Cr-CrN-Cr-CrAlN 多层膜厚度对结构和性能的影响

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摘 要: 采用电弧离子镀技术在 TC4 钛合金表面制备不同厚度的 Cr-CrN-Cr-CrAlN 多层膜, 研究了多层膜厚度对其结构及性能的影响。利用扫描电子显微镜、X 射线衍射仪、显微硬度计、划痕仪、应力测试仪、砂粒冲蚀试验仪和拉伸试验机检测分析了多层膜的表面及截面形貌、微观结构、硬度、结合力、残余应力、抗砂粒冲蚀性能和拉伸性能等。结果表明:随着多层膜厚度的增加,膜层表面颗粒增多,表面质量略有下降,择优取向由(200)晶面逐渐向(111)晶面转变;随着厚度的增加,残余应力逐渐增加,膜层硬度、膜基结合力、裂纹扩展抗力先上升后下降,在厚度为 10.58μm 时达到最佳,其硬度为 3404Hv、结合力为 58.6N、裂纹扩展抗力为 758.49,抗砂粒冲蚀性能提高 3 倍以上;TC4 钛合金表面镀多层膜后,屈服强度和抗拉强度均略有提升,但断后伸长率降低,当膜层厚度为 14.50μm 时,断后伸长率较基材降低 30%,断裂机制由韧性断裂转变为脆性断裂。在一定范围内增加膜层厚度有利于提升性能,但需合理控制其厚度以减小对钛合金基材的负面影响。

关 键 词: Cr-CrN-Cr-CrAlN 多层膜;抗砂粒冲蚀性能;拉伸性能;电弧离子镀;钛合金
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Effect of Thickness on Structure and Properties of Cr-CrN-Cr-CrAlN Multilayers

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Abstract: In order to study the effect of thickness on structure and properties of Cr-CrN-Cr-CrAlN coatings, multilayer coatings with different thicknesses were prepared on TC4 titanium alloy by vacuum cathodic arc ion plating. Scanning electron microscope(SEM), X-ray diffraction(XRD), microhardness tester, scratch tester, stress tester, sand erosion tester and tensile tester were used to analyze and detect the surface and cross-section morphology, structure, thickness, hardness, adhesion, residual stress, sand erosion resistance and tensile property of the multilayers. The results show that with the increase of multilayer thickness, particles on the surface of the film increase,the surface quality of the coatings decreases slightly and the coating growth orientation changes from (200) to (111) crystal plane. With the increase of multilayer thickness, the internal stress of the coatings increases, and the hardness, adhesion strength, crack propagation resistance increase first and then decrease. When the thickness is 10.58μm, the optimal mechanical properties with hardness of 3404HV, binding force of 58.6N, crack growth resistance of 758.49 are obtained, and the erosion resistance increases by more than 3 times. After TC4 titanium alloy surface is coated with multilayer film,the yield strength and tensile strength of TC4 are slightly increased, while the elongation after fracture is decreased. In particular, when the thickness of the coating reaches 14.50μm, the elongation after fracture is reduced by 30% compared with that of the substrate. Increasing the coating thickness in a certain range is beneficial to improving the mechanical properties. However, it needs to be controlled to reduce the negative impact on the mechanical properties of titanium alloy substrate.

Key words: Cr-CrN-Cr-CrAlN multilayer films;sand erosion resistance; tensile property; arc ion plating; titanium alloy

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