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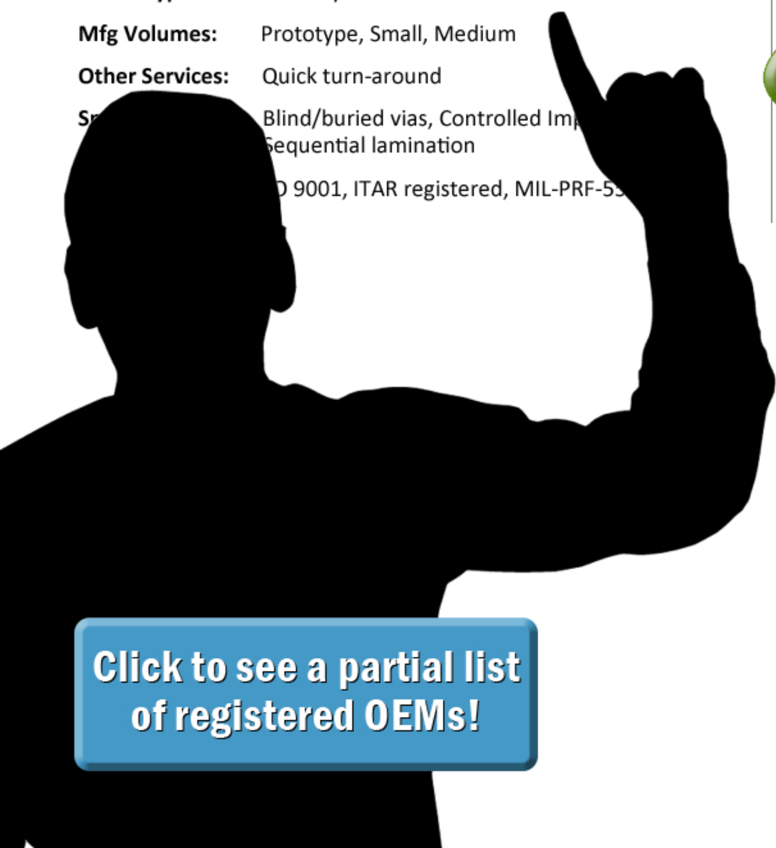

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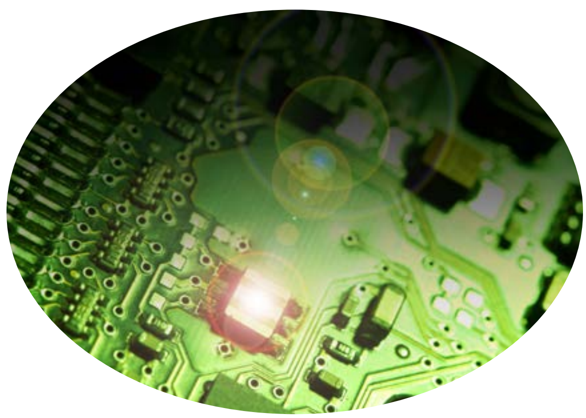
April 2014 Featured Content

SMT ASSEMBLY, PART 3

Closing out our three-part series, our expert contributors focus on what happens after the soldering process. How does cleaning affect reliability? How is conformal coating applied over no-clean flux? And how can forensic analysis uncover defects that might be missed by more traditional inspection methods? And don't miss our coverage of IPC APEX EXPO!



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SMT CONNECTIONS

Sustainability—What and Why?

by Joe Fjelstad
VERDANT ELECTRONICS

In 2013, Earth welcomed roughly 140 million new citizens, replacing approximately 60 million who passed away, netting a growth in the world's population of 80 million people—a number which happens to roughly match the population of Egypt. The Earth's population now stands at more than 7.2 billion. (For those interested, real-time statistical estimates for population and other subjects of significance including health and environmental matters can be found at www.worldometers.info.)

The numbers are staggering and border on the incomprehensible. They also present an ongoing challenge to us all to find ways to make certain that those just joining the human race have a chance to realize their potential. Without question, it is a huge challenge we collectively face. Presently and throughout history, there has existed a great divide between more advanced and exploitative cultures and nations and the many still developing peoples and nations of the world that coexist on this, our little 'blue marble' in space, or as futurist and visionary Buckminster Fuller aptly called it, "Spaceship Earth." He asserted, and rightly so, that we are all astronauts and as its crew, we needed to maintain the delicate balancing act to assure that Spaceship Earth will allow us to survive future trips around our sun.

The resources of our planet are unquestionably limited and thus are diminishing as we continue to unleash and ramp up a seemingly never-ending flow of products to both serve and amuse us with output of the global electronics industry likely to be nearing the top of the list of "offenders." In that regard, we are becoming victims of our own success, to one degree or another. For better or for worse, the engine of economics runs on the fuel that the consumers' wants must always exceed their needs. Moreover, product developers and promoters are putting forth their best effort to make sure that as many of their products as possible can be perceived as needs rather than simple wants. Presently, their focus remains targeted on those of us who inhabit the top of the world's economic pyramid and our numbers exceed 3.5 billion people. A substantial market to be sure and already there is evidence that we are, or soon will be, stretching the limits of natural resources. This leaves half of the world's population on the outside looking in. It would seem that, if

we are going to satisfy the expectations of those billions of people not fortunate enough to be born in the right place at the right time, we are going to have to make some adjustments in our approach to the design and manufacture of future products. In short, we are going to have to look very seriously at what we might need to do to create a truly sustainable electronics manufacturing industry in the future.

This begs the question: "What is a sustainably manufactured product?" Unfortunately this is not a simple question, and without surprise one finds that the answer is not simple either. That said, there are think tanks out there where people grapple with the problem. One such is the Lowell Center for Sustainable Production. They have created a reasonably comprehensive checklist for those seeking to make an effort to create products and processes that are sustainable. Following is a condensed summary of their "litmus test" checklist[1].

Sustainable products are:

1) Safe and ecologically sound throughout life cycle and:

- designed to be durable, repairable, readily recycled, compostable, or easily biodegradable
- produced and packaged using the minimal amount of material and energy possible

2) Processes that are designed and operated such that:

- wastes and ecologically incompatible byproducts are reduced, eliminated or recycled on-site
- substances or physical agents and conditions that present hazards to human health or the environment are eliminated
- energy and materials are conserved, and the forms of energy and materials used are most appropriate for the desired ends
- work spaces are designed to minimize or eliminate chemical, ergonomic and physical hazard

The above checklist is succinct but it also offers the user targets, which are reasonably clear and measurable. This is important for as every scientist and engineer knows, until you can apply numbers to any effort you have no way of knowing how well you're doing. The one thing that appears to be missing from the list in the view of this writer is a statement about the need for greater reliability. If we can make products that will last indefinitely, we don't have to make them again. This may fly in the face of the sensibilities of product marketers today who seek to have a new product on the shelf every 12–18 months, if not sooner. However, such product marketers have little or no appreciation of the situation of the peoples who inhabit much of the developing world. If one is making as little as two dollars a day, the products they purchase must be durable, for they cannot afford to replace them on a whim.

Fortunately, the CEOs of corporations large and small are beginning to appreciate the importance of sustainability even as they wrestle with the challenge of addressing it. This is evident based on results of a recent and broadly cited Accenture study on sustainability wherein 1,000 CEOs in 27 different industries were questioned about the importance of sustainability on the future success of their businesses. The answers to the questions were promising. A total of 93% of CEOs affirmed the importance of sustainability for the future of their company. And 80% felt the sustainability would offer them competitive advantage, while 78% felt that pursuing sustainability would enhance innovation and growth within their companies. Unfortunately, as pragmatists, only a third of them felt that the global economic situation was on track to meet targets or making the kind of effort required to address the sustainability challenge. Moreover, they seemed conflicted as less than half of them believed they can quantify their efforts and perhaps more importantly, they felt that sustainability efforts will likely always take a backseat to profitability.

"Therein lies the rub" as the Bard of Avon so nicely phrased it. Given there is no clear-cut and well-defined path to sustainability, given the wide range of electronic products being developed and sold as well as the myriad materials and processes used in their manufacture, it appears we are somewhat living the parable of the blind men describing an elephant. Here again for emphasis is repositioned the nagging concern that most of the attention of our electronics industry is focused on serving the needs of just half of the world's population—the top half. We have a long way still to go to meet the needs of those on the bottom, but as the philosopher Edmund Burke observed, "The greatest mistake that one can make is to do nothing because one can only do a little." Making the effort to build truly sustainable products seems a reasonable objective; but do we have the will?

