## Aluminum Anodizing Technology and Market Assessment

The rapid growth and widespread use of aluminum since World War II is tied directly to the ability of anodizing processes to protect it from corrosion, improve its appearance by way of brightening it and offering a rainbow of colors, and imparting ceramic-like toughness to its outer skin (especially through hardcoat anodizing).

Hydrated aluminum oxide is the stable form of aluminum in nature; thus, unprotected aluminum exposed to air and water will corrode, forming a discontinuous, powdery, white corrosion product. This form of natural oxide growth, if unchecked, will proceed as long as unreacted aluminum is exposed. Anodizing can actually be envisioned as an accelerated corrosion process; the difference between anodizing and the natural process is that anodizing forms a more dense, continuous, oxide layer.

Anodizing has several benefits over other coating choices. For example, while plating and painting protect aluminum, there will always be a barrier between the coating and aluminum substrate with these treatments; the only bond between the two is mechanical. If the bond in this barrier region is compromised by way of poor substrate preparation, mechanical damage (e.g., scratching), or gradual degradation (e.g., general corrosion), raw aluminum will be exposed and corrosion can commence.

Anodizing, on the other hand, is a conversion coating process that results in a chemical bond between an anodic aluminum oxide layer and the aluminum basis material, which is much stronger than a mechanical bond. Whereas painted or plated coatings over aluminum can be peeled away, there is no way to separate the anodic layer from the aluminum on which it formed.

In addition to the bonding issue, paints and plated metallic layers are much softer than aluminum oxide. On the well known Moh scale of mineral hardness, one form of naturally occurring aluminum oxide, namely corundum, is the ninth hardest out of ten. The only mineral harder is diamond! With this in mind, it's not surprising to learn that a component coated with the hardest plated metal (namely hard chrome) will wear more readily than an identical component that is hardcoat anodized.

Lastly, the mechanism of oxide growth during anodizing results in a porous structure. This permits further surface modification such as:

-Dyeing to impart nearly any color to the anodic layer
-Sealing with a lubricative material such as molybdenum disulfide or PTFE
-Infiltration with an adhesive primer for bonding applications

These factors, coupled with the fact that anodizing is more economical than either powder coating or plating, point to the continued importance of anodizing as the coating of choice for aluminum in a wide range of applications.

Having been practiced for decades, Guideline generally considers anodizing to be a mature technology. Changes to existing approaches tend to be incremental process enhancements (whether for functional of decorative purposes) such as new electrolyte "recipes", rather than revolutionary technology shifts.

In spite of this, we do see several areas where technological improvements might bring about significant new opportunities for anodizers.

The strongest growth category for anodized aluminum appears to be that of transportation. An expected increase in the production of new aircraft to replace aging fleets and the auto industry's trend of increasing the use of aluminum for vehicle frames and bodies are expected to be the primary drivers of this growth. Another large anodizing category, architectural aluminum, does not appear to be poised for significant growth; in fact, this market may already have reached its peak.

## About the Author

This is a summary of an annual strategic report on aluminum anodizing technology written by Guideline staff and experts. For more information please visit us at http://www.intota.com, or contact Brian Reuter, Director of Product Realization, breuter@guideline.com.