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Mitigation of galvanic corrosion on plasma-modified magnesium alloys by surface design

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Introduction: Magnesium alloys are attractive to applications in the aerospace, transport, and biomedical industry because of their light weight and excellent machinability. However, their corrosion resistance is often not favorable. Surface treatment is one of the effective ways to improve the properties of magnesium alloys and plasma-related techniques such as sputtering and plasma immersion ion implantation have been attempted in the past years [1, 2]. It is known that magnesium has the lowest standard potential of all the engineering metals, so galvanic corrosion must be carefully considered in the process of surface design. In recent years, we have attempted some surface treatment methods including sputtering and ion implantation on magnesium alloys and found several feasible ways to regulate and control the galvanic corrosion. In this talk, our recent work is described and reviewed [3-7].

Materials and Methods: Plasma immersion ion implantation, magnetron sputtering and metal ion implantation were applied to modify magnesium alloys in our study, respectively. The surface characteristics of the plasma-treated samples were studied by X-ray photoelectron spectroscopy (XPS) and scanning electron microscopy (SEM). The electrochemical experiments including polarization and electrochemical impedance spectroscopy (EIS) were performed on a Zahner Zennium electrochemical workstation using the conventional three-electrode technique to evaluate the corrosion resistance and analyze the associated corrosion mechanism. In addition, an immersion test was further applied to evaluate the long-term corrosion resistance.

Results and Discussion: Reactive sputtering can deposit an AlO_xN_y ceramic coating on the magnesium alloy. When a metallic interlayer such as Ti is used, galvanic corrosion occurs due to the presence of defects in the coating. C_2H_2 plasma immersion ion implantation and deposition (PIII&D) is used to treat the Mg alloy and after the plasma treatment, a thin and insulating diamond-like carbon film is formed on the surface, which improves the corrosion resistance due to its good barrier effect [3,4]. Metal ion implantation can introduce chromium into pure magnesium, but it induces a severe galvanic corrosion because chromium exists in the metallic state in the implanted layer. Fortunately, ensuing implantation of oxygen can oxidize the Cr-rich implanted layer to form a thicker surface film containing chromium oxide, which retards the surface corrosion successfully [5-7].

Conclusion: Plasma-related techniques are one of the facile ways to modify magnesium alloys for acquiring excellent properties. However, the micro-defects in the coatings or plasma-modified surfaces will induce galvanic corrosion on magnesium alloys, which leads to the failure of the coating/substrate systems. Plasma immersion ion implantation with C_2H_2 or O_2 as the working gas has been attempted in our study and it is found that these strategies are effective to mitigate the galvanic corrosion on magnesium alloys.

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