The elimination of solder, which is the primary cause of defects and failures, seems to be a likely target, but who in the developed nations will be the first to embrace such a radical concept? If coupled with the use of aluminum as a substrate, the impact provides immense benefits to those whose birthplace did not do them a favor. Sadly, most corporate leaders today are more akin to sheep and lemmings than to the bold thought leaders of earlier eras. They speak of boldness, but their actions are anything but. Given their self exclusion as agents of change, it will be left to the younger readers of this appeal to deliver the promise because it seems certain that it will not come from those about to retire or hanging around to enjoy the perks.

In closing, I am reminded of a senior engineer who sat behind me during my tenure at Boeing more than 30 years ago. He tried to calm me when my much younger self expressed deep frustration at the pace of progress with the implementation of some of our process improvements, by saying this: "Joe, you need to keep in mind the simple fact that everyone wants to go to Heaven but nobody wants to die." It was and still is the truth. So it goes...

Next time, an unflinching look at the dark side of solder. **SMT**

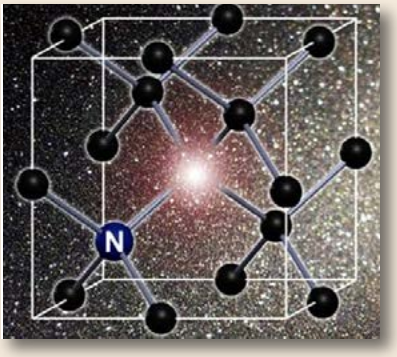
Reference

1. Lowell Center for Sustainable Production

Verdant Electronics Founder and President Joseph (Joe) Fjelstad is a four-decade veteran of the electronics industry and an international authority and innovator in the field of electronic interconnection and packaging technologies. Fjelstad has more than 250 U.S. and international patents issued or pending and is the author of Flexible Circuit Technology.

Flawed Diamonds Pick Up Small Magnetic Fields

Flawed but colorful diamonds are among the most sensitive detectors of magnetic fields known today, allowing physicists to explore the minuscule magnetic fields in metals, exotic materials, and even human tissue.



University of California, Berkeley, physicist Dmitry Budker and colleagues have now shown that these diamond sensors can measure the tiny magnetic fields in high-temperature superconductors, providing a new tool to probe these materials.

"Diamond sensors will give us measurements that will be useful in understanding the physics of high temperature superconductors, which, despite the fact that their discoverers won a 1987 Nobel Prize, are still not understood," says Budker, a professor of physics and faculty scientist at Lawrence Berkeley National Laboratory.

"The new probe may shed light on high-temperature superconductors and help theoreticians crack this open question," says coauthor Ron Folman of Ben-Gurion University of the Negev.

Climatic Reliability of Electronic Devices and Components

by Rajan Ambat
TECHNICAL UNIVERSITY OF DENMARK

SUMMARY: This article provides an overview of the climatic reliability issues of electronic devices and components with a focus on the metals/alloys usage on PCBA surface together with cleanliness issues, humidity interaction on PCBA surface, and PCBA design and device design aspects.

The miniaturization of electronic systems and the explosive increase in their usage has increased the climatic reliability issues of electronics devices and components, especially when metal/alloy parts are exposed on the PCB assembly surface or embedded within the multilayer laminate. Problems are compounded by the fact that these systems are built by multi-material combinations and additional accelerating factors such as corrosion causing process related residues, bias voltage, and unpredictable user environment. Demand for miniaturised devices has resulted in higher-density packing, with reduction in component size and closer spacing thereby increasing the electric field, while thinner metallic parts need only nanogram levels of metal loss for causing corrosion failures.

Introduction

During the past couple of decades, the use of electronic devices has increased in gigantic proportions. Mobile phones are obvious examples of how devices integrate more and more complex functions, such as camera, GPS and several wireless communication technologies. The integrated device is expected to be cheap, while the applications necessitate it to be robust, durable, and reliable at all environmental conditions, including severe conditions. Industrial electronics is another sector where the electronic controls and other devices are used irrespective of the type of industries and environmental conditions. The vast majority of these electronic systems are not produced with serious consideration of the climatic reliability aspects. Climatic reliability issues that led to corrosion can intro-

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For detailed technical and reliability information, visit **www.indium.com/SACM** duce intermittent malfunctions and permanent failures, which cause severe economic loss.

Miniaturization and high-density packing are other reasons for increased corrosion reliability problems for the electronic devices. In order to provide additional functionalities and increase the number of components per unit area on a PCBA, PCBs today are made with multilayers, commonly 8–12 layers. The line width, distances, and sizes of the components on the PCBAs are then reduced considerably. Over the last 10 years, the size of electronics has been reduced by over 70%. For flip-chip ICs, miniaturization amounts to –90%. Even material loss on the order of nanograms can cause reliability problems.

The average size of dew droplet formation on a surface at different temperatures varies from 20–50 mm at about 50% RH[1]. Hence, the smaller size of a PCB makes it easy for a local electrochemical cell to form, due to the formation of a water layer connecting two electrical points, the thickness of which is determined by the humidity levels, conditions on the PCBA surface including cleanliness, roughness, and the relative temperature to the atmosphere.

This article provides an overview of climatic reliability issues of electronic devices and components. Various aspects such as the PCBA materials and components, cleanliness issues, design aspects, and the environmental factors such as the humidity and temperature effects are discussed in relation to the corrosion and reliability problems. As a summary some suggestions for the corrosion mitigation are also discussed.

Overview and Key Factors of Electronic Corrosion

Corrosion issues on a PCBA surface under humid conditions can be summarized as shown in Figure 1. Three factors inherent on a PCBA surface, which are essential ingredients to cause corrosion, are: (i) the presence of metals/alloys, (ii) the potential bias/electric field, and (iii) the humidity levels determining the thickness of the water layer. These three factors together can cause formation of conventional electrochemi-

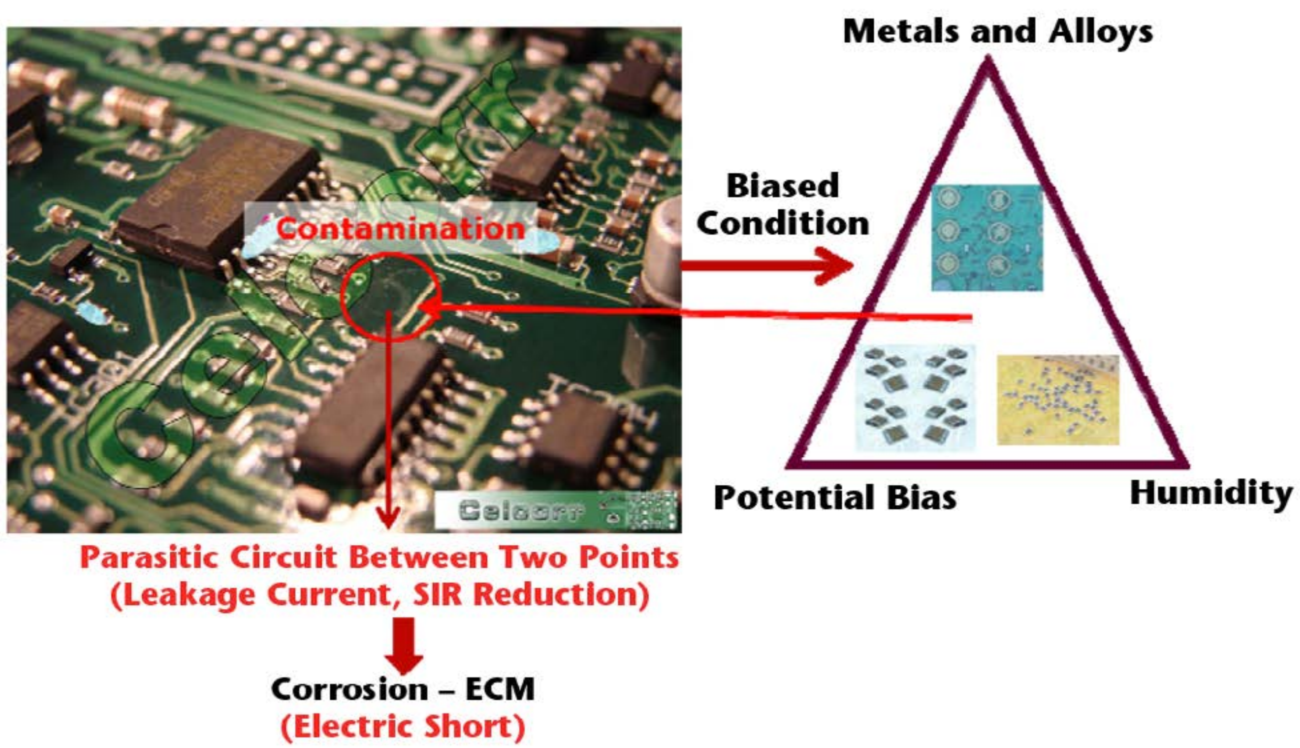

Figure 1: Schematic showing various factors on a PCBA surface causing leak current followed by corrosion such as ECM.

