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Editorial

Corrosion: Critical Challenge in Wider Use of Magnesium Alloys

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Magnesium alloys, given their high strength-to-weight ratio, are very attractive materials for applications such as aerospace and automotive components. They have also been used as fuel cladding material for nuclear engineering applications. However, magnesium alloys have not found widespread application, particularly in corrosive environments, due to their unacceptably rapid corrosion rates. So, there is a great commercial value in finding measures for durable corrosion resistance of magnesium alloys. It may be intriguing that because of the susceptibility of magnesium to corrosion, and the corrosion products of magnesium being non-toxic, there has been recent and increasing interest in these alloys for manufacturing biodegradable temporary implants (e.g., plates, screws, wires etc.). A success in use of magnesium alloy implants could altogether avoid the need for a second surgery that is required when temporary implants are constructed out of traditional materials, such as titanium alloys.

The special issue on 'Corrosion of Magnesium Alloys' was proposed with the background of advanced as well as traditional interest in mechanism and mitigation of corrosion of magnesium alloys described above. Some of the topical issues concerning corrosion magnesium alloys are: their use as temporary bioimplants, role of alloy microstructure in corrosion and effective coatings for corrosion resistance and corrosion modeling. There are articles on each of these topics in this special issue. An overview of the articles is presented below.

Magnesium alloys are hugely attractive as construction materials for biodegradable temporary implant devices. But their unacceptably rapid corrosion in human body fluid requires a coating that provides the required corrosion resistance, while also being biocompatible. To this end, the first study included in this special issue investigated the hexagonal boron nitride (hBN)-impregnated silane coating for an advanced magnesium alloy (WZ21) for bioimplant applications [1]. This coating was found to provide a five-fold improvement in the corrosion resistance in human body fluid. This study also includes thorough electrochemical analysis, and provides a mechanistic insight into the improvement in corrosion resistance due to the composite coating.

In the second study, alloying elements were added to magnesium to develop secondary precipitates for strengthening [2]. These secondary precipitates are invariably highly cathodic to the magnesium alloy solid solution matrix, and hence, cause severe localised corrosion. The large precipitates were found to be more detrimental. Rapid cooling, such as cryogenic quenching after heat treatment, can suppress the formation of large precipitates. The study showed that the alloy subjected to deep cryogenic quenching displayed the best corrosion resistance. Deep cryogenic quenching produced a new, smaller, square phase, which was responsible for the improved corrosion resistance.

Corrosion is the major bottleneck in wider use of magnesium alloys. A physico-chemical model that can accurately predict the corrosion rate under mechanical and stress corrosion of such alloys will be very useful in longer-term use of such alloys. Accordingly, the third study in the special issue focussed on development of a physico-chemical model capable of determining the strength of the alloy under corrosive conditions [3]. The formation of voids due to corrosive film formation was modeled by means of constitutive modeling in finite element analysis. Overall, the article provides a simulation framework wherein process models can be utilized to determine the optimal design parameters of magnesium alloys for specific applications.

Given the highly anodic nature of magnesium alloys and their unacceptably high corrosion rate, any durable use of such alloys in corrosive environment would require an effective coating. Accordingly, the fourth article in this issue focusses on formation of vacuum-annealed titanium carbonitride film on AZ31 alloy [4]. The article provides the influence of annealing temperature on the properties of the coated film. The last article in this issue presents an investigation of the role of coating parameters and the processing of the alloy substrate by equal-channel angular pressing (ECAP) on AZ91D alloy [5]. The study showed that increasing the number of ECAP passes results in more compact micro-arc oxidation (MAO) coating, subsequently improving the corrosion resistance.

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