TND311

Tin Whisker Info "Brief"

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APPLICATION NOTE

Tin whiskers are a potential concern with high-tin (Sn) content lead finishes (this includes alloys such as SnBi, and SnCu). SnPb alloys introduced in the 1950's have been the most successful in controlling whiskers. It is widely accepted that whiskers are a stress relief mechanism for a compressive stress that builds in the tin film after plating. There are two main models accounting for the stress: the intermetallic model and the recrystallization model.

- The intermetallic model requires intermetallic growth (Cu_6Sn_5) that occupies more volume than the amount of tin consumed thus generating a compressive stress in the plating. This stress is then relieved when whiskers grow through small defects in the native tin oxide. This model is probably valid for tin plated on copper lead frames. Unfortunately, whiskers have been observed to grow without intermetallic formation (i.e., on non-copper materials).
- The recrystallization model is more general and assumes that whisker growth is a mechanism for the plated Sn film to relieve residual stress because the preferred method of grain growth is somehow inhibited.

Unfortunately, neither model provides sufficient understanding to allow elimination of whisker growth through plating technology.

Plating process technology has advanced to the point where major plating developers claim whisker resistant plating. This is done through careful control of residual stress in the plated Sn film through the use of optimized plating parameters (current density, grain growth, impurity content especially carbon, hydrogen, and zinc, etc.). One would expect that better plating operations with sufficient process controls would be more likely to maintain the conditions required for whisker resistance. No high-Sn plating process can claim to be whisker-free. The most highly whisker-resistant Sn finishes on copper lead frames are those plated on a nickel diffusion barrier or those with reflowed (melted) Sn plating. Validating a manufacturer's claim of whisker resistance is a slow, imprecise process since a predictive acceleration test with quantified acceleration factors is unknown. This is complicated further by the highly variable "incubation" period during which stress builds before whiskers grow.

Matte Sn is a viable plated-lead frame finish in today's market. Other alternatives are being developed, including tin/bismuth, tin/silver/copper, tin/silver, tin/silver/bismuth and tin/copper. However, all of these alternatives have some drawbacks such as toxicity, higher melting points, low availability coupled with high cost and more complex and difficult process controls. The 232°C melting point matte Sn of 232°C fits well within the 230°C to 260°C heat-tolerance temperature of today's components. In addition, matte Sn is readily available, has very low toxicity and is easily controlled. In choosing a lead finish, it is more logical to convert to a single- element finish such as matte Sn, as the alternative binary- and ternary-plated finishes are inherently harder to control. Matte Sn is the only logical drop-in replacement available at this time; a plating finish that already has a history of reliability and successful manufacturing experience. The industry has always been driven to one standard in an effort to simplify the manufacturing strategy. Based on ease of manufacture and performance, reverting back to pure matte Sn from a controlled plating process is the most reliable and logical choice. Numerous matte Sn-plating baths are commercially available on the market today. These are ready for use with Pb-free solder paste; providing for a totally Pb-free product. Matte Sn finish is universally compatible with all existing lead-alloy and Pb-free solders, pastes and printed wiring boards, thus covering the spectrum of requirements as the industry transitions to Pb-free.

On Semiconductor's plan is to continue the implementation of matte Sn exterior finish within its internal manufacturing operations (as a replacement for the current SnPb finish). It should be noted that some packages from ON Semiconductor have been 100% matte Sn for many years, also, ON Semiconductor has been using matte finish on most all packages, thus a knowledge and experience level already exists.

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