

Understanding the nature and scheme of Al-Mg electrodeposition using chloride-based molten salt electrolyte system

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Aluminium-magnesium (Al-Mg) alloys were electrodeposited on commercial copper strip using AlCl_3 , NaCl , KCl , and MgCl_2 , employing Al or Platinum (Pt) as the counter electrode (C.E.) and Al as the reference electrode. Potentiostatic technique was employed for all the depositions at overpotentials (η) of -1.05 to -1.30 V at 180 °C in an Ar-filled glove box maintaining oxygen and moisture levels at <0.1 ppm and using CHI660E potentiostat. The deposits, upon employing Al as C.E., were categorised into two groups based on the obtained steady-state current density values. Moreover, the salt sedimented on Al C.E. in Group 2 showed the signs of AlCl_4^- from FTIR; whereas, that in Group 1 was only AlCl_3 . In both these groups, the deposit morphology coarsened with the increase in overpotential. The Mg (less noble) content in the deposits of Group 1 (η : -1.05 to -1.10 V) was negligible (~ 0.10 - 0.08 atom %), while that in Group 2 increased from 0.26 at.% ($\eta = -1.15$ V) to 4.02 at.% ($\eta = -1.30$ V) with overpotential. This agreed with one of the conditions for 'regular' deposition: the content of less noble metal increased with overpotential. For examining the other conditions of regular deposition spent electrolyte composition was also analysed. In both the groups employing Al C.E., the Al (more noble) content in the spent electrolyte was more than that initially added, suggesting anodic Al dissolution (confirmed with anodic weight loss). Al/Mg atomic ratio in deposit was plotted versus that in spent electrolyte. From this plot, a slight decrease in the Al/Mg ratio in the spent electrolyte paralleled with a drastic decrease in this ratio in the deposit. Further, the Al/Mg composition line was completely above the composition reference line (i.e. line of Al/Mg in deposit = Al/Mg in electrolyte) as seen in Figure 1. These trends along with the above-mentioned η -Mg (at.%) relation confirmed the 'regular' nature of Al-Mg alloy electrodeposition using chloride-based molten salt electrolyte. This nature was further ascertained by analysing deposits and spent electrolytes upon using Pt C.E., to mitigate the anodic Al dissolution. Interestingly, this nature is different from 'anomalous' and 'equilibrium' natures of Al-Mg deposition from organometallics and Grignard reagents, respectively [1-3]. This shows that electrolytic system (electrolytes and electrodes) plays an important role in deciding the deposition nature. The results were used to design schemes for Al-Mg electrodeposition using the chloride-based molten salt electrolyte system with Al as C.E. for both groups.

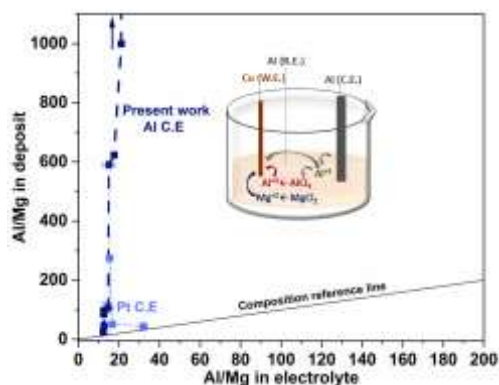


Figure 1. Composition plot of Al-Mg electrodeposition using chloride-based molten salt electrolyte system

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