Technology Readiness Level: 4
Component and/or Breadboard Validation
in Laboratory Environment

Eltron Research & Development

Tech Brief

Low-Cost , Environmentally Friendly Magnesium Anodization

Clean process for exterior vehicle components

A primary objective of the ALM (Automotive Light-weighting Materials) program (a part of the DOE's Vehicle Technology Program) is to reduce body and chassis average weight by 60% by 2011 without compromising safety, performance, recyclability and cost.

Currently, magnesium is used in interior components of vehicles, and for it to be used for exterior vehicle applications it must be alloyed for appropriate strength and creep resistance. It must also be able to withstand the moisture, salt and dirt encountered when driving. A major benefit of using magnesium in this application will be reduced pollution. Weight reduction improves fuel efficiency, and less gas burned means lower greenhouse gas emissions.

Benefits

- Environmentally friendly anodizing electrolyte: no fluoride, chromium, or permanganate
- Low porosity coatings for good corrosion resistance
- Tailorable coatings. Amorphous coatings for corrosion resistance. Crystalline coatings for wear and corrosion resistance
- Low-cost anodizing process

Eltron's Solution

Eltron Research & Development Inc. has developed a low-cost and environmentally friendly electrolyte for anodizing magnesium alloys. The electrolyte used in the anodizing process is the key distinction between different anodizing processes. It significantly affects the quality and type of coating produced. Electrolytes include alkaline phosphate solutions, electrolytes containing silicates, potassium hydroxide-aluminate electrolytes and electrolytes containing chromate additives. Both concentration and composition of the electrolyte affect the coatings produced.

Eltron's method utilizes a low concentration, basic electrolyte composed of hydroxide and phosphate salts. No fluoride, chromium, or permanganate is included in the process. This method has significant advantages over the commonly used Dow 17 and HAE processes in terms of cost and the environment. In addition, the coatings produced by this method have less porosity than the Tagnite process.

Figure 1 compares the surface of ZE41 magnesium alloy anodized with Eltron's process compared to the coating produced by the Tagnite process. Both images are at the same magnification. The Eltron process clearly produces a coating with fewer and smaller diameter pores. Minimizing the porosity of the anodized coating will prevent the need for additional sealing coats applied to the anodized coatings. Eltron's anodized surface can be painted if desired; however, it will not be necessary for corrosion resistance.

The thickness, composition, and morphology of the coatings prepared by Eltron's method can be controlled by electrolyte composition and applied voltage/current.

Figure 2 shows types of coatings prepared by Eltron's anodizing process.

The Technology

Magnesium anodization is not a new process (**Table 1** summarizes the three main magnesium anodizing technologies commercially available). The Dow 17 and HAE anodization processes have been used to form corrosion resistant surfaces on magnesium for the past 50 years. The Dow 17 process is a low voltage (<100 volts) process and utilizes a complex mixture of salts in the electrolyte. Sodium dichromate is one of the inorganic salts used in the Dow 17 electrolyte which has caused significant environmental concerns. The HAE process is also a low voltage anodization technique that utilizes a complex electrolyte. The electrolyte does not contain chromium but it does contain permanganate, which is another heavy metal with environmental concerns.

The Tagnite process is marketed as an environmentally friendly process compared to the Dow 17 and HAE processes. However, just as the HAE and Dow 17 processes, the Tagnite electrolyte contains fluoride, which is a potential environmental health hazard. The process utilizes voltages greater than 300 volts. Higher voltages lead to thicker coatings but often lead to higher porosities as well. Porosity of the anodized layer is the key to corrosion resistant coatings applied to magnesium alloys. The size and number of the pores is directly related to the magnesium alloy itself, the electrolyte composition and concentration, the maximum voltage applied and the current density. An environmental process is needed that produces thick coatings with reduced porosity.

