ABOUT SOME COATINGS FOR AEROSPACE APPLICATIONS

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Abstract: *This study is focused on some coatings used in aerospace area. The special inherent properties of many metals and their alloys have focused attention on their increasing application in aerospace and allied industries. However, severe operating conditions in air and space often limit the possibility of using these alloys directly. Therefore to reduce the influence of adverse environmental space conditions and for successful use in aerospace industry these metals and their alloys require special surface preparation, namely deposition of different types of coatings on their surfaces. In this paper we will briefly present several types of the most aerospace applicable coatings.*

ОТНОСНО НЯКОИ ПОКРИТИЯ ЗА АЕРОКОСМИЧЕСКИ ПРИЛОЖЕНИЯ

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Резюме: *Това проучване е фокусирано върху някои покрития за космическите изследвания и свързаните с нея области. Специалните присъщи свойства на много метали и техните сплави са фокусирали вниманието върху нарастващото им приложение в космическите изследвания и свързаните с нея промишлености. Въпреки това, суровите условия на работа във въздуха и космоса често ограничават възможността за използване на тези сплави директно. Следователно, за да се намали влиянието на неблагоприятните условия на околната среда и космоса, за успешното използване в космическата промишленост, тези метали и техните сплави изискват специална обработка на повърхността, а именно нанасяне на различни видове покрития върху техните повърхности. В тази работа ще представим накратко няколко вида от най-използваните за космически приложения покрития.*

Introduction

The present work is motivated by the nowadays tremendous interest in extremely stable in space environment coating materials. The evidence is the Space Programs and space budgets, which almost every country has. Today the coatings attract a lot of attention, especially in aerospace applications. We can not use directly the metals and their alloys in aerospace industry, or at least most of them for a long time. This is due to the negative influence of the unfriendly environment conditions in outer space. Therefore to reduce the influence of adverse environmental space conditions and for successful use in aerospace industry, these metals and their alloys, and all items made of them, require special surface preparation, namely deposition of different types of coatings on their surfaces. In this paper we will briefly present several types of coatings, namely some of the most applicable coatings in aerospace.

Examples of some coatings used in aerospace

In the literature and in the industry there are sufficient data for such coatings. Aluminium (Al) alloys are frontrunners among the structural materials used in space applications. But being a strong electronegative metal, aluminium has a strong oxygen affinity and forms a thin tenacious oxide films. For that reason, aluminium and its alloys require special surface treatment for successful use in aerospace industry. For example in [1] are presented studies on ultra high solar absorber black electroless nickel (Ni) coatings on aluminium alloys for space application. Process optimization was carried out by investigating the influence of various operating conditions, viz., pH of electroless nickel solution, thickness of electroless nickel deposit, formulation, concentration, temperature and processing time of etching solutions on the physico-optical properties of the black coating. The nature of the coating was evaluated by the thickness measurement, micro hardness evaluation and EDX studies. The microstructure of the deposits was examined under scanning electron and optical microscope. The space worthiness of the coating was evaluated by the environmental tests, viz., humidity, corrosion resistance, thermal cycling, thermo-vacuum performance and thermal stability tests. Optical properties of the coating were measured before and after each environmental test to ascertain its stability. The blackened electroless nickel provides high solar absorber in the order of 0.995. The results of these studies clearly indicate that the coating process described in [1] is extremely suitable as a solar absorber coating for space and allied application.

