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Reflow Profiling on the Electrical Reliability of No-Clean Solder Paste Flux Residues

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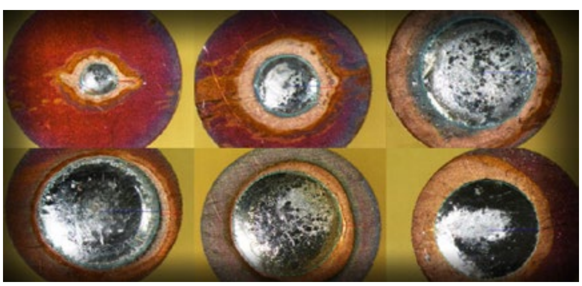

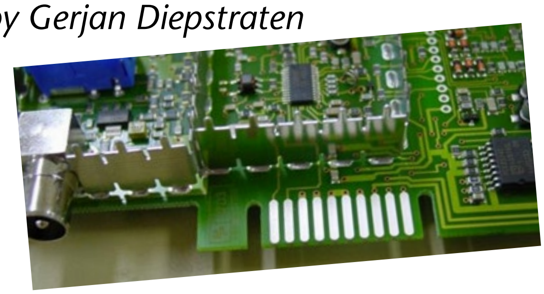

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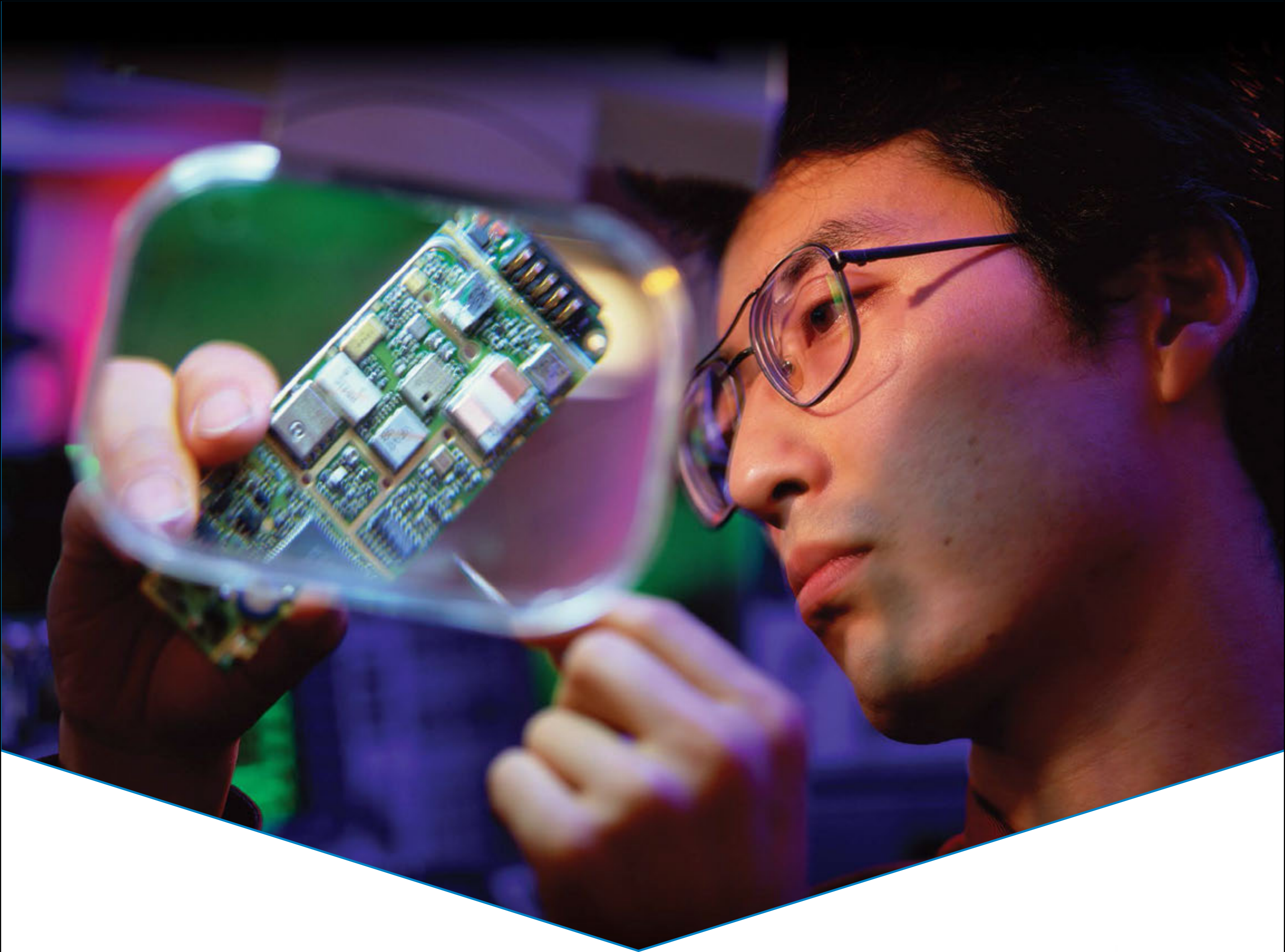
Reflow Profiling on the Electrical Reliability of No-Clean Solder Paste Flux Residues

by Eric Bastow
INDIUM CORP.

An estimated 80% of all SMT assembly in the world is performed with a no-clean soldering process, largely due to the predominance of consumer electronics. The continuing trend of increasing miniaturization that dominates modern electronics devices requires no-clean flux residues to be as benign and electrically resistive as possible. Solder pastes with an IPC J-STD-004[1] classification of ROL0 or ROL1 rely heavily on two basic mechanisms to render the flux residue as "no-clean": (1) the encapsulating properties that the rosin provides and (2) the heat activation/decomposition of the chemicals in the flux, commonly known as "activators." The latter is generally known in the industry, but is rarely taken into consideration for reflow profiling in SMT assembly.

Optimization of a reflow profile often focuses on mitigating defects such as voiding, tombstoning, graping, slumping/bridging, etc. However, little thought is given to the reflow profile's effect on the electrical reliability of the no-clean flux residue. Because of the wide variation in size and thermal density of SMT components and PCBs, achieving a reflow profile that equally heats the entire assembly can be challenging and often impossible. The temperature under a large component, such as a BGA,



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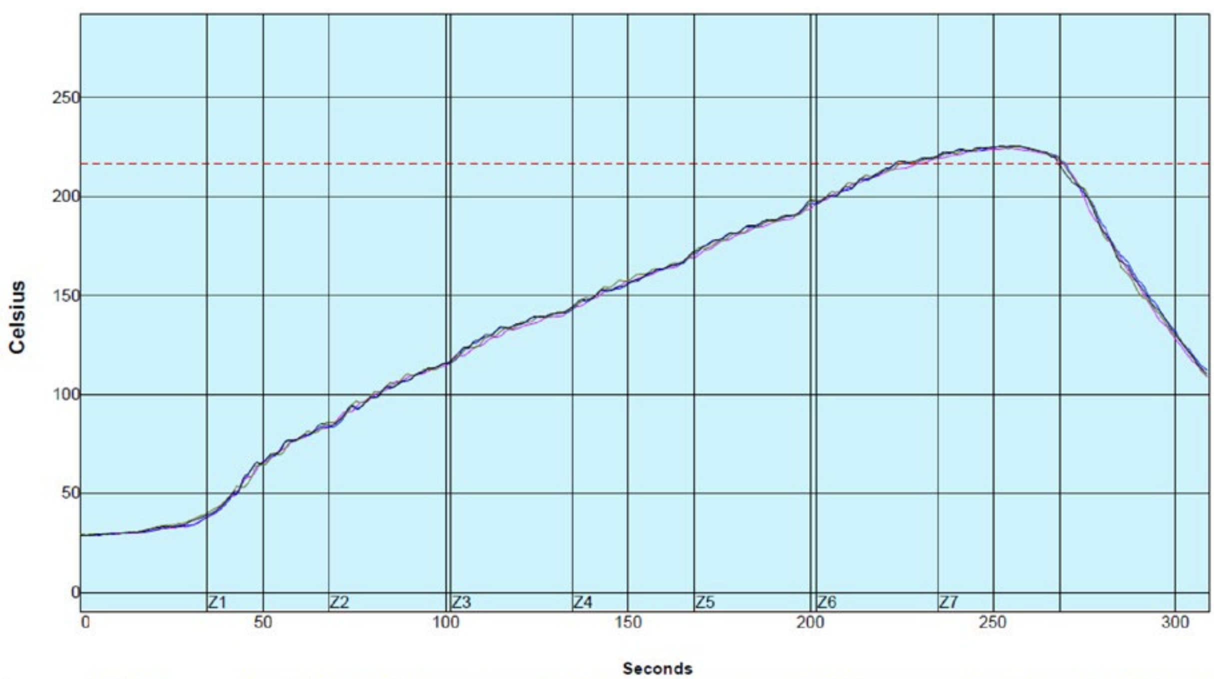
is often markedly cooler than a smaller component, such as a passive resistor or capacitor. This paper will discuss an experiment that studied the effect of reflow profiling on the electrical reliability of no-clean flux residues that can be measured using IPC J-STD-004[1] surface insulation resistance (SIR) testing. Both a halogen-free (ROL0) and a halogen-containing (ROL1) Pb-free no-clean solder paste, exposed to various reflow profiles, were used in this study.

Prior work had exposed the impact on SIR values of entrapping a solder paste flux residue under a component body or RF shield. What was unclear in that work is the impact of the reflow profile. Invariably, flux underneath a device does not get exposed to the same heat that an exposed flux does. So performing an experiment that focused solely on the effect of heating seemed pertinent.

Experimental

In this experiment, a total of eight reflow profiles were used for each solder paste; one paste being ROL0 and the other being ROL1. Both solder pastes used are standard commercially available products. All boards were reflowed in a standard convection belt furnace type reflow oven with an air environment. The reflow profiles consisted of four different peak temperatures: 225°C, 235°C, 245°C and 255°C.

Figure 1: IPC-B-24 SIR test coupon with thermocouples attached.



PWI= 78%	Max Rising Slope		Reflow Time /217C		Peak Temp		Slope1 (25-217C)	
2	1.72	-56%	37.69	-74%	224.44	-78%	1.03	-31%
3	1.83	-34%	40.63	-65%	225.50	-72%	1.02	-32%
4	1.69	-62%	44.60	-51%	225.39	-73%	1.02	-32%
5	1.79	-41%	44.54	-52%	225.73	-71%	1.01	-33%
Delta	0.14		6.91		1.29		0.02	

Figure 2: 225°C ramp to peak reflow profile.

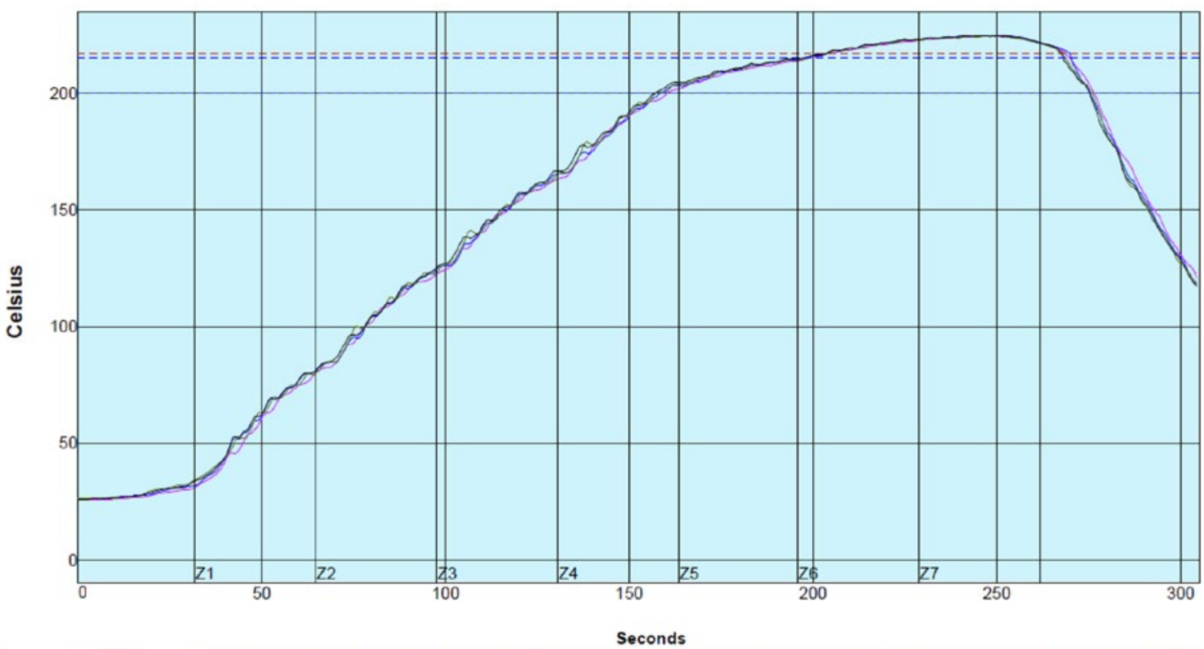
For each peak temperature, reflow profiles representing a "ramp to peak" and "soak" profile were created (Figures 2–9). The purpose of creating both a ramp to peak and a soak profile was to see if and how, not only the peak temperature, but also the "shape" of the profile, has an impact on SIR performance. For the sake of this work, the "soak" is defined as the period during which the PCB is between 200°C and 215°C. Figure 1 shows the SIR (IPC-B-24) test coupon used for profiling and the location of the thermocouples. All SIR board preparation, materials and processes were in accordance with IPC-TM-650 2.6.3.3 and 2.6.3.7.

Table 1 shows a compilation of the averaged parameters for each reflow profile scenario.

As mentioned at the beginning of this paper, two no-clean solder pastes were tested

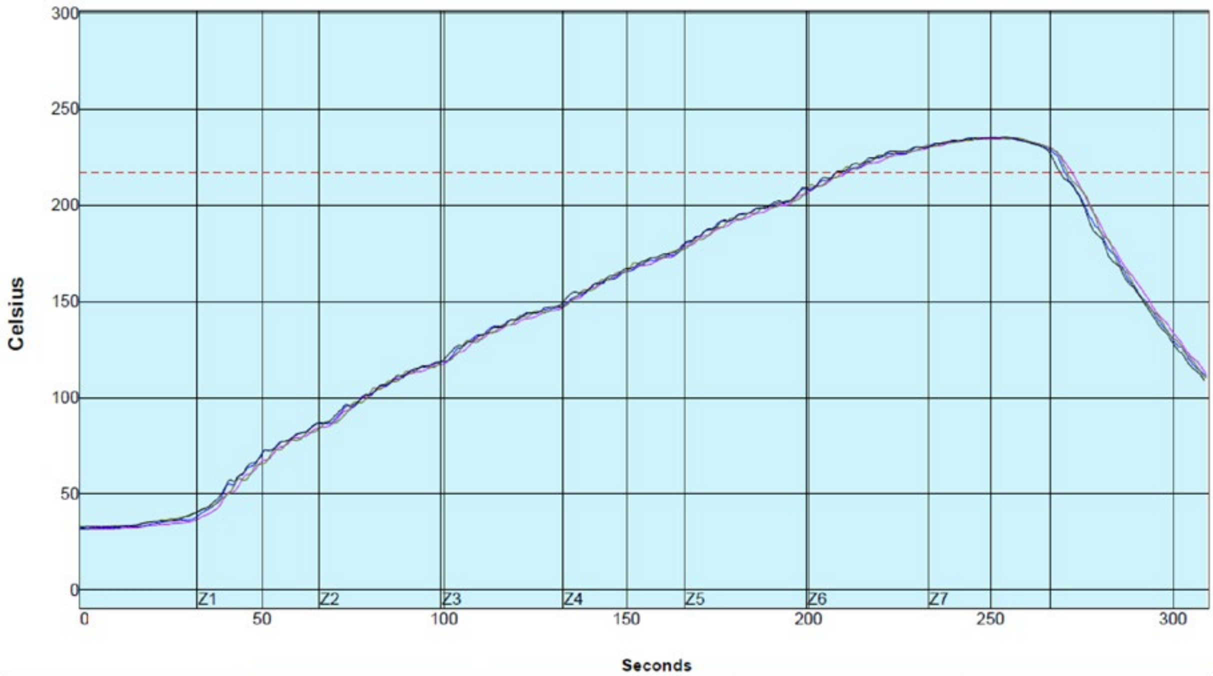
Peak Temperature	Profile Type	Ramp Rate	Soak Time (200 - 215C)	Time above 217C
225C	Ramp to Peak	1.02C/s	N/A	41.9s
225C	Soak	1.35C/s	39.7s	65.1s
235C	Ramp to Peak	1.08C/s	N/A	61.7s
235C	Soak	1.36C/s	38.2s	73.1s
245C	Ramp to Peak	1.14C/s	N/A	73.8s
245C	Soak	1.34C/s	37.4s	76.8s
255C	Ramp to Peak	1.12C/s	N/A	78.2s
255C	Soak	1.33C/s	33.3s	80.3s

Table 1: Compiled reflow profile parameters.



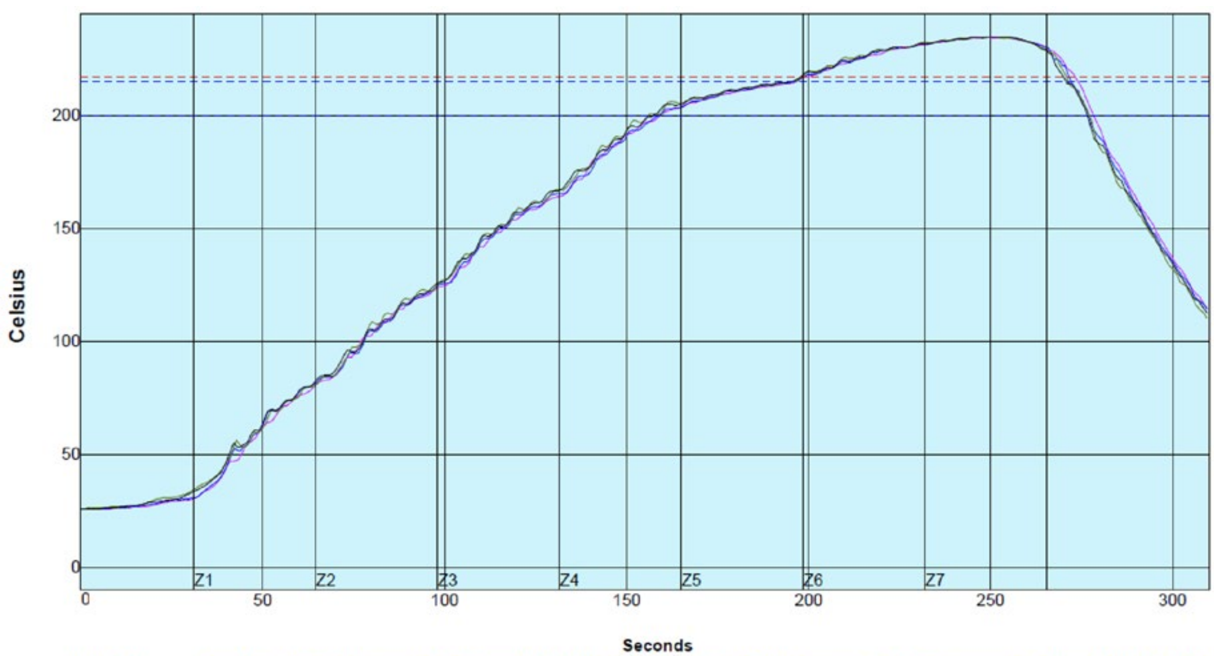
PWI= 83%	Max Rising Slope		Soak Time 200-215C		Reflow Time /217C		Peak Temp		Slope1 (30-217C)	
<TC2>	1.79	19%	37.79	-83%	65.05	17%	224.61	-65%	1.35	35%
<TC3>	1.87	25%	39.42	-79%	66.38	21%	224.83	-64%	1.35	35%
<TC4>	1.72	14%	41.43	-75%	64.79	16%	224.62	-65%	1.34	34%
<TC5>	1.75	17%	40.09	-78%	64.00	13%	224.78	-64%	1.35	35%
Delta	0.15		3.64		2.38		0.22		0.01	

Figure 3: 225°C soak reflow profile.



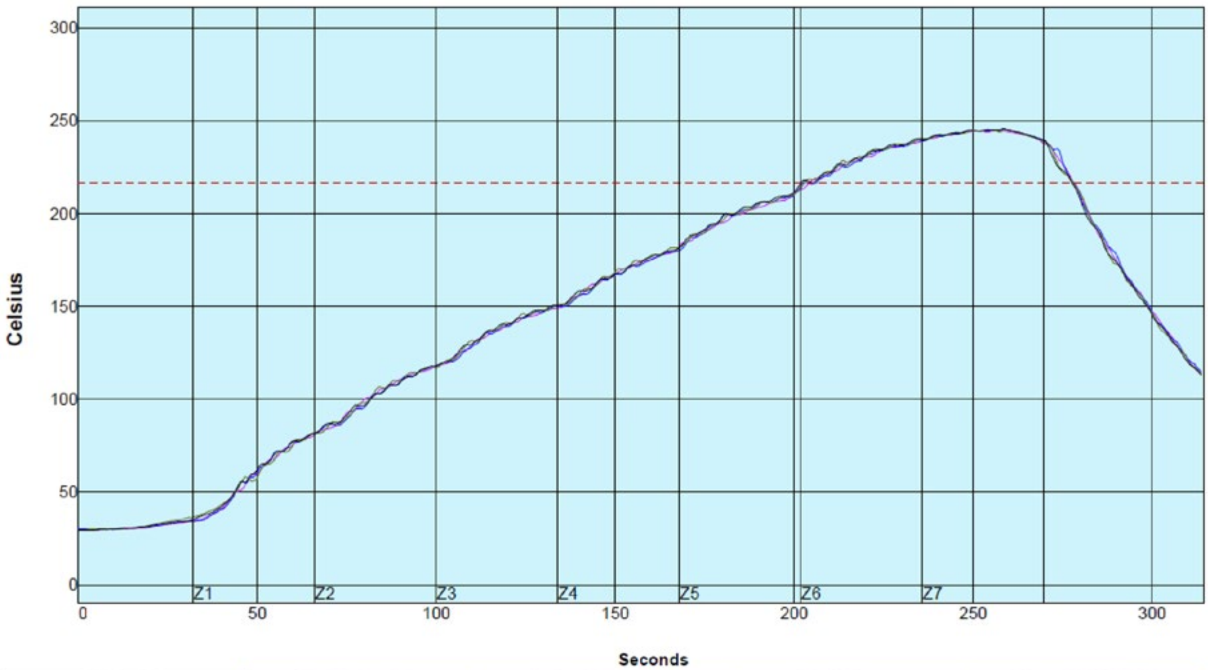
PWI= 66%	Max Rising Slope		Reflow Time /217C		Peak Temp		Slope1 (25-217C)	
2	1.76	-48%	62.06	7%	234.84	-26%	1.09	-28%
3	1.81	-38%	60.84	3%	235.44	-23%	1.08	-28%
4	1.67	-66%	62.09	7%	235.28	-24%	1.08	-28%
5	1.69	-61%	61.81	6%	235.61	-22%	1.07	-29%
Delta	0.14		1.25		0.77		0.02	

Figure 4: 235°C ramp to peak reflow profile.



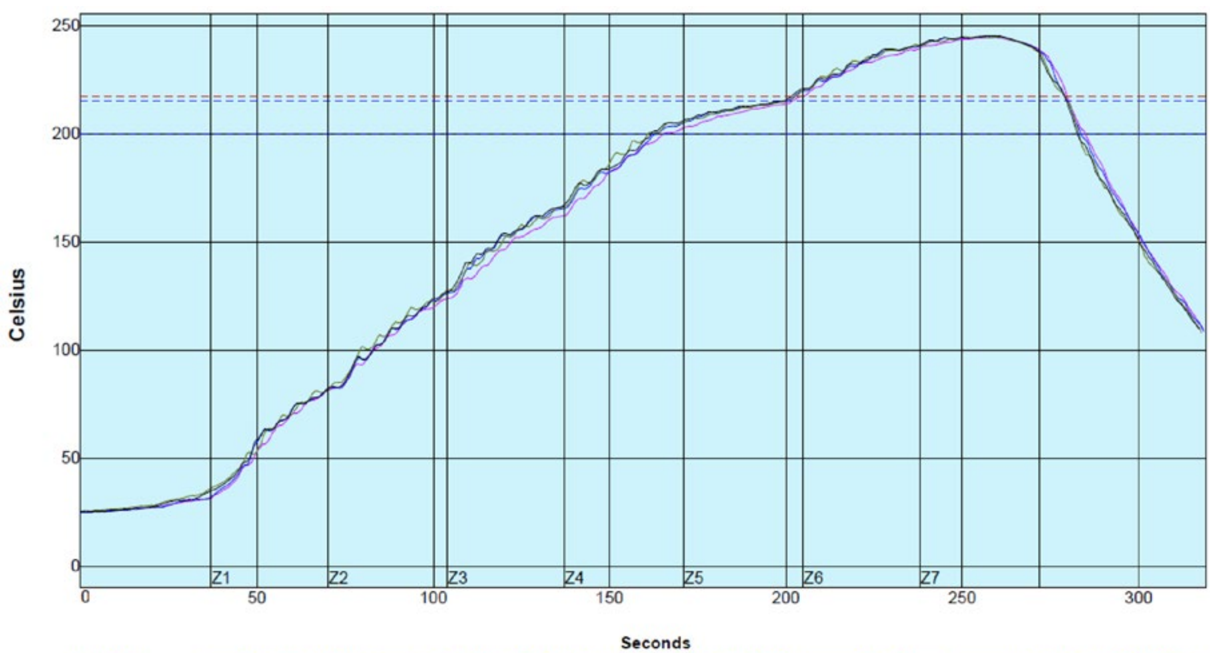
PWI= 84%	Max Rising Slope		Soak Time 200-215C		Reflow Time /217C		Peak Temp		Slope1 (30-217C)	
<TC2>	1.83	22%	37.50	-83%	74.41	48%	234.62	-18%	1.35	35%
<TC3>	1.95	30%	37.41	-84%	73.03	43%	234.93	-17%	1.36	36%
<TC4>	1.72	15%	40.01	-78%	72.77	43%	234.84	-17%	1.36	36%
<TC5>	1.77	18%	37.92	-82%	72.37	41%	234.88	-17%	1.35	35%
Delta	0.23		2.60		2.04		0.31		0.01	

Figure 5: 235°C soak reflow profile.



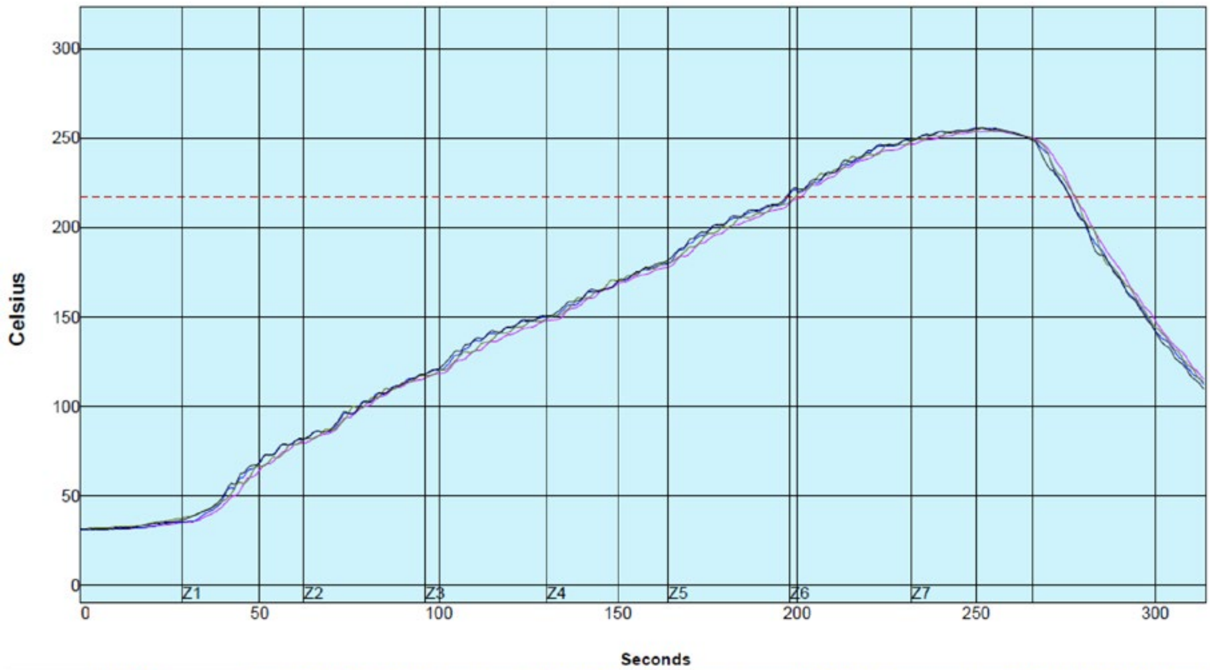
PWI= 61%	Max Rising Slope		Reflow Time /217C		Peak Temp		Slope1 (25-217C)	
2	1.78	-44%	73.58	45%	244.89	24%	1.14	-24%
3	1.84	-31%	72.20	41%	245.55	28%	1.14	-24%
4	1.70	-61%	74.93	50%	245.40	27%	1.13	-24%
5	1.78	-44%	74.46	48%	245.56	28%	1.13	-25%
Delta	0.14		2.73		0.67		0.01	

Figure 6: 245°C ramp to peak reflow profile.



