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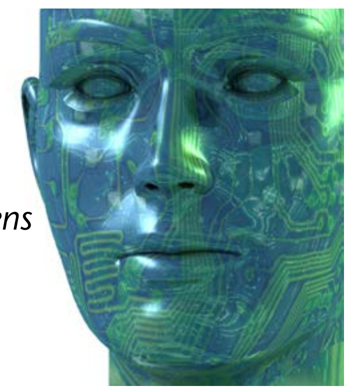

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THE WAY I SEE IT

Manufacturing Renaissance: For Show or For Real?

by Ray Rasmussen
I-CONNECT007

SUMMARY: It really never made sense to send most of our manufacturing to China. For some products, China was a no-brainer, but for many others it wasn't the lowest-cost producer. Now, more and more companies are figuring that out.

Apple's recent announcement that they'll be bringing back some manufacturing to the U.S. made headlines around the world. Market experts were quick to point out that the iMac mentioned by Apple CEO Tim Cook represents a very small piece of Apple's product portfolio and not a heck of a lot of volume. Although the comments by Cook caused quite a stir, it wasn't unexpected. Companies like Apple will do the right thing for their businesses. The decision was probably made to reduce shipping costs since some of the heaviest components (like the glass) are already made here, in the U.S. And, I suspect that most iMacs are sold here in the U.S., as well. I'm certain that whatever they do here in the States will likely be highly automated, making labor costs a non-issue. They'll probably save money on the deal so it's not an altruistic, support-American-jobs endeavor. Nor should it be.

Steve Jobs' famous comments to President Obama that the types of jobs created by assembly of the iPhones, iPads, iPods, etc., are never coming back is spot-on (although "never" is a long time). They won't come back and we don't want them. They aren't good for the economy or for American workers. If this type of manufacturing does return to North America we'll see factories filled with Foxconn's robots building them. And, as we've read over the last year or so, that will happen even in low-cost regions. Automation will be the great geographic playing-field leveler. It's going to remove labor from the equation.

Geography, Oil, and the Fukushima Effect

With labor becoming less and less of an issue, it's going to ultimately come down to the cost of moving components and then the final product to the assembly locations and end-markets. As factories around the world continue to drive the cost of labor out of their

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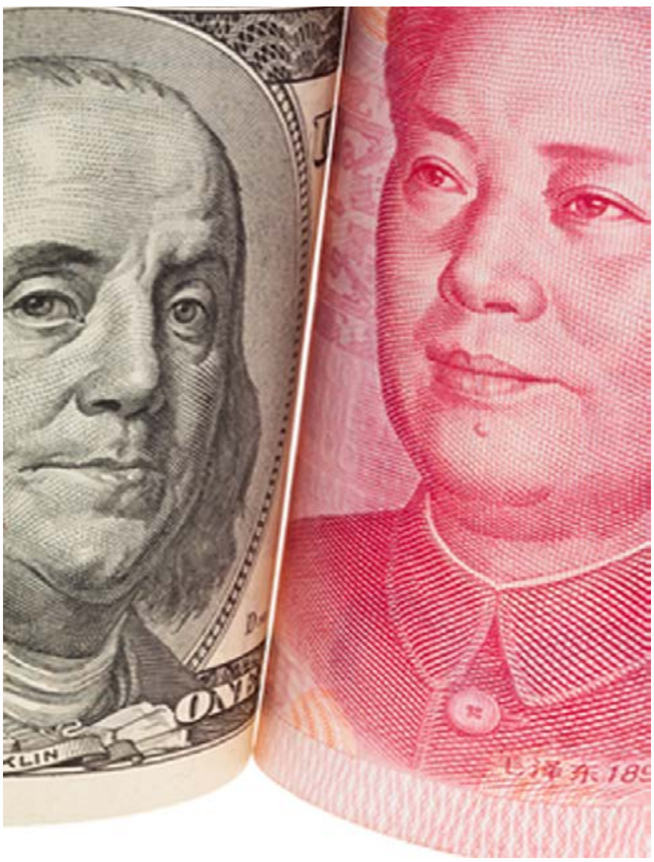
products, the location of final product assembly will ultimately come down to the cost and time associated with shipping. As supply chains relocate to support their OEM/EMS customers and to diversify their operations to avert the effects of disasters like Fukushima and the floods in Thailand, both of which disrupted the global supply chain, the supply base's location won't be a huge issue since all facets will be represented in all major geographical regions.

Flextronics CEO Mike McNamara said this recently about onshoring: "I think moving production back to the U.S. is a process, or it is a journey, almost. As our costs become pressured, it makes other choices more interesting. So, what that is going to do is probably push more work into Mexico. And, over time, as those costs continue to go up, you'll probably see more things get pushed back into the USA."

IPC's recent report about EMS companies returning to North America echoed McNamara's comments, mostly. The comments aren't reflective of some great renaissance of buy or build American; it's really just the markets doing their stuff. As the vacuum created by China fills (extremely low wages, costs and currency exchange rates giving way to normalized manufacturing costs), markets will tend to seek out balance. That balance is simply the market's way of leveling out and finding the lowest overall costs. For instance, much of the manufacturing in China will, more and more, service the Chinese and regional Asian markets just as European manufacturing will mostly serve the European market. The need for more secure, diversified supply chains will help move this along. Still, in regional markets, as we're seeing, manufacturing will flow into the lowest cost areas, i.e., Mexico for North America, Eastern Europe for Europe, South Asian countries for Asia, etc. The nice thing about being a global EMS provider is that they can turn on or off manufacturing as needed to take advantage of logistical or geographic opportunities to support their customers.



More Markets

As countries develop, they become targets for low-cost, regional manufacturing. The development of these markets creates many more consumers for the products we build. Just think about it. If we hadn't had the Chinese entry into the market in such a big way, there would be hundreds of millions of fewer consumers for electronic products. From Boeing, which predicts the need for 34,000 (not a typo) new planes over the next 20 years (7,400 in N.A. and the rest overseas) to Apple, sales would be dramatically less, leaving far fewer good paying jobs in the U.S. The World Bank said this about China's progress:

China's dramatic progress in reducing poverty over the past three decades is well known. More than 600 million people were lifted out of poverty as China's poverty rate fell from 84% in 1981 to 13% in 2008, as measured by the percentage of people living on the equivalent of US $1.25 or less per day, in 2005 purchasing price parity terms.

Those 600 million consumers are having quite an impact on the global economy and on the economy of the United States and Europe.

And, China is lifting most of Asia. I thought these comments, again, from the same World Bank report, were quite interesting:

> *Rapid economic ascendance has brought on many challenges as well, including high inequality; rapid urbanization; challenges to environmental sustainability; and external imbalances. China also faces demographic pressures related to an aging population and the internal migration of labor.*
>
> *Significant policy adjustments are required in order for China's growth to be sustainable. Experience shows that transitioning from middle-income to high-income status can be more difficult than moving up from low to middle income.*

Now, think beyond China. South Asia's countries have a population of about one billion and India has another billion. Those 2 billion people along with China's billion+ represent quite a few consumers for the sophisticated goods coming out of the developed world. The more cell phones they buy, the more cell towers and communications infrastructure they'll need along with medical services, banking, cars, computers, and more.

Another article in MIT's Technology Review, "Manufacturing in the Balance," talks about the future of manufacturing belonging to technology, leaving the decade of inexpensive labor behind. The article starts out with GE's expansion of their appliance manufacturing facility in Kentucky last year and repatriating their manufacturing from China and South Korea. GE's CEO Jeffrey Immelt addresses the major driver for their decision: "At a time when speed to market is everything, separating design and development from manufacturing didn't make sense. Outsourcing based only on labor costs is yesterday's model."

What blows me away is that a company the size of GE didn't get this until now. Hell, I could be their CEO. I wouldn't have made that mistake. Before shifting manufacturing to China I certainly would have carefully considered all my costs of product development and manufacturing.

> **“*There were scores of articles over the last decade by very competent groups trying to open the eyes of those rushing to China. Sure, for some products China was no-brainer, but for many others they weren't the lowest cost producer.*”**

We don't have to bring anything back to the U.S. It will come on its own, when it makes the most sense or when these companies come to their senses. It really never made sense to send most of our manufacturing to China. There were scores of articles over the last decade by very competent groups trying to open the eyes of those rushing to China. Sure, for some products China was a no-brainer, but for many others they weren't the lowest cost producer. Now, we're seeing more and more companies figuring that out.

I do believe that the longer low-cost manufacturing stays overseas and helps developing countries, employing future consumers, pulling people out of poverty, the better it is, ultimately, for us all. Leave the stuff that makes sense in those countries and bring the rest back.

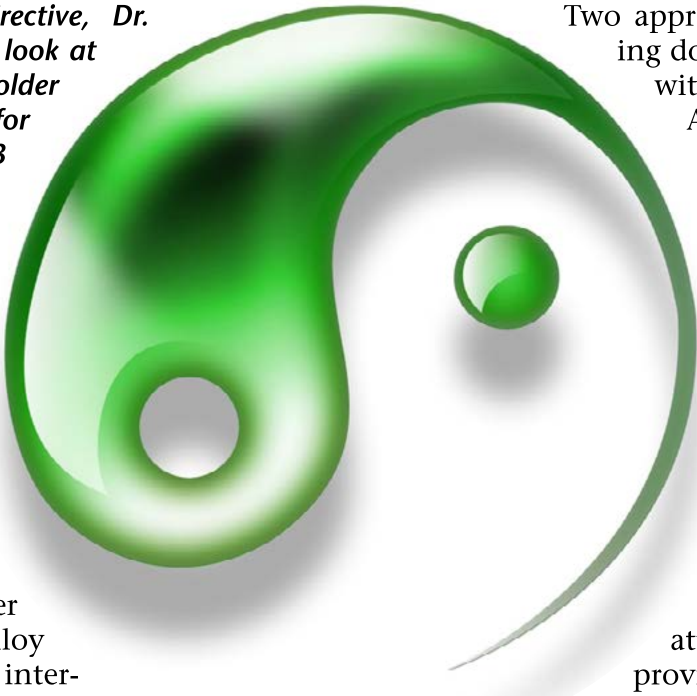
I know not everyone agrees with me on this, but if you're thinking short-term you'll miss the tremendous opportunity this affords the developed world. Look at the big picture, and position your business accordingly. If you don't, you'll spend most of your time complaining about low-cost competition instead of reaping the rewards of an expanding global market. **SMT**

Ray Rasmussen is the publisher and chief editor for I-Connect007 publications. He has worked in the industry since 1978 and is the former publisher and chief editor of CircuiTree Magazine. Contact Rasmussen here.

SAC System: A Revisit

by Dr. Jennie S. Hwang, ***CEO***
H-TECHNOLOGIES GROUP

SUMMARY: After a 10-year run, following the RoHS Directive, Dr. Jennie Hwang takes a look at SAC305, a lead-free solder interconnection alloy for IC packages and PCB assembly.



In compliance with the RoHS Directive initiated by the European Commission and later deployed globally, SAC305 (Sn3.0Ag0.5Cu) of SnAgCu (SAC) system has been used as a lead-free solder interconnection alloy for both second-level interconnection (e.g., IC packages) and the third-level interconnection (PCB board assembly) since the implementation of lead-free electronics.

Before the adoption of SAC305, other alloy systems outside SAC have been used (e.g., by lead-free pioneering Japanese electronics manufacturers in late 1990s). For a specific performance or other purposes, different alloys outside the SAC system have also been used in conjunction with SAC305 at OEMs' discretion. Nonetheless, SAC system has become widely known and the most prevalent alloy system.

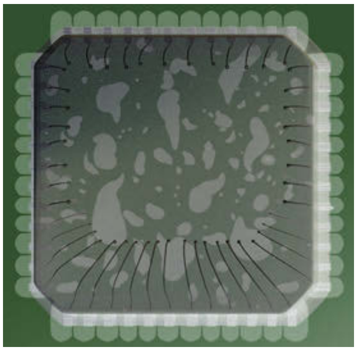
After a 10-year run, it is an opportune time to revisit SAC305, assessing its track record and its future.

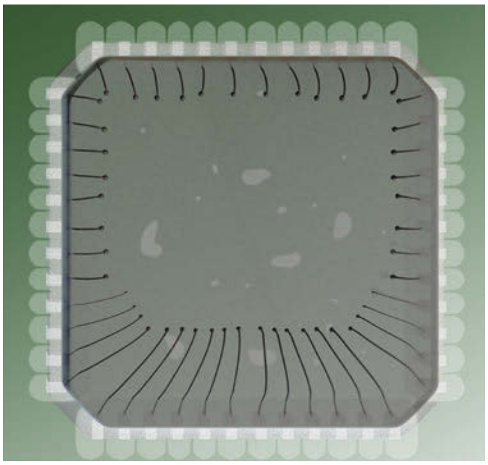
SAC System

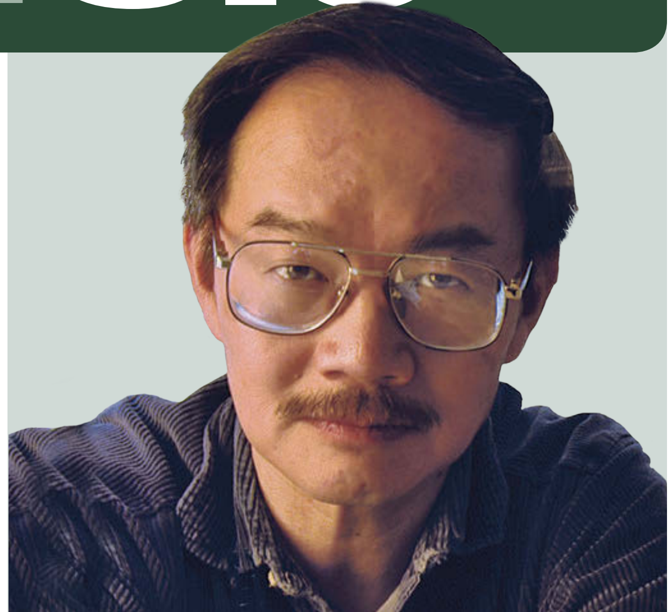
In addition to SAC305, the alloys within the SAC system have extended to various compositions during the past three years—some are far away from the composition of SAC305. Two approaches exist: One is adding doping elements to SAC305 with minor dosage shift in Ag or Cu or both; the other is reducing Ag content with minor shift of Cu content.

Compositions with Cu at 0.5 to 0.7% cover the range of Ag from 0.3 to 4.0%. Due to the near-eutectic nature of SAC305 (and SAC387, SAC405), the reduction of Ag from 3.0% results in an increase in melting temperature. The following table provides compositional examples and corresponding melting ranges (solidus and liquidus temperatures) in reference to SnCu eutectic, SnAg eutectic, and SnPb eutectic.

Alloy Composition	Measured Melting Range °C
SAC405	217-220
SAC387	217-220
SAC305	217-220
SAC105	217-227
SAC0807	217-227
SAC0307	218-229
Sn0.7Cu (E)	227
Sn0.7Cu+Ni, Ge	218-229
SnAg (E)	221
SnPb (E)	183







Performance Within SAC System: Expected Versus Actual

What is the performance track record of SAC305 and what is the impact of changing to the compositions containing the reduced Ag content? Relative to performance, the manufacturing process in making solder interconnections and the resulting solder joints' mechanical properties are two primary areas to be assessed.

SAC305 has performed to expectations, delivering satisfactory solder interconnections for most, but not all, application designs and service conditions, but with anticipated performance deficiencies. Specific deficiencies include the undesirable brittleness relative to SnPb counterpart and the potential occurrence of solder joint surface cracks.

One straightforward remedy to alleviate the brittleness of SAC305 is to reduce the Ag content, which consequently has lead to the introduction of low-Ag SAC alloy compositions. The compositions with reduced Ag content from the near-eutectic SAC305 result in an increased liquidus temperature. The increased liquidus temperature requires an increased process temperature in making interconnections at the package or board assembly level. Is the increase in process temperature a disadvantage? Yes, by any practical measures—all materials and components used in the assembly must have a higher temperature tolerance level in sync with the process temperature required.

"The increased liquidus temperature requires an increased process temperature in making interconnections at the package or board assembly level. Is the increase in process temperature a disadvantage? Yes, by any practical measures—all materials and components used in the assembly must have a higher temperature tolerance level in sync with the process temperature required."

As to mechanical properties of resulting solder joints, the yield strength, tensile strength, and creep resistance are expected to decrease with the reduction of Ag content. Within the ranges of Ag and Cu contents of this discussion, the fatigue resistance, which often involves more complex mechanisms, is also expected to decrease with the reduction of Ag content barring any extraneous factors.

Testing measurements coincide well with the expectations. For the effect of Ag content, at a range of 0.5 to 1.5% Cu, tests showed that yield strength and tensile strength increase almost linearly with Ag up to 4.1%; but its plasticity increases with decreasing Ag [1].

Despite some publications presented, the metallurgical principle stands. Test results show that the reduced Ag did not exhibit any downward performance. Lower strength is associated with lower Ag content. Apparently the reduced metal cost of the low-Ag compositions is an upside.

Relative Performance of SAC System Versus Non-SAC

What are the strengths and weaknesses of SAC system in comparison with non-SAC system for SMT applications? One appealing characteristic of SAC is its stability in relation to minor variations from the eutectic composition. Using the melting temperature as an example, the melting temperature of a near-eutectic composition is found to be not sensitive to the variation of Ag or Cu in the range of 0.5 to 1.5% Cu and Ag 3.0 to 4.1% Ag. Additionally, a good correlation exists between the mechanical properties and Ag content and Cu content, respectively.

Focusing on process requirements, it should be noted that the lowest melting temperature that the SAC system can achieve is 217°C. A superior system to SAC needs to carry a lower melting temperature than that of SAC305—desirably at a liquidus temperature between 183°C to 210°C. To achieve this lower liquidus temperature, it will have to resort to a quaternary alloy system.

Further, the intrinsic wetting ability of SAC system does not measure up to that of SnPb or SnCu. With SAC305's high liqiudus temperature, the tendency to use a process temperature below the desired temperature often leads to a marginal process, which aggravates the SAC305's lower wetting ability. In production, a marginal process should be avoided since it often causes production defects. **SMT**

Reference

1. Dr. Jennie S. Hwang, "Environment-friendly Electronics - Lead-free Technology," Chapter 8, Electrochemical Publications, Great Britain, ISBN-0 901 150 401.

Dr. Hwang will present a lecture on "Preventing Assembly Defects and Product Failures" at IPC APEX EXPO, February 18, 2013, in San Diego, California.

Dr. Hwang, a pioneer and longstanding contributor to SMT manufacturing since its inception as well as to the lead-free development, has helped improve production yield and solved challenging reliability issues. Among her many awards and honors, she has been inducted into the WIT International Hall of Fame, elected to the National Academy of Engineering and named an R&D Stars to Watch. Having held senior executive positions with Lockheed Martin Corporation, Sherwin Williams Co., SCM Corporation and IEM Corporation, she is currently CEO of H-Technologies Group providing business, technology and manufacturing solutions. She is a member of the U.S. Commerce Department's Export Council, and serves on the board of Fortune 500 NYSE companies and civic and university boards. She is the author of 350+ publications and several textbooks and an international speaker and author on trade, business, education and social issues. Her formal education includes four academic degrees, as well as the Harvard Business School Executive Program and Columbia University Corporate Governance Program. Contact her at (216) 577-3284; e-mail JennieHwang@aol.

Australian Researchers Print Materials for Soft Robotics

University of Wollongong researchers from the ARC Centre of Excellence for Electromaterials Science (ACES) and the School of Chemistry have printed materials which can actuate and strain gauge.

In their paper, ACES Chief Investigator Associate Professor Marc in het Panhuis and nanotechnology honors graduate Geoffrey Pidcock showed that gellan gum, a well-known food additive provides the optimum conditions for the printing of carbon nanotubes (CNT), a material at the forefront of developments in bio- and nanotechnology.

The research demonstrated that the printing process offers great flexibility over the geometry and application of the gauge and actuating material to soft substrates such as textile and gels.

Professor in het Panhuis said, "Actuators are all around us—just think of the muscles in our body which are the best known example of actuators which we use to run, catch a wave, or kick a ball."

Professor in het Panhuis said that the use of gellan gum opens up possibilities for the printing of wet strain gauges and actuators for applications in soft robotics. "Monitoring actuator motion in robotics and rehabilitation applications requires 'soft' strain gauges rather than the currently used 'hard' metal or silicon strain gauges. Our work is an important developmental step toward the realization of these concepts," he said.

For more information, click here.

Comparative Cleaning Study to Showcase the Effective Removal of OA Flux Residues

by Jigar Patel, Umut Tosun, and Michael McCutchen
ZESTRON AMERICA

***SUMMARY:** In the electronics manufacturing industry, pure DI-water processes are prevalent for removing water soluble (OA) flux residues. However, recent industry developments, as well as customer case studies, have shown that these water-only processes may no longer produce the required cleanliness levels and thereby guarantee the long-term reliability of assemblies.*

Editor's Note: This article was originally published in the Proceedings of SMTA International, Orlando, Florida, October 14-18, 2012.

Introduction

It is clear that water soluble fluxes are designed to be cleaned with water. However, it is also clear from customer data that it is becoming more difficult for DI-water cleaning systems to meet the cleaning challenges posed by the ever-increasing pack density of current board designs, miniaturization of components, and greater use of low standoff components. Additionally, the use of lead-free solder has greatly increased, requiring higher reflow temperatures. This results in more burnt in fluxes or tin oxide residues that are even harder to remove as they begin to produce water insoluble contamination [1]. DI-water alone has limited to no ability to solubilize these inorganic residues on the board surface and underneath low standoff components [2, 3].

To clean flux residues using batch or inline cleaning systems, four major influencing factors affect performance: Thermal energy, mechanical energy, cleaning media energy, and wash time or exposure to the cleaning media. For any given cleaning process, these factors are optimized to achieve the desired cleaning result. With regard to OA flux residues, if the cleaning media is DI-water, then only mechanical and thermal energy optimization remain to meet the ever-increasing cleaning challenges. If a chemistry-assisted solution is chosen, numerous cleaning media options exist including variations in concentration and alkalinity in addition to mechanical and thermal energy optimization. Certainly, cleaning equipment designs have improved particularly with regard to nozzle and spray bar design. Increasing wash temperature can be beneficial as well. However, at temperatures of 160°F and higher, this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stresses the equipment as well as dramatically increases energy costs.

The fact remains that cleaning media needs to reach the residue in order to solubilize and remove it. For boards with complex geometries and tight spacing, DI-water with its high surface tension is simply unable to reach the residue regardless of cleaning equipment design and operating parameters. However, a cleaning agent specifically designed for use with spray-in-air equipment, can penetrate shallow clearances and capillary spaces and solubilize and remove the residue thus assuring improved cleaning and eliminate the risk of electrochemical migration or leakage currents [2].

Article Summary

The design of experiment (DOE) implemented for this paper addresses the effectiveness of cleaning low standoff components with DI-water as compared to a cleaning agent. The cleaning agent selected for this study, labeled as Cleaning Agent A, is alkaline and is specifically formulated to solubilize low OA flux residue at very low concentrations and wash bath temperatures. Cleanliness assessments were made using visual analysis as well as with ionic contamination and ion chromatography. This DOE focused on low standoff components, that is, components having standoff height of less than 1 mil as these are more difficult to clean underneath. It should be noted that visual analysis was completed after removing all components from the substrate so that the board surface underneath the component could be analyzed for residual residues.

Furthermore, since customer field experience has demonstrated that even PCBs passing ionic contamination testing and ion chromatography analysis can and do fail in the field, the authors presented two case studies exemplifying this point.

Hypotheses

H1: Water soluble flux residues are more difficult to completely remove from underneath low standoff components (less than 1 mil) with DI-water alone.

H2: Increasing wash temperature improves cleaning results under low standoff components with both DI-water as well as a chemistry assisted cleaning process.

H3: Low concentration (3 to 5%) Cleaning Agent A can improve cleaning results and widen the process window.

Methodology

The DOE developed included analysis of five performance indicators. These were chosen by the authors to adequately and comprehensively assess the differences, advantages, and disadvantages of the use of low concentration Cleaning Agent A versus DI-water for cleaning PCBs. An inline cleaning process was selected for this analysis. All boards were populated and reflowed with five of the most commonly used leaded and lead-free solder pastes respectively.

Identified Performance Indicators

1. Cleaning Performance

Assess and compare the cleaning performance of Cleaning Agent A at 3% and 5% concentration levels, with that of DI-water. The test vehicle chosen is the new ZESTRON® test board (Figure 1) populated with numerous difficult to clean low standoff components. The boards were reflowed and cleaned in an inline cleaner at various temperature settings. Cleaning performance was determined in two separate phases:

- Phase 1: Visual inspection of board surface and underneath all components.
- Phase 2: Ionic contamination and ion chromatography analysis utilizing inline cleaning settings that produced the best cleaning results from Phase 1.

2. Material Compatibility

Utilizing Cleaning Agent A and DI-water, various sensitive metals were exposed for 15 minutes and 24 hours in a beaker test. Material compatibility was ascertained using visual inspection.

3. Power Consumption

Using an inline cleaner as a basis, the kilowatt load required to raise the wash bath from room temperature to set temperature as well as to maintain the wash bath at set-point temperature was recorded. The tests were conducted at four temperature settings. The energy usage data was obtained using an industrial power meter.

4. DI-water Usage

Data were provided by several independent sources identifying the amount of DI-water used in both pure water and chemistry assisted cleaning processes. The analysis was based on using closed-loop DI-water equipment with isolated wash tanks. An annualized cost comparison was developed based on this data.

5. Environmental Impact

There are numerous indicators representing environmental impact. One such indicator is volatile organic compound (VOC) value. This value was ascertained through an independent lab for Cleaning Agent A and compared against industry norms for engineered cleaning agents.

In addition to the analyses outlined above, the authors identified two companies seeking to evaluate chemically assisted cleaning processes. In each case, the customer was using a water soluble flux, employing a DI-water cleaning process and yet experiencing product reliability issues. Furthermore, the reliability issues were attributed to flux residues remaining on the PCBs. Thus, a DOE was structured to evaluate and compare the cleaning results of their DI-water cleaning process versus a chemistry assisted cleaning process utilizing inline cleaning equipment operated with Cleaning Agent A.

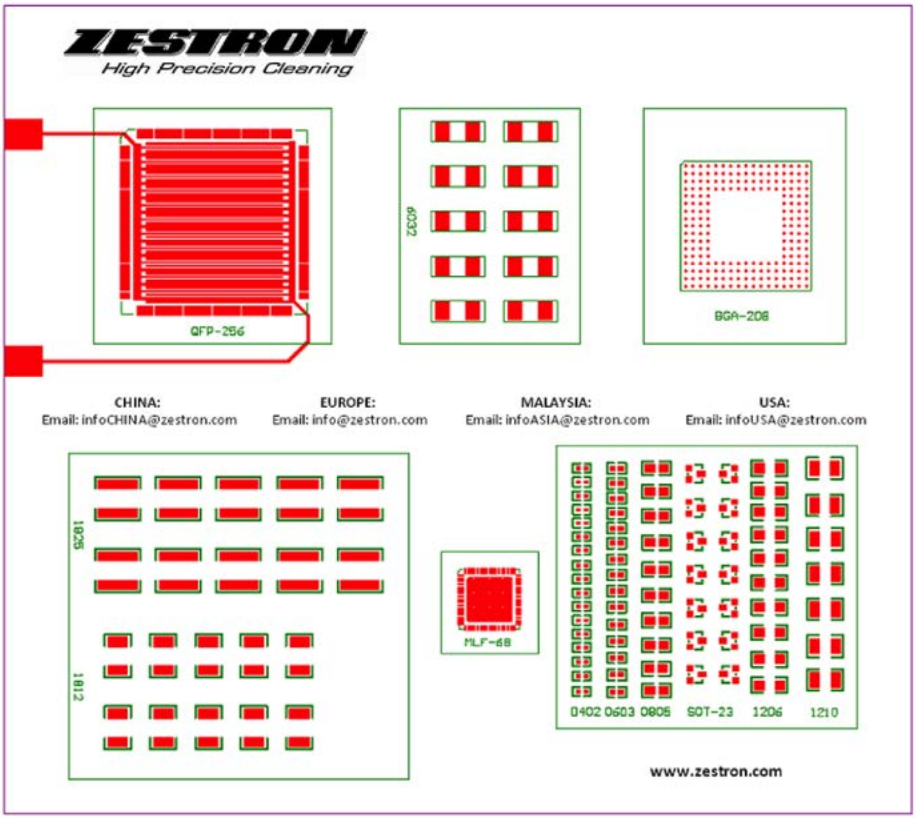

Figure 1: ZESTRON® test board.

Main Research

Performance Indicator 1: Cleaning Performance

In this first part of the study, the authors' goal was to determine the cleaning performance of DI-water versus Cleaning Agent A. The cleaning performance was assessed in two phases:

- Phase 1: Test boards were prepared and cleaned for visual analysis of the surface and underneath all components.