Magnesium has focused attention on increasing applications in aerospace and allied fields. Its density is two thirds that of aluminium-a conventional structure material for aerospace. Magnesium has one drawback: it is prone to atmospheric corrosion. Further, because of its high chemical affinity for aqueous solutions, it is categorized as a difficult metal for electrochemical treatments. The highly reactive nature of magnesium is clearly indicative by its position in the electromotive series. The situation is still more complex for magnesium alloys, where the alloying constituents introduce electrochemical heterogeneity. Communication satellites make use of a traveling wave tube (TWT) for amplification of signals. In a TWT the collector is the main source of heat dissipation. The electrodes are heated by the residual kinetic energy of the collected electrons; however, the electrodes must be maintained at a relatively low temperature. There are two ways to dissipate this heat into cold space. One of them is: heat radiation or conduction from the electrodes to a radiator, which is an integral part of TWT. This is called radiation cooling and is suitable for even high-power TWTs. This cooling method simplifies spacecraft thermal control. A fin structure is attached to the collector end to increase the heat transfer area, and a high-emittance coating is applied over it to improve heat-radiation characteristics (See Figure 2 in [2]). The radiator, top collector, and base plates of TWT (shown in Figures 3 to 5 [2]) were made out of magnesium alloy ZM21. In a conventional TWT, these are fabricated out of aluminium alloys. The magnesium alloy ZM21 was selected because of its inherent lightness and higher thermal conductance over conventional magnesium alloys. The radiator requires a high-emittance coating on the exposed portion to reject the heat in space. The inner area of the radiator and the complete surface of the top collector and base plates are to be coated with a high-corrosion-resistance coating with good solderability characteristics. These coatings should withstand elevated temperature for an extended period without degradation in their properties. In [2] an electroless nickel deposition process is described and applied. The process provides a high degree of corrosion resistance at elevated temperatures and a good solderability and wettability to the soldering material. A process of electroless nickel plating on magnesium alloys [2] using the sequence of fluoride activation, electroless nickel deposition, passivation, and heat treatment has been optimized for aerospace applications. The process provides excellent plating coverage inside narrow holes. The electroless nickel coating so obtained has adequate mechanical properties, corrosion resistance, solderability, and environmental stability for stringent space requirements.

In [3] are presented many examples of aerospace applications (and also in many other areas of applications) of electroless nickel. All of the properties of electroless nickel are used to advantage in this industry. In aircraft engines, turbine or compressor blades are plated with electroless nickel as protection against the corrosive environment they are exposed to. The coating thickness in this application is generally 1 to 3 mils of high-P electroless nickel. When the blades are plated with electroless nickel, there is about 25 percent less loss of fatigue strength than when plated with hard chrome. Electroless nickel coatings compliment aluminium's inherent characteristics (its density and, consequently, its light weight.) by adding hardness, wear resistance, corrosion protection, and solderability. Piston heads are a good example of the successful combination of aluminium and electroless nickel in the aerospace industry. The light weight of aluminium allows the piston to work more efficiently, while the electroless nickel provides wear resistance that extends the useful life of the piston. The main shafts of aircraft engines are plated with electroless nickel to provide good bearing surfaces. An additional advantage of electroless nickel is realized when rebuilding of the shafts is required during maintenance overhauls. The remaining electroless nickel can be stripped off and replated to the required thickness. This contrasts favorably with the more expensive machining required for chromium-plated shafts. The rear compressor hub sleeves and bearing liners of the TF30 Jet engine are reconditioned and replated with electroless nickel at a cost savings of several thousand dollars over the purchase of new components. The components are made of a titanium alloy containing 6 percent vanadium and 4 percent aluminium. Two mils of electroless nickel are used as the finish. In addition to engine-related applications, electroless nickel finds many other uses in the aerospace industry. The relatively low coefficient of friction of electroless nickel, coupled with its corrosion resistance, makes it useful in plating servo valves. Landing gear components are plated with 1 to 2 mils of electroless nickel to build up mismatched surfaces, as well as to provide corrosion resistance. Metallic optics are becoming widely used in spaceborne systems. In these applications, a strong coating must be deposited over a light, strong metal such as beryllium or aluminium. Special high-phosphorus electroless nickel deposits have been polished to 9 A (13), providing superior performance in space applications where high G forces are present and low inertia is required. Table 8.2 (form [3]) summarizes the major uses of electroless nickel in the aerospace industry.

