

Terry Munson

Dark Conductive Residues

Examining the impact of sulfur contact on copper traces.

A printed circuit board (PCB) assembler recently experienced shortage failures in the field. He noticed a dark residue had formed around the copper metal traces and the numerical labels on the board. He wanted to know the cause of the corrosive residue. The chief suspect was a liquid solution the boards were subjected to in the field.

Analysis

An analysis using scanning electron microscopy (SEM), coupled with an energy dispersive spectroscopy (EDS), was performed on a corroded board. The following chemicals were identified on a cross section of the solder plating (in order of concentration): copper, tin, carbon, oxygen and aluminum. When the list of chemicals was compared with the dark residue, tin was absent, but sulfur appeared.

Additionally, several assemblies, bare boards, components and samples of the suspect solution were analyzed using ion chromatography per IPC-TM-650, method 2.3.28. The following ionic contaminants were identified at significant detrimental levels: chloride on the corroded board; chloride on the bare board (and in the solution); sulfate on the corroded board; and sulfate in the solution (Table 1).

Root Cause

The sulfate levels were detrimentally high from the contact of the solution. Since copper was exposed on the sides of the interconnect, below the solder coating and above the board surface (Figure 1), the high sulfate levels in the suspect solution caused copper sulfate crystals to grow. Copper sulfate appeared as a dark crystalline residue (Figure 2) and was conductive—causing electrical current shorts. The residue was produced by a chemical corrosion process rather than an electro-chemical (electromigration) process. Hence, a voltage differential was not required to form a conductive path.

The chloride levels were also higher than recommend for long-term product reliability and, most likely, came from the hot-air solder leveling (HASL) flux applied during fabrication of the bare board. However, the failure mechanism was not electromigration and chloride residues had little to do with the root cause of the failure.

Corrective Actions

In this case, the finished product could not be

protected from exposure to the suspect solution. Therefore, the copper on the board had to be protected—a liquid photo-imageable (LPI) solder mask was placed over the board at the fabrication stage, with adequate coverage of the edge of the pads and traces. Additionally, the client worked with their bare board supplier to reduce chloride residue levels to abate potential reliability problems.

Conclusion

Carefully analyze the target environment intended for the finished product. If the environment contains gases, solutions or materials high in sulfur, the exposed copper on circuit boards must be protected. ■

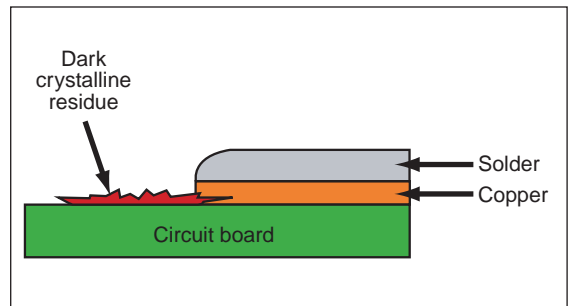


FIGURE 1: Sample cross section of a board exposed to high sulfate levels.



FIGURE 2: Sample of a corroded board.

Sample Description (Levels represent the mean of samples tested)	Chloride Levels ($\mu\text{g}/\text{in}^2$)	Sulfate Levels ($\mu\text{g}/\text{in}^2$)
Corroded boards	6.26	71.68
Bare boards (untested)	7.68	2.39
Component #1	1.10	3.52
Component #2	0.73	1.76
Suspect solution (exposure after production)	103.65 ppm	214.3 pp

TABLE 1: Summarized ion chromatography results.

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