- Phase 2: Test boards were prepared, cleaned, and assessed using ionic contamination and ion chromatography analysis.

For Phase 1 of the study, 60 ZESTRON® test boards (Figure 1) were populated with four each of 0402, 0603, 0805, 1206, 1210, 1812, 1825, 6032 chip capacitors and SOT-23 transistors, or 36 components per board in total. For Phase 2 of the study, 40 ZESTRON® test boards were fully populated with all components. All components are classified as low standoff with less than 1 mil spacing.

The new ZESTRON® test board has been specifically designed to present challenging and difficult to clean configurations.

	Preheat Zones							Reflow Zones			Cooling
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	
Top	100°C	120°C	150°C	180°C	190°C	210°C	225°C	235°C	245°C	225°C	4 Zones
Bottom	100°C	120°C	150°C	180°C	190°C	210°C	225°C	235°C	245°C	225°C	4 Zones

Table 1: Reflow profile as used during the trials for lead-free solder paste.

	Preheat Zones							Reflow Zones			Cooling
	Zone 1	Zone 2	Zone 3	Zone 4	Zone 5	Zone 6	Zone 7	Zone 8	Zone 9	Zone 10	
Top	90°C	100°C	130°C	160°C	170°C	190°C	210°C	220°C	230°C	210°C	4 Zones
Bottom	90°C	100°C	130°C	160°C	170°C	190°C	210°C	220°C	230°C	210°C	4 Zones

Table 2: Reflow profile as used during the trials for leaded solder pastes.

Based on previous DI-water versus low concentration chemistry-assisted cleaning studies, 10 of the most commonly used leaded and lead-free solder pastes were selected for this study. Leaded pastes were identified as Pastes A, B, C, D, and E. Lead-free pastes were identified as Pastes F, G, H, I, and J. The pastes were reflowed according to the following profiles (Tables 1 and 2).

Visual Inspection

Following reflow, Phase 1 cleaning trials were conducted. Sixty of the 100 boards were cleaned, 30 with DI-water and 30 with Cleaning Agent A. The cleaning trials were performed in an inline cleaner with four spray bars configured with V-Jet nozzles. The cleaning system process parameters are detailed in Table 3. After the cleaning process was complete, a visual inspection was conducted of the substrate surface and underneath all components according to IPC-A-610, Rev. E-2010 [4].

Analysis: Phase 1 Visual Inspection

Cleaning analysis was based on a single metric; that is, determining if OA flux residues were fully removed underneath each component. If yes, the component was classified as clean and tabulated. For each cleaning media and at each

Cleaning Process:	
Cleaning Media:	Cleaning Agent A 3% concentration 5% concentration DI-water
Conveyor Belt Speed:	2 ft/min
Wash Pressure (top/bottom):	85 PSI / 60 PSI
Cleaning Temperature:	120°F, 135°F, 150°F
Rinse Process:	
Rinsing Agent:	DI-water
Temperature:	140°F
Final Rinse Flow Rate:	2 gal/min
Final Rinse Temperature:	Room Temperature

Table 3: Inline cleaner process parameters: Phase 1 cleaning performance.

wash temperature, there were a total of 180 components to be inspected underneath for both leaded and lead-free paste respectively. All results are summarized in Table 4.

Additionally, cleaning results are graphed classified by cleaning media, wash temperature, paste, and component type. Component analysis is detailed in Figures 2-7, whereas paste analysis is detailed in Figures 8-13. These graphs indicate the number of components, that when removed from the test boards, were fully cleaned underneath.

	Leaded Components Cleaned (out of 180)	% Leaded Components Cleaned	Lead-free Components Cleaned (out of 180)	% Lead-free Components Cleaned
120°F Wash Temperature:				
DI- water	122	68%	154	85%
Cleaning Agent A (3%)	161	89%	172	96%
Cleaning Agent A (5%)	159	88%	177	98%
135°F Wash Temperature:				
DI-water	118	66%	153	85%
Cleaning Agent A (3%)	164	91%	177	98%
Cleaning Agent A (5%)	161	89%	180	100%
150°F Wash Temperature:				
DI-water	114	63%	128	71%
Cleaning Agent A (3%)	169	94%	180	100%
Cleaning Agent A (5%)	169	94%	180	100%

Table 4: Cleaning results: Underneath components.

Under Component Cleanliness Results — Component Analysis: Figures 2-7

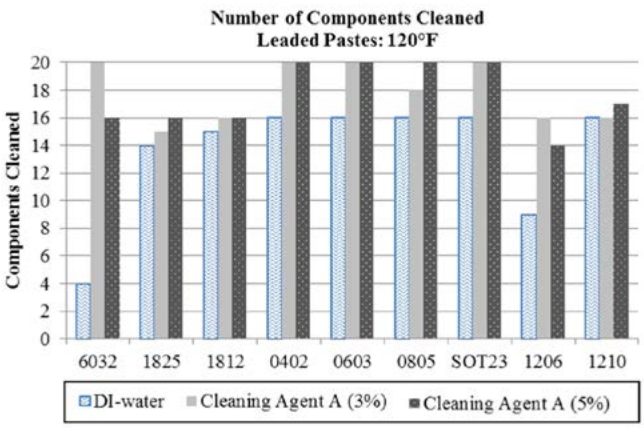

Figure 2: Results - Component Analysis
DI-water cleaned: 122 of 180
Cleaning Agent A (3%) cleaned: 161 of 180
Cleaning Agent A (5%) cleaned: 159 of 180nents.

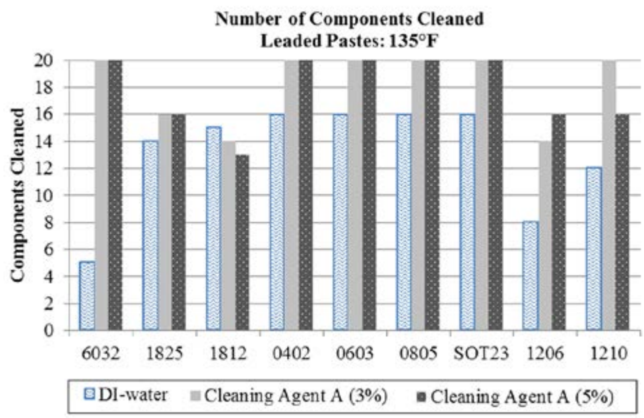

Figure 3: Results - Component Analysis
DI-water cleaned: 118 of 180
Cleaning Agent A (3%) cleaned: 164 of 180
Cleaning Agent A (5%) cleaned: 161 of 180nents.

Cleaning Process Analysis with DI-water

Surface inspection:

- With each temperature scenario, and with all leaded pastes, substrate surface was clean.
- With each temperature scenario for lead-free pastes minor white residue was observed around various pad areas with three of five pastes types.

Leaded paste underneath component inspection:

- Completely cleaned surface underneath all components at all temperature scenarios using Paste D (Figures 8, 9, and 10).
- Cleaning performance actually decreased with increasing temperature as evidenced underneath components 1825, 1812, 1210, 1206, and 0805 (Figures 2, 3, and 4).

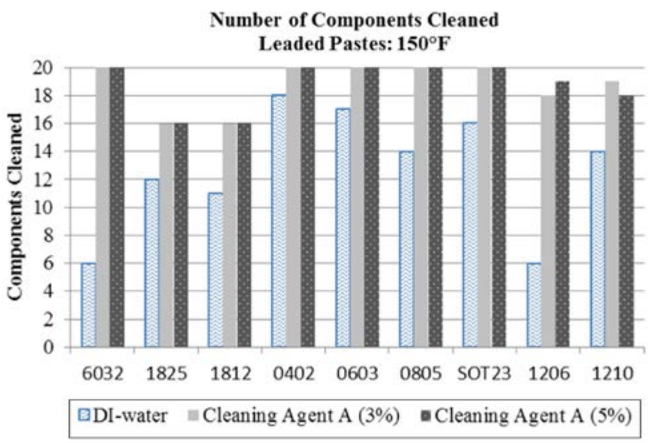

Figure 4: Results - Component Analysis
DI-water cleaned: 114 of 180
Cleaning Agent A (3%) cleaned: 169 of 180
Cleaning Agent A (5%) cleaned: 169 of 180

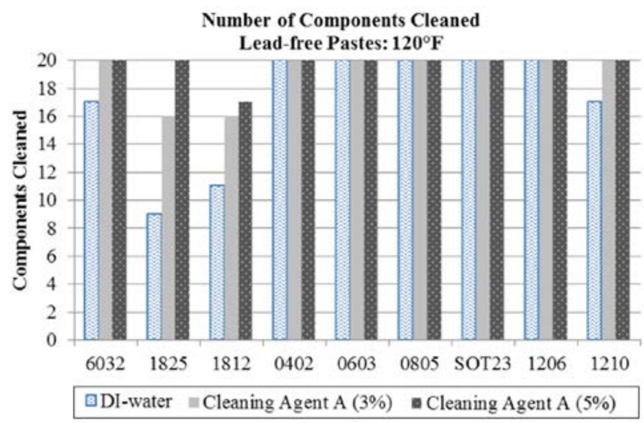

Figure 5: Results - Component Analysis
DI-water cleaned: 154 of 180
Cleaning Agent A (3%) cleaned: 172 of 180
Cleaning Agent A (5%) cleaned: 177 of 180

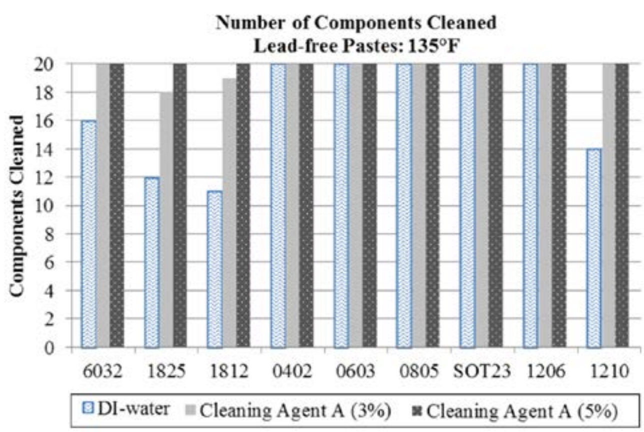

Figure 6: Results - Component Analysis
DI-water cleaned: 153 of 180
Cleaning Agent A (3%) cleaned: 177 of 180
Cleaning Agent A (5%) cleaned: 180 of 180

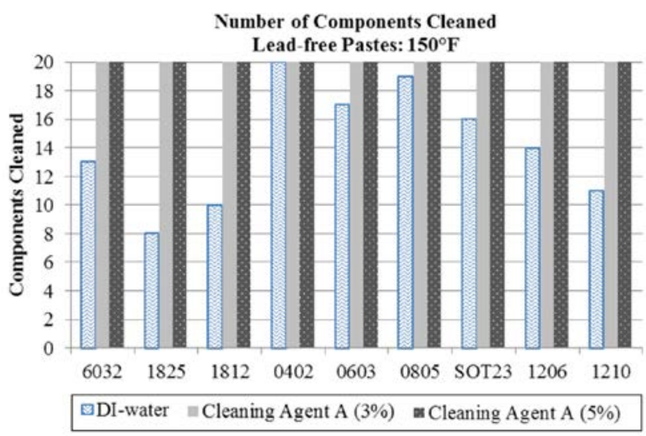

Figure 7: Results - Component Analysis
DI-water cleaned: 128 of 180
Cleaning Agent A (3%) cleaned: 180 of 180
Cleaning Agent A (5%) cleaned: 180 of 180

Lead-free paste underneath component inspection:

- Completely cleaned surface underneath all components at all temperature scenarios using Pastes F and G (Figures 11, 12, and 13).
- Increasing temperature did not improve cleaning results with the larger components and, in fact, decreased cleaning results with 6032 and 1812 (Figures 5, 6, and 7).
- Increasing temperatures did not improve cleaning results. In fact, fewer leaded and lead-free components were cleaned at 150°F as compared to 120°F reducing the percentage of cleaned components from 68% at 120°F to 63% at 150°F for leaded components and 85% at 120°F to 71% at 150°F for lead-free components (Table 4).

Under Component Cleanliness Results — Paste Analysis: Figures 8-13

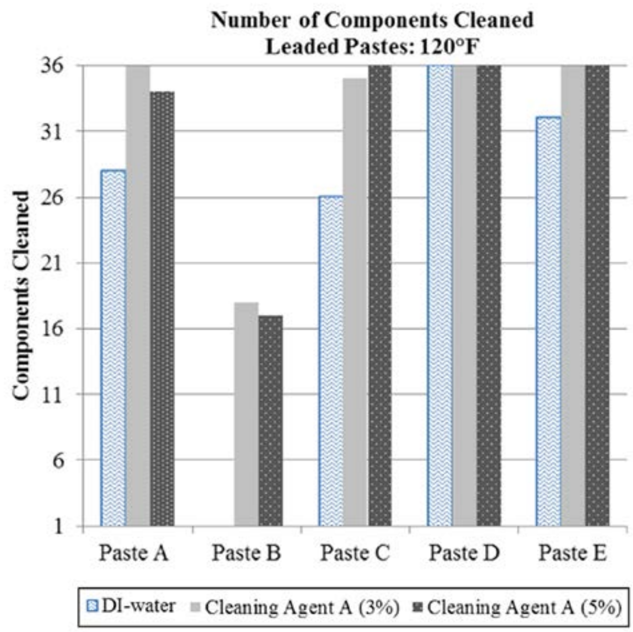

Figure 8: Results - Paste Analysis
DI-water cleaned: 122 of 180
Cleaning Agent A (3%) cleaned: 161 of 180
Cleaning Agent A (5%) cleaned: 159 of 180

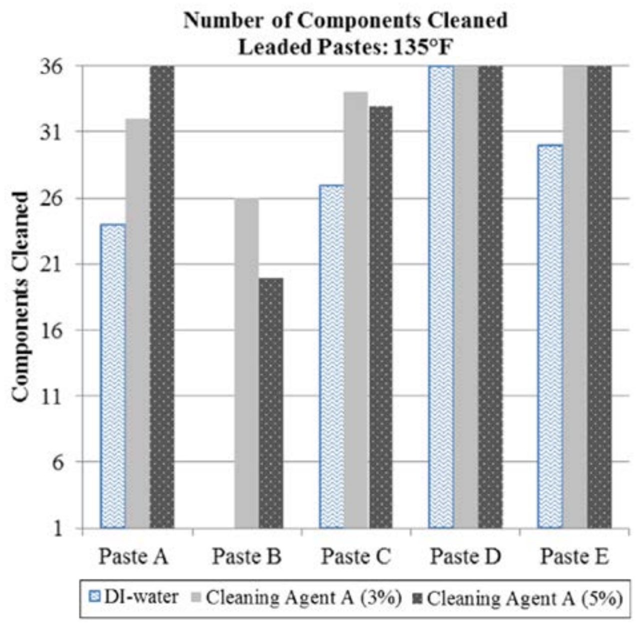

Figure 9: Results - Paste Analysis
DI-water cleaned: 118 of 180
Cleaning Agent A (3%) cleaned: 164 of 180
Cleaning Agent A (5%) cleaned: 161 of 180

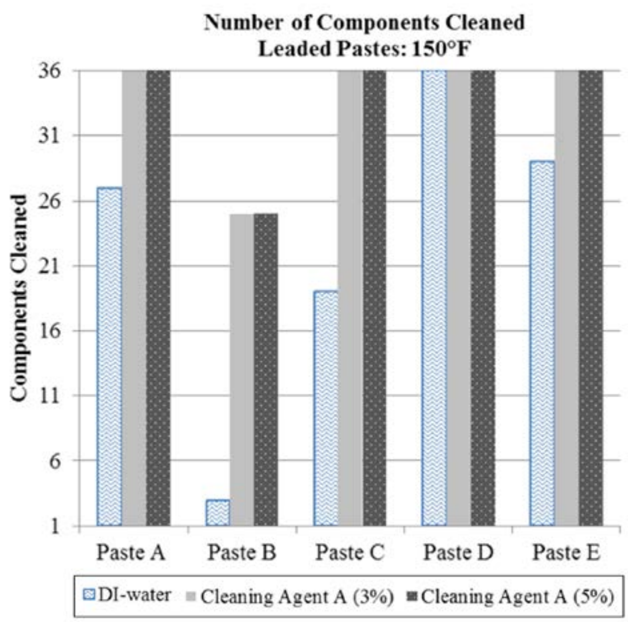

Figure 10: Results - Paste Analysis
DI-water cleaned: 114 of 180
Cleaning Agent A (3%) cleaned: 169 of 180
Cleaning Agent A (5%) cleaned: 169 of 180

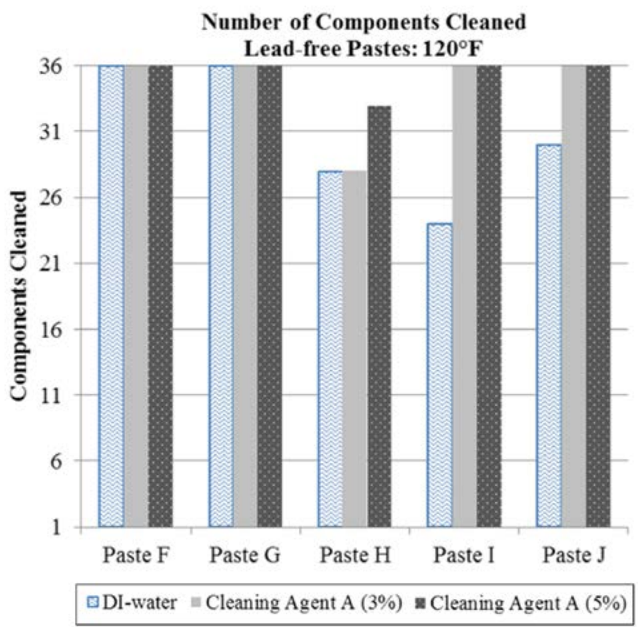

Figure 11: Results - Paste Analysis
DI-water cleaned: 154 of 180
Cleaning Agent A (3%) cleaned: 172 of 180
Cleaning Agent A (5%) cleaned: 177 of 180

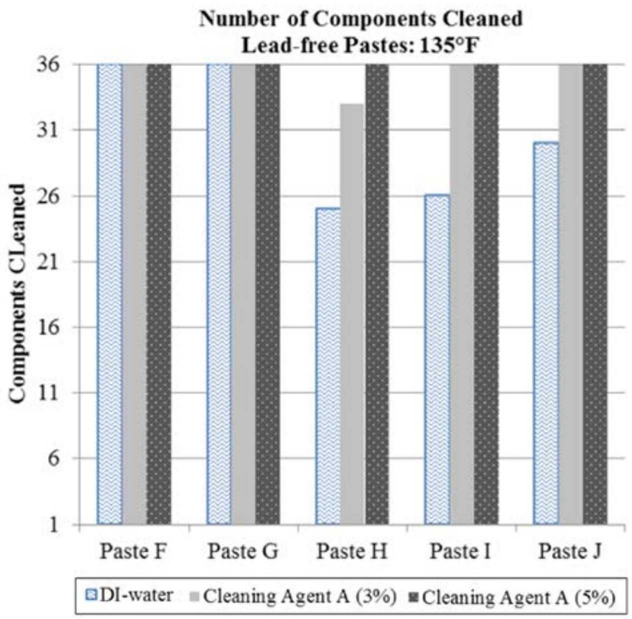

Figure 12: Results - Paste Analysis
DI-water cleaned: 153 of 180
Cleaning Agent A (3%) cleaned: 177 of 180
Cleaning Agent A (5%) cleaned: 180 of 180

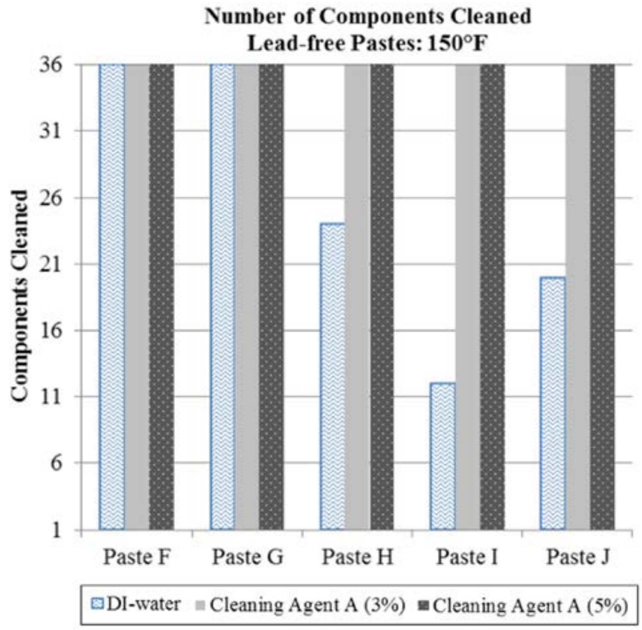

Figure 13: Results - Paste Analysis
DI-water cleaned: 128 of 180
Cleaning Agent A (3%) cleaned: 180 of 180
Cleaning Agent A (5%) cleaned: 180 of 180

Cleaning Process Analysis with Cleaning Agent A (3%)

Surface inspection:

- With each temperature scenario, and with all paste types, all surface pad areas were fully clean and no white residues were observed.

Leaded paste underneath component inspection:

- Completely cleaned surface underneath all components at all temperature scenarios using Pastes D and E (Figures 8, 9, and 10).
- Completely cleaned surface underneath all components at 150°F temperature using Pastes A, C, D, and E (Figure 10).
- Increasing wash temperature improved cleaning results at both 135°F and 150°F (Figures 9 and 10).

Lead-free paste underneath component inspection:

- Completely cleaned surface underneath all components at all temperature scenarios using Pastes F, G, I, and J (Figures 11, 12, and 13).
- Completely cleaned surface underneath all components at 150°F temperature using Pastes F, G, H, I, and J (Figure 13).

Underneath component cleaning performance improved for the most challenging components with increasing temperature. In fact, the area underneath all components was completely clean at 150°F with all lead-free pastes (Figure 7).

Cleaning Process Analysis with Cleaning Agent A (5%)

Surface Inspection:

- With each temperature scenario, and with all paste types, all surface pad areas were fully clean and no white residues were observed.

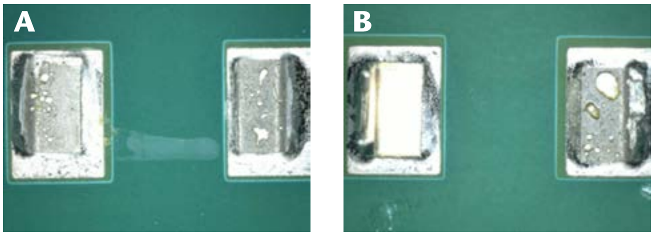

Figure 14A: Component 6032
Leaded Paste B, DI-water, 120°F
Cleaning Result: Residue remains

Figure 14B: Component 6032
Leaded Paste B, Cleaning Agent (3%), 120°F
Cleaning Result: Fully clean

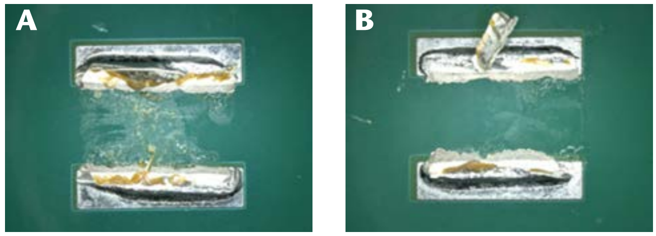

Figure 15A: Component 1825
Leaded Paste B, DI-water, 120°F
Cleaning Result: Residue remains

Figure 15B: Component 1825
Leaded Paste B, Cleaning Agent (3%), 120°F
Cleaning Result: Residue remains

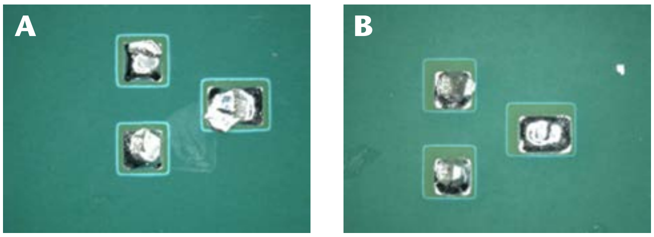

Figure 16A: Component SOT23
Leaded Paste B, DI-water, 120°F
Cleaning Result: Residue remains

Figure 16B: Component SOT23
Leaded Paste B, Cleaning Agent (3%), 120°F
Cleaning Result: Fully clean

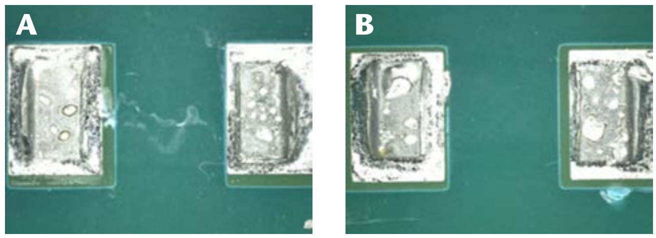

Figure 17A: Component 6032
Lead-free Paste J, DI-water, 120°F
Cleaning Result: Residue remains

Figure 17B: Component 6032
Lead-free Paste J, Cleaning Agent (3%), 120°F
Cleaning Result: Fully clean

Leaded paste underneath component inspection:

- Completely cleaned surface underneath all components at all temperature scenarios using Pastes D and E. Paste A resulted in underside of all components completely cleaned at 135°F and 150°F temperatures (Figures 9 and 10).
- Completely cleaned surface underneath all components at 150°F temperature using Pastes A, C, D, and E (Figure 10).

Lead-free paste underneath component inspection:

- Completely cleaned surface underneath all components at all temperature scenarios using Pastes F, G, I, and J (Figures 11, 12, and 13).
- Completely cleaned surface underneath all components at 135°F and 150°F temperature using Pastes F, G, H, I, and J (Figures 12 and 13).
- Improved cleaning performance of the most challenging components was realized with increasing temperature (Figures 5, 6, and 7).

Cleaning Agent A performance data at both the 3% and 5% concentration levels supports the authors' hypothesis H2 that increasing wash temperatures can improve cleaning results. Furthermore, this supports the fact that a cleaning agent formulated to solubilize OA flux residue, coupled with its reduced surface tension value, enables the chemistry to penetrate low stand-off areas and capillary spaces, thereby loosening and removing trapped residues.

Figures 14 through 18 detail representative

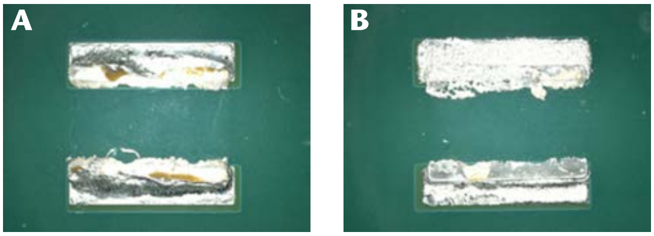

Figure 18A: Component 1825
Lead-free Paste J, DI-water, 120°F
Cleaning Result: Residue remains

Figure 18B: Component 1825
Lead-free Paste J, Cleaning Agent A (3%), 120°F
Cleaning Result: Fully clean

photographs of underneath component cleaning results using DI-water and Cleaning Agent A, Paste B (leaded), and Paste J (lead-free). Photos indicate outcome classification, that is, fully cleaned versus residue remaining. For these photos, the authors chose both successful and unsuccessful cleaning outcomes underneath larger components such as 6032, 1825, and SOT23.

Analysis: Phase 2: Ionic Contamination and Ion Chromatography

To further qualify and quantify these findings, 40 of the 100 test boards prepared were used for analytical analysis. Once reflowed (under same conditions used for Phase 1), they were passed through an inline cleaner. Twenty boards were cleaned with DI-water and 20 with Cleaning Agent A (5%). Cleaning process parameters used were based on those yielding the best cleanliness results as indicated through the Phase 1 trials. The inline process parameters are identified in Table 5.

Cleaning Process:	
Cleaning Media:	Cleaning Agent A (5%) DI-water
Conveyor Belt Speed:	2 ft/min
Wash Pressure (top/bottom):	85 PSI / 60 PSI
Cleaning Temperature:	135°F
Rinse Process:	
Rinsing Agent:	DI-water
Temperature:	140°F
Flow Rate:	2 gal/min

Table 5: Inline cleaner process parameters – Phase 2 analytical analysis.

Of the 20 boards cleaned with each wash media, 10 were analyzed using ionic contamination and ion chromatography test methods respectively.

Ionic Contamination

Ionic contamination measurements compare the conductivity of the extract solution before and after testing. The result is reported as a sodium chloride (NaCl) equivalent per unit area. Ionic contamination measurements are limited to only measuring ionic contaminants (versus non-ionic). Moreover, they measure the contamination washed off from the assembly and not what is left behind and do not define the exact source of contamination. The tests were performed in accordance with IPC-TM-650 and evaluated based on J-STD-001D.

