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TOMBSTONE CAPACITORS REVISITED, NOW DO WE NEED A PSL (PLATING SENSITIVITY LEVEL) SPECIFICATION FOR CHIP COMPONENTS

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ABSTRACT

Drawbridges or tombstone assembly defects for chip components has not been a topic of discussion for some years but these defects are on the increase as low cost vendors are providing parts into the electronic component supply chain. Land pattern design standards, improved solder paste materials and improved reflow soldering systems have all but banished tombstone type of defects from electronic assembly. Unfortunately it has raised its ugly head with a new source of these old defects surfacing during ongoing competitor component evaluation of low cost Asian manufacturers of MLC capacitors. Sudden out gassing or venting of trapped nickel plating solutions has been observed in a number of BME (Base Metal Electrode) capacitors resulting in a new source of drawbridge or tombstone solder joint defects in chips as small as 0402 and as large as 1825. Perhaps it is now time to add a test technique to evaluate plating sensitivity levels (PSL) when these chip components are reflow soldered like MSL[1,2] (Moisture Sensitivity Levels) ratings for molded components to minimize popcorn damage due to steam formation within the package. Unfortunately or fortunately depending on ones point of view there can only be a pass fail system vs. different levels found in MSL ratings for molded IC packages.

SPLATTER TESTING

Different vendors that supply chip components like capacitors, inductors and resistors have or should have in internal procedure to determine if termination materials are properly sintered to the respective ceramic body is high density or low porosity and has few glass regions on the surface prior to nickel plating.

High sintered termination porosity results in trapped nickel plating solution that can violently erupt spraying adjacent components with nickel plating salts. If the termination material is poorly designed or is improperly sintered to the component body there can be large glass regions on the termination surface. During nickel plating those regions can plate over with nickel also trapping nickel plating solutions. Additionally if termination sintering is not properly controlled there can be poor adhesion to the respective ceramic body allowing nickel plating solutions to become trapped between the termination and ceramic body and again can violently erupt during component reflow soldering on an assembly. If there are plating salts trapped between the chip body and termination then electrode corrosion will result in either increased leakage current or loss of capacitance.

