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Study and Development of Plasma Boriding with Solid Paste in Ti6Al4V Alloy

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Plasma boriding is a surface treatment that produces boride by the introduction of boron in the treated substrate, improving its properties. In conventional plasma boriding, the boron precursor corresponds to the gases BCL3 (boron trichloride), B2H6 (diborane), and BF3 (boron trifluoride), however, these boriding agents are toxic, corrosive and explosive. The solid boriding process is not commonly used in titanium alloys due to the high interaction of the titanium with oxygen, not allowing the effective diffusion of boron in the substrate. The objective of this work is to develop the plasma boriding treatment in the Ti6Al4V alloy using solid paste as a boron precursor. Three kinds of solid paste were studied, varying the Borax (Na2B4O7) as boron precursor and silicon carbide (SiC) used to the stability of the paste during the boron diffusion process in the substrate. The studied solid pastes were composed of 100% of Borax (Paste 1), 70% of Borax, and 30% of SiC (Paste 2), 30% of Borax and 70% of SiC (Paste 3). The plasma treatment was carried out with a gas mixture of 40% of H2, 40% of N2, and 20% of Ar at a pressure of 2 torr by 3 hours and 650oC. The results analysis was carried out to validate the boron diffusion in the substrate by metallography using the SEM/EDS (Scanning Electron Microscope/Energy Dispersive Spectroscopy) to evaluate the layer formation, thicknesses, and proportions of boron in the compound layer, diffusion zone, and substrate. The XRD (X-ray Diffraction) analysis was performed to identify the phases present in the treated samples, and Vickers microhardness was carried out to compare the behavior of the treated and untreated material. It can be observed that all treated samples showed a difference in their surface properties, in that higher Borax concentration in the solid paste (Paste 1) provided greater hardness of the studied material, and the paste produced with a high percentage of SiC and less percentage of Borax increased the stability of the treatment, but the amount of boron element available in the environment of treatment decreases. Differently from the solid boriding process, the layers obtained by the plasma process are thinner, with the formation of TiB (Titanium Boride) and TiB2 (Titanium Diboride) phases in the compound layer without the presence of oxides. It was possible to determine that Paste 2 presented better behavior during the process, produced a uniform layer, higher boron concentrations on the formed boride layer, and intermediated hardness compared to the other pastes and the base material. It can be concluded that this treatment was effective to modify and improve the surface behavior of the Ti6Al4V through an allowable plasma surface treatment.