

# Tin whiskers and RoHS: a perspective

*Here are practical strategies to mitigate tin whiskers in RoHS-compliant assemblies*

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The tin whisker phenomenon is a failure mode associated with a number of plated low-melting-point elements (tin, cadmium, and indium) used to promote good soldering. Recognized many years ago, the problem had been minimized by using plating finishes with lead, now identified as a hazardous substance and banned under the RoHS initiative rules.

Investigations by Vicor over the last three years have resulted in some practical strategies to mitigate tin whiskering. Exactly how and why a tin whisker grows is not completely understood, but because they are conductive and can carry high current they can certainly cause serious problems.

Whisker growth from copper-containing substrates finished with standard pure tin is of the greatest concern. Research has shown that whiskers will grow from tin-lead surfaces, although the length of those whiskers is much shorter than with pure tin.

## Choice of plating materials

Precious-metal plating, such as gold and palladium, are not susceptible to whiskering. Trials with pure tin finishes, which are much lower cost, have revealed that large grained 100% matte tin plating on copper-lead frames

resists whiskering even when exposed to compressive forces kept at high temperature/humidity.

Bright tin, however, had whisker growth reaching 700  $\mu\text{m}$  even at ambient temperatures. Extensive cyclic compression tests with select matte tin chemistries, considered a worst-case evaluation, yielded whisker growth of less than 20  $\mu\text{m}$ .

Simple SEM examination confirmed

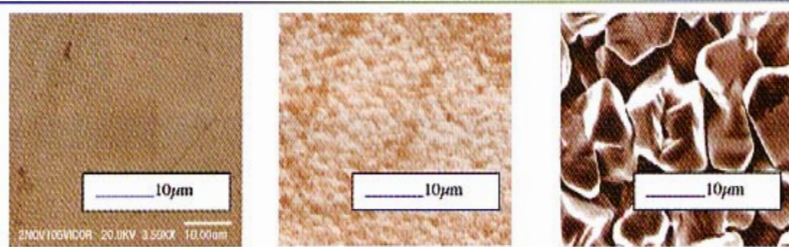


Fig. 1. SEM images: Left—Bright tin virtually featureless submicron grains; center—matte tin “A” small grained 1 to 2  $\mu\text{m}$  (less desirable); right—matte tin “B” large grained, >6  $\mu\text{m}$  (preferred).

that all matte tin plating may not be whisker resistant because of the presence of small grains structures. Figure 1 shows some SEM images of tin finishes observed at 4,000X.

## Use of a nickel barrier

In power device products, tin plating is used on IC packages, passives, internal connection pins, and external I/O pins. Tin-finished leads and pins are regularly subjected to Pb-free reflow during surface-mount operations, reducing residual plating stress and leading to reduced risk of whiskering. Where possible, a minimum 2- $\mu\text{m}$  nickel barrier layer under tin plating is used, based on iNEMI (International Electronics Manufacturing Initiative) and plating chemical supplier recommendations.

A nickel barrier under tin helps pre-

vent the formation of compressive stresses caused by the growth of CuSn intermetallics and hence reduces the one driving force for tin whisker growth. If a nickel barrier layer is not possible, tin plating is annealed after plating for 1 hour at 150°C to promote controlled intermetallic compound formation.

Vicor has chosen to ban the use of immersion tin plating on pc boards, primarily because the resulting thin layer, only 20  $\mu\text{m}$  thick, is susceptible to whiskering at higher voltage levels. We have chosen, in most ap-

plications, either silver or gold finishes, though they are considerably more expensive.

Of these finishes, ENIG has been shown to be the most robust for lead-free soldering. When hot air solder leveling (HASL)

has been required, a tin-silver-copper alloy has replaced tin-Pb. Immersion tin plating may be suitable for lower voltage applications, but we have found that the chemistries are not as well documented.

## Coatings can help

Conformal coatings or epoxies have been suggested as a way to reduce tin whisker risks. A thick conformal coating (silicone-based polymer with 90% to 92% filled ceramic particles)—used in power brick products as part of a thermal management strategy—adds resistance to whisker growth.

This fill material encapsulates all components, wets leads, and fills the space between package leads, components, and traces. Thinner coatings may also reduce whiskering, but certainly not eliminate it.