Results: Ionic Contamination

Twenty boards were tested using this methodology. Of these, 10 were cleaned with DI-water and 10 with Cleaning Agent A. All boards tested showed contamination levels well below the IPC pass/fail limit of 10.06 µgrams/in^2. Ionic contamination results are included in Appendix A.

This result is not surprising particularly for the DI-water cleaned boards. As reported in the visual inspection section of this study, DI-water cleaned all board surfaces satisfactorily. However, underneath component inspection of DI-water cleaned boards at 120°F resulted in underside residue in 32% of all leaded components and 15% of all lead-free components. Increased wash temperature failed to improve these results.

Ionic contamination testing utilizes a media consisting of 75% IPA (solvent) and 25% water (highly polar liquid). The polar liquid is used to solubilize all organic particles and the solvent is used to solubilize all inorganic particles. Ideally, the testing media extracts residues from test substrates and compares the conductivity of the extract solution before and after testing.

However, if DI-water is unable to penetrate low standoff components with the mechanical and thermal energy available in an inline cleaner, one cannot expect ionic contamination test equipment operated under static conditions to produce a better result. Thus, if this media is unable to reach the residues that are trapped under low standoff components, one cannot expect the test results to accurately reflect cleanliness underneath these components.

Ion Chromatography

Ion chromatography analysis was performed in order to characterize ionic residues on the board surface in terms of anions (fluoride, acetate, formate, chloride, nitrite, bromide, nitrate, phosphate, sulfate), cations (lithium, sodium, ammonium, potassium, magnesium, calcium), and weak organic acids. If contaminants are present on electronic assemblies and bare boards, they contribute to electrochemical failures when mixed with moisture and applied voltage [2].

Ion chromatography testing was performed according to IPC-TM-650 method 2.3.28 [4]. Test equipment used enabled analysis of anions, cations, and weak organic acids.

Results: Ion Chromatography

Twenty boards were tested using this methodology. Of these, 10 were cleaned with DI-water and 10 with Cleaning Agent A. All boards tested resulted in contamination levels well below IPC limits. As with the ionic contamination tests, this result is not surprising. Similar to ionic contamination analysis, this test method has difficulty penetrating underneath low standoff components and thus cannot accurately analyze cleanliness. Ion chromatography results are included in Appendix B.

Performance Indicator 2: Material Compatibility

Wash media compatibility with components, sensitive metals, and coatings is critical to a successful cleaning process. As more and more exotic materials are being used, particularly for coating electronic components, it is essential to confirm that the selected wash media will not adversely affect component appearance or functionality.

For this study, the materials selected by the authors for analysis were anodized coating, alodized coating, olive-drab coating, iridite coating, electroless nickel plating, aluminum, and copper. All parts were exposed to DI-water and Cleaning Agent A at 5% concentration, each at a temperature of 150°F for a period of 15 minutes and 24 hours. In each case, this is an exaggerated exposure time.

On average, the component exposure time is approximately two to three minutes for an inline process.

These tests were performed by immersing the coated parts in a beaker equipped with a magnetic stirrer. Following the desired exposure time, all components were rinsed with 140ºF DI-water and dried at room temperature. All components were inspected for material changes using a microscope with 40x magnification.

Results: Material Compatibility

For the 15-minute exposure time, all component coatings were found to be compatible with DI-water and Cleaning Agent A.

For the 24-hour exposure test, Cleaning Agent A had a dulling effect on the olive-drab and electroless nickel plating. The olive-drab coating resulted in minor stains with DI-water and the aluminum had slight dulling.

	Cleaning Agent A (5%), 150°F, 15 min	DI-water 150°F, 15 min	Cleaning Agent A (5%), 150°F, 24 hrs	DI-water 150°F, 24 hrs
Anodize Coating	+	+	+	+
Alodine Coating	+	+	+	+
Olive-drab Coating	+	+	Dulling	Minor stains
Iridite Coating	+	+	+	+
Electroless Nickel Plating	+	+	Dulling	+
Aluminum	+	+	+	Slight dulling (white haze)
Copper	+	+	+	+

Table 6: Material compatibility DI-water and Cleaning Agent A (5%). Fully Compatible: +

Performance Indicator 3: Power Consumption

A critical component of any cleaning process is thermal energy. As evidenced by the visual inspection results, increasing the wash temperature or thermal energy had a positive impact on the cleaning results when using Cleaning Agent A. However, no noticeable impact was identified with the use of DI-water. Thus, higher wash temperatures can positively impact cleaning results provided chemistry assisted cleaning media are employed.

However, higher wash temperatures require more energy. Thus, in this phase of the study and using an inline cleaner, kilowatt-hours (kWh) were measured to assess the initial electrical load required for the wash bath as well as the ongoing electrical load to maintain wash bath temperature for a minimum of one hour. During this test, the conveyor belt was stationary and no boards were cleaned. Thus, this data represents the minimal electrical load required to heat and maintain the wash bath.

As this data is used for comparative purposes only, the actual kWh are not the major consideration, however, the relative kWh increase required to raise the wash bath temperature from 120°F as well as to maintain the increased temperatures. For this analysis, four temperatures were selected: 120°F, 130°F, 140°F, and 150°F.

Results: Power Consumption

As indicated, 120°F was considered to be the baseline wash bath temperature against which higher temperature load requirements were measured. The base kWh load comparison is detailed in Table 7 and Figure 19.

As expected, an increase in wash bath temperature increases electrical load and resulting operating cost.

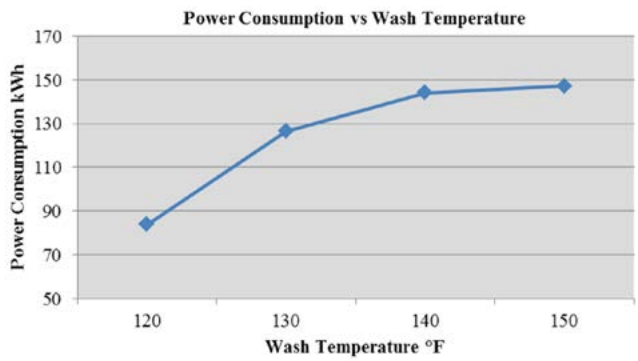

Figure 19: Power consumption versus wash temperature.

Performance Indicator 4: DI-water Usage

DI-water usage is essential to any cleaning process. In pure DI-water systems, it is used in the wash and rinse sections. In chemistry assisted systems, it is used to dilute the chemistry to the proper concentration as well as for rinsing.

For this part of the study, the authors obtained data from several independent sources to confirm the volume of DI-water used in both pure water and chemistry-assisted processes for an inline cleaner. The data provided were based on the average amount of DI-water used in closed-loop DI-water systems with isolated wash tanks. It was used to assess the actual cost of DI-water per gallon, the monetary and environmental impact of bath changes, and the maintenance labor cost associated with cleaning solution replacements. Assumptions made include:

- 80-gallon wash tank capacity.
- Average production cycle: 7 hours/day, 5 days/week, 52 weeks/year.
- Average cost of DI-water: $0.06 per gallon.
- Average disposal cost for 1,000 gallons of water: $6.45.

Initial Temp (°F)	Wash Temp (°F)	Time to reach set-point (min)	Power Consumption to reach set-point (kWh)	Heater on time 1hr operation (min)	Power Consumption 1hr operation (kWh)
68°F	120°F	12 min 37 sec	35.8	27.5	83.87
69°F	130°F	13 min 54 sec	39	41	126.42
68°F	140°F	16 min 38 sec	45.5	47	144.13
85°F	150°F	16 min 13 sec	48	48	147.2

Table 7: Inline cleaner power requirement.

- Average labor cost per hour: $10.
- Wash bath replacement frequency:
  –DI-water: daily.
  –Cleaning Agent A: monthly.

This analysis excluded the capital and variable costs of membrane and carbon filtration equipment.

Results: DI-water Usage

Using the assumptions detailed above, the annual cost of DI-water usage for the wash section was calculated to be $5,273 versus $243 for a chemistry-assisted process.

Based on this analysis for a chemistry assisted cleaning process, approximately 48 gallons of Cleaning Agent A used at 5% concentration are required annually. This excludes make up chemistry due to drag out losses and evaporation (variable depending upon wash bath temperature).

Thus, DI-water usage savings must certainly be taken into account when determining the ROI for a chemistry-assisted cleaning system.

Performance Indicator 5: Environmental Impact

Considering the environmental impact with the use of cleaning agents is critical. In most cases, there are federal and local government guidelines that must be adhered to regarding effluent streams and air emissions. One critical measurement for cleaning agents is VOC content. This is not a consideration for DI-water. However, the VOC spectrum for chemicals varies from 787 g/l for IPA to average values typically below 200 g/l VOC content for many modern cleaning agents.

In the case of Cleaning Agent A at 5% concentration, the VOC content is 37 g/l, an environmentally friendly option for a chemistry-assisted cleaning process.

Case Studies

In addition to the visual and analytical tests performed examining cleanliness differences between chemistry assisted and DI-water cleaning processes, the authors collaborated with an EMS provider and an OEM to analyze the benefits of a chemistry assisted cleaning process. In each case, the company involved was currently using a DI-water cleaning process and experiencing field reliability issues traced to residues remaining underneath components.

Case Study A

Company A is a mid-size, full service EMS provider serving customers within the defense, medical, instrumentation, and aerospace industries. Currently, within their manufacturing process they use OA flux (Paste G) and a DI-water inline cleaning process. Product reliability issues surfaced that were ultimately traced to flux residue trapped within coils and under low standoff components. Thus, a DOE was designed to explore the effectiveness of chemistry assisted cleaning utilizing an inline cleaning system.

The DOE was designed in two phases and partially executed at both ZESTRON and the customer location. Utilizing the ZESTRON test vehicle, six boards were populated and reflowed by the customer. Three were cleaned with DI-water at the customer location using their current DI-water cleaning system and three were cleaned at the ZESTRON Technical Center using an inline cleaning system and Cleaning Agent A. The cleanliness assessment for all boards was performed at the ZESTRON Technical Center by visual inspection and in accordance with IPC-A-610, Rev. E [4]. All components were removed from the board to enable surface inspection underneath them.

Design of Experiment

Test Vehicle:

ZESTRON® test board populated and reflowed with the following components:

- QFP-256, 6032, BGA-208, 1210, 1206, SOT-23, 0805, 0603, 0402, MLF-68, 1812, 1825.

Paste:

- Water soluble lead-free Paste G.

Phase 1: DI-water Process

Three boards were cleaned at the customer site utilizing their standard operating procedure and shipped to ZESTRON for visual analysis.

Visual inspection results:

- The board surface was completely clean. However, the underside of MLF-68 and 1825 components contained residue.

Phase 2: Chemistry Assisted Cleaning Process

Three boards were cleaned at the ZESTRON Technical Center utilizing an inline cleaner and Cleaning Agent A.

Inline cleaner test parameters:

- Belt Speed: 1.5 ft/min.
- Cleaning Agent A (5%).
- Wash temperature: 140°F.

Visual inspection results:

- The board surface and area underneath all components were clean.

Photographs detailing comparative cleanliness levels achieved between DI-water and Cleaning Agent A are represented in Figures 20 and 21.

Conclusion

DI-water was unable to completely remove flux residues underneath larger low standoff components such as micro lead frames (MLF) whereas the chemistry assisted system was able to completely clean underneath all components.

This result is also consistent with our primary study. As confirmed within the results section of Performance Indicator 1, the underside of all components soldered with Paste G were completely cleaned at all temperatures with DI-water as well as Cleaning Agent A. However, the MLF68 component was not included in the primary test, but was included in the DOE for this case study. DI-water was unable to clean underneath this component, whereas Cleaning Agent A succeeded. It is also interesting to note that the results detailed in Performance Indicator 1 clearly demonstrate that the DI-water cleaning system was unable to consistently clean underneath larger components (Figures 5, 6, and 7).

Case Study B

Company B is a mid-size OEM producing PCBs in support of their products serving the consumer electronics marketplace. Within their manufacturing process they use OA flux (Paste H) and a DI-water inline cleaning process. Product reliability issues surfaced and were traced to flux residues trapped underneath low standoff LED components. Thus, a DOE was designed to explore the effectiveness of chemistry assisted cleaning utilizing an in-line cleaning system.

The DOE was designed in two phases and partially executed at both ZESTRON and the customer location utilizing the customer's PCBs. In this case, one panel, including 12 LED components, was cleaned at ZESTRON utilizing an inline cleaner and Cleaning Agent A and two additional panels were cleaned at the customer

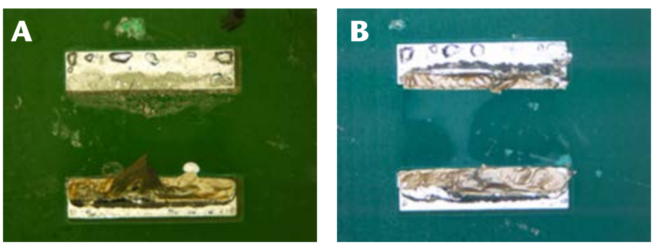

Figure 20A: Component 1825.
Lead-free Paste G, DI-water
Cleaning Result: Residue remains

Figure 20B: Component 1825
Lead-free Paste G, Cleaning Agent A (5%), 140°F
Cleaning Result: Fully clean

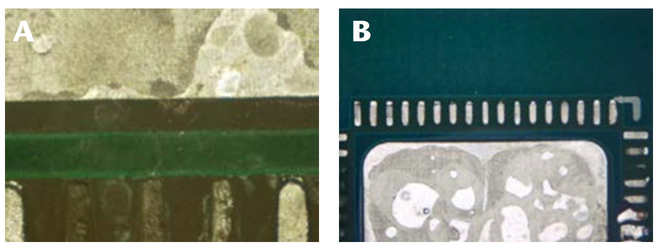

Figure 21A: Component MLF68
Lead-free Paste G, DI-Water
Cleaning Result: Residue remains

Figure 21B: Component MLF68
Lead-free Paste G, Cleaning Agent A (5%), 140°F
Cleaning Result: Fully clean

location utilizing their standard cleaning process. Cleanliness assessments were performed on all panels at the ZESTRON Technical Center via visual inspection and in accordance with IPC-A-610, Rev. E [4]. All LED components were removed from the panel to enable surface inspection underneath them.

Design of Experiment

Test Vehicle:

- Customer panel with 12 LED components.

Paste:

- Water soluble lead-free Paste H.

Phase 1: DI-water Process

These boards were cleaned at the customer site utilizing their standard operating procedure.

Visual inspection results:

- The board surface was completely clean. However, visual inspection underneath the LEDs confirmed the presence of flux residues that were untouched.

Phase 2: Chemistry Assisted Cleaning Process

Inline cleaner test parameters:

- Belt Speed: 2 ft/min.
- Cleaning agent A (5%).
- Wash temperature: 145°F.

Visual inspection results:

- Board surface and the area underneath the LEDs were clean.

Photographs detailing the comparative cleanliness level achieved between DI-water and Cleaning Agent A are represented in Figures 22A and 22B.

Conclusion

DI-water was unable to remove all flux residue trapped underneath the LED components, whereas the chemistry assisted process was able to remove residues on the surface as well as underneath the low standoff LED components.

Once again, this result is consistent with our primary study. As confirmed with the results section of the Performance Indicator 1, the area underneath all components soldered with Paste H was cleaned completely at 135°F and 150°F using Cleaning Agent A. However, DI-water was unable to consistently clean many components, in particular 1825 and 1812 regardless of wash bath temperature.

Conclusions

Cleaning Performance

Through analytical analysis, this study was designed to empirically determine the cleaning efficiency of a DI-water inline cleaning system

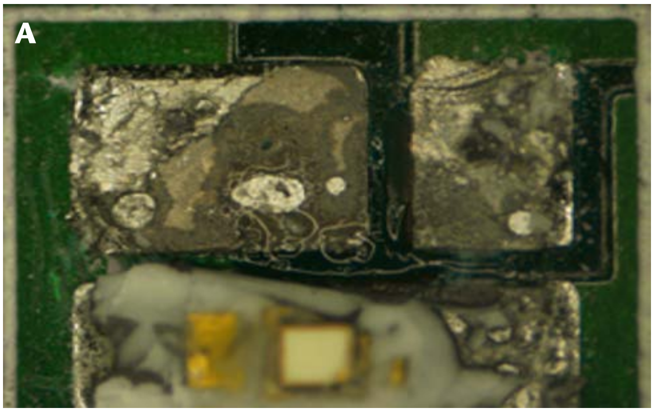

Figure 22A: Component LED
Lead-free Paste H, DI-water, 145°F
Cleaning Result: Residues remain

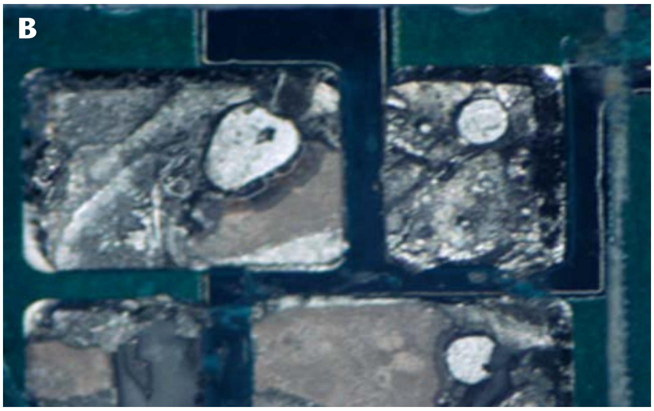

Figure 22B: Component LED
Lead-free Paste H, Cleaning Agent A (5%), 145°F
Cleaning Result: Fully clean

compared to a chemistry-assisted cleaning system for PCBs populated with low standoff components. However, the cleaning agent used was specifically designed to remove water soluble flux residue at low concentration from underneath low standoff components. The main criterion for success was the removal of all flux residues underneath all low standoff components on the test boards.

As discussed within the results section of Performance Indicator 1, Cleaning Agent A surpassed the cleaning performance of DI-water in all temperature scenarios at both the 3% and 5% concentration levels. Also, the lead-free paste proved easier to clean than leaded paste for both DI-water as well as Cleaning Agent A. In fact, Cleaning Agent A cleaned all lead-free components at 135°F with 5% concentration and at 150°F with both 3% and 5% concentration. It is interesting to note that with Cleaning Agent A used at 120°F wash temperature, there were marginal differences in the results using 3% or 5% concentration. Thus, cleaning costs can certainly be minimized using a low concentration cleaning agent and a low wash temperature, while ensuring excellent cleaning results and the required product reliability.

Additionally, Cleaning Agent A's performance improved as the temperature increased. That is, the underside of more components and component types were cleaned as the temperature increased. With regard to DI-water, the increased wash bath temperature did not substantially impact cleaning results.

These results confirm that Hypotheses H1 and H3 are indeed valid. Hypothesis H2 is also valid for Cleaning Agent A, however, invalid for DI-water.

Material Compatibility

Cleaning media compatibility with the substrate material is a critical factor for cleaning media selection. For this study, the 15-minute exposure time of both DI-water and Cleaning Agent A at 5%, had no impact on the selected materials. However, a 24-hour exposure time using Cleaning Agent A at 5%, caused a dulling effect on olive-drab coating and electroless nickel plating. DI-water caused staining and dulling on the olive-drab coating and aluminum, respectively. One should note that a 24-hour exposure is highly unlikely in practice. Thus, if planning to use one of the affected materials with either a DI-water or a chemistry-assisted cleaning process, additional exposure tests should be conducted at alternate time intervals to confirm the exposure limit.

	Contamination Level: mg/in^2	
	Cleaning Agent A	DI-water
Paste A	0.012	0.004
Paste B	0.018	0.005
Paste C	0.018	0.008
Paste D	0.005	0.005
Paste E	0.014	0.001
Paste F	0.004	0.001
Paste G	0.017	0.001
Paste H	0.002	0.008
Paste I	0.004	0.021
Paste J	0.008	0.014

APPENDIX A
Ionic Contamination.

Power Consumption

Regardless of the cleaning equipment used, the wash bath requires heat to bring it to working temperature. Within the industry, 120°F is the minimum wash bath temperature. However, if the residues cannot be solubilized at this temperature, assuming mechanical energy is optimized and the proper cleaning agent is selected, the wash bath temperature must be increased.

As reviewed in the results section of Performance Indicator 3, increasing the wash bath temperature from 120°F to 130°F, increases power requirement by 50.7%. Thus, it is most cost effective to operate a cleaning system at the lowest possible wash bath temperatures.

This comparative study confirmed that Cleaning Agent A used at 3% concentration and 120°F clearly outperformed DI-water in terms of fully cleaning underneath low standoff components soldered with either leaded or lead-free OA pastes.

A cleaning system must be optimized based on the substrate design and the paste used so

	Maximum Level (µg/in2)	Leaded Pastes: Contamination Level (µg/in2)					Lead-free Pastes: Contamination Level (µg/in2)				
		Paste A	Paste B	Paste C	Paste D	Paste E	Paste F	Paste G	Paste H	Paste I	Paste J
Anion Species											
Fluoride (F^-)	3	nd	nd	nd	nd	nd	0.85	0.81	0.9	nd	0.87
Acetate ($C_2H_3O_2$)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Formate (CH_2O_2)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Chloride (Cl^-)	4	1.93	2.16	2.66	2.63	2.11	2.22	1.99	1.93	2.48	2.36
Nitrite (NO_2^-)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Bromide (Br^-)	10	0.38	0.24	0.28	0.3	0.28	0.59	0.38	0.44	1.05	1.12
Nitrate (NO_3^-)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Phosphate (PO_4^{2-})	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sulfate (SO_4^{2-})	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Weak Organic Acid	25	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cations Species											
Lithium (Li)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sodium (Na)	3	0.67	0.63	0.51	0.49	0.48	0.42	0.34	0.4	0.38	0.9
Ammonium (NH_4)	3	0.21	0.26	0.23	0.29	0.38	0.38	0.39	0.4	0.4	0.37
Potassium (K)	3	nd	nd	nd	0.02	nd	nd	nd	nd	0.03	0.1
Magnesium (Mg)	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Calcium (Ca)	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

Ion Chromatography Test: DI-water – All boards passed. nd= not detected.

	Maximum Level (µg/in2)	Leaded Pastes: Contamination Level (µg/in2)					Lead-free Pastes: Contamination Level (µg/in2)				
		Paste A	Paste B	Paste C	Paste D	Paste E	Paste F	Paste G	Paste H	Paste I	Paste J
Anion Species											
Fluoride (F^-)	3	0.79	0.82	nd	nd	nd	nd	nd	0.37	nd	nd
Acetate ($C_2H_3O_2$)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Formate (CH_2O_2)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Chloride (Cl^-)	4	2.42	2.2	1.96	1.9	1.71	1.78	1.81	1.11	1.96	1.9
Nitrite (NO_2^-)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Bromide (Br^-)	10	0.26	0.33	0.23	0.21	0.16	0.34	0.29	0.25	0.66	0.69
Nitrate (NO_3^-)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Phosphate (PO_4^{2-})	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sulfate (SO_4^{2-})	3	nd	1.01	nd	nd	nd	nd	nd	nd	nd	nd
Weak Organic Acid	25	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cation Species											
Lithium (Li)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Sodium (Na)	3	0.28	0.3	0.29	0.26	0.29	0.33	0.28	0.14	0.28	0.3
Ammonium (NH_4)	3	0.53	0.42	0.25	0.25	0.37	0.35	0.5	0.26	0.43	0.42
Potassium (K)	3	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Magnesium (Mg)	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Calcium (Ca)	1	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd

APPENDIX B

Ion Chromatography Tests: Cleaning Agent A - All boards passed. nd= not detected.

that the combination of the lowest wash bath temperature or thermal energy, in combination with mechanical energy and cleaning agent selection and wash bath exposure achieves the desired cleaning results.

DI-water Usage

All cleaning systems use DI-water. As indicated in the results section of Performance Indicator 4, substantial savings are realized using a chemistry-assisted cleaning process versus a DI-water cleaning process. The savings in DI-water usage should certainly be considered when preparing a cost analysis of a chemistry assisted cleaning system.

Environmental Impact

Many factors should be considered regarding the environmental impact of a cleaning process, whether it is a DI-water system or chemistry assisted system. For this study, the cleaning agent VOC content was analyzed confirming that at 5% working solution concentration, the VOC value of 37g/l was well below the industry average and extremely favorable from an environmental standpoint.

Overall Conclusion

This comparative study confirmed through the DOE developed and executed that a DI-water inline cleaning system is challenged to consistently and effectively clean underneath low standoff components soldered with 10 of the most commonly used leaded and lead-free pastes in the market today. Furthermore, the hypotheses proposed were proven valid for the use of Cleaning Agent A, not only through this study, but also with the results of the case study data presented from customer A and B. Hypothesis H2 was proven invalid for the use of DI-water.

Residues left intact can lead to electrochemical migration, leakage current, and, ultimately, PCB failure. Thus, if product reliability is critical, low standoff cleaning is a must. The proper cleaning agent must be selected and optimized with thermal and mechanical energy to achieve the desired cleaning result. **SMT**

Acknowledgements

Special thanks to ERSA North America for providing the 10-zone ERSA Hotflow 320 reflow oven; Aqueous Technologies for providing the Zero Ion Ionic Contamination test equipment; and Speedline Technologies for providing technical support regarding machine optimization for DI-water and Cleaning Agent A.

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3. Sinisa Aleksic Ph.D.; Umut Tosun, M.S. Chem. Eng.; Dr. Harald Wack, Ph.D.; and Dr. Joachim Becht, Ph.D., "Fluid Flow Mechanics - New Advances in Low Standoff Cleaning," SMTA International Proceedings, 2008.
4. Ionic Contamination according to IPC-TM-650; Ion Chromatography according to IPC-TM-650, method 2.3.28; and Visual inspection according to IPC-A-610 Rev. E-2010 – Acceptability of Printed Boards.

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Top Ten Market News Highlights

World May Yet Again Dive into Recession

Growth of the world economy has weakened considerably during 2012 and is expected to remain subdued in the coming two years, according to the United Nations in its latest issue of the "World Economic Situation and Prospects 2013 (WESP)." The global economy is expected to grow at 2.4% in 2013 and 3.2% 2014 a significant downgrade from the UN's forecast of half a year ago.

Low-cost Tablet PCs Poised to Gain More Attention

Tablets have become an undisputed highlight for this year's peak season, with cheap, under-$200 devices such as Nexus 7 and Kindle Fire HD poised to gain major attention within the market. Considering how Google and Amazon are able to resort to advertising costs and other means to make up for their tablets' low prices, the PC vendors who traditionally rely on hardware sales for profit will be in for some serious competition.

IHS Releases Top 10 Solar Market Predictions for 2013

"The photovoltaic industry is in the midst of wrenching change—buffeted by government incentive cuts and nose-diving prices that have hurt solar suppliers worldwide, rocked by trade disputes among its major players, and hamstrung by a sputtering global economy," said Ash Sharma, director, solar research at IHS.

Significant Growth for Automotive Electronics Market

"Growth areas in automotive development include electrified powertrains, advanced driver assistance systems (ADAS), human-machine-interface (HMI), smartphone connectivity, and telematics," says Kevin Mak, automotive electronics analyst. "This has propelled regions such as Silicon Valley, California, into the automotive spotlight."

25% of PC Owners May Switch to Other Devices

Twenty-five percent of computer owners say they may not replace their PC when their current machine becomes unusable, signalling a possible trend of consumers becoming PC-less because they switch to a tablet or a similar device, according to a national survey conducted by the Center for the Digital Future.

Global IT Spending Forecast to Reach $3.7 Trillion in 2013

Worldwide IT spending is projected to total $3.7 trillion in 2013, a 4.2% increase from 2012 spending of $3.6 trillion, according to the latest forecast by Gartner, Inc. The 2013 outlook for IT spending growth in U.S. dollars has been revised upward from 3.8% in the 3Q12 forecast.

Global Semi Market Posts Strong November Sales

The Semiconductor Industry Association, representing U.S. leadership in semiconductor manufacturing and design, has announced that worldwide sales of semiconductors reached $25.73 billion for the month of November 2012, the largest monthly total of 2012 and a 2% increase from the prior month when sales were $25.22 billion.

Smartphones Lead Portable Consumer Electronic Market

Smartphones continue to steal market share from portable consumer electronic (CE) devices. Annual shipments of handheld game players are expected to decline at least 4% YoY with the North American market experiencing a fall of nearly 13%. In the digital camera market, shipments are expected to decline over 11% YoY worldwide and nearly 20% in North America.

UK Consumer Manufacturing Industry to See Revenue Drop

The UK consumer electronics manufacturing industry is expected to generate revenue of £2.17 billion in 2012-13, down 1.2% compared with 2011-12. According to IBISWorld industry analyst Nigel Fitzpatrick, "The industry is highly globalised, with exports amounting to £1.78 billion and imports amounting to £5.57 billion in 2012-13."

Global LTE Smartphone Shipments at 275 Million Units in 2013

According to the latest research from Strategy Analytics, global LTE smartphone shipments will grow threefold to reach 275 million units in 2013. It will be a record year for 4G technology. Companies leading the growth spurt will include Apple, Samsung, LG, and others.