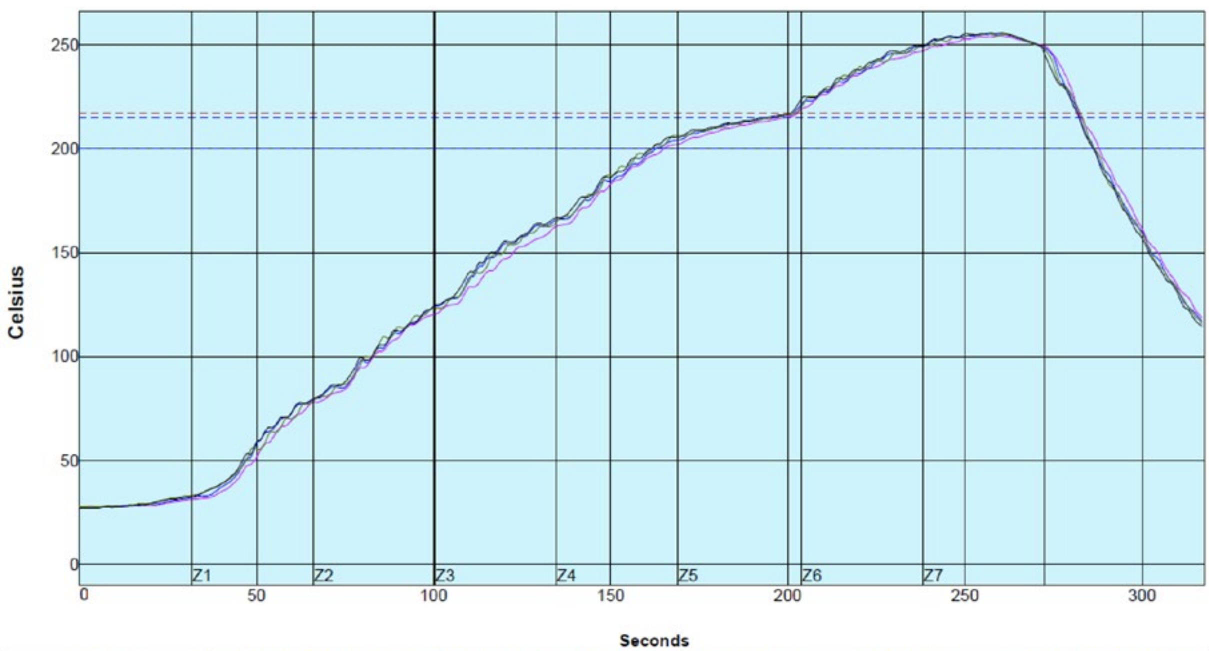
PWI= 86%	Max Rising Slope		Soak Time 200-215C		Reflow Time /217C		Peak Temp		Slope1 (30-217C)	
<TC2>	1.78	19%	36.27	-86%	76.05	53%	244.49	28%	1.33	33%
<TC3>	1.91	27%	36.77	-85%	76.79	56%	245.22	31%	1.34	34%
<TC4>	1.74	16%	39.64	-79%	76.68	56%	245.06	31%	1.34	34%
<TC5>	1.83	22%	36.95	-85%	77.67	59%	245.28	32%	1.34	34%
Delta	0.17		3.37		1.62		0.79		0.01	

Figure 7: 245°C soak reflow profile.



PWI= 79%	Max Rising Slope		Reflow Time /217C		Peak Temp		Slope1 (25-217C)	
2	1.73	-53%	76.22	54%	254.02	70%	1.12	-25%
3	1.86	-28%	78.86	63%	255.48	77%	1.12	-25%
4	1.67	-66%	78.44	61%	255.40	77%	1.11	-26%
5	1.79	-43%	79.33	64%	255.81	79%	1.11	-26%
Delta	0.19		3.11		1.79		0.01	

Figure 8: 255°C ramp to peak reflow profile.



PWI= 97%	Max Rising Slope		Soak Time 200-215C		Reflow Time /217C		Peak Temp		Slope1 (30-217C)	
<TC2>	1.80	20%	34.02	-91%	79.62	65%	254.28	73%	1.33	33%
<TC3>	1.91	28%	33.37	-93%	80.16	67%	255.33	78%	1.33	33%
<TC4>	1.74	16%	34.60	-90%	80.41	68%	255.59	79%	1.34	34%
<TC5>	1.85	23%	31.13	-97%	81.14	70%	255.84	81%	1.33	33%
Delta	0.17		3.47		1.52		1.56		0.01	

Figure 9: 255°C soak reflow profile.

Solder Paste	Peak Temp	Profile Type	Boards	Run
Halogen Containing	225	Ramp	2	1
		Soak	2	1
	235	Ramp	2	1
		Soak	2	1
	245	Ramp	2	2
		Soak	2	2
	255	Ramp	2	2
		Soak	2	2
Halogen Free	225	Ramp	2	1
		Soak	2	1
	235	Ramp	2	1
		Soak	2	1
	245	Ramp	2	2
		Soak	2	2
	255	Ramp	2	2
		Soak	2	2
Controls			4	1, 2
Total			36	

Table 2: Solder paste/reflow profile matrix.

with these various reflow profiles. Both were Pb-free, containing SAC305 as the alloy. One was halogen-containing and the other was halogen-free. The purpose of the two different chemistries was to see if halogen-containing and halogen-free solder pastes responded differently to the reflow profiles in terms of their SIR performance. A total of two SIR test coupons were prepared and tested for each solder paste/reflow profile scenario (Table 2). Because the SIR chamber had a limited capacity of 20 boards per test, the boards were tested in two groups. The results of the SIR testing are shown in the following section.

Results and Discussion

Figures 10 through 26 show the SIR results obtained from each scenario mentioned in the experimental section. A discussion of the SIR results can be found beginning after Figure 26.

The intent of this paper is to show the overall effect, if any, that reflow profiling has on the SIR performance of no-clean solder pastes. Figures 10 through 26 plot every SIR reading of every SIR pattern. Viewing the data in such a way makes it difficult to identify an overall trend from scenario to scenario. In order to be able to do this more easily, an average SIR value was calculated for each scenario. For each scenario, two boards were prepared, with four SIR patterns per board. SIR readings were taken for each SIR pattern every 20 minutes over the course of 168 hours (1 week). The result is the accumulation of 4032 SIR readings from which the average SIR value was obtained.

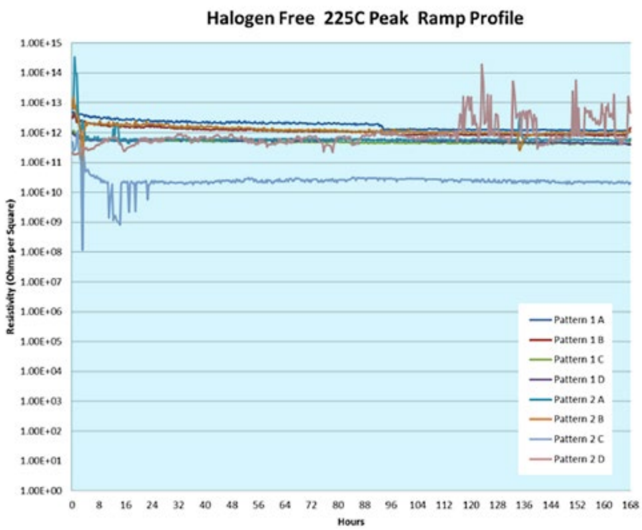


Figure 10: Halogen-free solder paste, 225°C peak temperature ramp profile (run 1).

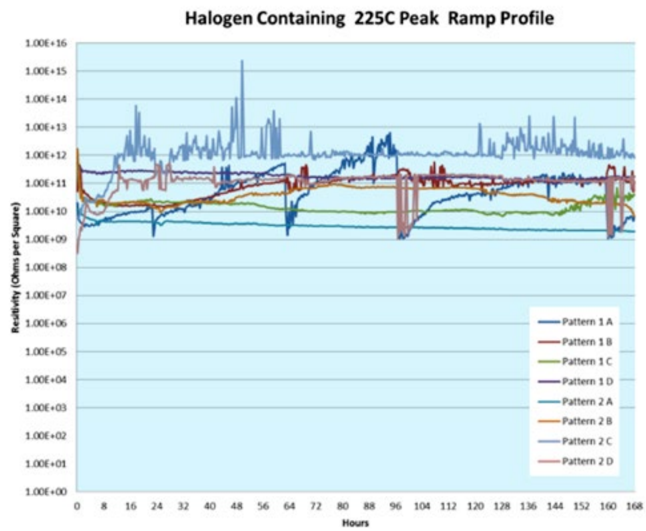


Figure 12: Halogen-containing solder paste, 225°C peak temperature ramp profile (run 1).

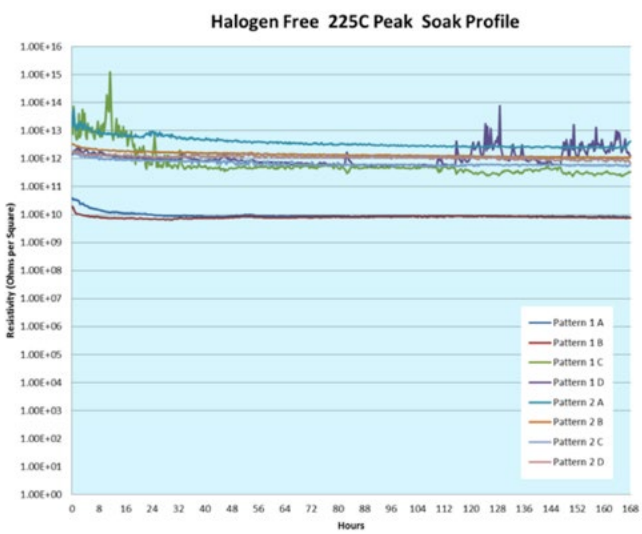


Figure 11: Halogen-free solder paste, 225°C peak temperature soak profile (run 1).

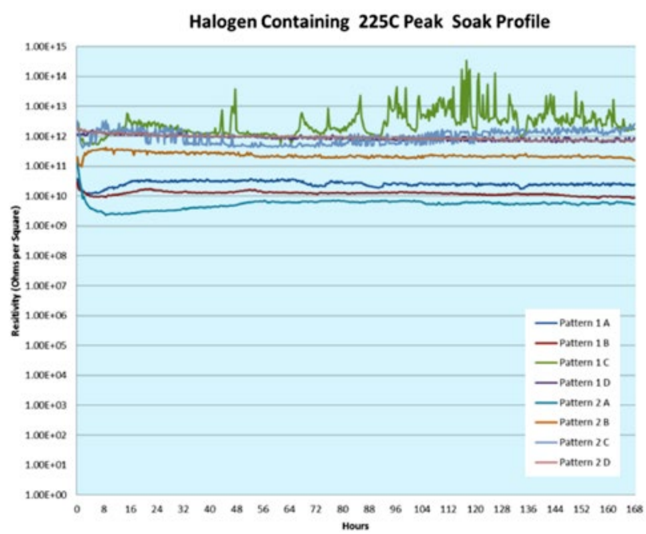


Figure 13: Halogen-containing solder paste, 225°C peak temperature soak profile (run 1).

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Because of the number of SIR boards and the test chamber's inability to accommodate all the boards at one time, the SIR testing had to be run in two separate batches, as mentioned earlier. An unintended side effect of running multiple batches is the possible occurrence of slight batch to batch variations. The best way to detect these variations is with the controls, as these are bare clean unprocessed (unreflowed) boards. A critical examination of the average SIR values obtained from each scenario seems to indicate that such a variation occurred in this study. The SIR values obtained from Run 2, including those values measured on the controls, were generally lower than those obtained from Run 1. In order to effectively compare all the data as one large data set and reduce the impact of the batch to batch variation, the data was later "normalized."

To normalize the data, the author divided the average SIR value from the controls in Run

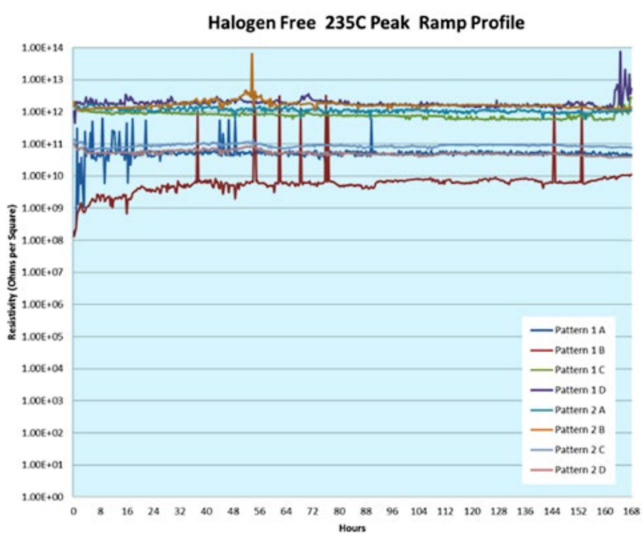

Figure 14: Halogen-free solder paste, 235°C peak temperature ramp profile (run 1).

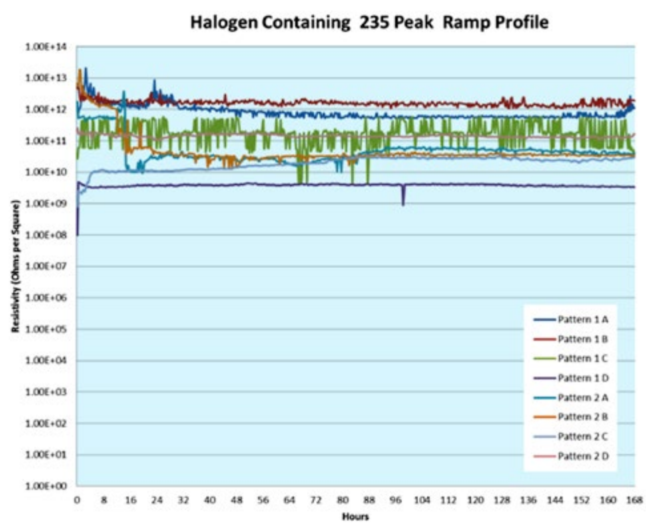

Figure 16: Halogen-containing solder paste, 235°C peak temperature ramp profile (run 1).

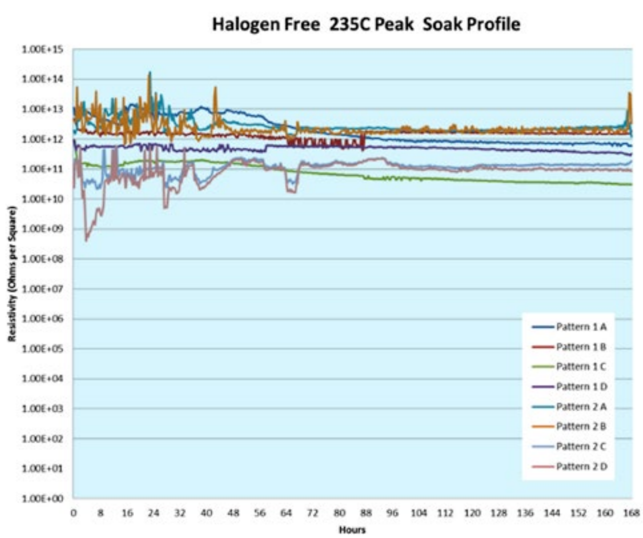

Figure 15: Halogen-free solder paste, 235°C peak temperature soak profile (run 1).

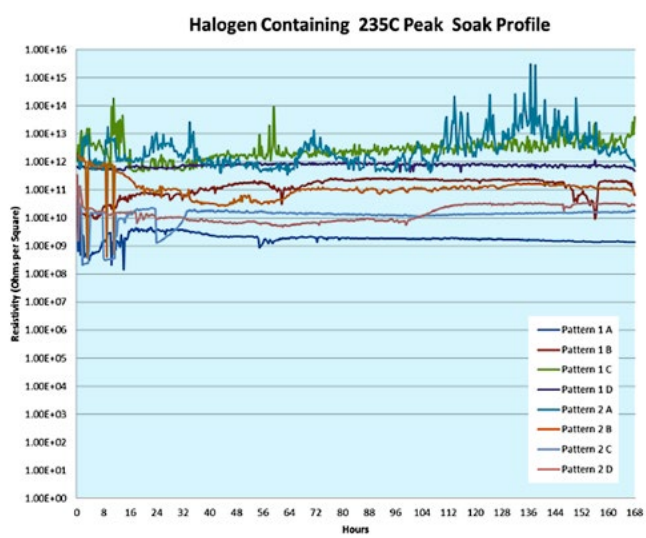

Figure 17: Halogen-containing solder paste, 235°C peak temperature soak profile (run 1).

1 by the average SIR value from the controls in Run 2. That quotient, 1.54, then became the factor by which the average SIR values from the scenarios in Run 2 were multiplied. Figures 27 and 28 show normalized data. Because it is normalized data, it should be used only for relative comparison with the intent of trying to determine any trends.

The minimal impact that reflow profiling had on the SIR performance of a no-clean solder paste was quite surprising. It was anticipated that a much larger difference in SIR performance would be observed as a function of the peak temperature. But even at a temperature of 225°C, a mere five degrees above the liquidus temperature of SAC305, very good (high) SIR values were achieved. This may be an indication of the advancements that have been made in no-clean flux technology. It should also be noted that there were no visual differences in

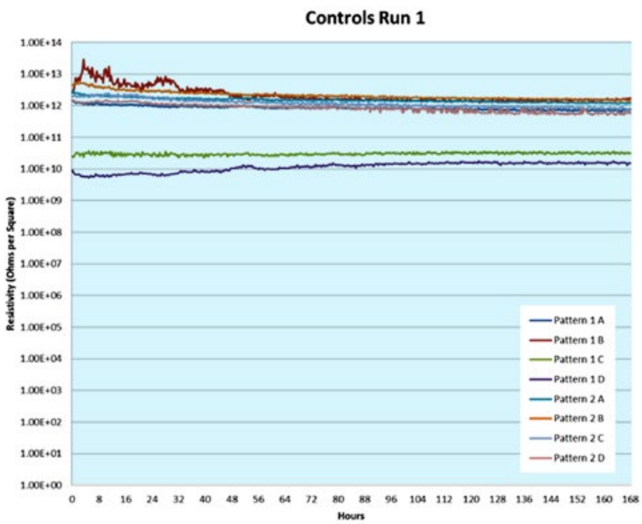

Figure 18: Controls (run 1).

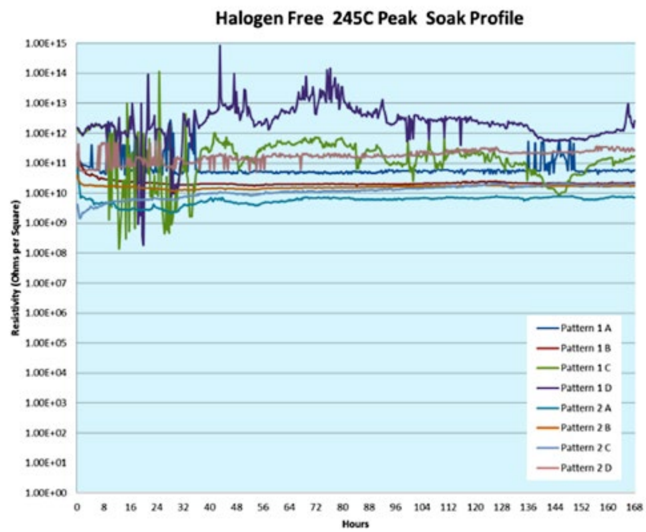

Figure 20: Halogen-free solder paste, 245°C peak temperature soak profile (run 2).

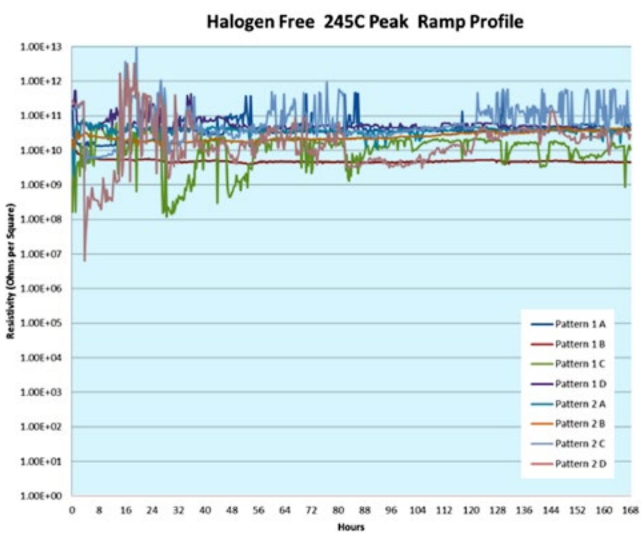

Figure 19: Halogen-free solder paste, 245°C peak temperature ramp profile (run 2).

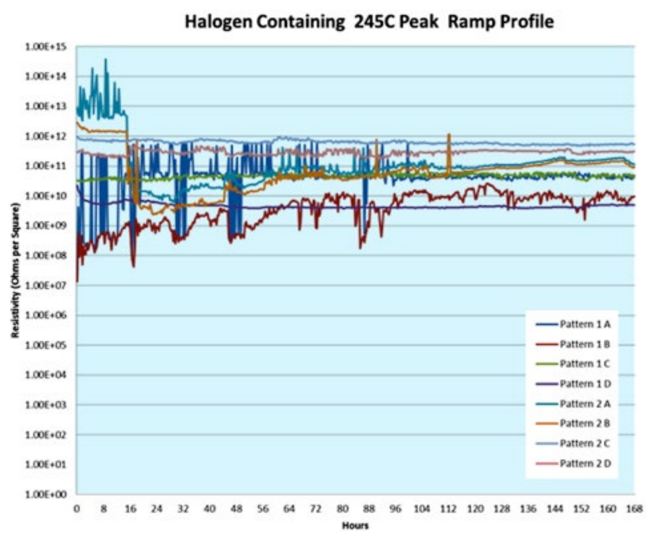

Figure 21: Halogen-containing solder paste, 245°C peak temperature ramp profile (run 2).

the appearance of the residues regardless of the reflow profile.

However, it should be kept in mind that the flux residues in this study were exposed on the surface of the PCB as opposed to being trapped under a component body or RF shield. An earlier work by the author shows that entrapment, somewhat regardless of peak temperature, can have a measurable negative effect of the SIR performance[2]. What is noticeable is the effect that a soak has on the SIR values. In all cases, except for the halogen-containing/255°C peak temperature scenario, the soak profile produced higher SIR values than its respective linear ramp profile. The results also imply that a brief soak improves the SIR values more than a 10-degree increase in the peak temperature with a linear ramp profile. It is worth noting that the soak need not be not excessively long to create this improve-

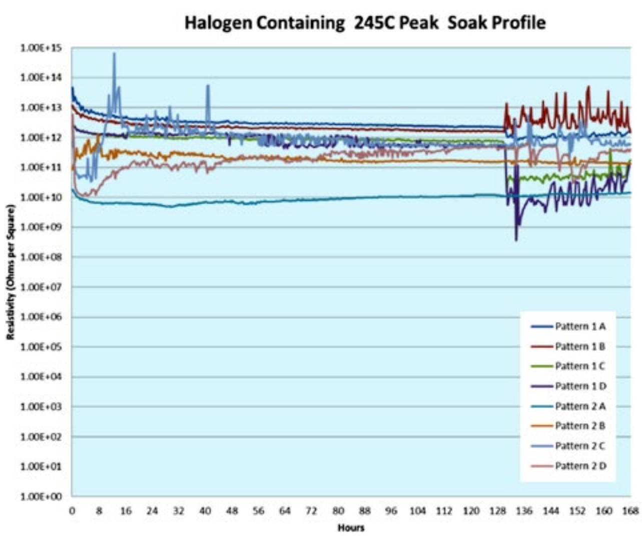

Figure 22: Halogen-containing solder paste, 245°C peak temperature soak profile (run 2).

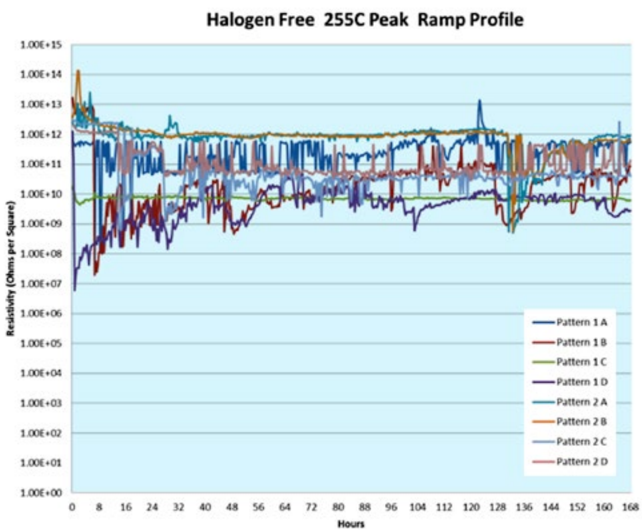

Figure 23: Halogen-free solder paste, 255°C peak temperature ramp profile (run 2).

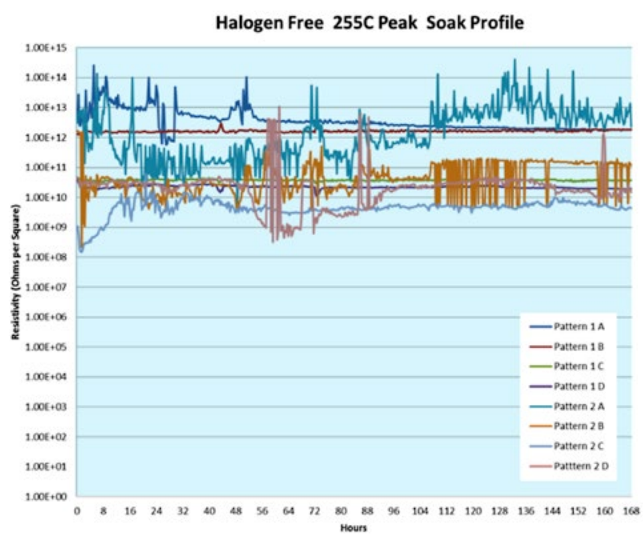

Figure 24: Halogen-free solder paste, 255°C peak temperature soak profile (run 2).

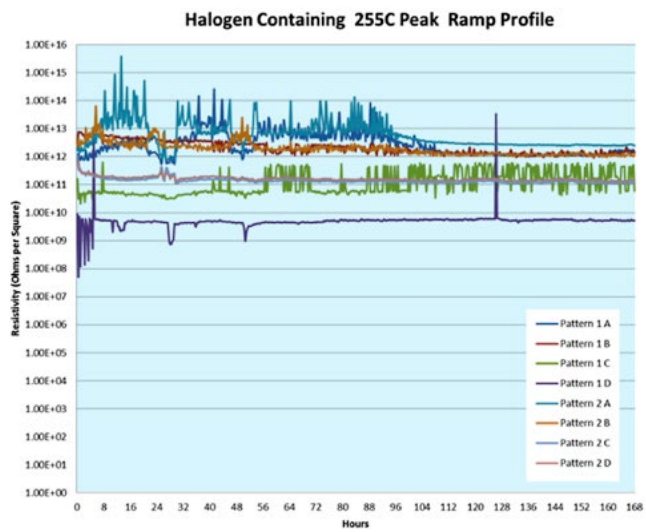

Figure 25: Halogen-containing solder paste, 255°C peak temperature ramp profile (run 2).

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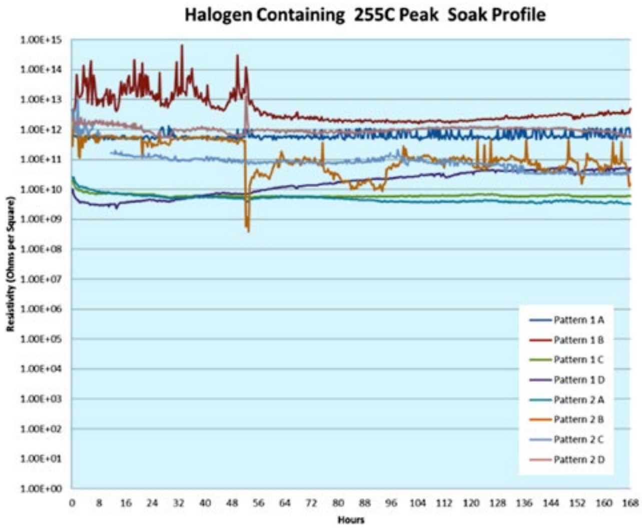

Figure 26: Halogen-containing solder paste, 255°C peak temperature soak profile (run 2).