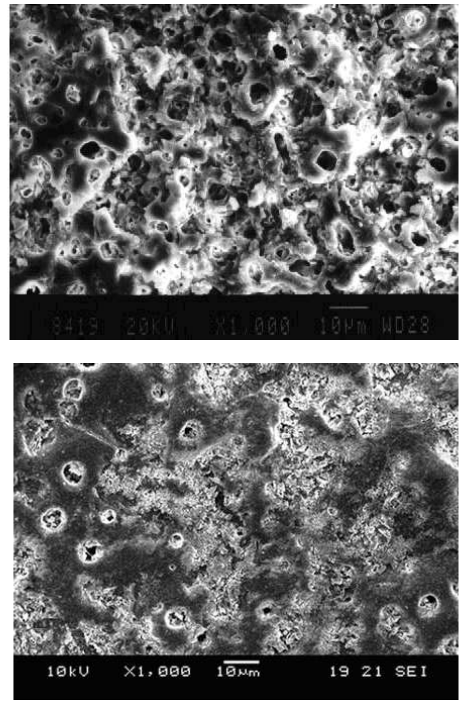

Figure 1. 1000X SEM images of the surfaces of anodized ZE41 magnesium alloy. Top: Coating produced by the Tagnite process.* Bottom: Coating produced by Eltron's low-cost process.

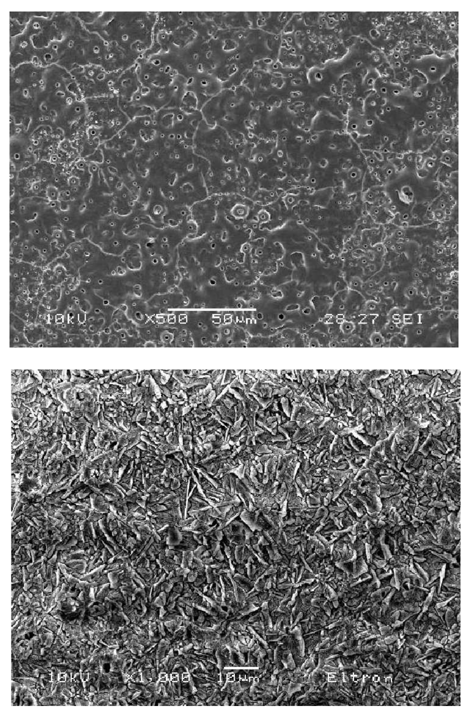

Figure 2. Anodized magnesium alloy coatings. Top: Amorphous coating. Bottom: Crystalline coating.

**Image courtesy of www.tagnite.com/coating_structure.htm*

Table 1.
Properties of commercial magnesium anodizing processes

Process	Electrolyte Composition	pH	Operating Temperature (°C)
HAE	120 g/L Hydroxide 35 g/L Fluoride 20 g/L $KMnO_4$ 34 g/L $Al(OH)_3$ 35 g/L Na_3PO_4	14	21–30
Dow 17	360 g/L $(NH_4)HF_2$ 100 g/L $Na_2Cr_2O_7$ 97 g/L H_3PO_4	5	> 71
TAGNITE®	4–8 g/L Hydroxide 5–10 g/L Fluoride 15–25 g/L Silicate	12.8–13.2	4–16

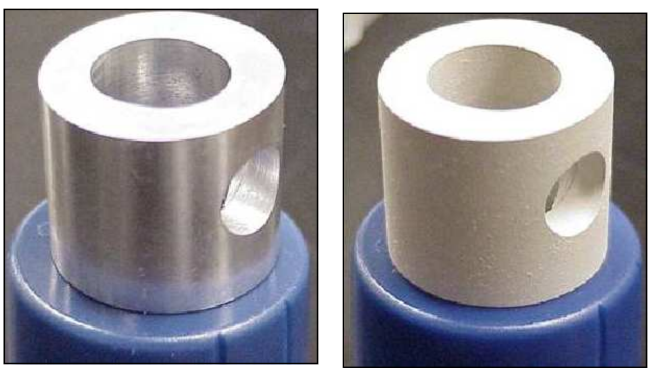

Figure 3. Left: AZ61 alloy before anodization. Right: AZ61 alloy after anodization.

Figure 4. Left: un-anodized AZ61 shows corrosion pitting after only 2 hours immersed in a 1.0 M $MgCl_2$ salt bath. Right: AZ61 anodized using Eltron's process shows no corrosion after 168 hours immersed in a 1.0 M $MgCl_2$ salt bath.

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Eltron Research & Development Inc.
Eltron Research & Development Inc. commercializes novel technologies involving advanced materials, energy, water and environmental systems.

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