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Editorial

A Brief Summary of Publications in the Special Issue: Advances in Corrosion Resistant Coatings

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This Special Issue, "Advances in Corrosion-Resistant Coatings", is situated in the section "Corrosion, Wear and Erosion" in the *Coatings* journal (ISSN 2079-6412). The objective of this Special Issue is to provide a core platform of ideas regarding basic and applied research on corrosion-resistant films and coatings, including related processing technologies, forms of corrosion, environmental responses, new metallic, nonmetallic, and composite coatings, the microstructural examination of various protective coatings, and thin films with the function for energy conversion. A total of eight publications are collected in the Special Issue, including one short communication, one comprehensive review article, and six original research papers. All eight publications have been cited. In the following part of this Editorial, a brief summary of the publications is given.

First, in a short communication, Wen, Wang and Ren [1] outline the latest progress made on the microstructural examination and corrosion resistance assessment of a high-velocity air fuel (HVAF)-sprayed aluminum-based glassy coating on Mg alloy substrate. The aluminum alloy coating with the approximate composition of $Al_{86}Ni_6Y_{4.5}Co_2La_{1.5}$ is found to have the required non-crystalline structure. The substrate is a ZM5 magnesium alloy and is found to be able to survive a salt spray test for 500 h without any observable degradation. The amorphous coating possesses much vaster positive electrochemical potential than the ZM5 substrate. A decrease in the corrosion current density of two orders of magnitude is achieved for the ZM5 alloy due to the existence of the spray-coated amorphous layer. The coating has a dense structure which contributes to enhancing corrosion resistance.

Secondly, transition metal oxide coatings for thermoelectric energy harvesting are reviewed in [2]. As is well known, thermoelectric coatings can generate electricity from waste heat. Such a function permits thermoelectric units to be used for energy conversion, temperature sensing, and thermal imaging. Transition metallic oxide films or coatings have the advantage of corrosion resistance at elevated temperatures in oxidative atmospheres; they show the capability of scattering phonons intensively. In addition, they possess strong quantum confinement behavior. Therefore, thermoelectric oxide coatings have begun to be used as new materials for thermoelectricity. They are especially suitable for energy conversion and temperature measurement in severe environments. This review paper provides a comparison of the thermoelectric properties of various oxides and other materials to demonstrate the advantages of transition metal oxides. Typical processing technologies are detailed. These processing technologies are used for making thermoelectric oxide coatings in the form of thin layers, superlattice films, and nanograin powder coatings. Specifically, liquid-phase deposition, chemical vapor deposition, nanocasting, solid-state approaches, physical vapor deposition, and energy beam techniques are emphasized. The micro- and nanostructures and thermal/electrical transport properties of the processed transition metal oxide coatings are presented. Moreover, the concepts of the devices and the applications of the oxide coatings for temperature sensing, thermoelectric energy conversion, and thermal imaging are illustrated. Perspectives of further research on transition metal oxide thermoelectric coatings are described.

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Thirdly, each of the six original research papers represents a direction detailing an aspect of a new coating material, an innovative coating processing technique, or a new characterization/evaluation method. For example, Samaniego-Gámez et al. [3] evaluate the degradation behavior of the AA2055 Al-Li alloy. Nanopores within the surface coating were produced by the anodization of AA2055 in sulfuric acid followed by pore-sealing in pure water and a sodium dichromate ($Na_2Cr_2O_7$) aqueous solution. EIS (electrochemical impedance spectroscopy), SEM (scanning electron microscopy), and XPS (X-ray photoelectron spectroscopy) were applied to analyze the coating. It is found that the $Na_2Cr_2O_7$ aqueous sealing solution increases the resistance to charge transfer and produces a denser and more uniform passivation coating. This coating inhibits the corrosion of the AA2055 alloy.

In the research introduced by Wu et al. [4], a CrN hard coating was incorporated with the noble metal Pt. An increase in the electrical conductivity is confirmed and the resistance of the CrN coating to marine corrosion is enhanced. Traditionally, the chromium nitride coating is used for protecting electronic connector devices in the ocean environment. High corrosion resistance and good electrical conductivity are properties that are in demand. This article [4] demonstrates the synthesis of the Pt-containing CrN hard coating with a dense texture. The addition of Pt into the CrN coating results in a significant increase in its electrical conductivity. The corrosion property is also improved. It is revealed that incorporating Pt into the coating plays a significant role in enhancing its electrically conductive behavior and increasing the corrosion resistance of the nitride coating for potential application in the ocean environment.