cal cells, which are either electrolytic or galvanic in nature (Figure 2)[2]. A typical example of an electrolytic type corrosion cell formation on PCBA surface is closely spaced conduction lines with opposite bias which is connected by a water layer, while galvanic type cells are formed for example by the coupling between the gold and underlying electroless nickel and the copper layer on a ENIG contact. Numerous other examples of both types can also be found on a PCBA.

However, a pure water layer on a clean PCBA surface has only limited conductivity to introduce any significant leak current or corrosion effects. But the PCBA surface is seldom clean due to the process related residues[3-5] (Figure 1), which dissolves into the water layer. Water layers with dissolved ionic residues are more conducting, which cause first-level corrosion effect such as the increased levels of leak current causing functionality problems. The leak current is generated by faradic reactions involving dissolution (from the positive electrode) and building up of metal ions in the solution layer, which over a long period of time—depending on the level of potential bias, thickness of water layer, and materials involved—will results in electrochemical migration (ECM).

Electrochemical migration results in the formation of metal dendrites between two adjacent electrodes connected by a water layer, resulting in an electric short. Electric shorts caused by these dendrites can be intermittent or permanent. Other forms of corrosion can also occur, depending on the materials and other parameters involved. However, ECM is a common failure mode on a PCBA surface if metals such as Sn, Pb, Ag, Cu, and Au are involved. The presence of ionic residues on the PCBA surface also influences the formation of a water layer; all ionic residues are hygroscopic in nature, therefore absorbing water at relatively low levels of humidity on a clean surface, while thickness of the water layer also changes with the amount of contamination. The following sections will provide a more detailed discussion on various aspects of electronic corrosion.

Corrosion Failure Mechanisms

Corrosion failure mechanisms of electronics can be divided into two major categories: (i) the electrochemical corrosion in aqueous environment and (ii) the gaseous corrosion caused by the corrosive gases. Other factors such as wear and vibration can superimpose on corrosion, causing varieties of tribo-corrosion such as fretting. Gaseous corrosion at room temperature or slightly elevated temperatures can also be assisted by aqueous conditions, and therefore it is difficult to differentiate between the elec-

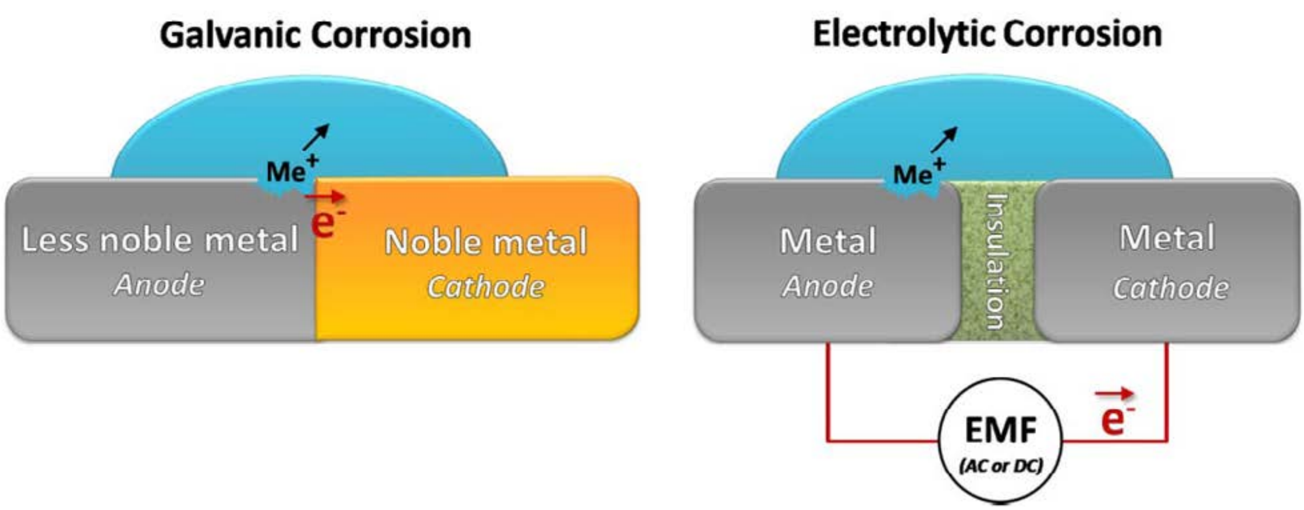

Figure 2: Two types of electrochemical cell formation possible on a PCBA surface. Left: Galvanic cell due to coupling between two different metals through water layer. Right: Electrolytic cell formation between similar metal/alloy parts due to opposite potential bias.

trochemical corrosion mechanisms and gaseous corrosion. Some important failure mechanisms on outer surfaces of the PCBA are discussed later, while the conductive anodic filament (CAF) failure mode usually found inside the laminate is not discussed.

Gas phase corrosion

Various gases such as sulphur, ozone, ammonia, etc., can cause corrosion of parts on a PCBA, depending on the material content. A detailed discussion is beyond the scope of this article; only a generalized discussion of corrosion of silver due to sulphuric gases is described.

The presence of low levels of sulphur gases can create severe corrosion problems on Ag and Cu parts. Moisture from the humidity can assist gaseous corrosion due to the dissolution of gases into the water layer generating various acid species. Therefore, at ambient temperatures, it is difficult to distinguish between chemical corrosion due to sulphur gases and the electrochemical corrosion. Figure 3 shows corrosion of silver parts on a PCBA due to sulphur-containing gases from a pig farm environment. Formation of silver sulphide dendrites can be seen all over the surface[6]. Usually sulphur corrosion on PCBAs is found with sulphur gas levels below 50ppb.

Anodic corrosion and Electrochemical migration

Electrochemical migration is a typical form of corrosion found on electronic systems. Electrochemical migration is caused by the presence of a potential gradient between two closely spaced conductors on a PCBA (terminals of a capacitor, resistor, or legs of an IC, for example), connected by a thin layer of water due to humidity. Under such conditions, metal ions dissolve into the solution layer from the positive electrode (anode) which, due to the effect of high electric fields, migrate towards the oppositely charged negative electrode (cathode), depositing there in the form of a dendrite depending on the local chemistry of the solution.