Plasma Polymerization:

A Versatile and Attractive Process for Conformal Coating

by Andy Brooks, Siobhan Woollard, Gareth Hennighan, and Tim von Werne, Ph.D.,
SEMBLANT LIMITED

SUMMARY: This paper discusses the plasma coating process and the equipment used. The application of this type of coating to electronic assemblies and high-frequency RF applications, and the results of tests to demonstrate the protection offered by these coatings, is also addressed.

Editor's Note: This article was originally published in the Proceedings of SMTA International, Orlando, Florida, October 14-18, 2012.

Abstract

Conformal coatings are designed to protect electronic assemblies and products from damage caused by exposure to the environment and to extend the working life and reliability of the device. These coatings are specially formulated lacquers and are applied by brushing, spraying, dipping, or selective coating in a time-consuming and expensive process that often requires deposition of multiple materials and masking of areas where coating is not allowed. The lack of a simple, inexpensive and effective method of conformally coating electronics has prevented many manufacturers from implementing any protection for their products.

A new class of conformal coat has been developed using a low-power plasma chamber and depositing an ultra-thin polymer coating. The types of materials that can be deposited using this method range from acrylics to silicones and fluoropolymers. Plasma deposition is a simple one-step process that can be used to apply a thin, uniform film as a true conformal coating which requires no curing or the use of any solvents. In some cases this can also remove the requirement for masking contacts and connectors, eliminating a labour and time-intensive step from the conformal coating process.

Introduction

The function of a conformal coating is to protect electronic assemblies from damage

caused by exposure to the environment. These coatings are generally applied as a liquid, using manual techniques such as brush coating, spray coating, or dip coating. Spray coating, needle dispense, and dip coating can also be automated using robots to apply the conformal coating in a more controlled manner. All of these techniques can be time and labour intensive, and generally require that sensitive areas of the assembly, such as connectors and RF components, be masked off prior to coating to prevent the liquid conformal coating materials from coming into contact with these areas. After application of the coating, these materials generally need to be cured to harden, typically using either UV exposure or heat, or some combination of the two. This step adds more time to the coating process, and can emit unpleasant and potentially harmful solvents as the coatings dry. A new method of applying a thin protective coating to electronics would be highly desirable if it could deliver the required level of protection from the environment while eliminating the unwanted process steps. Plasma polymerization offers such a solution.

Plasma Polymerization

Plasma polymerization is defined as the formation of polymeric materials under the influence of plasma conditions [1]. The deposition of solid coatings under plasma conditions has been well studied since the 1960s, with a very wide range of materials now accessible [2]. The solid materials deposited under plasma conditions are generally referred to as plasma polymers, but they are unique and distinct from traditional polymers in that they lack the repeat structure that typically defines a polymer chain. Additionally the materials tend to be highly cross linked, and not soluble in any chemical solvents. One of the advantages of plasma polymers is the fact that they tend to deposit as thin, pin-hole free films in a relatively simple one-step process. This property is key in the application of plasma polymers as conformal coatings for electronics. Figure 1 shows the chemical structures of traditional straight chain PTFE polymer and a plasma deposited fluoropolymer. The plasma polymer is composed of a mixture of C-F and C-C bonds, and is highly cross linked while the PTFE material consists solely of CF2 repeat units.

Another key property of plasma polymerization is that the coatings tend to deposit in a very uniform, conformal nature on all surfaces in the plasma system which are exposed to the active plasma gas. This means that it is possible to easily coat around corners and edges of components, which can be problematic with traditional liquid coating methods as the liquids can tend to run off of these sharp edges. Plasma polymers also tend to be very adherent and form good bonds with the substrates being coated. This can eliminate problems such as coating delamination during high or low temperature exposure.

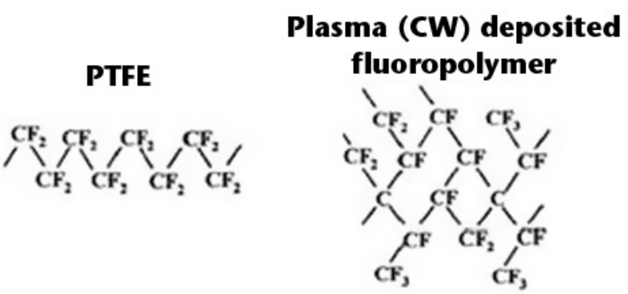

Figure 1: Chemical structures of a traditional linear PTFE polymer and a plasma deposited fluoropolymer [3].

Figure 2: Examples of typical plasma deposition systems suitable for conformal coating. Left to right: A small-volume/R&D system, a medium-volume system, and a high-volume manufacturing plasma system.

Plasma Deposited Conformal Coatings						
Coating Class	Hydrophobicity	Corrosion Protection	Abrasion Resistance	Contact Resistance	Creep Corrosion Resistance	Liquid Immersion Resistance
Fluoropolymer	Very High	Very Good	Moderate	Very Low	Excellent	Good
Acrylate	Moderate to High	Good	Moderate	Low	Unknown	Very Good
Silicone	Moderate to High	Moderate	Good	Moderate	Unknown	Moderate

Table 1: Properties of typical plasma polymers.

Plasma Polymerization Mechanism & Equipment

The mechanism of plasma polymerization is very complex. The high-energy ionization which takes place in the plasma system breaks the precursor gas into ions, free electrons, radicals, and neutral fragments, all of which can be involved in the recombination of these fragments into plasma polymers on the surface of a substrate. The exact chemistry of the resulting coating is dependent on the chemistry of the precursor along with a host of parameters specific to the plasma deposition system such as chamber design, electrode configuration, RF frequency and power, pressure and flow rate of the precursor.

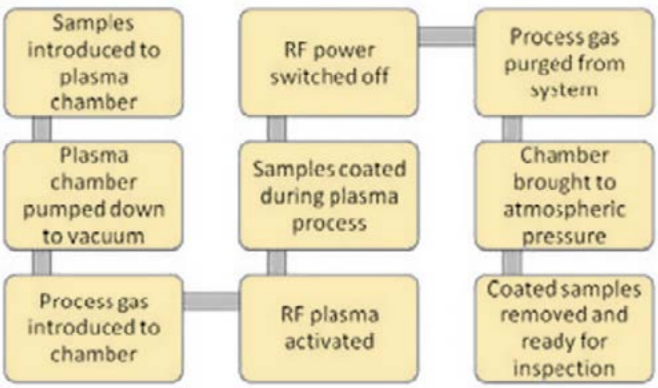

Figure 3: Samples are placed in the plasma chamber. The plasma chamber is evacuated. The precursor gas is introduced and the plasma activated. After the desired thickness has been deposited, the chamber is brought to atmosphere and the coated samples can be removed.

There are a range of plasma systems in the market which are suitable for use as plasma polymerization coaters. Figure 2 shows three such systems manufactured by Nordson MARCH, which vary in size and can be useful for anything from small-volume R&D work to high-volume manufacturing. These systems have been specifically engineered to run optimized coating processes and to convert both gaseous and liquid precursors into plasma polymerized coatings. The small-volume system has an internal volume of 4.5 cubic feet, the medium volume system has an internal volume of 15.5 cubic feet, and the high volume manufacturing system has an internal volume of more than 30 cubic feet.

Example Coating Process

The coating process used in plasma polymerization is typically a simple, one-step process. Samples are placed into a plasma chamber using appropriate racking such that all important surfaces will be exposed to the active plasma gas. The plasma chamber is then pumped down to a vacuum level on the order of 10s to 100s of mTorr depending the specific process. The precursor material is then introduced to the plasma chamber as a gas. This precursor may be a gas at normal atmospheric conditions, such as some hydrocarbon, fluorocarbon, and amine gases, or it may be a liquid that has been converted to gas. This conversion can be achieved using methods as simple as pulling a vacuum on the headspace of a high vapour pressure liquid, passing a carrier gas through the liquid and then introducing the precursor-saturated carrier gas to the chamber, or as complex as direct liquid injection via an atomization process for liquids which have a very low vapour pressure.

Once the flow of the precursor into the chamber has stabilized, the RF generator is switched on and the precursor vapour is ionized into a gas plasma. When run at the appropriate conditions, the precursor will then deposit a coating on the surface of the samples and the thickness of the coating can be controlled by adjusting the length of time that the process is allowed to run. After the desired coating thickness has been achieved, the RF generator is switched off and the precursor gas purged from the plasma chamber. The chamber is then brought back to atmospheric pressure and the coated samples are removed from the system. No further drying or curing of the samples is required. This process is illustrated in Figure 3.

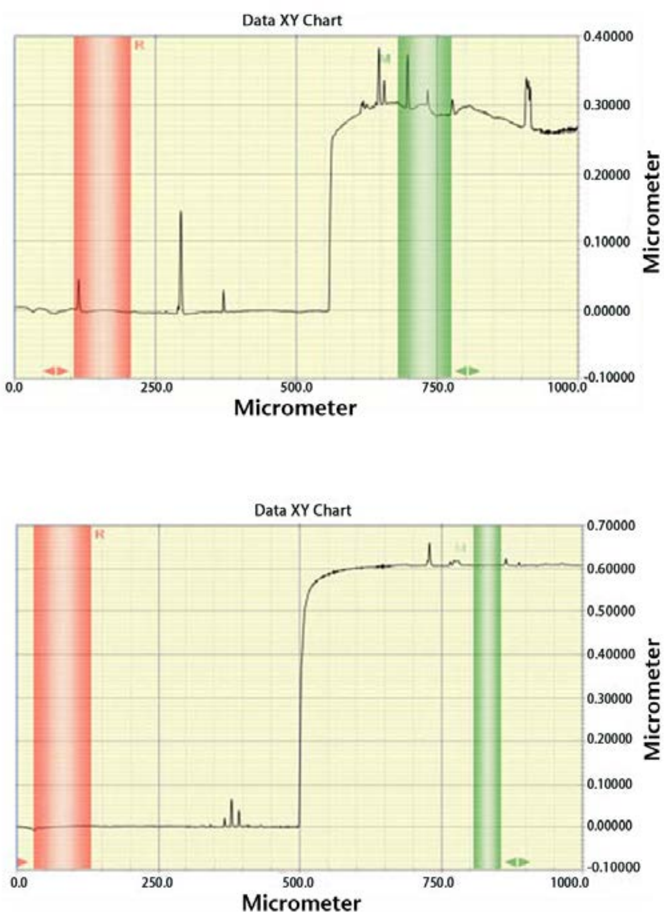

Figure 4: Dektak surface profilometer measurements of two plasma-deposited conformal coatings showing thickness of 300nm (top) and 600nm.

Plasma Deposited Conformal Coatings

As described above, the plasma polymerization process can be used to deposit a wide range of materials. These include simple hydrocarbons, more complex hydrocarbons, such as acrylates and vinyl monomers, fluoropolymers and other halo-hydrocarbons, as well as silicones and other silicon containing materials.

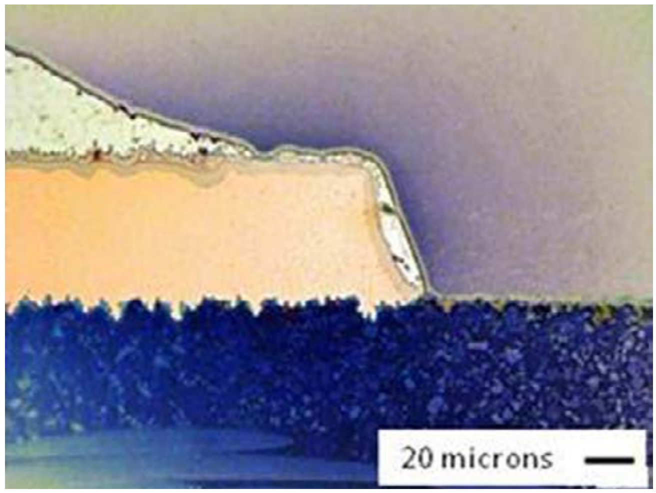

Figure 5: Optical micrograph of a cross-section of a soldered pad on a PCB which has been coated with 1,500nm conformal coating using plasma polymerization.

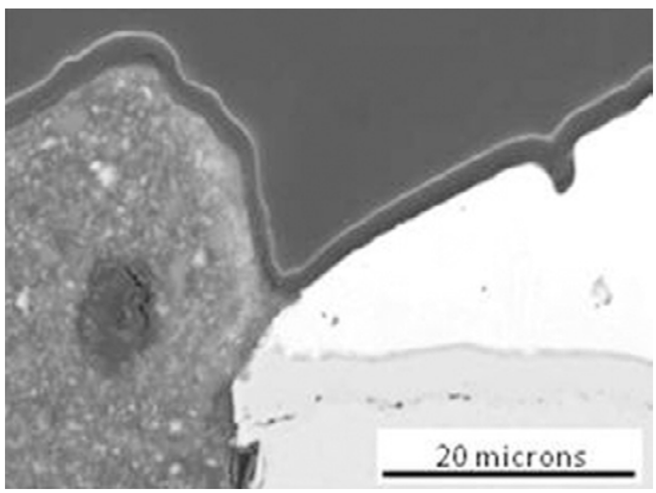

Figure 6: SEM micrograph of a cross-section of a soldered pad on a PCB which has been coated with 1,500nm conformal coating using plasma polymerization.

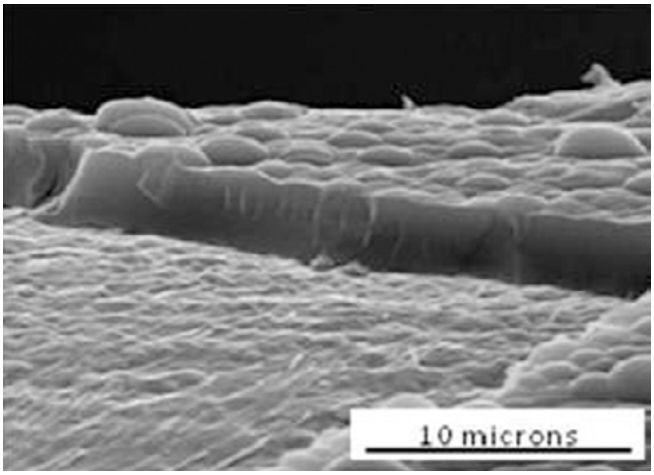

Figure 7: SEM micrograph of a section of a 1,500nm conformal coating using plasma polymerization.

Table 1 lists the types of materials which have been coated and characterized and highlights their key properties.

The plasma polymer coatings can range in thickness from a few tens of nanometers to several micrometers depending on the application requirements. The thickness of the coating can be measured using physical techniques, such as surface profilometry or atomic force microscopy, or it can be measured optically using ellipsometry or reflectometry. Figure 4 shows the thickness of two coatings as measured by a Dektak surface profilometer. In this case, the coating thicknesses are approximately 300nm and 600nm.

It is possible to image the coatings deposited in the plasma using high resolution optical microscopy and by scanning electron microscopy (SEM). Electronic assemblies have been coated using this plasma polymerization process and then potted and microsectioned to inspect the conformal nature of the coating. Figure 5 shows the presence of a thin conformal coating across the surface of a soldered pad on a PCB assembly. The thin coating can be seen to follow the contours of the metal along the edge of the pad, and then continues along the surface of the PCB and over the soldermask. The lighting and contrast in the image have been modified and enhanced to highlight the presence of the thin film. The coating thickness in this case was approximately 1.5 micrometers.

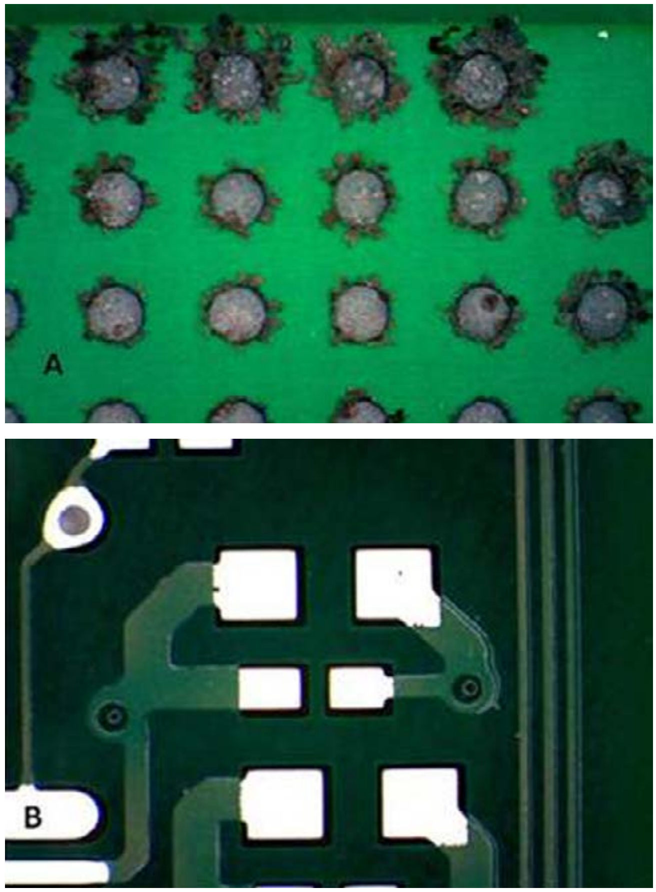

Figure 8: Optical micrographs of immersion silver-finished electronic circuits which are uncoated (left) and coated using plasma polymerization. The uncoated sample shows severe creep corrosion while the plasma-coated sample looks pristine.

A higher-resolution scanning electron micrograph (Figure 6) again shows the uniformity of the coating coverage and the conformal nature of the coating as it covers the metal pad and the adjacent soldermask. It is important to note how the coating easily covered the complex contours of the interface between the solder pad and the soldermask. The coating replicated the bumps in the surface of both materials and even filled in a small divot in the solder. The final SEM micrograph (Figure 7) details a section of the surface of a sample where the coating has been removed. This image shows a coating that is relatively uniform in thickness and density and has grown uniformly from the surface. The coating was seen to be continuous and defect free for all samples that were inspected.

Corrosion Resistance of Plasma-Deposited Conformal Coatings

Previous work has shown how plasma-deposited fluoropolymers can be used as board-level protective coatings for PCBs [4]. These coatings have been shown to be highly effective at preventing oxidation and corrosion on PCBs exposed to harsh environments. The plasma-deposited fluoropolymer coatings have been shown to be particularly effective at preventing corrosion driven by high-sulphur environments. The fluoropolymers have even been shown to prevent creep corrosion when applied over an immersion silver surface finish which is known to be extremely susceptible to creep corrosion [5]. Figure 8 shows micrographs of immersion silver finished electronic circuits which are uncoated and coated using plasma polymerization after exposure to a high-sulphur, high-humidity environment for seven days. The uncoated sample shows severe creep corrosion while the plasma-coated sample looks pristine.

An important characteristic of a many conformal coatings is the ability to protect the circuitry in an electronic assembly from exposure to the combination of moisture and corrosive elements when the circuit is in operation. These conditions can arise when the product is placed in a high-humidity environment, if the sample is exposed to a condensing environment, or if any water accidentally reaches the surface of the circuit. An unprotected electronic assembly can often suffer from catastrophic failure in these conditions. One failure mechanism is the growth of dendrites across the surface of the electronic assembly. These dendrites are conductive metal salts formed by the combination of water and corrosive elements on the surface, and are driven to grow by applied voltages across the circuit.

It is possible to show the impact of this dendritic growth when a circuit is exposed to tap water and a voltage is applied. There are enough salts in the tap water to set up an electrochemical cell which results in the growth of dendrites between the two electrodes of the circuit. In this experiment one set of samples was coated with a 1 micron thick conformal coating using plasma polymerization, while a second set of samples was left uncoated. Bare copper and immersion silver-finished circuits were used in these sample sets. The samples were then connected to a voltage source and immersed in tap water under a microscope so that they could be observed. The first set of images in Figure 9 shows low and high magnification images of an unprotected

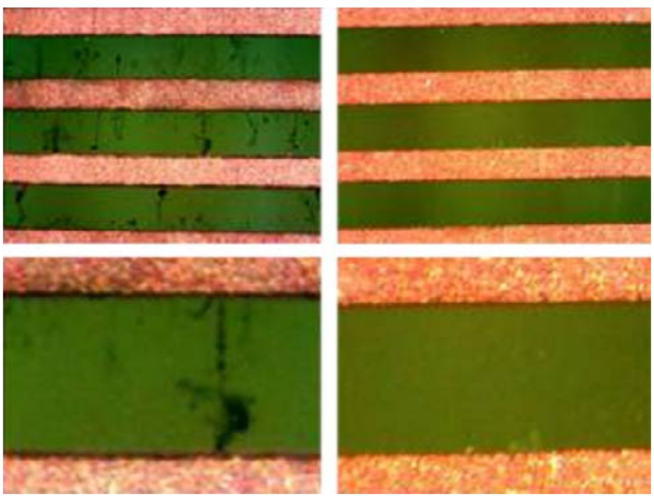

Figure 9: Low-magnification and high-magnification images of bare copper (left) and plasma polymer coated copper after applying voltage while immersed in tap water. The uncoated samples show the presence of dendrites between the electrodes.

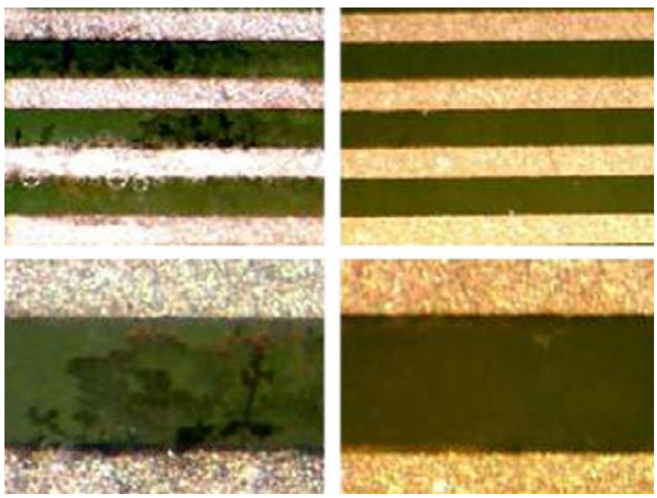

Figure 10: Low-magnification and high-magnification images of bare immersion silver (left) and plasma polymer coated immersion silver after applying voltage while immersed in tap water. The uncoated samples show the presence of dendrites between the electrodes.

copper circuit and a copper circuit which has been coated with a plasma deposited conformal coating. The uncoated sample clearly shows the growth of dendrites between the electrodes, while the plasma-coated sample shows no damage to the circuit.

Conclusion

Plasma deposition has been shown to be a very attractive coating method for the protection of electronic products. The deposition process itself is very simple and can be accomplished with minimal handling or sample preparation, in some cases even eliminating the requirement for masking contacts and connectors prior to coating. Plasma polymerization offers access to an incredible range of coating materials, as virtually any material which can exist in the gas phase can be polymerized in the plasma. We expect that use of plasma polymerization for the conformal coating of electronics will enable a new generation of improved reliability electronics as the ease of use and low cost allow more and more products to be conformally coated. **SMT**

Acknowledgements

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Tim von Werne, Semblant’s CTO, is responsible for the company’s technical roadmap, research and development strategy, and new product and process development. Prior Semblant, he spent seven years at Plastic Logic in Cambridge, where he was director of research, responsible for development of an innovative application of polymer thin film technology. Von Werne holds a Ph.D. in organic chemistry from the University of California, Davis, a BS in chemistry from Florida International University, and continues his studies in technology and innovation management at the Judge Business School at Cambridge University.

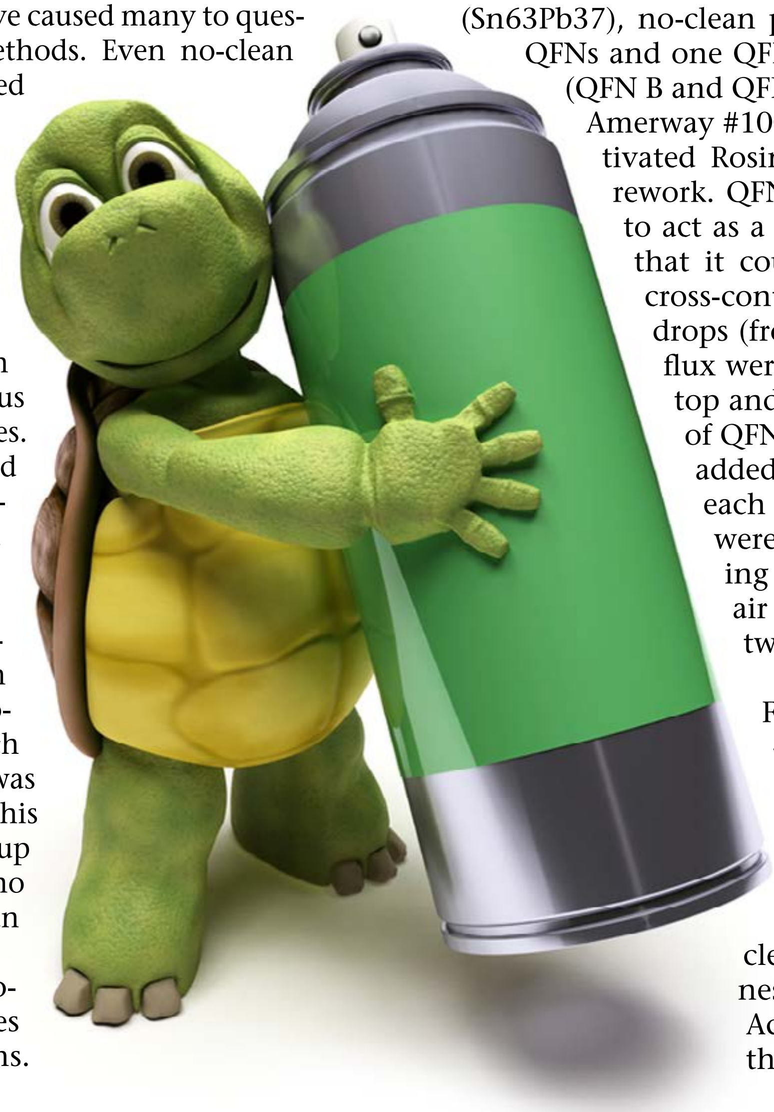
High Reliability and Low Variability Results with Benchtop PCB Cleaning

by Lindsey Shehan
TECHSPRAY

SUMMARY: With the rise of new cleaning standards, some are beginning to question once standard cleaning methods. Lindsey Shehan examines the role different variables play in aerosol cleaning and offers guidelines to improve the process.

Introduction

Historically, dip-and-brush, often with isopropyl alcohol (IPA), was the most common method used in benchtop (manual) cleaning of PCBs. More stringent cleaning standards, necessitated by miniaturization, have caused many to question tried-and-true methods. Even no-clean residues have raised questions; should they be cleaned? Or should they be left alone as the name implies? The dip-and-brush method was innately flawed and even more problematic when used on more tenacious no-clean flux residues. Boards were cleaned with contaminated solvent and brushes held onto contaminants, leaving the question as to how much residue was removed from the board by this process and how much cross-contamination was introduced through this process. Did you end up cleaner, dirtier, or no better, no worse than when you started?



By its nature, aerosol cleaning eliminates both of these problems. Aerosol cleaning introduces a continuous supply of clean, or virgin, solvent throughout the entire cleaning process. Aerosol cleaning prevents the introduction of new contaminants. While there are some obvious pros of aerosol cleaning, questions remain as to whether this method of benchtop cleaning can consistently and reliably clean a board. This paper examines the role that different variables play in aerosol cleaning and offers guidelines to improve an aerosol cleaning process.

Testing Method

Boards were built using Kester's FL250D (Sn63Pb37), no-clean paste to attach two QFNs and one QFP. Two components (QFN B and QFP) were fluxed, with Amerway #100 Type "R" Non-Activated Rosin Flux, to simulate rework. QFN A was untouched to act as a control and also so that it could be checked for cross-contamination. Two drops (from glass pipette) of flux were added, one to the top and one to the bottom of QFN B. Four drops were added to the QFP, one to each side. The boards were then reflowed using the handheld heat/air gun at 400°F for two minutes.

Techspray's G3 Flux Remover (part #1631-16S) aerosol was then used for benchtop removal of the flux. This solvent was chosen due to its cleaning effectiveness of Type "R" Non-Activated Rosin Flux, the flux used to simu-

late rework. The objective was to use a solvent with a known cleaning effectiveness in order to study the impact of the solvent delivery. Board cleanliness was determined by a visual inspection under 64X magnification.

Results and Discussion

Straw Attachment

The use of the straw attachment allowed for a more controlled spray, thus eliminating excessive solvent waste. The straw was also useful in directing exactly where the solvent went. This allowed the user to guide the solvent under the component. Without the straw attachment, solvent was sprayed at the target area (for instance, the sides of the component); however, much of the material was wasted on areas surrounding the target and very little ended up traveling under the component (see Figure 1).

