



Coatings

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Surface Science of Degradation and Surface Protection

Edited by: Matic Jovičević-Klug, Patricia Jovičević-Klug and László Tóth

Metallic surfaces and advanced coating systems are a diverse and vital class of materials that influence many aspects of modern life. Due to their unique combination of mechanical, chemical, physical, and functional properties, metallic substrates and organic, inorganic, hybrid, and self-healing coatings are widely used across a variety of industries. They are used to create protective barriers against wear and corrosion, as well as for catalytic surfaces, optical components, electrical conductors, biomedical materials, and structural elements in demanding environments.

Despite the widespread use, the long-term applicability of coatings and modified metallic surfaces is often limited by degradation processes. Material degradation is a complex process involving the gradual deterioration of a material's structure, functionality and performance in operational conditions. This can be caused by various factors, such as static and cyclic mechanical loading, abrasive and erosive wear, corrosive environments, thermal fluctuations, biological interactions, and repeated contact with other materials. These mechanisms may act independently or synergistically, resulting in significant changes to surface properties and, ultimately, leading to material failure. It is essential to understand how coatings and metallic surfaces evolve over time when exposed to specific environmental and service conditions. This knowledge is crucial for developing durable materials, improving predictive maintenance strategies, reducing economic losses, and supporting sustainability objectives by extending material lifetimes and improving resource efficiency.

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