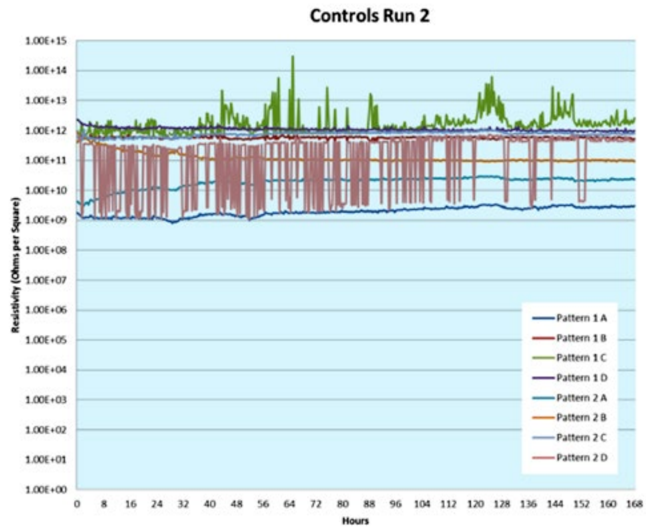

Figure 27: Controls (run 2).

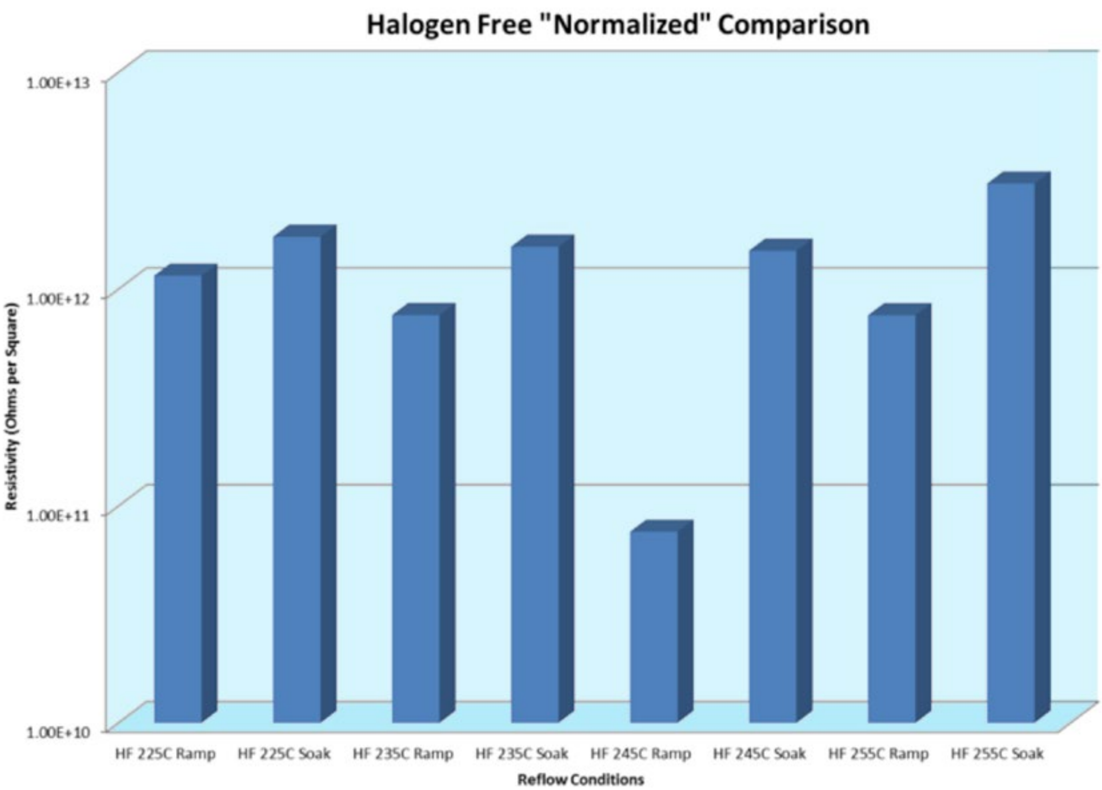

Figure 28: Halogen-free normalized average SIR values.

ment in SIR performance. The soak times in this study ranged from only 31 to 40 seconds (time between 200°C and 215°C). This may be good news for applications involving thermally sensitive components and/or substrate materials, or in applications where achieving a higher peak temperature may be challenging due to thermal density. The effect of flux chemistry—

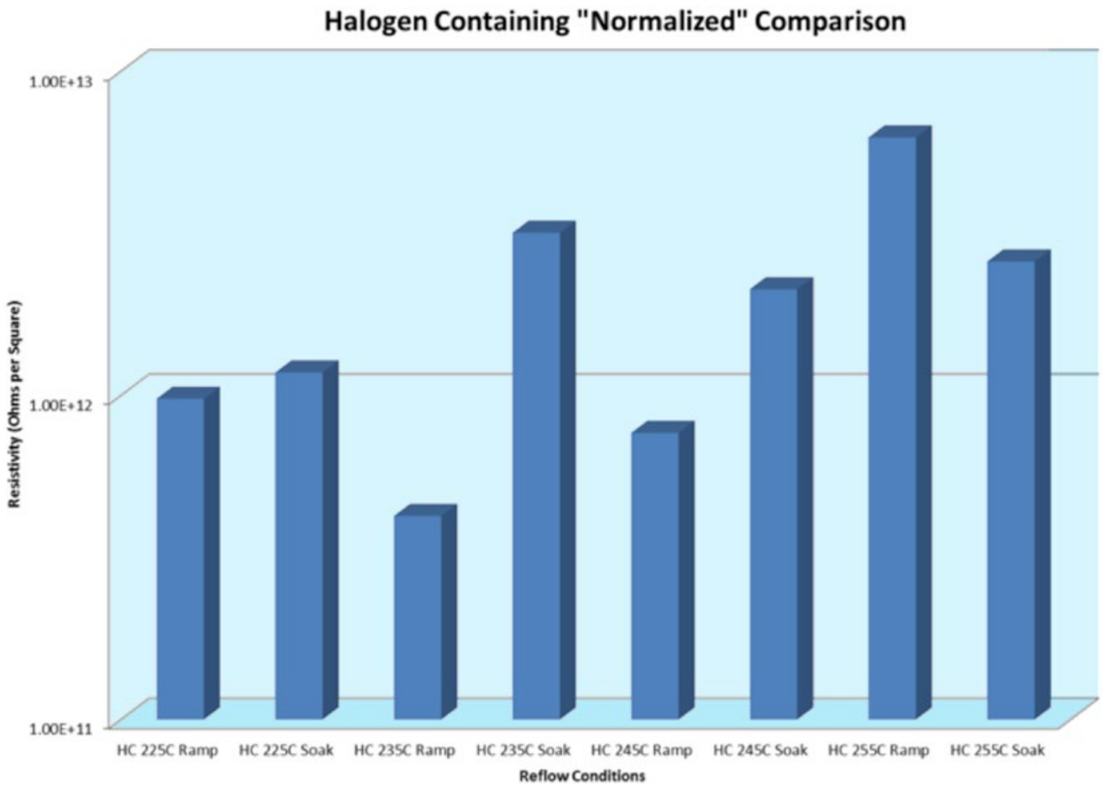

Figure 29: Halogen-containing normalized average SIR values.

halogen-free versus halogen-containing—does not appear to have a significant impact.

Conclusions

There are many variables that affect SIR performance. And with the specific knowledge of the impact of proper heating on a flux's SIR performance, such an experiment as this seemed appropriate. What was surprising is that even with a very short "soak" the SIR performance of a residue can be "improved" more than by using a higher peak temperature. Such knowledge could be useful in such problematic situations as temperature sensitive assemblies and flux residues trapped under component bodies and RF shields. The latter situations can produce unusual visual anomalies and gooey flux residues, as was discovered in a prior work, with less than optimum SIR performance. As the acumen of knowledge increases relative to the parameters which affect SIR performance of flux residues, no-clean processes can be honed to provide reliable products. For those processes involving cleaning/removal of no-clean residues, especially with the ever decreasing standoff of SMT components, more work should be done to understand the impact of partial or incomplete removal of such residues. **SMT**

Originally published in the IPC APEX EXPO 2014 proceedings.

References

1. IPC J-STD-004: Requirement for Soldering Fluxes.

2. E. Bastow, The Effects of Partially Activated No-Clean Flux Residues Under Component Bodies and No-Clean Flux Residues Entrapped Under RF Cans on Electrical Reliability, IPC APEX EXPO 2011 conference.

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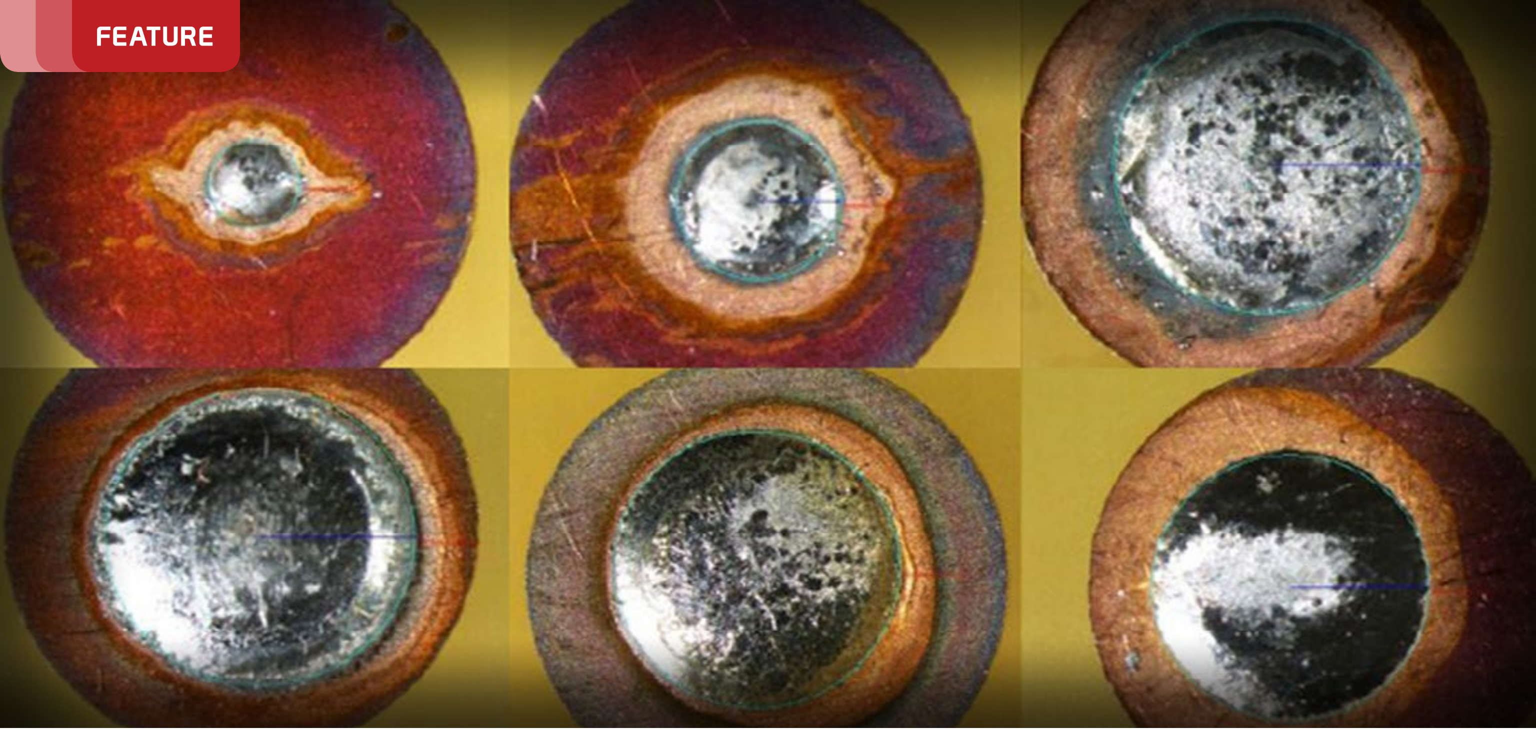
FEATURE



Reliability Assessment of No-clean and Water-soluble Solder Pastes, Part II

by Emmanuelle Guéné and Steven Teh
INVENTEC PERFORMANCE CHEMICALS

Note: Part 1 of this article published in the March 2014 issue of SMT Magazine, available here.

Abstract

Twenty-five years ago, solder paste residues had to be cleaned after reflow due to their corrosive nature: two ways of cleaning were available, either with solvent or by using water, with or without detergent. Now the assembly world is mainly no-clean: paste formulation is safer in terms of chemical reliability and process costs are reduced without cleaning. However, some applications (i.e., military, aerospace, high-frequency, and semiconductor) require a perfect elimination of the residue after reflow. Several options can achieve this result: a no-clean paste which allows residue to be removed with the most suitable cleaning method, or a paste designed to be cleaned, such as a water-soluble solder paste.

Water-soluble solder pastes generally show great wettability because of their strong activation but they are also known to have shorter stencil life and to be more sensitive to working conditions as temperature and humidity, compared to the no-clean pastes. Additionally, with the components stand-off getting smaller and smaller, washing residues with water only is more and more challenging due to its high surface tension: the addition of detergent becomes often necessary.

The purpose of this article is to highlight the differences between these two families of solder pastes to guide users in their choice. This will be achieved through the comparison of several recent water-soluble and no-clean formulations as far as reliability is concerned. First, the printing quality will be evaluated (viscosity, tack, cold slump, printing speed according to pressure, stencil life, idle time, printing consistency). Next, the reflow properties will be compared (hot slump, solderballing, reflow process window, wetting ability on different finishes). Finally, the residue cleanability will be assessed. The IPC SIR will be also done to conclude the study. Both standardized tests and production tests will be used to evaluate the performance of these two kinds of solder pastes.

Introduction

Six lead-free pastes were extensively studied, three being water-soluble and three being

no-clean. The first part of the study[1] focused on printing performance. The pastes were characterized using standardized tests and internally developed tests: dynamic viscosity, tackiness, slump and solderballing. The influence of accelerated storage at elevated temperature, the influence of time and conditions between printing and reflow and the influence of continuous shear according to time were shown. The printing performances were also evaluated in a printer. Although the number of pastes studied was restricted, the water-soluble pastes generally yielded results below the no-clean pastes with more sensitivity to temperature and humidity, tendency to slump during preheat and narrower printing window. Water-soluble solder pastes must be stored, handled and used with more caution before reflow.

In the second part of the paper, the reflow properties will be compared: wettability, reflow process window, anti-graping properties. Finally the residue cleanability with water, then with water and detergents will be examined. The cleanliness will be assessed using visual inspection, ionic contamination and surface insulation resistance tests.

Experiments

The pastes used for this evaluation were all made of SnAg3Cu0.5 (SAC305) alloy with type 3 (25/45 microns, -325/+500 mesh) particle size. The selected water-soluble pastes are named A, B and C and the no-clean pastes are named D, E and F. Metal content and flux designation according to J-STD-004A are given for each solder paste. A summary is done in the Table 1.

The wetting properties of the pastes were assessed using on cleaned copper coupons, on copper finish FR-4 substrates, on test boards

Paste	A	B	C	D	E	F
Nature	Water-soluble	Water-soluble	Water-soluble	No-clean	No-clean	No-clean
Alloy	SnAg3Cu0.5					
Particle size	Type 3					
Flux type	ORH0	ORH1	ORH1	ROL0	ROL0	ROL1
Metal Content	88.0	89.0	89.5	88.0	88.5	88.5

Table 1: Solder pastes characteristics.

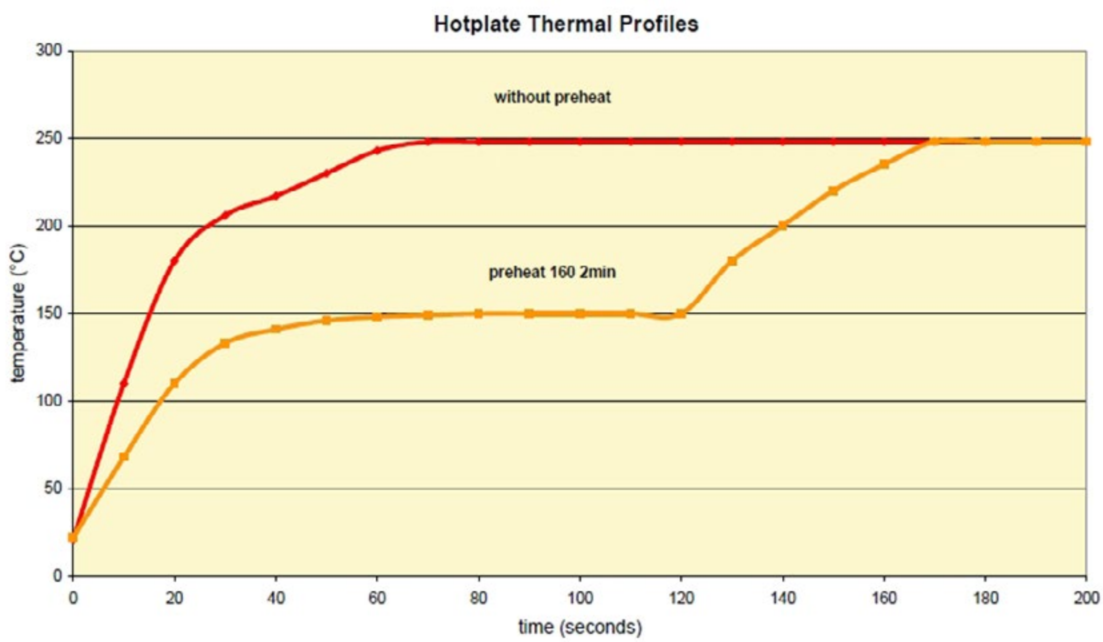


Figure 1: Hotplate thermal profiles.

with several finishes, on hotplate and reflow oven. The details are described below.

Wettability on Copper Coupon Using Hotplate and Reflow Oven

First, a wetting test on 0.4 mm thickness cleaned copper coupons was performed: the pastes were printed on substrates through a 0.250 mm thick stencil with two round openings of 5 mm diameter, with a distance between centers of 25 mm. A set of cleaned coupons was placed on a hotplate at 250°C for immediate reflow while the other sets were submitted to preheat before reflow, respectively during two minutes at 160°C and five minutes at 160°C. The profiles recorded on the hotplate are given below (Figure 1).

Second, a wetting test on the same copper coupons was done in a reflow oven (BTU VIP70 5 zones) using two profiles: P1 is a gentle profile with a short and linear preheat; P5 is a harsh profile with a long soak at high temperature. A graph of these profiles and their characteristics are given below (Figure 2/ Table 2).

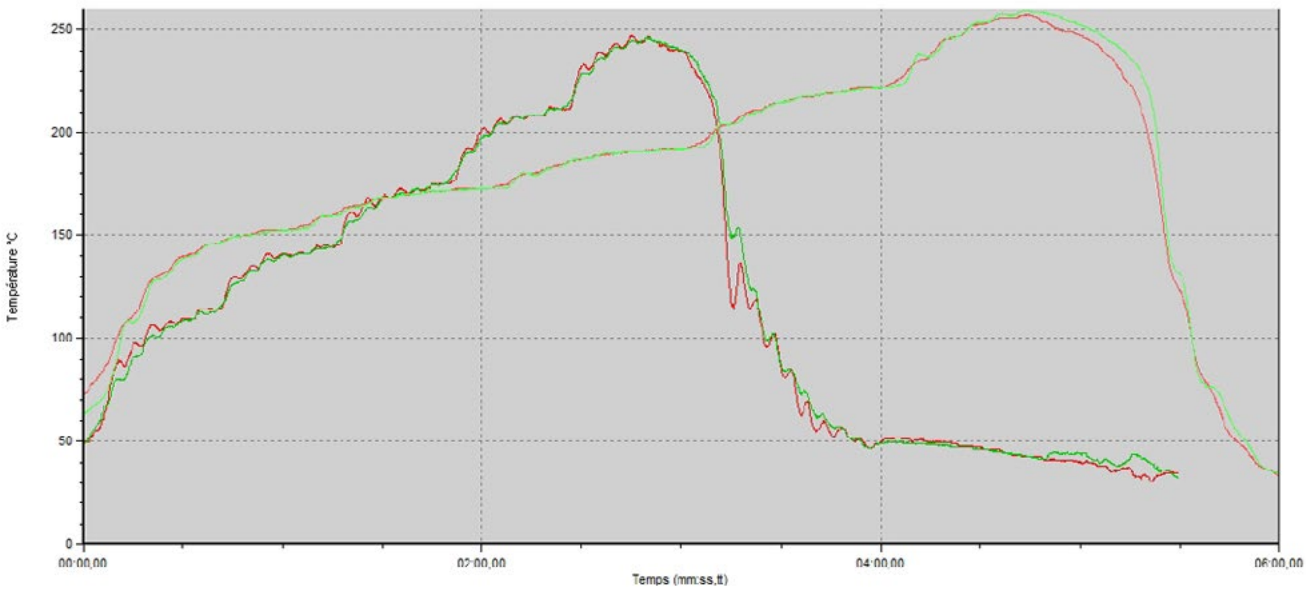


Figure 2: Thermal profiles P1 and P5.

	reflow profile P1 (short / linear preheat)		reflow profile P5 (long / high soak)	
	Time (s)	Ramp rate (°C/s)	Time (s)	Ramp rate (°C/s)
Preheat 1 (50-100°C)	25	2.0	10	5.0
Preheat 2 (100-150°C)	52	1.0	40	1.25
Preheat 3 (150-200°C)	58	0.9	139	0.36
Reflow (200°C to peak)	57	0.8	94	0.6
Total time to peak	192s		283s	
Time above 217°C (TAL)	40s		100s	
Peak temperature	248°C		257°C	
Oven temperature set-up (°C)	120/160/180/220/260		150/170/190/220/260	
Oven speed set-up	60cm/mn		35cm/mn	

Table 2: P1 and P5 characteristics.

After reflow, each coupon was rated according to the following criteria:

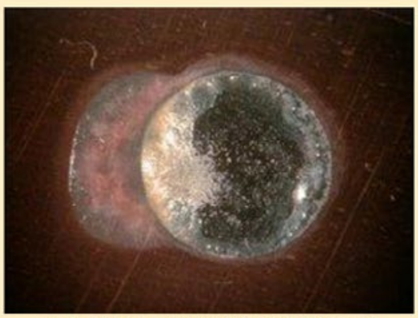
- Class 1 (C1): Solder spreads more than printed area with no evidence of de-wetting or non wetting
- Class 2 (C2): Solder spreads equal to printed area with no evidence of de-wetting or non-wetting
- Class 3 (C3): Solder spreads less than printed area or evidence of de-wetting or non-wetting

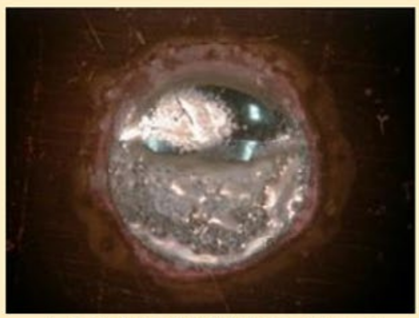
The results are summarized in Table 3, with pictures.

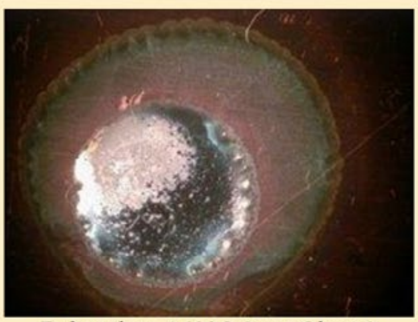
Wettability on FR-4 Copper Substrates Using Reflow Oven

The purpose was first to quantify the wetting performance of solder pastes and secondly to evaluate their ability to avoid graping. Graping phenomenon is characterized by unreflowed solder powder on the surface of solder joints. Graping is due to the consumption of the flux activators during preheating. This phenomenon

Paste	A	B	C	D	E	F
Hotplate No preheat	C1	C1	C1	C2	C1	C1
Hotplate 160°C 2 min	C1	C1	C3	C2	C2	C1
Hotplate 160°C 5 min	C3	C2	C3	C3	C2	C2
Oven Short/linear profile P1	C2	C1	C2	C2	C2	C2
Oven Long/high soak P5	C3	C3	C2	C3	C2	C2


A-hotplate-160°C 2mn-Class 1


A-hotplate-160°C 5mn-Class 3


D-hotplate-160°C 2mn-Class 2

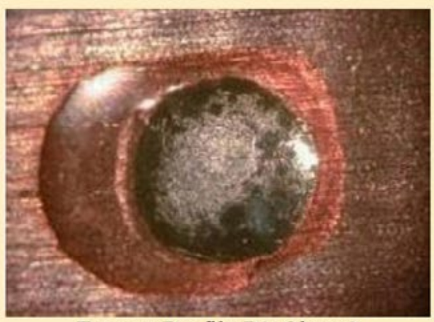

E-oven-Profile P1-Class 2

Table 3: Wetting on copper coupons summary.

is enhanced for small deposits because of the higher exposed surface area compared to the paste volume, for paste with less activation and for thermal profiles with long and high soak.

To perform such tests, FR-4 substrates of 1.6 mm thickness with round copper pads of 5 mm were used. After cleaning the substrates, the pastes were printed through a 120 microns stencil with five openings of respectively: 5 mm, 3 mm, 1 mm, 0.76 mm and 0.38 mm diameters. The substrates were placed in the reflow oven using P1 and P5 thermal profiles. Each test was done three times to assure repeatability. The diameter after reflow was measured for every pad and any sign of graping was recorded. A general view of the wetting substrate after reflow is shown in Figure 3. Examples of appearance after reflow are given in Figure 4: graping for 0.38 mm diameter deposit; no graping for 0.76 mm diameter deposit with the same solder paste; diameter measurement for an initial deposit of 0.38 mm.

Table 4 presents the mean of the measured diameters where Di states for the initial diam-

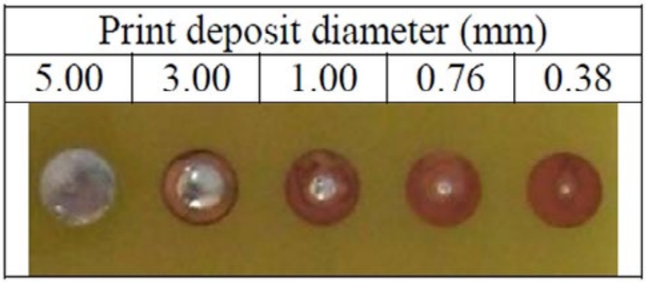


Figure 3: Wetting substrate description.

Figure 4: (l) Graping on 0.38 mm; (ctr) No graping on 0.76 mm; (r) Diameter 0.41 mm (initial 0.38 mm).

		A	B	C	D	E	F
P1	Di (mm)	Df (mm)	Df (mm)	Df (mm)	Df (mm)	Df (mm)	Df (mm)
	5,00	5,00	5,00	5,00	5,00	5,00	5,00
	3,00	3,20	3,25	2,96	3,00	2,98	3,20
	1,50	1,70	1,78	1,49	1,50	1,40	1,60
	0,76	0,92	0,92	0,90	0,75	0,78	0,81
	0,38	0,42	0,44	0,44	0,39	0,42	0,42
P5	Di (mm)	Df (mm)	Df (mm)	Df (mm)	Df (mm)	Df (mm)	Df (mm)
	5,00	5,00	5,00	5,00	5,00	5,00	5,00
	3,00	3,25	2,95	3,03	3,00	2,97	3,20
	1,50	1,75	1,50	1,58	1,50	1,44	1,58
	0,76	0,98	0,87	0,87	0,71	0,75	0,82
	0,38	0,42	0,43	0,46	0,35	0,41	0,44

Table 4: Wetting diameter.

eter after printing (mm) and Df is the diameter after reflow; the wetting percentage (Df/Di) according to paste type and thermal profile is reported as a histogram in Figure 5. Graping was only observed for pastes C and D with an initial diameter of 0.38 mm.

Some pictures of wetting are shown in the table below (Table 5). A, B and C solder pastes perform better than no-clean solder pastes D, E and F. Paste A has the largest wettability and paste D the lowest one. The thermal profile has no noticeable influence. The influence of the size of the initial paste deposit is relatively low for pastes D, E and F, a bit more significant for A, B and C. The wettability according the initial diameter size is different for each paste.

