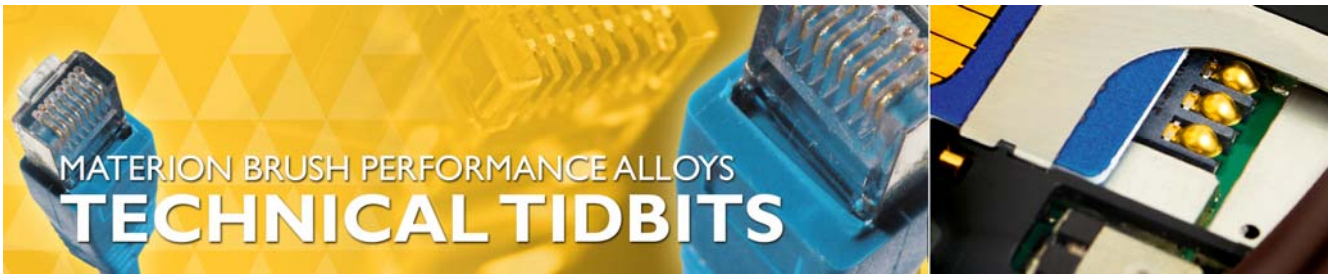

Issue No. 32 – August 2011 **Updated from Original February 2002 Publication**

If I only had a heart…
An overview of tin coatings on electrical contact surfaces.

- **Inter-metallic**
- **Whiskering**
- **Wipe**
- **Fretting Corrosion**

The next issue of Technical Tidbits will discuss fretting corrosion.

Tin as a Coating Material

Tin is a relatively low cost coating material, and is thus very popular in the automotive industry. It can be applied by hot dipping, electroplating, and cladding. Due to its low melting temperature, it is an easily solderable coating, which makes it a versatile material. However, it does have some specific limitations, which must be kept in mind when designing contacts.

When hot dipping, an **intermetallic** layer consisting of Cu_6Sn_5 and Cu_3Sn forms between the tin and the copper base metal. In fact, it is the formation of this intermetallic that allows the tin to adhere to the strip in the first place. However, since this intermetallic layer can be very brittle, care must be taken to ensure that it does not grow too thick. Otherwise, the service life of the contact may be limited.

Electroplated tin coatings are subject to **whiskering**. Electroplated tin may contain high stresses induced during the deposition process. Over time, these stresses may cause recrystallization of the tin, since tin has a low recrystallization temperature. The new crystals formed will grow out of the surface. These new crystals are relatively long and thin, resembling whiskers. If the whiskers grow sufficiently long, they can create short circuits between adjacent connectors.

There are two methods to controlling whiskering. The first is to alloy the tin with lead. According to various sources, an addition of 1.5% to 7% lead is sufficient to inhibit growth of the crystals. The second method would be to reflow the tin once it is plated, by bringing the tin up to a sufficiently high temperature to melt it. The stresses are relieved as the tin flows across the surface, and the coating will refreeze without the residual stress. Note that hot-dipped tin surfaces are not subject to whiskering.

Tin will naturally form a hard, brittle oxide on its surface. This oxide is stable and helps to prevent further corrosion of the base metal. However, since this oxide is an electrical insulator, it must be disrupted in order to achieve a good electrical path for the signal or current passing across the electrical interface. Fortunately, the underlying tin is much softer and more ductile than the tin oxide on the surface. With sufficient normal force, the mating contact will break through the oxide film. Unoxidized tin will then extrude through the cracks in the oxide, making good electrical contact, as shown in Figure 1.

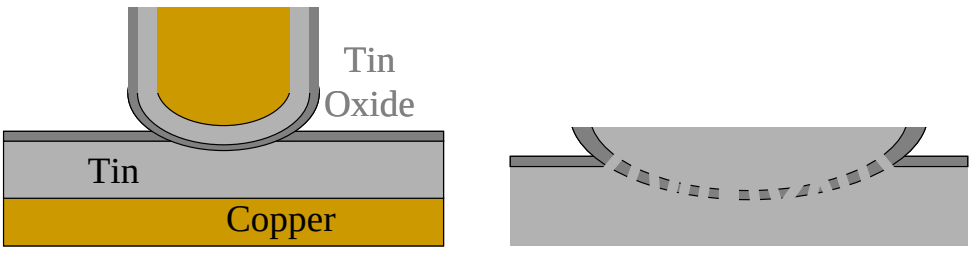

Figure 1. Disruption of tin oxide film and extrusion of fresh, ductile tin through cracks in the oxide during initial mating of the tin-plated contact interface.

Tin as a Coating Mateiral (continued)

Tin-coated contacts require high normal forces due to the formation of the oxide on the surface. A general rule-of-thumb states 100 grams of normal force are required to break through this oxide. Additionally, there should be some kind of **wiping** action during mating. This will tend to push any oxides or other debris away from the contact area. However, tin is not a durable coating, which means that repeated mating and disconnection can tend to wear away the tin. To combat this, tin-coated contacts should be lubricated to minimize wear and oxidation. Thick tin coatings (100 micro-inches or more) will also last longer than thin ones.

Fretting corrosion is another possible degradation mechanism for tin coated contacts. This occurs under repeated micro-motion of the contact point. The use of high normal force and lubricants will mitigate this phenomenon, which will be discussed in greater detail in next month's edition of Technical Tidbits.

Often, tin-based solder alloys are applied instead of pure tin. This allows for the contacts to be easily soldered to circuit boards, or for terminals to be easily soldered to the ends of current-carrying wires. Tin-lead alloys are the most widely known and commonly applied solders. Other common additions to create solders with different properties include antimony, bismuth, silver, and even copper. With increased pressure to eliminate the use of lead, these other solders are gaining in popularity.

Tin and tin-based solders do have temperature limitations. At higher temperatures, the intermetallic layer tends to grow. One often hears that tin is not recommended for temperatures above 100°C. However, in some automotive applications tin has been known to work successfully in temperatures up to 150°C. Additionally, the low melting temperatures of tin and tin-based solders make them unsuitable for use in contacts where there is a potential for electrical arcing.

Tin-coated contacts work best when mated against other tin-coated contacts. Degradation of the contact interface accelerates when tin is mated to gold or other noble metals like palladium, and these mismatches should be avoided. However, there are several sources which indicate that a tin to silver interface is an exception to this rule.

No discussion of tin plating would be complete without a mention of J.H. Whitley's "The Tin Commandments." This is a collection of ten general rules that should be followed when using tin as a coating material, and is strongly recommended as further reading. Even though tin coatings are subjected to numerous degradation mechanisms, following these simple rules ensures that tin-coated contacts will function properly.

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