Abstract

The surface properties of functional materials are often more important than the bulk properties because of its varied applications. In case of biomaterials, the surface properties become even more important because the surfaces of biomaterials are either in close contact with the body or the surfaces are exposed to an in-vivo biological system. Therefore it is highly desirable to tailor the surface properties of currently used and potential candidate biomaterials. Surface properties of metallic biomaterials are improved using two techniques; ion implantation by 2MV pelletron accelerator and by plasma focus system. The experiments based upon ion implantation are presented in this thesis. Currently Stainless steel and nearly equiatomic nickel-titanium alloy are selected to study different mechanical and biomedical properties after ion implantation. Stainless steel samples are selected to investigate for corrosion properties, hardness, hydroxyapatite growth and cell viability likewise nickel-titanium alloy samples are tested for toxic ion releases in the simulated body fluid, corrosion potential and hardness.

Stainless steel 306 is implanted with various doses of nitrogen ions using a 2MV pelletron accelerator for the improvement of its biomedical surface properties biomedical. Raman spectroscopy reveals incubation of hydroxyapatite (HA) on all the samples and it is found that the growth of incubated HA is *greater in higher ion dose samples*. SEM profiles depict uniform growth and greater spread of HA with higher ion implantation. Human oral fibroblast response is also found consistent with Raman spectroscopy and SEM results; the cell viability is found the maximum in the samples treated with the highest (more than 300%) dose. XRD profiles signified greater peak intensity of HA with ion implantation; a contact angle study revealed the hydrophilic behavior of all the samples but the treated samples were found to be lesser hydrophilic compared to the control samples. *Nitrogen implantation yields greater bioactivity*, improved surface affinity for HA incubation and improved hardness of the surface.

The effect of hydrogen ion implantation on surface wettability and biocompatibility of stainless steel is investigated. Hydrogen ions are implanted in the near-surface of stainless steel to facilitate hydrogen bonding at different doses with constant energy of 500 KeV, which consequently improve the surface wettability. Treated and untreated sample are characterized for surface wettability, incubation of hydroxyapatite and cell viability. Contact angle (CA) study reveals that surface wettability increases with increasing H-ion dose. Raman spectroscopy shows that precipitation of hydroxyapatite over the surface increase with increasing dose of H-ions. Cell viability study using MTT assay describes improved cell viability in treated samples as compared to the untreated sample. It is found that low dose of H-ions is more effective for cell proliferation and the cell count decreases with increasing ion dose. Our study demonstrates that H ion implantation improves the surface wettability and biocompatibility of stainless steel.

Carbon ions are implanted on nickel titanium alloy (nitinol) and nickel ion release is investigated along with affinity of calcium phosphate precipitation on nickel titanium alloy. Four annealed samples are chosen for the present study; three samples with oxidation layer and the fourth without oxidation layer. X-ray diffraction (XRD) spectra reveal amorphization with ion implantation. Proton-induced X-ray emission (PIXE) result shows an insignificant increase in Ni release in simulated body fluid (SBF) and calcium phosphate precipitation up to 8×10^{13} ions/cm^2. Then Nickel contents show a sharp increase for greater ion doses. Corrosion potential decreases by increasing the dose but all the samples passivate after the same interval of time and at the same level of V_{SCE} in Ringer lactate solution. The hardness of samples initially increases at a greater rate (up to 8×10^{13} ions/cm^2 and then increases with the lesser rate. It is found that 8×10^{13} ions/cm^2 ($\approx 10^{14}$) is a safer limit of implantation on nickel titanium alloy, this limit gives us lesser ion release, better hardness and reasonable hydroxyapatite incubation affinity.