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激光熔覆纳米 TiC 颗粒增强 CoCrFeNi 高熵合金涂层

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摘要：904L 不锈钢搅拌桨叶由于硬度低在磷酸反应器中易出现腐蚀和磨损。为了提高其硬度和耐蚀性，在 904L 不锈钢表面采用激光熔覆技术制备纳米 TiC 增强 CoCrFeNi 高熵合金复合涂层（CoCrFeNi-*x*TiC, *x*=0, 5, 7.5, 10, 12.5, 15vol%）。通过 XRD、SEM/EDS、TEM、显微硬度计、摩擦磨损试验机和电化学工作站等表征复合涂层显微组织和性能。该复合涂层主要由 FCC 固溶体和少量 TiC 相组成。纳米 TiC 颗粒主要沿树枝晶分布。随着 TiC 增加，涂层组织中 TiC 颗粒尺寸增大，体积含量增多。然而 TiC 添加量大于 12.5vol%时，涂层中产生裂纹。透射结果表明，TiC 颗粒在激光熔覆过程中没有发生分解。随着 TiC 添加，复合涂层显微硬度、耐磨性、耐蚀性逐渐增加。当 TiC 添加量为 15vol%时，涂层硬度最高达到 357.4 $HV_{0.2}$，约为基材的两倍。该复合涂层磨损率(3.974 $mm^3 \cdot N^{-1} \cdot m^{-1}$)低于基材(5.545 $mm^3 \cdot N^{-1} \cdot m^{-1}$)。此时涂层的腐蚀电流密度减少约一个数量级，阻抗提高 3.5 倍。

关键词：纳米 TiC 颗粒，高熵合金涂层，激光熔覆，耐磨性，耐蚀性

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Laser cladding TiC nanoparticles reinforced CoCrFeNi high entropy alloy coating

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Abstract: The agitator blade made by 904L stainless steel was subjected to serious corrosion-wear due to its low hardness in phosphoric acid reactors. In this aspect, various nano-TiC particles reinforced CoCrFeNi HEA composite coatings were fabricated on 904L stainless steel by laser cladding. The microstructure and properties of the HEA composite coatings were characterized using XRD, SEM/EDS, TEM, hardness tester, friction-wear testing machine and electrochemical workstation. The phase structure of the composite coatings was composed of FCC solid solution and TiC phase. The microstructure observation detected that tiny TiC particles widely distributed along the inter-dendrites of FCC matrix. Also, the particle dimensions and volumes rapidly enhanced with the addition of TiC. Whereas, excessive TiC addition (≥12.5vol%) led to the generation of microcracks. The TEM results further confirmed that TiC particles did not decompose during laser cladding. With the addition of TiC, the microhardness, wear and corrosion resistance of the composite coatings gradually increased. Especially, the microhardness of CoCrFeNi-15vol%TiC coating reached the peak value of 357.4 $HV_{0.2}$, approximately twice higher than that of the substrate. It's specific wear rate (3.974 $mm^3 \cdot N^{-1} \cdot m^{-1}$) was lower than substrate (5.545 $mm^3 \cdot N^{-1} \cdot m^{-1}$). Compared with 904L stainless steel, it's corrosion current density was reduced by nearly an order of magnitude, the impedance

was increased by 3.5 times.

Keywords: TiC nanoparticles; High-entropy-alloy coating; Laser cladding; Wear resistance; Corrosion resistance