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Investigation of Morphology and Corrosion Behavior of Electroless Ni-P Coating on Mg-7Li Alloy with Different Pre-treatments

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1- Introduction

Mg‑Li alloys have the lightest density amongst all metal structural materials. Their density is between 1.3‑1.6 g/cm^3, and only accounts for 1/4‑1/3 of conventional Mg alloys. Magnesium‑lithium alloys have high specific strength, stiffness, excellent sound damping capabilities and resistance to penetration of high-energy particles. The application fields of Mg‑Li alloys have been limited because of the chemical activeness, and poor corrosion resistance with micro-electrochemical cell. Due to poor corrosion resistance of Mg‑Li alloys such as MA21 and certain difficulties of Ni‑P plating, two–step complex electroless Ni-P plating process is carried out and should be further investigated. In this work, $NiSO_4$ is the main salt for electroless Ni process on the surface of Mg-7.5Li (MA21), and the influence of different pretreatment processes on the coating structure, micro-hardness and corrosion behavior in synthetic seawater solution are investigated. The nickel electroless plating is prepared on the surface of MA21 alloys with different pickling processes.

2- Experimental

In this work, Extruded (EX) MA21 alloy plates (15×15×2 mm) were used as the substrates, with a nominal chemical composition (wt.%) of 7.5Li-2Al-1Zn and balance Mg. Pretreatments before electroless plating include mechanical sandpaper polishing, cleaning in acetone, alkaline degreasing, acid etching and HF acid activation. Using 125 g/L CrO_3 (#2) and 110 ml/L HNO_3 then using 180 g/L CrO_3 and 1 g/L KF (#1) during pre-treatment.

3- Results and Discussion

The result show that the MA21 alloy mainly consists of (α-Mg and β-Li) dual phase matrix, and the content ratio of phases is approximately 1:1. A large number of strengthening particles can be seen in the lithium rich β-phase while α-phase is free of these particles. The electrode potential difference between α-Mg and β-Li phases of MA21 alloy matrix is large, which is not conducive to homogeneous nucleation of electroless nickel coating. Pickling is an important pre-processing step, aimed at forming a fluoride film on the surface of MA21 alloy to reduce the difference in the electrode potential between α-Mg and β-Li phases, so as to be beneficial to depositing on the matrix. The SEM image shown in Fig. 1 reveals that the structure with metallic luster is homogeneous, compact, bright and smooth, without obvious defects such as peeling, pitting, cracking, bubbling, delamination or nodulation. Cellular structure of the coating is compact without apparent porosity defects with pickling #2, so as to protect the substrate well, which is shown in Fig. 1. A few porosities exist on the boundary of coating cellular with pickling #1.

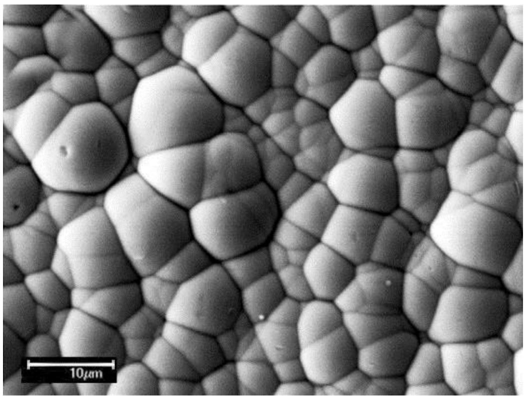

Fig.1 Surface morphology of electroless Ni coating with pickling #2

Fig. 2 shows the cross-section morphologies and EDX spectrum of Ni‑P electroless coating. The transitional pre-coating between the coating and matrix is not very clear with pickling #1, and the thickness of the coating is about 7 μm, shown in Fig. 2(a). It can be seen from Fig. 2(b) that the P content close to the substrate is very low, while the P content of the coating surface is the highest.

Therefore, the coating and the substrate could be adhered well with pickling #2.

The potentiodynamic polarization behaviors show that the E_{corr} of electroless Ni-P coating is greater than that of the substrate, and the corresponding corrosion current density significantly increases with pickling #1, while it decreases a little with pickling #2. The corrosion potential of the coating is improved, and the corrosion current density with pickling #2 is lower than the substrate. Thus, the electroless nickel coating has good corrosion resistance. Therefore, the MA21 alloy can be protected effectively.

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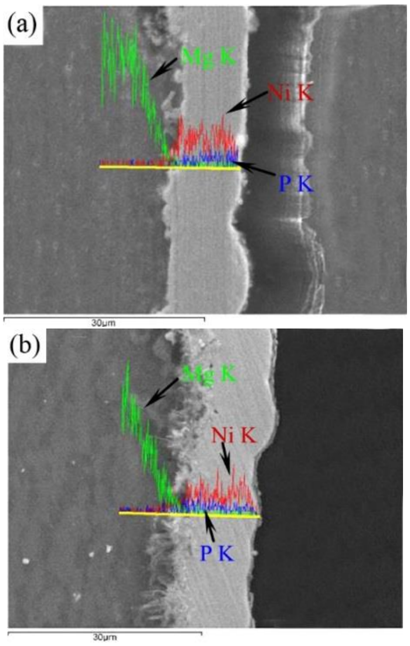

Fig. 2 Cross-section morphologies and EDX spectrum of electroless Ni-P coating with different pickling: (a) pickling #1; (b) pickling #2

Table 1 Dynamic parameters of the corrosion process by liner regression

Parameters	substrate	Electroless coating	
		Picking #1	Picking #2
E_{corr} (V)	-1.489	-1.344	-1.306
i_{corr} (A/cm^2)	0.0012	0.0044	0.0007
β_a (V)	0.095	0.104	0.094
β_c (V)	0.188	0.120	0.1
Corrosion rate (mpy)	63	87	4

The electroless Ni coatings have excellent corrosion resistance due to amorphous structure and surface passivation film. The amorphous coating is without grain boundaries, dislocation and other defects, and exhibits relatively well corrosion resistance. The dynamic parameters of the corrosion process by liner regression are shown in Table 1.