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Tin/Nickel Plated Leads Qualification Summary

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Executive Summary

In order to comply with customer requests for RoHS compliant packages, Apex will begin supplying RoHS compliant models in the Apex PSIP packages. Historically, this package has used leading built with a 60/40 tin/lead solder plate over alloy 510 phosphor-bronze. In moving to a RoHS compliant package, the tin/lead solder plating has been replaced with a matte tin over nickel finish. Qualification of these materials was modeled after JEDEC standards JESD22A121[1] and JESD201[2], though some difference in test conditions were made as noted in the Qualification Test Description section.

Customers may notice a visual difference in the lead appearance. The section of the lead next to the SIP package will show a reflowed appearance whereas areas of the lead further out will have a matte tin finish. This is due to the high melting point of tin (232C) which prevents the entire lead from fusing when run through the Apex manufacturing processes. In addition to tin whisker testing, the parts have passed solderability and salt spray tests. The difference in appearance has therefore been determined to be a cosmetic issue only and does not present a functional or reliability concern for Apex Microtechnology or its customers.

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[1] Test Method for Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes. JEDEC SOLID STATE TECHNOLOGY ASSOCIATION. October 2005. http://www.jedec.org/download/search/22a121-01.pdf January 23, 2007.

[2] Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes. JEDEC SOLID STATE TECHNOLOGY ASSOCIATION. March 2006. http://www.jedec.org/DOWNLOAD/search/JESD201.pdf January 22, 2007

Background

The European Union has instituted a list of prohibited materials in its Restrictions on Hazardous Substances (RoHS) Directive among which is lead[3]. The leads in the Apex PSIP products have historically used 60/40 tin/lead plating. In order to comply with the RoHS requirements, Apex is changing this to a tin over nickel coating. A concern with the tin coating is the possibility of generating tin whiskers. While these whiskers would not be internal to the product, they could present a reliability concern if present. The industry standard for making a change to a tin coating is to take steps to mitigate the propensity of tin whiskers to be generated and then verify through a series of tests (as discussed in JESD22A121 and JESD201) that the risks of whiskering have been minimized. This paper documents the qualification efforts made in preparation for this change.

Several steps have been taken with the design and manufacturing of these devices which will mitigate the possibility of tin whisker creation and subsequent reliability concerns. As has been documented elsewhere[4], the use of a nickel underplate is a key method of reducing both the appearance and size of tin whiskers. Industry data also indicates that thicker (greater than 50µ") tin plating also helps to mitigate tin whiskers.[5]

Qualification Test Description

The testing described below was made to qualify the use of a matte tin (150-300µ") over nickel (50-100µ") underplate in the Apex PSIP package. The qualification plan is modeled after JEDEC standards JESD22A121 and JESD201. Some modifications were made to the long term high temperature testing conditions. Specifically, the packages were subjected to a high temperature (150C) and low humidity condition (less than 1%). Two separate lead configurations were used in the qualification, these being the standard straight lead (DP package) and the 90˚ bent lead (EE package). As these packages are not typically used in a SMT applications, it was determined that no pre-conditioning would be required. Production lots were processed through all standard manufacturing and inspection processes. From these production lots, three separate sample groups were randomly selected (8 devices/sample group). This gave a total of 96 leads (8 x 12 leads/device) to evaluate in each of the sample groups. The three sample groups were separately run through the following tests:

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[3] Directive 2002/95/EC of he European Parliament and of the Council of 27 January 2003. February 13, 2003. Official Journal of the European Union. http://europa.eu.int/eur-lex/pri/en/oj/dat/2003/l_037/l_03720030213en00190023.pdf. January 22, 2007

[4] iNEMI Recommendations on Lead-Free Finishes for Components Used in High-Reliability Products Version 4. December 1, 2006. http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/Pb-Free_Finishes_v4.pdf. January 20, 2007

[5] iNEMI Recommendations on Lead-Free Finishes for Components Used in High-Reliability Products Version 4. December 1, 2006. http://thor.inemi.org/webdownload/projects/ese/tin_whiskers/Pb-Free_Finishes_v4.pdf. January 20, 2007

Temperature Cycle: Modified Condition A. Temperature range: -40C to +85C for 1,000 cycles, with an interim inspection at 500 cycles.

Ambient Temperature/Humidity Storage: 30 ± 2C and 60 ± 10% RH for 3,000 hours with interim inspections every 1,000 hours.

High Temperature Storage: 150 ± 5C for 3,000 hours with interim inspections every 1,000 hours.

Test Results

All leads in all the sample groups were inspected immediately after completion of the standard manufacturing processes. It was noted that the portion of the leads closest to the substrate (including the lead shoulder) all exhibited what appears to be a reflowed (or fused) grain structure. An "as received" normal matte tin grain structure was present on the remainder of the leads. Photo 1 is an example of the grain structure change after reflow. The somewhat smooth area shown on the left of the photo shows the change after reflow, while the right side of the photo show the typical grain structure of the matte tin. This is a 1500X magnification taken at the transition of the shoulder standoff to the straight lead. Photo 2 shows the difference between the reflowed tin and matte tin as it is normally observed. Apex has concluded through the testing described in this paper that this is a cosmetic artifact only and does not present a functional or reliability risk for customers.

