Abstract

The present research is motivated to make an ideal biomaterial which possessed high strength, elastic modulus comparable to bone; good wear resistance and excellent biocompatibility. Since Ti and its alloys are light weight, possessed excellent mechanical strength, high corrosion resistance and good biocompatibility therefore they are frequently used in joint replacement, bone plates and screw, dental root implant, vascular stents and spinal fixation devices. Commercial pure (CP) titanium is a good candidate for biomedical application. However its low mechanical strength and surface hardness limits its use in load bearing applications. On other hand Ti6Al4V and NiTi alloys are two most useable Ti alloys, but vanadium (V) and nickel (Ni) hampered their properties, as both are toxic and produce the allergic reaction. Therefore it is imperative to improve their surface properties to make them an ideal biomaterial. A plasma surface modification is an attractive method to improve the surface properties of biomaterials; because it is not only economic and efficient, but we can also tailor only surface properties without any change in bulk. In present research work we performed three experiments to improve the surface properties of Ti and its alloy using the glow discharge.

In first experiment, titanium oxynitride films were deposited on NiTi samples by high vacuum magnetron sputtering for various nitrogen and oxygen gas flow rates. The composition of deposited film was characterized using X-ray diffraction (XRD) and x-ray photoelectron spectroscopy (XPS). The results reveal the presence of TiN, and rutile and anatase phases of TiO_2 in the titanium oxynitride thin films. Energy dispersive spectroscopy (EDS) elemental mapping of samples after immersion in simulated body fluids (SBF) shows that Ni is depleted from the surface and cell cultures corroborate the enhanced biocompatibility in vitro.

In second experiment, zirconium oxide nanostructure thin film has been deposited on the surface of Ti6Al4V alloy via plasma immersion ion implantation and deposition (PIII&D) technique at the various voltages 15, 20 and 25 KV. The chemical composition and surface morphology of deposited film is characterized by the X-ray photoelectron spectroscopy (XPS) and Atomic force microscope (AFM) respectively. The XPS results confirm the formation of ZrO_2 film. AFM results show the formation of smooth film was

formed with maximum roughness of 8.4 nm. The effects of the implantation voltages on the wear characteristics are also investigated by pin-on-disk test. It is observed that wear resistance improves with an increase in the applied voltage and is found to be maximum at 25 KV. Moreover the nanohardness is improved in treated specimens and is almost doubled as compared to untreated specimen at the maximum voltage. The variation in wear resistance and nanohardness is attributed to the formation of hard nanostructure ZrO_2 film on substrate surface.

In third experiment, Ti-Al-O composite film has been formed by using pulsed DC magnetron sputtering system at various powers (100, 150, 200 watt). The effect of deposited film on mechanical properties and biocompatibility of CP Ti has been studied. The composition of film has been examined through X-ray diffractometer (XRD). Surface morphology of deposited film was observed using atomic force microscopy (AFM) and scanning electron microscopy (SEM) techniques. It was found that surface roughness of film increase with increasing plasma excitation power. To determine the strength of film, tensile test was carried out using Universal testing machine. The hardness was also measured by Vickers microhardness tester. The results show that composite film improved the mechanical properties such as YS, UTS and hardness of CP Ti without any reduction in percentage elongation. Moreover, the biocompatibility of deposited film also performs by culturing the MC3T3-E1 cell for three days. Results exhibit that composite film significantly improves the biocompatibility of titanium. Micrographs of cell culture indicate that better cells growth/proliferation (elongated morphology) is observed on film prepared at 150 watt.