Therefore, whether a specific metal ion deposits on the cathode or not depends on the stability of the ion in the aqueous solution and local chemistries generated between the electrodes at high potential levels. As a result, only a few metals such as Sn, Pb, Cu, Ag, Au, etc., are susceptible to electrochemical migration, while other metals just precipitate as hydroxides or other compounds as corrosion products. A typical example of a non-migrating metal used in electronics is aluminium. In humid environments with chlorides, aluminium dissolves and forms hydroxide (or hydroxy chlorides) instead of migrating to the cathode regions. On the other hand, metals like Cu, Ag, Sn, Pb, etc., migrate upon dissolution and deposit at the cathode at least over a range of potentials and pH under which a particular ion is stable as predicted by the Pourbaix diagram[7]. A detailed discussion on the mechanism of ECM is beyond the scope of this article, but can be

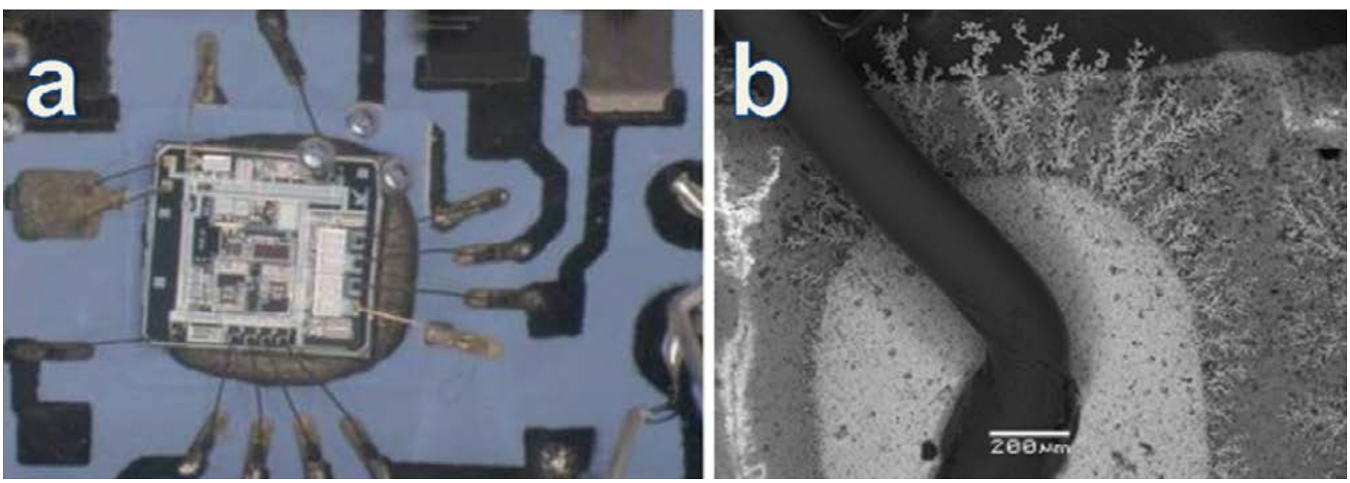

Figure 3: Sulphur corrosion on silver parts on a PCBA (a) and formation of silver dendrites (b).

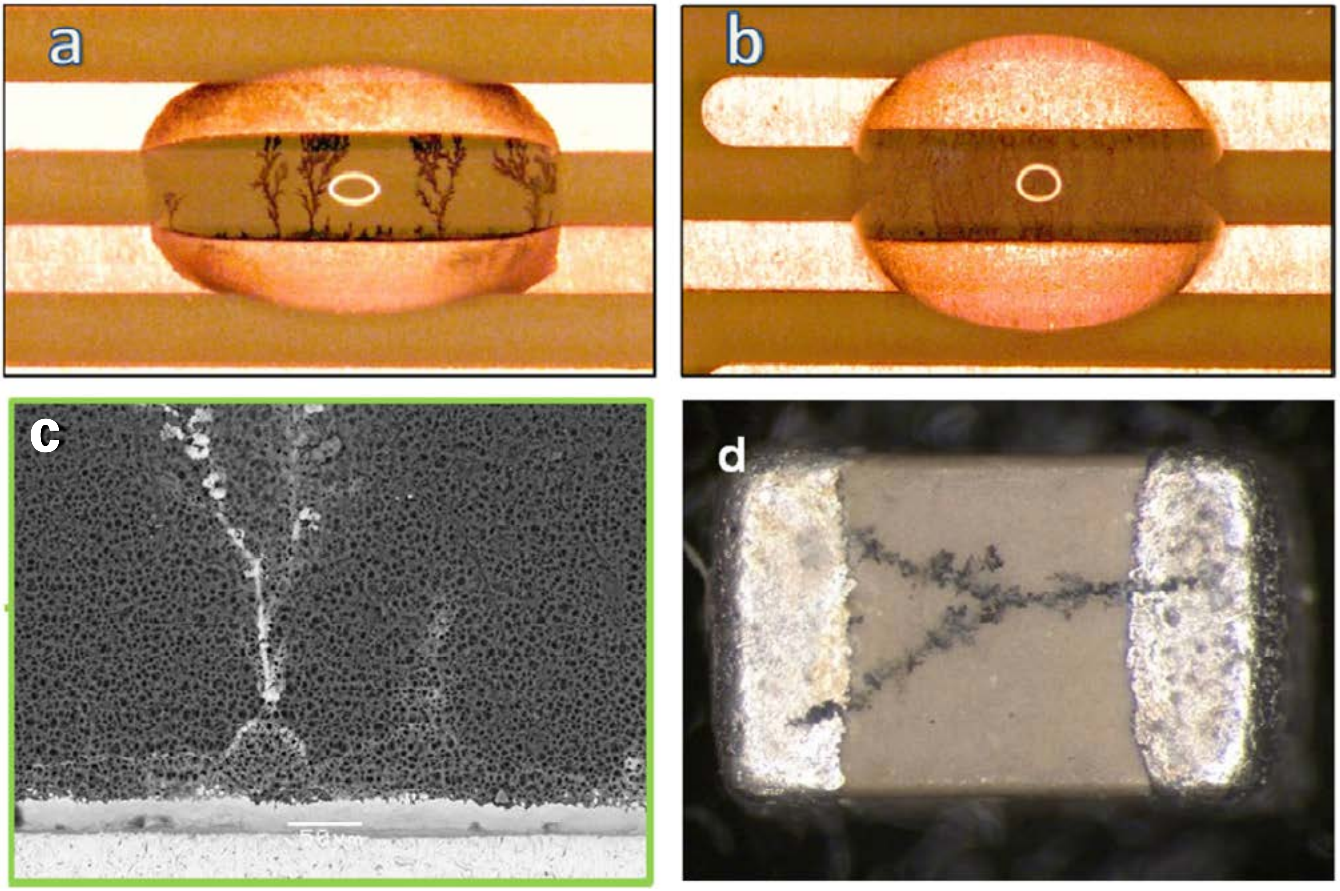

Figure 4: Dendrite formation due to ECM: (a) Copper comb pattern at 2.5 V, (b) Copper comb pattern at 10 V, (c) SEM picture of dendrite between copper lines, and (d) ECM on chip capacitor at 10 V.

found elsewhere[8]. Figure 4 depicts ECM caused by dendrite formation between two copper conduction lines at 2.5 V and 10 V potential difference and on a chip capacitor at 10 V. Formation of dendrites can cause electric shorts, compromising the functionality of the device intermittently or permanently.

Cathodic corrosion

Some metals used for electronic systems are soluble in acidic and alkaline environments over a wide range of potentials and pH. For example, the Pourbaix diagram[7] for Al and Zn shows solubility in acidic and alkaline environments above the equilibrium dissolution potential, which itself is a function of pH in the alkaline range. In a microgalvanic cell, oxygen reduction takes place at the cathode, which produces OH^- ions. Production of OH^- ions at the cathode surface shifts the pH to alkaline values, which causes the metals like aluminium to dissolve.

Therefore, although in principle the metals should be cathodically protected, due to the change in pH a new dynamic equilibrium is created at the cathode surface at which certain metals could dissolve. Among the metallic materials used for electronic applications, aluminium metallization lines on IC chips are susceptible to this type of corrosion. A schematic of the anodic and cathode corrosion process is shown in Figure 5.

