不同厚度 Cr/CrN 粘结层对铜合金表面碳基薄膜性能影响的研究 *

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摘 要:为提高铜合金表面硬质薄膜的抗冲击性能,在 KK3 铜合金表面制备了不同厚度 Cr/CrN 粘结层的铬掺杂类金刚石(Cr-DLC)碳基薄膜,采用扫描电镜、拉曼光谱仪、纳米压痕仪和连续冲击试验机分别分析了 Cr-DLC 薄膜的截面形貌、微观结构、力学性能以及抗冲击性能。结果表明:Cr-DLC 薄膜的残余应力、弹性模量、结合强度及抗冲击性能等与 Cr/CrN 粘结层厚度存在密切关系;铜合金表面 Cr-DLC 薄膜的残余应力随着粘结层厚度的增加先降后升,当粘结层厚度为 1.01μm 时,薄膜的残余应力最小,仅为 -0.47GPa,硬度与弹性模量分别为 11.68GPa 和 144.54GPa; 薄膜的结合强度随粘结层厚度的增加呈先升后降的趋势,当粘结层厚度为 1.01μm 时结合强度最高,达到了 50N;经 30000 次连续冲击试验后,不同厚度 Cr/CrN 粘结层的 Cr-DLC 薄膜样品表面均出现冲击坑, 且中心区域均出现一定面积的薄膜剥落, 其中粘结层厚度为 1.01μm 的 Cr-DLC 薄膜样品冲击坑体积最小,仅为 $9.241\times10^6\mu m^3$,表现出最好的抗冲击性能。综上,针对铜合金表面不同厚度 Cr/CrN 粘结层的 Cr-DLC 碳基薄膜,当 Cr/CrN 粘结层厚度为 1.01μm,总厚度不大于 8μm 时,其抗冲击性能最好。

关 键 词:铜合金;碳基薄膜;抗冲击性能;粘结层

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Effects of Cr/CrN Interlayer Thickness on Properties of Carbon-based Films Prepared on Copper Alloy

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Abstract: In order to improve the poor impact resistance of thin films prepared on copper alloy, chromium doped diamond-like carbon (Cr-DLC) films with Cr/CrN interlayer of different thickness were prepared on KK3 copper alloy. Cross-section morphology, microstructure, mechanical properties and impact resistance of Cr-DLC films were studied by scanning electron microscope, Raman spectra, nanoindentation and repetitive impact tester, respectively. The results illustrate that the residual stress, elastic modulus, adhesion strength and impact resistance of Cr-DLC films have close connections with thickness of Cr/CrN interlayer. Residual stress of Cr-DLC coated copper alloy decreases first and then increases with the interlayer thickness increasing, which reaches the least value of -0.47GPa when the interlayer thickness was 1.01μm, and the hardness and elastic modulus of Cr-DLC films are 11.68GPa and 144.54GPa, respectively. Adhesion strength increases first and then decreases with the increase of interlayer thickness, which reaches the maximum of 50N when the interlayer is 1.01μm. Impact craters are generated on the surface of all Cr-DLC coated samples with Cr/CrN interlayer of different thickness after repetitive impact test of 30000 times, a certain area of film spallation is observed at the central zone of impact craters, and the sample with Cr/CrN interlayer of 1.01μm has the least indentation volume of $9.241\times10^6\mu m^3$, which shows the best impact resistance. In summary, for Cr-DLC films with Cr/CrN interlayer prepared on copper alloy, when the thickness of Cr/CrN interlayer is 1.01μm and the whole thickness of the films is less than 8μm, the films show the best impact resistance.

Key words: copper alloy; carbon-based film; impact resistance; interlayer

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