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Editorial

Special Issue: Tribological Coatings—Properties, Mechanisms, and Applications in Surface Engineering

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Tribological coatings are found on machine elements (e.g., gears, bearings, and sliding elements), tools (e.g., drills, milling cutters, and knives), electromechanical parts (e.g., electrical contacts, and coils), parts of fluid machines (e.g., rotors of pumps, blades of water turbines, and parts of valves), parts of turbomachines (blades of steam and gas turbines), biomedical implants, electronic and optoelectronic devices (e.g., computer and mobile phone screens), and objects for everyday use (e.g., eyeglass lenses, cutlery, and construction fittings) [1–3]. In all these applications, the use of tribological coatings is intended for reducing wear that could be caused by the action of individual specific wear mechanisms or by a combination of several basic mechanisms, such as abrasion, adhesion, surface fatigue, and tribocorrosion [4,5]. Combinations of two or more basic wear mechanisms under certain operating conditions, along with a certain type of motion of tribosystem elements (e.g., sliding, rolling, and impact) and the materials involved (metal materials, polymers, ceramic materials, and composite materials) result in a number of wear processes. Some of these processes, which are important for applications in engineering, are classified in DIN 50320 and VDI 3822 standards. In a tribosystem, there are three stages in the wear process: initial wear or running-in, predictable normal wear, and advanced abnormal wear; the latter makes the tribosystem dysfunctional and unusable. In the action of the wear process in a tribosystem, there are differences between initial wear or running-in, predictable normal wear, and advanced abnormal wear, which lead to the dysfunctionality and unusability of the tribosystem. The main goal of tribological coatings is to enable a certain tribosystem to function in the normal wear regime until the end of the designed service life or longer. The application of surface coatings for protection against wear and corrosion is today the most researched area of tribology. The scientific field of surface engineering deals with the development of and research on coating and surface modification procedures and the properties and application of tribological coatings. [2,4,6,7]. Numerous requirements can be imposed on a tribological coating; thus, an ideal coating should fulfill the following set of requirements [1,6,8]: (a) good adhesion to the base material, (b) increased hardness to withstand abrasion, (c) sufficient toughness to prevent peeling, (d) good chemical stability, (e) activity in forming a tribological film of lubricant or oxide, (f) thermal stability, (g) sufficient shear strength to resist contact pressures, and (h) adaptability to the substrate.

Several excellent review papers deal with the classification [6,9] and development trends of tribological coatings [10–12]. They list several basic divisions of tribological coatings. According to the type of chemical bonds, coatings are classified as coatings with metallic, ionic, and covalent bonds [13]. According to their composition and microstructure, tribological coatings are classified as single-component, multi-component, multi-layer, gradient, composite, and multi-phase coatings [6,7,9,14]. According to hardness, tribological coatings can be divided into hard and soft coatings. Soft tribological coatings are mainly used to reduce friction in sliding contacts (polymeric coatings, graphite, lead, copper, and nickel coatings). Hard tribological coatings are used to increase resistance to abrasion, erosion, or impact wear (carbides, nitrides, oxides, borides, and hard diamond-like layers). Both types of coatings are applied to hard substrates or substrates with a hardened surface layer [1,2,4,6,15]. In most applications of tribological coatings, such as thermal barriers for gas turbines [16], hard coatings for cutting tools [17] or hard and tough coatings for molds for casting metals [18] or polymers [19], they serve as multifunctional coatings with a special combination of properties. Due to their microstructure and application in the most difficult conditions, special groups of tribological coatings include nanostructured and nanocomposite coatings [20–22] and biomedical coatings [23].

Modeling the behavior of tribological multi-functional coatings requires sophisticated analytical, numerical, and statistical methods to include the effects of mechanical, thermal, and tribological processes on the changes in the properties and durability of coatings [24–26]. Experimental tests carried out on multifunctional tribological coatings include methods that simultaneously monitor changes in their properties (mechanical, tribological, electrochemical, and thermal) caused by loads (mechanical, thermal, electrochemical) and by wear processes [26–29].

This Special Issue aims to provide a forum for researchers to share current research findings and to promote further research into the mechanical behavior of advanced multifunctional coatings, including experimental modeling and theoretical calculations.

Experimental studies on the application of PVD CrN and PVD CrAlN tribological coatings on the 308 stainless steel in heat exchangers in nuclear reactors, where operating conditions include high temperatures of 500 °C and abrasive wear, were presented by Y. Luo et al. [30]. To investigate wear resistance, the authors proposed an innovative design of a device in which impact abrasive wear of heated samples is caused by a sand jet. The properties of the coatings before the wear test were determined by XRD analysis and microhardness testing. In the impact-abrasive wear process, the energy of sand micro-impacts absorbed by a sample with the coating was monitored in real time. Using light and the electron microscopy, the worn surfaces were analyzed by recording the geometric profile of the wear track and by analyzing the microstructure and morphology of the damaged areas. The proposed testing methodology is also applicable to other similar coatings that serve as thermal barriers or are subjected to the simultaneous action of thermal load and abrasion or erosion wear.

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