CONTROL OF SURFACE TOPOGRAPHY ON ALUMINIUM PRIOR TO COATING APPLICATION

Francisco Jose Garcia-Garcia[1,2], George Edward Thompson[2], Glenn Smith[3]
[1]*Ingeniería y Ciencia de los Materiales y del Transporte, Escuela Técnica Superior en Ingenierías, Universidad de Sevilla, Sevilla, España*
[2]*Corrosion and Protection Centre, School of Materials, University of Manchester, UK*
[3]*Bridgnorth Aluminium Limited, Wolverhampton, UK*
E-mail de correspondencia: fgarcia49@us.es

ABSTRACT

The study investigates the influence of nickel and magnesium additions to AA1050 aluminium alloy on the alloy electrochemical behaviour in sodium hydroxide and nitric acid solutions under conditions relevant to industries that use alkaline etching as a standard surface treatment procedure and to the lithographic and electronic industries where surface convolution is assisted by pitting in nitric acid. Nickel is shown to be incorporated into second phase particles, which mostly consisted of Al3Fe and α-(AlFeSi) phases, resulting in enhanced cathodic activity on the aluminium surface. In contrast, the addition of magnesium to the alloy had negligible influence on the etching and pitting behaviour.

1. INTRODUCTION

AA1050 aluminium alloy is used for lithographic applications and is increasingly important as a substrate for Computer to Plate offset plates in a revolutionary digital printing technology. In order to produce an offset printing plate, AA1050 is subjected to alkaline etching, electrograining, anodising and light sensitive coating (Garcia-Garcia, Skeldon, Thompson, Smith, 2012). Alkaline etching is used to eliminate defects originating from thermo-mechanical processing of the alloy. Electrograining is employed for surface convolution (Amor y Ball, 1998). Anodic and light sensitive coatings are functional coatings, which provide separation of ink and water on the plate (Thompson y Wood, 1981).

During printing, water is attracted to the hydrophilic anodic coating and ink is attracted to the oleophilic light sensitive coating. Optimised ink-water balance on the plate is one of the major parameters responsible for the quality of printing. This balance is influenced by the level of substrate roughening prior to formation/application of functional coatings, namely anodic alumina coating and light sensitive coating. Therefore, the development of well-defined and uniform pit structures during electrograining is crucial for high printing quality.

It is known that alloy composition influences surface morphology in alkaline etching, and affects pit growth and propagation during electrograining. The effect of nickel and magnesium added to the AA1050 alloy on the electrochemical behaviour and surface topography has been studied in alkaline etching and electrograining solutions.

2. MATERIALS AND METHODS

Commercially produced AA1050 and model 1050 alloy with increased amounts of magnesium (0.06 wt.%) and nickel (0.03 wt.%) are used. The magnesium concentration in the modified alloy was more than two orders of magnitude higher than in the typical alloy, whereas the nickel concentration was of about 6 times greater than in the typical alloy.

Open-circuit potential measurements were made during immersion of specimens in 0.5 mol dm-3 sodium hydroxide (NaOH) solution at 40 °C for 300 s. Cyclic voltammetry and galvanostatic anodic polarization measurements were made in 0.24 mol dm-3 nitric acid (HNO_3) solution at 38 °C. The electrochemical measurements were made in a three-electrode cell, with a saturated calomel reference electrode (SCE) and a platinum counter electrode. The specimen area exposed to the solution was 1.5 cm^2. The variation of the potential with current or time were monitored and controlled by a Solartron SI 1287 potentiostat.

3. RESULTS AND DISCUSSION

Figure 1. shows the electrochemical behaviour of both alloys in NaOH solution.