Spray Technique

Best results were obtained when both corners and sides of each contaminated component were addressed, as opposed to focusing on only one or the other, corners or sides. Directing solvent directly into the corners helped to break up any flux dams located there. Because the corners were cleared first, when the sides of the components were addressed, the number of channels opened to allow solvent to pass was greater than it was when corners were not addressed first. The more open channels available, the greater the opportunity for the flux to be exposed to the solvent, and as a result the higher likelihood that all flux trapped under the component will be able to flow out from under the component.

The choice to use an oscillating or stationary spray was dependent on the size of the component. For a small component it was sufficient to use a stationary spray on the component sides; however, for larger components a cleaner board was achieved when the spray was oscillated back and forth across each side of the component. This oscillating spray gave the solvent the opportunity to flow up, under the component from many angles, similar to the way that the flux had.

Spray Angle

An exact straw angle of 30°, 45°, or 60° to the board had no impact on the cleanliness of the board. General downward or upward angles were sufficient. To make the most of the straw, think about the direction in which the residues need to travel. When trying to remove residues from under a component, spray close to the board at an angle that guides the solvent under the component. When all of the residues have been removed from underneath the compo-

Figure 1: Visual comparison of an aerosol spray without (left) and with a straw attachment.

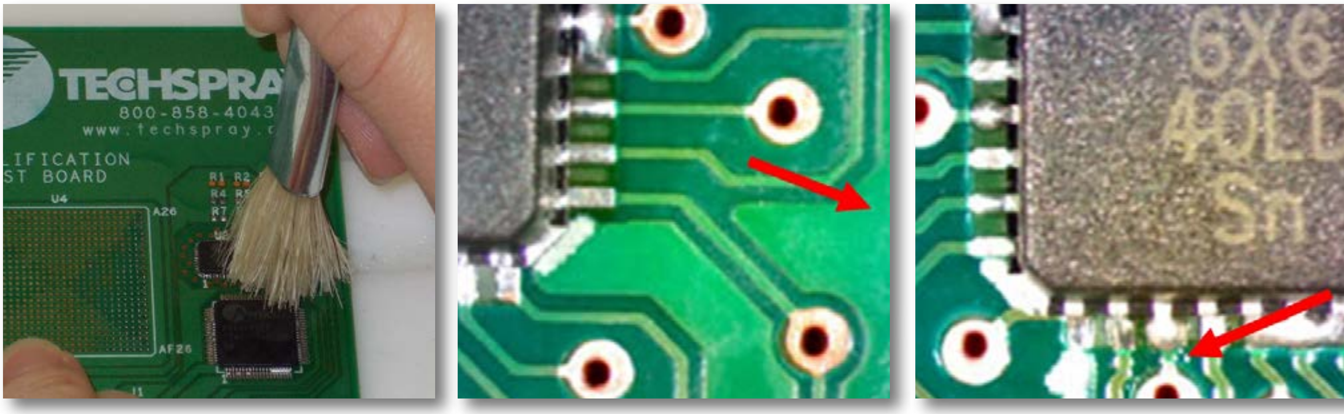


Figure 2: Board cleaned with handheld brush. The components were wetted, and then the brush was wetted and used to scrub the contaminated area. The board in the first picture did not undergo a final rinse. The board in the second picture did. (Note: All flux was not removed.)

nent, spray from on top of the component, angling out along the edges to push any residues out, away from the component.

Cleaning Tools

Handheld brushes and swabs left the board looking dirtier than it started. Brushes and swabs spread partially solvated flux around the components which then dried, leaving a white residue. None of the polyurethane foam swabs held up well in this application. Foam swabs became flimsy when saturated with aggressive solvents and were easily torn. Another problem with handheld tools was that the solvent evaporated too quickly. Best results were achieved when a final rinse was utilized (see Figure 2). The key is not to let the board dry out. When the board dries, the partially solvated flux dries leaving the white residue mentioned earlier. A slower evaporating solvent, like IPA, would avoid the evaporation issue, but should be followed by a rinse (see more details on rinsing below). In addition, some solvent may travel under the component during scrubbing, but without the force of an aerosol spray, the likelihood that the residues under the component will be pushed out is slim.

Brush Attachment

Some solvent cleaners come with a brush that attaches directly to the spray head, and the solvent flows through the brush at a slow rate (see Figure 3). This is particularly common in defluxers available in Europe. Brush attachments produced results that were a step above handheld tools, due to the benefit of a constant supply of virgin solvent. However, they did not produce the same level of cleanliness observed in aerosol only cleaning. The brush attachment allowed for scrubbing problem areas, which can be beneficial. However, the force of an aerosol through a straw attachment produced similar results.

Brush attachments, like handheld tools, have the potential to introduce new contaminants. In addition, for a brush attachment to reach its full potential, a separate aerosol is required for cleaning under components and for the final rinse. Like handheld tools, without the force of an aerosol spray, some solvent may travel under the component during scrubbing; however, the likelihood that the residues under the component

Figure 3: Brush attachment.

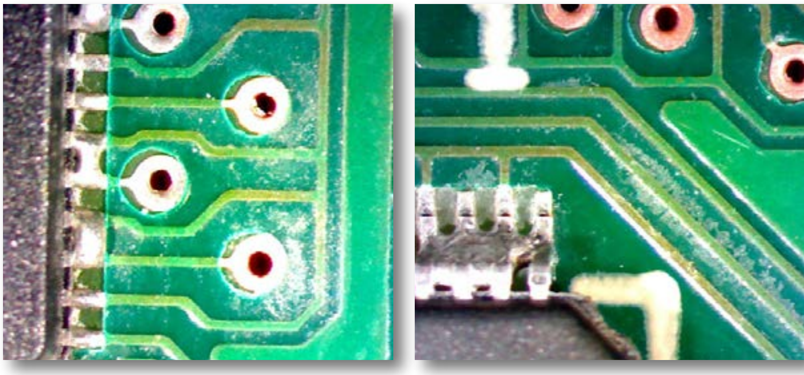


Figure 4: Board cleaned with brush attachment (no separate aerosol was used). No pre-rinse or final rinse utilized. White residue is shown around QFN B and QFP, respectively.

will be pushed out is slim. Because the use of a brush attachment requires that the target area remain saturated, the target area remains in a solvent pool throughout the cleaning period. This increases the likelihood that residues may only be relocated on the board instead of being removed completely. A final rinse, then, was found to be especially important, to ensure that all of the residues were removed from the board (see Figures 4 and 5).

A commercially available brush system provides a separate brush mechanism for cleaning, which is continually fed by the aerosol can. No cleaning advantages to this system were observed compared to a brush attachment. A brush system or attachment is often used to reduce solvent usage, but this advantage is greatly decreased if a proper rinse is applied.

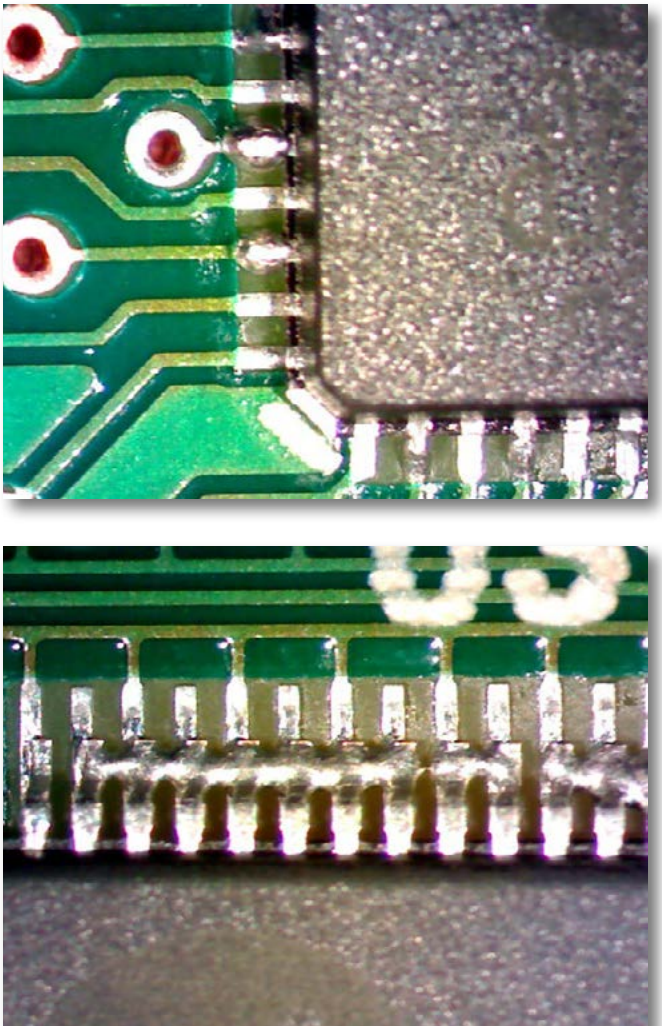


Figure 5: Board cleaned with brush attachment (separate aerosol was used for pre-rinse and final rinse). Some white residue is shown around QFN B and QFP, respectively.

Final Flush/Rinse

The final rinse was found to be a necessary step. This step ensures that all of the solvated flux residues, which have been removed from under and around components, flow off the board completely, and are not simply relocated.

Conclusions

No "one size fits all" approach exists for aerosol benchtop cleaning. There are too many variables involved in benchtop cleaning that prevent developing a method/formula for cleaning that appears to be (per visual inspection) 100% effective all of the time. That being said, some methods do work better than others and selecting the correct combination and formalizing the process will reduce variability. **SMT**

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Comparing Conformal Coatings

by Sean Horn
DIAMOND MT

SUMMARY: With an in-depth look at the pros and cons of each, Sean Horn addresses the use of three conformal coatings: Silicone, urethane, and paraxylene. Which is the better coating? Read on to find out.

Silicone and urethane are two of the most popular conformal coating types today; both are used for a variety of reasons, but which is the better coating? What about paraxylene, a transparent polymer conformal coating deposited from a gas phase in a vacuum that can be applied uniformly to virtually any surface and shape including glass, metal, paper, resin, plastics, ceramics, ferrite, and silicon?

While the choice ultimately depends on the application, let's take a look at the pros and cons of each.

Silicone Conformal Coatings

Many typical silicone coatings have continuous operating temperature ratings of 200°C. This is far higher than most urethanes (125°C). Some silicone coatings are rated as high as 600°C for ultra-high temperature applications. Silicones are in great demand for the automotive industry, where temperatures can reach upwards of 175°C in the engine compartment.

An additional benefit of a silicone conformal coating is its excellent moisture protection. Silicones are used in cases where extreme temperature differences occur—environments that result in excessive moisture. Other conformal coatings fail within hours or days, but silicone, especially when applied thickly, succeeds.

One particular application is for electronically-controlled heaters developed for arctic temperatures. The heaters warm to almost 150°F and then cool to ambient temperature, sometimes as cool as -40°F. This wide temperature swing happens very quickly, resulting in a high-moisture environment. Other coatings, like urethanes, result in board failures. Silicones are the only proven alternative.

Silicone conformal coatings are also among the easiest to apply and rework. Typically low on solvents, they also ensure a smooth coat that cures very quickly—about one hour at room temperature. Apart from this, silicone's flexibility and softness, as well as its relatively weak resistance to solvents, is suitable for assemblies requiring work after coating. The flexibility keeps labor time down without compromising coating integrity.

When Not to Use

Because silicone conformal coatings must be applied thicker (target thickness of between 0.00197" and 0.00827") than other conformal coatings, it's wise to seek other coating options

if your application has tight clearance tolerances or if the solder joints cannot support the stresses placed upon them by the thicker layer of coating.

Types of silicone conformal coating include:

- Humiseal 1C49;
- HumiSeal 1C49LV;
- HumiSeal 1C51;
- HumiSeal 1C55;
- Dow Corning 1-2577;
- Dow Corning 3-1753;
- Dow Corning 3-1765;
- Dow Corning 3-1744;
- Dow Corning 3-1953;
- Dow Corning 3-1965;
- Dow Corning 3-1944;
- MG Chemicals 422B;
- Peters DSL 1705 FLZ;
- Peters DSL 1706 FLZ;
- Electrolube SCC3; and
- Electrolube SCC4.

Urethane Conformal Coatings

Type UR conformal coatings are quite resistant to chemical solvents—second only to parylene. As such, applications requiring any prolonged exposure to harsh chemical solvents should consider urethane resins.

Long-term NASA studies [1] have shown that urethane conformal coatings are one of the few ways to successfully mitigate tin whisker growth. Since there's no known way to completely eliminate tin whisker growth, you must select a proper tin whisker mitigation strategy (see sidebar, "Tin Whisker Mitigation and Conformal Coating"). Urethane conformal coatings are a great place to start.

Applications that see direct mechanical wear against the coating should consider urethane conformal coatings. Urethane resins are very hard and resistant to mechanical wear. Their hardness is second only to epoxy conformal coating, but rework is much easier with urethanes.

When Not to Use

For products going into a high-vibration environment, urethane conformal coatings are not a good choice. Because of the mechanical strength and resistance to abrasion characteristics that urethanes typically exhibit, a high-vibration environment could ultimately end up weakening the integrity of this rigid coating. A better choice would be a completely conforming, flexible coating, such as parylene conformal coating.

If an application will see a high-heat environment, urethanes will not provide the protection required. Leading urethanes, such as HumiSeal 1A33, offer protection to 125°C.

Types of urethane conformal coating include:

- HumiSeal 1A33;
- HumiSeal 1A20;
- Humiseal 1A27;
- Humiseal 2A64;
- HumiSeal 1A34;
- Hysol PC18M;
- CONATHANE CE-1155-35;
- CONAP CE-1170;
- CONATHANE CE-1164;
- Techspray Fine-L-Kote;
- MG Chemicals 4223; and
- Electrolube PUC.

Paraxylene Conformal Coatings

Parylene polymers are polycrystalline and linear in nature, possess superior barrier properties, have extreme chemical inertness, and, because of the deposition process, can be applied uniformly to virtually any surface or shape.

Parylene is unique in that it is created directly on the surface at room temperature. And because there are no liquid phases involved, the coatings are truly conformal, of uniform controllable thickness, and are completely pinhole-free at thicknesses greater than 0.5µ. In fact, a parylene coating completely penetrates spaces as narrow 0.01 mm.

In addition to its excellent electrical properties—low dielectric constant and loss with good high-frequency properties, good dielectric strength, and high bulk and surface resistance—parylene also has good thermal endurance, performs in air without significant loss of physical properties for 10 years at 80°C, and, in the absence of oxygen, to temperatures in excess of 200°C.

Parylene is often applied to substrates or materials where there is no room for any voids in the protective coating. These materials are likely to be placed in harmful chemicals, a moisture packed environment, or even the human body. Such materials are often mission-critical devices that cannot allow environmental factors to alter their performance. When devices need such a stringent level of protection from the elements, parylene is the only logical choice.

Disadvantages of Parylene

Even with all of these benefits, there are still disadvantages to using parylene versus other conformal coatings. One important factor is cost. The cost for parylene is typically higher than other conformal coatings due to many factors: The process itself, the raw materials involved, and the labor required in preparing a device for coating. While this is not necessarily true for all applications, when an item is quoted in parylene and wet chemistry, the parylene pricing will be higher.

The parylene process is a batch process. This means that there is only a finite amount of space available in the chamber for every coating machine run. The goal is to maximize the amount of items to be coated in the chamber. If there is a suboptimal amount of items to be coated available, the difference in price per piece could escalate drastically.

The raw material, parylene dimer, is rather expensive, ranging from $200 to $10,000+ per pound. Because parylene is applied through a vapor deposition process, everything, including items that don't need to be coated (like the inner diameter of the chamber), are coated. This makes parylene an inherently inefficient process and wasteful with materials, which escalates the end cost to the customer.

Masking and otherwise prepping an article for parylene coating can be a labor-intensive affair. Because parylene is applied as a vapor, it literally gets everywhere that air can. Operators and quality inspectors should take this into account prior to coating to ensure that all coating-free areas are just that.

One major issue that often comes up for some high-volume manufacturers is the limited throughput of parylene. Runs of the parylene machine can take anywhere from eight to over 24 hours. As a result of the limited chamber space, a fixed amount of product can be processed during one coating cycle. This, coupled with the high capital cost of new equipment, can wreak havoc with internal and customers' delivery schedules.

One final disadvantage of parylene to consider is its poor adhesion to many metals. Parylene has always had poor adhesion to gold, silver, stainless steel, and other metals. Many PCB manufacturers use gold in their products because of its conductivity. While there are some adhesion promotion methods that will greatly improve adhesion to these metals, they are either material or labor heavy and can increase costs significantly.

Conclusion

There are many benefits to using silicone, urethane, or paraxylene conformal coating. Certainly either coating is better than none, but the trick is to align your product's potential issues with the strengths of the conformal coating that can best protect it. Only by addressing and working through these issues will you be able to determine the correct coating for you. If there is some doubt to which coating is best, it may be worth it to have an outside party provide consultation services for your application. **SMT**

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Tin Whisker Mitigation & Conformal Coating

Tin whiskers are electrically conductive, crystalline structures of tin that sometimes grow from surfaces where tin (especially electroplated tin) is used as a final finish. Tin whiskers typically grow from lengths of 1 to 2 mm, but have been observed to lengths in excess of 10 mm. Electronic system failures have been attributed to short circuits caused by tin whiskers that bridge closely-spaced circuit elements maintained at different electrical potentials.

People sometimes confuse the term "whiskers" with a more familiar phenomenon known as "dendrites," which are commonly formed by electrochemical migration processes. Therefore, it is important to note here that whiskers and dendrites are two very different phenomena. A whisker generally has the shape of a very thin, single filament or hair-like protrusion that emerges outward (z-axis) from a surface. Dendrites, on the other hand, form in fern-like or snowflake-like patterns growing along a surface (x-y plane) rather than outward from it. The growth mechanism for dendrites is well-understood and requires some type of moisture capable of dissolving the metal (e.g., tin) into a solution of metal ions, which are then redistributed by electromigration in the presence of an electromagnetic field. While the precise mechanism for whisker formation remains unknown, it is known that whisker formation does NOT require either dissolution of the metal NOR the presence of electromagnetic field [2].

According to NASA, the mechanisms by which tin whiskers grow have been studied for many years. A single accepted explanation of the mechanisms has NOT been established. Some theories suggest that tin whiskers may grow in response to a mechanism of stress relief (especially "compressive" stress) within the tin plating. Other theories contend that growth may be attributable to recrystallization and abnormal grain growth processes affecting the tin grain structure which may or may not be affected by residual stress in the tin plated film [2].

Are Tin Whiskers an Issue?

NASA noted that tin whiskers pose a serious reliability risk to electronic assemblies. Several instances have been reported where tin whiskers have caused system failures in both earth and space-based applications. To date, there are reports of at least three tin whisker induced short circuits that resulted in complete failure of on-orbit commercial satellites. There have also been whisker-induced failures in medical devices, weapon systems, power plants, and consumer products [2].

Four main risks should be considered with tin whiskers:

1. Stable short circuits in low-voltage, high-impedance circuits.
2. Transient short circuits.
3. Metal vapor arc.
4. Debris/contamination.

Of these, a metal vapor arc is often the most destructive. A metal vapor arc occurs when a tin whisker initiates a short in an environment possessing high levels of current and voltage.

Unfortunately, there is no known way to eliminate tin whisker growth, only the use of mitigation strategies to limit their affect on product.

Viable Tin Whisker Mitigation Strategy

In 1998, Galaxy IV commercial satellite failed on-orbit due to a metal vapor arc initiated by tin whiskers growing from supposedly tin-lead surfaces. The surfaces were later confirmed as being pure tin, despite certificates of compliance stating otherwise. This failure interrupted pager services for days.

As a response to the Galaxy IV failure, NASA initiated a study to assess the effectiveness of a urethane conformal coating in whisker mitigation. Polyurethane conformal coating (Uralane 5750) was chosen as a coating most common to space applications.

As a result of the NASA study, conformal coating was proven to be a viable tin whisker mitigation strategy. While thinner coats of conformal coating were unsuccessful at preventing tin whisker penetration, Arathane 5750 (a urethane resin) applied at 2 mils thick was found to be strong enough to prevent tin whiskers from penetrating the coating and causing any potential issues.

Environmentally-Responsible Defluxing

by Michael Konrad
AQUEOUS TECHNOLOGIES

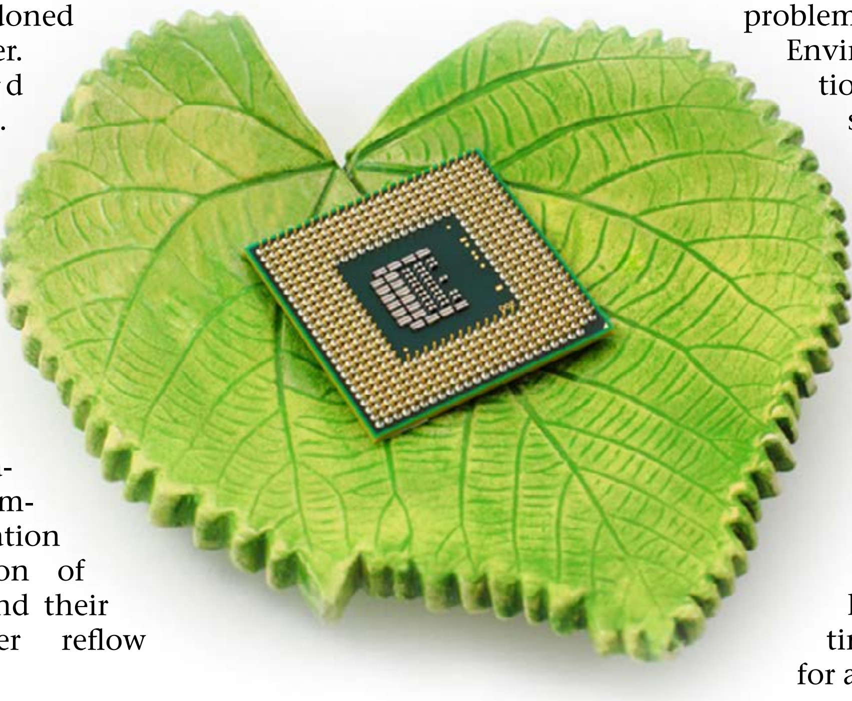
SUMMARY: Cleaning is on the rise and today it is possible to improve assembly reliability via cleaning—all while maintaining an environmentally-friendly configuration. Michael Konrad explains how.

No longer does one have to exchange one problem for another.

The New Year brings a sense of déjà vu. Flashback to the late 1980s. In that era, virtually all circuit assemblies were cleaned after soldering. Flux and other process-related contaminants were removed as a matter of standard process. Cleaning was not considered to be an option.

Concerns about the environment, specifically ozone depletion, lead to the elimination of the industry's most popular cleaning solvents. No-clean flux alternatives eventually replaced cleaning as a standard process, relegating cleaning mainly to high-reliability assemblers such as military and medical manufacturers. Most commercial assemblers, representing the majority of all electronic assembly, abandoned cleaning altogether.

Fast-forward to modern times. Today, cleaning has returned for many commercial assemblers. Many reasons exist for the return of cleaning as a mainstream process. Primary reasons include assembly miniaturization and the adoption of lead-free alloys and their associated higher reflow temperatures.



Unlike past defluxing processes, which utilized CFC-based solvents, most modern defluxing processes use aqueous-based chemical additives. By far, the majority of all defluxing processes are aqueous-based. Aqueous-based cleaning processes, while capable of removing all flux types (rosin, no-clean, water-soluble), are not associated with ozone depleting reactions. While aqueous-based cleaning chemicals contain VOCs, which are regulated in some urban regions, most are designed to operate well in VOC-controlled regions. In regions where VOCs are regulated, the majority of the regulations restrict VOC content to 50 grams per liter (in usable concentrations). In Southern California, the restriction is 25 grams per liter. Fortunately, effective defluxing chemicals are available for both non-restricted and VOC restricted regions.

Cleaning improves assembly reliability. Many assemblers have returned to cleaning to solve product reliability problems in the field. It does not make sense to swap one problem for another. For some assemblers, contamination-caused reliability problems were solved at the expense of environmental problems. Between the Environmental Protection Agency (EPA), state agencies, and municipal water districts, many regulatory authorities may be interested in your cleaning processes. With so many agencies claiming jurisdiction, and with potential environmental liability at an all-time high, the need for an environmentally-responsible cleaning process has never been greater.

In the past, environmental concerns were mitigated by reducing the volume of effluent being directed to the drain. Today, simply reducing the volume of effluent may not be enough. Two specific actions eliminate environmental liability:

1. Utilize VOC-compliant defluxing solutions.
2. Operate in a completely zero-discharge configuration.

VOC Compliance

As stated earlier, all regions of the United States allow the use of VOC-containing chemicals for use in defluxing applications. When regulated, most regions allow VOC levels up to 150 grams per liter. In specific urban areas, VOC content may be limited to 50 grams per liter. In specific regions known for air pollution, i.e., Southern California, VOC contents may be limited to 25 grams per liter. All major defluxing chemical providers offer effective VOC-compliant solutions. Consult with your defluxing chemical provider to ensure compatibility with both the contamination removal requirement and local air quality regulations.

Effluent Elimination

Over the years, the subject of effluent mitigation has changed from the minimization to the elimination of discharge. For the past two decades, the desire to "close-loop" the cleaning process was fueled by economic, not environmental interests. Close-looping part of a cleaning process could save money and therefore was embraced by many assemblers. The problem is assemblers were chasing the wrong "green." While it is true that closing-looping part of the cleaning process will reduce specific consumable expenses, it formally was only successful by directing the most contaminated effluent to the drain so that the cleaner effluent could be captured, filtered, and reused. In other words, sacrifice the dirty water so that the cleaner water can be reclaimed. This process does not make environmental sense.

Recent advances in defluxing machine technology have allowed all process solutions (wash and rinse solutions) to be reused. While both inline and most batch defluxing machines maintain the ability to capture, filter, and reuse the wash solution, the same has not been true for the rinse water. Inline defluxing systems often are equipped with rinse water recycling systems, allowing the used rinse water to be captured, filtered, re-deionized (via traditional carbon and ion-exchange resin media), and reused. For the rinse water within inline defluxing systems to be re-used as described, the machine must be equipped with a suitable chemical isolation section, allowing the dragged-out chemical-containing wash solution to be blown and/or rinsed off the assembly prior to entering the pre-rinse and final-rinse sections of the machine. The stripped-off wash solution along with the water used to remove it would be directed to the drain. This is required due to the fact that the volume of defluxing chemical dragged out from the wash section, if not stripped off of the assembly, would prematurely cause carbon and ion-exchange media failure, adding thousands of dollars annually to the operating cost. Because of this, it is unlikely that an inline defluxing system running with a defluxing chemical would be a candidate for a complete closed-loop (zero-discharge) configuration.

Historically, batch-format defluxing systems have not been able to operate with defluxing chemicals in a complete zero-discharge configuration. Like their inline format counterparts, wash solution drag-out from wash to rinse has prevented the reuse of 100% of the rinse water. Formally, the solution was to connect the rinse water drain to an evaporation system. The wash solution would be filtered and reused while the rinse water would be evaporated. While this configuration eliminated the need to connect the batch-format defluxing system to a drain line, there was a need to remove "sludge" (highly contaminated/concentrated solution) from the evaporator several times per year. Rather than connecting to a drain, the user had to remove sludge as hazardous waste. Alternatively, some batch-format defluxing systems allowed one to more of the rinse cycles to be directed to the drain, allowing the balance of the rinse water to be close-looped. This configuration still witnessed contaminated rinse water being sent to drain and only the cleaner water close-looped. This configuration, like the evaporative approach, did not eliminate a waste stream.

Recent advances in batch-format defluxing systems have allowed 100% of the rinse water to be captured, filtered, and re-deionized via traditional carbon and ion-exchange methods without fear of severally premature filter media failure. The ability to send all of the rinse water directly to the filter media is possible by substantially reducing the volume of chemical-containing wash solution dragged out into the rinse water.

Two sources exist for wash solution to mix with the rinse water:

1. Plumbing.
2. Wetted surface area.

Plumbing

Most batch defluxing machines utilize the same pump for several applications including wash, drain, and rinse functions. Virtually all defluxing machines utilize centrifugal pumps. Centrifugal pumps provide both high-volume and high-pressure fluid flow. Unfortunately, they also lack the ability to fully drain the fluid from inside their caverness interior. This results in a high volume of fluid retained in the pump at the end of a cycle. Normally, this results in wash solution mixing with the rinse water and then rinse water mixing with the wash solution. When wash solution is allowed to mix with the rinse water, added defluxing chemical is sent to the rinse water recycler, damaging the carbon and ion-exchange media.

In addition to the centrifugal pump issues, many plumbing designs require pump pressure to drain the lines. When the pump begins to cavitate at the near end of a drain cycle, the pump loses pressure and the ability to push fluids through a pipe. This allows fluids to stay in the plumbing lines, eventually mixing with the rinse water in subsequent cycles. One solution to this problem is to utilize segregated pumps. One pump may be used for generating spray pressure to wash and rinse the assemblies while another may be used for draining or fluid transfer. In a multiple pump configuration, the high-flow/pressure centrifugal spray pump may be mounted in a vertical format rather than in the traditional horizontal configuration. By mounting the spray pump in a horizontal and inverted (upside down) configuration, the fluid will immediately "fall" out of the suction section of the pump head when the pump turns off. This action eliminates the high volume of pump-caused drag-out associated with horizontally-mounted centrifugal pumps.

