

Plasma Electrolytic Oxidation of Coupled Light Metals

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The use of multi-material components is rapidly increasing in modern designs in order to optimize performance and reduce weight. If these are subject to corrosive environments, protection schemes may be required to ensure durability of the product. In the case of light metals, protection usually requires application of conversion coatings, anodic coatings and paints as part of a coating system. However, conversion and anodic treatments are usually metal-specific, i.e. designed for application to aluminium, magnesium or titanium parts, and hence are not suited individually to treatment of a mixed-metal component in a single treatment process. However, plasma electrolytic oxidation offers a potential to overcome this difficulty. Plasma electrolytic oxidation involves polarization of a metal at a high potential in an aqueous electrolyte, usually under AC or pulsed DC conditions. The high potential results in numerous, short-lived discharges on the treated surface, where coating material is formed through a combination of anodic oxidation, thermal oxidation, thermolysis and plasma-chemical processes. The mechanism of

coating growth is not well-understood, since the discharges are small and have lifetimes often of the order of microseconds, making it difficult to probe the formation mechanism by conventional approaches. Nevertheless, coatings of up to several hundred microns thickness are readily formed in suitable electrolytes that are regarded as environmentally-friendly and safe to handle. Further, the coatings can provide excellent wear resistance due to the formation of high-temperature, crystalline oxide phases, and can also provide corrosion protection; for the last case, this may require a sealing treatment or paint top-coat since the coatings contain porosity. Many studies are available in the literature on the formation of coatings on aluminium, magnesium and titanium and their respective alloys, usually using different compositions of the electrolyte and different electrical regimes. However, only one study has addressed the applicability of the process to treatment of mixed-metal systems. Thus, within the LATEST2 programme, investigations have been carried out on the treatment of mixed-metal systems consisting of a combination of either aluminium and AA 7075-T6 aluminium alloy or of ZE41 magnesium alloy and AA 7075-T6 aluminium. These have shown the possibility of successfully forming thick coating on both combinations of metals. The work utilized an alkaline electrolyte and an AC electrical regime, with

various RMS current densities applied. A key observation was the requirement to select an appropriate current density to achieve similar thicknesses of coating on the metal combination. Clearly, due to the dissimilar compositions of the metals, the details of the discharge conditions and the coating compositions differ between the two metals. Consequently, the current flow to the two parts is not stable during the coating formation as each of the coupled metals presents a different and varying resistance as the coating builds in thickness, as shown in Figure 1. If an inappropriate current density is employed the currents may diverge, such that large differences in the coating thickness result on the treated metals. However, with proper selection of the current, the current flow to each metal can be maintained at a similar level, such that coatings can be formed of similar morphology and thickness to those on the individually treated metals, as shown in Figure 2. Thus, the work has demonstrated the potential suitability of plasma electrolytic oxidation for the treatment of mixed light alloys. However, further investigation is required to ascertain the general applicability of the approach, for instance to combinations with titanium, to treatments under voltage rather than current control and to combined metals with different area ratios.

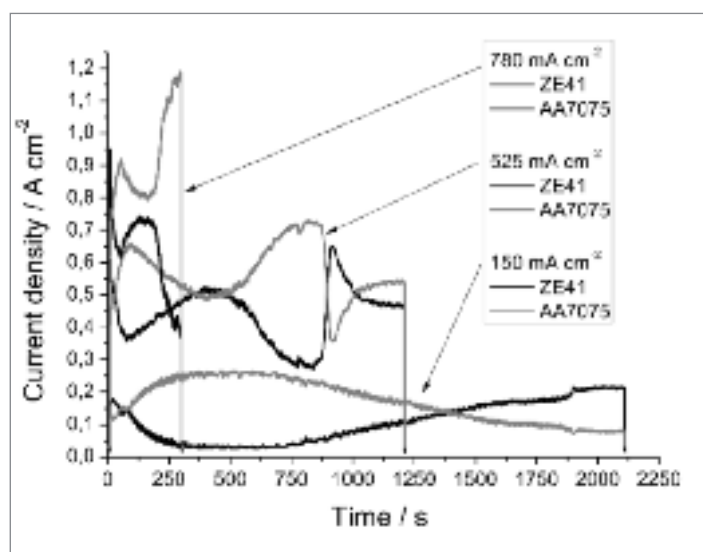


Fig. 1 Current density responses of AA7075 alloy/ZE41 alloy couples oxidized in sodium phosphate/sodium silicate electrolyte at 150, 525 and 780 mA cm⁻².

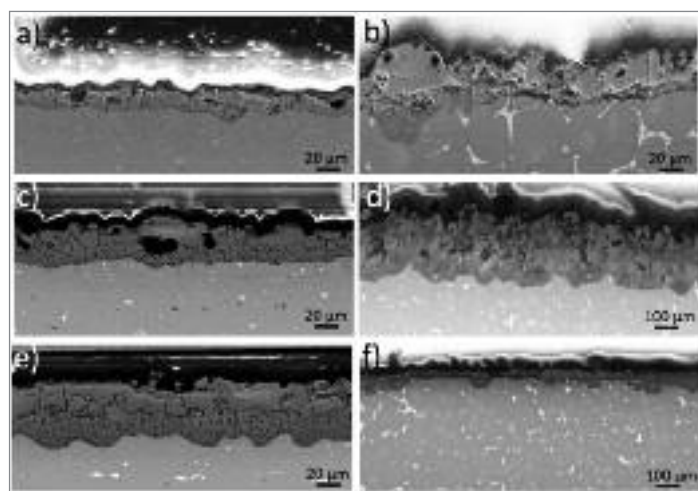


Fig. 2 Cross-sections of coatings formed on the coupled AA7075/ZE41 substrates at (a,b) 150 mA cm⁻² and (c,d) 525 mA cm⁻². (e,f) Coatings formed on the respective individually-oxidized alloys.

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