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SURFACE ENGINEERING OF 316L STAINLESS STEEL USING DUPLEX CRN/TIN COATINGS VIA DC MAGNETRON SPUTTERING: MICROSTRUCTURAL, TRIBOLOGICAL, AND HARDNESS EVALUATION

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Abstract:

Surface engineering plays a critical role in improving wear resistance, corrosion resistance, and overall service life of industrial components. This study presents the deposition and characterization of duplex chromium nitride/titanium nitride (CrN/TiN) coatings on AISI 316L stainless steel substrates using physical vapor deposition (PVD) via DC magnetron sputtering. Substrate temperature, working pressure, and nitrogen gas flow rate were selected as primary control variables, identified from literature review and RSM considerations. Coatings of approximately 4 μm thickness were deposited and examined using XRD, SEM, and tribological testing according to ASTM G99 standards. XRD analysis confirmed distinct CrN and TiN phases, while SEM micrographs revealed uniform coating coverage with good adhesion and minimal porosity. Wear testing demonstrated that duplex CrN/TiN coatings significantly outperformed both uncoated and single-layer TiN-coated samples, showing reduced wear rates and lower coefficients of friction even under increased normal loads. Hardness measurements indicated that duplex coatings possessed hardness values nearly five times greater than the base 316L substrate. These improvements are attributed to the synergistic combination of TiN's lubricity and CrN's high hardness and corrosion resistance. The findings suggest that duplex CrN/TiN coatings are highly promising for applications requiring enhanced durability, such as plastic molding tools, die-casting dies, and mechanical components subject to severe wear.

Keywords: *CrN/TiN duplex coating, DC magnetron sputtering, PVD, wear resistance, hardness, surface engineering, stainless steel*

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