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Electronics

Keeping Tin Solderable

Tin plating on a component lead makes its soldering easier. Everybody knows that. Not so well known is that tin plating has shelf life -- its ability to be easily soldered degrades over time. The speed and severity of degradation depends both on storage conditions and on the plating itself.

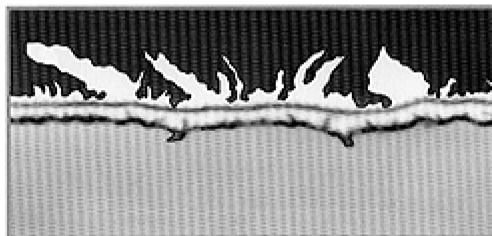
Both the component manufacturer and the user share responsibility for the shelf life of the tin plating. The manufacturer must use platings and thicknesses less prone to rapid degradation. The user must store components in an environment that does not accelerate degradation. Principally, this means avoiding high temperatures. In addition, the user should understand shelf life sufficiently so that components are used before the soldering failure becomes likely.

Soldering Basics

Soldering involves bringing together liquid tin-lead solder and the components being soldered. The tin or tin-lead plating provides a surface that remains solderable for a long time. At the common soldering temperatures of 250 to 260 degrees C, the platings melt and alloy with the molten solder, which in turn wets the substrate. Wetting -- akin to the way water wets wood -- is essential. A nonwettable surface, such as glass is nonwettable by water, does not solder. Oxides are nonwettable.

At temperatures below the plating's melting point, the solder dissolves the tin plating. Bond integrity depends on how well the solder and the substrate/underplating bond. The interaction of the molten solder with the copper substrate or nickel underplating creates a copper-tin or nickel-tin intermetallic.

Solder bonds depend on the solder's tin being either soluble in or capable of forming a metallic bond with the material being soldered. Solderability demands that the plating surface be clean and remain clean and wettable by the solder and flux.



Intermediate growth begins at the plating-underplate/substrate boundary and moves outward.

Loss of Solderability

The commonly accepted definition of solderability failure of 5% of the solder surface to be soldered. Loss of solderability in tin and tin alloy plating stems from three conditions:

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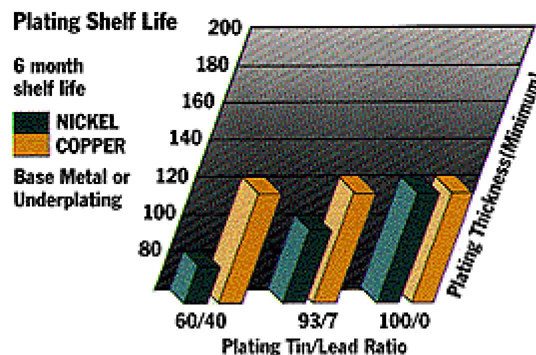
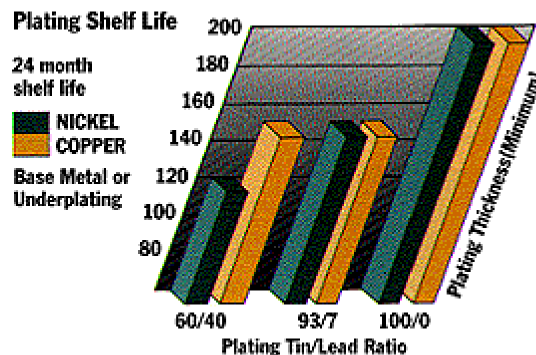
- Excessive thickness of the intermetallic layer
- Excessive amounts of oxides and other surface contaminants on the plating
- High levels of codeposited carbon from the organic brighteners in bright tin coatings

Each of these conditions can become worse over time; storage conditions -- temperature in particular -- can influence the rate of degradation and therefore the shelf life of the plating.

Intermediate Growth The tin plating can react with the underplating or substrate to form an intermetallic that grows as a function of time and temperature. An intermetallic forms when the plating and the underplating (or substrate) interdiffuse. The materials mix and react chemically to form new compounds -- principally Cu_3Sn and Cu_6Sn_5 for a tin-copper interface and Ni_3Sn_4 and $NiSn_3$ for a tin nickel interface. The intermetallic grows by continued diffusion and reaction. Copper-tin intermetallics grow in a "lumpish" manner, with high peaks pushing upward. Nickel-tin intermetallics grow as tendril-like platelets, with each tendril snaking upward toward the surface.





Eventually an intermetallic grows to the surface of the plating, where it oxidizes. An oxidized intermetallic layer will not solder.

Intermetallics from more rapidly with a copper substrate than with a nickel underplating. They also form faster at higher temperatures. At low temperatures, lead added to the tin slows intermetallic growth. At high temperatures, lead can actually accelerate growth with a copper substrate. At 170 degrees C, for example, a mixture of 40% lead/60% tin exhibits faster intermetallic growth than pure tin.

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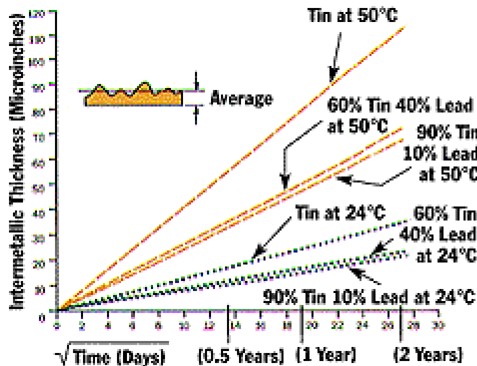
The characteristics of intermetallic growth suggest that growth can be minimized by:

- Using a nickel underplating between the copper and tin
- Storing components at room temperature

Surface Contamination Oxides and other contaminants formed at room temperatures are easily removed by flux and do not affect solderability. Elevated temperatures, high humidity, and corrosive gasses can lead to excessive surface films that degrade solderability. Again storage conditions are important.



Intermetallic growth, a leading cause of solderability failures, depends both on the composition of the tin plating and on storage temperatures.

Carbon Accumulation Excessive carbon from brightness used in the plating bath also leads to solder failures. Accumulating at the intermetallic boundary, the carbon causes dewetting on nonwetting when the part is soldered. However, careful control of the brightener levels allows bright tin plating to offer the same solderability as unbrightened matte plating.

To prevent soldering failures, storage time and temperatures must be carefully considered, as does the plating type or thickness. Avoid elevated temperatures; room temperatures suffice to achieve maximum shelf life.

Be sure the plating is thick enough (see chart) for expected storage times. What's important is minimum plating thickness, not average thickness. Intermetallics will reach the surface faster and oxidize into unsolderable spots faster through a thin point in the plating.

Getting maximum shelf life from tin-plated components is easy to achieve once you understand the influencing factors.

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