TECH TIP 24

EPOXY TECHNOLOGY

Bonding to Aluminum

WHAT

Bonding to Aluminum Using Epoxy

WHY

Aluminum, a popular metal, has unique physical properties to be considered for proper bonding with epoxy adhesives.

Why Bonding to Aluminum Needs Special Considerations

Aluminum is a popular metal that is often chosen in various manufacturing processes. It has many important physical properties including: light weight, corrosion resistance, excellent conductivity, high reflectivity, and high strength, along with low cost. Since aluminum is such a pervasive metal in manufacturing, the ability to join it properly using an epoxy is crucial in the manufacturing process.

There are many forms of aluminum that exist and some, such as anodized aluminum, can be difficult to bond. Additionally, aluminum is commonly alloyed with copper, magnesium, manganese, silicon, and zinc. With proper handling and preparation, epoxy can bond well to most aluminums and aluminum alloys. For more information on compatible metals for epoxy bonding, see *EPO-TEK® Tech Tip 12*.

Special Considerations for Bonding to Aluminum and Aluminum Alloys

Aluminum presents a particular concern in bonding as it readily oxidizes to form an insulative/passivation layer of aluminum oxide. Interestingly, both aluminum and aluminum oxide alike can maintain their apparent shine and reflectivity in a dry environment. However, aluminum, when oxidized, becomes an electrical insulator and mechanically will cause a weaker bond than when non-oxidized. This can result in decreased lap shear strength of as much as 50%. Oxidized aluminum can also cause issues with bonding and electrical properties over both the short term as well as the lifetime of a bond.

Another issue with aluminium is galvanic corrosion. Galvanic corrosion results in the formation of a thick oxide passivation layer causing electrical conductivity to plummet and the bond to weaken. Aluminum and aluminum alloy can galvanically corrode when electrically connected to metals with a large anodic index difference, such as silver found in silver-filled electrically conductive adhesives (ECAs). Aluminum has an anodic index of -0.90 – -0.95V, while silver is a noble metal with an anodic index of only -0.15 V. This large anodic difference can lead to significant corrosion of the aluminum. A common method of preventing galvanic corrosion is to electroplate the aluminum with a metal that will not corrode, such as nickel or gold.

What About Anodized Aluminum?

Although aluminum is a common bonding substrate for epoxy, anodized aluminum can present its own set of bonding problems. Anodized aluminum is an electrolytically induced passivation process, where several physical changes occur to the surface including: thicker aluminum oxide layer, increased porosity, and increased strength/brittleness.

An epoxy's mechanical bond strength can be aided by the increased porosity of an anodized surface. These pores can act as anchor points (similar mechanism to Velcro®) which binds the epoxy to aluminum. The problem, however, comes from the fact that most anodized aluminum is sealed after the anodizing process. Sealing can be done with a wide array of methods all of which shrink the pore size in order to increase corrosion resistance. These methods include immersion in such solvents as: water, nickel acetate, cobalt acetate, hot sodium, or even Teflon®. Many of these sealing processes can leave the aluminum with below average bondability.

Examples of Applications Where Aluminum is Often Bonded Using Epoxy

- Photonics and ferrules
- Solar panels
- Housing for RF modules
- Heat sinks
- Aerospace
- PCB level plating

Solutions for Better Bonding to Aluminum

The best solution to any aluminum bonding issue is good surface preparation and proper electroplating. Proper surface preparation greatly increases the epoxy's ability to adhere properly. For additional information on surface preparation see *EPO-TEK® Tech Tip 13*. There are also several ways to minimize the passivation layer that may form on the surface of aluminum. The most straightforward and simple way of handling this is combining abrasion with an acetone or IPA wipe.

For optimal cleaning/surface preparation a more in-depth four step cleaning process can be used:

1. Cleaning/degreasing: The aluminum is immersed, sprayed or wiped with a chlorinated solvent, ketone, or mineral spirits. The aluminum could also be vapor degreased with chlorinated solvent.

2. Abrasion: The surface would be detergent scrubbed or abraded.

3. Etching: The surface is chemically treated with a strong acid solution. Examples include: sulfuric acid and sodium dichromate or citric acid for a less effective, but more environmentally friendly cleaning option.

4. Rinsing: The part is then rinsed with in DI water.

REACH COMPLIANCE

RoHS COMPLIANT

MIL STD 883/5011 COMPLIANT

ISO 9001 COMPLIANT

CONCLUSION

With proper preparation, most types of aluminum can easily be bonded using epoxy adhesives for a wide variety of applications.

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