Chapter 71
Advances in Functional Nanocoatings Applied in the Aerospace Industry

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ABSTRACT

Surfaces of aerospace components are subjected to heat, water, ice, electromagnetic waves, corrosion, abrasion, wear, thermal shock and/or fire during their lifetime. Materials science and engineering have introduced the use of coatings to protect the surface of the materials under these operating conditions. Materials such as ceramics, polymers, and metals and their combinations either as composites or hybrid materials, as well as functionalized versions of them, have been proposed as different design alternatives. Six different types of coatings can be identified: anti-corrosion, abrasion and wear-resistant, thermal barrier and flame-retardant, conductive, anti-icing, and superhydrophobic. This chapter will review the most important advances in functional nanocoatings, which are being researched and those already used in aerospace applications, as well as the profits that these materials can provide to the surfaces of the components where them are used.

INTRODUCTION

Military and commercial aviation is suffering high maintenance cost and poor availability of assets (Del. 2013). Premature damages are found in engines, due to deterioration produced by hot erosion, distortion, clearance, and corrosion, as well as, by impact failure during operating cycles. Therefore, the use of coatings for aerospace industry must offer attractive design solutions, in terms of resistance at climate, durability and reliability during their operation. The use of coatings is imperative in harsh climatic conditions such as varying temperatures and humidity ratios, as well as when drag is presented. Researchers, around of the world, have been designing coatings with the aim of offering materials with low densities, anti-corrosive properties, reinforced-dragging, supporting to failure mechanisms both dynamic and

DOI: 10.4018/978-1-5225-1798-6.ch071

static type, abrupt changes in harsh conditions, and good tribological properties. For example, a coating must be erosion resistant and must have low thermal conductivity, when it is applied as thermal barrier.

In aerospace industry, substrates based on aluminum (Al) and its alloys (Al); magnesium (Mg) and its alloys, as well as, titanium (Ti) and its alloys have been used to the manufacture of aerospace components (Wang, 2013). Moreover, conventional coatings based on chromium (Cr(VI)), phosphate and permanganate have been used in aerospace applications such as fasteners, adhesive joints, and corrosion protection. With the advent of nanomaterials, novel nanocoatings have been introduced in different technological applications. Nanostructured materials have the capacity of developing intelligent, functional or smart coatings such that they provide multiple or specific physicochemical properties exploited to protect surfaces of the substrates. These coatings are manufactured with composite materials and functional materials based on combinations of polymeric, ceramic and metallic materials. Composite materials are defined as a combination of a material called matrix and at least a material used as reinforcement, with the aim of providing better physicochemical properties that properties of the individual components. Functional materials are materials with designed physicochemical properties that serve for specified application needs and whose properties can be controlled. A composite material is considered as a particular case of the functional materials.

A coating is a covering applied to the surface of an object called substrate. The coatings have purpose decorative, functional, or both (Makhlouf, 2011). The coating itself may be an all-over coating on the substrate, or it only cover parts of the substrate. Functional coatings have the purpose of changing the surface properties of the substrate to offer adhesion, wettability, electrical conductivity or electrical insulation, thermal insulation or thermal conductivity, corrosion resistance, or abrasion and/or wear resistance. Coatings can be used in a variety of industries and applications and these can be applied to the substrate as liquids, gases or solids. A coating is formed by a system of materials involving the bulk material (substrate), interface (interaction between substrate and covering), and a modified surface layer. In practice, the interface region between the coating and the substrate material can represent the weakest link. A mechanical interlocking is favored if the substrate has a rough surface and contains large pores. In addition, a surface with high reactivity or with wetting conditions is preferred, since between the coating and substrate material will form a stronger interface. In particular, polymeric coatings are composed by binders, fillers, solvents, pigments, and additives (Wu, 2015). Coating processes may be classified as: vapor deposition either chemical (CVD) or physical (PVD), chemical and electrochemical techniques, spraying, and roll-to-roll processes.

Nanocoatings based on functional materials represent the technological proposal for replacing to conventional coatings, since these materials possess unique physicochemical properties and also to satisfy the environmental fulfillment (Makhlouf, 2014). A coating based on functional material must be lightweight and thin can be very attractive for practical applications in areas of aircraft and aerospace. Nanocoatings have the following functions in aerospace and aviation: 1) facilitate crack-healing by means of high-temperature strength and creep resistance, 2) increase service life of turboengines through of the application of multilayer structures to provide temperature resistance, thermal shock, as well as, anti-corrosion and erosive wear-resistance, 3) reduce high maintenance costs through of the use of anti-corrosion coatings in parts subjected to harsh environments, 4) save fuel-burn by means of the drag reduction using blended winglets to improve fuel efficiency and reduction of emissions into atmosphere, and 5) decrease ice accretion through of the control of climatic conditions of the surfaces of airfoils. The application of these coatings will be increased in next decade, until them can be manufactured

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