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Editorial

Special Issue: Advances in Corrosion Resistant Coatings Volume II

Yong X. Gan

Department of Mechanical Engineering, California State Polytechnic University Pomona, 3801 W Temple Avenue, Pomona, CA 91768, USA; yxgan@cpp.edu; Tel.: +1-909-869-2388

Among the various corrosion prevention methods as described in [1], the application of protective coatings on the surface of metallic alloys is considered as an effective and commonly used method in engineering design. Protective coatings are able to form a barrier between a material and its environment [2]. Advanced coatings possess some required performances of high chemical stability, high thermal resistance, excellent mechanical robustness, enhanced durability, and good friction and wear behavior [3]. Significant progress has been achieved in the research and development of numerous coatings for protecting materials subjected to the exposure to strong corrosion media, such as seawater, animal wastes, and aggressive gases. New composite coatings containing nanotubes and nanoparticles, advanced passivation and conversion coatings, and novel plasma induced coatings are some of the examples. Coating processing technologies have also reached a new level. It is revealed by the recent progress in using diversified electrochemical and chemical conversion means, the sol–gel approach, plasma-enhanced growth technique, laser peening method, etc. Searching for new coating materials, including metallic alloys, polymers, ceramics, composites, and nanostructured materials has led to the findings of multifunctional films and coatings for various applications in aircraft structures, heavy machinery, and biomedical implants.

This Special Issue provides a forum on the following basic and applied research on corrosion-prevention coatings, including manufacturing techniques for thin films and coatings, degradation types of protective films, seawater corrosion behavior, newly found organic, inorganic, and composite coatings, micro- and nanostructure characterization of films, and functional coatings for energy conversions. There are eight papers published in this Special Issue, including one communication, one review and six research articles. In the communication, Wen, Wang and Ren [4] reported their recent work on microstructure observation and corrosion resistance evaluation on an HVAF (high-velocity air fuel)-sprayed Al-based amorphous coating on magnesium alloys. The Al alloy coating has a nominal composition of $Al_{86}Ni_6Y_{4.5}Co_2La_{1.5}$ with an amorphous structure. The substrate, a ZM5 magnesium alloy, was HVAF-spray coated by this amorphous coating. The coating survived the 500-h neutral salt spray test without any apparent corrosion. The coating has a much more positive corrosion potential than the substrate and a two-order magnitude corrosion current density drop of the substrate was found due to the sprayed coating. The dense structure of the coating is believed to be the reason for the improvement of the corrosion resistance. Oxide coatings for thermoelectric energy conversion were reviewed [5]. Thermoelectric coatings can generate electricity when a temperature difference exists. Such a function allows thermoelectric devices to be used for waste heat harvesting, thermal imaging, and temperature measurement. Transition metal oxide coatings are highly corrosion resistant when they are used at elevated temperatures. They show strong phonon scattering behavior and large quantum confinement effects. Therefore, thermoelectric oxide coatings are considered to be used as new candidates for waste heat recovery, thermal imaging, and temperature measurement in high temperature severe environments. In this review article, oxides and other materials were compared in view of their thermoelectric characteristics