In references [4,5,6] the authors thoroughly presented the types of conformal coatings used in space applications. Conformal coatings are used in space applications on printed circuit board (PCB) assemblies, on spacecraft electrical circuits, primarily as a protective barrier against environmental contaminants. Such coatings have been used at Sandia National Laboratories for decades in satellite applications including the GPS satellite program. There are five primary types of conformal coating materials used for environmental protection of electronics: acrylics, silicones, polyurethanes, epoxies, and parylenes. The first four are typically applied with spray or dip operations, while parylenes are applied using a vacuum deposition process. Proper selection of conformal coating material may increase lifetimes and improve performance of electronic assemblies. In [4,5] authors give us also recommendations for future work in the field of conformal coating space applications.

In the work [7] are studied some of the properties (microstructure, mechanical, electrochemical, wear-corrosion) of electroless nickel–phosphorus (ENP) coatings on carbon-fiber-reinforced plastic (CFRP) composites, commonly used in aeronautical and astronautical applications due to their superior properties such as high specific strength and modulus. Experimental results demonstrate that a uniform ENP coating was successfully deposited on a CFRP substrate via electroless plating after appropriate sensitization, activation and mechanical polishing pre-treatments of the CFRP substrate exhibited excellent protection from corrosion and wear corrosion for CFRP composites. The microstructure, phosphorus content, thickness and electrochemical and wear-corrosion properties of the ENP coatings were strongly correlated with the pre-polishing condition (the corresponding surface roughness) of the CFRP substrate. High P content ($P > 7$ wt.%), low micro-porosity, smooth morphology, high thickness and hardness of ENP coatings on the CFRP substrate were obtained when substrate surface roughness was ≥0.3 μm (grinding with 800-grade emery paper). The resulting electrochemical behavior exhibited a strong passivity that is favorable to enhanced wear-corrosion resistance properties.

The corrosion in space is described in [8] by the effect of atomic oxygen on several materials. The metals investigated are Cu, Au, Al, stainless steel, Ta, Al alloys and Mo. These materials were exposed with and without coatings, such as silicones. Other groups investigated Os, Pt, Ni, Fe-alloys and carbon. The metal which was most affected was silver. Silver oxidizes according to a linear-parabolic law and due to the thermal stresses the oxide layer continuously breaks up, resulting in a linear degradation. Atomic oxygen not only attacks materials in the line of sight of the ram flux, but also by reflected atomic oxygen. Many materials form an adherent oxide layer, such as Cu, Al, and stainless steel and are as such protected once this oxide layer is formed. Some materials have a volatile oxide such as Osmium and many polymers materials. On way to protect the silver of being oxidized by atomic oxygen is by plating with gold. The tests on polymers show that each polymer appears to be sensitive to a different component of the environment. The conclusion in [8] was: the effect of atomic oxygen on surfaces in laboratory experiments might be different from the effect encountered during low earth orbit exposure. During orbit the exposed samples undergo a thermal cycling sequence of +100/-100°C. This might have a detrimental effect on some oxides. The simultaneous action of atomic oxygen attack and thermal cycling might be compared with such effects as static stress and corrosion (stress corrosion) and fatigue and corrosion (corrosion fatigue), where the result of the combined action is more than the sum of the separate effects. To predict materials performance in low earth orbit, one must accurately simulate the conditions of the low earth orbit environment or at least understand how the performance of materials under simulated conditions relates to that in space.

In [9] were prepared the Ni-Fe-La-P rare earth alloys of glass fiber. Rare earth element lanthanum (La) was first introduced into glass fiber by electroless plating, in order to improve and adjust the chemical, physical properties and microstructure of alloy coatings. The application of rare earth element La in electroless plating was explored. The results showed that an appropriate amount of rare earth element La could improve the stability of the chemical plating solution and reduce the temperature of electroless plating by 6°C - 20°C. La not only could make the morphology of alloy coatings compacted, smooth and uniform, but also could greatly improve the contents of Fe, Ni and could tremendously reduce the content of P in the alloy coatings of glass fiber. The conductivity and magnetic properties of the alloy coatings could be increased by La. La could promote the transition of alloy coatings from amorphous state to crystal state, improve the electromagnetic performances of alloy coatings, and enhance the electromagnetic wave absorbing properties and application areas of alloy coatings.

