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Editorial: Corrosion and protection of magnesium alloys

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Editorial on the Research Topic
Corrosion and protection of magnesium alloys

As green metal engineering materials in the 21st century, magnesium (Mg) and its alloys are abundant in nature and exhibit high commercial value and diverse application prospects in structural engineering, such as automotives, electronic communications, aerospace and defense industry. However, Mg alloys are highly active in terms of chemistry and prone to corrosion, which is one of the key bottlenecks in terms of large scale engineering services. This Research Topic was compiled aiming to highlight the state-of-the art research in relation to corrosion and protection of Mg alloys and provide guidance to the future development of Mg alloys towards robust and sustained corrosion resistance through nine articles combining critical reviews, scientific explorations, and perspectives.

Thermal control over oxidation is a common and conductive approach for tackling corrosion challenges of Mg-based materials for aerospace services. Jiang et al. calculated the Pilling-Bedworth ratio of oxides preferentially formed from the precipitated phases in Mg alloys. Results show that enrichment in Y_2O_3 in the composite oxidation film leads to improved corrosion resistance of Mg-Y samples. Wen et al. explored corrosion behavior of Mg alloy LA103Z with a thermally controlled oxide film in 3.5% NaCl solution. It is evident that corrosion of the Mg-Li alloy with a chemical oxidation film is initiated in pitting format, expands in depth in the early stage, forms corrosion holes, and then gradually develops into river-like morphology. In the last stage, the increasing corrosion products progressively cover the entire sample surface, which reduces the corrosion rate of the Mg alloy.

Combinations with corrosion inhibiting chemicals (*e.g.*, graphene oxide) have been applied to Mg alloy surfaces. Zhang et al. reported a (3-aminopropyl)-triethoxysilane-modified graphene oxide (GO) composite film upon Mg alloy AZ31 substrates. Due to the high barrier properties of layered GO, the silane-GO coatings provide effective protection to Mg alloy substrate and reduce surface defects in the GO film that occur during silane modification. In addition, corrosion products between the outer silane-GO film and Mg alloy substrate improve the corrosion resistance of Mg alloys. Gao et al. proposed a graphene-modified oil-based epoxy resin coating (G/OEP) on Mg alloy AZ31 with epoxy resin (polyurethane) and corresponding curing agent as primary ingredients. Graphene fills up the physical defects in the hydrophobic coating and improves the shielding ability against attack from corrosive media. A critical concentration (0.6 wt%) of graphene is determined with optimal corrosion resistance.

Rare Earth salts containing chemical conversion coatings is a promising solution to the corrosion challenges of Mg alloys. Li et al. employed micro-arc oxidation to prepare zirconium-containing films with varying concentrations on the surface of Mg alloy AZ91. It was stated that the $ZrSiO_4$ particles in the electrolyte enter the MAO film and reduce film defects. Hong et al. doped yttrium (Y) into Mg-Al layered double hydroxide films (MgAlY-LDHs) upon surface-anodized Mg-2Zn-4Y alloy by means of a hydrothermal approach. Y ions are doped into the MgAl-LDHs film in an isomorphic substitution manner and exhibit high corrosion resistance. The ternary LDHs film grown *in situ* on the Mg-2Zn-4Y alloy provides an alternative option for controlling corrosion of Mg alloys. Han et al. prepared anticorrosion films with superhydrophobic properties. *In-situ* layered double hydroxides (LDHs) were deposited on etched Mg alloy AZ31, and then they were modified into films with micro/nano hierarchical surface morphology. The super-hydrophobic LDH films provide high corrosion resistance owing to the double-protection derived from the LDHs and super-hydrophobicity.

In a Na_2SiO_3-Na_3PO_4 system, Silvina Román et al. investigated corrosion susceptibility of two Al-Mg dilution alloys (Al-0.5wt.%Mg and Al-2wt.%Mg) obtained by directional solidification (columnar, equiaxed and columnar-to-equiaxed transition, CET) at room temperature with different grain characteristics. The columnar grain zone presents higher corrosion resistance than the equiaxed grain zone, and the transversal section presents higher corrosion resistance than the longitudinal section. In addition, the decreasing polarization resistance as a function of distance from the base increases grain size, secondary dendritic arm spacings and hardness. When the polarization resistance increases, the critical temperature gradient decreases. Calado et al. reviewed the latest progress of WE series Mg alloys (such as mechanical properties, corrosion properties) in terms of correlations between those properties and microstructure, the individual role of specific alloying elements in the WE series, and sound protective strategies to manage their corrosion behavior.

The present contributions in the compiled articles are broad in nature, emphasizing the science and technology in relation to corrosion and protection of Mg alloys. This is also the purpose of this Research Topic, in which various methods of protecting magnesium alloys from corrosion are widely depicted. Cross-fertilization of new ideas are likely to emanate by compiling such complementary but not necessarily overlapping articles.

Author contributions

LW drafted the manuscript. X-BC and Y-WS edited and proof-read the manuscript.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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