Chapter 9
Tribological Performance of Coatings Obtained by PVD Techniques: From Industrial to Biological Applications

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ABSTRACT

The chapter presented a short review related to the factors that dictate the wear and friction behavior of various coatings obtained by PVD techniques used for various applications. An important parameter with high impact on the final properties of the coatings prepared by cathodic arc evaporation is the reactive atmosphere. The friction and wear performance of the carbide coatings were strongly dependent on the carbon content which can be controlled by varying the C2H2 mass flow rate and the arc current on the cathode. Regarding the carbonitrides coatings, the ratio of C/N plays an important role; the coating with a low C/N ratio showed reduced friction coefficients, while for the coatings with a high C/N ratio the wear was improved. For biomedical applications, the magnetron sputtering deposition technique was employed to enhance the tribological performance of Ti6Al4V alloy in Ringer solution using various types of coatings such as carbonitrides, carbide, or hydroxyapatite.

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INTRODUCTION

The present chapter highlights the tribological results obtained by the authors during the last decade and it takes into consideration the friction and wear behavior of various coatings obtained by Physical Vapour Deposition (PVD) techniques such as magnetron sputtering and cathodic arc evaporation. It should be noted that within the next few years the tribological properties of functional surfaces are set to become a vital key factor in several interdisciplinary fields of physics, engineering, biology, chemistry, and materials science. Also, the tribological knowledge advancements are receiving an increasing attention in the new context of the accelerated global warming, electronics components shortage crisis or to the increasing number of patients with medical devices. In addition, the past decade has seen a renewed importance in prolonging the service life of nanomaterials as the Fourth Industrial Revolution is ongoing and the opening of new areas of applications is mandatory. In order to address the above-mentioned specific issues, the researcher's worldwide efforts were focused on developing eco-friendly technologies (no harmful substances are used or result from) which are capable to produce cost-efficient coatings with enhanced tribological properties. This approach was meant to have a social, economic and ecological impact by introducing a new generation of wear resistant coatings, complying with all the environmental and health regulations, with increased life quality outcomes for the citizens. By carefully controlling the PVD deposition processes one may obtain coatings with different component elements in mono- and multilayer structures depending on their final applications. The high deposition rate and reproducibility are crucial assets of PVD processes that are currently used in industry for large area coaters. Considering the increasing need for developing wear resistant coatings, the PVD techniques represent a suitable solution which is able to address all market demands. Through selective modification of deposition parameters, it is possible to achieve a high tunability of tribological and mechanical properties. Therefore, the phase structure of nitride coatings can be changed by varying the reactive gas flow rate, bias voltage or substrate temperature (Kazmanli et al., 2003). Also, similar effects with an additional increasing of wear resistance at elevated temperatures can be obtained by controlling the doping element within the binary or ternary coatings (Tillmann & Dildrop, 2017). Besides, by using a high plasma density PVD technology such as High Power Impulse Magnetron Sputtering (HiPIMS), high performance protective films with good mechanical properties ($H \geq 20$ GPa, $E \geq 300$ GPa) were produced (Zin et al., 2018). Superior tribological behavior of quintenary duplex coatings as compared to non-duplex or nitrided layers can be achieved by combining surface treatments such as plasma nitriding with PVD deposition techniques such as cathodic arc evaporation (M. Braic, Braic, Balaceanu, Vladescu, et al., 2011). The aim of this chapter is to extend current knowledge of wear resistant coatings developed for industrial, severe service and biological applications. The information included in this chapter can be beneficial for the scientific community in order to obtain an optimal surface finish for tools working in dry or wet environment, at room temperature or in severe conditions, or even in the human body.

BACKGROUND

In broad terms, tribology can be defined as the science and technology of rubbing surfaces in contact and relative motion and entails the study and application of friction, lubrication and wear principles. There is a considerable amount of available literature on the outstanding mechanical properties of carbides, nitrides or carbonitrides which were found to be suitable for a large variety of tribological applications