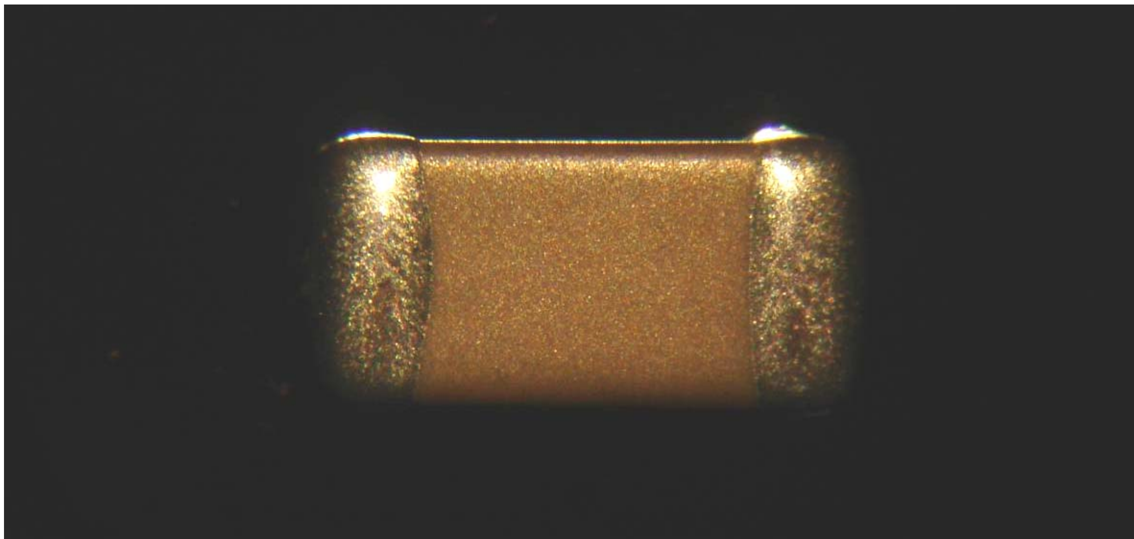

Photo 1. A typical well made capacitor no ejected plating salts or tin plating

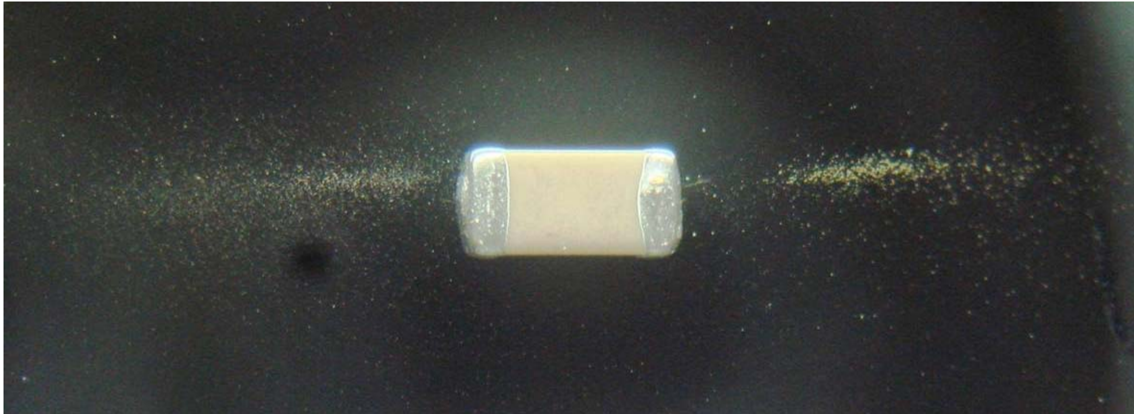

Photo 2. A reject part from a low cost Asia vendor with ejected plating salts and tin particles

Nickel sulphamate (Ni $(SO_3HN_2)_2$ x H_2O) is the typical electro nickel plating solution and we can see that there is not much of a jump to decompose to very corrosive products like sulfuric (H_2SO_4) or nitric (HNO_3) acids. Plating salts deposited on electronic assemblies during reflow soldering are detrimental to long term reliability and need to be avoided due to ionic contamination leading to leakage currents and corrosion. Johanson Dielectrics uses a splatter test to determine if plating solutions are trapped beneath the nickel layer or between termination and ceramic body during termination material qualification and evaluation. The test procedure is to place a number of chip components on a 4" diameter silicon wafer that is then placed on a hot plate set to 250°C +/- 5°Cfor 1 ½ minutes and the removed from the hot plate and allowed to cool. Inspection for out gassing is performed at 10X magnification. A silicon wafer is used because it has very high contrast with metal ejected by parts and has an exceptionally smooth surface. The following photographs are of well made parts with no splatter and those from low cost Asian vendors discovered during competitive part analysis.

The silicon wafer in Photos 4 and 5 was upside down showing its matte or dull side as the shinny side makes it difficult to focus the camera. The capacitors moved and hopped out of position within 1 minute at 250°C and finished moving at about 1 ½ minutes at that temperature. The bottom left capacitor in Photo 5 shows evidence of termination rupture during the violent venting of trapped boiling plating solution. Photos 6 and 7 show ruptured terminations from venting trapped plating solutions.

