Exploring the diffusion mechanisms of nanostructured ZrN-Cu coating produced by a hybrid HiPIMS-DCMS system

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Abstract Globalization has brought many benefits for the cost-effective transportation of goods. However, the shipping industry still faces challenges such as corrosion, biofouling, and restrictions on heavy pollutant products used in paintings according to the laws imposed around the world. The present study proposes a solution using a state-of-the-art nano-structured zirconium nitride and copper coating. This is obtained applying a hybrid magnetron co-sputtering system which consist on two different power sources (high-power impulse and direct current) working under a reactive atmosphere (Ar + N_2). SEM, EDX, STEM, SAED, and EELS were employed to unravel the coatings features such as morphology, structure, and chemical bondings. Corrosion resistance was assessed by potentiodynamic polarisation (PP) and Electrochemical Impedance Spectroscopy (EIS) for up to 30 days, employing saline solution (3.5% w/w NaCl) as electrolyte. The results pointed out to the coating nano-architecture is able to control the copper release effectively regardless of the employed mobilizing agent (NaOCl solution or saline solution plus electrical potential), and demonstrating a good corrosion resistance after 30 days of exposure to the electrolyte. A three-stage diffusion

mechanism was observed, starting with the surface oxidation/passivation, passing through the nano-galvanic coupling assemble and later, the movement of Cu nanoparticles. XPS and EELS results indicate the formation of CuO species on surface as well as ICP-OES measuments demonstrates the active Cu^{2+} ionic release and STEM micrographs corroborate the voids left by the nanoparticles during diffusion. The environmentally friendly process of obtaining the ZrN-Cu coating makes it a promising option for the naval industry, offering controlled biocide release and corrosion resistance and opening the possibility of application in the naval industry.

Keywords HiPIMS, maritime, corrosion, diffusion, multifunctional.