In [10] were investigated 3 new crystalline and amorphous MoS_2 based coatings for space applications. The study focus on understanding what governs the tribological behavior of dry lubricated contact to find out the keys to develop new coatings for space applications. Firstly conducted on sputtered columnar MoS_2 coatings and amorphous MoS_2+Ti coatings, experiments show that contamination modulates the 3rd body rheology and helps controlling the 3rd body generation (particlesizeand amount). To dissociate the role of both Ti and the coating microstructure in the tribological behavior of the coatings, a sputtered amorphous MoS_2 coating was studied. The study confirms the beneficial impact of the addition of a controlled amount of contamination on their tribological behavior . It also brings some recommendations to design coatings for space applications in terms of microstructure, addition of metal and gaseous dopants, etc.

Electromagnetic interference (EMI) and electromagnetic compatibility (EMC) are garnering more attention due to the rapid growth in the use of telecommunication and electronic devices in residential and industrial applications. A number of materials for the EMC purposes have been proposed that are capable of absorbing electromagnetic radiation. However, the conventional absorptive materials such as metal powders and ferrites are quite heavy, and this restricts their usefulness in applications requiring lightweight mass (such as earospace). In the study [11] highly conductive Ag thin film is coated on hollow silica microspheres via electroless plating for application in lightweight microwave absorbers. Their microwave absorbing properties were analyzed in relation to the electrical properties of the thin film. The microwave absorbance was enhanced with decreases in the electrical resistance of microspheres due to the increased dielectric loss. As a result, the lightweight and thin microwave absorbers were proposed with the Ag-coated microspheres with a controlled electrical resistance for lightweight mass applications.

Every year energy requirements of people increase, because all human activities require energy. Many researchers look for possible alternate sources of energy. There has been a significant interest on hydrogen evolution reaction (HER), which is one of the most intensively studied reactions industrially. Hydrogen can be produced by a number of processes, one of which is alkaline water electrolysis. This method however is too expensive and consumes too much energy. There are several ways to reduce the cost of hydrogen production by means of improving the electrode's performance leading to low energy consumption. New electrode materials capable of catalytically reducing the energy barrier of the HER have been investigated. In order to improve the electrocatalytic performance of the surface, a number of metal alloy coatings have been recently developed and reported to have low over potential and high exchange current density as available in recent literatures. Literature reports also confirm that nickel and its alloys could be considered as the highly active electrode materials among all the various types of metal or alloy coated electrodes studied for the hydrogen evolution reaction in alkaline solutions. The effects of nano NiO incorporation on enhancement of electrocatalytic efficiency of the electroless Ni–P coatings for HERs in alkaline medium were systematically investigated in paper [12] with respect to both metallurgical and electrochemical characteristics. An improvement in the hardness and thickness of electroless coatings along with a mirostructural surface grain refinement was achieved by the incorporation of the nano NiO into the Ni–Pmatrix. The role of nano NiO on enhancement of electrocatalytic efficiency of the coatings for catalyticHER is evident from the results of potentiodynamic polarization and cyclic voltammetric studies.

Magnesium and its alloys have excellent physical and mechanical properties for a number of applications. In particular its high strength:weight ratio makes it an ideal metal for automotive and aerospace applications, where weight reduction is of significant concern. Unfortunately, magnesium and its alloys are highly susceptible to corrosion, particularly in salt-spray conditions. This has limited its use in the automotive and aerospace industries, where exposure to harsh service conditions is unavoidable. The simplest way to avoid corrosion is to coat the magnesium-based substrate to prevent contact with the environment. The review [13] details the state of the art in coating and surface modification technologies, applied to magnesium based substrates for improved corrosion and wear resistance. The topics covered include electrochemical plating, conversion coatings, anodizing, gas-phase deposition processes, laser surface alloying / cladding and organic coatings. A great deal of research is still required to develop better, simpler, cheaper coating technologies (especially protective coatings that can withstand harsh service conditions) so we can take advantage of the lower weight and excellent mechanical properties of Mg.

