PLASMA OXIDIZED Ti6Al4V AND Ti6Al7Nb ALLOYS FOR BIOMEDICAL APPLICATIONS

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Introduction

Titanium and its alloys besides many advantageous mechanical properties and high corrosion resistance is characterized by high coefficient of friction (in combination with almost all materials), low resistance against wear and a tendency to galling. This substantially limits the use of titanium and its alloys form components operating in conditions of friction. Alloying additions and heat treatment also do not improve their tribological properties.

In order to fully exploit the potential of titanium and its alloys the use of thermo-chemical treatment has been applied. Surface modification of titanium and its alloys is carried out mainly through incorporation into the surface layer such element as: N, O, C, B, Si, which form the corresponding compounds of solid solutions [1-5]. In this work are presented the results of the influence of the plasma oxidizing of titanium alloys on the evolution of its structure, mechanical and corrosion properties.

Materials and Methods

Two titanium medical grades: Ti6Al4V and Ti6Al7Nb were subjected to glow discharge oxidation. After the modification both substrate materials were characterized in terms of structure, thickness of the oxygen diffusion zone, distribution of hardness and surface geometrical structure. Samples were subsequently tested in the tribological tests using the ball on disc method with zirconium oxide as a counter sample. After the tests the coefficients of friction were determined and wear rates calculated for both samples and ZrO_2 balls. The corrosion measurements were made with use of electrochemical methods. The corrosion potential E_{cor} was measured in an open circuit (OCP) while recording the potential of the sample relative to the reference electrode for 1800 s. The value of polarization resistance, R_p, was determined according to Stern–Geary method in a scanning range of ± 20 mV vs. E_{cor} potential at the rate of 0.3 mV/s. Potentiodynamic characteristics were measured in a wide range of anodic polarization starting at potential E_{cor} – 0.2V V to 4V with the scan rate of 1 mV/s.

Results and Discussion

The conducted processes of diffusion strengthening of titanium alloys by interstitial oxygen atoms positively influenced the investigated properties. We managed to increase twice the hardness of the surface of the tested alloys and the thickness of the diffusion zone was estimated to be approx. 85 µm. These parameters resulted in a reduction of the wear rate determined in ball on disc tests. The registered value of the wear rate of the Ti6Al4V alloy decreased by one order of magnitude, whereas for the Ti6Al7Nb alloy it was 7 times lower. The lower values of wear rate were achieved despite the fact, that the friction coefficients, compared to the unmodified alloys, have increased from 0.45 to 0.7. The plasma oxidation of Ti alloys favorably affected their corrosion resistance. The value of the corrosion potential significantly increased (approx. 0.36 V). At the same time the polarization resistance increased three times for the Ti6Al4V alloy and 10 times for the Ti6Al7Nb alloy, which demonstrates the better corrosion resistance of the modified samples. The results of the potentiodynamic studies also confirmed a high resistance of the modified alloys against the pitting corrosion. As a drawback of the process of oxidation an increase in surface roughness can be pointed out. It results in the need of additional polishing treatment restoring the original surface smoothness and removing a thin surface layer of a porous oxide.

Conclusions

In summary, it can be stated that the plasma oxidation of titanium alloys favorably influenced the tribological and corrosion properties of both Ti6Al4V and Ti6Al7Nb alloys.

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