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THE RESEARCH AND DEVELOPMENT OF HIGH ENTROPY ALLOY COATINGS APPLIED IN HARSH ENVIRONMENTS

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The pioneering studies on multicomponent alloys and high-entropy alloys (HEAs) by Prof. Cantor [1] and Prof. Yeh [2] in 2004 introduced a transformative materials design paradigm based on compositional complexity and configurational entropy. Since then, HEA thin films fabricated by magnetron sputtering have attracted considerable attention due to their tunable structures and multifunctional properties. In this work, a series of functional HEA-based thin films were developed using high power impulse magnetron sputtering (HiPIMS) or magnetron sputtering for electrochemical and corrosion-resistant applications in harsh environments. $VNbMoTaWO_x$ oxide films were deposited on graphite felt electrodes for vanadium redox flow batteries (VRFBs). The influence of oxygen content and O:W ratio on electrocatalytic activity and cell performance was systematically investigated in 1.6 M $VOSO_4$ + 4.3 M H_2SO_4 electrolyte. The optimized films achieved outstanding energy efficiencies of 81.40% at 100 mA cm^{-2} and 71.40% at 160 mA cm^{-2}. The $CrMoNbTiWC_x$ carbide films were synthesized under controlled target poisoning ratios via HiPIMS. When deposited on 304 stainless steel, these coatings exhibited exceptional corrosion resistance in 0.5 M H_2SO_4, demonstrating strong potential as protective layers for metallic bipolar plates in proton exchange membrane fuel cells. For $(HfVTiZrW)B_2$ boride films, the effect of deposition temperature on corrosion resistance in acidic 0.5 M H_2SO_4 media and resistance to HF plasma etching was examined, confirming their suitability for chemically aggressive and plasma-exposed environments. Furthermore, nitrogen-doped $AlCoCrFeNiN_x$ films grown on nickel foam showed significantly enhanced electrocatalytic activity in alkaline–saline electrolyte (1.0 M KOH + 3.5 wt.% NaCl). The optimized coating delivered a low overpotential of 329 mV at 10 mA cm^{-2} and maintained stable operation for 300 h at 100 mA cm^{-2}, highlighting its promise for seawater electrolysis. Overall, this study demonstrates that precise compositional design combined with controlled HiPIMS processing enables HEA thin films with tailored multifunctionality, offering strong potential for advanced energy and corrosion-resistant applications in harsh environments.

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