"In addition to the centrifugal pump issues, many plumbing designs require pump pressure to drain the lines."

The use of a self-priming positive displacement drain/transfer pump physically mounted at the lowest gravity point within the hydraulic system will allow all fluids that drain from the spray pump to be suctioned from the plumbing system and removed. These specific pump configurations substantially reduce the volume of plumbing-caused dragged-out effluent to a tolerable amount.

Wetted Surface Area

Wetted surface areas include the walls of the cleaning chamber and the surface area of the assemblies being cleaned. Even though assemblies are mounted and cleaned in a near vertical configuration (in batch-format defluxing systems), a tangible volume of fluid may remain on the wetted surfaces for a short time. Use of a programmable rest-time delay between the end of the wash cycle and the transfer of the wash solution is beneficial. By allowing assemblies to "rest," even for 30 seconds, will allow wash solution to be drained off of the assemblies and chamber walls, reducing the wetted-surface fluid drag-out volume by as much as 90%.

To review:

- It is no longer enough to reduce environmental liability; it is better to eliminate it.

- Determine the VOC restrictions (if any) in your region and select a defluxing chemical additive compatible with the target contamination and any VOC regulations.
- Select a defluxing machine with wash solution filtration and re-use capabilities.
- Utilize a rinse water recycling system (may be part of the defluxing machine or a separate appliance).
- Select a defluxing machine designed to direct all of the rinse water to a recycling system (no requirement for first-rinse bypass/segregation), and with specific drag-out reducing designs to maximize filter media life while operating in a complete zero discharge configuration.

It is possible today to increase assembly reliability through cleaning while maintaining an environmentally-responsible configuration. No longer does one have to exchange one problem for another. **SMT**

Mike Konrad has worked continuously within the electronics assembly equipment industry since 1985. In 1989, in response to the Montreal Protocol, he designed a new generation of aqueous-based defluxing equipment, allowing rosin-based fluxes to be removed in water-based cleaning equipment. In 1992, Konrad founded Aqueous Technologies Corporation, North America's largest manufacturer of fully automated defluxing and cleanliness testing equipment where he serves as president and CEO. Aqueous Technologies manufactures defluxing, stencil cleaning, cleanliness testing, and water recycling equipment designed specifically for the electronics industry.

Konrad previously served on the U.S. Navy's EMPF Manufacturers Committee in the late 1980s, is a current member of the SMT Magazine Editorial Advisory Board, and has published dozens of articles on cleaning and cleanliness testing. He is a regular speaker at industry conferences has taught cleaning and cleanliness testing workshops around the world. Contact him at konrad@aqueoustech.com.

Conformal Coating Inspection: What Do You See?

by Dr. Lee Hitchens
SCH TECHNOLOGIES

SUMMARY: Dr. Lee Hitchens takes a look at conformal coating standards, what they actually mean, what you can achieve with new automated conformal coating inspection technology, and what must be considered to ensure a reliable inspection process.

Inspection is a key aspect of the conformal coating application process and a successfully coated PCB.

Conformal Coating Standards

In today's world of conformal coating processing, the main international standard used by most companies globally is IPC-A-610 Acceptability of Electronic Assemblies. The current version, IPC-A-610E, is available commercially from IPC. Other standards exist, including internal (company) standards, but this article focuses on the A610 for help in understanding the needs of conformal coating inspection.

IPC-A-610: Understanding the Issues

When looking at the IPC-A-610 standard, it should be considered section by section. This will make it easier to understand for both the needs of the operator and the conformal coating process itself. The standard is broken down into three sections: General, coverage, and coating thickness.

Conformal Coating – General

The IPC standard states that, in general, conformal coatings should be transparent, have a uniform colour and consistency, and cover the board and components uniformly. The coating coverage will depend on the application method.

From this there is much to infer, which can cause problems if interpreted incorrectly. Consider the fact that every conformal coating process is different—whether it is brush coating, robotic selective application using an airless valve, or spraying with an aerosol. All will produce different levels of finish and these finishes can vary depending on how the process is set up, which operator carries out the process, and the environment during production.

An interesting term used in the standard is "uniform." Alone, the word could mean a great deal of things, but it must be taken in context with coverage details and thickness requirements discussed later. Ultimately, without them the term is of very little help.

The coating should be transparent. This calls into question the issue of using pigmented coatings and whether or not they are acceptable. This would be a customer query to be raised and the impact on the performance of the conformal coating should be assessed.

Conformal Coating – Coverage

Most conformal coatings now carry an optical brightener which, when exposed to ultraviolet (UV) light, fluoresces. This, in turn, allows easier inspection. However, some defects cannot be seen under UV and white (natural) light may also be needed. Some coatings have poor UV fluorescence due to the nature of the material. This can be seen in many silicone conformal coatings and can make inspection more difficult.

Whether or not the laminate or resist fluoresce at a similar level to the coating is also important—some conformal coating materials deliberately have no UV fluorescence because the optical brightener used has a detrimental impact on the coating and the PCB in the field.

In terms of coverage, the standard offers finish quality targets and different levels of quality: Class 1, 2, and 3. Targets include:

- No loss of adhesion.
- No voids or bubbles.
- No de-wetting, mealing, peeling, wrinkles, cracks, ripples, fisheyes, or orange peel.
- No embedded/entrapped foreign material.
- No discolouration or loss of transparency.
- Completely cure and uniform.

Achieving all of the above is virtually impossible for many conformal coating processes, circuit boards, and materials. To approach such a target consistently will, in general, be extremely costly in terms of money and investment and in process control time and effort.

Consider target of no bubbles. Even when using the naked eye to view the PCB it is normally impossible to not find bubbles anywhere on a circuit board, UNLESS:

- The conformal coating process is completely controlled.
- The material was selected correctly to achieve this result.
- The environment the process is in is completely optimised.
- The operators are fully trained to understand why the bubbles occur to control the process.
- The manufacturer of the PCB laminates, the assembly process, the components, or the conformal coatings do not change anything to cause an undesirable reaction.

Fortunately, approaching such targets is the desire, but not the necessity, for most companies. If it were necessity, conformal coating would be the exclusive realm of a few experts and unachievable by most. IPC helps here by offering acceptable criteria for the targets above.

IPC Acceptance Criteria for Conformal Coating

The IPC outline the acceptance criteria within the coverage section as being:

- Completely cured and homogeneous.
- Coating only in those areas where coating is required.
- Loss of adhesion adjacent to masking.
- No bridging of adjacent lands or conductive surfaces from:
  –Loss of adhesion.
  –Voids or bubbles.
  –De-wetting.
  –Cracks.
  –Ripples.
  –Fisheyes or orange peel.
- Foreign material does not violate minimum electrical clearance between components, lands, or conductive surfaces.

- Coating is thin, but still coats component/device edges.

These seem reasonable until you really consider what IPC is suggesting you attempt with your conformal coating process. You may realise your process or the process your customer requires is not as straightforward as it first appears.

First, consider having thin coverage on component/device edges. To achieve sharp edge coverage is an extremely tricky process and almost unachievable by most standard coating processes. It is quite difficult to actually tell if the sharp tips have coating using a normal inspection process. If a customer states that this is a requirement it must be considered very carefully.

Further, consider all the defects above and the requirement that there must be no bridging across conductive areas. This means that an operator must inspect EVERY spacing on a component populated PCB and ensure there are no defects like bubbles that cause a violation of this acceptance criteria. Not only is this an extremely skilled role to complete, but it is also extremely time consuming and may require an army of inspectors for high-volume work.

Before you agree to all acceptance criteria for conformal coating with a customer or your design engineer, considering exactly what you are agreeing to.

Conformal Coating Thickness

The final point addressed by IPC is conformal coating material thickness. The table in the standard gives the acceptable ranges for various resin materials such as acrylic conformal coating at 0.03 to 0.13mm (30 to 130µm) when dried. This is a large range for application of conformal coating if all processes are set up correctly. It is also easy to be below or above this value if unaware of the fundamental issues. The key is to understand your conformal coating process and material capabilities.

For instance, using an automated dip coating system and achieving >30um dry film thickness with acrylic and polyurethane solvent-based coatings and avoiding all the defects in the acceptance criteria can be difficult to achieve. The coating tends to go on thinner than this and may not be thick enough to meet the criteria.

Further, a direct link exists between the number of bubbles preserved in a dried coating and the applied wet coating thickness for a single pass of coating. This is not difficult to understand: Put too much coating down in one go and the surface area cures (dries) before the bubbles in the body of the coating escape and they are trapped forever. Applying thin layers is critical to avoid bubbles. Yet, a selective robot normally applies only one coating. Therefore, there must be a trade-off and the application process must be fine-tuned to give optimum results.

> ***"This is not difficult to understand: Put too much coating down in one go and the surface area cures (dries) before the bubbles in the body of the coating escape and they are trapped forever."***

If the coating is to be uniform, what does this really mean? Is this "uniform" within the range of 30 to 130um? Do you need to consider thin edge coverage where the coating pulls away from the sharp edges? Finally, as IPC points out, if the coating gathers under a device it is very easy to apply more than the 130um tolerance in certain areas. Unfortunately, contrary to natural thought, more is not better and should be avoided because, long term, the coatings may crack or craze if they are applied too thick.

Conformal Coating Automated Inspection Processes

As stated previously, meeting the acceptance criteria would require careful inspection of the entire PCB. Such inspection is an extremely difficult job due to factors such as eye strain, concentration drift, and throughput considerations. Can we not use automated conformal coating inspection?

The answer is "yes," but with a few considerations and limitations.

Consider the conformal coating automated systems available. Some very sophisticated systems are now available with excellent camera or scanner technology, excellent software, and great process control. They can be either batch or inline and appear to be bridging the technology gap.

Camera systems can be fixed on three- and four-axis systems. Each camera will have to address parallax issues on 3D PCBs where there will be hidden areas down the sides of components. Scanner-based systems have the same parallax issues and parallax-free scanning systems are now available.

However, all these systems are somewhat flawed: They can look at all angles on every inch of the board, but still miss problem areas. But, this is not normally the critical factor with automated conformal coating inspection. Automated optical inspection (AOI) systems highlight the difficulty of the average conformal coating process to achieve IPC inspection acceptance criteria. AOI systems show the defects within the coating on the PCB and "see" more than an operator ever could.

This revelation can be like opening Pandora's Box to the system user since now they can have a full line of PCBs with defects all over them. If this is the case, and the AOI system is set to inspect the conformal coat PCB using these rules, the production line will soon grind to a halt. Is this the fault of the AOI system? Is it the fault of the conformal coating process? Where does the fault lie?

The answer is simple: Most conformal coating processes are not producing the level of quality IPC inspection criteria desired. AOI systems see all defects (as long as mechanical and optical factors allow) very clearly. In fact, they see defects more clearly than the naked eye.

What is the Solution?

Create an investigative loop to develop the right solution.

1. Determine what defects/inspection criteria are acceptable and define them.

2. Determine what level of control and what defects can be generated through your current process or the new conformal process.

3. If the system can achieve acceptance criteria everyone will be happy. If the process cannot meet acceptance criteria, change the criteria or the process.

Common sense is the ultimate solution and, with the right level of knowledge, the right solution is achievable. Finding the right inspection process will help you avoid excessive costs, arguments, and recriminations later on when problems arise. **SMT**

Dr. Lee Hitchens has worked in the conformal coating and reliability sector of the electronics industry for over 15 years and has considerable experience in all areas of reliability and conformal coating processing. He now divides his time between the roles of technical director of SCH Technologies in the UK, Diamond SCH in Shenzhen, China, and Nexus3c, a Conformal Coating Centre, providing unique global services of independent consultancy, troubleshooting, and training in conformal coating and long-term reliability issues.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Top Ten Most-Read Supplier/ New Product Highlights

NRI Boosts Capabilities with Juki Mounter & Tray Changer

"The Juki KE-2080EN high-speed flexible mounter and TR-6DER matrix tray changer give NRI the ability to assist customers from both smaller start-up quantities to large volume 'high-speed' production quantities. NRI grows with you," said Brian Benda, corporate director of operations.

Cookson Completes Materials Division Demerger

Cookson Group plc has announced that all conditions to the scheme of arrangement of Cookson, which was announced November 1, 2012, in connection with the proposed demerger of the Performance Materials division of Cookson to Alent plc have been satisfied and the Scheme has now become effective.

Essemtec Debuts New hyQ Feeder

Essemtec introduces the PC-TF16-24 hyQ feeder for Paraquda and Cobra pick-and-place machines. The new feeder can be used for both 16 and 24 mm tape widths. Variable width feeders increase flexibility and reduce the total number required production. Feeders can be installed from all four sides of the machine—even on in-line machines.

Avnet Expands Portfolio; Acquires TSSLink

"This acquisition supports the strategic expansion of our services portfolio and further strengthens our ability to deliver a comprehensive IT solution for our business partners," said Jeff Bawol, president. "A key component of our solutions distribution strategy is the ability to drive growth for our suppliers and value-added resellers in markets where demand is continually increasing, such as storage and virtualization."

Koh Young America Adds Hults as Field Service Engineer

Timothy Hults has joined the technical support team at Koh Young America as a field service engineer, providing equipment installations, training, and technical support for the company's inspection equipment system customers. He will serve customers in the U.S. Northeast Region.

Vitronic Unveils 2D Auto-ID System

VICAMsnap! is the only hands-free, camera-based auto-ID reader built for both automated conveyor and manual sorting applications that provides both visual and audible feedback for efficient warehouse and inventory sorting operations. Vitronic Machine Vision Ltd. is proud to announce the new camera-based auto-ID system for hands-free reading of 1D barcodes and 2D machine-readable matrix codes.

Electrolube Debuts Hexane-Free Flux Remover

Electrolube will launch a new hexane-free flux remover at the Southern Manufacturing and Electronics Exhibition in February. HFFR is a fast-drying cleaning solvent that eliminates the use of the hazardous material n-Hexane. Flux removers commonly consist of a blend of solvents, which can contain low levels of n-hexane, a solvent that has been identified as hazardous to human health; long term exposure can affect the peripheral nervous system.

Technic Launches New Goldeneye Barrier Layer System

Technic Inc. has announced the commercial release of its Goldeneye Barrier Layer System specifically engineered for improved corrosion resistance in high-speed reel-to-reel connector applications. The system is a newly developed universal metal stack, designed to enhance functionality of subsequent precious metal deposits. It enables the deposition of application specific options from a universal base electrolyte through the use of specifically designed additives.

ZESTRON Opens Japan Headquarters, Technical Center

Incorporated in December 2012, ZESTRON Japan is located in Kanagawa and represents the company's forth Asian technical center. Coupled with comprehensive customer service and local expertise, this investment enables the company to introduce leading-edge aqueous-based cleaning agents in the market as an environmentally sound alternative to the many solvent based cleaning products currently used.

Arrow Acquires Business Unit of Waching Company

Arrow Electronics, Inc. has signed a definitive agreement pursuant to which Arrow will acquire all of the assets and operations of the wireless and infrastructure business unit of Waching Company Ltd., a distributor in China with strong demand-creation capabilities and a leading position in the fast-growing wireless and infrastructure market. Waching has sales and engineering resources based in Shenzhen, Shanghai, and Beijing.

Welcome

to the 2013 IPC APEX EXPO Show Guide

You'll find more than 50 countries at our industry's premier event this year, held once again at the San Diego Convention Center, on the waterfront in downtown San Diego, California. Featuring advanced and emerging technologies in printed board design and manufacturing, electronics assembly, test, and printed electronics, IPC APEX EXPO is a great place to find new suppliers with new solutions and connect with colleagues from around the world, plus there are plenty of free offerings. Click here for a complete show guide.

Just a few highlights of what attendees may expect include:

- FREE! More than 400 exhibitors showing equipment, materials, and services for printed boards and electronics manufacturing—plus printed electronics! There's no better place to see and compare.

- The largest technical conference for our industry in the world. Highly selective, the conference presents new research and innovations from experts in the fields of electronics assembly, test and board fabrication, and design.

- FREE! Industry poster sessions—Catch up on the latest research and meet the authors.

- Professional development courses provide comprehensive updates on pressing industry concerns.

- Standards development meetings that help shape the future of our industry.

- IPC International Hand Soldering Grand Championship—Compete in or watch the excitement on the show floor.

- On the show floor, view cutting-edge products and services in the New Product Corridor; get support on cleaning and contamination monitoring at the Printed Board Assembly Cleaning and Contamination Testing Center Live; and check out informational resources at the IPC Bookstore.

- Networking opportunities including an International Reception, First-Timers' Welcome, IPC Tech Talk, Women in Electronics Networking Meeting, and IPC Government Relations Committee Open Forum allow attendees to meet colleagues, get updates on key issues, and share ideas.

To register to attend IPC APEX EXPO 2013, click here.

For an inside look at the show and in-depth interviews with industry insiders directly from the show floor, be sure to visit I-Connect007's Real Time With... site during the show. We're the only publication posting interviews and events in real time!

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IPC APEX EXPO Free Keynote Addresses—*All Three Days!*

Opening Keynote Address:
Tuesday, February 19, 8:30-9:30 a.m.

Michio Kaku, Ph.D.

Imagine, and Create, the Future

Join theoretical physicist, best-selling author and futurist Dr. Michio Kaku for an awe-inspiring look at the future! Dr. Kaku is an internationally recognized authority on Einstein's unified field theory and known for using science to predict trends affecting business, commerce and finance.

Dr. Kaku's keynote will present a vision of life in the year 2100, culled from ideas of 300 of the country's most influential scientists. He will explore revolutionary advancements in medicine, energy production, artificial intelligence and aeronautics that will forever change our way of life.

"Electronics has completely revolutionized our world over the past 50 years. Your industry is a critical building block for future advancement, and it is my great pleasure to share my research and predictions with you."

Let yourself be drawn into a future where innovations like Internet-enabled contact lenses let you surf the Web with the blink of an eye…where your commute to work is stress-free, because your car drives itself while you relax…and where tiny brain sensors let you move objects using only the power of your mind. Don't miss this wild and inspirational ride into the future with Dr. Kaku!

Dr. Kaku is one of the world's most widely recognized figures in science. His television documentaries for the BBC, and Science and Discovery channels, as well as his radio shows, such as Science Fantastic, and his New York Times best-selling books like *Physics of the Future* have popularized science and roused the interest of millions of followers around the globe. A prolific writer, Dr. Kaku has also authored articles for scores of publications ranging from major-market newspapers to popular business, computer and science magazines.

Following his keynote, Dr. Kaku will sign copies of his latest book, *Physics of the Future,* which will be available for purchase on-site.

Day Two Keynote Address:
Wednesday, February 20, 8:00-9:00 a.m.

Dr. Larry Burns

Reinventing the Automobile

Can you imagine driverless cars?

According to Dr. Larry Burns, former corporate vice president of research and development and strategic planning at General Motors, some of the transformational technology needed is only five to 10 years away from being mass-produced. Speaking from 30 years of experience with GM, along with his new pursuits as a director of the Program on Sustainable Mobility for The Earth Institute at Columbia University; a consultant for Google's pioneering self-driving car program; a contractor with National Renewable Energy Laboratory; and a professor of engineering practice, industrial and operations engineering at the University of Michigan, Dr. Burns will share his

compelling vision of the design and technology innovations that will drive a new, very different future of personal transportation.

Day Three Keynote:
Thursday, February 21, 8:00-9:00 a.m.

B. Gentry Lee

Journey to Mars: Curiosity Rover Mission

On August 6, 2012, a mobile laboratory known as the Curiosity rover made an amazing landing on Mars. Curiosity boasts the biggest, most advanced payload of scientific instruments ever sent to the Martian surface. Its mission: To assess whether Earth's neighbor has ever had conditions favorable to life.

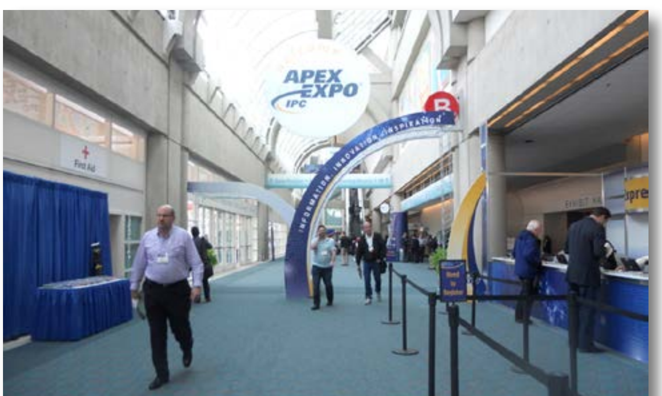
B. Gentry Lee, chief engineer for the Solar System Exploration Directorate at the Jet Propulsion Laboratory (JPL) in Pasadena, California, is responsible for the engineering integrity of the robotic planetary missions managed by JPL for NASA—including the wildly popular Curiosity rover mission. Join Lee for a fascinating inside look at the mission to Mars that has captured the imaginations of millions and learn about the feats of engineering that brought the Curiosity itself into existence.

BUZZ Sessions

February 19-21, 2013

Free BUZZ sessions will be offered at IPC APEX EXPO. The industry's top technical experts will comment on subjects ranging from automotive and new technologies to conflict minerals, export controls, and technology roadmaps.

Jasbir Bath, IPC principal engineer for assembly technology, will address "New Technologies," February 19. He will chair a discussion on new and emerging component technologies. Advancements in state-of-the-art electronic component interconnections will a central theme. Following Bath, C. Don Dupriest, Lockheed Martin Missiles & Fire Control, will moderate a panel featuring a who's who in electronics, during which IPC Hall of Fame Award recipients will take audience questions on technology and trends and share the wisdom earned from a collective 300-plus years of experience.



On February 20, Chris Mitchell, Prime Policy, will moderate a panel on "Export Controls: Understanding ITAR and IT Reform." The panel of experts will provide an overview of International Traffic in Arms Regulations' (ITAR's) application to printed boards.

Later, Fern Abrams, IPC director of government relations and environmental policy, will moderate a session on conflict minerals, which will provide an overview of conflict minerals disclosure and reporting regulation finalized by the U.S. Securities and Exchange Commission last August. A panel of experts will discuss tools for regulatory compliance and customers' requirements. And later that day, a session dedicated to "Automotive Technologies" will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BUZZ Sessions *continues*

provide a current and future view of electronics technology used within the automotive electronics industry.

On February 21, the final two BUZZ sessions on the reclassification of FR-4 composite materials and technology roadmaps will be held. Crystal Vanderpan, UL LLC, will discuss UL initiatives and provide an update on UL recognition for laminate and printed board materials. In addition, Marc Carter, IPC director of technology transfer, will take session attendees on a tour of technology roadmapping efforts for printed circuit cards and electronics assemblies. He will highlight the major trends in the evolution of technology across multiple disciplines during the "IPC/iNEMI Technology Roadmap" session.

Admission to the BUZZ sessions and the exhibit hall is free to pre-registrants. Click here for more information.

IPC APEX EXPO 2013 Technical Conference

IPC APEX EXPO 2013 Technical Conference Tuesday-Thursday, February 19-21, 2013

The IPC APEX EXPO technical conference is known worldwide as one of the finest and most selective in the world. Learn about new research and innovations from key industry players in the areas of board fabrication and design and electronics assembly.

Sign up for one day, the full conference or get the most of your money with the Maximum Value Package. To register for IPC APEX EXPO 2013, click here.

Click here to search a complete listing of approximately 250 technical conference sessions by topic, category, speaker name, company, and more.

IPC EMS Management Council Meeting

Monday, February 18, 8:00 a.m.-5:00 p.m.

Networking Breakfast:
7:30 a.m.-8:00 a.m.

Networking Reception and Dinner:
6:00 p.m.-9:00 p.m.

Receive the information you need to lead. With a unique high-level focus, this event will keep you up to date on current trends and strategies so you can make the best choices for your company's future. Network with your peers and learn how other EMS executives are resolving problems you may also be facing:

- Disruptive Environmental Regulations
- Business Outlook: The Global Electronics Industry
- IPC EMS Management Council Committee Update
- Economic Update for Small to Medium EMS Companies
- M&A Update for Tier 2 and 3 EMS Companies
- EMS Market in India: Current Status and Future Opportunities
- Developing a Disaster Preparedness Plan
- State of the Industry: The Distributor Perspective
- Best Practices of Customer Relations: Secrets of a Certified EMS Program Manager
- Roundtable Discussions

View the agenda for the EMS Management Council Meeting here.

IPC EMS Program Management Training & Certification

Newly revised to reduce travel expenses and out-of-office time for attendees, IPC EMS Program Management Training and Certification is a three-part training program that tailors topics, such as operations management, finance management, contract management, and leadership skills, to the EMS industry. To learn more about the program or to download a registration form, click here.

Essentials of EMS Program Management
Thursday, February 21, 8:00 a.m.-5:00 p.m.
Friday, February 22, 8:00 a.m.-5:00 p.m.
Saturday, February 23, 8:00 a.m.-5:00 p.m.

EMS Leadership Training
Friday, February 22, 8:00 a.m.-5:00 p.m.

EMS Program Management Certification Exam
Saturday, February 23, 8:00 a.m.-12:00 p.m.

It's Not Just for Program Managers

This training and certification program is for anyone who must possess an understanding of the many business, operations, and management issues specific to an EMS company. Past participants include:

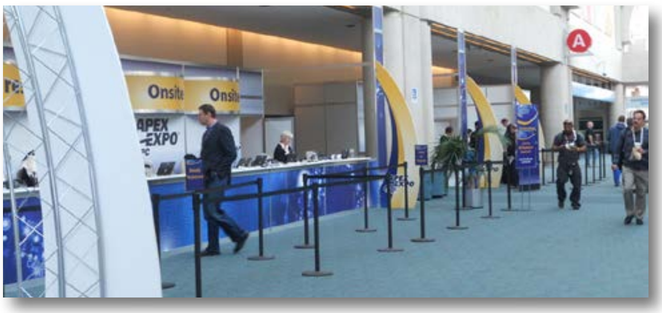
- Senior Project Engineers
- Quality Managers
- Industrial Engineers
- Operations Directors
- Marketing Managers
- Executive Vice Presidents
- Global Account Managers
- Materials Managers
- Business Development Managers
- Vice Presidents of Sales
- Business Unit Managers
- Directors of Quality
- Technology Development Managers
- Directors of Product Realization
- Customer Operations Managers
- Presidents
- Senior Vice Presidents
- VPs of Business Development
- Engineering Managers
- Quoting Managers
- CEOs

Professional Development Courses

February 17-18 and 21, 2013

Comprehensive updates on pressing industry concerns, challenges and developments will be addressed in 50 IPC APEX EXPO professional development courses, February 17-18 and February 21, 2013, at the San Diego Convention Center.

Covering issues in design, lead-free technology, materials, process improvement, solder joint reliability, and more, the courses will go beyond theory to provide practical solutions to industry issues and challenges. Each course is led by a subject-matter expert, runs for three hours and will include an instruction handbook.



Course highlights include:

- Design for Manufacturing (DFM): Best Practices (PD08);
- Extreme HDI: Designing for Maximum Density (PD10);
- Best Practices in Electronics Assembly Processes (PD13 and 17);
- Tin Whiskers: Failure Risk and Mitigation Strategies (PD21);
- Ball Grid Array: Principle and Practice (PD30); and
- Package on Package: Design, Assembly, Rework and Inspection (PD44).

"The courses at IPC APEX EXPO will enable engineering and management staff to work smarter in an era of increasing product sophistication," says Susan Filz, IPC director of industry programs. "Attendees will bring home new insights and solutions to boost their productivity."

The complete list of professional development courses along with full descriptions and instructor biographies is available here.

Real Time with...

This year, I-Connect007 and the Real Time with...IPC APEX EXPO program will return to San Diego, California, bringing you complete coverage of IPC APEX EXPO 2013. Last year, we brought you nearly 200 interviews—this year promises to be even more exciting.

Real Time with...IPC APEX EXPO and its team of editors, guest editors, videographers, and video editors will be working throughout this seminal event to capture the keynotes and bring you interviews with the industry's top technologists, engineers, and business leaders.

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Visit www.realtimewith.com for updated information about IPC APEX EXPO 2013.


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The PCB List

Demos Planned on the Show Floor!

Brought to you by PCB007, The PCB List is the world's most comprehensive online directory of printed circuit manufacturers, anywhere. Buyers, specifiers, designers, and others looking for a PCB fabricator will appreciate the intuitive navigation, detailed search capability, and global reach of The PCB List. With a Showcase listing, a PCB fabricator can create a neat, organized presentation that puts all pertinent information right at a potential customer's fingertips.

Drop by the I-Connect007 booth for a demo and see for yourself how easy it is to find a fabricator, or create a Showcase!