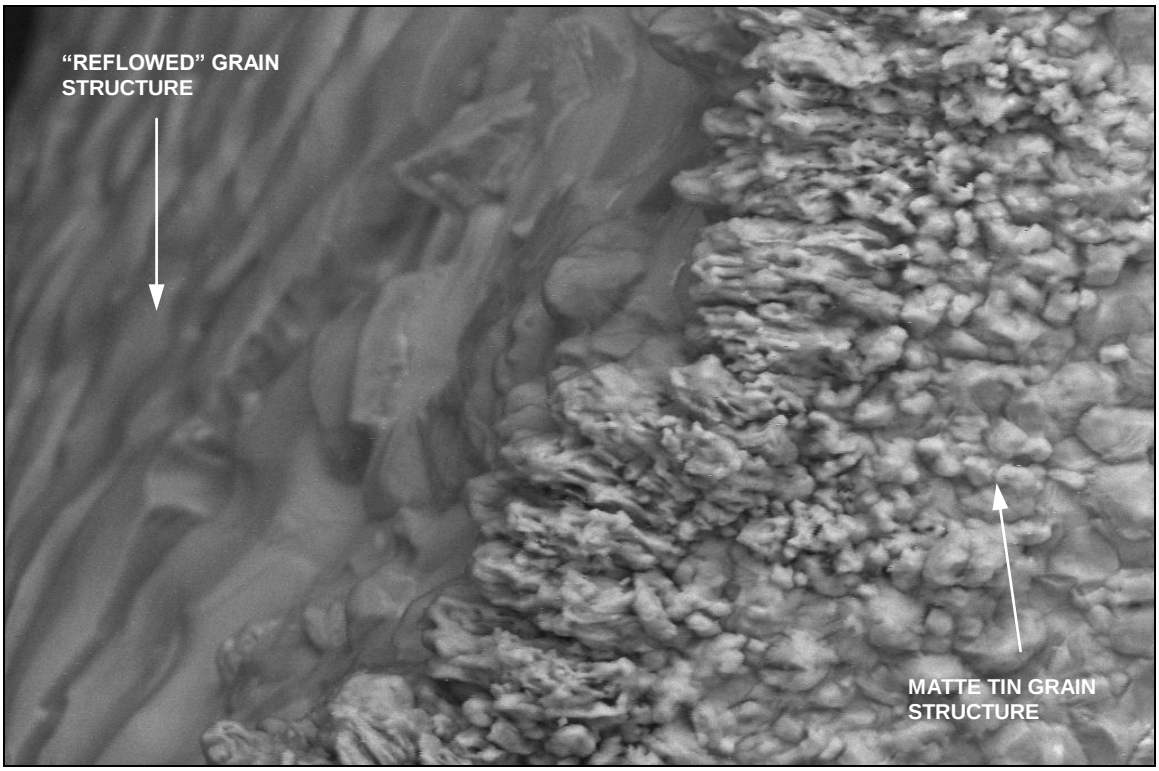

Photo 1. Reflowed vs. Matte Tin Grain Structures (1,500X)