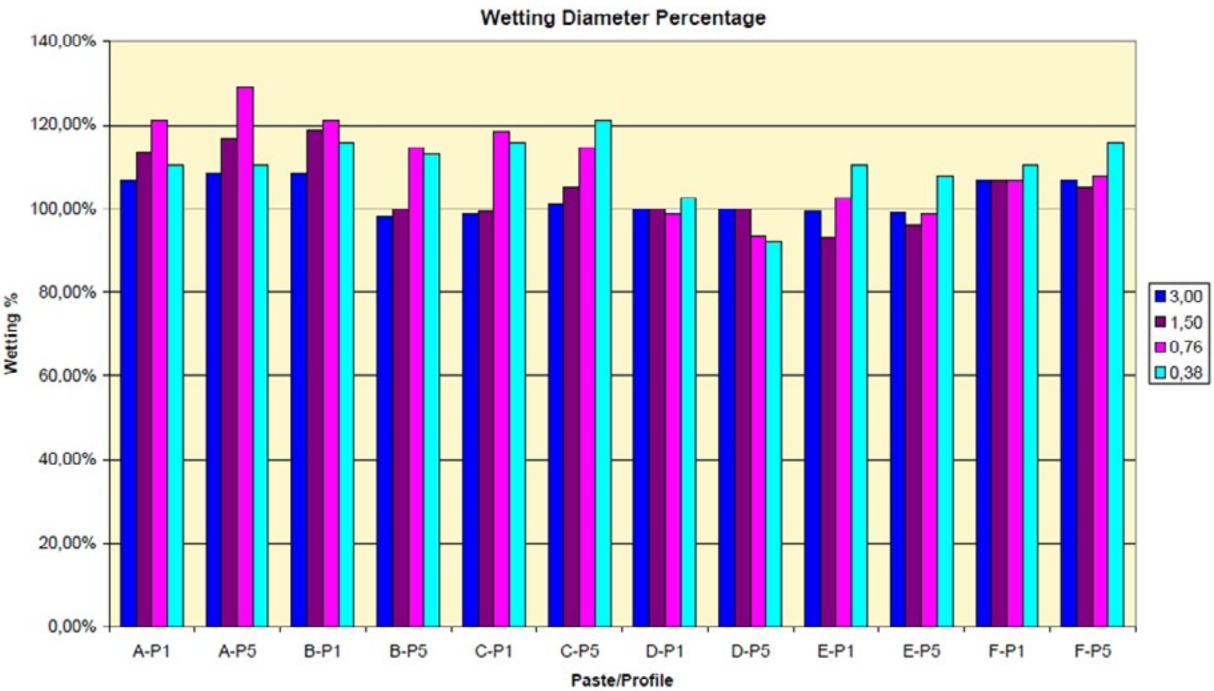


Figure 5: Graph of wetting percentage according to paste type and thermal profile.

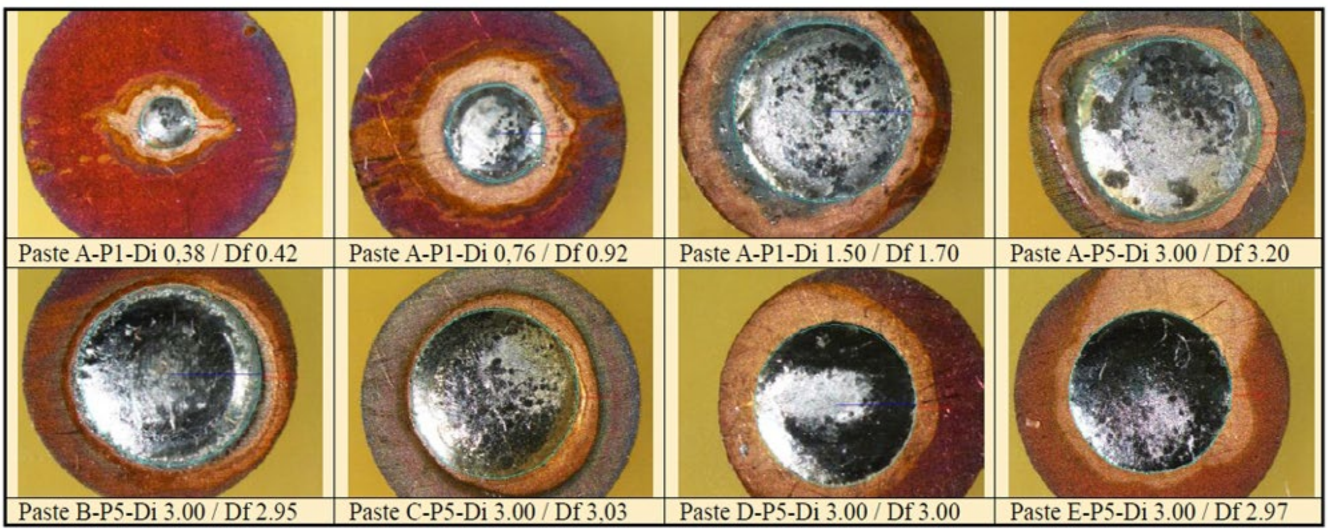


Table 5: Examples of wetting diameters.

Wettability on Test Board Using Reflow Oven

The pastes were printed through a 100 µm stencil on a test board designed for wettability (Figure 6). In order to pre-oxidize the test boards, they were submitted to one prior reflow. P5 was used. Organic solderability preservative (OSP) and electroless nickel immersion gold (ENIG) finishes were tested. Wetting performances were checked. Pictures of wetting on patterns A and G are given in Table 6 and Figure 7.

On OSP finish, the ranking was similar to the test previously made on the FR-4 copper substrate whereas the ranking on ENIG finish was dependent on paste and on pattern type. The average results are, in decreasing order of wettability: A, E and F almost equal, then C, B and D. Only the wetting properties of D were constant and always the worst.

Tombstoning

The water-soluble solder pastes being usually more prone to create tombstoning defects due to their high activation, a test was performed: Forty 0603 capacitors were placed with an offset on the wetting test board comprising several aperture designs. Special reflow conditions were used, in order to observe a significant tombstoning percentage. The conditions will not be described in this paper. The experiment was repeated three times for each paste. The table below (Table 7) indicates the percentage of tombstoning observed.

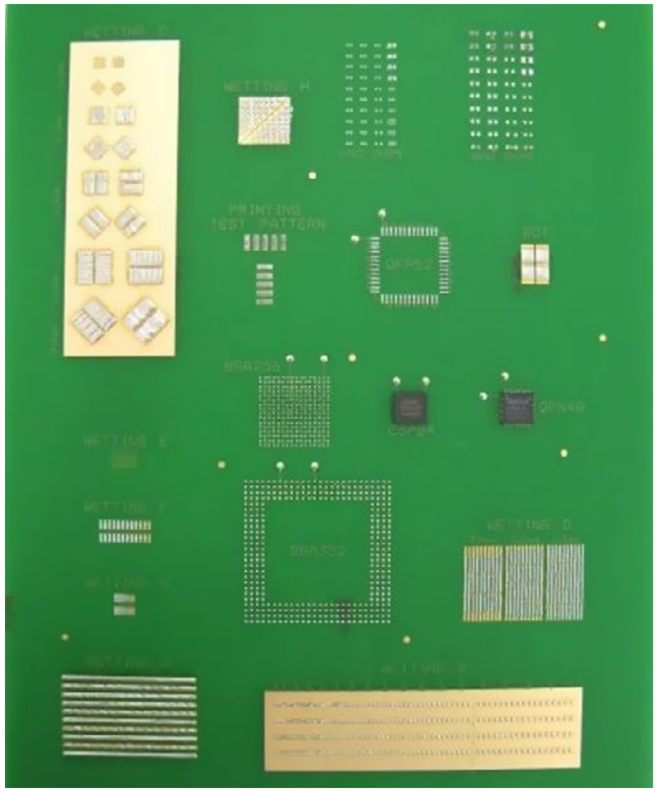


Figure 6: Wetting test board.

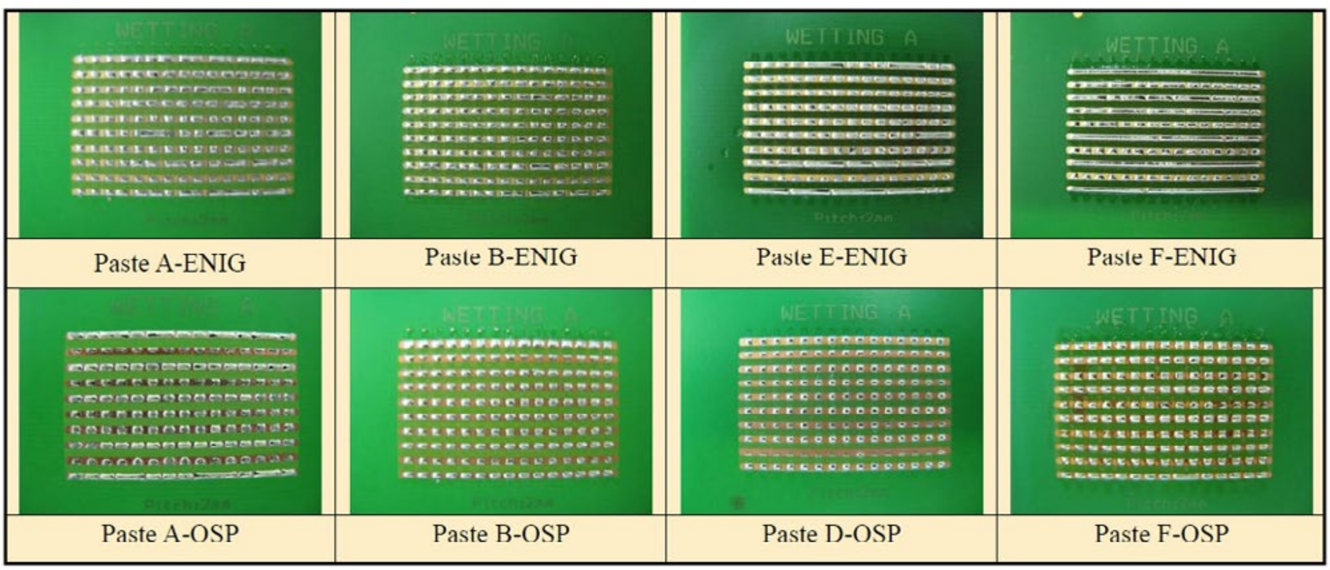


Table 6: Wettability on test board pattern A.

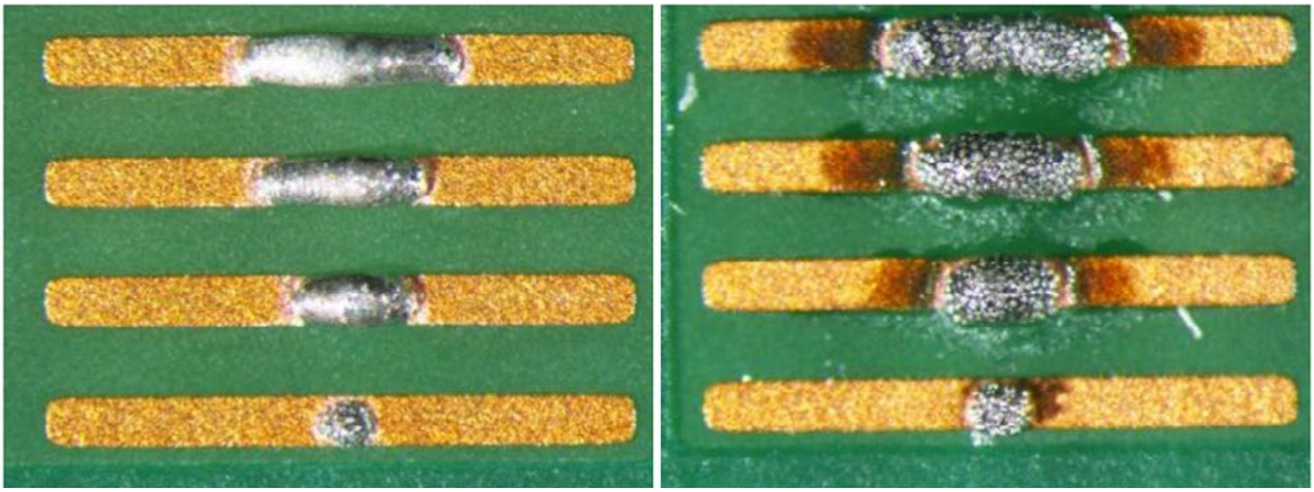


Figure 7: Wettability on test board pattern G (ENIG): (l) Paste A; (r) Paste D.

Paste	A	B	C	D	E	F
Tombstoning	13%	8%	15%	5%	4%	2%

Table 7: Tomsbtoning percentage.

Copper Mirror

The induced corrosion on copper mirror was done according to IPC-TM-650 method2.3.32. The evaluation was made according to J-STD-004 criteria:

- Type L: No complete breakthrough, as evidenced by white background showing through anywhere on the test spots; this condition includes discoloration of the copper due to a superficial reaction or a reduction of the thickness of the copper film without complete breakthrough
- Type M: Partial or complete copper mirror removal in less than 50% of test area
- Type H: Complete copper mirror removal allowed in more than 50% of test area

The results were in accordance with the initial specifications of the pastes; a summary is done in the Table 8 below.

Corrosion Test

The corrosion test was done according to IPC-TM-650 method 2.6.15 and the results were assessed according to J-STD-004 criteria:

- No corrosion: No evidence of corrosion is present
- Minor corrosion: Any initial change of color, which may develop when the test panel is heated during soldering, is disregarded. Discreet white or colored spots in the flux residues or a color change to green-blue without pitting of the copper or formation of excrescences is regarded as minor corrosion
- Major corrosion: Any initial change of color, which may develop when the test panel is heated during soldering, is disregarded; subsequent development of green-blue discoloration with observation of pitting of the copper panel or excrescences at the interfaces of the flux residue and copper boundary is regarded as major corrosion.

The results are summarized in the Table 8.

Surface Insulation Resistance (SIR)

Water-soluble solder pastes are designed to be cleaned after soldering: SIR values given in the datasheet of cleanable solder pastes are

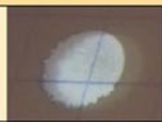
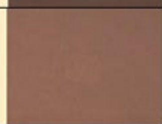
Paste	Nature	Flux type according to specification	Picture of copper mirror	Copper mirror test result	Corrosion test result	Picture of corrosion test
A	WS	ORH0		H	Major	
B	WS	ORH1		H	Major	
C	WS	ORH1		H	Major	
D	NC	ROL0		L	No	
E	NC	ROL0		L	No	
F	NC	ROL1		L	Minor	

Table 8: Copper mirror and corrosion test results.

measured after complete removal of their residues. However, in order to observe the effect of non-cleaned or poorly cleaned corrosive residues, it was decided to measure the surface insulation resistance of all the pastes according to IPC-TM 650 method 2.6.3.3 without prior cleaning. The solder pastes were printed onto IPC B24 coupons (track/space width 0.4/0.5 mm) and the coupons were reflowed using P1 thermal profile. Additional coupons for pastes A and D were made and cleaned before SIR as references. Boards were placed in the chamber and the test took place at 85°C and 85% relative humidity for 168 hours. A graph is presented in Figure 8, where values of water-soluble solder pastes without cleaning all drop under the limit within the first 24 hours; A and C remain under the limit till the end of the test while B recovers. Pastes D, E, F as well as pastes A and D after residue removal all meet the requirements. Dendrite growth was observed for pastes A, B and C (pictures of C and D are presented in Figure 9).

Cleanability

Water-soluble solder pastes are designed to be cleaned using hot water only as they already contain saponifiers and/or surfactants allowing their removal. On the other hand, no-clean solder pastes cannot be cleaned using hot water only. Nevertheless it was decided to submit all the pastes to the same cleaning tests.

The wetting test boards with OSP finish were used: one CSP 84 3 rows 0.5 mm pitch 7 mm² and several 0603 chips were placed (Figure 6). After reflow with P5 thermal profile, the boards were cleaned in a water-based spraying machine. Five conditions were used: cold deionized (DI) water, 50°C DI water, 65°C DI water, 50°C DI water with 5% detergent, 50°C DI water with 25% detergent; each cleaning cycle was set to 10 minutes and was followed by a rinsing step with DI water and a drying step of five minutes at 80°C with hot air. The cleanliness was evaluated by visual inspection under binocular.

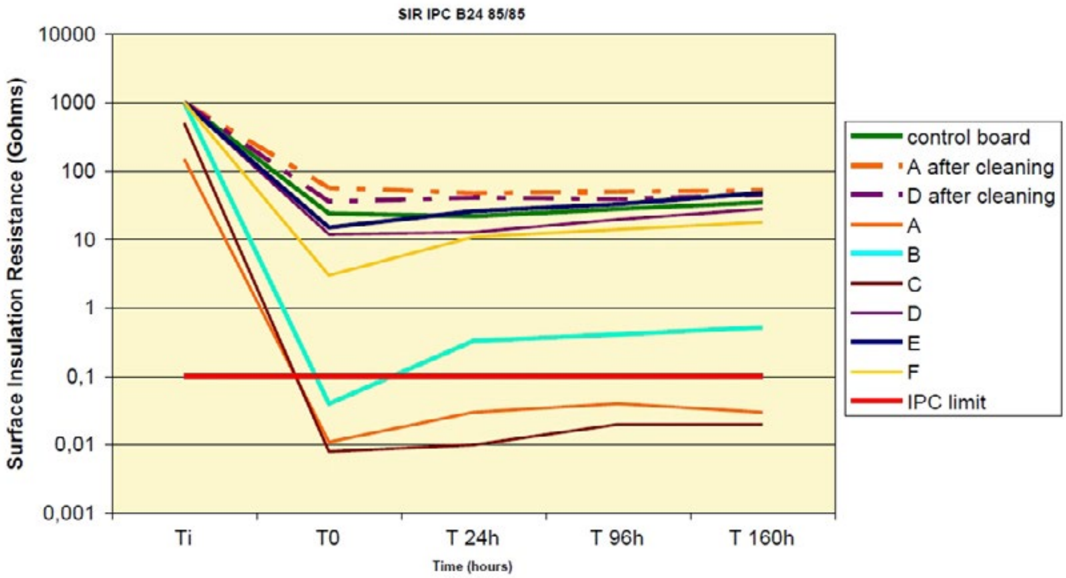


Figure 8: Surface insulation resistance graph.

Figure 9: Observation under back-light: (left) dendrites with paste C; (right) no dendrite with paste D.

The boards were considered clean when no residues were detected. Results are summarized in the table below (Table 9). Anionic contamination test was performed on the boards regardless of their cleanliness level. This test was done in accordance with the IPC-TM-650, method 2.3.25C: The board is immersed in a solution of water/isopropanol while analyzing the evolution of this cleaning solution contamination which circulates in closed-circuit inside the contaminometer. The results are expressed in µg equivalent NaCl per cm² of circuit and are reported in Table 9. A test board with no paste but submitted to the same reflow profile was used as control board: its ionic contamination measured was 0.21µg/cm².

Paste A was the easiest to clean, even using cold water, followed by paste C and B for WS solder pastes. Cleanability of pastes D and F was achieved using detergent at 25% whereas E was not (a second cycle in the same conditions was necessary to clean it properly). As long as the cleaning was successful, the ionic contamination levels were acceptable and far below the MIL and DEF criteria (respectively 1.3µg/cm² and 1.5µg/cm²) for all the pastes. But, in case of incomplete cleaning, the level of ionic contamination for WS solder pastes was above

Paste	A	B	C	D	E	F
Water cold	OK	NOK	NOK	NOK	NOK	NOK
	0.46	2.04	>3	0.29	0.28	0.30
Water 50°C	OK	NOK	OK	NOK	NOK	NOK
	0.18	1.57	0.20	0.45	0.37	0.44
Water 65°C	OK	OK	OK	NOK	NOK	NOK
	0.25	0.14	0.14	0.56	0.42	0.57
Water 50°C / detergent D 5%	OK	OK	OK	NOK	NOK	NOK
	0.22	0.19	0.21	0.40	0.43	0.84
Water 50°C / detergent D 25%	OK	OK	OK	OK	NOK	OK
	0.18	0.20	0.18	0.23	0.34	0.16

Table 9: Cleanliness according to cleaning method (visual/ionic contamination).

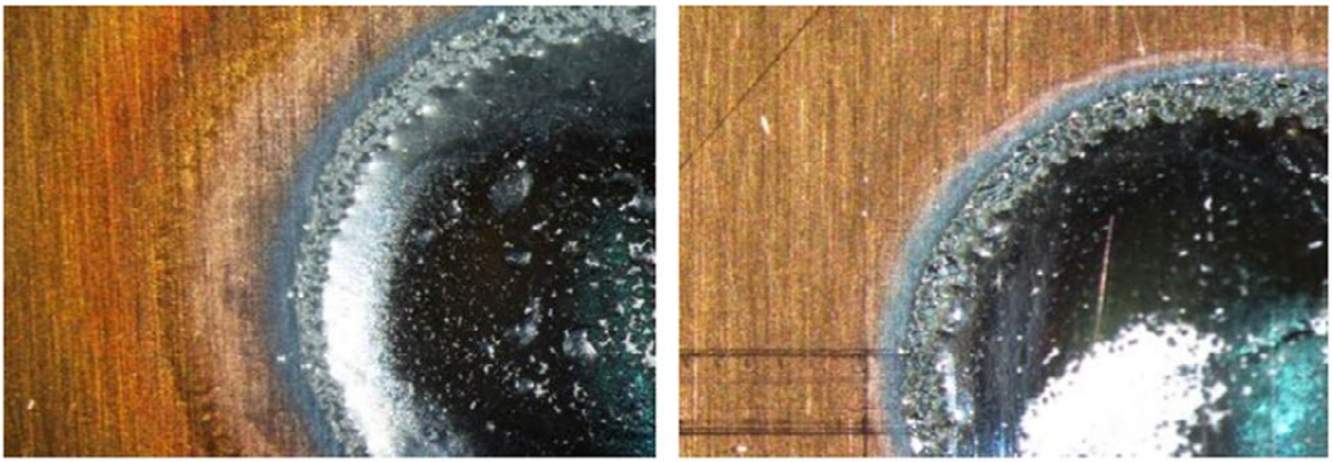


Figure 10: Poor/good cleaning on wetting H pattern: (left) Paste B/poor; (right) Paste B/good.

specifications. On the contrary, all no-clean solder pastes showed an ionic contamination level below the specifications. Some pictures of the boards are given as examples of poor and good cleaning in Figure 10 and 11.

Discussion

Wettability on copper coupons was generally worse for water-soluble pastes using long preheat on hotplate and in reflow oven. Nevertheless opposite results were obtained when using FR-4 substrates with cleaned copper finish: larger wetting diameters were found for WS pastes and a slight de-wetting for no-clean paste D was observed. These results were confirmed using the wetting test board with OSP finish. On the other hand, the same wetting test board with ENIG finish has led to more mixed results: wetting performance was dependant on solder pastes and on pattern types. Pastes A, E and F gave similar results, C and B were behind; the only constant was the poor performance of paste D for all patterns and graping on small deposits. WS solder pastes have demonstrated more predispositions to generate tombstoning than no-clean solder pastes. In terms of residue corrosiveness, due to their formulation, WS pastes exhibited high corrosivity as far as copper mirror, corrosion on copper and surface insulation resistance tests are concerned. And due to their chemistry, their residues were also easily cleaned with water only, paste A being the best, then C and B. However, in case of incomplete cleaning, the ionic contamination was very high for water-soluble solder paste while

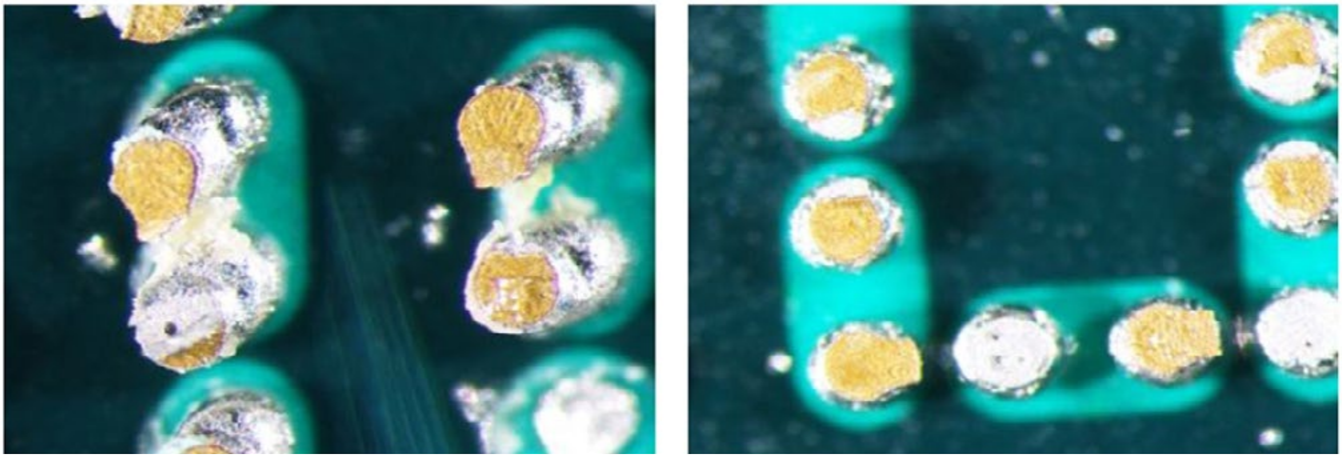


Figure 11: Poor/good cleaning under CSP (after removal): (left) Paste B/poor; (right) Paste B/good.

it remained low for incomplete cleaning of no-clean solder pastes.

Conclusion

The purpose of the paper was to highlight the differences between water-soluble and no-clean solder pastes in order to guide users in their choice. To achieve this goal, six lead-free solder pastes were extensively studied, three being water-soluble and three being no-clean. In the first part of the paper, water-soluble pastes generally yielded results below the no-clean pastes with a significant sensitivity to temperature and humidity, a tendency to slump during preheat and a narrower printing window. It was concluded that the WS pastes had to be stored, handled and used with more caution before reflow compared to no-clean pastes. In the second part of the paper, regarding wetting properties, WS pastes rank generally better, especially for oxidized substrates. As far as cleanability is concerned, of course only water-soluble pastes can be cleaned with water only whereas no-clean pastes need detergent to achieve a complete removal of their residues. However, in case of poor cleaning, as the amount of ionic species usually found in WS residues is high (presence of ionic surfactants especially), the risk of corrosion is very high: This is the major drawback of such pastes.

The use of water-soluble pastes generally takes place in high-reliability assembly as medical, military or aerospace fields where close attention is paid to the quality of substrates, components, where reflow is done in inert atmosphere (nitrogen, vapor phase or under vacuum ovens) and where cleaning is compulsory for the majority of the products. The use of aggressive chemistry may not be necessary when using such equipments. Moreover, the risk of tombstoning is increased. In such fields, in case of new solder paste evaluation, it is useful to also consider the option of no-clean solder pastes in comparison with water-soluble solder pastes and even to think about review the whole cleaning process. This paper can then be used as a guide to study the critical aspects of these two types of solder pastes. **SMT**

Acknowledgments

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Position Accuracy Machines for Selective Soldering of Fine-Pitch Components

by Gerjan Diepstraten
VITRONICS SOLTEC

Figure 1: (Above) Example of selective soldering metal shielding.

Abstract

The drive towards fine-pitch technology also affects the soldering processes. Selective soldering is a reliable soldering process for THT (through-hole technology) connectors and offers a wide process window for designers. THT connectors can be soldered on the top and bottom side of boards, board in board, PCBs to metal shields or housing out of plastic or aluminum and are today's state of the art.

The materials used to make solder connections require higher temperatures. Due to the introduction of lead-free alloys, boards need more heat to get the barrels filled with solder, which not only affects the properties of the flux and components, but the operation temperatures of solder machines become higher. A nitrogen tunnel wave solder machine requires a temperature control in the tunnel to prevent overheating, and advanced systems are available that insert cold nitrogen. The closed tunnel wave soldering process has a wide process window and is not sensitive to small changes in environmental conditions; the same goes for wave solder machines that have nitrogen blanket systems over the wave. Improved preheaters will bring sufficient heat in the assembly and exhaust systems are adequate enough to maintain required process conditions. The nitrogen will improve the soldering and minimize dross amounts at these elevated solder temperatures.

Selective soldering is a different process. Compared to wave soldering there are additional process parameters that are affected by the higher temperatures. Solder joints have to be made close to SMD pads or components. An off-set of 0.5 mm may result in solder skips or re-melting SMD components. Additionally, the higher temperature may cause warpage of the board, which also affects the position accuracy

of the solder nozzle. All materials will expand at higher temperatures, but not all expansion coefficients of the materials used are equal. This not only introduces stress, but also may create off-sets.

Introduction

First, the impact of temperature will be discussed for the separate process steps and for machine tooling. In the experimental part measurements are done to verify the accuracy that can be achieved using today's selective soldering machines. Dedicated tooling is designed to achieve special requirements with respect to component position accuracy.

Flux Unit

A selective soldering process has three process steps: fluxing, preheating and soldering. During the first step, the fluxing of the solder side of the assembly, the board and machine parts have an ambient temperature. A high-frequency drop-jet device is able to apply very fine droplets. The device is mounted on a robot that is moving in an x, y direction to shoot fine droplets on those spots where the printed circuit will meet the liquid solder. The position of the flux is critical. Not only should the flux be on the soldering area to clean the board and support the wetting, but there should not be flux anywhere else on the board. It can be critical if non-activated flux is mixed with solder paste flux residues close to the soldering spot. Any non-activated flux on the assembly may cause electro-migration in the field when it is exposed to humidity and a bias. Flux that is not applied correctly may affect reliability during the lifetime of the product.