Galvanic corrosion

This type of corrosion is attributed to the use of metals/alloys with widely varied electrochemical properties. On PCBAs, galvanic corrosion manifest in many ways and are considered

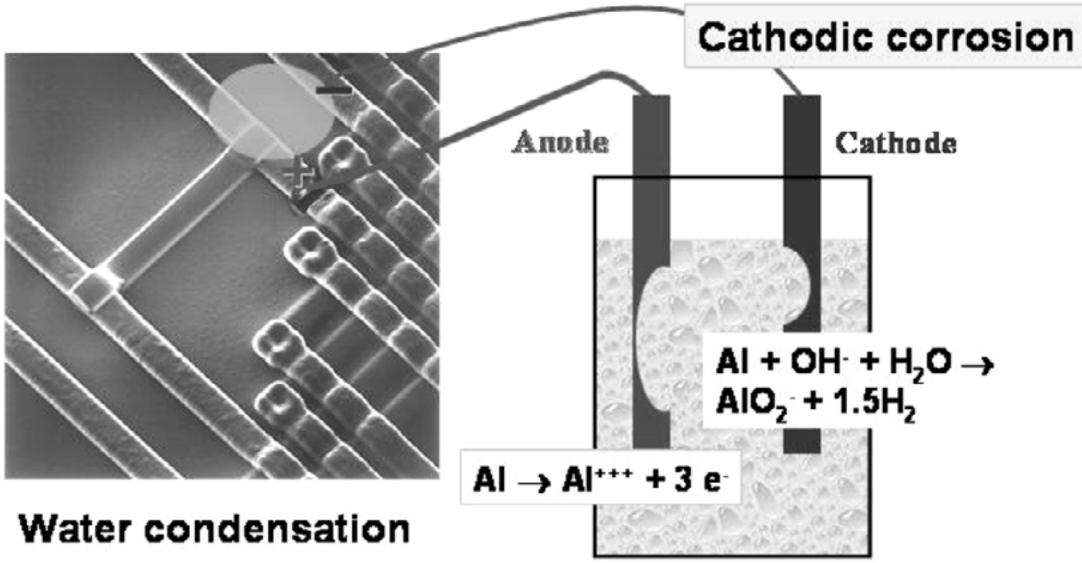

Figure 5: Schematic of the anodic and cathodic corrosion process.

as dreadful for connectors and switches. For connectors and switches, the corrosion products formed by the galvanic corrosion induce high resistance in the circuit. Usually the connectors are made of multilayer metallic coatings as described earlier. The metallic layers have distinctly different electrochemical properties. A typical example is the ENIG parts on the PCB.

Figure 6 depicts a mobile phone keypad made by the ENIG process, with corrosion due to galvanic coupling between layers. As shown in Figure 6d, the immersion gold (IM Au) layer is porous, exposing part of the EL Ni layer. The large difference in electrochemical potential between EL Ni and IM Au causes corrosion of EL Ni (Figure 6c), while the Au layer acts as powerful cathode. As the corrosion proceeds, pitting of EL Ni layer exposes Cu at deep pit areas. Even in the absence of porosity on the top coating, the gap between metallic component and resist edge can be a point where all the metallic layers get exposed to the solution. Palladium has been introduced as a substitute for gold, but Pd has faster cathodic reaction kinetics than gold. Therefore, use of Pd can enhance the galvanic corrosion problems. Metals in the various PCB finishes (Cu, Sn, Ag, Ni, Au, and Pb) have large difference in the electrochemical potential for galvanic corrosion (Figure 6e).

The bonding process for ICs uses different metals, which can generate galvanic corrosion problems if moisture ingress occurs due to any damage in the encapsulation material. Often a gold/aluminium bonding is used for IC chips and the combination is seldom safe from corrosion because of the large difference in electrochemical potentials. The lead frame is also coated with solderable coatings, which are generally nobler than the base material. Therefore, any mechanical defects in the coating can cause corrosion problems.

Fretting corrosion

The most reliable material for electronic switches is gold. However, gold is expensive, so from time to time the electronic industry has been trying to use tin-coated copper switches. The tin-coated copper surface is solderable as well. The most important problem with electronic switches and contacts is the relative motion between the contacting parts due to small amplitude vibrations. The vibratory motion can be relatively low (10–200 micron) and caused by the floor vibration, the thermal stresses, etc. The relative movement of contacting parts due to the vibration destroys the oxide film on the contacting surface. The new surface generated reacts with the environ-

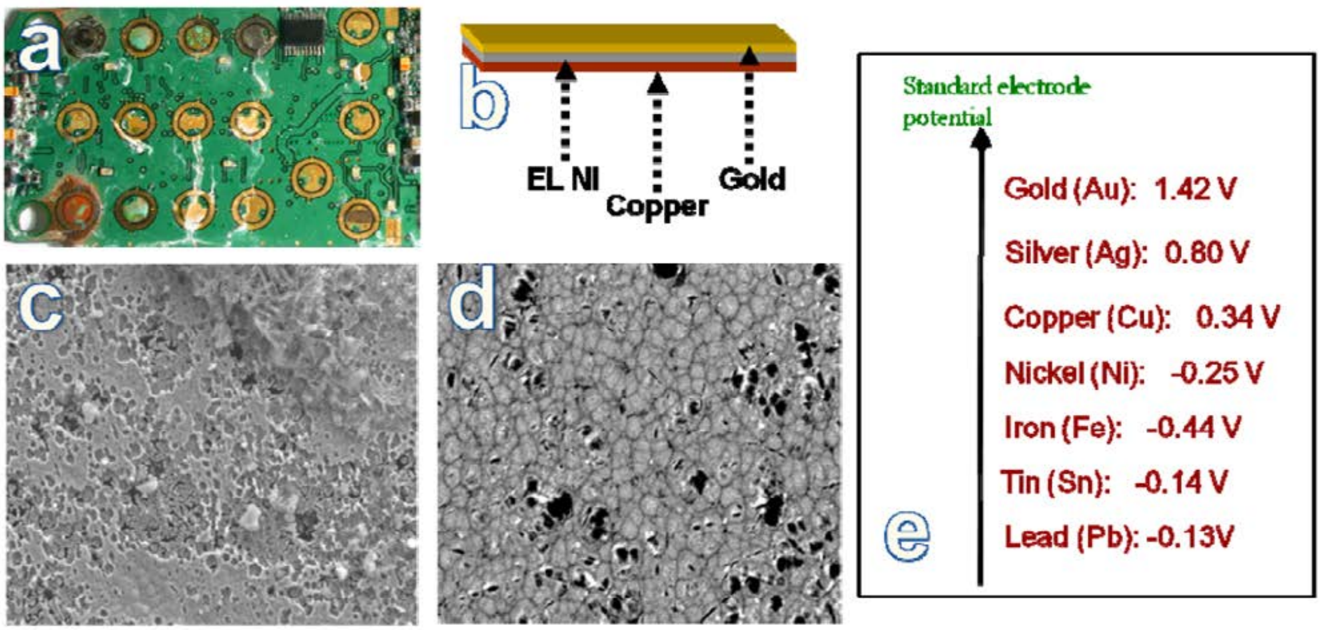

Figure 6: Galvanic corrosion of mobile phone key pad due to galvanic coupling: (a) Mobile phone key pad, (b) Schematic of the multi-layer coating, (c) corrosion of Ni and Cu under layer due to porosity in the gold layer, (d) SEM BE image showing porosity in the gold layer, and (e) a list of standard electrode potential of various metals.

ment to form a new film, which will be destroyed during the subsequent movements. In this way, a large number of oxide debris will be produced, which will affect the electrical properties by increasing the contact resistance. This results in current spikes and damage to the electronic device.

Due to fretting corrosion, the switches in an oscillating movement (10 cycles/min) have experienced an increase in the connection resistivity from 1 milliohm to 1 ohm within 20 min. It is obvious that the use of gold, which does not produce an oxide layer, as the connection material could solve this problem except for the cost. Another way of solving the problem is to use a good design for switches and contacts to ensure mechanical stability.

Corrosion Susceptible Materials and Components

The materials used today in electronic devices include all classes of materials such as polymers, plastic, and elastomers, ceramics, and metals and alloys. Among them the most important for the corrosion reliability are metals and alloys. A number of metals and alloys—from the noble gold to metals such as silver, tin, lead, aluminium, copper, nickel, iron, etc.—and combinations of these are used in the form of alloys (e.g., solder alloys or components terminals) or multi-layer coatings (e.g., PCB surface finishes such as ENIG).

Polymers and plastics used in electronic devices are also susceptible to degradation in various climatic conditions, but to a lesser degree, and not life-threatening like corrosion problems related to metallic parts. However, polymers and plastic parts on the device can act as a medium for the adsorption of humidity, gases, and ions, thus accelerating corrosion inside or outside of the assembly. A typical example is the transport of water molecules through the interface between the glass fibers and matrix in glass epoxy laminate and the resulting CAF formation between embedded copper conduction lines.

Similarly, the surface morphology of the polymer or ceramic parts can also have an impact on the water layer formation due to the presence of porosity and roughness acting as capillaries for the absorption of humidity. Another aspect is the content of the polymers and plastics, and the possibility of the release of chemical species during processing or service that could have influence on reliability. A typical example is the use of various types of fire retardants, which can release fractionalized compounds causing corrosion reliability issues (see section on fire retardant and degassing in Part 2 of this article).