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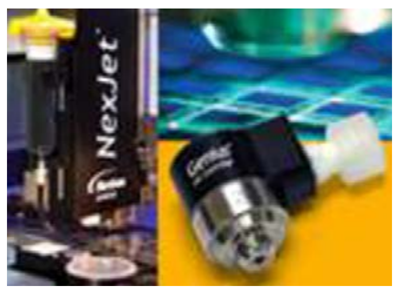
New Product Showcase

This year at IPC APEX EXPO, more than 400 exhibitors will showcase equipment, materials, and services for PCB and electronics manufacturing and printed electronics. What better place than San Diego to gather to see what the industry has to offer?

Many of those 400+ exhibitors are bringing new products to introduce to the world. For a preview of these new and innovative products, visit the IPC New Products Showcase.



The Intricacies of RF Design and Assembly

by Zulki Khan
NEXLOGIC TECHNOLOGIES, INC.

SUMMARY: RF design in the past was nearly an impossible task for engineers—the know-how and technology were simply nonexistent. Now, with demand for such design growing at an incredible pace and the technology needed readily available, the PCB designer and assembly engineer should fully understand how to deal with RF intricacies.

Decades ago, successfully and economically completing an RF design was a monumental, almost impossible task due to the fact that much of the necessary technology and know-how were not available. Consequently, great demand for such design just didn't exist, although most focused on costly applications going to high-end industrial and mil/aero applications. Today, the demand is back, and growing, as greater numbers of handheld portable communications applications escalate in practically every facet of life. Yet, the same basic principles of the past, and a few new ones, play vital roles in achieving high-caliber RF design and assembly.

The PCB designer and assembly engineer must be experienced enough to skillfully and successfully cope with and properly handle countless intricacies dealing with an RF design and manufacturing. Hundreds of such intricacies exist with this technology and the PCB designer and assembly engineer must have enough savvy to maneuver through such a maze. Here, I want to focus on only the most important issues facing engineers.

PCB Design Intricacies

At the top of the list of PCB design intricacies is the need to fully understand how, what, why, and when to optimize. One must always ask: Does the PCB designer know enough about RF to apply the right optimization techniques? It's vital to have a good handle on this aspect of the process because the PCB designer must create an RF design right the first time—without mistakes.

He or she must keep in mind RF integrated circuitry architecture. Specifically, this means the designer must segregate and divide different frequency spectrums within the circuitry. As part of this design step, it's important to properly design so-called self-shielding circuitry to isolate or curtail electromagnetic frequency (EMF) effects (Figure 1). In most cases, an RF design may have four to six shields

Figure 1.

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New for 2013!

Thermal Management Executive Briefing: Thermal Management Market Visions & Strategies
Monday, March 18
Presented in association with MEPTEC and Electronics Cooling Magazine

Where in the market are the opportunities, directions and challenges that will be created over the next few years? SEMI-THERM aims to answer that question and provide exclusive market and technology insight at this new event. With nearly thirty years of direct industry involvement and its long-time location in Silicon Valley, SEMI-THERM is perfectly poised to offer this new information stream to the industry.

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at different board locations as a means of containing different frequencies within the same RF circuitry on a board.

If PCB designers are dealing with high frequency, they must keep that module separate when it comes to layout. As far as low-frequency analog, those modules must be clustered together when routing is performed. Likewise, CMOS low-frequency digital circuitry has to be lumped together and set aside from the other circuitry.

By taking this approach, the PCB designer is optimizing the design. As a result, damaging spikes and jitter in the signal are avoided. When there is a considerable high-end frequency delta between circuit portions special attention must be given to separating them. At times, in these instances, a ground plane or pour must be created in the middle. Sometimes, the RF signal needs to be routed on different layers if there are extremely different circuit spectrums running on the board.

"A common low-impedance ground plane offers a robust and practical solution for creating a balanced approach. But there is no generic solution for every case—special consideration must always be given. In this category, unusual, unexpected, and strange issues show up when designing RF circuitry."

For example, an extremely high frequency can be routed on one layer while a low frequency is routed on another. This technique isn't required in every instance, but it's a good idea. However, it comes with a cost factor because fabrication of high layer count is more expensive, although with RF circuitry some extra cost is acceptable and often as crucial since it incurs non-standard design practices.

Balanced and Tuned

Aside from optimization, non-standard practices include the fact that RF circuitry has to be balanced and tuned. The PCB designer must make sure transmit and return paths are equal in length and within extremely tight tolerances of impedance control and match length. A rule of thumb, strange as it may seem, is that layout aspects—taken for granted in a commercial PCB design—might otherwise be creating problems in a PCB populated with RF circuitry. PCB design rules take on new meaning when it comes to RF design.

For example, placing a distributed power plane between two ground layers enables an evenly distributed field for RF. In effect, it creates an even amount of decoupling capacitors between supply and ground. Plus, a power plane provides a very low-impedance path at radio frequency.

The PCB designer must also control radiated emissions at the board edge levels. For example, if he or she is dealing with noisy power supply traces on a two-layer board, those noisy traces are more difficult to resolve compared to the same noisy traces on a four-layer board. Also, transmit and return current paths must be carefully devised if there is a ground in a power plane targeted at suppressing cross-talk and noise generating events within the board.

Avoid Going Under RF Circuitry

Moreover, the PCB designer must make sure those transmit and return paths are not routed under RF circuitry blocks. If a return current path is routed under RF, then it'll create problematic jitters and spikes, thus mismatching the impedance, and the PCB designer has to correct this issue when the board undergoes a second iteration.

A common low-impedance ground plane offers a robust and practical solution for creating a balanced approach. But there is no generic solution for every case—special consideration must always be given. In this category, unusual, unexpected, and strange issues show up when designing RF circuitry. Experience pays handsomely here because the savvy PCB designer must intuitively deal with those unorthodox aspects. In most instances, they're difficult to explain, but the experienced PCB designer correctly resolves them.

Decoupling capacitors represent another design intricacy category. Here, the PCB designer must make sure current loops are minimal. Minimum current loops reduce unnecessary impedance mismatches and careful decoupling avoids noise generation from circuitry such as reference oscillators or frequency synthesizers. How do you minimize current loops? They are minimized by placing the decoupling capacitors and the port being decoupled to the ground plane or via as close as possible. Assurances must be made that each decoupling capacitor has its own via connection to the ground. If too many decoupling capacitors are tied to one via, noise suppression efforts will be diluted, resulting in an uneven signal and inaccurate return path. On the contrary, the idea is to avoid shared via and make sure only one via is ground at a time when using decoupling capacitors.

The PCB designer must also make sure power supplies are decoupled as close as possible to localized ground planes. If there are multiple ground planes on the board, it's critical that power supplies are localized as well.

The thermal relief pad under an RF device is yet another intricacy to be dealt with. As the name implies, it provides both thermal relief and a solid ground reference to the RF chip. This pad is used not only to radiate the heat the IC generates, but is also the shortest possible connection from that chip portion to the reference ground plane. Normally, it's connected from the component side to the ground and then the localized ground is connected to the main ground.

When using thermal relief to distribute the vias, the PCB designer should distribute or diversify the vias and not localize them in one section—the goal is to have an even factor of getting to the ground plane and a normalized way of heat transfer for optimum distribution. The PCB designer can stitch different vias together whereas the connection of the thermal relief pad uses multiple vias. The thermal relief pad can be directly stitched to the main ground layer rather than going through the localized way. These and other methods are used to assure that transmit and return paths are even and possess matching impedances.

PCB Assembly Intricacies

Test accessibility is embedded once the PCB RF design is completed and before it goes to production or right after new product introduction (NPI) is performed. Test accessibility depends on the type of coverage the design requires. An experienced PCB designer assures 70 to 80% minimum test coverage, whereas an inexperienced designer might settle for 30% testability. Even if the board is subjected to flying probe testing—if minimal coverage is designed in—the test is not going to be effective.

After the board is tested, some RF circuits will likely require tuning. Tuning means a number of different steps of which only a savvy assembly engineer is aware. For example, the frequency of some relays may need changing; a potentiometer might need adjusting; or a variable resistor network may need its resistance changed. All tuning is performed to achieve the correct match and allow the product to properly transmit and receive.

These and others are the intricacies involved at assembly in terms of tuning. It may take a little, or a lot, of time for proper tuning to be performed, but once the RF PCB is tuned, engineers should avoid touching the board to prevent causing new problems or disrupting previous tuning work. **SMT**

Zulki Khan is the founder and president of NexLogic Technologies, Inc., in San Jose, California, an ISO 9001:2008-certified company, ISO 13485-certified for manufacturing medical devices and a RoHS-compliant EMS provider. Prior to NexLogic, Khan was general manager for Imagineering, Inc. in Schaumburg, Illinois. He has also worked on high-speed PCB designs with signal integrity analysis. He holds a B.S. in EE from NED University in Karachi, Pakistan, and an M.B.A. from the University of Iowa. He is a frequent author of contributed articles to EMS industry publications.

If You're Going to Do It, Do It Right...Right?

by Sjef van Gastel
ASSEMBLÉON NETHERLANDS B.V.

SUMMARY: The two major causes of defects are poor solder printing, estimated to cause over 50 to 70% of equipment defects, and pick-and-place errors, which cause the rest. Developing a process to detect defects early means an incredible savings opportunity that manufacturers can't afford to ignore.

Electronic equipment manufacturers know that rework and scrap cost money, but rarely do they know just how much. It is relatively easy to estimate: The cost of low yield is simply the difference in rework and scrap between the manufacturer's production line and that of a benchmark line.

The two major causes of defects are poor solder printing, estimated to cause over 50 to 70% of assembled equipment defects, and pick-and-place errors, which cause the rest. The benchmark figure for stencil printing is approximately 10 defects per million (dpm) and, until recently, that for a pick-and-place machine was 5 dpm. Allowing for defects from PCB manufacture and reflow soldering, that translates to a whole-line benchmark of around 25 dpm. And, over the last few months, the pick-and-place benchmark has been cut again to a fairly astounding 1 dpm: One defect for every million components placed. That gives a whole-line benchmark of approximately 20 dpm.

Compared with a typical whole-line defect level in the industry of 50 to 100 dpm for standard components (the dpm for miniature components such as 01005-types can be 200 or more), that number might seem wildly optimistic. In high-value industries, the costs of field returns are out of all proportion to component costs. For example, to automotive customers, right the first time manufacturing is an absolute requirement.

The savings potential of these quality levels can be huge. For a typical board with 1,000 components, a whole-line quality of 20 dpm gives a benchmark first pass yield (FPY) of 90%. A production line turning out 100 boards per hour (100,000 components per hour) will need one rework station. A typical three-shift operation will need three rework operators. In practice, in-line repair will find only 90% of all defects. The remaining 10% will be detected at a later stage, increasing repair costs by a factor of 10 at each stage [1].

With annual U.S. labor costs of nearly $45,000, total repair costs for a well-controlled line at 20 dpm will be around $270,000 per year. By contrast, a typical 100 dpm production line would have a yield of 61% and would need six rework stations with repair costs up to $1,000,000 per year.

Reducing Variation Keeps Yields High

Reaching benchmark performance means optimizing each of the three major surface-mount processes: Stencil printing, pick-and-place, and reflow soldering. Several key signs of the manufacturing processes going out of control exist, and they tend to fall into distinct classes and with distinct causes. Identifying these signs helps trace faults quickly to bring the process back into control and keep yields high.

Three related IPC documents—IPC-A-610D, IPC-9261A, and IPC-7912A—describe how to calculate yields for a particular board on a particular production line. The standards distinguish the types of SMT defect and count the number of possible opportunities for defects on each board. These depend primarily on the board's complexity and, particularly, the number of high-pin-count ICs.

Figure 1 demonstrates how yield depends on the number of defect opportunities for vari-

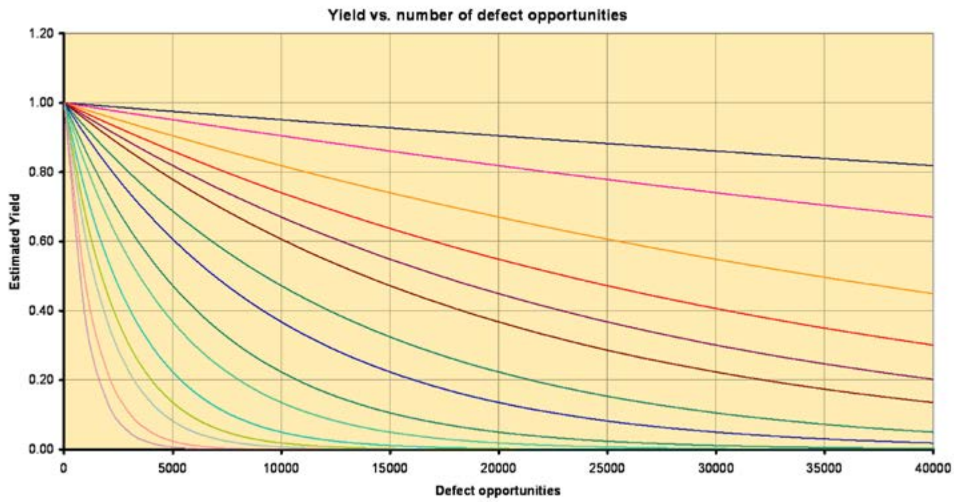


Figure 1: Yield very quickly drops to zero for complex boards with large numbers of defect opportunities in poorly controlled processes.

ous defects per million opportunities (DPMO) figures—the key quality figure. Depending on the process quality, the DPMO shows whether defect opportunities are converted into actual defects. With a low DPMO, the yield drops slowly and almost linearly with the number of defect opportunities. Yield remains good for even complex boards.

Different applications have different defect opportunity windows. Automotive boards tend to have a low component count, with a defect opportunity window typically between 2,000 and 12,000, but the cost of a defect can be very expensive. The window for smart phones is typically between 6,000 and 20,000 and that for complex communications and server boards from 25,000 up to 60,000.

Calculating Rework

The first-pass yield gives the percentage of boards with good quality, so 100-FPY gives the percentage of boards needing repair (rework).

The major determining factor for yield, and therefore rework costs, is placement technique. Sequential placement is by far the most common industry technique, with machines usually having one or two multiple pipette heads working at very high speeds. Parallel placement machines instead have multiple, up to 20, placement robots with single pipette placement heads. The individual heads can take 10 to 20 times longer to transport and settle the components before placing them. This has been key to achieving the new 1 dpm pick-and-place benchmark. Improving quality involves moving process control limits (what you can deliver) further and further within your customers' specification limits (what they ask for). For pick and place, that largely means reducing machine vibration so that the component and board have the same relative positions, placement after placement.

The actual savings depend on the capacity of the line and are almost double for a line placing 200,000 components/hour over a 100,000 components/hour line. In Germany, rework savings can rise to $1,130,000 per line per year for automotive engine controllers (typically 340 components per circuit, six circuits per board, approximately 10,000 defect opportunities per board and a line capacity of 130 kcph). Reducing DPMOs from 60 to 20 can save similar amounts on mobile phone lines and factories can have up to 50 or 100 lines. For example, manufacturers can keep their production lines in Europe and the U.S., saving on distribution and logistics costs while retaining all the advantages of short supply lines.

Combining Inspection Methods

In well-controlled processes the reasons for defects can be quickly found and corrected, but actually finding the defects is becoming more difficult.

Research by Nokia and the University of Oulu shows that most inspection technologies provide 90% coverage while 10% of all defects go undetected. Finding defects requires a combination of technologies (Figure 2). Even then, some defects will slip through. This demonstrates a basic quality principle—you can't inspect quality into a device, but you can improve the process.

Engine controller (Germany)	Components per board	Defect opportunities per board	FPY	Annual rework cost (per line) [k€]	Rework cost above benchmark (per line) [k€]
DPMO = 25	2040 (6-fold board)	10038	78%	506	0
DPMO = 50			61%	886	380
DPMO = 100			37%	1418	912
Smart phone (Canada)					
DPMO = 25	3740 (4-fold board)	20960	59%	365	0
DPMO = 50			35%	570	205
DPMO = 100			12%	764	399
Notepad PC (China)					
DPMO = 25	1400 (2-fold board)	8870	80%	153	0
DPMO = 50			64%	220	67
DPMO = 100			41%	379	226

Table 1: Cost of rework for different DPMOs in different industries and countries (assuming 6,100 productive hours per year and 100,000 components/hour output).

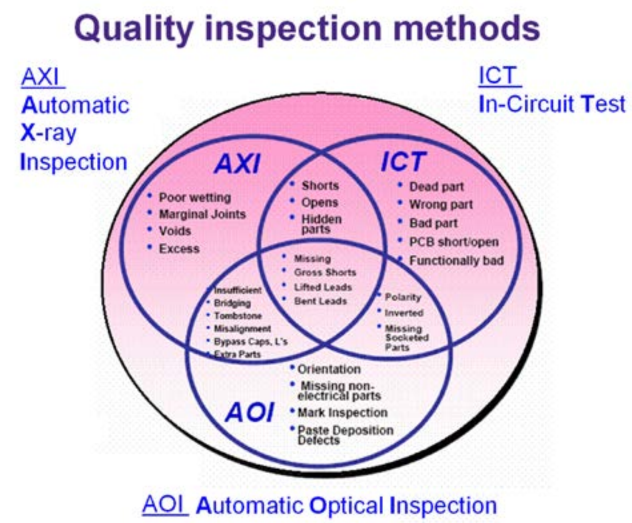


Figure 2: No single inspection technology gives 100% coverage.

Whole-Line Rework Costs

Compared with a whole-line benchmark figure of 25 dpm, typical and poor figures would be 50 and 100, respectively. As shown in Table 1, a complex smartphone producing a whole-line DPMO of 25 would give a 59% yield. For a DPMO of 50 the yield drops below 40%. For 100 it is an impossibly low 12%.

And these are only the visible costs. As the "Rule of 10" suggests, detecting a defect at final test costs 10 times more than detecting it immediately after placement, 10 times more than that at the retailer, and 10 times more than that in the shop. Another basic rule of quality improvement is that faults getting through to the customer are the most expensive of all—they damage your reputation. **SMT**

Reference

Dr. David M. Anderson, "Design for manufacturability & concurrent engineering," CIM Press, 2008, ISBN 1-878072-23-4.

In addition to playing the clarinet in two bands, Assembléon's Sjef van Gastel has another passion: SMT. He has been with the company since its start-up as a Philips division in 1979. As the current Manager for Advanced Development, he combines his experience as systems architect and machine designer to explore technical and business opportunities from emerging technologies. van Gastel holds many patents and is a frequent speaker at international conferences related to SMT. He is also the author of "Fundamentals of SMD Assembly," which has become a standard piece of literature in the industry.

Top Ten Most-Read Mil/Aero007 Highlights

Jabil to Manufacture FLYHT's AFIRS 228

FLYHT has executed an agreement with Jabil Defense and Aerospace Services to manufacture the AFIRS 228 product line. Jabil will begin manufacturing the AFIRS 228B for FLYHT customers globally in the first quarter of 2013 and the AFIRS 228S soon thereafter.

ERAPSCO Inks $71.2M in Navy Sonobuoy Contracts

Sparton Corporation and Ultra Electronics - USSI, a subsidiary of Ultra Electronics Holdings plc (ULE) have announced the award of subcontracts valued at $71.2 million to their ERAPSCO joint venture, for the manufacture of sonobuoys for the U.S. Navy. ERAPSCO will provide production subcontracts in the amount of $29.2 million and $42 million to Sparton Electronics Florida, Inc. and USSI respectively.

Kitron to Manufacture Modules for Kongsberg's RWS

Kitron has received new orders of approximately NOK 50 million from Kongsberg for delivery of electronic modules that are part of Kongsberg's weapon control system remote weapon station (RWS). The orders are related to an international vehicle program and include industrialization services, test development projects, and delivery of products. Manufacturing will take place at Kitron's factories in Johnstown, and in Arendal, Norway.

Moog Acquires Broad Reach for $48 Million

"The acquisition of Broad Reach brings several very strong products to our space portfolio, as well as an experienced team of individuals," said Jay Hennig, president of Moog's Space and Defense Group. "Their engineering team brings extensive spaceflight heritage, industry expertise, and entrepreneurial spirit to Moog. Our ability to provide complete solutions to our customers is strengthened by Broad Reach's avionics, software, and mission design heritage."

PartnerTech Provides Manufacturing Services to CybAero

PartnerTech AB and CybAero AB, a company developing and manufacturing autonomous unmanned helicopters, have signed a framework agreement covering production and assembly of products and systems for CybAero AB. The cooperation between the companies was initiated in 2012 and the now signed agreement covers PartnerTech's combined expertise within electronics, mechanics, and systems integration.

Orbit's Electronics Group Wins Displays Subcontract

Orbit International Corporation's Electronics Group has received a letter subcontract with a not-to-exceed value of $1,180,000 to manufacture displays for a major helicopter program. Work on this project will be performed at Orbit's Tulip Development Laboratory (TDL) subsidiary located in Quakertown, Pennsylvania.

MTI Electronics Updates Certifications

MTI Electronics, an EMS provider of PCB assemblies, has received an update to their ISO 9001:2008 and AS9100C certification. These updates reflect the commitment of MTI Electronics to meet and exceed quality requirements for customers' and the industry. Both standards are for the contract manufacture and test of printed circuit board assemblies and thick film microelectronic circuits.

U.S. Army Develops Roadway Threat Detection System

Explosives along roadways remain an unrelenting hazard for deployed soldiers. In line with this, U.S. Army engineers have developed a system for detecting possible threats. The Shadow Class Infrared Spectral Sensor-Ground (SCISSOR-G) could allow soldiers on a route clearance patrol to achieve greater standoff ranges during missions.

Global Homeland Security Market to Reach $281B by 2022

In a report titled "The Global Homeland Security Market 2012-2022 - Market Size and Drivers: Market Profile," market analyst Strategic Defence Intelligence forecasts that the global homeland security market will reach $198 billion in 2012 and increase at a CAGR of 3.55% during the forecast period to reach its peak of $281 billion by 2022.

N.A. Military Avionics Market Report 2012

The Canadian and United States military has spent a considerable amount of money to purchase avionics for new aircraft and as retrofits for older aircraft. As pressure on the budgets of both countries forces reassessments of that spending the military services will need to think strategically about the future procurements and methodologies.

Five Ways to Improve Supplier Selection

by Chris Torrioni
SENSIBLE MICRO CORPORATION

SUMMARY: To improve your network of reliable suppliers you must first improve your selection process for new vendors. The process can be tedious, but the resulting boost in product integrity and quality will be worth it. Chris Torrioni offers five simple steps to get you started.

Whether you want to comply with the newly released AS6081 standard or just vastly improve your company's vendor base, securing your supply chain can be tedious and difficult. Here are five simple steps to help you get started.

Step One

If purchasing directly from the manufacturer or an authorized reseller is not possible due to obsolescence or an allocated lead time, the first step should be obtaining a copy of your independent distributor's Counterfeit Avoidance Plan. I've seen too many OEMs and contract manufacturers assume that just because a distributor is ISO 9001-certified or even AS9120-certified that their quality check points are in place. These management systems, while essential to the improvement of a quality program, only manage a company's procedures; they do not evaluate the effectiveness of a counterfeit mitigation program unless it has been written into the ISO procedure.

A robust counterfeit avoidance and mitigation plan should include sections for supplier management, incoming receiving, and parts inspection as well as the responsibility and review of found suspect items for reporting and quarantining of material. Industry terms should be clearly defined. A slew of new words and terms are floating around the industry which can be confusing for those not quite up to speed.

If your independent supplier does not have a counterfeit mitigation plan in place, the exposure of risk your company is assuming could be catastrophic. For government contractors, only using trusted suppliers as defined in section 818 of the National Defense Authorization Act is a must. However, commercial manufacturers need to be equally aware of the potential dangers and risks counterfeit parts can pose to their products and reputation.

Step Two

Create an in-house vendor rating system. Rating systems can provide a quick and easy snapshot of historical purchases. My company uses its rating system to electronically link vendor performance to a percentage amount. The rating system looks at positive experiences, which include parameters such as on-time delivery, zero quality incidences, and fair pricing. The rating system will also measure negative occurrences such as receiving substandard product or late deliveries. For every logged feedback result there is a notes section where our purchasing or quality team can expand further into the situation if needed.

The addition of our rating system has allowed our purchasing department to make more informed vendor selections in a shorter amount of time. If we find ourselves in the situation of many of our suppliers having the same products available, the rating system quickly allows us to narrow the list down to the most reliable and quality-driven sources. Many times, independents are faced with a new source where no purchase history has been recorded. New sources are given an electronic quality survey to complete for review prior to a purchase taking place.

Step Three

Quality surveys are a beneficial tool in reviewing a new supplier's capabilities. Of course, on-site audits are the best way to evaluate how a potential supplier conducts their business. However, it is also not always possible to audit in person. Quality surveys should be comprehensive enough to gain a good understanding of a vendor's strengths and weaknesses.

The vendor survey my company introduced is set up in a questionnaire format. Questions focus on four areas: Procurement control, receiving and inspection control, in-process inspection control, parts and component technical data, and general quality controls. The survey also asks for a minimum of two industry business references and provides a section for additional comments about the company's quality process. Utilizing open market channels can be difficult especially when using a new supplier. A supplier may look great on paper and then deliver the complete opposite result. This is why my company has a vendor rating system in place and for 2013 will begin issuing quarterly vendor score cards.

Step Four

Vendor score cards are not only used to measure a supplier's effectiveness, but also allow the vendor to understand what their score means and how to elevate their performance and increase their score for the following quarter. The score card weighs certain criteria such as counterfeit avoidance and product preservation, such as ESD and MSD compliance, as well as on-time delivery, competitive pricing, and overall satisfaction. Vendors will get to see the scoring rationale and how it is weighted to better understand their current score against the previous quarter. As an independent distributor, it is vital to our business to increase the level of supplier scrutiny so that the most informed buying decisions are consistently made.

Step Five

Create a concession form with your vendors—actually, the vendors should offer this option first. This is especially important for manufacturers building for mission-critical applications and cannot obtain parts through authorized channels or full traceability. We now require customers to sign off on any open market purchases being made, as well as any type of testing or services required. Quality managers and engineers should be involved in this process. Too many times buyers and sales reps are negotiating types of inspections or testing arrangements. With all due respect, those who have both the technical and quality expertise in place need to be making those calls. Sales reps who just want to get an order and a buyer who just wants to get the order filled aren't always the best team members to determine best course of action for testing or inspection criteria.

If set up properly, a concession form is utilized for high-level transparency, allowing all key people to fully understand the aspects of parts being procured and next steps for identifying the integrity of that device. Vendors that are unwilling to present a transparent approach to such crucial sourcing requirements aren't the best fit for a secure supply chain and should be considered for AVL removal.

Improving the selection process for new vendors has never been more critical. Establishing a network of reliable and transparent suppliers that continuously measure themselves for the better is the only way forward. Though tedious and time consuming, the extra time and effort it takes to manage new suppliers will cut down on quality issues and elevate an end-user's product integrity and keep reputations intact. **SMT**

Christopher Torrioni is president and co-founder of Sensible Micro Corporation, a professional stocking distributor and sourcing partner to hundreds of global OEM and EMS manufacturing companies. He obtained his bachelor's degree from the University of Central Florida and brings 11 years of industry knowledge and experience in electronic component supply, market news, procurement pitfalls and quality assurance standards. Torrioni is also a corporate sponsor to the SMTA Tampa Bay Chapter as well as the Tampa Chamber of Commerce and Tampa Bay Technology Forum.

EVOLUTIONARY SOLUTIONS

Magical Results

by Karla Osorno
EE TECHNOLOGIES, INC.

SUMMARY: Using technology in manufacturing is both magical and practical. Amazing results, like improved costs, efficiencies, and quality, can sometimes seem like magic, but, more often, dramatic changes come from using the technology we have in new and innovative ways.

We love technology, right? Technology is a word used by many in a general way, but what does it really mean? Technology is defined as the application of practical sciences to industry. True, although not always that easy to understand. Commonly, when thinking of technology, people come up with descriptors such as new, breaking barriers, exciting, innovation, and opportunity. But is technology science or magic? Or is it both?

Using technology in manufacturing is both: Practical science with results that are magic. Magic can be defined as the art of producing a desired effect or result through forces of nature. The magic-like results in manufacturing show up in improved costs, efficiencies, and quality. EMS providers regularly look for and procure the latest in technology to capture this magic-like effect. Sometimes the basic technology has been around for quite some time, but is being used in new and improved ways. Either way—when approached with the right attitude, an eye for return on investment (ROI), and a focus on the benefits to the end customer—technology is magical.

But We've Always Done it This Way

Why invest in technology? It would be tempting for EMS companies operating on very narrow profit margins to ask themselves this question and just assume that the way it has always been done is good enough. However, great EMS companies are not content with the status quo. Great EMS companies respond to customers by understanding needs and providing the processes and technology to meet those needs. Such companies have the right attitude about the role of technology in today's world.

EMS companies are continually faced with new opportunities and decisions to make regarding the latest technology. Capital equipment representatives keep EMS company managers informed of the newest equipment and tools relating specifically to their niche. This is advantageous as EMS company managers are busy with the day-to-day operations and do not always have the time or access to keep up with technological developments.