Photo 3. Another Reject from a low cost vendor part showing ejected plating salts and tin particles trapped beneath the chip

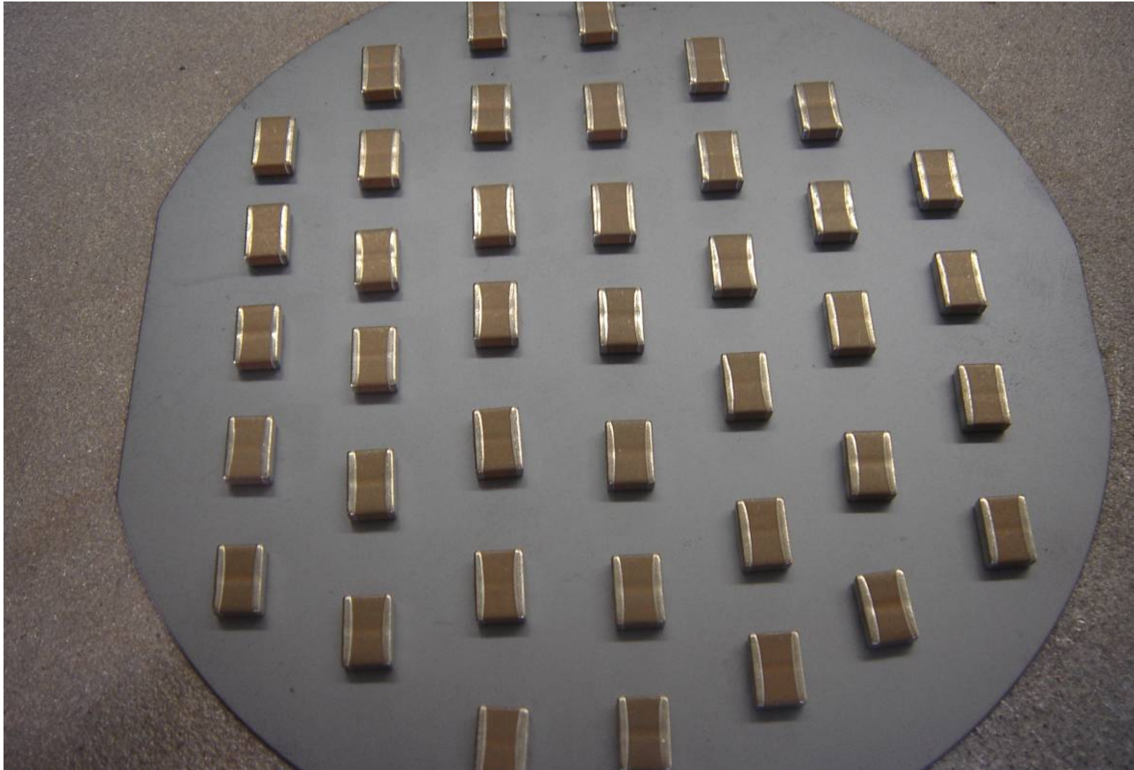

Photo 4. A silicon wafer with 1825 parts from a low cost vendor mounted when the splatter test began

