

HYBRID INTERNAL COMPONENTS WITH PURE-TIN TERMINATIONS; HYBRID, VOLTAGE REGULATOR

Date: March 29, 2005

Problem Description:

The OMR9601 voltage regulator and its derivative designs were identified with internal elements that contained pure tin during the performance of DPA (Destruct Physical Analysis) whereby a MLCC (Multilayer Ceramic Capacitor) and Tantalum capacitors component with pure tin plating were used to build the hybrid microcircuit products. SEM/EDS elemental analysis detected the presence of pure tin on the component plated terminations. MIL-PRF-38534, General Specification for Hybrid Microcircuits, paragraph E.4.2.7.1 states that the use of pure tin is prohibited from internal element finishes. Tin is considered to be pure if it contains less than 3% alloy material. In addition, NASA requirements prohibit the use of pure tin in any application due to a phenomenon called 'whisker growth' and/or 'sublimation' (refer to the following web site for further information. <http://nepp.nasa.gov/whisker/>). While no field operational failures have been reported with the hybrid product which is directly or indirectly related to this issue, industry studies have shown that the use of pure tin finish can promote the growth of tin (Sn) whiskers, which might cause potential reliability risks related to electrical short circuits, debris or contamination.

1) The MLCC component was manufactured by Novacap Inc. and supplied with a certificate of conformance stating the 90Sn/10Pb plated termination code. Subsequent EDS (Energy Dispersive Spectrum) testing revealed a pure tin finish on the terminations (refer to Figure 1 herein). MIL-PRF-123, the Performance Specification for fixed ceramic capacitors states that tin plating is prohibited as a final finish or as an undercoat. Tin-lead (Sn-Pb) finishes are acceptable provided that the minimum lead content is four percent. For additional information, see ASTM B545 (Standard Specification for Electrodeposited Coatings of Tin).

An investigation by Novacap revealed that the plating line chemistry did not produce the required amount of Lead (Pb). Novacap's failure to detect the proper content of lead can be attributed with inadequate testing and analysis method used to verify the plating line chemistry. The lead content of the plating line was monitored with the use of XRF (X-Ray Fluorescence) equipment.

The subject MLCC component part number used in the hybrid was manufactured by Novacap, specifically a ceramic, multilayer, 0.1uF, 25V, Part Number 0805B104K250Y.

2) The Tantalum component was manufactured by Nemco Electronics Corp. EDS (Energy Dispersive Spectrum) testing revealed a pure tin finish on the leads.

An investigation revealed that the manufacturer converted the 90Sn/10Pb plating finish to pure tin (100% Sn Matte tin finish) beginning January 2004. This change was made in response with the growing demand for environmentally friendly components / lead-free initiatives. The component part number nomenclature was not changed to reflect the new plating type, hence not detected by International Rectifier.

The subject Tantalum component part number used in the hybrid was manufactured by Nemco, specifically Low Profile, Tantalum Capacitor, 4.7uF, 10V, Part Number PCT4.7/10AK.

Experiment:

In an effort to evaluate and assess the tin (Sn) whisker growth from the subject MLCC with pure tin end-terminations, experiments were conducted on a sample base. The evaluation consisted of capacitor termination inspection, specifically for the presence of tin whiskers and growth thereof. The samples used originated from QCI life test groups (post 1,000 hours at 125 °C). Following the inspection of the chip capacitor terminations, samples from the groups were submitted to temperature cycling and re-assessed.

Samples: Samples used in the evaluation consist of ten hybrids: (5) F-packs (OMR9601SFK), and (5) C-packs (OMR9601SCK).

Results:

As received (post life test), nine (9) of ten (10) hybrids exhibited tin whiskers. All ten (10) devices were screened through burn-in and steady state life for a total of 1,240 hours @ + 125 °C and a minimum of ten (10) temperature cycles during lot screening. At this stage, whiskers detected using SEM method measured ~ 5 µm and were randomly observed on the capacitor end-terminations. Following submission through 100 temperature cycles (-65 °C to 150 °C), inspection revealed growth of whiskers which measured up to 20.5 µm. Following submission through an additional 100 temperature cycles (210 cumulative cycles), whisker lengths were unchanged, however whisker growth/count was greater per unit area as seen following 110 temperature cumulative cycles where growth was only observed on upper and lower edges of the capacitor end-terminations. Refer to SEM Image 1 herein for reference. (IR HiRel report 05-004b).