"A high-frequency drop-jet device is able to apply very fine droplets. The device is mounted on a robot that is moving in an x, y direction to shoot fine droplets on those spots where the printed circuit will meet the liquid solder. The position of the flux is critical."

Flux amount and position should be controlled to avoid field issues. The robot in the machine should move the drop-jet to the right spot. These locations are imported from the CAD-files or by teaching the cold print by a camera.

Preheat Unit

After the flux is applied, the board is transferred to the preheating unit. This can either be an IR lamp device or a forced convection heater. The board is heated to a topside temperature of 120°C. A typical FR-4 board has a coefficient of thermal expansion (CTE) of 14 ppm/°C in x-direction and 17 ppm/°C in y-direction at temperatures from ambient to the T_g (glass transmission temperature) of the board.

The heating will extend the board length. An FR-4-print is heated to 120°C ($\Delta T = 100°C$). The length of the board is 250.00 mm. After preheating the board will have a length of 250.35 mm. Not only should the expansion of the print be considered, but also the warpage. Due to the heat and mass of components the warpage might give problems in the z-position. This deviation in the z-axis can be measured with laser sensors. The offset data is used to modify the robot position towards the solder nozzle to have a consistent contact time/immersion depth all over the print. If not compensated, warpage may give open joints (no contact or contact with solder too short) or bridging (contact time too long). An alternative to compensate warpage is to have dedicated tooling vacuum or mechanical holders installed in the gripper that keep the board flat.

Robot Gripper

After preheating, the board is picked up by the robot, which then moves the print to the soldering station where the board has to be positioned towards the solder. But first, the position of the board in the gripper has to be defined. There are different ways to define the print location:

- Fiducial camera: A camera can recognize fiducials on the print and calculate the off-set of the fiducials to a reference point.

• Mechanical fix: The majority of PCBs has tooling holes for positioning the print in fixtures and machines to process the board. Pins in the gripper will lock the board in the defined position.

The machine software knows where the robot is and once the print is locked or defined by the fiducial camera, the position of the print is defined in the software.

Dip Soldering Station

The robot will move the print to the solder unit. There are two soldering options: dipping on a nozzle plate or dragging over a small nozzle.

Dipping on a Nozzle Plate

For high volume assemblies the dip soldering on a nozzle plate that is dedicated for each print design is the most efficient method for a short cycle time. In one single dip, all solder connections are made. It is a challenge to dip a preheated printed circuit board onto a nozzle plate that is installed in liquid solder of 280°C–320°C. The nozzle plate is made with the Gerber/CAD data of the assembly. The temperature difference and expansion of the stainless steel is compensated. The CAD data has the dimensions defined at ambient temperature, but in the selective dip process the robot (aluminum) may have a temperature of 50°C, the print (FR-4 material) 120°C and the nozzle plate (stainless steel) 320°C. Different temperatures, CTEs and materials should result in a robust process where joints are soldered up to 1 mm from surrounded SMD, metallized pads or other components.

In order to match the hot nozzle plate with the preheated PCB, the following equation can be used:

$$L_{Nozzle\ (Ta)}/L_{PCB\ (Ta)} =$$

$$(1 + Ec_{PCB} * (Tp - Ta))/(1 + Ec_{Nozzle} * (Ts - Ta))$$

The factor $L_{Nozzle\ (Ta)}/L_{PCB\ (Ta)}$ expresses the multiplication factor for the nozzle plate dimensions at ambient temperature related to the PCB dimensions at ambient temperature, so that both will fit at soldering conditions.

L_{PCB} = PCB length [mm]
L_{Nozzle} = Nozzle plate length [mm]
Ta = Ambient temperature [°C]
Tp = Preheat temperature [°C]
Ts = Solder temperature [°C]
Ec_{PCB} = Thermal Expansion Coefficient of the PCB [ppm/°C]
Ec_{Nozzle} = Thermal Expansion Coefficient of the nozzle plate [ppm/°C]

All the programming needed to solder the board can be done off-line on a separate computer. However, teaching of the machine points can only be done in a machine that has achieved its operation temperature. The robot has to learn where the machine points are. Machine points are the reference of a part in the process, like teach camera, solder pot, pick up, and fluxer position. To compensate, tempera-

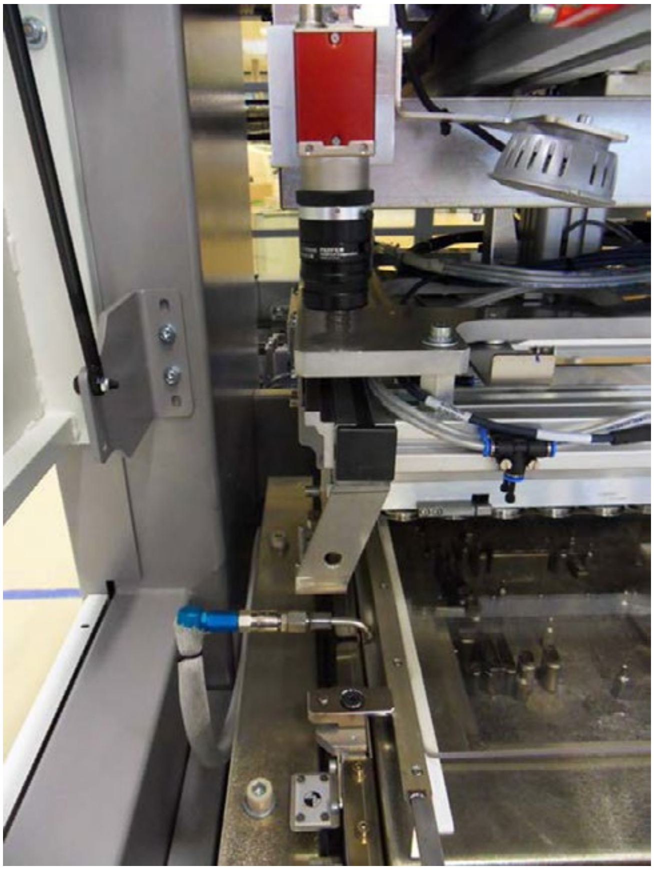

Figure 2: The camera mounted on the gripper verifies the position of the solder pot by checking the location of the fiducials.

ture differences and expansion differences of the different parts' fiducials can be installed in the machine. With a fiducial camera mounted on the gripper it is possible to make corrections if required. The camera on the gripper measures the offset of the solder pot and the software will guide the print in the correct position. Dip soldering is an application that is common used in high-volume lines where cycle time is critical so the camera should respond fast to minimize time loss.

Another method that is used for most assemblies is to have a position pin on the gripper that slides into a position hole on the nozzle plate. Thus the position of the print toward the nozzle plate is mechanically secured. Also, this point has to be learned with a machine at operation temperatures otherwise, due to difference in expansion, the robot might have an offset of 1 mm or more.

On the nozzle plate there are spacers installed with a defined height. In this way the z-position of the print is always guaranteed and board is kept in a flat position.

Drag Soldering Station

The more flexible soldering method is to have a small nozzle and drag the assembly over the wave. This single-point soldering is a robust method, but it is time-consuming and creates longer cycle times. There are four methods for drag soldering. The first selection is the nozzle material. This can be wettable or non-wettable. Second, one can solder horizontal or under an angle.

For a non-wettable nozzle the solder-flow direction is defined and the board or the nozzle should have a U-rotation option to drag the print in the right direction over the wave. For a wettable nozzle the solder overflows in all directions, which make it possible to drag the print from all directions.

Nozzles have different shapes and even may have a different height. Therefore the machine should have a dedicated machine point for each nozzle. After changing a nozzle this machine point may have been changed in x, y-position or even in height (z-position). A general rule is that after maintenance or removing parts, machine points must be verified to avoid small offsets. The nozzle has been taught and the position of the print in the robot gripper is mechanically secured or defined by fiducials, so all required information is there for the system to drag the board properly over the small nozzle without touching the surrounded SMD components. The board warpage should be compensated by to robot z-position to avoid that the board is immersed too deep in the solder.

Experiment

The next experiments are done to verify the accuracy of the robots used to transport the print to the proper position. These measurements are also part of the quality program that is run for every new machine before production starts. For many automotive lines this capability analyses are repeated before an audit or after the machine has been moved. Each machine has at least two robots. The drop-jet nozzle of the fluxer is installed on a x,y robot. This moves the drop-jet to spray at those spots that require flux. A very sensitive liquid flow measurement guarantees a controlled flux amount per connector. The low flux flow can be measured using a device that contains a heating element that registers every temperature change which is directly related to the flow rate of the flux. A fork laser sensor can be used to define if the sprayed

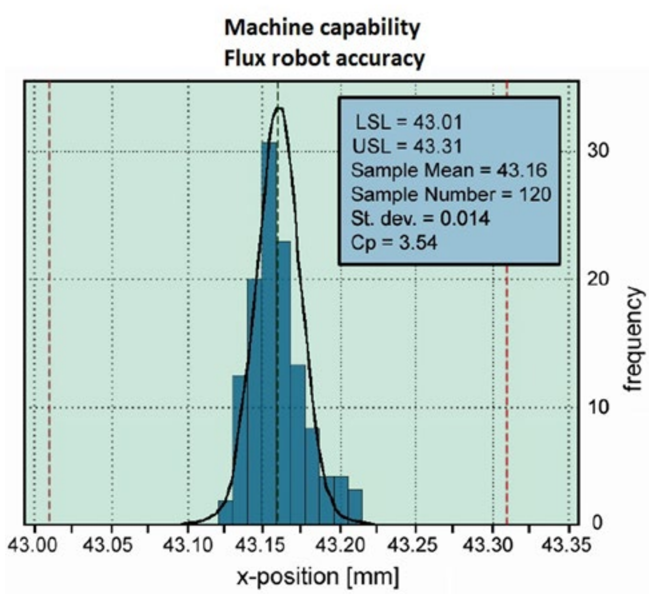

Figure 3: The normal distributed placement accuracy of the fluxer robot in the x-direction.

flux is going in the right direction, perpendicular to the print. For a given flux type, machine settings and solder mask the software will define the spread of the flux on the board ensuring there is no excess flux on the assembly.

Flux Robot Accuracy Test: To define machine capability (accuracy of the flux robot) laser sensors were installed to measure the distance of the robot to a pre-defined point. Repeatability is required without influence by environmental noise, like temperature and humidity changes.

For the flux robot, an accuracy of ±0.15 mm is defined in the specification. As shown in the graph the robot is capable and has a standard deviation of only 0.014 mm. The robot moved 120 times to this position over a time period of two hours. No drift was visible in the raw data. The robot was even more accurate in the y-direction where the standard deviation was only 0.007 mm.

Gripper Robot Accuracy Test: The robot gripper that picks up the board after preheating and moves the PCB exactly above the nozzles in the solder pot has to be more accurate than the flux robot. The specification of this unit is defined ±0.10 mm. This is more accurate than systems that move a solder pot underneath the printed circuit board. Using an identical measurement device as in the previous test the x, y and z-direction of the gripper robot are tested for consistency. Despite the higher specified accuracy the x, and y-direction positioning of the gripper robot proved to be consistent. For both directions the standard deviation is approximately 0.008 mm resulting in Cp values of approximately 4.

When the pins on the board are dipped into the solder the height (z-direction) of the robot gripper should be placed at the correct height. The board may warp due to the higher temperatures. To make sure that the board is not touch-

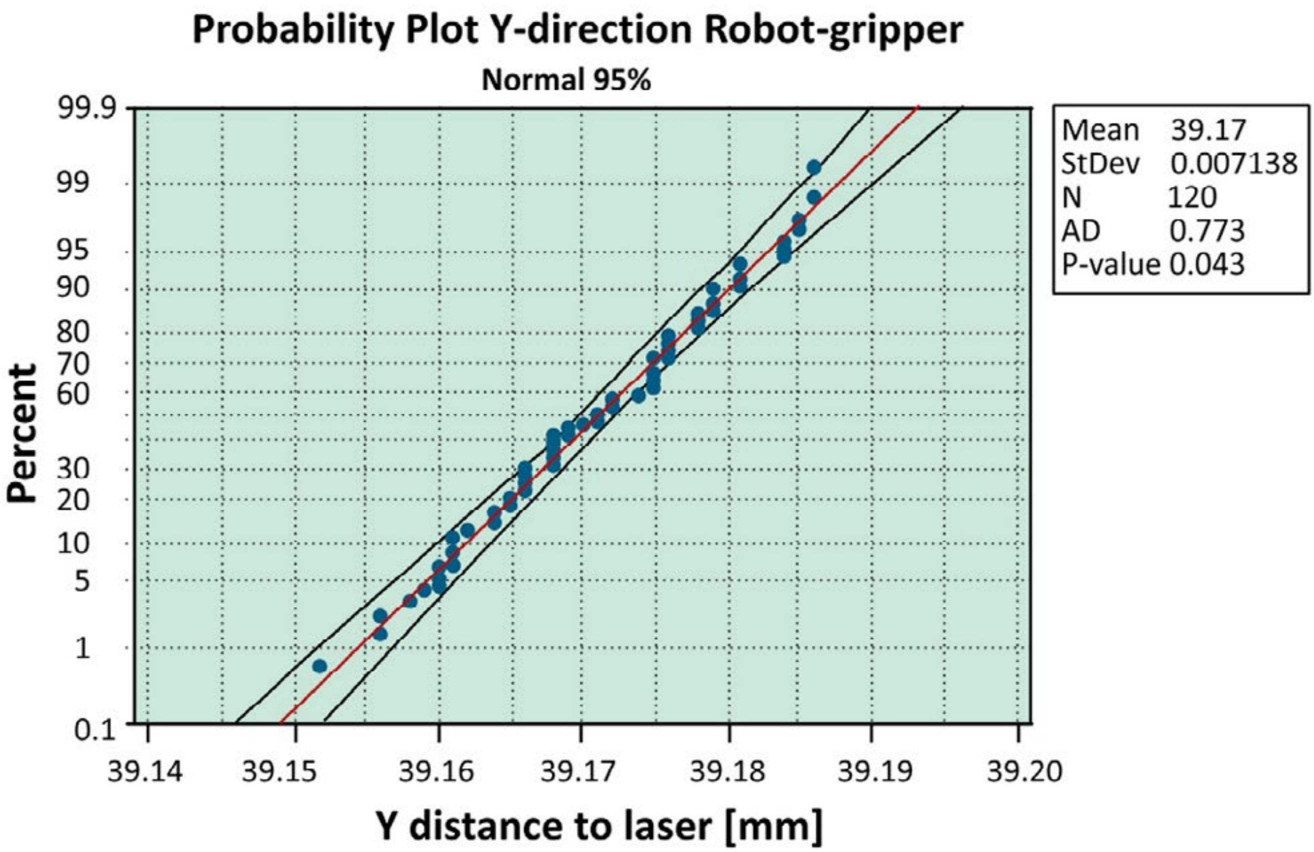

Figure 4: Probability plot of the y-direction robot gripper. Consistency of placement is measured toward laser sensor.

ing the nozzle rim, which would result in solder webbing/oxides on the solder mask, the nozzle plate has stand-off pins to support and level the board. The robot gripper itself is also accurate in z-direction. The standard deviation is equal to x and y-direction, 0.008 mm.

Select Wave Nozzle

Multi-wave nozzle plates have stand-off pins which provide a mechanical means to fix the z-position. The small select wave nozzle has no mechanical tooling to secure the height which makes this soldering more challenging. Three parameters are critical and all have variation: board flatness (warpage), z-position accuracy of the robot gripper, and the stability of the wave height.

How Stable is a Small Wave?

In order to address the wave height stability of a small nozzle a special test with a camera measuring the wave height was designed.

For a given design of nozzle there are three factors that define the wave height and its stability:

1. Solder alloy
2. Solder temperature
3. Pump speed

For the experiment, a 5 mm (inside diameter) wettable nozzle was used. The solder was lead-free SACX and the solder temperature varied from 280–320°C.

The wave height of the select wave can be controlled by the pump speed. As shown in Figure 5, there is a small process window. The height can only be changed with a few rpms, otherwise it becomes more unstable. In this example the wave height is most stable between 2.4 and 2.9 mm (460–475 rpm).

Special Tooling and Component Accuracy: In a robot gripper, dedicated tooling can be installed for increased accuracy or for special requirements. Examples of these tools are:

Wave height [mm]		Solder temperature [°C]				
		280	290	300	310	320
Pump speed [rpm]	455	2.10	2.17	1.98	2.02	1.99
	460	2.41	2.45	2.41	2.38	2.43
	465	2.60	2.64	2.61	2.56	2.59
	470	2.75	2.80	2.76	2.71	2.74
	475	2.86	2.88	2.85	2.80	2.83
	480	2.97	3.03	2.96	2.90	2.90
	485	3.04	3.02	3.00	2.96	2.98
	490	3.14	3.20	3.10	3.07	3.05
	495	3.21	3.29	3.17	3.10	3.20
	500	3.31	3.36	3.29	3.18	3.17

Table 1: The average wave height at different pump settings. The number of samples is 120 for each setting.

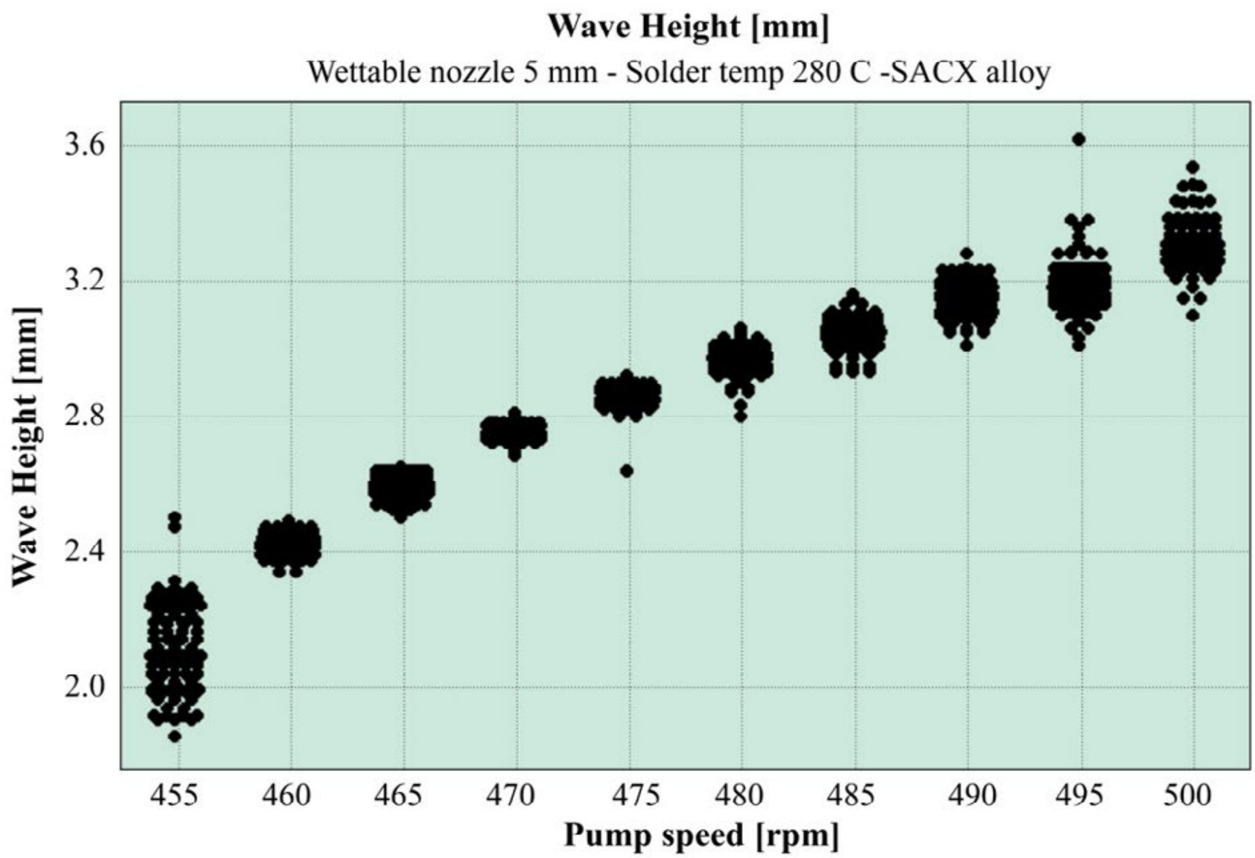

Figure 5: The variation in wave height as a function of the pump speed.

- Topside heaters to reduce temperature drop and keep the board at temperature
- Cooling devices to avoid overheating of components
- Vacuum or other devices to keep the board flat and avoid warpage
- Tooling to prevent components from moving or lifting due to the heat of the solder
- Tooling to keep the component in place and achieve accurate placement (up to flatness of -0 to +0.1mm)

Conclusions

Selective soldering is a robust soldering process when the process parameters are addressed and under control. In the different process steps we identified critical parameters:

Flux process: In this first process there are no elevated temperatures and accuracy is established by the following:

1. Accurate x and y position of the robot.
2. Flux flow measurement.
3. Verification of the flux flow direction.

Preheat process: No special requirements for board handling or placement accuracy. The temperature of the print is measured with a pyrometer to guarantee flux activation and prevent overheating.

Dip soldering process: Several requirements need to be fulfilled to have a consistent dip process:

1. Position of the PCB in the gripper has to be defined via either mechanical fix or fiducial recognition.
2. Position of the nozzle plate must be defined via machine point verification with fiducials or mechanical fix of PCB/gripper with nozzle plate.

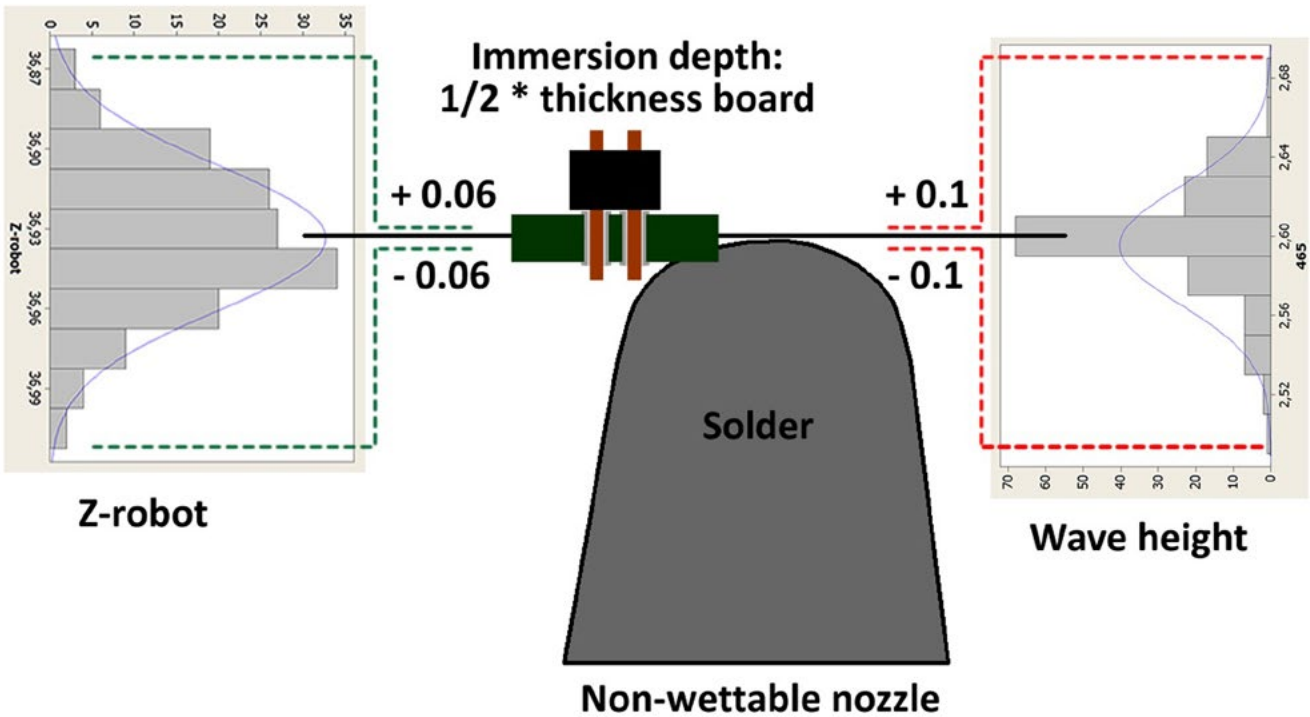

Figure 6: The variation of wave height and robot in z-direction. Most critical for this process is the flatness of the board.

3. Z-direction is guaranteed by stand-off pins on the nozzle plate.

Drag soldering over select wave: The requirements for a consistent drag process are:

1. Position of the PCB in the gripper has to be defined via mechanical fix or fiducial recognition.
2. Machine point of the nozzle should be verified via fiducial x, and y position or z-height verification with a sensor.
3. Z-position of the PCB is critical during soldering. Special attention is needed to make sure that there is no excessive warpage. Special tooling in the gripper or warpage compensation (measured with laser) by software are methods to compensate for a lack of flatness.

Experience and machine capability data show that despite the temperature changes and board warpage, THT connectors can be soldered in a very accurate way. The knowledge of the process and small, but very efficient, tooling devices help improve accuracy. Special designed nozzles have non-wettable screens mounted on top to avoid bridging. This option requires a place accuracy of 0.10 mm. The robot showed to have a consistent placement accuracy that can meet the tough placement requirements with the help of mechanical fixtures or fiducials. **SMT**

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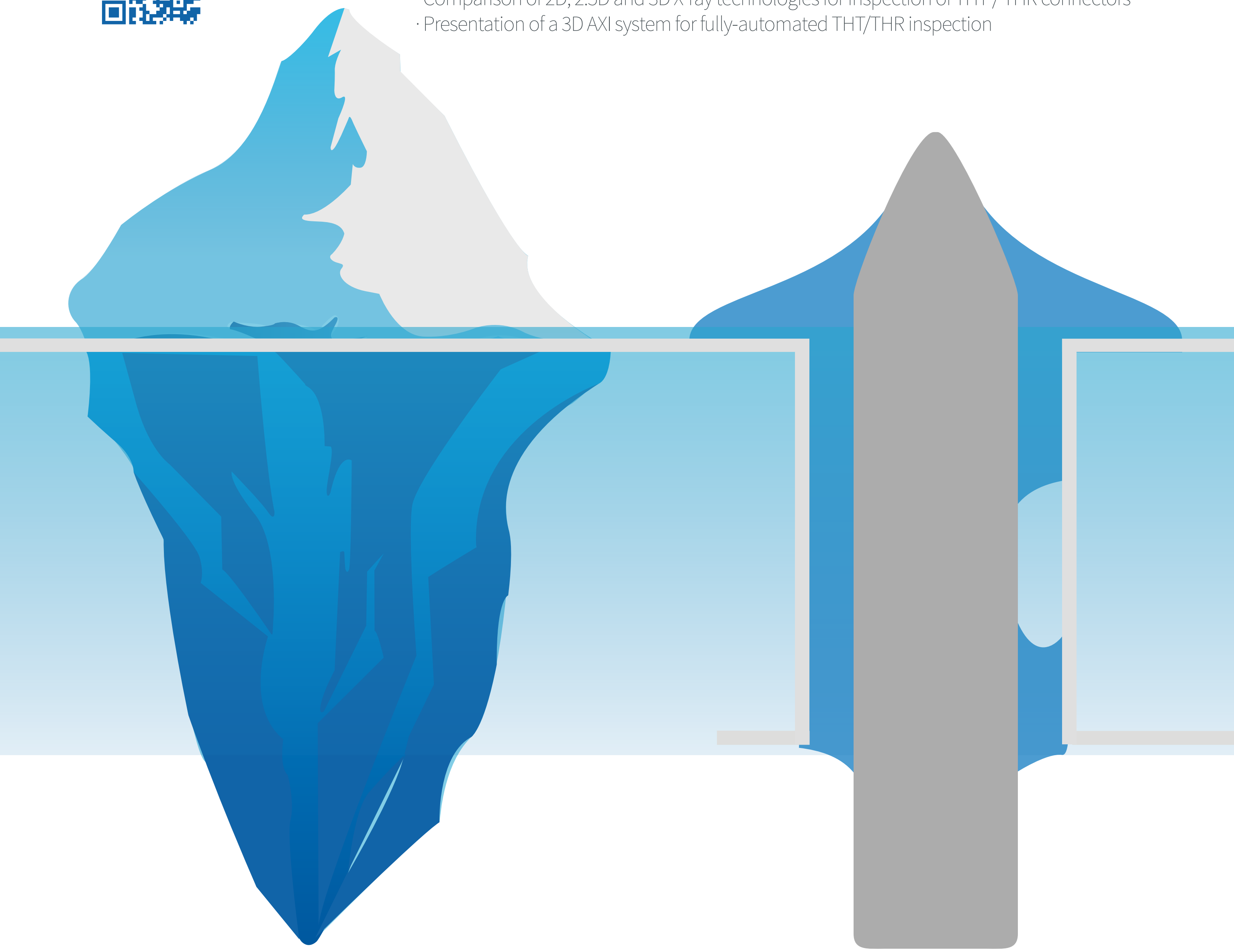

Jetting Strategies for mBGAs: A Question of Give and Take

by Gustaf Mårtensson and Thomas Kurian
MICRONIC MYDATA AB

The demands on volume delivery and positioning accuracy for solder paste deposits are increasing as the size and complexity of circuits continue to develop in the electronics industry. Board designs that include advanced BGAs, CSPs with 0.4 mm and 0.3 mm pitch, as well as simpler 01005 and 008006 components, raise the bar for positioning demands and volume delivery for solder paste deposits. According to the iNEMI 2013 Roadmap, placement accuracy for these kinds of components will reach 6 sigma placement accuracy in X and Y of 30 µm by 2023[3]. This level of placement accuracy for components must be accompanied by a related accuracy for the deposit of solder paste and related fluids. Among the alternatives for the deposition of solder paste and other fluids on a PCB is jetting, which offers advantages concerning precise volume repeatability, software control and local volume control (Figure 1).