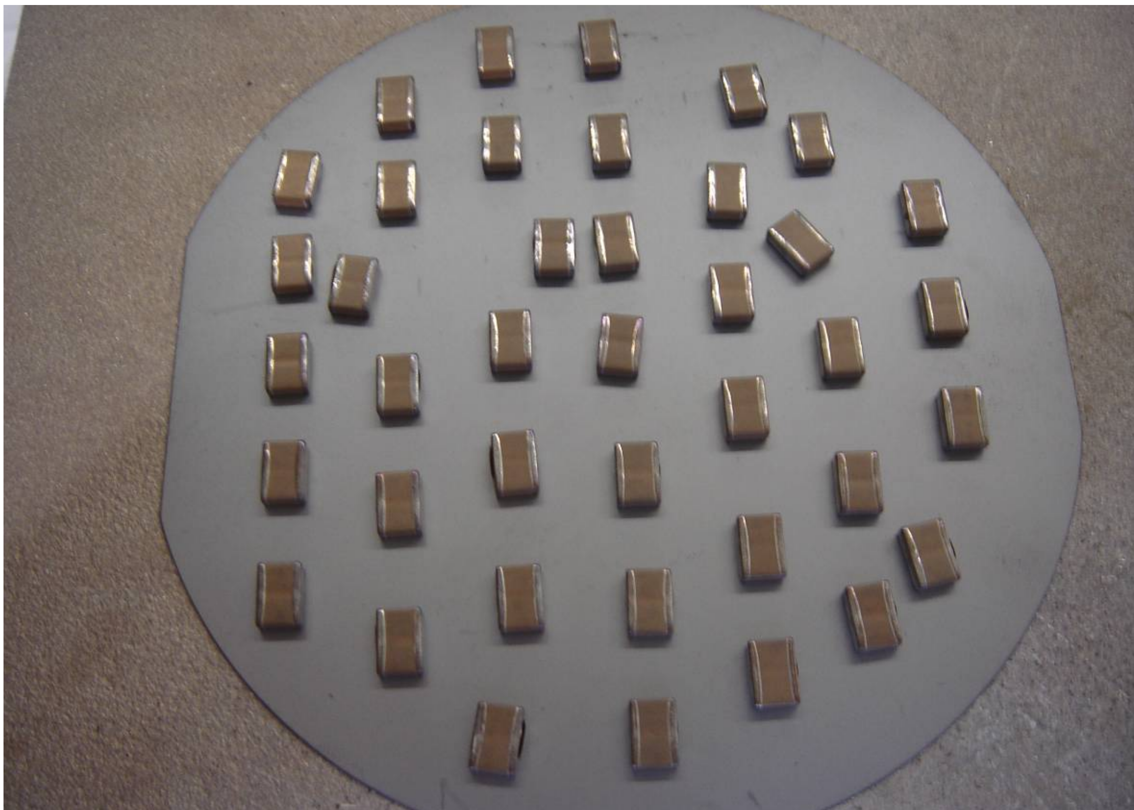

Photo 5. A silicon wafer with 1825 parts from a low cost vendor mounted when the splatter test was finished

