Abstract

In the present investigation, surface engineering of AISI 316L stainless steel has been carried out by laser and plasma based surface modification treatments to improve surface dependent engineering properties like wear resistance, corrosion resistance and bio-activity with an objective of its application as bioimplant. The surface treatment processes carried out were divided into three parts (a) laser surface melting and laser surface nitriding, (b) laser surface cladding of Ti-6Al-4V on AISI 316L stainless steel and (c) sputtering of Ti-6Al-4V on the surface of AISI 316L stainless steel and its nitriding by plasma nitriding and nitrogen ion implantation. Laser surface melting of AISI 316L stainless steel was carried out using a 5 kW continuous wave (CW) fiber optics delivery Nd:YAG laser with a beam diameter of 4 mm in argon and nitrogen atmosphere. Microstructure of the surface melted layer consists of grain refined austenite when melted in Ar shroud and precipitates of iron nitrides (Fe_4N) and chromium nitrides (Cr_2N) dispersed in austenite matrix when melted in N_2 shroud. The microhardness of the surface increases from 240 VHN for as-received AISI 316L stainless steel to 375 VHN (when melted in Ar atmosphere) and 475 VHN (when melted in N_2 atmosphere). There was a significant improvement in wear resistance, corrosion resistance and bioactivity due to laser surface melting. In an another attempt, laser surface cladding was carried out on the AISI 316L stainless steel substrate by simultaneous feeding of Ti-6Al-4V powder using a 5 kW continuous wave (CW) fiber optics delivery Nd:YAG laser. Microstructure of the clad layer consists of acicular α' phase and the interface consists of equiaxed grains of α phase and white precipitates of FeTi intermetallics at the grain boundaries. The microhardness of the clad zone and the interface increases to 320 VHN and 684 VHN, respectively. There was also a significant improvement in wear resistance, corrosion resistance and bio-activity due to laser surface cladding. Finally, sputtering of Ti6Al4V was applied on AISI 316L stainless steel and it was subjected to plasma nitriding and nitrogen ion implantation. Microstructure of sputtered surface consists of very fine particles of α in the form of clusters and formation of titanium nitrides dispersed in the matrix of α and β after nitriding and nitrogen implantation. Nano hardness and young's modulus were improved in modified surface. A significant improvement in macro hardness (614 to 2350 VHN) and wear resistance were observed after sputtering as well as nitriding and nitrogen ion implantation. Corrosion resistance (in Hank's solution), wettability and bioactivity were also improved after surface modification. A comparison of all treatments was stated with the effectiveness in application of them on real time component.

Keywords: AISI 316L stainless steel, laser, melting, cladding, sputtering, wear, corrosion, bioactivity