The ejection of fluid from a jetting head has been studied extensively for low-viscosity fluids. This research has naturally been driven by work related to inkjet printing[1]. The jetting of more complex fluids is challenging and the amount of research is limited. An interesting theoretical study on jetting in general was carried out by Clasen[3].

The goal of this study is to examine the effect of piezo actuation profile on deposit quality with respect to positioning, shape and satellite levels in order to achieve adequate deposition quality for applications such as 0.4 mm BGA.

Methods

The jetting for this study was performed with a MY500 jet printer. The jetting mechanism is based on the increase of pressure in a

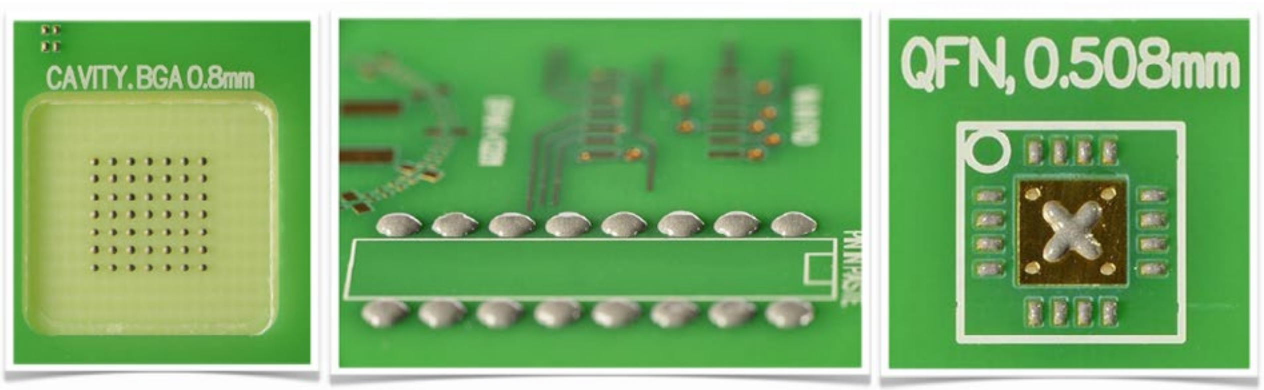

Figure 1: Example of jetting application of solder paste for various component types, such as BGA, pin-in-paste and QFN.

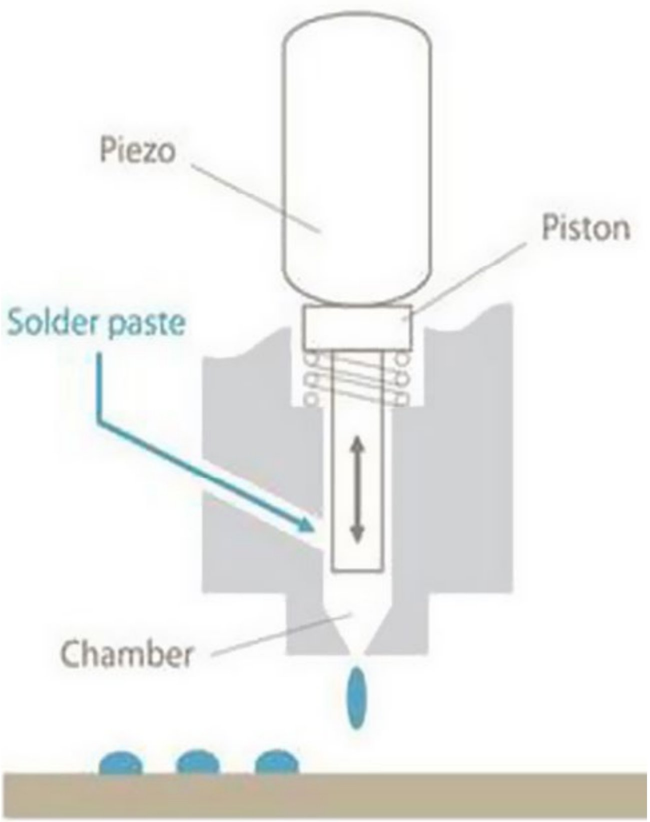

Figure 2: A schematic of the jetting device used in the test.

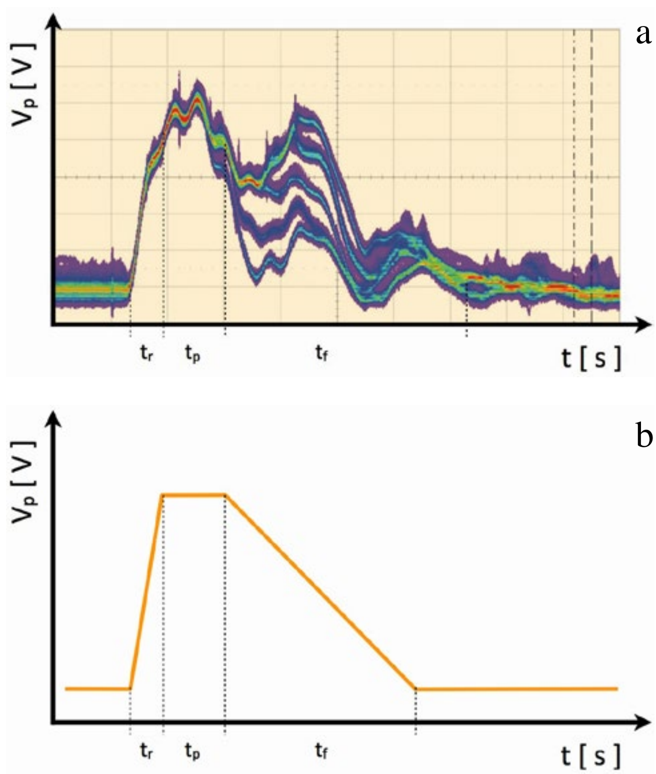

Figure 3 : An example of a) the time-dependent voltage applied to the piezo and b) a three-step signal with a given rise time, tr, plateau time, tp, and fall time, tf, as used in the study.

jetting chamber due to the movement of a piston induced by the expansion of a piezo-lamellae stack. A schematic of the jetting mechanism used in this study can be found in Figure 2.

The piezo actuation device is activated by an applied time-dependent voltage. This signal was originally controlled only by a rise time, tr, and plateau time, tp. An example of this actuation voltage can be seen in Figure 3a. The implementation of a new electronics control system enables an elaborate control of the signal with a choice of control points along the voltage signal. In the described study, a three-step signal with a given rise time, plateau time, and fall time, tf, is used to study the quality of jetting (Figure 3b).

The quality of jetting is judged using for qualities for each deposit, namely diameter, positioning, shape and satellite level. Figure 4 will be used as the basis for a description of the above-mentioned jetting qualities. In Figure 4, a circle is shown which represents an ideal perfectly circular deposit with diameter d. The irregular curve in Figure 4 represents an actual deposit. The area of the shaded area is used to extract an equivalent diameter for the deposit by using this equation,

$$d_{\text{eq}} = \sqrt{\frac{4A}{\pi}} \quad \text{Equation 1}$$

where A is the area of the deposit. The mass centrum for the area of the deposit is used to calculate the positioning deviation, ΔX and ΔY, for the expected position of the deposit on the substrate. The shape of the droplet is calculated by taking the norm of the radial difference of the deposits edge from a circle with the calculated equivalent diameter in accordance with the expression

$$s = \sqrt{\left(\sum_{i=1}^{n} \left|\Delta\left(r_i - \frac{d_{\text{eq}}}{2}\right)\right|^2\right)} \quad \text{Equation 2}$$

where ri is the local radius at a point on the periphery of the deposit and n is the number of points used along the periphery. Satellites are defined as free bodies outside the main deposit. The position and diameter of the satellites are registered in the same way as for the main deposit.

A type 5 lead-free SnAgCu 305 solder paste was utilized for the tests. For each combination of actuation parameters, tr, tp and tf, a set of three jobs consisting of X deposits each were jetted for four different deposit volumes. The volume of deposits for the jetting device is controlled by the amount of solder paste transported to the jetting chamber for each individual

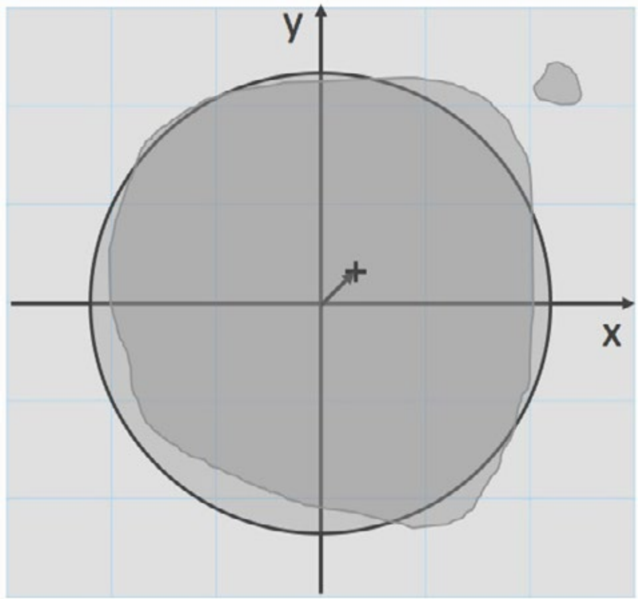

Figure 4: The quality of jetting is judged using for qualities for each deposit, namely diameter, positioning, shape and satellite level.

deposit. The jobs were jetted on a custom 230 mm x 317 mm substrate with spray-mounted photographic paper to enhance contrast for image processing purposes as well as to simplify cleaning.

Data evaluation was carried out using Matlab.

Results and Discussion

Among the most important criteria for any deposition of solder paste on a printed circuit board are positioning, deposit size, volume and volume uniformity. In Figure 5, the correlation of deposit diameter and positioning deviation as a function of piezo actuation profile is presented. Although the absolute values of diameter and positioning vary for the various piezo actuation profiles, the trend is clear in that positioning errors increase almost monotonically with decreasing droplet volume.

In Figure 6, the correlation of deposit diameter and satellite level as a function of piezo actuation profile is presented. The data here is not as clear as for the positioning deviation, which signals that we have a stronger dependence on the actual form of the actuation profile on the formation of satellites during the filament break-off process.

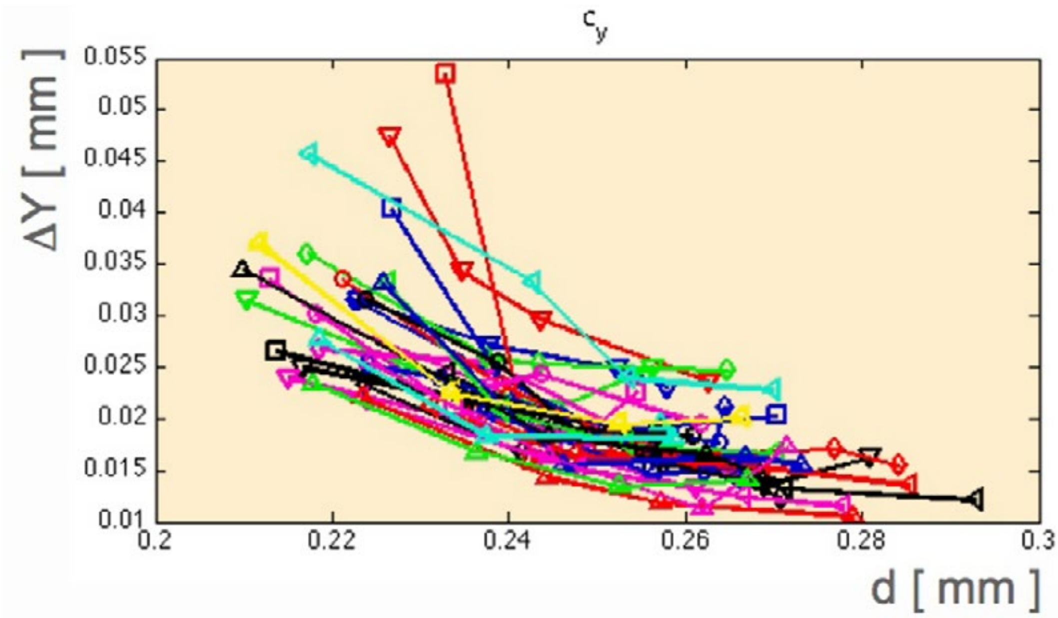

Figure 5: The correlation of deposit diameter and positioning deviation as a function of piezo actuation profile.

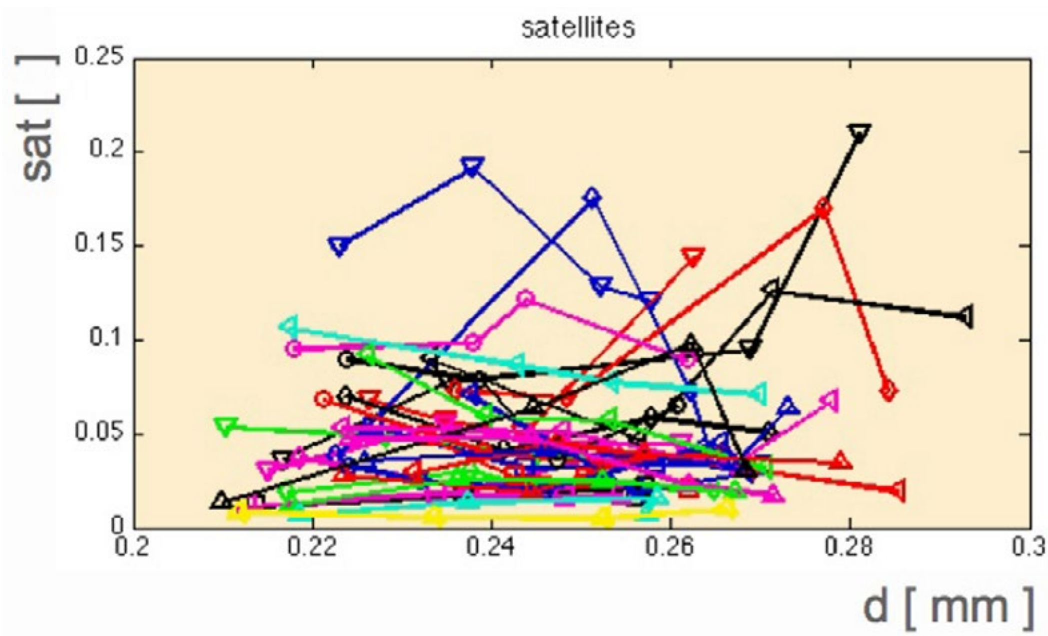

Figure 6: The correlation of deposit diameter and satellite level as a function of piezo actuation profile.

A number of the piezo actuation profiles suggest that there is a slight decrease in satellite level for smaller droplet volumes. In the context of these jetting experiments, satellites are primarily formed during the break-off process and not as a result of impact splashing[6]. A possible explanation for this behavior ties the increase in positioning deviation with the decreased production of satellites. The speed of the fluid during break-off will scale with the mass of the droplet, such that a smaller droplet will have a lower speed. The lower

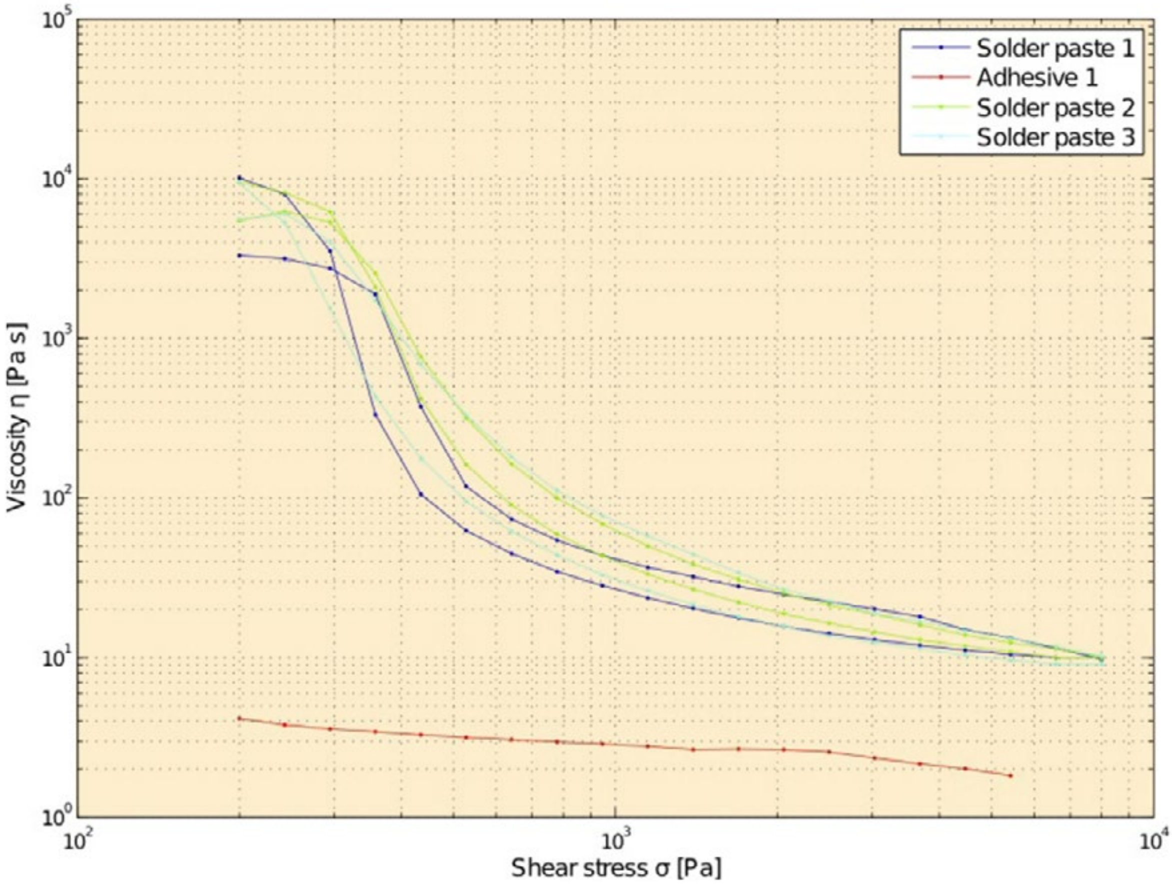

Figure 7: Viscosity of three solder pastes and an adhesive as a function of the local shear stress on the fluid.

speed of the mass of fluid during the break-off process will follow a more gradual passage through the three phases of filament break-off for a dense suspension controlled by inertia, viscosity and capillary forces, as described by Bonnoit[2], and thus decrease the probability of islands of suspension that will develop into satellites.

In the observations above, quantities have been obtained as statistical quantities of a large number of droplets. This is appropriate on one level, since the positioning error of any droplet must be ensured to some level of confidence. At the same time, it is essential to understand that the rheological qualities of jetting fluids are dependent not only on the local shear on the fluid, but also on a relaxation time scale of the fluid. A plot of the viscosity of the solder paste as a function of the local shear on the fluid is presented in Figure 7.

The relaxation time of the paste will primarily affect the first of a series of droplets as can be seen in Figure 8. The plot in Figure 8 shows the effect of various piezo actuation profiles on the evolution of deposit diameter in a number of strips consisting of 20 deposits. For this set of piezo actuation profiles, it is apparent that the behaviour of the diameter of the first deposit is insensitive to the choice of actuation profile. If an adjustment of the actuation profile is inadequate to maintain a constant deposit diameter throughout the entire strip, it is possible that a preferential actuation pattern for the first deposit could be used to attend to this strip property.

An example of jetting results for a 0.4 mm pitch uBGA can be seen in Figure 9. Although the photograph in Figure 9 only provides an aesthetic test of the jetting quality, a number of the quantified quantities described above can

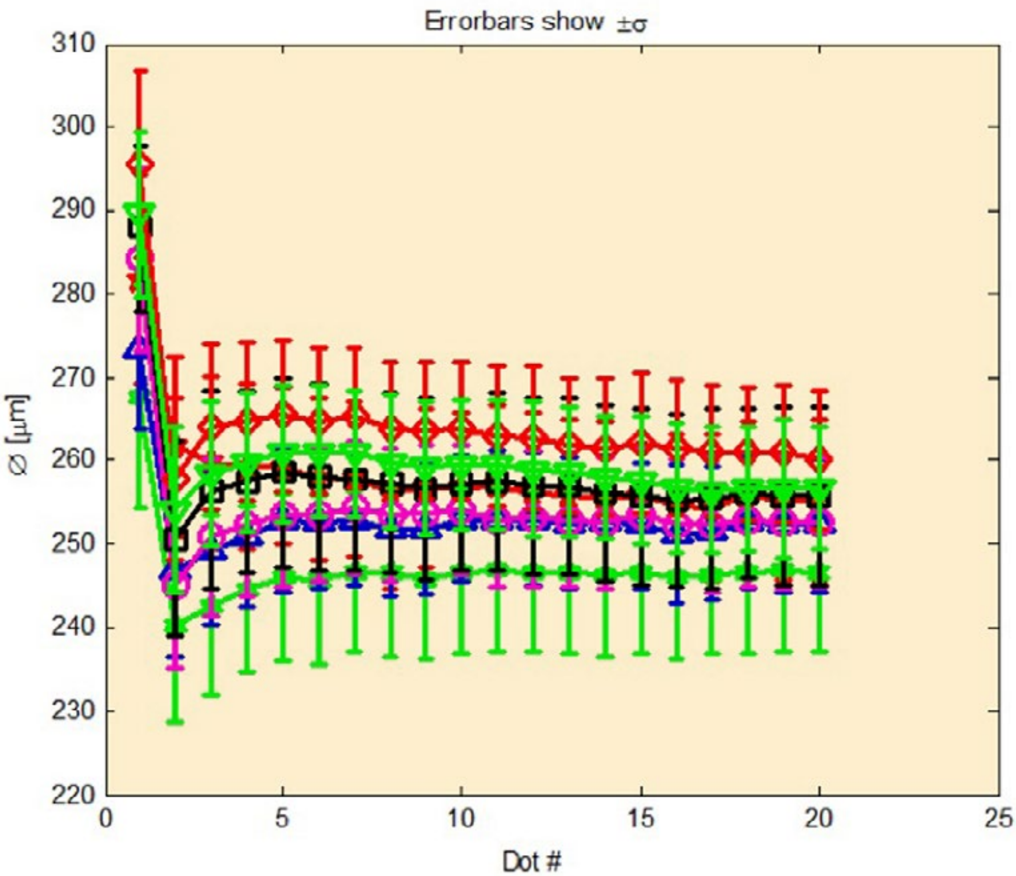

Figure 8: The effect of various piezo actuation profiles on the evolution of deposit diameter, Ø, as a function of deposit number, n.

be observed. Slight deviations in size for a number of the droplets can be observed and would result in a poor shape factor.

Summary

The demands on volume delivery and positioning accuracy for solder paste deposits are increasing as the size and complexity of circuits continue to develop in the electronics industry. This study attempts to understand the dependencies on piezo actuation pulse profile on jetting deposit quality, especially focused on positioning, satellites and shape. The correlation of deposit diameter and positioning deviation as a function of piezo actuation profile shows that positioning error for deposits increase almost monotonically with decreasing droplet volume irrespective of the piezo actuation profile. The trends for shape and satellite levels are not as clear and demand further study. The insights

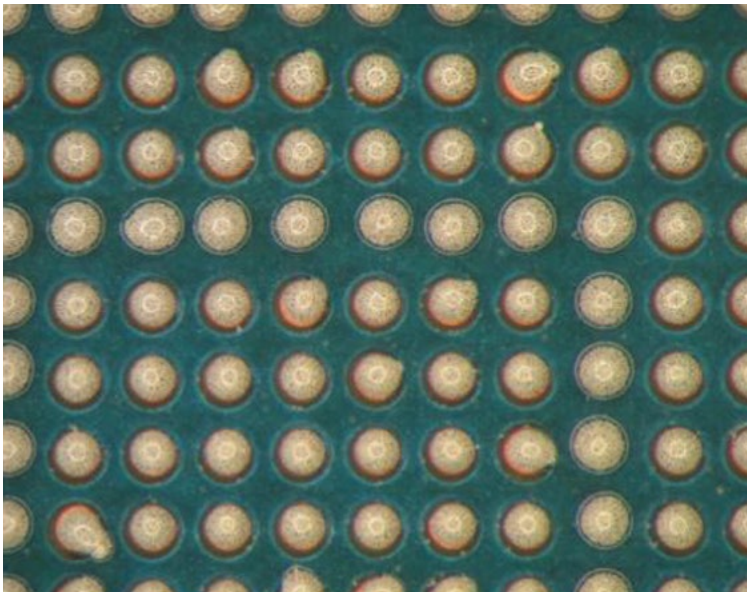

Figure 9: Example of jetting deposits on 0.4 mm BGA with 250 µm pad size.

gained above indicate that reaching deposit specifications becomes a game of give and take; smaller deposits introduce slightly larger positioning uncertainty, while increased positioning accuracy demands slightly larger deposits. The game will be won by the combination that ensures process quality. **SMT**

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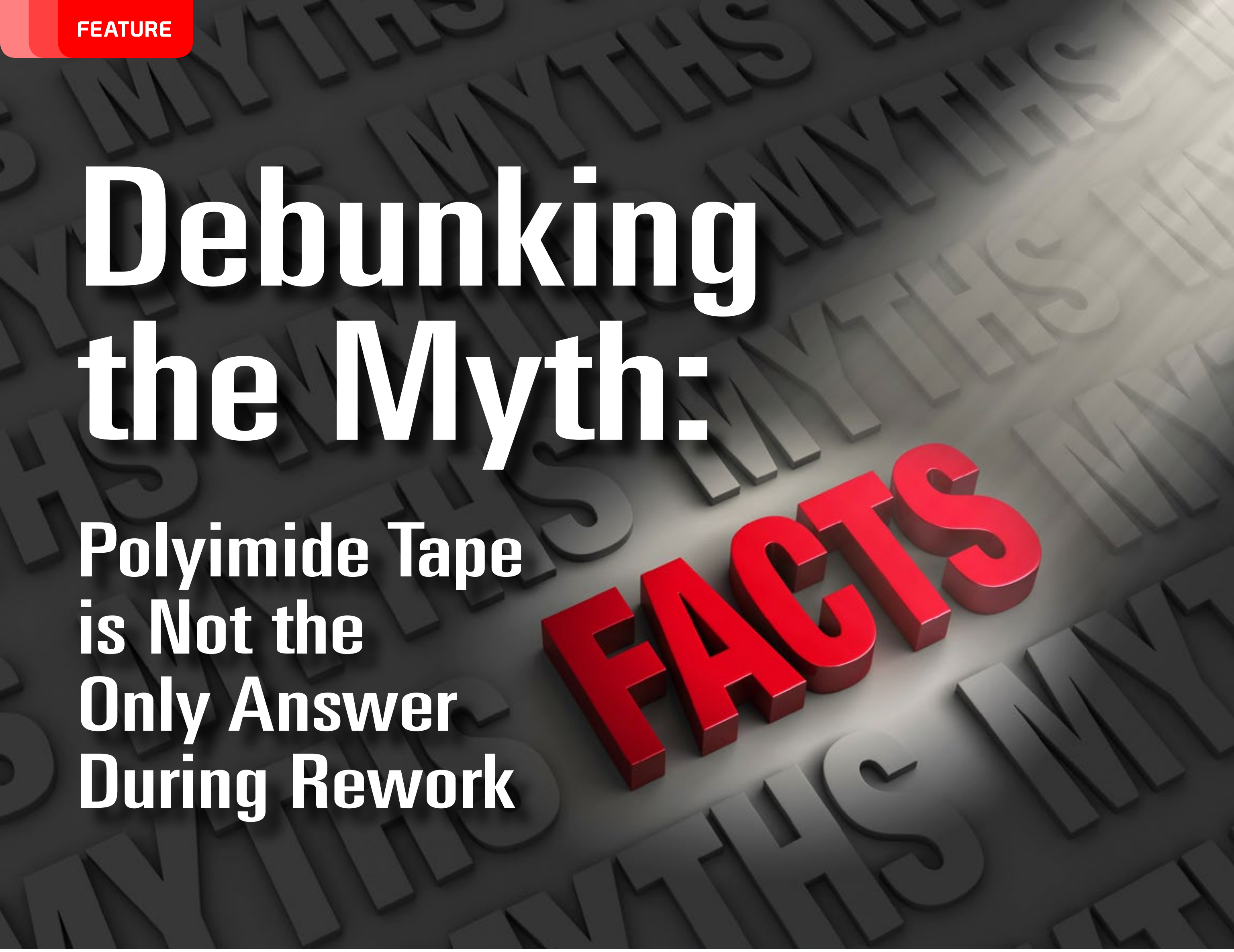
VIDEO INTERVIEW

High-End Assembly Requirements for Precision Dispensing

by Real Time with... IPC APEX EXPO 2015

Dispensing is the cost-effective solution for repeatably placing precise amounts of underfills, encapsulants and sealants in otherwise inaccessible areas as packaging complexity increases, particularly in the third dimension. Brian Chung sees mobile and wearable electronics driving the leading edge of precision dispensing technology.

realtimewith.com



Debunking the Myth:

Polyimide Tape is Not the Only Answer During Rework

by Bob Wettermann
BEST INC.

