E. Jan Vardaman

Tin Whiskers: An Old Problem Reappears

The answers to today's problems may lie in yesterday's research.

Nearly 20 years ago the industry was entertained with with photos of microscopic tin whiskers on TAB tape. With the movement to environmentally friendly manufacturing and the elimination of lead, tin-plated leads are one alternative. Today we are seeing photos similar to the ones now two decades old (see photos). Does anyone remember the problems, issues and solutions? Can lessons learned from so many years ago help us today?

With the switch from solder to pure tin as a component finish, the problem of tin whiskers has re-emerged. The problem with pure tin is that a long whisker growing from the electroplated tin surface has the potential to short adjacent leads or break off, causing an unwanted electrical connection between two adjacent terminals.[1] Why is this a concern? Because companies like STMicroelectronics, Infineon, Intel, Philips and Freescale (formerly Motorola) supply components with matte tin finishes. Contract packaging assemblers such as Amkor and ChipPAC offer matte tin finish for their customers.

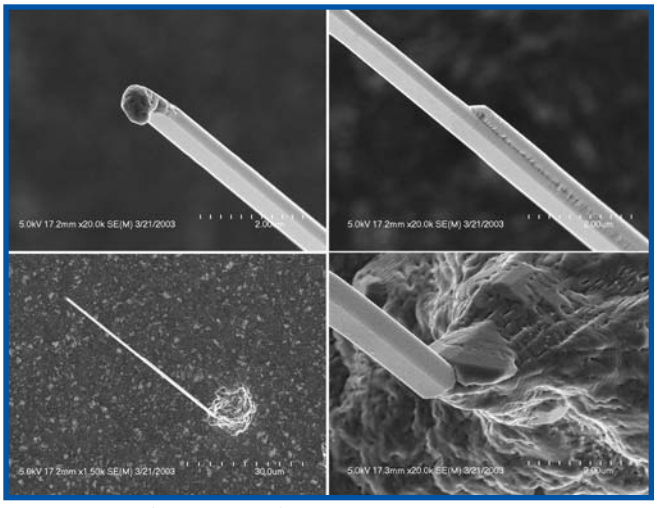
Some companies are wary of substituting another finish, such as nickel/palladium, because of the perceived cost increase.

Extensive research is underway to study tin whiskers. NIST has published an extensive document that details the issues with tin plating. IPC also has extensive documentation. The National Electronics Manufacturing Initiative has released a draft proposal of tin-whisker acceptance test requirements (see nemi.org). JEDEC has also issued guidelines for tin-plated components. The topic may also be up for discussion at the Electronics Goes Green 2004+ conference (http://egg2004.izm.fraunhofer.de) in Berlin this month.

Many researchers are investigating the problem. At Infineon in Malaysia, researchers evaluated a pure tin plating (3 to 5 µm matte tin) on K75 copper leadframes with samples stored at less than 50°C in their oven with 60% relative humidity and ambient temperature with 60% relative humidity. Samples with NiFe42 material were also evaluated at -40° to 125°C, -40° to 85°C and -35° to 125°C. Each sample was plated with 6 µm of pure tin. Samples were exposed to temperature cycling with a ramp rate of less than 10° to 14°C and checked after 1000 cycles. Almost no whiskers were observed after one week of storage at 50°C and at an ambient 26°C. After one week of storage, whiskers were observed with the Cu K75 sample subjected to annealing conditions of 60°C for 30 min., 60°C for 90 min. and 105°C for 60 min. No whiskers were observed for the NiFe42 samples or the Cu K75 samples annealed at 150°C. After two years the Cu K75 samples with annealing of 150°C for 30 min. or 90 min. showed no tin whiskers. The researchers concluded that an annealing process at 150°C would prevent whisker growth on the Cu K75. Reflowing the sample at 245° to 260°C could prevent whisker growth on the NiFe42 material.[2]

Problem Solved for TAB Tape

Tin-plated tape has been used in LCD driver ICs for 20 years. The driver IC with its gold bump on the I/O pad is thermocompression-bonded to the tin-plated copper inner lead of the tape. Tin whiskers



Whisker details (courtesy NIST).

***E. Jan Vardaman** is president and founder of TechSearch International (techsearchinc.com); jan@techsearchinc.com.*

were a problem in the early days. In a TAB seminar held by Shindo Denshi in March 1989, the problem of tin whiskers was described. "The phenomenon in which a single crystal of tin extends from the plating surface (whisker) takes place in tin plating. When a whisker is formed and it becomes remarkably long, a short circuit occurs between it and the adjacent pattern. Although if is impossible to completely prevent tin whiskers, it is possible to control them so that they do not become a problem in practical use."[3]

To solve the whisker problem, tin-plate tape was annealed for a short time after plating and thermocompression-bonded to the tape within a specified period of time (30 days). Shindo later demonstrated that no tin whiskers were observed for 120 days after products have been subjected to heat treatment (after bonding). A longer annealing time eliminates the whisker growth, but decreases bondability. The tin-plated tape was stored at low temperature to prevent tin diffusion into copper. If the tape is stored at room temperature, the thickness of tin decreased by 0.1 µm in 40 days. It changed very little when stored at 5°C. Shindo Denshi, one of the major tape suppliers in Japan, indicated that most of its customers did the inner lead bond and encapsulation within one or two weeks after receiving the tape. The heating process prevented the tin whisker from occurring. Other Japanese companies solved the tin whisker problem in similar ways. Fujitsu reported that using rolled copper foil had less tin whiskers than the electrolytic copper foil. In addition, Fujitsu recommended annealing after plating, the addition of 10% lead (not acceptable today), and low-temperature storage of the tape. Research was also conducted on tin-plated outer leads mounted to a PCB.

While much of the research was conducted more than 15 years ago, some relevant knowledge may be gained by examining the research. While today's technical conferences are filled with papers discussing tin whisker problems and the debate spills into the hallways, the major Japanese reliability conferences do not have presentations on this topic. Is this because the problem has been solved? The answer may be just a Japanese language translation away. ■

References

1. L. Hu, D. Guihamet, H. Chan, A. Katz, "Whisker Evaluation of Tin Plated SMT Components," IPC Annual Meeting, Oct. 2003, pp. 97-101.
2. S. L. Goh and W.B. Lee, "Challenges in Pure Tin Solder Plating," APiA Seminar, SemiCon China, March 2004.
3. K. Saito, Tape Automated Bonding Seminar, 1989, pp. 40-41.