To improve the corrosion resistance of copper–zinc alloys to seawater in the marine environment, hydrothermal synthesis of a carbonized coating was conducted in [5]. Although hydrothermal synthesis [6] has been reported for nanomaterial production, its new application for making surface coatings to protect materials from corrosion is introduced in this paper [5]. The hydrothermal carbonization coating was formed on both brass (a Cu-Zn alloy with the designation of C26000) and pure copper. The effect of the carbon-rich coating on the seawater corrosion performance was studied. Briefly, a solution containing 10 wt.% sugar in water was hydrothermally carbonized at 200 °C under 1.35 MPa for 4 h to form the carbon-rich coating. The thickness, surface morphology, hardness, composition, and wettability to seawater were investigated. Specifically, the corrosion resistance to seawater for the brass and pure copper specimens with and without the hydrochar coating immersed in seawater was measured. The associated Tafel constants for each specimen were calculated. Electrochemical parameters including the equilibrium potentials of corrosion, corrosion current density, and polarization resistance for both brass and pure copper with and without the carbonized coating were generated from the polarization measurement results. It is found that the hydrothermal carbonization of sugar solution generates a fairly dense hydrochar coating at the surface of both copper and brass. The thickness of the carbon layer varies depending on the processing time. The coating is found to be corrosion resistant, and the corrosion current densities of Cu and Cu-Zn alloy in seawater are reduced significantly by the hydrothermal carbonization coating. It is believed that the hydrothermally generated carbon coating is similar to the passivation layer on Cu or Cu-Zn alloys, leading to low corrosion rates in seawater.

Ti and its alloys have been increasingly used in the aeronautical industry. It is important that they have high corrosion resistance to acidic agents and/or chlorine ions. Generally, Ti and its alloys are better than other alloys in terms of electrochemical properties because of the formation of the protective TiO_2 coating on their surfaces. In [7], the corrosion behaviors of anodized titanium and its alloys with a TiO_2 protective coating are investigated. First, the paper demonstrated the procedures for the formation of the protective oxide coating. Then, the electrochemical corrosion performances of Ti and Ti alloys with the compositions of Ti-6Al-2Sn-4Zr-2Mo and Ti-6Al-4V were outlined. The anodization of pure Ti and the two alloys was performed in both diluted H_3PO_4 and H_2SO_4 (1.0 M) solutions at a current density of 250 A/m^2. Corrosion tests on the anodized specimens were carried out in 3.5 wt.% NaCl and 3.5 wt.% H_2SO_4 solutions at ambient

temperature. SEM (scanning electron microscopy) was used to reveal the morphology of the anodized surfaces, and the electrochemical responses of the anodized coatings were examined. The results show that the Ti alloys treated in the H_3PO_4 electrolyte demonstrate electrochemical behavior associated with a uniform passive film being exposed to the 3.5 wt.% NaCl solution. The Ti alloy containing more beta-phase stabilizers produced a less uniform oxidized coating.

In the paper published by Samad et al. [8], the mechanical, thermal, nanomechanical, and electrochemical properties of epoxy coatings containing varying amounts of ZnO NPs (nanoparticles) were studied. Epoxy coatings were examined after complete curing for seven days. The dispersion of ZnO NPs in the epoxy matrix was examined by SEM (scanning electron microscopy) followed by FTIR (Fourier-transformed infrared spectroscopy) to assess the effect of the addition of ZnO NPs on the curing of epoxy. DSC (differential scanning calorimetry) was applied to study the thermal properties of the composite coatings. The electrochemical (anticorrosion) properties of the coatings were tested by immersing the prepared composite coatings into the solution containing 3.5% NaCl. The results reveal that the addition of the ZnO NPs is effective at lower loading ranges, and that higher loadings of ZnO NPs lead to particle agglomeration. In the higher NP loading ranges, the curing of epoxy is adversely affected and an insufficient curing state is shown. The lower degree of curing adversely influences the thermal, electrochemical, and mechanical properties. The upper boundary for the ZnO nanoparticle incorporation is found to be 2%.

Lastly, paper [9] outlines how to enhance the corrosion properties of carbon steels used for manufacturing carabiners, considering the issue of worker safety. Carabiners are considered crucial components in safety systems; they are used to connect various other elements within systems, building the connections between systems and anchor points. Therefore, to maximize safety, the materials used to make carabiners must have high corrosion resistance in various environments. This paper is a comprehensive study that aims to improve the corrosion properties of carbon steels for carabiners. Previous studies have proven that the corrosion resistance of carbon steels in various corrosive environments could be improved by depositing different types of phosphate coatings and other coatings. The work introduced by Burduhos-Nergis et al. [9] concentrated on evaluating the galvanic corrosion of different galvanic couples (duralumin-coated specimens, aluminum–bronze-coated specimens, and carbon–steel-coated specimens) tested in three different corrosive media. For the first time, comprehensive studies were carried out on the galvanic corrosion of potential materials for the manufacturing of carabiners. It is confirmed that the specimen coated with the zinc phosphate layer exhibits the best performance in the corrosive media, including fire-extinguishing fluids and saltwater.

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