Some urban legends or myths have been developed over time to where they almost become "true" without any real basis in fact. For example, urban legend has it that Walt Disney wanted so much to finish the projects prior to his death that he had himself (or some believe just his head) cryogenically frozen so that his cancer could be healed at some future date. The infamous "Nessy" of Loch Ness monster fame was photographed showing a head and neck in the "physician's photograph" purporting that a sea monster or previously thought to be extinct dinosaur lives in a deep inland lake in Scotland. The electronics manufacturing industry has its own myth in polyimide tape being the most effective way to shield neighboring components from heat exposure. Legend has it that this thin, adhesive-backed "protector" will shield components from damage.

Within the last year we undertook an experiment to determine how effective different materials including polyimide tape would be in protecting neighboring devices during localized heating. This unwanted heating of components is driven by a desire to reduce neighboring component damage, to eliminate the need for removing components near the device being reworked which could be reflowed increasing the IMC layer thereby reducing the reliability of the interconnection. Historically, non-semiconductor components have been able to meet the heat withstand requirements of board assembly temperature conditions. For lead-free reflow, wave soldering components are qualified for 275°C for 10 seconds. Similarly, for SMT reflow soldering, components

Polyimide tape Type MT	304 Stainless	Copper	Ceramic Fiber	Cold Shield
0.37	≈18	379	0.14	Unknown

Figure 1: Thermal conductivity Watt/m K @ 330°C.

are typically qualified at 260°C for 40 seconds (though component body temperatures can reach 260°C during reflow).

This work examined the current state of shielding options that rework technicians have in protecting neighboring devices. The purpose of this study was to determine the shielding effectiveness by measuring the temperature at select neighboring devices based on a set distance from a rework source location. The options included polyimide tape, 304 stainless steel, and copper tape with an adhesive backing as common rework shielding materials. Non-traditional materials such as a ceramic non-woven fiber and an organic water/clay gel, both of which are utilized outside of the electronics industry, were also part of this study.

While protection against conductive heat transfer will have to be left up to the design engineers, shielding against radiation and convective heating sources is a function of the shield material properties. Shown below in Figure 1 is a list of the materials used in this study as well their respective thermal conductivity values at 300°C.

From the chart one would expect ceramic fiber to be the best performing thermal shield material.

There are a variety of materials (Figure 2), namely stainless steel, copper tape, polyimide tape, clay/water gel or a ceramic non-woven material which can shield the aforementioned heat energy from being transferred from the rework area to other areas of the PCB. Stainless steel metal shields are designed to shield a component from absorbing excessive heat either by dissipating, reflecting or simply absorbing the

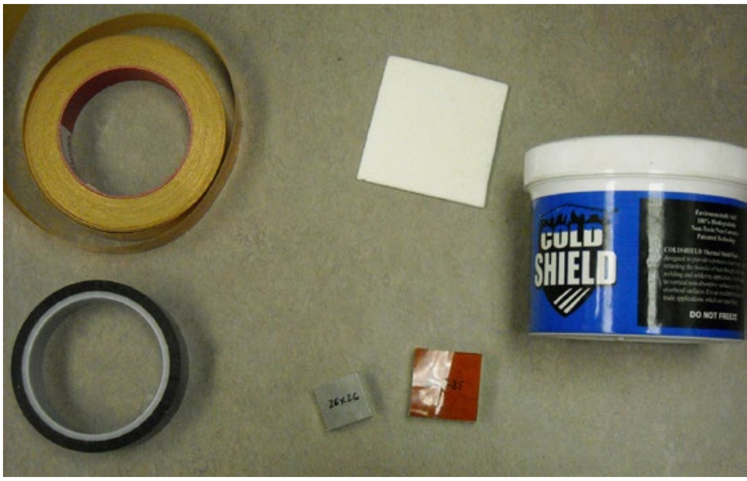


Figure 2: Materials used for shielding study, clockwise from upper left: copper tape, ceramic non-woven, clay/water, stainless steel and polyimide tape.

heat. The physical properties of stainless steel's reflectivity and emissivity, thermal conductivity and specific heat capacity make it the ideal material for the fabrication of heat shields. The copper tape allows the copper shield to be flexible and be easily applied to a PCB in the rework area. The adhesive side allows it to adhere to a board surface and stay tacked down. Polyimide tape is the most commonly used (and misused) methodology for masking areas on a PCB. The ability of polyimide tape to maintain excellent physical, electrical, and mechanical properties over a wide temperature range makes it an ideal "duct tape" for the PCB assembly industry. The one drawback with this material is its relatively poor thermal insulation properties. The clay/water gel shielding material is a product which

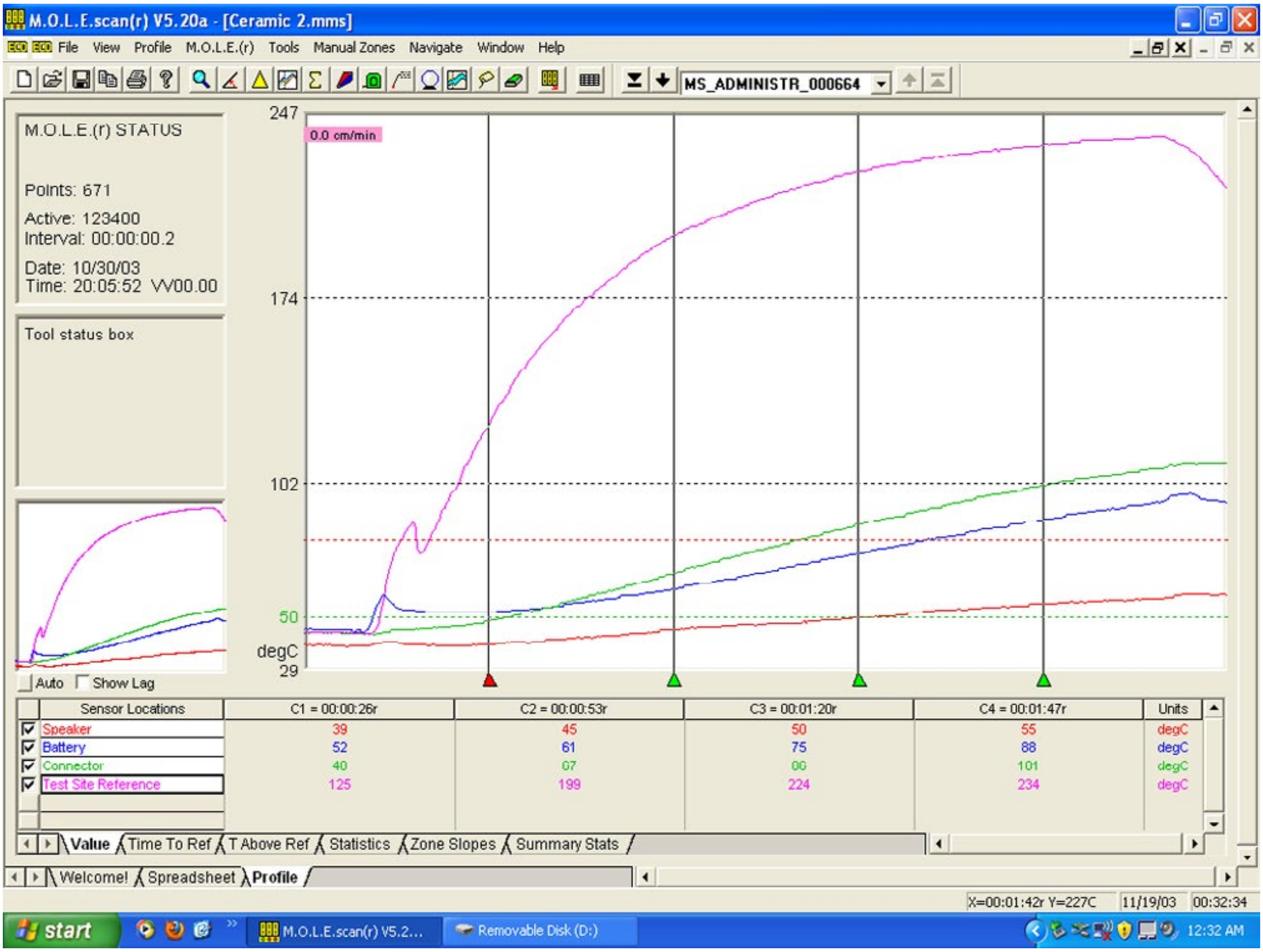


Figure 3: Sample output reflow profile.

has been used in welding applications due to its extreme resistance to heat. The gel contains deionized water and clay. The product is easily applied and, due to its consistency, able to work its way into small spaces on a PCB. The gel residue can simply be "washed off" using water. Ceramic fiber non-woven shields, previously relegated to aerospace, nuclear energy and high temperature processing industrial environments, offer users several properties which makes it well-suited for PCB rework shielding. This ceramic fiber material offers several advantages including the properties of high-temperature stability, low thermal conductivity, high heat reflectance and the ability to be easily wrapped and cut to shape. These final (2) materials are not commonly used in the PCB assembly area but are new materials requiring further testing of their impact.

Experimental Procedure

In order to determine the thermal shielding effectiveness of various materials, a controlled heat source simulating a rework process was placed onto an IC reference site of a (10) layer mixed technology printed circuit board. The board was fabricated with a SAC305 solder alloy with a HASL finish. A reference site component (U3) was then chosen as the sample rework location. It was not connected to the same copper layer as the components of interest. Various heat-sensitive components on the board were then identified, and the distance from the reference site to these locations was measured with a pair of calibrated calipers. A five-minute reflow profile with a peak profile temperature of 230°C was applied at the reference site location.

Four Omega type K thermocouples were attached to heat-sensitive components in the vicinity of the reference IC site. The thermocouples were connected to a MOLE scan thermal profile scanning system and profiles were developed for each of the five trials per part. The first shield tested was a stainless steel 304 formed rectangular open box shields of sizes 38 x 38 mm (polyimide tape coated) and 26 x 26 mm. The second, product number 1650 Venture Tape, was a copper based shielding tape. Next, a ceramic fiber heat shield was used. Polyimide tape was used to hold one 38 x 38 mm and one 38 x 76 piece a ceramic material in place. Polyimide tape of one-inch in width and 3 mils in thickness was then used by itself as a shield. A control condition with no shielding followed. Each material including the control was heated five times for a total of 25 heating cycles. A sample profile is found in Figure 3.

The board was first placed on a board holder as part of a hot air system used for the trials. The wires were placed on a speaker, connector, battery, and the IC reference site location (Figure 4).

The ceramic fiber heat shield was then held in place on the board using a polyimide tape in order to protect the connector, battery, and speaker (Figure 5). Copper tape was then applied. Next, polyimide tape alone was applied liberally and used as the only shielding material for one of the trials. Stainless steel 304 open-ended "boxes" were used to shield components. A gel type heat shield made of clay and water was easiest to work into the board spaces. After heating, the gel left a whitish gray

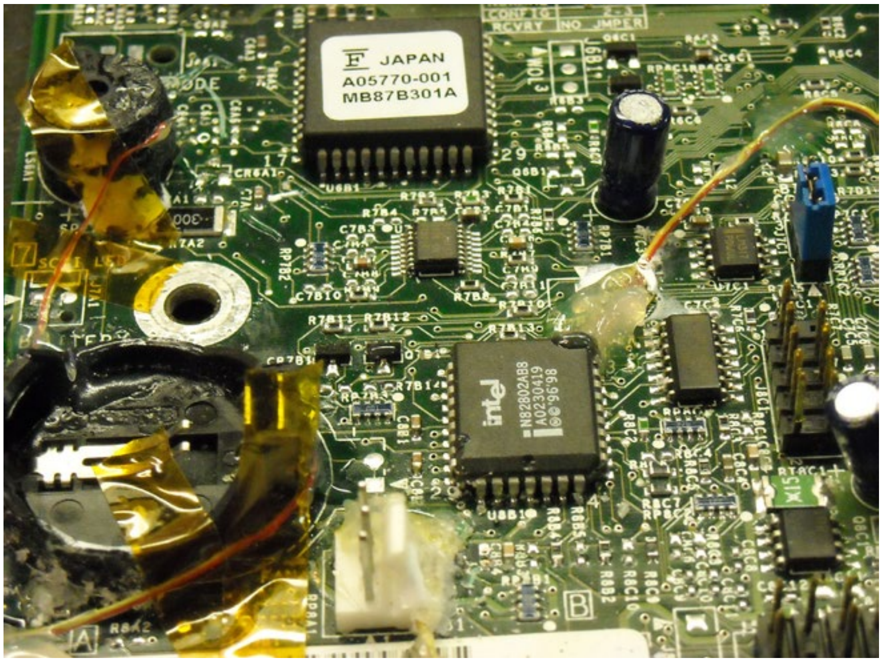


Figure 4: Locations on PCB where temperature measurements were taken.

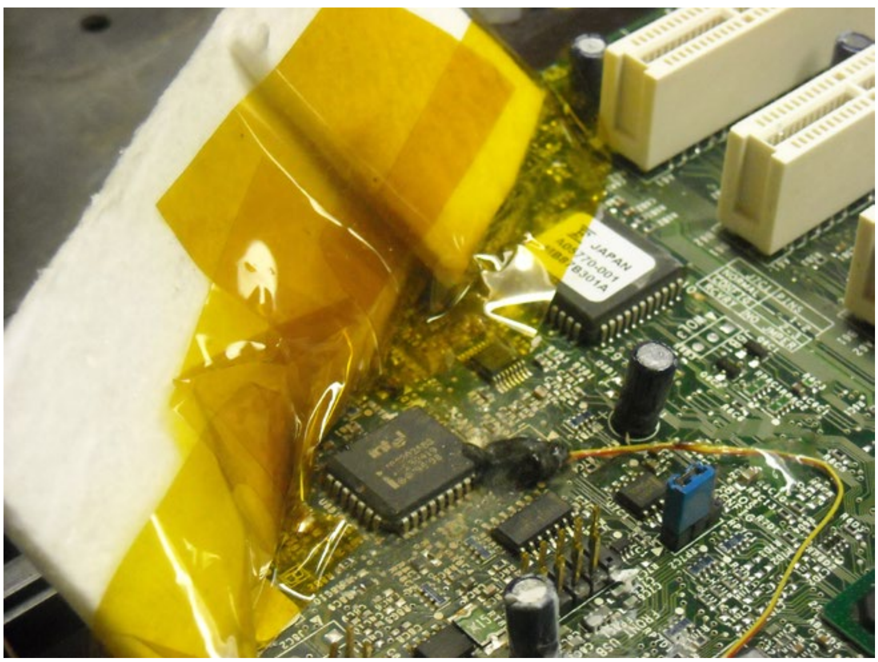


Figure 5: Ceramic non-woven fiber heat shields affixed to different board locations.

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ITI & IPC Conference on Emerging & Critical Environmental Product Requirements
Milpitas, CA, USA (San Jose area)

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October 13
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Essen, Germany
Discussion with international experts on regulatory issues

October 13–15
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Questions? Contact IPC registration staff at registration@ipc.org or +1 847-597-2861

Test Site	Speaker	Battery	Connector	Test Site IC
Distance from test IC	30.95 mm	9.73 mm	6.14 mm	
Control (no shields)	123° C	227° C	173° C	232° C
Copper Tape	106° C	129° C	128° C	232° C
Stainless Steel	61° C	158° C	143° C	239° C
Clay/Water Gel	66° C	89° C	86° C	231° C
Polyimide Tape™	99° C	145° C	153° C	241° C
Ceramic Fiber	63° C	111° C	113° C	231° C

Figure 6: Maximum temperature for various shielding materials at select locations on a PCB.

residue on the board. This was easily cleaned with alcohol and a soft brush.

Results and Analysis

The temperature measurements below are for each of the shielding materials with the reference IC temperatures between 232–240ºC for an accurate comparison.

Conclusion

Through the repeated measurement of outlying component temperatures during the reflow process, the clay/water gel (as seen in this YouTube video) was determined to be the best performing heat shield material. More testing, however, is needed to prove its suitability for electronics manufacturing (ionic cleanliness, SIR and reliability testing). The best performing material that would have little impact on the electronic assembly was the ceramic fiber material. The next closest performing materials in order were the copper tape, stainless steel, and polyimide tape. Polyimide tape simply lacked the thickness and thermal resistance and was found to be the least effective shielding material thereby debunking the myth that this is the best material to use for PCB rework shielding. **SMT**

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Thanks to Adam Gaynor, EE student at Miami of Ohio who performed the experiments for this work.

Bob Wettermann is the quality manager of BEST Inc.

Electronics Industry News
Market Highlights

Gartner: Smartphone Sales Tops One Billion Units in 2014

Worldwide sales of smartphones to end users had a record fourth quarter of 2014 with an increase of 29.9% from fourth quarter of 2013 to reach 367.5 million units, according to Gartner, Inc. Samsung lost the No. 1 spot to Apple in the global smartphone market in the fourth quarter of 2014.

Wearable Tech Market to Reach $70B by 2025

There will be over 3 billion sensors in wearable technology devices by 2025, with more than 30% being emerging sensor types. Wearable Sensors 2015–2025: Market Forecasts, Technologies, Players is a brand new IDTechEx report which provides the only up-to-date and specially tailored analysis of every prominent sensor type for wearable technology.

China Eyes Bigger Share in Mobile Phone Display Market

According to a new report from IHS, the leading global source for critical information and insight, Chinese display module makers have resolved to increase their share of global mobile-phone display shipments. In Q3 of 2014, BOE unseated Samsung Display to become the leading global mobile phone display module supplier.

WLAN Market Witnessed Sluggish Growth in Q4 2014

According to the results published in the International Data Corporation (IDC) Worldwide Quarterly WLAN Tracker, the enterprise segment continued to grow at a steady rate and increased another 7.4% over the same period last year. After an uptick in year-over-year growth in 3Q14 (9.4%), the enterprise WLAN market growth rate resumed a pattern of incremental growth rate decreases.

Passive Optical Components Market to Hit $38B by 2019

The report states that the worldwide market for passive optical components stood at US$10.01 billion in 2013. Registering a CAGR of 21.1% from 2014–2020, the passive optical components market is projected to reach a total worth of US$38.19 billion by the end of 2020.

Transition to Welding Robotics is Inevitable

Modernisation needs in the competitive global market and the rising emphasis on energy efficiency are steering industries towards automation. This trend is driving the uptake of welding robots over manual welding methods.

$1.36T Market Potential of Increased Digitization

The increased use of digital technologies could boost productivity for the world's top 10 economies and add US$1.36 trillion to their total economic output in 2020, according to a new study by Accenture. The study is based on the Accenture Digital Density Index, a tool that helps companies make better strategic investments based on granular measures of digital performance.

PMI Experienced Loss in 2014 but Expects Better 2015

Probe Manufacturing Inc. (PMI), a Product Development Accelerator providing engineering and manufacturing services to innovative technology companies reports sales of approximately $3,550,000 and gross profit margin of $920,000 for the year ended December 31, 2014.

Small Business Slows in February

U.S. small businesses added 15,000 new jobs in February, making for more than 910,000 jobs added since March 2010, but revenues per small business decreased by 0.2% in January, which translates to a decline of 1.8% when annualized, according to Intuit.

U.S. Economic Growth Seen to Continue

UCLA Anderson Forecast's first quarterly report for the U.S. economy says that the nation "looks like an island of stability in a very volatile world." The implication is that the U.S. is still on track for 3% GDP growth for the next two years, despite slow growth and currency devaluations throughout much of the rest of the developed world.

Reducing SMT Print Cycle Time: The Effects on Assembly Cost and Quality

by Mitch Holtzer
ALPHA

Models have been available for over 10 years showing how reduced stencil wiping frequency can lower print cycle time. More recently, solder paste formulations have been widely adapted that offer higher transfer efficiencies at small area ratios (<0.6) when subjected to higher sheer forces associated with faster squeegee speed and pressure over the stencil. A case history is presented below that shows how these two cycle time reducers increase throughput when the print step is the rate controller in an SMT process. Reduced print cycle time may not result in significant benefits for producers of complex SMT assemblies where hundreds or thousands of surface mount devices are being placed, unless a large investment in a sufficient number of in-line placement devices has been made.

As an example, using a relatively slow printing process on a large server board, a baseline print cycle time can be estimated. Using process inputs of a 50 mm (2 inches)/second squeegee speed, a card load/unload time of 30 seconds (including stencil snap off and squeegee vertical motion time), and a 20-second stencil cleaning cycle after each print, the cycle time is estimated to be 60 seconds. In Table 1 below, the inputs are in yellow, and the outputs are blue.

The 1,260 assemblies per day assume 100% yield, and three shifts with seven hours up-time per shift.

Assuming the panel size is constant and the panel load/unload time is fixed, as is the number of assemblies per panel, Table 2 shows what happens to throughput if only the squeegee speed is increased (from 50 mm (2 inches) to 100 mm (4 inches)/second, without decreasing the frequency of stencil cleaning. Cycle time is reduced by five seconds per board and daily throughput increases by 9.1%. Optimal squeegee speed for a modern solder paste could be even faster.

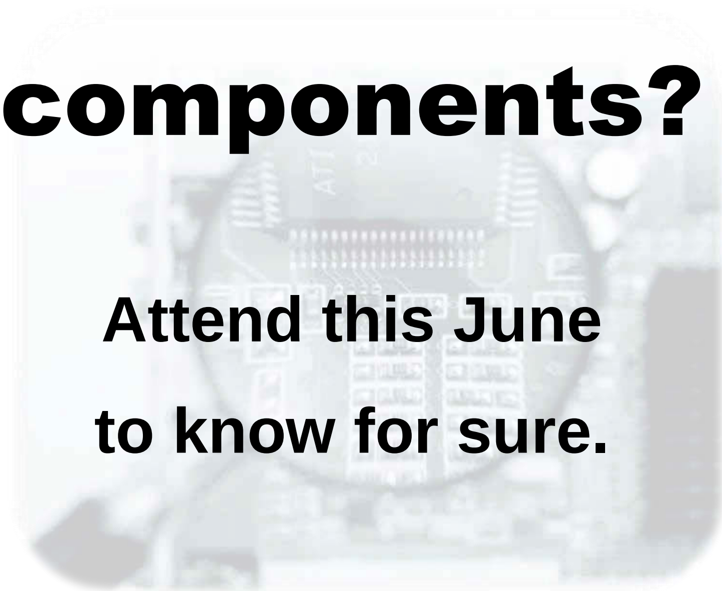
Table 3 examines the sensitivity of print cycle time as a function of stencil cleaning frequency. All inputs and assumptions from Table 1 are used, other than the number of prints between cleaning cycles. One can see that even with a relatively long cleaning cycle time, the returns diminish rapidly after eight prints/stencil cleaning.

Baseline Summary		
Print Cycle Time		**Unit of Measure**
Print Speed (Squeegee Speed)	50	mm/Second
Squeegee Travel Distance (Stroke)	500	mm
# of Prints between Stencil Cleaning Process	1	Prints
Stencil Cleaning Process Cycle Time	20	Seconds
Panel Load/Unload Time	30	Seconds
Number of Assemblies/Panel Printed	1	Boards/Panel
Minimum Print Cycle Time	60.0	Seconds
Potential Maximum Hourly Throughput	60	Assemblies/Hour
Potential Maximum Daily Throughput	1,260	Assemblies/Day

Table 1.

Symposium on Counterfeit Parts & Materials 2015

Do you know if you have legitimate components?



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Increased Squeegee Speed Only		
Print Cycle Time		**Unit of Measure**
Print Speed (Squeegee Speed)	100	mm/Second
Squeegee Travel Distance (Stroke)	500	mm
# of Prints between Stencil Cleaning Process	1	Prints
Stencil Cleaning Process Cycle Time	20	Seconds
Panel Load/Unload Time	30	Seconds
Number of Assemblies/Panel Printed	1	Boards/Panel
Minimum Print Cycle Time	55.0	Seconds
Potential Maximum Hourly Throughput	65	Assemblies/Hour
Potential Maximum Daily Throughput	1,375	Assemblies/Day

Table 2.

Case Study

A global OEM recently asked for a process audit to help reduce costs. Because of the nature of their assemblies and process equipment set, print cycle time was identified as their rate controlling step. The process manager reported that he was cleaning after each print cycle, using a 15-second wipe/dry vacuum process, and using a squeegee speed of 75 mm (3 inches)/second.

The assembler has 40 SMT lines and runs 16 shifts per week. Actual current output will not be disclosed in this article, but the ratios of throughput improvement are proportional. Table 4 shows how increasing squeegee

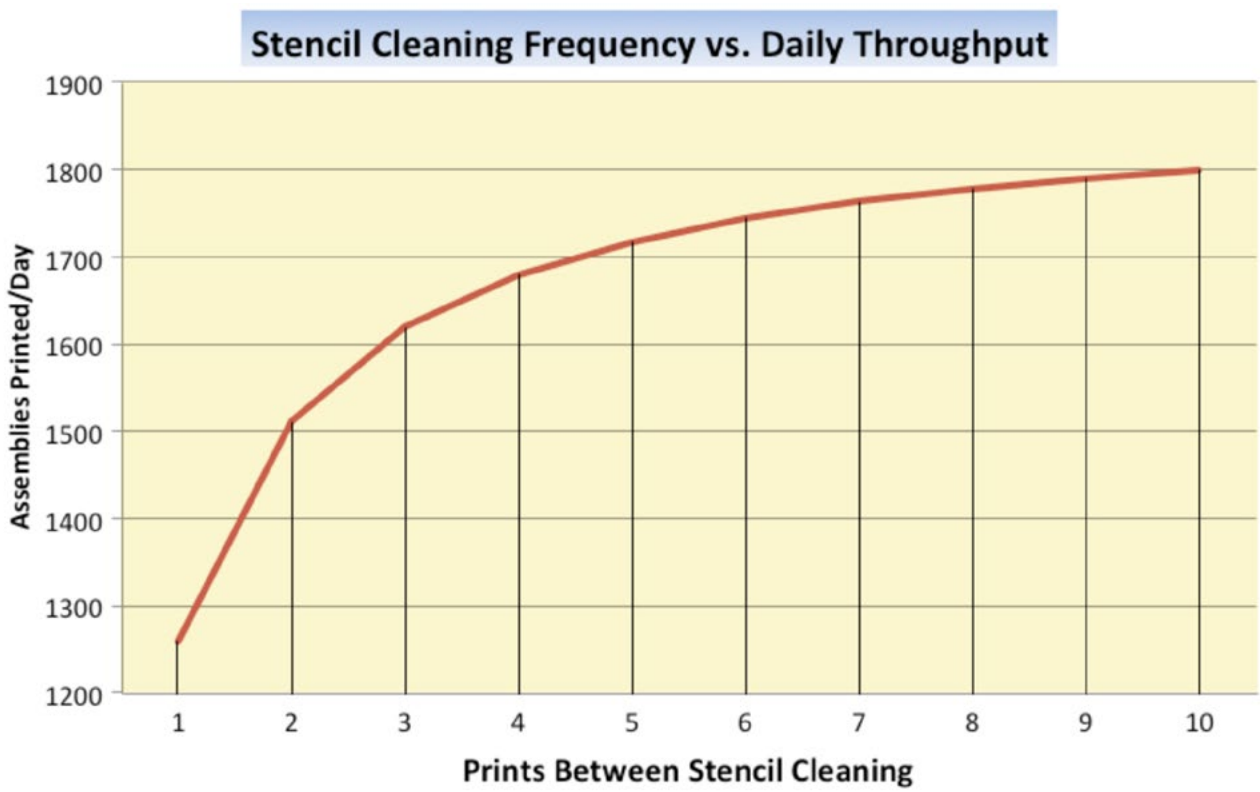

Table 3.

