Surface Coatings for Ti6Al4V – A Review

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In this paper, different surface coating process and their influence on Ti6Al4V are reviewed. Coating process like electrical discharge coating (EDC), sol-gel method (SGM), Scholzite conversion coating (SCC), physical vapor deposition (PVD, laser surface engineering (LSE), laser surface texturing (LST), plasma spray physical vapor deposition (PS-PVD), Selective Laser Melting (SLM), Magnetron Sputtering (MS) were considered. PVD increases the hardness of the material decreases friction, smoothness the surface, and improves wear resistance. Coating with arc ion plating could produce super high hardness and low coefficient of friction. SSC can produce good corrosion resistance and could be used for orthopedic and dental implant fixation. Use of low laser power in laser surface coating can make cracks and pores on the coating so high-power laser should be used. LSE increases the microhardness and wear resistance of the composite coatings.

Keywords: Ti6Al4V, Coatings, Friction, Wear.

1. Introduction

Ti6Al4V (also referred to as "Ti64," grade 5) is a multi-phase (α+β) Ti alloy with significant applications in engineering, medicine, and research. The alloy has its own downsides such as poor thermal conductivity that is about 60% lower than that of the pure titanium (Ti). Due to the material's poor tribo-properties, high friction and wear conditions occur during body-to-body interactions, resulting in material loss and seizure. The wear mechanism in Ti64 encourages material transfer to the counter-face under critical sliding circumstances of high speed and load [1]. In order to improve these tribological properties different surface modification processes are carried out. Given, this work specifically focuses on the various coating techniques utilized for improving the tribo-mechanical properties of Ti64.

2. Coating Process

In order to improve the tribological properties of Ti64 different surface modification process are performed. Surface modification processes can be broadly classified into two, viz. surface treatment and surface coating. The latter can be used for improving the tribological and surface properties of Ti64. Distinct surface coating methods like EDC, SGM, SCC, PVD, LSE, LST, PS-PVD, SLM, and MS were evaluated in this work. The TiN coatings prepared by PS-PVD, the nitriding effect was diminished as spraying distance increased, and the hybrid structure of TiN coating altered from dense to porous, which may be attributed to the longer heating time, lower reactant concentration, and lower substrate temperature. As a result, TiN coatings' average H and E fell [2].When the alloy was coated by arc ion planting of TiSiCN coating, the TiSiCN coating contains two species of nanocrystals of TiN and TiC, the grain size is very small and the coating has a super high toughness. As a result, the hardness is extremely high[3]. Scholzite conversion coatings adhered tightly to the substrates and provided good corrosion resistance for cpTi and Ti64 in a 0.9 percent NaCl solution, with the Ti64 coating exhibiting higher bonding strength and chemical protection due to its fine and homogeneous structure[4].

When laser surface coating was performed in low laser energy density there was the formation of tiny amount of Al_2O_3 formed which increase the hardness but on increasing the laser energy density the microhardness dropped [5]. Table 1 shows the different coating process and their influence on the substrate

Table 1 Coating process and their influence on surface and mechanical properties/responses of Ti64 (CoF - coefficient of friction, WR - wear resistance, CR - corrosion resistance, H - hardness, SR - surface roughness)

Coating Process	Specification	CoF	WR	CR	H	SR	Ref
EDC	powder metallurgy	↓	↑	↑	↑		[5]
SGM	TiO_2 and B doped TiO_2		↑	↑	↑	↑	[6]
SCC				↑			[4]
PVD		↑	↑		↑	↑	[7]
PS-PVD	TiN coatings				↓		[2]
LSE		↑	↑		↑		[8]
LST	GPS Zr		↑		↑		[9]
AIP	TiSiCN	↓			↑		[3]
EBM					↑	↑	[10]
SLM	AM	↓	↓		↑	↑	[11]
MS		↓			↑	↓	[12]

3. Discussion

When Ti64 was treated with EDC using powder metallurgy tools, the material properties/responses, viz. wear resistance, corrosion resistance, hardness was improved. But the coefficient of friction was reduced. When the alloy was coated with sol-gel coated with TiO_2 and B doped TiO_2 tribological properties like wear resistance, corrosion resistance and hardness was improved. Nonetheless, the surface roughness also increased. Other processes like PVD and LST improved the wear resistance, hardness and coefficient of friction. EDC and PVD can be used to alter many tribological properties. New techniques are also been introduced like combining two different coating methods to enhance the properties of the alloy. When the alloy was modified through LSE the microhardness and wear resistance was improved by a factor of 4.7 and 3.9 [8]. The corrosion resistance was improved by TiO_2 and while raising the B molar ratio improved it when the alloy was undergone with sol gel process [6]. When the alloy was coated with TiSiN by arc ion planting a low friction coefficient of 0.3 was obtained [3]. Different surface coating process can be performed together to achieve the desired output. When the alloy was treated with SLM additive manufacturing and plasma oxidizing, at 650 °C-1 h oxidation, the hardness value increased by about 2 times, and at 750 °C-4 h oxidation, it increased by roughly 4 times [11].

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5. References

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