Metallic materials on the PCBA are of prime interest for corrosion reliability, as electrochemical corrosion can occur on these parts leading to material loss or several other problems, which leads to the failure of the device in a short span of time. Basically metals/alloys used on the PCBA vary in their reactivity towards the environment, determined by its nobility. Metals like gold are noble (find in metallic form in the earth crust), while metals like Cu, Ni, Sn, Pb, Ag, etc., are less noble than gold and has a tendency to go back to its native state as stable compounds once they come in contact with an environment. Even gold can corrode under some conditions on the PCBA surface involving high potential bias and contaminations such as chlorides. From the aqueous corrosion point of view, many of the tiny components or conduction lines are made of active metals/alloys, which also can have opposite potential bias when the device is functional. Together with humidity it can cause corrosion as shown in Figures 1 and 2. Some of the important components on a PCBA, which are susceptible to various types of corrosion, are briefly described below with a discussion on the materials' make-up and possible climatic reliability issues.

From the aqueous corrosion point of view, many of the tiny components or conduction lines are made of active metals/alloys, which also can have opposite potential bias when the device is functional.

Bare printed circuit board and manufacturing process

The PCB is, in general, the substrate for mounting and connecting electronic components, while it mechanically supports the components and other devices from mechanical and thermal vibrations. A PCB consists of conductive pathways embedded in a glass epoxy polymer or other types of laminates. The conduction lines on a PCB are made of copper, while the non-conducting substrate, for example, is made from glass epoxy polymer. However, the surface of the PCB on which the components to be mounted will have an surface finish added to the base copper lines, where the type of surface finish depends on the type of application or product. A PCB can be single-sided, double-sided, or multilayered.

Functional electrical circuits and PCBAs are formed by interconnecting packaged integrated circuits with other devices using printed circuit boards. As such, these boards can be viewed as the second-level packaging. Individual devices are attached to the PCB using mainly two types of soldering techniques namely wave soldering and reflow soldering process. Wave soldering is used for through-hole components with legs, while reflow is used for surface mount components. Manual hand soldering is used only for special components that cannot be soldered using either of the above process. Tin-lead alloys were the predominant choice for soldering until recently, but due to the ban on lead, lead free soldering technology is in place today.

Printed circuit board surface finish and metallic combinations: Most commonly employed PCB surface finishes are: electroless nickel-gold (ENIG), immersion tin, hot levelled solder finish (either Sn-Pb solder or lead-free solder alloy), immersion silver, and copper finish. In the case of gold surface finish PCB (ENIG), gold is not directly plated onto copper, as this can easily form diffusion couples that produce various types of intermetallics at the interface. In order to avoid this problem, gold surface finish PCBs are the ENIG type: copper and the gold layer are separated by 5–6 micrometers of electroless nickel. A nickel layer provides both a diffusion

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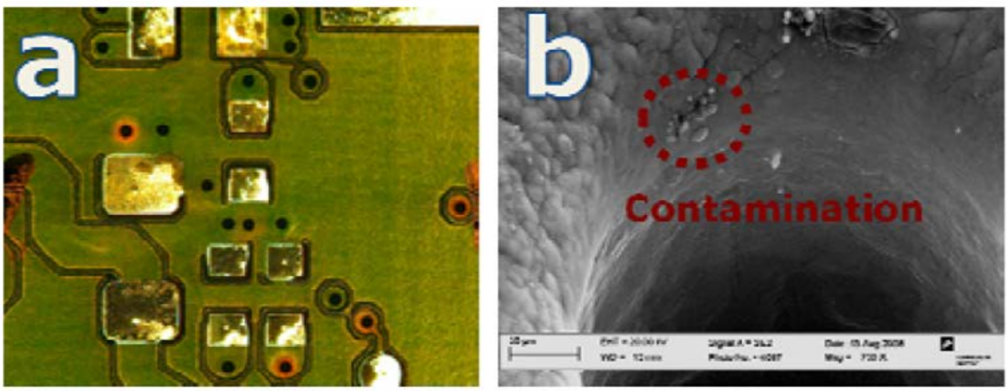
barrier and the necessary hardness, especially for contact applications. A thin layer of gold is plated onto the nickel layer using an electroless process called immersion gold plating. In this case the gold layer is plated on to the surface by ion exchange process with palladium activated nickel. With immersion Au finish, thickness of the gold layer is extremely low to the level of 50–100 nanometers. But gold layer on the electronic contacts are usually much thicker of the order of 500 nm—1 µm. In this case higher thickness is achieved by electroplating process.

For a tin finish, immersion tin is mainly used, produced by plating a thin layer of tin onto the copper conducting lines. The tin layer in this case is usually not more than 1 µm. The immersion tin plating process is similar to immersion gold plating process, which is carried out by electroless process using an ion exchange mechanism. Hot-levelled PCB surface finish PCBs are made by coating the solder material (with lead or lead-free) on to the copper lines by dipping the whole PCB into a molten solder bath followed by removal of excess material using an air knife. The thickness of the layer in this case is of the order of 1 micrometer.

Irrespective of the overall surface finish, low-voltage, low-force connectors and contacts are usually present on a PCB for connecting the device with other parts of the device[9,10]. A variety of different configurations exist, but the most used substrates are copper, brass, bronze, or copper-beryllium. The use of copper alloys ensures some susceptibility to environmental degradation. To reduce interfacial resistance and corrosion, the substrate is plated with a nickel diffusion barrier and then with a precious metal (e.g., gold, palladium)[9,11].

Printed circuit board and electronic corrosion: Important effects of a bare PCB on the corrosion reliability are the following: (i) source of contamination, (ii) water permeation through laminate and related corrosion issues, and (iii) corrosion issues related to multimetallic layers on the surface. Due to miniaturization, features on the PCBs are tiny and the smallest distances between the conducting lines on the external



c

Ions	Amount, ppm
H2PO2-	0.9412
Cl-	1.6117
SO4(2-)	1.8880
Br-	0.7007

Figure 7: Trapped contamination in via holes and ion chromatographic analysis: (a) overview of vias, (b) localized contamination in a vias, and (c) levels of different ionic residues.

surface and interior of the PCB is approximately 100 µm. Thickness of the conduction lines are also of similar magnitude.

Sources of contamination: Although at tiny levels, leftover chemical species from the PCB manufacturing process can influence the corrosion process by increasing the conductivity of the water layer formed on the PCB during service. Overall cleanliness of the PCB after manufacture is ensured by the ROSE test (solvent extract test, IPC-TM-650 2.3.25 ROSE test standard) which defines an overall allowed contamination level of 1.56 µg/cm^2 NaCl equivalent. However, contamination at localized sites can be significantly higher if there is local condensation especially at sites where hygroscopic residues are present. Important trapping sites for process chemicals on a PCB surfaces are via holes (plated through holes), edges of conducting lines or any other features where entry of the cleaning solution is difficult. Figures 7a and 7b show examples of trapped chemicals in vias mainly constituting ionic residues such as chloride, sulphates, hypophosphite etc. Vias can also act as water trapping sites due to the capillary effect during service, while also maintaining water for longer times compared to the flat regions during thermal cycling. Therefore, the chances of forming a thicker layer of water at high humidity surrounding a set of vias are higher than typically seen in flat regions.

The aspect ratio of the vias is an important factor in achieving cleanliness. High aspect-ratio vias have higher chances of trapping contamination than low aspect-ratio vias due to the difficulty of entry for the cleaning solutions. Similarly, it is quite common to find defective plating inside the vias (example wicking) for higher aspect ratio vias. This can expose the underlayers and glass fibers of the polymer to the opening of the vias acting as a site for easy water transport. This can cause formation of conductive anodic filament (CAF) between buried conduction lines.

The release of chemicals from the PCB laminate is another issue, especially during reflow or wave soldering due to the increase in temperature as high as 250–270°C. Most important in this case is the possibility of release of fractionated chemicals mainly from the fire retardant chemistries. Typical examples are the release of bromine resulting from the use of fire retardant tetrabromobisphenol (TBBA) (See section on fire retardants and degassing).

