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Finding Residue Sources

Finding Residue Sources in PCB Fabrication Using Six Sigma Techniques

Foresite Inc.

Dorian Shainin, the great quality improvement consultant, taught a problem solving technique called the dictionary search. The premise of the dictionary search is that the source of a problem can be located by subdividing the solution space. This technique, which takes its roots from René Descartes, has now become part of the Six Sigma methodology.

The Dictionary Search Technique

He would begin by asking a class participant to open the dictionary he handed them and pick a word – any word. Without knowledge of the word, he then would ask if the word was between A-M, or N-Z. Then he would divide the solution space in half again, and so on. Within 17 questions he could identify the exact word picked by the participant. Taking 2 to the power of 17 means he could find the source from 131,072 words within the 17 questions.

The dictionary search technique can be used to search for residue sources in printed circuit board (PCB) fabrication.

A Case Study – The Problem

A client experienced failures during environmental stress testing on rigid multi-layer PCBs.

Analysis

The failed PCB's visually had a whitened spot indicating an inner layer had partially delaminated. They were then cross-sectioned, and completely delaminated for examination. On the ground plane, layer 6 of the 8-layer board, a large blister had formed, with subsequent corona, arcing and burning, indicating that electromigration of the metal had occurred. Layers 3 and 7 did not show signs of failures.

Next, we wanted to know what was different chemically between the various layers. We also wanted to know if there were differences within each layer, so we compared two locations on each layer – the failure location to a reference (non-failed) location. Several samples were analyzed using Ion Chromatography per IPC-TM-650, method 2.3.28.

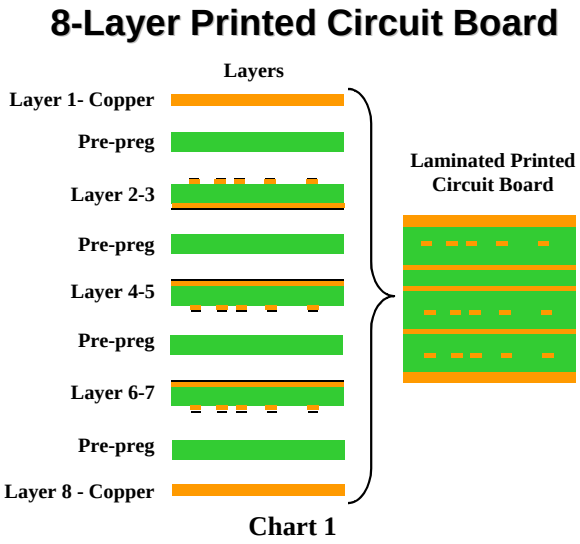

Chart 1

Root Cause

The following detrimental ionic contaminants were identified: bromide, chloride, sulfate, and weak organic acids. The data (see chart 2) showed a significant difference between layer 6 residue levels and the other layers. Moreover, the levels of bromide, chloride, and sulfate on layer 6 were above our recommended limits for long-term product reliability.

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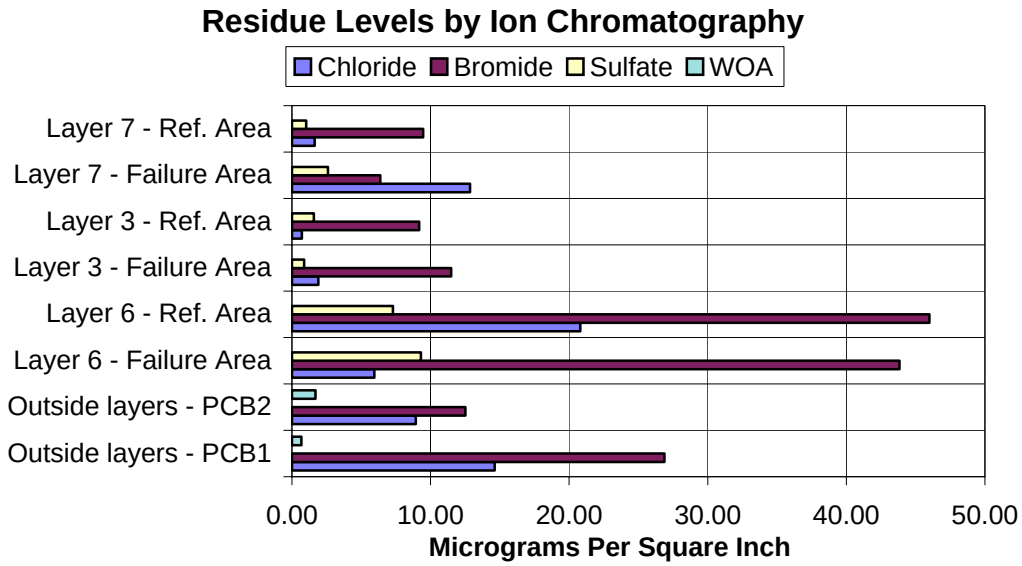
Chart 2



Corrective Actions

Working with the client and the bare board fabricator, we identified the source of the residues on layer 6 to be originating at the plating line. They worked together to reduce the levels of the detrimental residues, and the failures ceased. Then the fabricator placed process controls on the plating line.

Conclusion

PCBs can be examined forensically using Six Sigma techniques, such as the dictionary search, to pinpoint the sources of chemical residues left behind during the manufacturing process. In this case, the 'book' of PCB layers, like a dictionary, had been re-opened and analyzed. In other cases, the dictionary can be product processed to various points in the manufacturing process. Furthermore, Ion chromatography analysis provides the electronics industry a tool that both identifies and objectively quantifies detrimental process residues.