Electromagnetic waves have been widely used in both military and civil applications: radar, wireless communication tools, local area networks, personal digital assistant, aerospace, etc. However, there are many problems caused by the increasing usage of electromagnetic waves. In order to provide solution to electromagnetic interference (EMI) and microwave absorption, the absorbers of electromagnetic waves are becoming very important, which have attracted much attention of many scientists. Carbonyl iron, as well as ferrites, has been extensively studied for a long time as magnetic components of polymeric composites for the application of electromagnetic wave absorbers. However, carbonyl iron is more suitable to be applied in a broad frequency range than ferrites. In paper [14], Co-coated carbonyl iron was synthesized using an electroless plating method, using flaky carbonyl iron particles as raw materials. This preparation method has the advantages of simplicity, low-cost and high-purity in practical applications. The antioxidation and electromagnetic properties of the Co-coated carbonyl iron were discussed in detail. So the Co-coated carbonyl iron has much better antioxidation property and can also serve as a super thin microwave absorber for different applications.

Black coatings on metallic substrates are widely used for numerous applications; for example, as decorative coatings, as solar absorption coatings in solar panels, as antireflective coatings in optical instruments etc. It has been reported that there is a strong relationship between the optical properties of black nickel coating and its thickness. The coating exhibits solar absorber property only in a narrow range of thickness and with increase in thickness, the coating behavior changes from a solar absorber coating (high absorbance and low emittance) to a flat absorber coating (high absorbance and high emittance). High emittance coatings play an important role in passive thermal control of spacecraft. These coatings are predominantly applied on internal packages of spacecraft to improve their heat radiation characteristics. In a spacecraft, the electronic packages that are in operation may become too hot due to large heat dissipation while other standby may have the tendency to get colder. High emittance coating helps in minimizing the temperature gradient between the operational and standby components by improving their heat radiation characteristics. In [15] black nickel, an alloy coating of zinc and nickel, was obtained on copper substrate by pulse electrodeposition from a modified Fishlock bath containing nickel sulphate, nickel ammonium sulphate, zinc sulphate and ammonium thiocyanate. The main objective of this work [15] was to optimize the process parameters to develop high emissivity space worthy black nickel coating to improve the heat radiation characteristics of the substrate surface.

The guide [16] to reflectance coatings and materials contains the description of many coatings and materials suitable for many space applications. One example: Infragold NIR-MIR reflectance coating; the typical reflectance of Infragold is >94% above 1000 nm and data is traceable to the National Institute of Standards and Technology (NIST). Infragold can be applied to metal parts, generally aluminium, nickel or steel, although it has been applied with success to copper and tungsten. It is generally used for reflectance integrating spheres and accessories for NIR to MIR applications and is suitable for many space applications.

[17] reports a method of fabrication for small-feature-sized nickel microbumps on gold using a newly developed technique called electroless Ni plating with noncontact induction (ENPNI). This technique, differing from conventional electroless Ni plating with contact induction (ENPCI), which directly connects an active metal with an inactive metal to induce Ni electrochemical reaction, is characterized by separation of the active metal and the target metal. The mechanism of ENPNI is interpreted by employing the electric-double layer theory, and some phenomena are explained by the proposed mechanism. Ni microbumps with a diameter of 3–6 μm and a height of 3–4 μm have been successfully fabricated using ENPNI. The resistance of the Ni microbumps is measured, and yield and uniformity are evaluated. By breaking the restriction of contact, ENPNI has the advantages of no need for pretreatment and contact induction, allowing fabrication of microbumps with small feature sizes for applications in which direct contact of an active induction metal is impossible. The obtained in [17] results demonstrate that ENPNI is a promising method to fabricate microbumps for 3-D integration of MEMS arrays with ICs (it is obvious, that very small devices are very applivable in space).

