

**What** > Bonding to Aluminum Using Epoxy

**Why** > Aluminum, a popular metal, has unique physical properties that need to be taken into consideration for proper bonding with epoxy adhesives.



## Bonding to Aluminum

### 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, 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 production/manufacturing process.

There are many forms of aluminum that exist and some, such as anodized aluminum, can be difficult to bond. 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 additional information on compatible metals for epoxy bonding, see *EPO-TEK Tech Tip 12*.

### Special Considerations for Bonding with 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 its' non-oxidized form, resulting in decreased lap shear strength of as much as a 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 in the 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, for example the silver found in electrically conductive adhesives (ECAs) silver epoxy. Aluminum has an anodic index of -0.90 – -0.95V, while silver is noble metal with an anodic index of only -0.15 V. This large anodic difference can lead to the 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 or Velcro which binds the epoxy to the 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: water, nickel acetate, cobalt acetate, hot sodium, or even Teflon®. The result often is that many of these sealing processes can leave the aluminum with below average bondability.

## Examples of Applications Where Aluminum is Often Bonded With Epoxy

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

## Solutions for Better Bonding to Aluminum

The best solution to any aluminum bonding issues 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 three 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.

## Summary

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



For other useful tips, contact our Tech Service Group:  
[techserv@epotek.com](mailto:techserv@epotek.com) or [www.epotek.com](http://www.epotek.com)



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Epoxy Technology Inc. • 14 Fortune Drive • Billerica, MA 01821  
phone 978-667-3805 fax 978-663-9782 Toll Free 800-227-2201 [techserv@epotek.com](mailto:techserv@epotek.com)

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