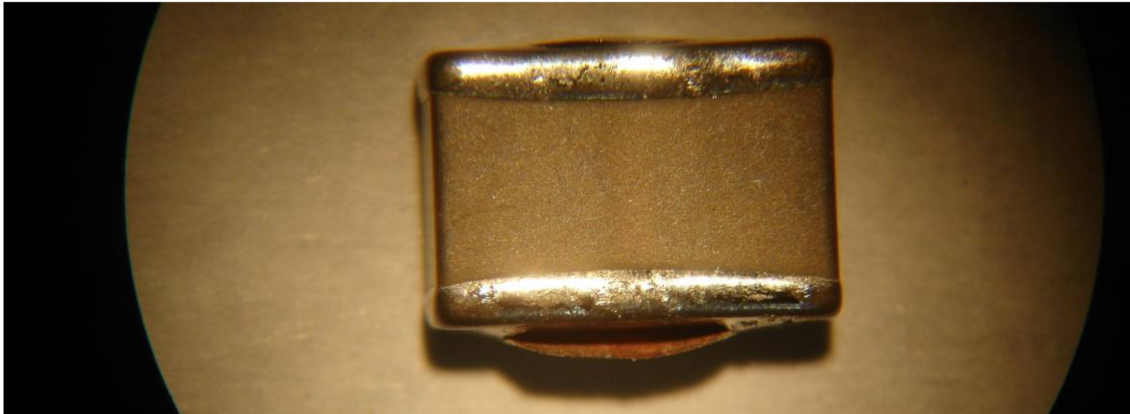

Photo 6. Damaged termination of a failed 1825 chip

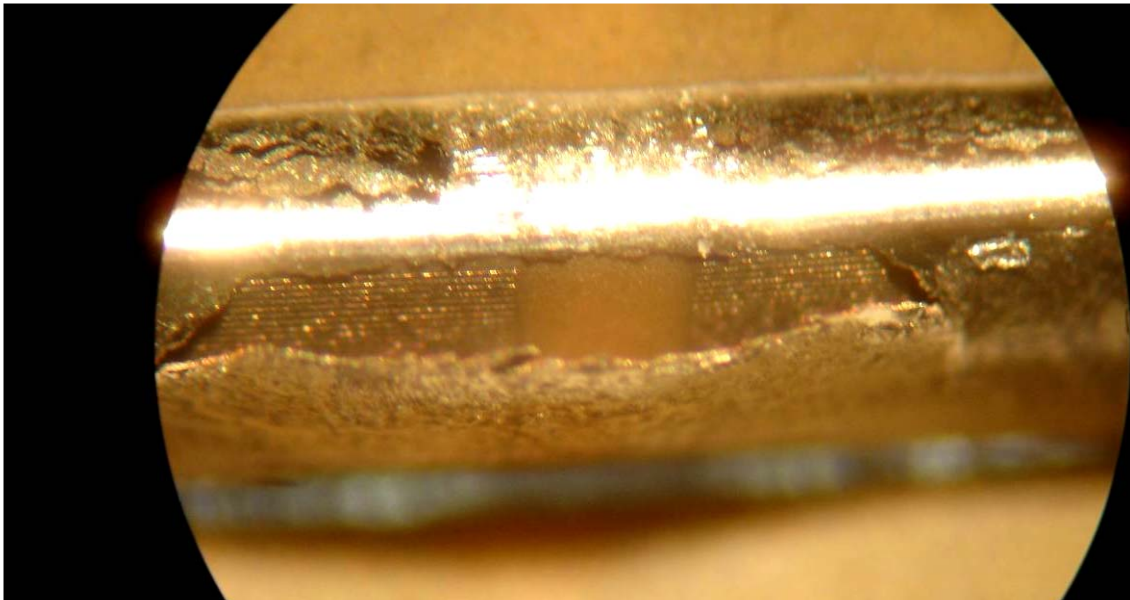

Photo 7. A failure showing copper termination separated from the ceramic body by boiling plating solution violently ejected during solder heat exposure

Photo 8. A test board with 96 1206 capacitors with splatter from a low cost Asia vendor

Photo 8 shows a sample board reflow soldered with 96 1206 capacitors from a low cost Asia vendor that exhibited splatter. Out of the 96 pieces, 8 were tombstone defects, 11 jumped off the board and 9 parts flopped around on the board bridging to other parts or hopping off pads.

CONCLUSIONS

Component vendors should have active internal termination evaluation test methods that simulate end customer solder conditions to insure that boiling plating solutions do not rupture termination plated layers ejecting corrosive plating salts onto an assembly. The splatter is a corrosion problem and cause tombstone defects, which is the detected symptom. The technique shown in the paper is just but one procedure that a vendor can use to determine termination density and suitability for all customer applications.

At the same time customers need to validate that new low cost vendors used by manufacturing sites in Asia are using parts that do not present reliability or rework hazard due to this defect. Most of these defects were observed in BME capacitors with nickel electrodes and copper terminations during competitive part evaluation.

Bottom line, know thy vendor and ask, how they evaluate termination and plating integrity. Qualify all component vendors in the supply chain and do not change without evaluating a number of factors including termination splatter. What is in the MLC capacitor vendors control plan, what test techniques are used and what is the sampling frequency to insure that splatter does not occur on electronic assemblies?

REFERENCES

1) **J-STD-020C**, Joint IPC/JEDEC Standard for Moisture/Reflow Sensitivity Classification for Non Hermetic Solid State Surface-Mount Devices

2) **J-STD-033B,** Joint IPC/JEDEC Standard for Handling, Packaging, Shipping and Use of Moisture/Reflow Sensitive Surface-Mount Devices

3) J. Maxwell and C. England, “Tombstone Capacitors, Do We Now Need a PSL (Plating Sensitivity Level) Specification for Chip Components like MSL (Moisture Sensitivity Level) for Molded Components” CARTS (Capacitor and Resistor Technology Symposium, March 2009