High efficiency, thin-film Epitaxial Lift-Off (ELO) III–V solar cells offer excellent characteristics for implementation in flexible solar panels for space applications [18]. However, the current thin-film LO solar cell design generally includes a copper handling and support foil. Copper diffusion has a potentially detrimental effect on the device performance and the challenging environment provided by space (high temperatures, electron and proton irradiation) might induce diffusion. It is shown that heat treatments induce copper diffusion. The prime alternatives for a different metal foil carrier known to be compatible with thin-film cell processing are silver and gold, which are much more expensive than copper. Other alternatives of particular interest for implementation in GaAs solar cells would be the electroplated titanium and nickel diffusion barriers suggested for silicon solar cells [18].

There are many companies on the market space today, which offer various coated items for space applications. One of them, Glenair Inc. (United States) offers composite thermoplastic interconnect components (instead of coated metals), which are manufactured from high-grade engineering thermoplastics for the toughest application environments. Specifically geared for high-performance air, sea, land and space applications, Glenair's line of composite connectors and backshells are ideally suited for systems which require electromagnetic compatibility, reliable environmental protection and long-term durability. Through the use of selective plating—which limits easy-toscratch plated surfaces to the protected portions of the part—Glenair has effectively eliminated superficial damage to coupling nuts, saddle bars and box exteriors. The parts are free from visible wear-and-tear problems that forces premature replacement of backshells, connectors, box assemblies and other EMC interconnect components. Over the past 15 years, Huber+Suhner AG, has been manufacturing microwave assemblies, offering outstanding electrical and mechanical characteristics, which have been successfully employed in various scientific and commercial space projects. The use of its space application ranges from low earth orbit (LEO), geo synchronous orbit (GSO) to interplanetary unmanned vehicles as well as manned missions. Its carefully balanced range of cables and connectors covers the frequency range up to 65 GHz having at the same time flexibility, increased mechanical strength or protection against abrasion. Their patented connector assembly system ensures a reliable connection between the connector and the cable in any situation. The most important: the most of the connector parts of their space flight power sub miniature connectors (which are made of different alloys) are plated with different coatings (gold, ceramic coating, etc.).

Every year in the USA is accepted Joint industry standards “Space Applications Electronic Hardware Addendum to IPC J-STD-001E Requirements for Soldered Electrical and Electronic Assemblies” [19]. In this important document are listed all necessary properties for coatings in space applications.

Aluminium metal matrix composites (MMCs) are the most significant materials in aerospace and automotive industries due to their superior mechanical properties. A variety of methods have been used for synthesizing these composites, but the liquid-state route is the simplest technique with lower cost. However, low wettability of ceramic particles as reinforcement by liquid metal matrix is a major problem in fabrication of MMCs via casting (liquid- state) method. This important challenge is addressed by the use of metal-coated ceramic particles to increase the wettability of the composites. Metallic coating of ceramic powder particulates is commonly performed in order to alter the specific properties of ceramics. The mass gain (MG, %) of coated metal on ceramic particle plays an important role in this regard. Copper, nickel and cobalt are three important metals, which were reported for fabrication of metal-coated ceramic particles as reinforcements of MMCs. As example, the investigation [20] was undertaken to predict the MG of cobalt electroless deposition (ED) on ceramic SiC particles.

