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Escape Artist: On a Flat Note - Part 2

Design changes involving a standoff allow for flux trapped under PQFN to volatilize and escape

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In my last column, I discussed an assembler's problem with flux entrapment under PQFN components. These PQFN components were entrapping flux residues by not permitting a path of volatilization for the no-clean flux. Ultimately, these assemblies were failing in the field due to stray voltage causing LEDs to stay on. Based on our failure analysis of these assemblies, it was definitively found that this entrapped flux was the primary contributor to the field failures, and that fabrication residues played no significant role. Foresite was then asked to develop a corrective action plan to prevent future field failures, and recover the contaminated assemblies through rescue cleaning.

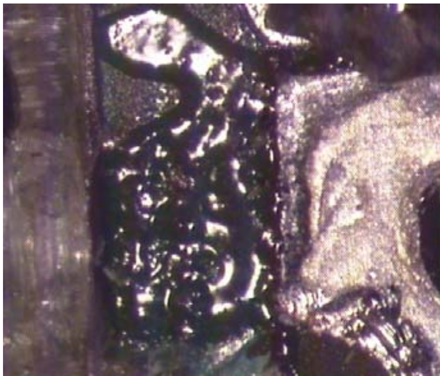
This customer implemented several corrective actions suggested by Foresite in order to prevent the flux entrapment. The first action involved the design of a standoff to support the PQFN part during reflow. Under previous design conditions, the PQFN package sat atop solder paste at a 6 mil stencil thickness, and as the solder paste entered its molten phase, was allowed to sink down to 3 to 4 mils. This created the opportunity for flux to sink over, becoming entrapped underneath the package where it could not become complexed and released. To remedy this situation, I suggested a design modification in which 5 mil standoffs were designed to fit into the vent pipe vias. These standoffs would physically hold up the parts, not permitting columns of solder to collapse under the parts. A second design change that I suggested which was implemented by the customer was to remove some of the pads from underneath the PQFN components. Fewer pads means lowered opportunities for contamination. The final design change I suggested was the widening of the gap between the power and the ground. This wider spacing decreases the risk of bridging. In addition to these design changes, I also suggested closer monitoring of solder paste deposition, and the use of less solder paste.

To analyze whether or not these suggested changes were effective in eliminating the problem of gooey contamination under the PQFN parts, Foresite analyzed samples manufactured with the original process and compared them to assemblies manufactured with the suggested design changes. As seen in the analysis from our previous column, the original process produced assemblies with high amounts of weak organic acid flux residues, and exhibited a thick, gooey flux residue underneath the PQFN components. This held true in our follow up analysis of the original process, but the assemblies built with the suggested design changes, including the standoffs and modified spacing and pad placement, showed acceptably low levels of weak organic acid residues. The flux residue was able to volatilize under these conditions, and all ionic residue levels for these assemblies fell within Foresite's recommended limits for reliable field performance. (Chart 1)

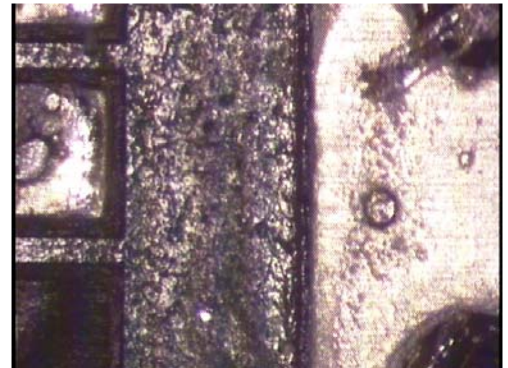
	Ion Chromatography Data					**C3 Tester**	
	Cl^-	**Br^-**	**NO_3^-**	**PO_4^{2-}**	**WOA**	**Results**	**Time(sec)**
Foresite's Recommended Residue Limits for no-clean assemblies with SMT components	**3**	**12**	**3**	**3**	**25**	**n/a**	**n/a**
Sample Description							
Unit Built with Foresite's Recommended Design Changes							
Area 1: PQFN Removed from Board	0.83	10.38	0.25	0	4.46	Clean	180
Area 2: PQFN Removed from Board	0.64	10.62	0.21	0	2.99	Clean	180
C3 extraction of Area 1 on Board	1.78	1.04	0.43	1.69	19.35	Clean	180
C3 extraction of Area 2 on Board	1.06	1.69	0.28	3.66	18.81	Clean	180
Unit Built with Original Process - Gooey Contamination under PQFN							
Area 1: PQFN Removed from Board	0.51	9.99	0.16	0	28.57	Dirty	27
Area 2: PQFN Removed from Board	0.81	10.01	0.29	0	30.16	Dirty	23
C3 extraction of Area 1 on Board	1.12	0.67	0.55	1.99	49.39	Dirty	18
C3 extraction of Area 2 on Board	1.46	0.87	0	1.42	43.41	Dirty	13

Our ion chromatography findings were very encouraging, but we still had to determine whether or not the assemblies built with the old manufacturing process with entrapped flux under PQFN components were recoverable. Foresite was able to develop a localized recovery cleaning protocol to clean only the PQFN area of the contaminated assemblies. Through the use of localized deionized steam cleaning with a good saponifier, we were able to effectively remove the harmful weak organic acid residues and gooey flux that was entrapped underneath the PQFN components. Based on a follow-up proof of cleaning investigation, it was found that this cleaning protocol produced results well below our recommended ionic residue limits for reliable field performance of a no-clean assembly. (See before & after photos)

Flux residues are so often the culprit when contamination is creating reliability problems for an assembler. We want to continue to reiterate to the industry how important it is to fully volatilize fluxes to avoid costly field returns. In this case, a few design changes were able to correct the problem, and localized steam cleaning was able to recover the contaminated products. Understanding processing residues and their sources can prevent these issues from happening in the first place.



Assembly under pqfn area before cleaning: 120 µg / in^2 WOA



Assembly under pqfn area after steam cleaning: 7.23 µg / in^2 WOA