Permeation of water through laminate: Water permeability of polymer laminate is an important aspect in determining the corrosion of buried conduction lines in the case of multilayered PCBs. For FR-4 types of laminate, easy pathway for water is along the glass fibre interface, which will be contaminated with various species along its way through the polymer. In this case, the fiber-epoxy interface is also the preferential solution connecting path for two conduction lines situated inside the PCB to form corrosion cell. Water permeated to the polymer can act as a conductive media causing corrosion between the conducting lines especially when the PCB is working, which introduce potential bias between the lines. A typical corrosion issue related to water entry into the polymer is the corrosion of copper conduction lines due to conductive anodic filament formation as described earlier. Major PCB factors controlling this corrosion are the amount of water, fibre matrix interface acting as a connecting path, and the presence of ionic residues. Typically, CAF is found between two oppositely charged vias due to the possibility of a gap between vias and epoxy to collect water and the possibility of several fibre-matrix interfaces acting as a pathway for the solution layer between the vias overall length of the hole.

Corrosion of multimetallic surface finish: Depending on the surface finish of the PCB, there is a possibility of two or more different metals/alloys comes in contact, which can together interact with the environment leading to galvanic corrosion (See section on galvanic corrosion in Part 2). Galvanic coupling between the various metallic layers is a clear possibility especially for the features that are open on the PCB surface namely electronic contacts such as the pin contacts or edge contacts. Other features usually get buried below the solder joints after the component mounting, therefore expected to have comparably less effect on corrosion.

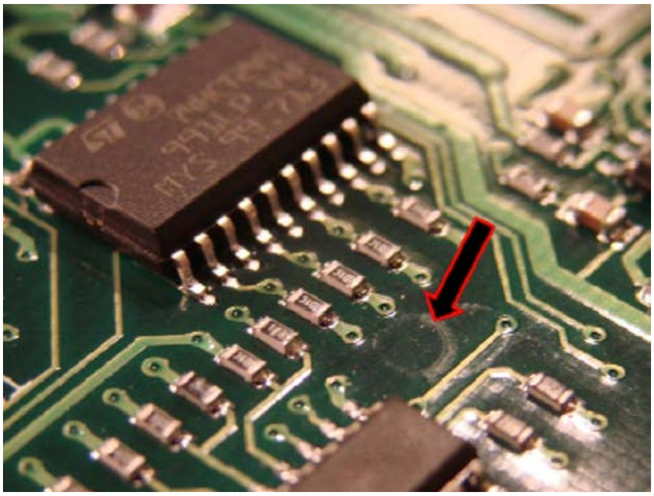


Figure 8: A view of the wave solder flux residue on a PCBA.

Component assembling and soldering: The next level of packaging is the introduction of components by the soldering process to produce final assembly for the device. Additional materials and process related parameters are introduced at this stage, namely: (i) solder alloy to join the component on to the board, (ii) components with various shapes and material content, and (iii) chemicals (solder flux) used during the soldering process. Soldering carried out by wave, reflow soldering, or in some cases by selective soldering/hand soldering depending on the nature of the components. Apart from the solder alloy and components, an important factor to contribute from this stage to the corrosion reliability is the solder flux residues from the soldering process. The type, quantify, composition, and morphology of the flux residue introduced from the wave, reflow, and hand soldering process are different, and therefore interact differently to the humid environments (See section cleanliness issue, leak current, and corrosion in Part 2). Figure 8 shows the wave solder flux residue on a PCBA resulting from the use of no-clean weak organic acid (WOA) based flux.

Electronic components and corrosion reliability

Chip capacitor: Practically capacitors for electronic applications are available in variety of forms, but the discussion here is limited to the most commonly used type today namely surface mount chip capacitor (SM capacitor). These are flat components which can be directly surface mounted on to the PCB by the reflow soldering process. Due to its bipolar nature, the chip capacitors are found to cause corrosion problems on a PCBA, especially the failure mode electrochemical migration. Also, the open circuit nature of a capacitor makes it very sensitive to leakage currents (e.g., if a condensed layer of water bridges the two electrodes). As the stored electrical energy can be released from the capacitor even after the potential bias has been switched off, a capacitor can cause corrosion failures after the electronic device has been switched off.

For example, an SEM picture of the cross-section of a SM capacitor is seen in Figure 5[2]. The ceramic part of the SM capacitor is commonly based on titanium dioxide or barium titanate (Ba_2TiO_3), with small additions of other elements to increase the dielectric constant. The electrodes of the comb pattern are made from nickel or silver-palladium[12]. The connecting electrodes has copper layer, which is covered with a layer of nickel followed by a top layer of tin as shown in Figure 9. Both copper and nickel layers are made by thick film technique,

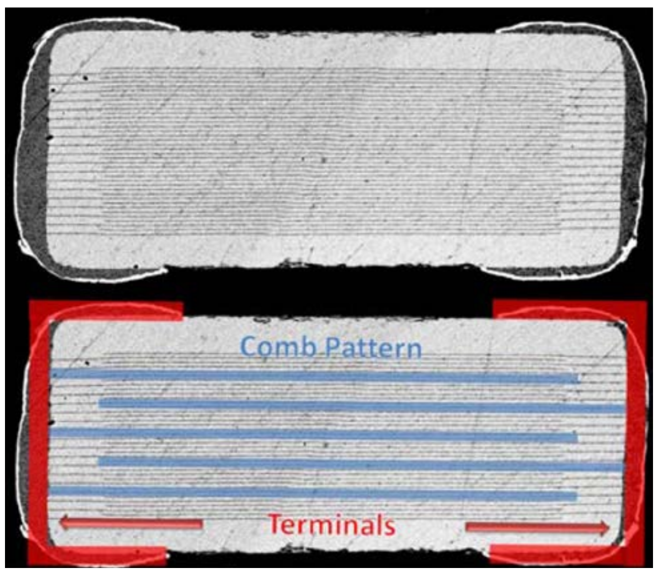


Figure 9: Cross-section of a SM chip capacitor showing comb electrode pattern and end electrodes.

where as the tin layer is made either by solder dip process or barrel plating.

The outer layer of tin has very rough surface morphology due to the barrel plating process. For more details on the manufacturing of multilayer ceramic chip capacitors the reader is referred to Kahn, et al.[12]. **SMT**

This article will be continued in the May issue of *SMT Magazine*.

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Forensics Uncovers Elusive Defects and Saves PCB Designs

by Zulki Khan
NEXLOGIC

SUMMARY: Products and their supporting PCBs and packages have shrunk so much that it is considerably challenging to detect extremely small problems. But a forensic approach can help uncover defects that traditional methods may miss.

Can something as tiny as a micro-CSP-packaged device, as shown in Figure 1, be the cause of a PCB design defect or its complete failure? As you can see, this tiny package is as small, or even a bit smaller than the letter "L" in the word "Liberty" that is printed on the dime.

That's only part of the story. The other part is you and your CM or EMS provider have no clue that's where the defect lies, and worse, even if you guessed that the micro-CSP-packaged device posed the problem, you couldn't find it because it is so elusive and so extraordinarily small.

Today, OEMs are increasingly moving toward smaller, more portable products and systems. Most of those used to be larger, desktop models a few years ago. However, with recent advances in electronics technologies, various markets are demanding smaller products and systems with the same or greater functionality than their larger ancestors.