**Figure 1 – SEM / EDS
Measures & Results**

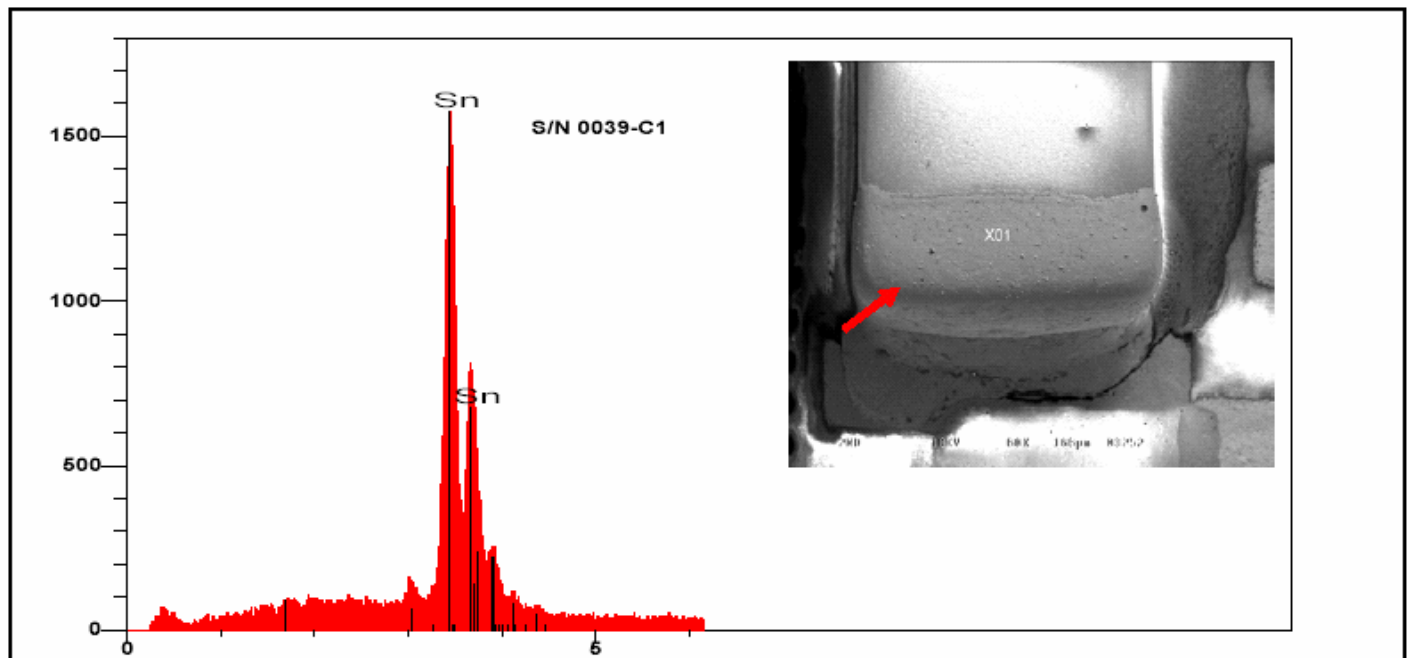


IMAGE 1 – Whisker Growth on Capacitor End-Terminations



Image 1

Part #: OMR9601SCK
Date Code: 0423
Life Test: 1,240 hrs @ 125C
Temp Cycle: 110 (-65 to 150C)
Magnification: 20.4X
Accel Voltage: 17KV
Cluster of Whiskers Growth
Whisker Length = 20.5um

Corrective Action:

1. The subject hybrids constructed with the subject components have been identified and contained. Customers were notified of the problem including product affected. See Table 1 herein for part number family and date code range.
2. All plated component raw material procured was identified for review and contained for validation. Plating finish validation was performed using EDS analysis on the suspect components.
3. International Rectifier has instituted EDS testing to verify plating composition on a sample basis for each new component lots received. This test is performed to validate proper component termination finish.

Table 1 - Affected Hybrids with Pure Tin

Part List 1/	Effectivity
OMR9601SCK	DC 0305 - 0440
OMR9604SCK	DC 0305 - 0440
OMR9605SFK	DC 0305 - 0440
OMR9608SFK	DC 0305 - 0440
OMR13529SCK	DC 0305 - 0440
OMR13530SCK	DC 0305 - 0440
OMR13577SCK	DC 0305 - 0440
OMR1357SCX	DC 0305 - 0440
OMR13587SCX	DC 0305 - 0440
OMR13622SCX	DC 0305 - 0440
OMR13733SCX	DC 0305 - 0440
OMR13776SCX	DC 0305 - 0440
OMR13777SCX	DC 0305 - 0440

Note 1/ - Through EDS analysis, IR determined that the following part numbers and date code range contained component(s) with pure tin termination.

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