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Is Cleaning Really Worth the HASL?

Quantity of wash cycles does not compensate for quality

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Introduction

Traditionally, flux manufacturers have formulated hot air solder leveling (HASL) fluxes using one of three activator packages: chloride-activated, bromide-activated, or a mixture of both. In addition, there has been the introduction of methane sulfonic acid (MSA) as an alternative activator in a small number of HASL fluxes. Regardless of the choice of activator, elevated levels of HASL flux residue that remain on finished bare boards present a considerable reliability risk for electrochemical failures to occur on finished assemblies. Such high levels of HASL flux residue are a result of insufficient post-HASL cleaning. This case study is one example of how undesirable amounts of HASL flux residue withstand what many fabricators may see as a more-than adequate cleaning process (at least in theory).

Outlining the Evaluation

We were tasked to evaluate the ionic cleanliness on three sets of bare board designs from a large PCB fabricator. Despite the different board designs, each set of boards experienced the same fabrication process and cleaning regimen.

All six board samples consisted of FR-4 laminate with liquid photoimageable (LPI) solder mask, solder mask over bare copper (SMOBC), and tin/lead HASL metallization. We subjected each board to Ion Chromatography (IC) testing per IPC-TM-650, method 2.3.28.

TABLE 1. Bare Board Ion Chromatography Data (in μg/in^2)

Sample #	Sample Description	Chloride	Bromide	Sulfate
	Board Design #1			
1	Sample #1 of 2	14.89	0.17	3.95
2	Sample #2 of 2	15.96	0.11	3.63
	Board Design #2			
3	Sample #1 of 2	14.55	0.25	2.85
4	Sample #2 of 2	12.96	0.20	3.24
	Board Design #3			
5	Sample # 1 of 2	19.67	0.09	5.39
6	Sample #2 of 2	9.96	0.05	3.72

Analyzing the Data

Our data shows bromide levels that are well within the typical range for the fire-retardant material in FR-4 laminates, and are therefore not an electrochemical reliability threat on finished assemblies. A serious threat for electrochemical failures exists when we can attribute the bromide levels to flux residues.

Chloride is a different story. Tolerable levels of chloride for finished bare boards depend upon the type of assembly process that they will eventually encounter. An assembly process that incorporates cleaning, such as one that uses water-soluble fluxes, can tolerate higher levels of incoming chloride than can a low-solids (no-clean) assembly process. As a conservative guideline, we recommend no more than 2.5 μg/in^2 for an assembly process with cleaning and 2.0 μg/in^2 for one without cleaning. The test samples in this evaluation exhibit chloride levels four to nearly seven times greater than our recommended maximum for an assembly process that incorporates cleaning and five to eight times greater for an assembly process devoid of cleaning. Such high chloride levels clearly indicate the primary source of chloride residues on the cleaned bare boards is the HASL flux. Consequently, each bare board sample with its high chloride level is at risk of developing electrochemical failures on finished assemblies.

Sulfate is a good measuring stick for assessing the effectiveness of a fabricator's cleaning process. Sulfate in sufficient quantities can be detrimental to reliability. The level of sulfate on each of the six samples exceeds our 3.0 μg/in^2 guideline. These high sulfate levels indicate that the cleaning process is not effective and that the bare boards are at risk of developing electrochemical failures on finished assemblies.

But It Looks Good on Paper!
Looking at the cleaning process flow, most everyone would agree that the fabricator exceeded the efforts that most fabricators would make with respect to bare board cleaning. After all, one would expect three heated wash stages and six rinse stages to be more than sufficient to combat even the most stubborn fabrication residues. As our example confirms, what theoretically looks good on paper does not always fulfill our expectations in real life. This cleanliness evaluation proved the adage that quality is more important than quantity, especially when it comes to cleaning electronic circuit boards.

What must a fabricator consider when implementing an effective (quality) cleaning process? A variety of parameters can significantly impact the effectiveness of a cleaning process, including:

- Belt speed (no more than 4 ft./min. recommended)
- Pressure (35 - 45 psi recommended at a high volume)
- Water quality (deionized throughout)
- Wash and rinse temperatures (140 - 160°F recommended)
- Exposure time to wash and rinse (at least 35 to 40 seconds recommended)
- Cleaning equipment maintenance (regular scrubbing and descaling)
- Choice of materials (e.g., soldermask, laminate, metalization, saponifier, HASL flux, etc.)

The use of deionized-quality water throughout the process is the only known parameter this customer used that conforms to the aforementioned list. Beyond this are many unknowns, such as belt speed, exposure time and pressure. This cleaning process also did not use optimal wash temperatures.

A less obvious factor in this customer’s cleaning process is the choice of two different saponifiers. The first wash stage used a saponifier (Vendor "A") that is much less effective at removing HASL process residues than is the saponifier chosen for the second wash stage.

In the end, we advised our client to consider optimizing the fabrication cleaning process using the list of recommendations above. Subsequent evaluations with our client would eventually reveal vast improvements in both chloride and sulfate levels after implementing the more effective saponifier (Vendor "B") at increased wash temperatures.

The question, "Is cleaning really worth the HASL", should seem a bit rhetorical. The real question a fabricator should be asking is, "Did my cleaning process remove an adequate amount of HASL flux residue?" Knowing the answer to this question will go a long way in nipping those pesky electrochemical failures on finished assemblies in the bud.