Chapter 20

Progress in Advanced Materials Used in Electromagnetic Interference Shielding for Space Applications

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ABSTRACT

Aerospace applications experience electromagnetic interference produced by the space environment and by the materials, devices, and systems used in satellites, space shuttles, the international space station, and airplanes. The advanced materials represent a technological possibility to develop coatings that are able to offer a better shielding effectiveness against electromagnetic interference due to the possibility of controlling its electrical and magnetic properties as well as to that the size of the materials is very similar to the electromagnetic waves that it receives. In this chapter, an analysis of progress over advanced materials is presented with the aim of diffusing the role that nanomaterials have had, have and will have to increase the shielding to electromagnetic interference. Nanomaterials will protect aerospace components in the range of Hz to THz, but the huge advantage is that the range of protection can be optimized according to the technical requirements with a considerable weight reduction.

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INTRODUCTION

Surfaces of aerospace components are subjected to heat, water, ice, electromagnetic waves, corrosion, abrasion, wear, thermal shock and/or fire during their lifetime (Vargas-Bernal, 2016). 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. 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 increase in the use of electronic devices in all the applications of high technology vanguard has produced an excessive electromagnetic radiation contamination in our surrounding environment. This situation leads to serious hazards related to the normal operation of electronic devices associated with strategic systems such as nuclear reactors, transformers, aircraft and aerospace systems, control systems and communication systems. Electromagnetic interference can be defined as any electromagnetic emission from a device or system which interferes with the normal operation of another device or system. Thus, electronic systems must have electromagnetic compatibility with their environment or be able to tolerate a fraction of electromagnetic interference and not generate more than a specific amount of interference. Electronic systems experience the effect of indirect lightning strikes which involves damage or failure of their operation due to the application of a near-lightning flash. Among the experiments found are the tripping of circuit breakers due to the physical damage of input or output circuits on the electronic equipment. With the overuse of telecommunication systems, digital systems, and innovative design practices in military, commercial and aerospace systems, the design of electrical products that meet electromagnetic compatibility standards becomes increasingly restrictive. Researchers around the world are continually proposing technological alternatives to minimize the generation of electromagnetic interference from their sources, reducing or eliminating coupling paths by appropriate arrangement, through shielding, filtering and grounding practices, as well as through design hardware with inherent immunity to interference. Three different types of interference can be found on an aircraft: on-board systems (electronic devices used during flight), devices carried by passengers (portable electronic devices that can transmit and receive frequencies), and externally generated interference (lightning strike, high-intensity radiated fields (HIRF), and electromagnetic pulses (EMPs)) (von Klemperer, 2009). The key to achieving successful electromagnetic interference shielding lies in the development of advanced materials and appropriate process technologies.

Electromagnetic shielding is achieved by blocking fields of the same type by means of barriers made of electrical and/or magnetic materials. The amplitude of the reduction of electromagnetic shielding depends on the material used, its thickness, the size of the object to be shielded, the frequencies of the applied fields, as well as the shape, size and orientation of the openings of an object to an electromagnetic field incident. All metals used in the aerospace industry must be lightweight, strong and resistant to corrosion. The most common choices are titanium, aluminum, stainless steel, and nickel. Additionally, these materials must have a high strength-to-weight ratio, be refractory, heat and wear resistant, and flexible with increasing temperature. Materials commonly used for electromagnetic shielding are metals such as copper or nickel, in the form of sheets, screens, or foams. The gaps of these structures must be smaller than the wavelength of the applied electromagnetic fields. More recently, polymers are being combined with electrically conductive or semiconductor materials based on metals or ceramic materials. The substitution of metallic materials by composite materials guarantees to maintain good mechanical