The overviews [21,22] presented the guides to the use of electroless nickel for engineers, metallurgists, designers and others involved in materials selection. The important properties of electroless nickel deposits are described and examples are given of how these properties have been used successfully to solve materials problems in various industries. In [21] special attention is given to the use of electroless nickel in aerospace industry. Initially, the main interest was in the use of electroless nickel during engine overhaul and maintenance programmes. On jet engines, it has also been used on fuel control assemblies and bellows and in the space programme, it has been used effectively on the docking, cargo bay and ruder mechanisms of the space shuttle. Applicatins in the aerospace industry are not limited to engine components. Electroless nickel is used on many airframe assemblies 30 such as landing gear components, ramp locking systems and flap and actuator components. Several parts of the mai landing gear of the Boeing 727 are protected from corrosion and erosion by electroless nickel. These are mostly high strength steel parts that previously were coated with cadmium and now have extended service life since a change to electroless nickel was made. In addition, electroless nickel is used on some critical and advanced aircraft navigational systems. The expanding use of metallic optics17 in the aerospace industry has resulted in another successful application for electroless nickel. The requirement is for a high strength coating to be applied to a strong, light metal such as aluminium or beryllium. A deposit, containing 12.2 to 12.7% phosphorus, polished to an extremely fine finish has provided outstanding performance in space applications where high G forces are present and low inertia is required. Many components used in the space programme are plated with electroless nickel to provide corrosion protection, wear protection and excellent lubricity as required. These include components on the space shuttle-31 used in fuel systems, gear systems and fluid transfer systems for example. Composite coatings of electroless nickel and fluorinated carbon [21-23] are also used for various applications, including battery components and satellite systems.

As already mentioned above, Al alloys and Al-based composites constitute a very important class of engineering materials widely employed in the aircraft and aerospace industry for the manufacturing of different parts and components due to their high strength-to-density ratio and being the second cheapest of all commercially important metals after magnesium. In our department in SRTI-BAS [24,25] was synthesized a new Al-based alloy, namely Al alloy B95 with certain additions of tungsten (W) and some nanodiamonds (ultrafine diamond particles, ND). These detonation nanodiamonds were used as strengthening particles for improving the mechanical properties of Al alloy. Also some of us [23,26,27] have experience in electroless nickel composite coatings with nanodiamond (ND) additives. The so modified, with nanodiamonds and W, aluminium alloy B95 (B95+W+ND), prepared in our department, was a part of the DP-PM module of the international outer space experiment “Obstanovka” (carried out in the Russian sector of the International Space Station). In the international project "Obstanovka" were involved six countries: England, Bulgaria, Poland, Russia, Ukraine and the Czech Republic, on the International Space Station. On 02.12.2013, at 0:40 pm., with the transport spacecraft "Progress 18M" on board of the International Space Station was supplied scientific equipment, including the DP-PM module with our alloy. The aim of this international space experiment was to investigate the 2 years and a half influence of outer space environment on the properties of the alloy (B95+W+ND). The box, on which were mounted the samples of the so modified (see above) Al alloy B95 (for being exposed directly to the outer space conditions, for about a 2 years and a half stay), was coated by a bilayer composite electroless Ni coating (Ni / Ni + ND) to improve the surface characteristics of the box alloy. After this exposure to the outer space influence, the samples and the box were returned to the Earth for future research. Today the comparative analysis of the samples (i.e. of the both types of materials, that were and that were not in the outer space) is under study.

Conclusions and outlook

Here is presented a brief (because of the lack of space) survey of some coatings for aerospace applications. We see the important role of different coatings for space research and applications. Both experimental and theoretical studies of the coating structures, properties and materials are quite important for development of the new coatings and their new space applications.

Hence it is very interesting and useful to study the material properties in the context of new coatings of considerable interest for application in space technology and in particular for aerospace instrumentation.

We see that some of the unique properties of electroless nickel and electroless composite nickel, such as thickness uniformity, hardness, corrosion resistance, not expensive and magnetic response have resulted in its use in many different industries. Today it is firmly established as a functional coating in the electronics, oil and gas, chemical, aerospace and automotive industries, for instance. It is also recognized and used effectively in many others and the number of applications continues to grow.

Last but not least, our experience in the electroless nickel depositions and electroless composite coatings will be of great help in the future study of unknown coating properties, coating structures, new reinforcing particles (in composite coatings) for new potential aerospace applications.

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