ICB Coating Technologies, Inc. has been developing and utilizing Plasma Electrolytic Oxidation coatings and is interested in characterizing the bath life. In determining bath life, various characterization techniques were used including optical microscopy, scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy (EDS), hardness testing, and X-ray diffraction. Using these techniques, structure-property relationships relevant to bath life were identified.

**Project Background**

Plasma electrolytic oxidation (PEO) is a next generation coating process that submerges a metal substrate such as aluminum, magnesium, or titanium in an aqueous electrolyte bath in which a voltage is applied. This creates localized micro-plasma discharges on the surface of the substrate and facilitates the growth of a ceramic oxide layer. PEO coating results in improved tribological properties and facilitates the growth of a ceramic oxide layer. PEO in an aqueous electrolyte bath in which a voltage is supplied to the electrolyte.

**Coating Thickness**

Due to the surface roughness of the coating, the coating thickness can be measured in a multitude of ways. Measurements were obtained by determining coating thickness. Literature has analyzed several factors that affect the coating characteristics, but little has been done to analyze the electrolytic bath itself. The goal of this research is to determine the life expectancy of the electrolytic bath and develop structure-property relationships that relate bath use to film structure and performance in the PEO coatings.

**Materials**

Nine sample pucks of PEO coated 7075 aluminum were provided by IBC Coatings Technologies. The pucks were from various stages of the electrolytic bath life ranging from 0-101 amperes per liter (A*hrs/L).

**Coating Structure**

Three different layers were discovered when analyzing the cross-sections of the samples using scanning-electron microscopy (SEM). The first is a barrier layer just above the substrate, the second is a middle layer which makes up most of the coating, and the third is a top layer with varying surface roughness. Mechanical ion slice testing revealed that visible features throughout the coating are not pores but rather a result of cracking that occurred during sample preparation.

**XRD Diffraction**

XRD spectra from the 18-21 and 98-101 A*hrs/L samples conclude that the overall structure of the material remains the same. There is little to no variation to this structure as the bath life increases.

**Hardness Testing**

Vickers microhardness testing was performed on polished cross-sections of the PEO coatings using a 50 gram load. Hardness testing was done to characterize the layers as distance from the substrate increases. Indents in the barrier layer had low hardness values due to the effect of the soft aluminum substrate. Figure 9 displays the average hardness of each sample at varying thickness ranges.

**Conclusions**

PEO coatings produced throughout a period of 0-101 A*hrs/L show:

- 8% decrease in thickness of coating with respect to bath life
- Presence of a newly identified cellular-like structure that forms due to compositional differences in the PEO film as a result of impurities in the substrate
- Little difference in aluminum phase ratios present with 84.3% γ-Al2O3 near the beginning of the bath life and 84.7% γ-Al2O3 at the end of the 101 A*hrs/L bath life
- Around 7% decrease in average hardness of the coatings with respect to bath life

ICB Coating Technologies has developed a robust plasma electrolytic oxidation process that produces films with uniform composition, high hardness, and relatively little degradation over 101 A*hrs/L of bath life.