A design strategy for high-performance Mg alloy with high-strength and high-corrosion resistance based on corrosion thermodynamics and kinetics

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Abstract A high-performance Mg (HPM-Mg) alloy with high-strength and high-corrosion resistance was designed based on the corrosion thermodynamics and kinetics using model of dissolution, ionization, diffusion and deposition (DIDD) by adding various low-alloying (LA) elements and micro-alloying (MA) elements. The detailed design principle is as follows: Screening of suitable Mg alloys with high-strength, followed by the design of asynchronous dissolution and deposition between the alloying elements and Mg. The priority deposited elements will provide nucleation sites for the subsequent deposited elements reducing their surface energy of nucleation and accelerating the nucleation rate of the corrosion products. Depend on this "downwards-magnifying" effect, a dense protective film will be rapidly formed on the alloy surface achieving the passivation and improving the corrosion resistance of the alloy while maintaining its high mechanical strength. Based on this design principle, Mg-(Gd, Y, Nd, Dy, Tb)-(Zr, Mn, Zn, Al)-(In, Ga, Sn) alloys are expected to be HPM-Mg alloys. In this work, the designed HPM-Mg (Mg-6Gd-3Y-0.5Zn-0.5Zr-0.5In) alloy was fabricated by extrusion followed by aging. The HPM-Mg alloy possessed a yield strength of 338.6 MPa, tensile elongation of 20.4%, and corrosion rate of 0.38 mm/a in 3.5 wt.% NaCl solution. After the immersion in NaCl solution, a dense multi-layered passive film enriched with the oxides/hyrdroxides of MA, LA and Mg from the inside out was formed, which is consistent with the design principle. The experimental results proved that the proposed design principle for HPM-Mg alloys in this work is feasible.