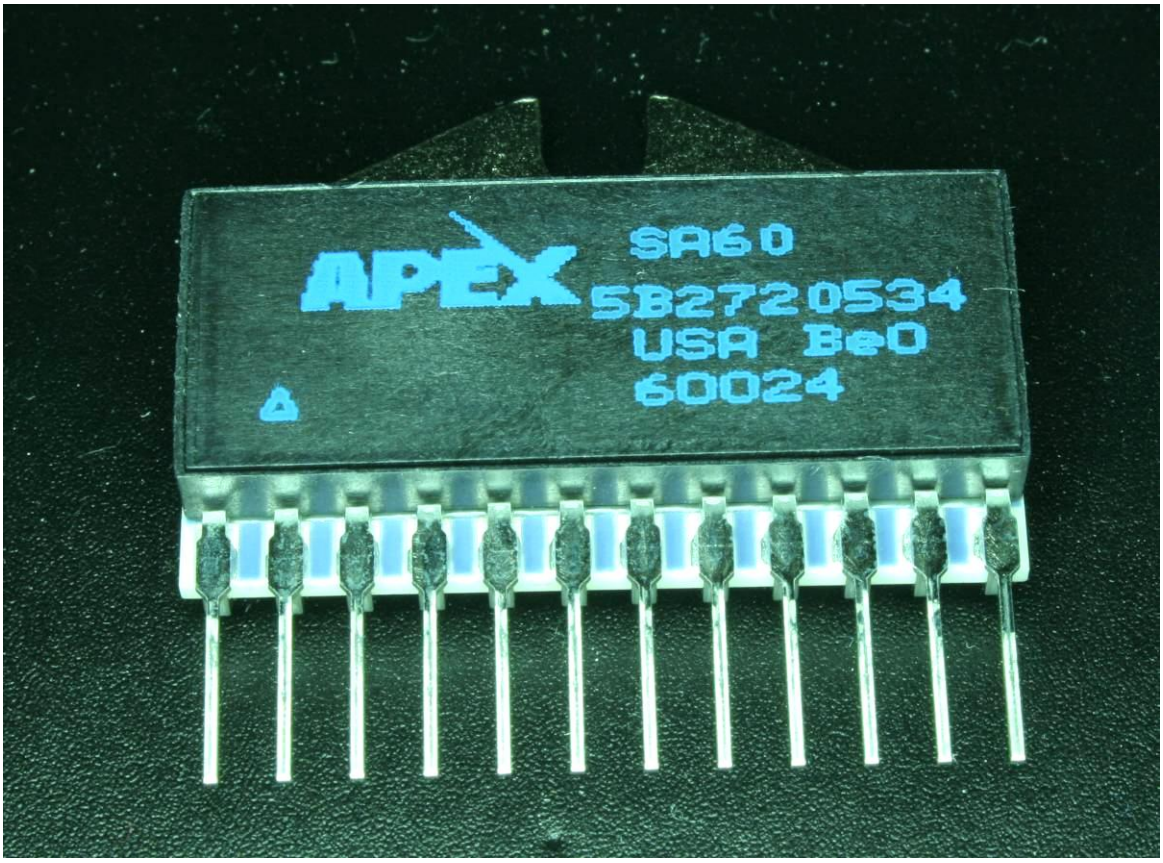

Photo 2. Reflowed Tin vs Matte Tin Appearance

Temperature Cycle Results:

500 Cycle Interim Inspection: After 500 cycles from -40C to +85C, all 192 leads were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. No evidence was found, therefore no SEM microscopy was performed

1000 Cycle Final Inspection: After 1,000 cycles from -40C to +85C, all 192 leads were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. No evidence was found, therefore no SEM microscopy was performed.

Temperature/Humidity Storage:

1,000 Hour Interim Inspection: After 1,000 hours of storage at room temperature/ humidity (30 ± 2C and 60 ± 10% RH), all 96 leads of each sample group were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. No evidence was found, therefore no SEM microscopy was performed.

2,000 Hour Interim Inspection: After 2,000 hours of storage at room temperature/humidity (30 ± 2C and 60 ± 10% RH), all 96 leads of each sample group were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. No evidence was found, therefore no SEM microscopy was performed.

3,000 Hour Final Inspection: After 3,000 hours of storage at room temperature/humidity (30 ± 2C and 60 ± 10% RH), all 96 leads of each sample group were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. No evidence was found, therefore no SEM microscopy was performed.

High Temperature Storage:

1,000 Hour Interim Inspection: After 1,000 hour at high temperature storage (150 ± 5C), all 96 leads of each sample group were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. No evidence was found, therefore no SEM microscopy was performed.

2,000 Hour Interim Inspection: After 2,000 hour at high temperature storage (150 ± 5C), all 96 leads of each sample group were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. No evidence was found, therefore no SEM microscopy was performed.

3,000 Hour Final Inspection: After 3,000 hour at high temperature storage (150 ± 5C), all 96 leads of each sample group were visually inspected at both low magnification (10-40X) and high magnification (100-400X) for evidence of whisker growth. One device from each of the two production lots exhibited areas of interest when inspected at 400X magnification. The two devices were then further examined with a scanning electron microscope (SEM) at 1,000X magnification. The SEM scan of all 96 leads on the SA60 production lot was negative for any evidence of whisker growth. A similar scan of the SA60EE at 1,000X determined that no whisker growth was present on the 96 leads.

Other Testing: The devices were also tested for solderability and plating peeling.

Solderability: Three devices were subjected to an 8 hour steam age per the requirements of MIL-STD-883, TM2003. All three devices passed the solderability test.

Plating Peeling: Three devices were subjected to a plating peeling test. All three devices passed the plating peel test.

Conclusion

Based upon testing modeled on the JEDEC standards JESD22A121 “Measuring Whisker Growth on Tin and Tin Alloy Surface Finishes” and JESD201 “Environmental Acceptance Requirements for Tin Whisker Susceptibility of Tin and Tin Alloy Surface Finishes”, the qualification data show that the matte tin plating over a nickel underplate on the Apex PSIP package provides a satisfactory finish in regards to tin whiskers for all three of the qualified test conditions. The use of a matte tin finish in conjunction with the Apex manufacturing process may give the leads a partially fused appearance and is cosmetically different from prior Apex parts that featured the lower temperature (181 C) tin/lead finish. However, this partially fused tin finish does not affect the solderability, functionality or reliability of the part.