-structured brass are explored by measuring I-V characteristics of targets under UHV condition in diode-configuration using self designed and fabricated setup. Field enhancement factor (β) is estimated from the slope of Fowler-Nordheim (F-N) plots in both laser and ion irradiated targets. For laser irradiated targets, significant increase in field enhancement factor (β) i.e. from 5 to 492 is evaluated via Fowler-Nordheim (FN) plots. Whereas turn on field (E_o) has been reduced from 65 V/μm to 20 V/μm and maximum current density (J_{max}) increases from

12 μA/cm^2 to 254 μA/cm^2. In same manner, for ion irradiated targets, field enhancement factor (β) shows significant increase from 5 to 1911, whereas a reduction in turn on field (E_o) from 65 V/μm to 30 V/μm and increment in maximum current density (J_{max}) from 12 μA/cm^2 to 3821 μA/cm^2 is observed. These enhancements in field emission characteristics are correlated with the growth of surface structures, specifically cracks in laser irradiated targets and agglomers in ion irradiated brass are responsible for electric field convergence. Energy dispersive X-ray spectroscopy technique is used for elemental analysis of both laser and ion irradiated targets. No new element has been detected by this technique. XRD is performed for ion irradiated target that shows no new phase, however slight change in peak intensity and angle shifting is observed. Electrical conductivity has been measured and correlated with maximum current density for both laser and ion treated targets. Decreasing trend is observed in electrical conductivity with increasing laser fluences and proton doses. However, higher laser fluences and ion doses are responsible for decreasing current density of brass.