Another incredible way for EMS company managers to stay in the loop is to attend global equipment conferences. And, of course, another great way to stay up to date is to read industry publications. The bottom line is that both a curiosity about the newest options and a commitment to serving customers are required to maintain a competitive advantage in the EMS industry.

Return on Investment

EMS companies use ROI to evaluate technology purchases and compare options. ROI measures the efficiency of an investment. To calculate ROI, the benefit (return) of an investment is divided by the cost of the investment and the result is expressed as a percentage or a ration. It is helpful to see the formula (below) to visualize that you are considering the cost of the investment versus the gain that will be realized in making the purchase.

$$\text{ROI} = \frac{(\text{Gain from Investment} - \text{Cost of Investment})}{\text{Cost of Investment}}$$

For a manufacturer the gains from investment may refer to the proceeds obtained from selling the technology or, more likely, the labor or other savings that result from having the technology.

ROI is a popular metric because of its versatility and simplicity. If the ROI is not positive or if there are other opportunities with a higher ROI the decision becomes clearer to company managers.

Another calculation that is helpful in assessing technology purchases is the payback period. The payback period in capital budgeting refers to the period of time required for the ROI to repay the sum of the original investment. For example, a $1,000 investment returning $500 per year would have a two-year payback period.

Benefits: Short and Long Term

When the ROI is positive and the decision is made to purchase technology, the technology arrives and implementation occurs. The quantitative benefits that supported the ROI will undoubtedly be realized. And there will also be other short- and long-term benefits that are qualitative. Some of these qualitative benefits may include increased employee morale, better than expected efficiencies, savings that can be shared with end customers, and cultural improvements.

Companies see long-term increased employee morale as employees often appreciate the streamlined processes and efficiencies that occur with the technology. Often the technology is suggested by employees who see an issue or problem that the technology addresses. So, when the technology arrives, there is an excitement and pride in being a part of the solution.

Once the technology is fully implemented and in place for awhile there are often better than expected efficiencies gained. These can result directly from the technology or indirectly as other processes are impacted by the technology. These savings may be realized over the long term.

Usually, EMS companies make choices that offer a relatively short payback period. Thus short-term savings are experienced and can be shared with the end customers. A natural consequence of this shared savings is a stronger partnership which ultimately results in future business making technology purchases beneficial for both the EMS provider and the end customer.

Cultural improvements relate to the increased awareness, training, and skill sets that result as employees get to experience more practice with technology. The culture can become one of continual improvement, appreciation of technology, and recurring new idea generation. These are all qualitative benefits that result in both the short and long term.

Real Results

Consider this example of technology being used at an EMS company. For years manufacturers manually marked circuit boards using labels placed by hand. Laser etching technology has existed for quite some time, but recently many EMS providers have started using laser etching machinery (such as the Nutek 2D Laser) to mark PCBs.

Several types of manual labels are possible including human readable, barcode, and 2D barcode. This specialized laser can create the same barcodes as was possible with the labels. Of course, the laser etching offers much less error at a fraction of the time.

This laser works in two different ways. One is to go straight in and etch the board with the barcode. The other option is to etch only the surface of the board. The machinery is programmable to meet the needs of the EMS provider and end customer. Ultimately, the boards magically appear with the right barcode label and ready for the next step in the manufacturing process. This is just one of many examples of technology being used by EMS providers to achieve success.

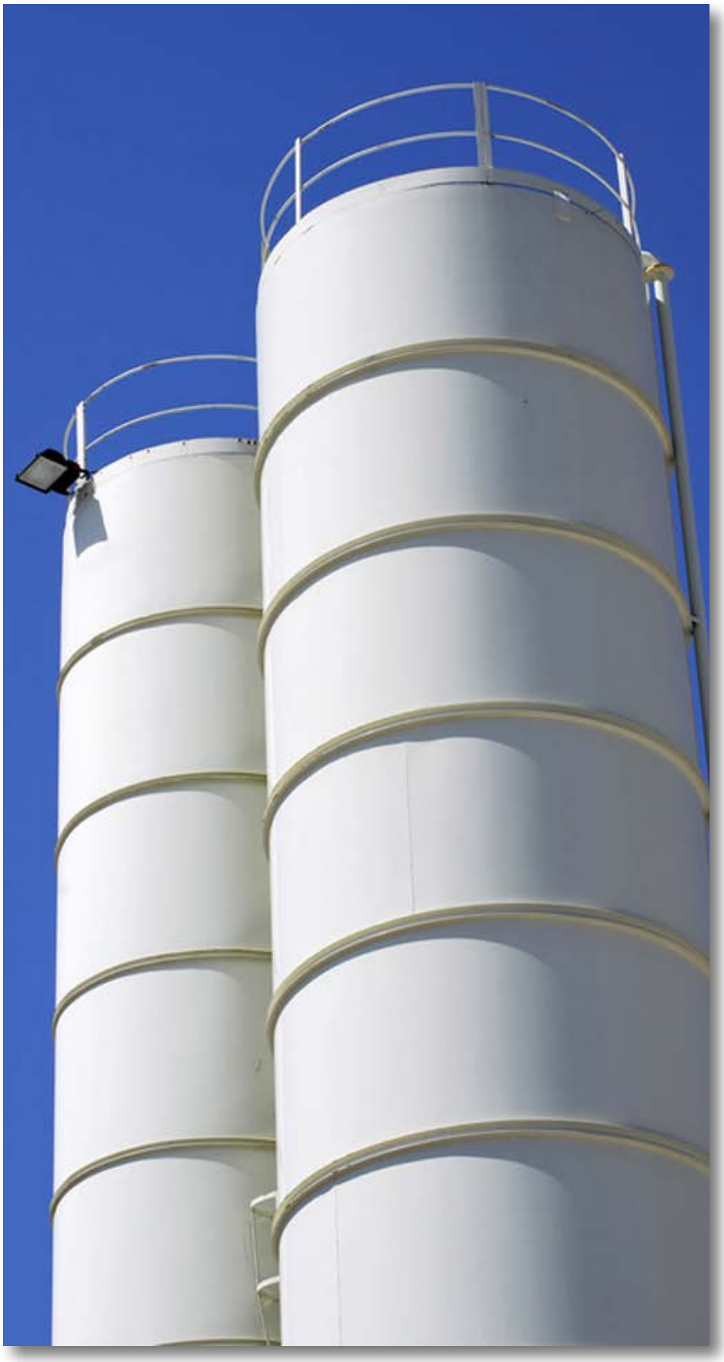
Although it is not always possible to directly connect each specific benefit to the technology, most EMS providers would tell you that benefits exist and technology is a welcome friend. Based on historical experience, technology offers both the science and magic and, most importantly, the results critical for EMS companies to thrive. One thing is for sure—there will be no technology disappearing acts in the near future. **SMT**

Karla Osorno is business development officer for EE Technologies, Inc., an EMS provider delivering complete engineering and manufacturing services with locations in Nevada and Mexico. With education and more than 20 years' experience in finance and operations, Osorno drives completion of projects in marketing, business development, operations, and process improvement. Her passions are to educate and empower others to make changes and a daily difference in the world. Contact Osorno here.

Breaking Down Management Silos

by Michael Ford
MENTOR GRAPHICS CORPORATION

SUMMARY: Every day the silos of management appear to work together on the shop floor, but things are not always harmonious. To understand the reasons why, Michael Ford considers a typical problem that can occur on a dysfunctional shop floor and describes the hazards of the "blame game."



The manufacturing shop floor is a funnel that brings together several manufacturing disciplines, each required to make the overall operation work effectively. When changes to processes or procedures are proposed, each involved group must give buy-in. Traditionally, each of these groups acted individually—each with an agenda supporting their particular discipline and not taking into account the requirements of the other groups—forming management silos, groups unable to consider or effectively communicate with other groups.

As manufacturing execution systems become more and more integrated and widespread, weaknesses among the management silos are exposed. Proposed changes to the operation can lead to two outcomes: The creation of opportunity for improvement with everyone working together or a complete breakdown of effectiveness as rivalries persist. What factors should be addressed to ensure that the benefits and opportunities of manufacturing execution systems (MES) are realized and do not become part of the overall problem?

Silos in Action

Every day the silos of management appear to work together on the shop floor, but things are not always harmonious. To understand the reasons why, consider a typical problem that can occur at any time on a dysfunctional shop floor.

Production Manager

A machine stops because it has run out of a certain material unexpectedly. The key priority and motivation of the

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production manager is to keep manufacturing running, no matter what. The responsibility for the completion of products lies with production management. No time for investigation here: Just find the materials and get the machine running again. Every second the machine is stopped costs serious money. Productivity and on-time delivery are the upper-most issues in the mind of manufacturing managers and operators. Material is found and replenished. A report is made, in which the materials manager is criticized for not providing adequate material to production.

Materials Manager

The priority for the materials manager is the accuracy and availability of materials inventory for production. The management of materials in the warehouse is a challenge, with materials being returned late with unknown quantities, other materials somehow being lost in the manufacturing process, and some materials just simply disappearing. Having so much unmanaged material inventory on the shop floor is a major issue which leads to many problems. It is amazing how much material production needs in excess of that which the BOM specifies.

The nature of spoilage in SMT is the key challenge to materials management success. Machines tolerate spoilage as if it hasn't happened. It can be small random quantities, but sometimes can suddenly become quite significant. Care is often taken with expensive parts, but the materials manager knows that if even the most insignificant component is missing, the entire product cannot be completed.

Addressing the issue in this material shortage example, the materials manager states that the correct number of materials was supplied, calculated from the bill of materials, the number of products to be produced, and the agreed allowance for spoilage. Proof can be shown that materials were selected and included in the kit sent to the shop floor. What happened after this is not the fault or issue of the supply chain. In fact, an alternative part number had been selected instead of the originally specified one, due to a potential shortage of the main part number. The usage of the alternative part was approved by the engineering department.

Engineering Manager

Many challenges arise day to day when attempting to ensure products are made with the correct versions of machine programs following engineering changes. This is the most important aspect for the department. The basic BOM could be quite simple: A list of components to be placed on PCBs. One challenge comes with engineering changes. Many of these are not planned well enough in advance for material order changes to be effective, so availability of materials may be affected. Additional materials may be required and some may become obsolete. Materials are very expensive, which drives the motivation to re-use them as much as possible. Obsolete parts from one product may become re-assigned to another product. This creates the need for materials flexibility.

To ease the constraints for materials availability, engineering can approve material equivalents or alternatives. This helps address both last-minute revision changes, and also those cases in the market where there is a shortage of the intended materials and alternatives are sought. This is what happened in this example: The work order was pulled and the material in question was in short supply, so an alternate part number was supplied to make up the required number. The planning manager is criticised for not knowing what actual materials are available before pulling a work order forward. Surely he talks to the materials manager, right?

Planning Manager

Ensuring that the shop floor is fully loaded and in line with customer expectation is a clear priority for the planning manager—this is where the money is made. Inefficient planning and utilisation of assets leads to excessive and needless costs. The challenge is the need for agility. As customer demand changes, the production plan should be adjusted to ensure changes are accommodated without loss of efficiency or opportunity, and that resources, including materials, are not exhausted. This is made difficult since the inventory of materials, especially those on the shop floor, is not accurate. Sometimes opportunities are lost when materials thought to not be available are actually on hand.

Figure 1: To operate with peak efficiency, management silos must be removed and all disciplines must work toward a common corporate goal.

In other cases, work orders are executed during a period when materials suddenly run out. The decision is a balance of risk without knowing the accurate level of inventory. In our example, the plan was changed: Engineering confirmed that the change of material needed was acceptable, so the order went forward. This particular work order also had quality problems which slowed progress, creating a problem for follow-on schedules. This came from the quality manager, who had a real issue with the production manager.

Quality Manager

The number one priority is quality. Defects cannot be tolerated in the market, which would put brand image and market opportunity at risk. Good quality needs a stable and managed production process. If something changes it inherently threatens the operation. Quality data collection can show and highlight which changes cause problems. The quality manager has the power to stop the operation should there be a serious quality issue. For the work order in our example, there was an issue at inspection where the first-pass yield was much lower than expected. Several defects were detected and considerable rework was needed. The quality reports show that the main quality issue was around components that were placed from the material in question. This slowed the progress of the line and the SMT line kept running, but it was not seen to be serious enough to be an epidemic problem. In later analysis, the change of material from the original part number to the alternative occurred part way through the work order. In fact, the reels of original materials and the alternatives were mixed. Though engineering had signed off on the material change, the alternate part had a slightly different height as compared to the original.

The problem escalates, since many of the products made might have defects which passed inspection within tolerance, but which could have fragile connections due to misplacement. Now the blame game begins: Why didn't

BREAKING DOWN MANAGEMENT SILOS *continues*

engineering know about the height difference? Why didn't the machines detect the change? Why were the material reels mixed? Why didn't quality stop the line? These are all good questions, but the problem has already occurred and consequences must be faced. By not seeing the whole picture as it happens, the real fault in this scenario is mistakes in judgement.

With humans involved, however, faults have to be tolerated. In this example, the effect of the issue could have been minimized if the simplest initial symptom had been seen and understood. More material was being consumed by the machine than expected. Looking at the patterns of usage and spoilage should have immediately identified a serious issue, long before the resultant shortage for material for the work order was reported. An MES system with direct machine connections collects and shows this information, but the data must be used to be effective.

Management and engineers can become stuck in old habits, using MES to automate what has always been done rather than looking for a better way. The reason is simply momentum. Production is a very complex machine and if something changes, it affects everyone. One aspect on which all silos agree is that change carries risk. Incremental, small changes, such as Kaizen, are eagerly accepted. Bigger changes are not so easily accepted.

"Production is a very complex machine and if something changes, it affects everyone. One aspect on which all silos agree is that change carries risk. Incremental, small changes, such as Kaizen, are eagerly accepted. Bigger changes are not so easily accepted."

Breaking Down Silos

The state-of-the-art for manufacturing systems is now integration. The best systems available will not only combine information from many sources, but will also use that information in real-time to manage processes, deliver materials just in time, assure quality, adjust the plan, and maintain the highest performance including required agility. The visibility from MES information can expose long-standing challenges in the operation. Clearly, the objectives need to change and the barriers between silos need to dissolve. The final business goals need to come into clear focus. With unambiguous, immediate, and accurate data in front of everyone an opportunity exists; the silos disappear and people are really working together.

It sounds too good to be true. How can such a change happen? How did the silos get to be there in the first place? Asking people to work in an environment where there is both uncertainty and risk of failure creates virtual walls and barriers which end up creating the silos. The motivation to start building barriers was justified by the need to be in control of their assigned area. The negative element that often then creeps in, however, is that the barriers between the silos are used to shield blame and responsibility. The adoption of integrated technologies exposes the gaps between the silos.

One thousand reasons can be raised by silo managers to show why MES technology is not suitable for the operation and its special operational needs. Many of these special operational needs, however, are those which have been created simply to protect the silo. The challenge is to know which needs are genuine and which are simply consequences of old working practices. These can be small things such as a part of the engineering flow, with one process now replacing several previous ones, or much more significant things, such as a complete paradigm change for materials flow from the warehouse to the machines.

The compelling need for MES today is that incremental Kaizen-style improvements can only go so far. For many companies, the business needs demand step-change improvements to keep up with competition and attract additional business. Quality must work with manufacturing to assure all processes are quality driven, all the time. Planning must improve to increase asset utilisation and agility, with continuous interaction with materials and engineering. The commonality for all of these is accessibility of accurate and live information which integrated MES systems, especially those connected directly to automated processes, provide. The pace with which this is moving is escalating, especially in operations that are newer to the industry and don't have the legacy of old working practices and egos behind them.

People will always be the most vital part of any production operation. Whether managers or operators, each person contributes to the success or failure of the company. Motivation is a key factor and is strongly influenced by the culture of the operation. An open culture, where everyone works together solving problems, is far more agreeable than an environment where it is best to keep your head down in case the responsibility for some issue is thrown around. MES can be the answer to provide the tools to achieve an open culture. The tool, or solution as some would like to think of it, is only as good as the way it is adopted and used by the entire shop floor management team. Now is your chance to break down management silos and achieve real improvement. **SMT**

Michael Ford is senior marketing development manager with the Valor division of Mentor Graphics Corporation. Utilizing his 30-year experience of industry knowledge, Ford examines key business objectives with his technology expertise to find solutions and opportunities where the industry had previously faced challenges. He began his career as a computer software and hardware engineer and created and managed manufacturing solutions for Sony where, he became one of the first successful adopters of computer technology for manufacturing, materials, and testing for the PCB-A shop floor. Ford is well versed in the principles of Lean thinking and sustainability and offers his expertise and knowledge in this bi-monthly column.

Video Interview

Cleaning and Contamination With Bob Willis

by Real Time with...
SMTAI 2012

For years, most didn't worry about cleaning, but that's changed with the increasing component densities. Bob Willis joins Editor Andy Shaughnessy to discuss a program on cleaning and contamination he'll be conducting at IPC APEX EXPO 2013.

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TOP TEN

Most-Read News Highlights from SMTonline this Month

1 Pentagon EMS Relocates Manufacturing to Hillsboro

"The new facility is perfectly situated to support the growth of our company," says Pentagon vice president of operations, Liv Taylor. "We are excited to begin operations here in Hillsboro, and look forward to continued success." The 38,000 square foot facility is located at 570 NE 53rd Ave., Hillsboro, OR 97124.

2 Foxconn Acquires $200 Million or 8.88% Stake in GoPro

GoPro® has announced that Hon Hai Precision Industry Co., Ltd., the world's largest electronics manufacturing company also known as Foxconn, has acquired an 8.88% full-diluted stake in GoPro for $200 million, valuing the company at $2.25 billion.

3 CTS Acquires D&R Technology

CTS Corporation has announced the acquisition of D&R Technology (D&R), a privately-held company with annual sales of approximately $50 million. D&R is a leading manufacturer of custom designed sensors, switches, and electromechanical assemblies primarily serving the automotive light-vehicle market.

4 Markus Walther New CEO of ESCATEC

ESCATEC has named Markus Walther chief executive officer of the ESCATEC Group. Walther started at ESCATEC as a technical manager 23 years ago and advanced through the company to his current role as chief operating officer (COO). The position of COO will remain open until a suitable candidate is selected.

5 Jabil's EMS Biz Grew 20% in Fiscal 1Q13

Jabil Circuit, Inc. has released preliminary, unaudited financial results for the first quarter of fiscal year 2013. The company reported first quarter revenue of $4.6 billion. "Diversified manufacturing services increased to 47% of our overall business, paced by outstanding growth in specialized services," said Timothy L. Main, president and CEO.

6 NOTE's Board of Directors Rejects Offering from Lifco

NOTE's board feels that the bid from Lifco significantly under-values NOTE, and that it does not reflect the company's long-term earnings capacity. Despite a bid premium of 35%, Lifco's valuation is only at 87% of NOTE's equity as of the end of the third quarter of 2012, which cannot be considered an accurate valuation of NOTE. Accordingly, the board recommends that shareholders do not accept the offering.

7 Axiomtek to Acquire Suntron's ECS Business

"With the added experience and skill set of ECS, we are now poised to provide our customers with a portfolio of robust industrial computing products along with outsourcing services anchored by operational excellence," said YT Yang, CEO and president of Axiomtek. "It is a perfect match."

8 EMS Expands Service Offerings; Acquires Applied Assembly

"This comes at a perfect time and provides a vast range of opportunities for EMS," said Bernard Chubb, managing director. "We have achieved an outstanding level of growth over the last two years and we want to enhance this with investments of this nature."

9 Elecsys' EMS Sales Down in Q2

Sales for the company's custom EMS business segment decreased 21% to approximately $2,990,000 for the quarter ended October 31, 2012, a decrease of $782,000. Karl B. Gemperli, CEO, said, "With the return of meaningful growth in our national economy still uncertain, we are steadfast in our resolve to expand Elecsys through targeted strategic investments."

10 Benchmark Electronics Expects to Exceed 4Q12 Guidance

Benchmark Electronics, Inc. expects to report revenue and earnings per share modestly above the high end of guidance for the fourth quarter 2012. The company previously provided fourth quarter revenue guidance of $580 million to $610 million, with corresponding diluted earnings per share between $0.26 to $0.31, excluding restructuring and Thailand flood related charges.

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Social Media: It's Nothing New...or Is It?

by Barry Matties
I-CONNECT007

I was told recently that I sounded like an "old man" during a discussion on social media. The name-calling happened when I shared a comment from a friend who told me she values social media as important because she can better keep in touch with friends and family; get updates from her favorite companies about specials and discounts; learn about activities happening each weekend at the local farmers' market; and even win free dog treats from a dog food company. If agreeing with and sharing the view of a 30-something-year-old friend makes me sound like an old man, so be it.

The conversation I was engaged in wasn't about whether or not social media has a place, though I believe that's how my friends viewed it. I believe it does. However, I'm looking at it differently. I see social media as the new venue for doing what we have done for thousands of years—communicate messages. And when it comes to messages, everyone seems to have one these days. The nice thing about social media is just that—it's social. We are just getting hung up on naming the activity and the delivery tools. I think what we are really witnessing is mass media in its most explosive state. The rules are still being defined while people continue to learn new ways to express themselves.

The outlet for messages in the past were available only to those with access to the news media, billboards, TV networks, cable TV, radio, newspapers, magazines, newsletters, speeches, chain letters, etc. Now, everyone has immediate access to tools that will broadcast their message to anyone who will listen or read. Dog food companies to their customers, rock stars to their fans, a politician to his base—the messages go to whomever cares what you may have to say…and even to those who might not care at all. But the real strength, right now, is for those who need to reach a broader group. And the broader the target market, the more effective social media becomes.

My social media discussion really just revolved around a tendency to confuse social media with B2B marketing. The basic concept I was sharing is that no matter what you call it—social media, tweeting, posting, blogging, advertising, connecting, Facebooking, circles, spheres, groups, forums, friends, etc.—strength in B2B marketing is found in efficiently focusing on a specific community. Many different communities make up our life—work, friends, family, sports, religion, politics, hobbies—and we all like to share our opinions, comments, or insights with a like-minded group of people.

What's happening now is a rush to social media, everywhere. Do you remember when the Internet really started catching on? Okay, now I do sound old, but back then everyone was rushing to be a part of this new community. Millions of dollars were made, and then lost, on

SOCIAL MEDIA: IT'S NOTHING NEW...OR IS IT? *continues*

Internet start-ups. As Alan Greenspan said, an "irrational exuberance" lead to a huge bubble that eventually popped. Is social media following that same path? Perhaps, to a degree, but I think the fallout will be less monetary and more social.

The ultimate goal of social media is to get a message to a target audience in the most efficient way possible. When it comes to niche market B2B, advertising during the Super Bowl or purchasing a billboard along a highway may not be the best use of your resources. So, what's the answer? When you are looking to market to a particular community, find out where the community already exists and get your message there. Where do you find the communities? Trade journals are a good place to start...and it's not just advertising, it's positioning yourself in a market in a way that allows you to gain market share.

Trade publications focus relevant and valuable information to an established community. If you want to blog, post your blog in an industry publication that already has the attention of the right community. If you want direct connections to the audience, invite them to subscribe to your blog. Once they subscribe you will have direct contact with them. The point I'm making here is to start your efforts in the place where the community already exists.

Become a columnist to share your expertise with the industry. If your message is so important that a magazine invites you to be a columnist, that brings a higher level a credibility to you and your message, compared to just a posting on a social media site. If you want to introduce a new product, submit press releases where your target market goes to get industry information. It streamlines the process for you, and when potential customers read the press release they are in the right frame of mind.

Social media marketing isn't limited to texting or status updates; it's also about people communicating in person. Trade shows, an assembly area for your community, are a great place to share your message. But keep in mind that trade shows offer much more than just a place to exhibit. Become a speaker, chair a session, or take part in technical discussions. Be a part of the content. Remember, it's not the size of your booth that matters, it's how you connect with your target community and how they connect with you.

An argument was made during my social media discussion that by using social media sites you can conduct surveys. That's true, but you have to first develop a network (target customers) that fits into the circle, sphere, group, or whatever you call it. Only then will you have a base upon which to draw. I shared with my friends that a smart company—smart because they know how to tap into a community with little effort on their part—looking for detailed market information asked us to conduct a survey for them. Within days we provided over 500 detailed responses to their questions. The results we acquired came from the exact target market the company was looking for and was not limited to companies with which they already had relationships, or as some might call them, the company's "circle of friends." Not only did it give them important market intelligence, but it also gave them direct leads.

It's not whether or not social media is good, bad, or here to stay; it's about focusing on your community and delivering your message. Social media is nothing new; it's been around for thousands of years. The difference now is that new outlets allow any person to have an immediate voice and be relevant.

I'm not saying the new media outlets don't play a part in your marketing. In fact, I think they do. But I would say be smart about it and start by going where the community already assembles and grow from there.

So, if telling people they should focus their message to the right market makes me sound like an old man, I am okay with that. I've also been told there is no substitute for experience. When experience makes you sound old, well, I take it as a compliment. **SMT**

Barry Matties is the publisher of the I-Connect007 family of publications. He started in PCB manufacturing in the early 1980s and in 1987 became a founder of CircuiTree Magazine, which sold nearly 13 years later as the leading industry publication. In the early 2000s, Barry and longtime business partner Ray Rasmussen joined forces again and acquired PCB007 and launched the I-Connect007 family of publications. Later, in July 2010, SMT Magazine and SMT China were also acquired by I-Connect007. With his proven successful business development and leadership skills, Barry now produces this column relating over 25 years of successful business experience, including business, marketing and selling strategies that really work. Contact Barry here.

Tablet Looks and Feels Like a Sheet of Paper

The PaperTab looks and feels just like a sheet of paper. However, it is fully interactive with a flexible, high-resolution 10.7" plastic display, a flexible touchscreen, and powered by the second generation Intel® CoreTM i5 processor. Instead of using several apps or windows on a single display, users have 10 or more interactive displays or "PaperTabs:" One per app in use.

Ryan Brotman, research scientist at Intel, says, "We are actively exploring disruptive user experiences. The 'PaperTab' project, developed by the Human Media Lab at Queen's University and Plastic Logic, demonstrates innovative interactions powered by Intel Core processors that could potentially delight tablet users in the future."

PaperTab's intuitive interface allows a user to send a photo simply by tapping one PaperTab showing a draft e-mail with another PaperTab showing the photo. The photo is then automatically attached to the draft e-mail. The e-mail is sent either by placing the PaperTab in an out tray, or by bending the top corner of the display. Similarly, a larger drawing or display surface is created simply by placing two or more PaperTabs side by side.

The device can file and display thousands of paper documents, replacing the need for a computer monitor and stacks of papers or printouts. Unlike traditional tablets, PaperTabs keep track of their location relative to each other and the user, providing a seamless experience across all apps, as if they were physical computer windows.

PaperTabs are lightweight and robust, so they can easily be tossed around on a desk while providing a magazine-like reading experience. By bending one side of the display, users can also navigate through pages like a magazine, without pressing a button.

For more information, click here.

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 of events, check out *SMT Magazine's* full events calendar here.

SPIE Photonics West 2013
February 2-7, 2013
San Francisco, California

6th Annual Mobile Deployable Communications
February 7-8, 2013
Amsterdam, The Netherlands

Medical Design & Manufacturing
February 11-14, 2013
Anaheim, California

Electronics Manufacturing Korea 2013
February 13-15, 2013
Seoul, Korea

IPC APEX EXPO® Conference & Exhibition 2013
February 19-21, 2013
San Diego, California

CMSE - Components for Military & Space
February 20-21, 2013
Los Angeles, California

Embedded World
February 26-28, 2013
Nurnberg, Germany

MEDTEC Europe
February 26-28, 2013
Stuttgart, Germany

IEEE CPMT Advanced Packaging Material
February 27-March 1, 2013
Irvine, California

Medical Devices Summit
February 28-March 1, 2013
Boston, Massachusetts

Economic Retreat
March 7-9, 2013
Snowmass, Colorado

29th Annual SEMI-THERM Expo and Conference
March 17-21, 2013
San Jose, California

Executive Briefing: Thermal Management Market Vision & Strategies
March 18, 2013
San Jose, California

SOLARCON China 2013
March 19-21, 2013
Shanghai, China

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ADVERTISER INDEX

Next Month in SMT Magazine

The March issue of *SMT Magazine* will address the industry's many legislation and environmental issues, including the impact of such legislation with a focus on RoHS and REACH compliance and enforcement, ITAR compliance, conflict minerals, and corporate social responsibility.

The March issue will also include our exclusive IPC APEX EXPO post-show coverage. Our veteran team of guest editors and staff will bring you the latest from the show floor, including new technologies and products, a review of key panel discussions, and, of course, our in-depth Real Time with...IPC APEX EXPO video interviews. Last year, we compiled 162 video presentations highlighting the best our industry has to offer!

If you're not yet a subscriber, don't miss out! Click here to receive *SMT Magazine* in your inbox each month.

See you in March!