CASE STUDY

Saponified Aqueous Cleaning of a HASLed Bare Board

Project Overview

The goal of this evaluation was to compare standard fabrication rinsing techniques after HASL to the saponified D.I. water cleaning techniques of two different-in-line cleaning systems. The boards in this case study measured approximately 11” x 16”. They are mixed technology boards. The substrate material was FR-4 (epoxy-glass) and the board was coated on both sides with a liquid photo-imagable (LPI) solder mask. The surface metalization was tin-lead (solder) applied by a HASL process.

Data Discussion - Ion Chromatography

1. The data for this evaluation is shown on the attached data pages and graphs. The ion chromatography data is shown as micrograms of the residue species per square inch of extracted surface, unless otherwise noted. **This measure should not be confused with micrograms of sodium chloride equivalent per square inch, which is the common measure for most ionic cleanliness test instruments, such as the 600R.**

2. For this project, ion chromatography detected the following anion residues: chloride (Cl), and bromide (Br). Each residue is discussed in greater detail below.

3. **Bromide** is generally attributable to the bromide fire retardant added to epoxy-glass laminates to give fire resistance, and which is subsequently extracted in the ion chromatography analytical procedure. Bromide can also sometimes come from solder masks, marking inks, or from fluxes which have a bromide activator material. Bromide, when from the fire retardant, is not a material considered to degrade long term reliability of electronic assemblies. If bromide is from a flux residue, then the bromide can be corrosive as other halides can be. The level of bromide can vary depending on the porosity of the laminate and/or mask. The degree of over/under cure of the laminate or mask, or the number of exposures to reflow temperatures.

4. Bromide levels of 0-7 micrograms per square inch ($\mu g/in^2$) are considered nominal for FR-4 laminate. Levels as high as 12 $\mu g/in^2$ can be seen with 3-4 exposures to reflow temperatures. When bare board bromide levels exceed 15 $\mu g/in^2$, we look for the use of a brominated flux. When we see levels bromide levels over 25 $\mu g/in^2$, it is certain that a brominated HASL flux (such as hydrobromic acid) or fusing fluid was used. When bromide levels are this high, electrical leakage and corrosion are highly likely.

5. The low levels of bromide come from an effective cleaning process during fabrication and the use of a non-brominated flux. The bromide levels are reduced by both cleaning systems to pose a minimal risk of electromigration on assembled boards.

6. Weak organic acids, such as adipic or succinic acid, are used as activator compounds in many fluxes, especially no-clean fluxes. WOAs are presently considered benign materials and are not considered a threat to long term reliability. In order to avoid formulation disclosure difficulties with flux manufacturers, we group all detected weak organic acid species together and refer to them collectively as WOAs.

7. No WOAs were found on the bare boards, as expected. Fabricators, as a rule, do not use WOA-based fluxes, and generally prefer the more active halide-based fluxes.

8. Chlorides can come from a variety of sources, but is most often attributable to flux residues. Chlorides will generally initiate and propagate electrochemical failure mechanisms, such as metal migration and electrolytic corrosion, when combined with water vapor and an electrical potential. The amount of chloride that can be tolerated on an assembly depends on the flux chemistry being used. Assemblies processed with high-solids rosin fluxes (RA, RMA) can tolerate higher levels of chloride due to the encapsulating nature of the rosin. Water soluble fluxes and no-clean fluxes are generally based on resins or very low levels of rosin, and so do not have this encapsulating protection, therefore, they require lower levels of flux on final assemblies.

9. We recommend maximum chloride levels of 4.5 – 5.0 micrograms per square inch for final assemblies processed with water soluble fluxes and 2.0 – 3.0 micrograms per square inch for a bare board (tin-lead coated) intended for a water soluble flux process. These recommended maximums do not presently appear in any nationally accepted specifications or standards, but are based on our failure analysis efforts with numerous customers.

10. Using these standards, we see that the chloride levels on the incoming bare boards are well above our recommended maximums. The source of the chloride is primarily from the HASL flux. When post-HASL rinsing is ineffective, it is also likely that there are high levels of residual polyglycol, which is often the carrier fluid for the HASL flux. Polyglycols are not detectable by ion chromatography, since the residues are not electrically conductive, but their presence can be inferred. Polyglycols, when left on the surface of an assembly, tend to turn that surface from hydrophobic (water repelling) to hydrophilic (water attracting). This would mean a much easier formation of the water film that seems to initiate the arcing problem. Fortunately, the same saponifier cleaning that reduces chloride level will also reduce the polyglycols.

Conclusions

1. Water alone, and especially tap water alone, is insufficient to reduce the harmful residues to levels which do not produce electrical failures.

2. The remedial cleaning of the bare boards cleaned in EnviroGold 816 @ 3% effectively reduced the levels to below our recommended acceptable levels of residues. This is due to good D.I. water with a good saponifier removing the fabrication flux residues using the equipment parameters of low pressure high flood and not high blasting pressure.

3. The shorter Marseco Cleaning systems reduced the chloride levels well below the larger in-line Electrovert H501 cleaner. We believe that this is the result of a larger turnover of water and brushes in the Marseco system.

Reported By:

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Ion Chromatography Cleanliness Data
Of Bare Unprocessed Boards
Anion Data

All values are in µg/in^2, unless otherwise noted   Ion Chromatography

Sample Description	Chloride	Bromide	WOA
Bare board (date code 9619)	12.54	1.82	0
Bare board (data code 9619)	13.85	1.42	0
Bare board (date code 9619)	11.94	2.06	0
Mean	12.78	1.77	0
Board 1 Cleaned in EnviroGold 816 @ 3% At American Assemblers 6-97			
H501 In-line Aqueous Cleaned Bare Boards	3.85	0.46	0
H501 In-line Aqueous Cleaned Bare Boards	3.97	0.47	0
H501 In-line Aqueous Cleaned Bare Boards	3.71	0.34	0
Mean	3.84	0.42	0
Board 1 Cleaned in EnviroGold 816 @ 3% At Diversified 6-97			
Marseco Aqueous Cleaned Bare Boards	2.05	0.41	0
Marseco Aqueous Cleaned Bare Boards	1.84	0.39	0
Marseco Aqueous Cleaned Bare Boards	1.91	0.38	0
Mean	1.93	0.39	0