Increased Squeegee Speed Only		
Base Print Cycle Time		**Unit of Measure**
Print Speed (Squeegee Speed)	75	mm/Second
Squegee Travel Distance (Stroke)	333	mm
# of Prints between Stencil Cleaning Process	1	Prints
Stencil Cleaning Process Cycle Time	15	Seconds
Panel Load/Unload Time	30	Seconds
Number of Assemblies/Panel Printed	9	Boards/Panel
Minimum Print Cyle Time	49.4	Seconds
Potential Maximum Hourly Throughput	655	Assemblies/Hour
Potential Maximum Daily Throughput	13,762	Assemblies/Day

Reduced Print Cyle Time		
Reduced Print Cycle Time		**Unit of Measure**
Print Speed (Squeegee Speed)	150	mm/Second
Squegee Travel Distance (Stroke)	333	mm
# of Prints between Stencil Cleaning Process	6	Prints
Stencil Cleaning Process Cycle Time	15	Seconds
Panel Load/Unload Time	30	Seconds
Number of Assemblies/Panel Printed	9	Boards/Panel
Minimum Print Cyle Time	34.7	Seconds
Potential Maximum Hourly Throughput	933	Assemblies/Hour
Potential Maximum Daily Throughput	19,597	Assemblies/Day

Table 4.

speed and reducing wipe frequency to within the suggested window of a widely used solder paste can increase throughput in this example. Figure 4 shows a 42% reduction of print cycle time in this example.

Results and Discussion

Some argue that increased throughput only benefits an assembler if they can sell all they can make. This may be true for a single line contract manufacturer or a small OEM. However when a company has dozens of lines and works three shifts per day, six days a week, increased throughput can have a major effect.

Even if one assumed that a 20 SMT line factory could engineer a 5% increase in throughput by increasing the squeegee speed. This means that one line could be shut every week for preventative maintenance and calibration of the printer, solder paste inspection unit, pick-and-place equipment and the reflow ovens. I wonder how many factories would improve process capability with increased PM and calibration efficiency?

In addition, if one or two lines were down because they were not needed, less energy and labor would be required, proportional to the increase in throughput. Also, peak demands could be less difficult to fulfill during pre-launch and prior to the holiday seasons in the West and Asia.

These process improvements are being made by nimble, competitive and growing SMT assemblers. If your print process is the bottleneck in your throughput, and you are printing slowly and cleaning your stencils too frequently, there are opportunities for process improvement. **SMT**

Mitch Holtzer is global director of customer technical service (CTS) for Alpha. To reach Holtzer, click here.

SMT007 Supplier/New Product News Highlights

[Henkel Launches LOCTITE GC 10]
"Truly, this is the most exciting thing that's happened in solder materials development in decades," says Dr. Mark Currie, Henkel Global Product Manager for Solder Materials. "A material that has temperature stability from shipping all the way through to final assembly is a remarkable achievement."

Industrial Scientific Upgrades their AOI with MIRTEC
When it became clear some months ago that their AOI capabilities needed to be stepped up, the project proceeded in a fashion characteristic for the company. As SMT engineer Jeremy Goodman explained, "We are an employee-first organization; two key members of our evaluation team reviewing six potential vendors were line operators responsible for running the process."

Arrow Enters Agreement to Acquire immixGroup
"immixGroup shares our strategic focus on solution selling into the higher value segments of the data center and will bring us an expanded presence in the public sector market," said Michael J. Long, chairman, president, and chief executive officer of Arrow.

Mek Installs Fourth AOI System at Projects Concer
Mek (Marantz Business Electronics) has recently announced the installation of a fourth AOI system at Projects Concern Manufacturing. The Johannesburg-based EMS provider recently commissioned an iSpector HDL with Mek statistical control software including CS Center, Repair and Analyser. The system complements their existing three Mek systems.

Alpha Co-Chairs 2015 iNEMI Solid State Illumination Industry Roadmap
Alpha, the world leader in the production of electronic soldering and bonding materials is proud to announce that the Alpha Energy Technologies team co-chaired the 2015 iNEMI Solid State Illumination Roadmap. Gyan Dutt, technical marketing manager for LED, co-chaired the roadmap and Amit Patel, project management engineer for LED, led the section on LED Materials.

Nordson Reports Positive Q1 Results
Second quarter 2015 guidance: Sales expected to decrease in the range of down 5% to down 1%, inclusive of a negative 7% impact related to unfavorable currency translation, compared to same period a year ago; GAAP diluted EPS in the range of $0.80 to $0.90.

Ellsworth Europe Now Offers LC50 PB Mix & Dispense Machine
Ellsworth Adhesives Europe is pleased to confirm availability of the latest mix and dispense machine to hit the market—the LC50 PB from Fluid Research Ltd (formerly Liquid Control).

MIRTEC Honors Murray Percival with Prestigious Award
MIRTEC, "The Global Leader in Inspection Technology," announces that it has named the Murray Percival Company 'MIRTEC Manufacturers' Representative Organization of the Year 2014'. Brian D'Amico, president of MIRTEC Corp., presented the award to the company during the IPC APEX EXPO 2014 in San Diego, California.

Eckard Wendt Joins Alpha's Die Attach Sales Team for Europe
Alpha, the world leader in the production of electronic soldering materials, has announced the appointment of Eckard Wendt to the role of Die Attach Sales Manager for Central Europe.

Ellsworth Offers New Henkel Loctite Solder Paste
The electronics division of Henkel has just announced the launch of an innovative new temperature stable solder paste material, Loctite GC10, which can be ordered from Ellsworth Adhesives Europe.

SMART BUSINESS SOLUTIONS

Advanced Business Intelligence Systems are Not a Luxury

by Bill Moradkhan
PORTUS INC.

Recently, I saw an innocuous LinkedIn thread that eventually became the inspiration for this article. In the thread, one of my connections mentioned that he had read an article touting the features of a new software tool that allowed users to create interactive Excel spreadsheets and charts with real-time links to their underlying ERP systems data (I am not affiliated in any way with the company or solution that was being described). My contact had simply said something like "looks good" or "sounds powerful." It was the reply from one of his contacts that struck me. It stated something like, "looks good until you find out it costs $50,000." On the surface, this statement about the implied exorbitant price tag was a reflection of a cost conscious decision maker. Scratch under the surface and it is the perfect example of a pervasive strategic error that costs manufacturing companies many multiples of $50,000 annually.

The problem is that in those few words ("looks good until you find out it costs $50,000") the LinkedIn contributor had in effect conducted an ROI analysis on investing in the software tool. Manufacturing companies are experts in conducting ROI analyses when it comes to production equipment, but most of the analysts and executives who prepare and review ROI analyses do not approach the purchase of software solutions with the same rigor. To clarify this point further, not all software tools suffer this bias. If a piece of hardware or software will impact the production or engineering processes within the organization, an ROI is usually conducted. Investments in CAD tools and other DFM, DFT, and DFx enablers come to mind as great examples of software for which ROIs are explicitly or implicitly conducted as part of the purchasing process. However, if the software is a business intelligence or data analytics solution it is basically treated as an expense or luxury product where the decision amounts to "Should we splurge and get this expensive tool?"

The problem with this approach is that it ignores an undisputed fact: Business intelligence solutions bring efficiencies to an organization's most expensive and most influential functions. The irony here is significant. In effect, many companies are saying, we will spend countless hours poring over projections to analyze and justify adding a machine that will make our direct labor more efficient, but we will not invest in making our executives, operations analysts, financial analysts and supply chain professionals more efficient. Why is it acceptable to have executives wait for reports that drive key business decisions? Why is it acceptable to continue to drive business analysis and reporting in largely manual ways by

downloading information into Excel and spending many hours creating the final report that provides the key business insight, only to repeat the process a week later? What exacerbates the situation is that the information that is being sought is often time-critical and so being inefficient in obtaining the information is a double whammy.

Dig a little deeper and you will see more hidden dysfunctional effects of not having the right analytics solutions in your business. Frequently, underinvestment in such systems manifests itself in lack of consistency in analyzing key business metrics that need consistent attention. For example, managing excess and obsolete inventory is an important mainstay of a healthy manufacturing business. A healthy business should have an analysis of their excess and obsolete inventory available on a moment's notice with the necessary infrastructure in place to drill into any particular part number to study the dynamics that are driving its excess position. Too often, the process of putting this information together is so laborious and time consuming that businesses do not conduct the analysis often enough to minimize their exposure to excess inventory. So as an executive, ask yourself this question: If you became convinced that an advanced business intelligence solution would reduce your excess inventory by 10%, how much would that system be worth?

> "Well if investing in a system allows my resources to be 20% more efficient, I will not recognize any gain because I cannot reduce my headcount by 20%, so the savings are imaginary."

You don't need a dramatic example like excess inventory reduction to find value in an advanced business intelligence system. In a manufacturing environment, everyone from the operator on the floor to the president of the company will spend at least part of their day (for some functions the majority of their day) analyzing different part numbers. What if you could obtain real time information about all of the dynamics of a part number (inventory, orders, shortages, excess, approved manufacturers, etc.) 50% faster? The efficiency gain may come from a combination of not waiting as long for reports to run or running one report rather than having to run several reports and combining the result. What is the value of doing something that your organization does 300,000 times a year 50% faster?

This is an opportune time for me to debunk an old fashioned and severely flawed approach to investment analysis in general and ROI analyses in particular. This flawed reasoning goes along the lines of, "Well if investing in a system allows my resources to be 20% more efficient, I will not recognize any gain because I cannot reduce my headcount by 20%, so the savings are imaginary." Underlying this type of reasoning is a defeatist attitude that assumes a stagnant business that has no growth potential where economic gain can only be achieved through cost reductions. Making your workforce more efficient allows you to be prepared for new opportunities. It allows your people to get all of their tasks done, rather than focus on only the essential ones because there is no time to do the other important stuff. And it allows your professional work force to have bandwidth to look at process improvement and driving quality throughout your business.

Another ROI analysis mistake that pervades assessment of business intelligence solutions is comparing their costs to nothing (i.e., zero). The line of reasoning goes something like "we get the reports and analysis that we need now without this new wiz bang system, so why should we spend the money." This thought process is based on the false premise that the organization is currently producing reports at no cost. In fact, the time spent downloading information, organizing it, combining it and formatting it to be presentation-ready is significant and involves the efforts of multiple, often expensive resources. Add to this the factor that these efforts need to be repeated on a regular basis and the implicit investment in reporting is enormous. Remember this fundamental tenet of analytical processes: The time spent gathering, combining and organizing information is necessary but is 100% non-value add; only the decisions made based on that analysis are value add and drive change. Your strategy should be to automate the non-valued-added activities as much as possible and focus your resources on the value-added activities.

Perhaps the biggest reason to take a much more careful approach to your reporting and analytics systems is that more than ever they are a strategic imperative that drive customer satisfaction and healthy supplier relationships. In today's interconnected world, often times, the reporting and analysis are being produced for the customer. Your ability to produce the necessary information that is expected from your customers in an efficient manner with the proper depth to drive substantive discussions is a competitive imperative. If you are not able to satisfy your customer's needs for information you will engender a reputation of lacking proper controls or not running your business effectively. Similarly your ability to drive the desired behavior from your suppliers and other partners is largely based on your ability to supply them tangible information in a timely manner to make the case for a particular agenda. If you have more mastery over your data than your competitors, your customers will simply be more comfortable and confident in dealing with you, and your suppliers will better understand your expectations and requirements.

Not only is having advanced business intelligence and analytics systems not a luxury, it is a critical strategic imperative that should be approached with care and decisive action. Any investment in an analytics solution should be justified with an ROI analysis that balances the cost of the solution with the expected efficiency gain in your workforce, the impact to your business of making timely and better decisions, the gain in customer satisfaction and the improvement of your supplier relationships. **SMT**

Bill Moradkhan is the president at Portus Inc. To reach the author, click here.

Mil/Aero007
News Highlights

Frost Lauds Jabil's Excellence in Aero & Defense Industry

Despite the cutbacks in defense, Jabil's industry-specific suite of anti-counterfeit procedures, dedicated industry design expertise, and obsolescence management solutions have set the company apart from its peers. Its tailored solutions efficiently meet the niche and dynamic needs of the A&D industry with their quality, reliability, and cost-efficiency.

Kitron AS Secures F-35 Lightning II Contract

Kitron ASA's subsidiary Kitron AS will develop a test program set (TPS) for evaluating and troubleshooting F-35 Lightning II Joint Strike Fighter aircraft avionics under a four-year development contract awarded by Northrop Grumman Corporation. The contract has a total value of NOK 16 million.

Ducommun Nets $7.3M Tomahawk Cruise Missile Contract

Ducommun Incorporated has received contracts valued, in aggregate, at approximately $7.3 million from Raytheon to continue producing a variety of interconnect and electronic assemblies for the U.S. Navy's Tomahawk cruise missile through 2016.

Naprotek Earns ISO 13485, Recertifies to AS9100C

Naprotek, Inc. has received ISO 13485:2003 certification. The company also completed AS9100 Rev. C recertification. Its Registrar for ISO 13485 was TUV SUD America Inc., and for AS9100 it was NSF International Strategic Registrations.

API Technologies Appoints Tavares as President and CEO

API Technologies Corp., a leading provider of high-performance RF, microwave, millimeterwave, power, and security solutions, announced today that Robert Tavares has been named president and CEO, effective immediately.

Electronics Group Pulls Down Orbit's Q4 Results

Mitchell Binder, president and CEO, stated, "Our earnings for the quarter were adversely impacted by lower revenues at our Electronics Group which were attributable to weak bookings in the first half of 2014, which directly impacted delivery schedules in our fourth quarter."

Libra Industries Completes ISO Recertification Renewal

Mike Lynch, Libra Industries' Quality Manager, commented, "This renewal maintains Libra Industries' continuous approval of ISO certification since it was first achieved in March 1993. Libra Industries was one of the earliest ISO approved electronic contract manufacturers in the region."

Sparton, Ultra Electronics JV Nets $57M Sonobuoy Contract

Sparton Corporation and Ultra Electronics Holdings plc (ULE) announce the award of subcontracts valued at $57 million to their ERAPSCO joint venture, for the manufacture of sonobuoys for the United States Navy.

TT Electronics-IMS Facility Earns Nadcap Accreditation

TT Electronics Integrated Manufacturing Services (IMS) announces that its Fairford facility (formerly New Chapel Electronics Ltd) has received Nadcap accreditation for Electronics Cable and Harness Assemblies (AC7121).

Nortech Systems Posts Positive Q4, FY 2014 Results

"We're pleased with our increased net income for the year and increased sales in the fourth quarter," said Rich Wasielewski, Nortech Systems' president and CEO. "Sales to medical customers rose for the year, offsetting lower sales to defense customers."

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THE EDA TECHNOLOGY LEADER

To Be Lean is to Be Human

by Michael Ford
MENTOR GRAPHICS VALOR DIVISION

The concepts related to Lean thinking continue to be interpreted in different ways by different people. Relating what happens in real life with principles of Lean as applied to manufacturing can serve to demystify the subject, opening up appreciation and acceptance for the adoption of new Lean ideas in a way that is simple and non-threatening.

Let's take the example of queues, which have evolved naturally as a respectable alternative to a mad, free-for-all scramble. However, a queue for some people is a less-than-humanizing experience. They associate it with being driven like sheep or cattle, wasting precious time. Being stuck in queues is frustrating if the concept of queuing is abused.

For example, the number and frequency of people arriving at a postal office counter is variable, as is the time that each person will spend at the counter, depending on the transaction. The number of people who can be processed at the counter is relatively fixed by the number of counters that are open. If more people come in to the post office than the available counters, the queue grows longer. If fewer people come in, the queue grows shorter or disappears. The most efficient length of the queue is one person. If this was to stay constant, it would ensure that all counters were busy all of the time, at the same time, and that no one is needlessly waiting in line.

If we apply the principles of Lean thinking to the queue, the target should be to keep the queue size to one. The process has to be adjusted to achieve this with an uncontrolled input variable, in this example, the counter staff, to open or close windows dynamically. But rather than applying Lean principles to the post office worker's job, which is valid, we can look at process optimization from a higher level. Many

International Conference on Soldering and Reliability

May 19 – 21, 2015

Hilton Markham Suites

Markham, Ontario, Canada

SMTA Soldering and Reliability

www.smta.org/icsr

Conference Overview

Join us for the 9th annual International Conference on Soldering and Reliability. Materials as different as graphene, nanofibers and coatings will be discussed. Common topics like stencils for disparate-sized components, tin whiskers, head on pillow and specific reliability issues will be highlighted. RoHS initial implementation may be well behind us, but the implications are still resounding through our industry. There will be two sessions on lead free solders, with one concentrating on bismuth-containing possibilities. It will be an information-packed two days!

Workshops: May 19

Conference: May 20 – 21

Toronto Expo & Tech Forum: May 21

Keynote Address:

Electronic Industry Collaboration – Critical 21st Century Supply Chain Tools

Bill Bader
CEO, iNEMI

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such levels of any problem can be looked at simultaneously when applying Lean principles. In practice, however, the application of Lean to the different levels of the problem hits an imposed ceiling.

In our example, the resource to work the counters is limited in the short term by the number of counter staff present, unless the manager steps in at peak times. In the longer term, the post office does not want to employ staff if the budget does not allow it and their time will not be fully utilized. Fixed management principles get in the way of process improvement. The cost of having excess counter staff would be more significant to the business than the cost of the longer queues for extended periods throughout the day, the majority of which is borne by customers or the public infrastructure.

Applying this queue theory to a problem with a complexity similar to that of manufacturing is illustrated by a recent trip to the emergency room. The average waiting time to be seen was four hours, which has become normal in the United Kingdom. Instead of taking the four-hour wait, a suggestion was made to go and "take your chances" at a nearby Minor Injury Unit (MIU). Even a 30-minute drive each way sounded better than four hours queuing, so it seemed worth a try. The MIU was totally unlike the emergency room scenario. In, processed, X-rayed, splinted up and out in 20 minutes. Barely time to check any emails. Queue size: one. This was not unusual. The MIU deals with a focused range of issues, mainly suspected broken bones or minor burns. The staff, who are all nurses, simply deal with cases one by one like a simple production line. Even busy times do not seem to put a strain on the operation because the flow is continuous, similar to a high-volume SMT production line.

The key difference in the emergency room is the high mix of issues and severities. Someone who comes in with serious injuries will be moved to the front of the queue immediately. If there are many serious injuries coming in, waiting times for those with less serious conditions become open ended. The resulting sense of helplessness is significant for people, especially at a time when they are in pain and concerned about the effects of their injuries becoming worse. Some injuries also cause bottlenecks in the process because any key resource issue for one type of injury effectively blocks the processing of other patients, even those who are not dependent on that resource.

"Similar to the post office, if there are many people in the queue just there to buy stamps, then what they need is a stamp machine out front. The idea that everything and everyone needs to go through the same process becomes increasingly flawed as variation in the process increases."

This is a critical point. If the bottleneck is because there are no beds available for patients, then those who don't need them can be processed. Similar to the post office, if there are many people in the queue just there to buy stamps, then what they need is a stamp machine out front. The idea that everything and everyone needs to go through the same process becomes increasingly flawed as variation in the process increases.

Prioritization needs to evolve so that immediate requirements that may not be serious can be dealt with in parallel to those that are. In the emergency room, unlike that of the post office, the cost of inefficiency is born by the hospital. Consider the waiting room, large but full, with heating, lighting, toilet facilities, and cleaning expenses. The car park is completely full and people have to park in no-wait zones blocking access for essential services. Requests are put in to purchase more land for parking or to build a multi-story car park. A huge amount of resource that could be applied to taking care of people is actually spent on the excess infrastructure to support a wasteful system, when the majority of people attending the hospital at any one time need not be there.

The kinds of examples of the post-office counter and the visit to the emergency room have been experienced by most people, and so, whether or not people are actually thinking about the process at the time or not, we all know what it feels like.

The SMT factory has similar parallels. High-volume SMT manufacturing, when running, is efficient so long as what is being built satisfies the immediate delivery requirement. The reality, however, is that high-volume lines are often slowed down or stopped from time to time because the incoming demand for products, or "queue," of work varies, rendering them less productive. High-volume lines can keep producing at high efficiencies, of course, but the cost is to build high levels of stock, which often need to be stored for extended periods, costing space, management overhead, and potential depreciation. For lower volume, higher mix SMT production, process changeovers become the bottleneck, including the resources to change materials and feeders.

The latest challenge to SMT production is from increased demand volatility, when factory plans can suddenly change based on the customer updating the rate at which they will accept products. This new situation is closer to the post office and emergency room scenarios in which demand for services is increasingly unpredictable.

Can this level of unpredictability in the manufacturing environment be managed using Lean methods? Final assembly can often involve the use of Lean production cells, which can adapt more quickly to sudden customer changes in the requirements. The Lean pull system then propagates requirements through the operation, pulling materials to production cells and subassemblies from preceding processes, including SMT, and from there, materials to SMT machines.

The pull signal, however, is subject to the same issues as the post office queue—the significant variance and unpredictability will be propagated until the effects of fixed management principles appear. If the SMT processes are stable, the need for material supply and exchange will likely reduce. The effective queue of material supply jobs reduces or even for short periods may disappear altogether, like the scenario where the queue disappears at the post office counter. At other times, there may be many changes needed, which can overload the resources dedicated to material deliveries, which would be analogous to the queues going out of the door at the post office. In this case, the SMT machines could stop because of lack of materials.

Figure 1: You just know when your time is being wasted, so if you were the SMT production flow, how would you feel?

As with the post-office queue size of one, an optimum pull-volume ensures that all resources are effectively used with no delays of delivery to the requesting processes. This again brings us back to the critical point that a resource within a part of the supposedly Lean process becomes the bottleneck. The scope of this problem goes beyond SMT materials, and it includes all operations that interact using pull signals. In the

Lean factory, the pull system replaces the static production plan, enabling the factory to more easily make what is needed with reduced waste. As the factory moves toward increased flexibility, however, inevitable bottlenecks are exposed.

The solutions are likely to be different across different manufacturing operations in different sectors. The way to find solutions may not be as difficult as you might think. At the post office counter, the queue is there as a buffer to bring people to the counters in an orderly fashion, prioritizing requests for processing in a simple "first come, first served" way. When standing in a long line at the post office, many people will think that they should simply open another window. This would certainly help to reduce the queue until it went back down to a reasonable level.

In our SMT factory, additional materials operators could be allocated to react to pull signal requests for materials. However, people and their roles in production need to be more flexible so that there can be dynamic assignment to different roles as required, in the same way as the manager at the post office counter could open a window himself during busy periods. The same applies where machine processes are the bottleneck—automation needs to be flexible and as easy to change over as a human process.

Looking around a hospital, a post office, or an SMT operation in the factory, it is surprising that the major cause of lost opportunity and productivity is people. People themselves are not the problem; it is the constraints placed on them by the old-fashioned approach to roles to which they are assigned.

"Looking around a hospital, a post office, or an SMT operation in the factory, it is surprising that the major cause of lost opportunity and productivity is people. People themselves are not the problem; it is the constraints placed on them by the old-fashioned approach to roles to which they are assigned."

The key elements in our SMT factory, even the SMT machines themselves, have evolved to become extremely flexible. With the right process preparation software, production jobs can be allocated from line to line with ease. Common loading of feeders ensures that SMT machines can perform continuously, making a high mix of products as if they were high volume lines. Dynamic planning software can optimize short-term demand fluctuations so that these can be kept at optimum efficiency as new products come along and old ones reach end-of-life. These issues have already been discussed over the last six months or so. Having applied all of that, though, we are left with the fundamental human challenge.

The way in which Lean is applied going forward certainly needs to be expanded. It is no longer about the consideration of a process dedicated to making a part of a product while eliminating all of the waste in that process alone. The scope of the process definition needs to be expanded, not just to take in a single product on a single line or even a set of products sharing a common material setup, but to take into account the SMT operation as a whole—all products over all lines and supporting resources.

How much better would the experience be going to the post office counter with short queues, as the post office business took responsibility for the waste of time that they caused their customers?

Manufacturing in the future, faced with unpredictable and changing demands, may well start to resemble triage more than the near static factory models of today. The science of queuing, together with the application of Lean principles, is going to be significantly challenged. What has been regarded as the most flexible resource of all is the one that now needs to really be flexible, ensuring that essential pull system resources do not become the bottlenecks. **SMT**

Michael Ford is senior marketing development manager with Mentor Graphics Corporation Valor division. To read past columns, or to contact the author, click here.

TOP TEN

Recent Highlights from SMT007

1 Ready to Hire! Blackfox Provides IPC Class 3 Training to Veterans

I-Connect007 Publisher Barry Matties caught up with Al Dill, president and CEO of Blackfox Training Institute, for an in-depth discussion on Blackfox's expansion plans for North America (Tempe, Arizona and Guadalajara, Mexico) and Malaysia (Penang). Dill also describes the highly successful veteran's training program, which is being spearheaded at the Blackfox headquarters in Longmont, Colorado.

2 Advanced Printing for Microelectronic Packaging

The concept of dispensing a wide range of materials in three dimensions presents a potential change in electronic packaging. This article will cover the concept of combining dispensing technologies on a single platform to build integrated and monolithic electronic structural circuits.

3 Epec Takes U.S. Manufacturing to the Cloud

Epec has been utilizing cloud-based software since 2007, when it started expanding its supply chain into Asia. Epec quickly outgrew its old ERP system, which was making it difficult to exchange data with its partners. After evaluating several options, Epec selected NetSuite, which is still being used today as the company's standardized cloud platform to provide end-to-end manufacturing for all of its products.

4 IPC Opens Latest Statistical Programs

IPC's global statistical programs for the laminate, solder, process consumables and assembly equipment industries are now open to new participants for 2015. The deadline for IPC members to sign up is April 15. Participation is free to IPC-member companies as a benefit of membership.

5 Zentech's Matt Turpin Joins IPC's Committee

Zentech Manufacturing Inc. is pleased to announce that CEO and President, Matt Turpin, was appointed to the IPC Government Relations Steering Committee at the IPC Annual Meeting (APEX) in San Diego, California, in February.

6 Scanfil Expects Growth Momentum to Continue in 2015

Scanfil expects its turnover to increase by 2–8% in 2015. More turnover is generated in the second half than in the first half of the year. The company believes that its turnover will decrease slightly in the first half of the year, and particularly in the second quarter, compared to 2014. Its operating profit before non-recurring items for 2015 is expected to be EUR 13–17 million.

7 Venture's FY2014 Revenue Up 5.8%

For the financial year ended 31 December 2014, Venture Corporation registered a 5.8% year-on-year increase in revenue to S$2,465.5 million. All product segments except for Computer Peripherals & Data Storage registered revenue growth year-on-year with the Test & Measurement/Medical & Life Science/Others segment recording the highest revenue improvement.

8 Exception EMS Enhances Capability with Aegis MES

Mark O'Connor, CEO at Exception EMS said, "We've worked closely with Aegis across this implementation to create a system that fits our needs exactly, and those of our customers. Implementing FactoryLogix improves overall automation, increases traceability and fundamentally offers a real time view of every aspect of the production facility."

9 Cemtrex's Romanian Facility Earns ISO 9001:2008

Cemtrex Inc. today announced that its Romanian manufacturing center has recently completed its ISO 9001:2008 certification. ISO 9001:2008 sets out the criteria for a quality management system and is the only standard in the family that can be certified to.

10 Neways Posts Growth in 2014 amid Volatile EMS Market

Neways recorded net turnover of € 308.6 million in 2014, an increase of 16.5% compared with 2013 (€ 265.0 million). Net profit increased to € 7.0 million, from € 1.9 million in 2013. Net profit from ordinary operations came in at € 5.3 million in 2014, compared with € 4.7 million in 2013.

EVENTS

For the IPC's Calendar of Events, click here.

For the SMTA Calendar of Events, click here.

For the iNEMI Calendar, click here.

For a complete listing, check out *SMT Magazine's* full events calendar here.

Intermountain (Boise) Expo & Tech Forum
April 7, 2015
Boise, Idaho, USA

South East Asia Technical Training Conference on Electronics Assembly Technologies 2015
April 14–16, 2015
Penang, Malaysia

Atlanta 19th Annual Expo
April 15, 2015
Duluth, Georgia, USA

NEPCON China 2015
April 21–23, 2015
Shanghai, China

Printed Electronics Europe 2015
April 28–29, 2015
Berlin, Germany

Graphene and 2D Materials Europe
April 28–29, 2015
Berlin, Germany

Internet of Things Applications Europe 2015
April 28–29, 2015
Berlin, Germany

Wearable Technology Europe
April 28–29, 2015
Berlin, Germany

SMT Processes Certification
April 28–30, 2015
Kokomo, Indiana, USA

IMPACT 2015: IPC ON CAPITOL HILL
(IPC Members-only)
April 29–30, 2015
Washington, DC, USA

Michigan Expo & Tech Forum
May 5, 2015
Livonia, Michigan, USA

Oregon Expo & Tech Forum
May 5, 2015
Beaverton, Oregon, USA

Puget Sound Expo & Tech Forum
May 7, 2015
Bellevue, Washington, USA

Wisconsin Expo & Tech Forum
May 12, 2015
Milwaukee, Wisconsin, USA

IPC Technical Education
May 13–14, 2015
Fort Worth, TX, USA

International Conference on Soldering & Reliability 2015
May 19–21, 2015
Markham, Ontario, Canada

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MAY:
Paste Printing & Component Placement

JUNE:
Test & Inspection

JULY:
Supply Chain Management