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and the advantages of metal oxide materials were shown. The review article also described the newly developed processing and manufacturing technologies in much detail. Typical manufacturing technologies for thermoelectric metal oxide coatings in the forms of thin film, superlattice, porous layer, and nanocrystal layer were presented. Physical vapor deposition (PVD) and chemical vapor deposition (CVD), liquid phase deposition (LPD), nanocasting, solid state powder metallurgical approach, and high energy beam irradiation techniques were delineated. The structure, electrical, thermal and thermoelectric properties of the processed transition metal oxide coatings were briefly discussed. In addition, the device design and fabrication concepts based on the applications of oxide coatings for heat energy harvesting, thermal imaging, and temperature sensing were mentioned. Directions for future research and development on oxide thermoelectric coatings were also dealt with. Each of the six original research articles represents a cutting-edge direction in view of new coating processing, new material and new characterization/evaluation techniques. Samaniego-Gámez et al. [6] presented their work on the corrosion behavior of the nanoporous coating formed on the AA2055 aluminum–lithium alloy. The nanopores in the surface were generated through the anodization of the AA2055 in a sulfuric acid bath, followed by pore-sealing in water and sodium dichromate ($Na_2Cr_2O_7$) solution. Electrochemical impedance spectroscopy (EIS), scanning electron microscopy (SEM) and X-ray photoelectron spectroscopy (XPS) were used to characterize the coating. It has been found that the $Na_2Cr_2O_7$ sealing solution is effective in increasing the charge transfer resistance and produces a more homogeneous and dense passivation coating. Consequently, corrosion inhibition and protection to the AA2055 were obtained. In the work performed by Wu et al. [7], Pt was added into the CrN hard coating. Increased electron transport and enhanced corrosion resistance of the CrN coating were found. The transition-metal nitride coating, CrN, has been considered to be used to protect the electronic connector devices for the services in the marine environment. High electrical conductivity and good corrosion resistance are among some of the critical requirements. This article [7] introduced the synthesis of a novel Pt containing CrN layer with a compact structure. The addition of Pt induced a dramatic increase in electrical conductivity. The corrosion resistance was also increased. It is confirmed that Pt as a dopant has a critical role in improving the conductive behavior and enhancing the corrosion resistance of nitride coatings for potential applications in off-shore structures. To increase the seawater corrosion resistance of a copper–zinc alloy in the marine environment, a hydrothermally carbonized coating was prepared [8]. The hydrothermal processing method [9] has been studied for nanomaterial production. However, its new application for making surface coatings to slow down material degradation is only introduced in this study [8]. The hydrothermally carbonized coatings were deposited on both pure copper and its alloy, C26000 brass. The effect of the hydrochar coating on the seawater corrosion performance was investigated. First, hydrothermal carbonization of 10 wt.% sucrose aqueous solution at 200 °C, under 1.35 MPa pressure for a period of 4 h was performed to produce the hydrochar coating. The results of the microstructure, composition, hardness, coating thickness, and seawater wettability of the coating were presented. The corrosion resistance of the copper–zinc alloy and pure copper with and without the hydrothermally carbonized coating was evaluated through the measurement of the Tafel constants in a seawater environment. Characteristic parameters, such as the potentials of corrosion, corrosion current, and polarization resistance, for the pure copper and the copper–zinc alloy coated with and without the hydrochar were determined from the polarization measurement data. It was revealed that the hydrothermal carbonization of sugar generated a relatively compact carbon-rich layer on the surface of the pure copper and the copper–zinc alloy (brass) specimens. This carbon layer with a thickness of 120 μm is highly corrosion resistant. The corrosion current of the copper and its alloy in seawater is reduced dramatically via the hydrothermal carbonization treatment. The carbonized coating suppressed the corrosion current significantly, but only resulted in a slightly positive shift of 0.05–0.1 V in the electrochemical potentials. The hydrochar coating is similar to a passivation film on both the pure copper and the copper–zinc alloy, which reduces their corrosion rates in seawater. Ti and its alloys have better electrochemical properties than other alloy systems due to the formation of a protective TiO_2 coating on their surfaces. Electrochemical corrosion of anodized titanium and titanium alloys with the protective coating were studied [10]. The article showed how to generate the protective oxide layer and characterized the electrochemical corrosion behavior of titanium and its alloys with the compositions of Ti-6Al-4V and Ti-6Al-2Sn-4Zr-2Mo. Anodizing the pure Ti and its alloys was carried out in 1.0 M H_2SO_4 and H_3PO_4 solutions, respectively, with a current density of 0.025 A/cm^2. Such Ti alloys are widely used in aerospace engineering. It is important that they have satisfactory anticorrosion performance in the environment containing chlorine ion and acidic substances. Electrochemical tests on the anodized alloys were carried out in H_2SO_4 and NaCl solutions with the same concentration of 3.5 wt.% at room temperature. Scanning electron microscopy (SEM) was employed to observe the morphology of the anodized surfaces. The electrochemical behavior of the anodized coating was characterized. The results indicated that the Ti alloys treated in the H_3PO_4 electrolyte showed the electrochemical behavior associated with a uniform passive coating when they were exposed to the 3.5 wt.% NaCl corrosion medium. Ti alloys added with more beta-phase stabilizers generated a much less uniform anodized coating.

Samad et al. [11] investigated the thermal, electrochemical, micro- and nanomechanical, and properties of the epoxy matrix composite coatings containing various dosages of ZnO nanoparticles. The processed coatings were characterized after the full curing of the epoxy resin for seven days. The uniform distribution of the nanoparticles within the matrix was observed using scanning electron microscopy (SEM). Following that, Fourier-transformed infrared spectroscopy (FTIR) was used to examine the influence of the nanoparticle addition on the curing of epoxy resin. Differential scanning calorimetry (DSC) was used to investigate the thermal responses. The corrosion performances of the coatings were analyzed by immersing the prepared composite coatings in a 3.5% NaCl electrolyte. The generated experimental data revealed that the addition of the ZnO nanoparticles into epoxy was effective at lower contents; higher dosages of the nanoparticle addition led to the formation particle aggregation. At higher nanoparticle dosages, the epoxy curing process was impeded, resulting in the insufficient curing state. The lower degree of curing negatively affected the mechanical, thermal, and electrochemical properties. The upper limit for the nanoparticle addition is 2%.

Burduhos-Nergis et al. [12] studied how to improve the corrosion properties of a carbon steel used for manufacturing carabiners. They raised the issue on the safety of workers. Carabiners are the critical components in safety systems. They connect other components in the systems or build connections between the systems and the anchor points. For safety, the materials for making carabiners require good corrosion protection in various environments. This paper is part of a comprehensive study that aims to improve the corrosion properties of carbon steel used for producing carabiners. Early studies have shown that the corrosion resistance of the carbon steel in aggressive environments has been improved by various types of phosphate coatings and many other subsequently deposited coatings. The research work introduced in [12] focuses on evaluating the corrosion behavior of different galvanic couples. The galvanic couples were made of duralumin-coated samples, aluminum bronze-coated samples, and carbon steel-coated samples. The galvanic corrosion tests were implemented in three types of corrosive media. For the first time, comprehensive studies were carried out on the galvanic corrosion of the steel used for manufacturing carabiners. The samples with a Zn phosphate coating exhibited the best performance in the two corrosive media, including a fire extinguishing fluid and saltwater.

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