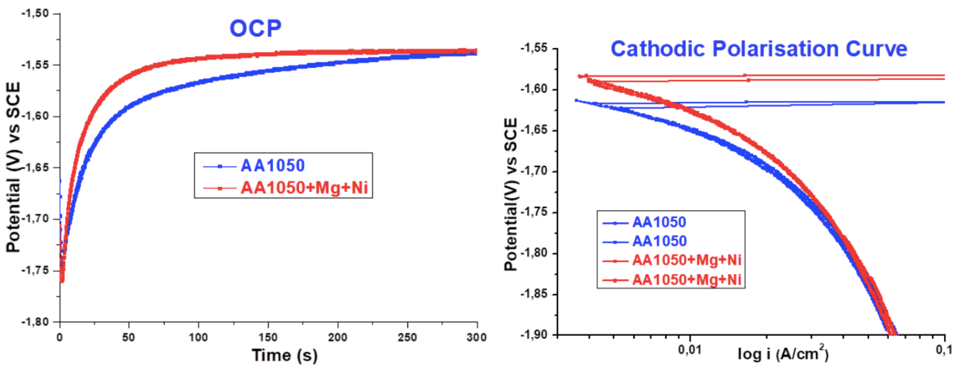

Figure 1. Open circuit potential and cathodic polarisation in NaOH solution at 40 °C.

Increased OCP and E_{corr} during cathodic polarisation indicate enhanced cathodic activity on the surface of modified 1050 alloy compared with standard AA1050 alloy. EDX-SEM of alloys after alkaline etching, not shown, revealed the presence of nickel in second phase particles of the model alloy (Garcia-Garcia, Skeldon, Thompson, Smith, 2012).

Figure 2 shows the electrochemical behaviour of the alloys in diluted nitric acid solution.

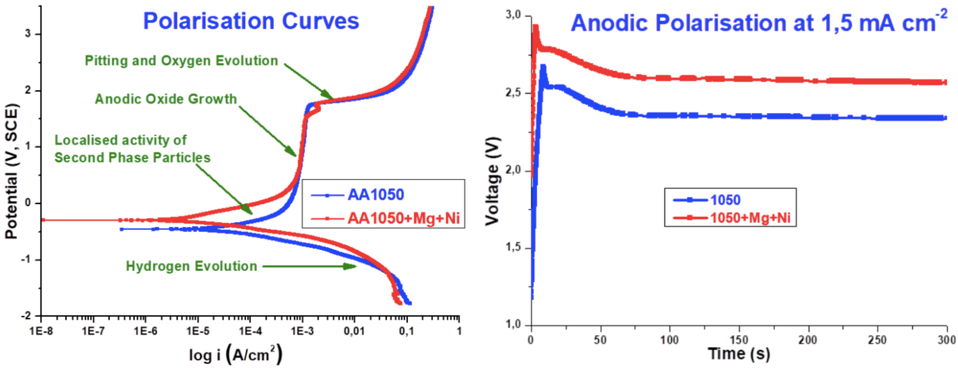

Figure 2. Voltammetry at 10mV·s^{-1} and galvanostatic polarisation in HNO_3 at 38 °C.

Increased E_{corr} during polarisations indicates enhanced cathodic activity on the surface of model 1050 alloy compared with standard AA1050 alloy. Presence of the arrest before the pitting potential on the model alloy polarisation curve is probably associated with reduced overpotential for oxygen evolution on the surface of second phase particles containing nickel. Electrograining results in uniform and controlled pitting of the alloy surface achieved by limiting polarisation above the pitting potential, where pits grow, and introducing polarisation, during which the alloy surface is passivated. For anodic polarisation below the pitting potential, anodic film forms.

Galvanostatic anodic polarisation at current density similar to limiting current density observed during voltammetry measurements. The shape of the V-t curve is typical for porous anodic film formation in acids. In fact, properties of porous films formed can be obtained from galvanostatic curves and TEM micrographs, not shown in here. It is confirmed that the porous film forms on the model alloy with less current efficiency, due to the presence of the nickel containing second phase particles, oxygen evolution, pitting and additional oxidation of magnesium.

4. CONCLUSIONS

- Nickel is incorporated into the second particles, whereas magnesium is in solid solution in the alloy bulk.

- Modified composition of the second phase particles increases cathodic activity by enhancing hydrogen evolution in alkaline and acid solutions.

- Through enhanced cathodic dissolution, aluminium dissolution increases in the model 1050 alloy during alkaline etching in sodium hydroxide.

- Voltammetry confirmed that hydrogen evolution, dissolution of second phase particles during anodic film formation and pitting accompanied by oxygen evolution are processes alternating during electrograining and responsible for pit shapes and sizes.

- Reduced efficiency of porous anodic film formation on the surface of the model alloy is associated with presence of the nickel containing second phase particles, oxygen evolution, pitting and additional oxidation of magnesium.

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