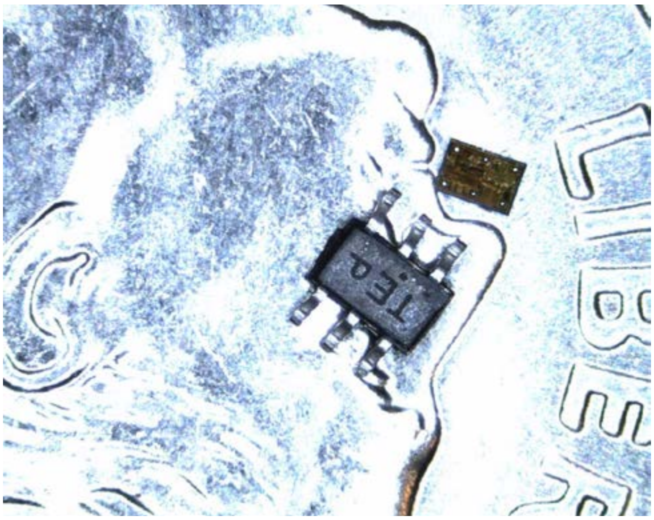
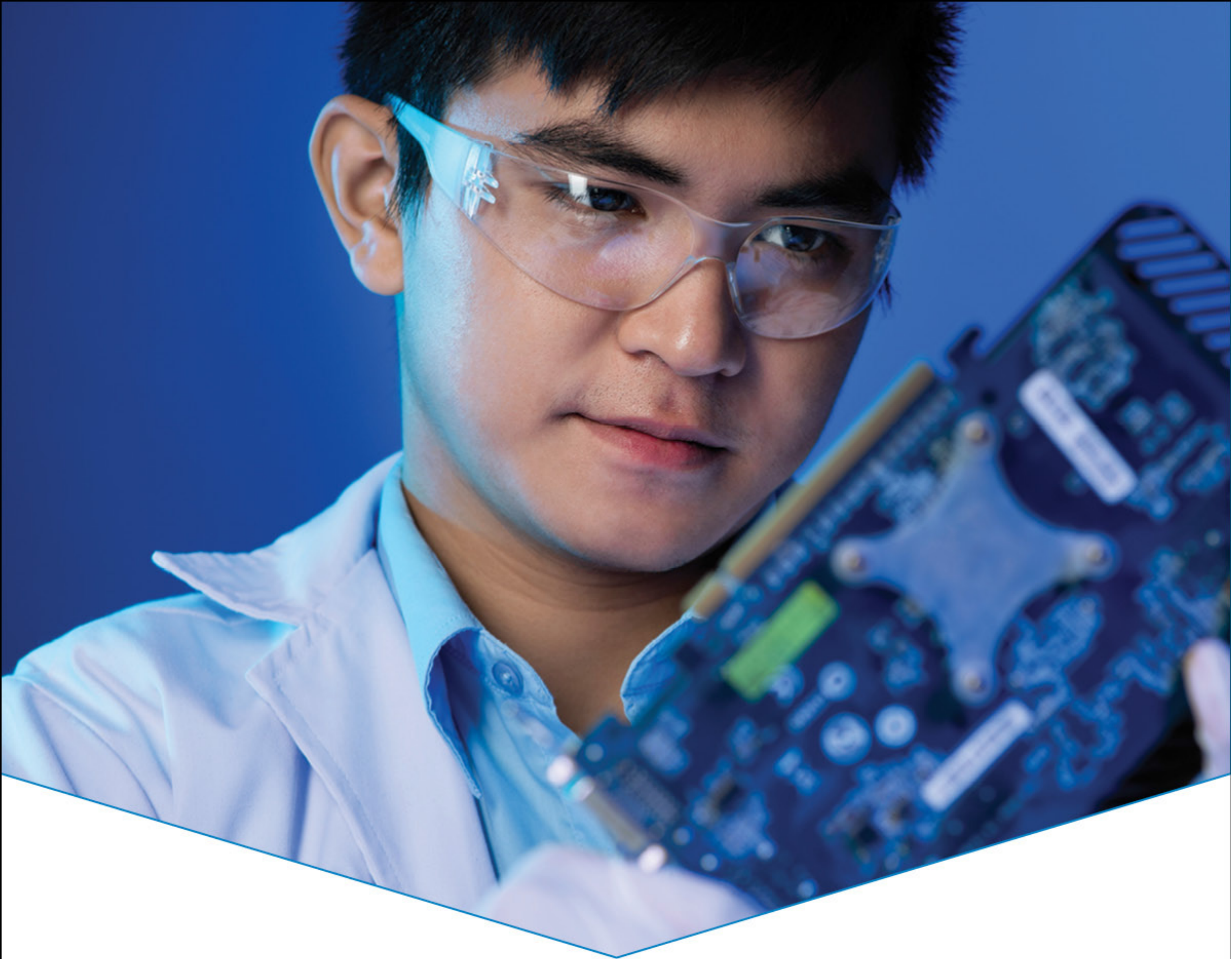


Figure 1: MicroCSP compared to SOT 23 package on a U.S. dime.



As a result, semiconductor and electronics suppliers are constantly shrinking their products and adding more functionality to comply with market demands. For CMs and EMS providers, it means moving toward smaller form-factor boards populated with such advanced, but smaller component and device packaging as micro-BGAs, micro-CSPs, package-on-package (PoP), 01005s, and others.

Finding the Defect and Saving the Design

Conventional inspection methodologies on the assembly floor include using advanced X-ray and automatic optical inspection or AOI and continue to be at the forefront for most PCB designs.

Yet, because these advanced inspection and analysis systems aren't able to deliver, a newer form of inspection is making its presence known in our industry. We call the new form forensic analysis.

Here are just a few examples of the extremely small flaws and defects that forensics can locate.

- Micro hairline crack in a BGA ball (Figure 2)
- Voids due to air gaps created inside the solder due to poor plating (Figure 3)
- Trapped air bubbles between via walls (Figure 4)
- Head-on-pillow defect in assembly (Figure 5)
- Contaminated plating with air gaps on an ENIG PCB surface (Figure 6)

Detecting Elusive Flaws and Defects

An OEM might be completely unaware of a small defect or flaw that crept in during assembly or was inadvertently included during design/layout. In a number of cases, OEMs basically throw up their hands and give up because they simply cannot find the problem; they start all over again, thus sacrificing thousands of dollars.

But if there's an assembly error or even a miscue after the design is sent to manufacturing, forensics is standing by to uncover those potentially unsolvable issues that conventional inspection failed to catch and unwittingly passed. Some of these defects could be hard to find and some are intermittent, which makes it difficult to catch or duplicate them for doing the root cause analysis.

Take a PoP-populated PCB, for example. You determine that the pass rate and yields are extremely low; the product is not performing or is failing. A cross-section view of the PoP is taken to provide physical evidence and a root cause of the failure mode. Plus, the cross-section shows the failure site location, and then isolates it from suspected versus non-suspected devices. As shown in Figure 5, two BGA balls

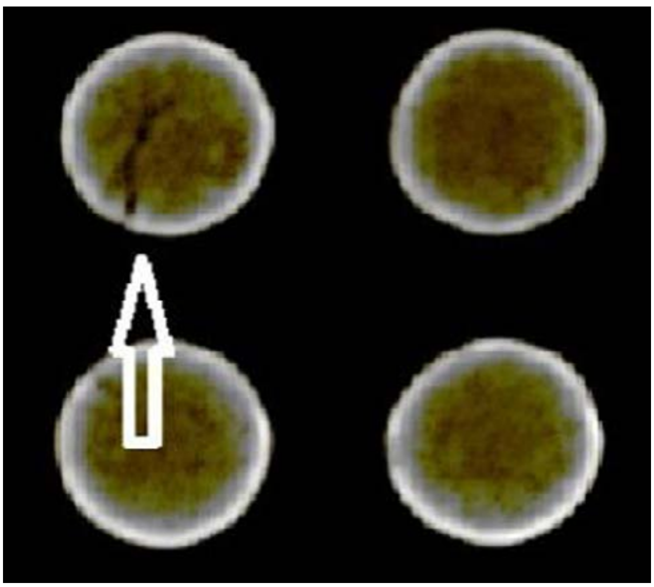


Figure 2.

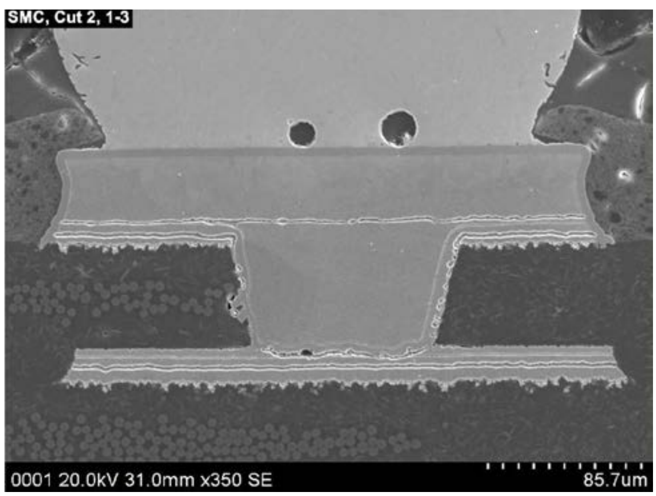


Figure 3.

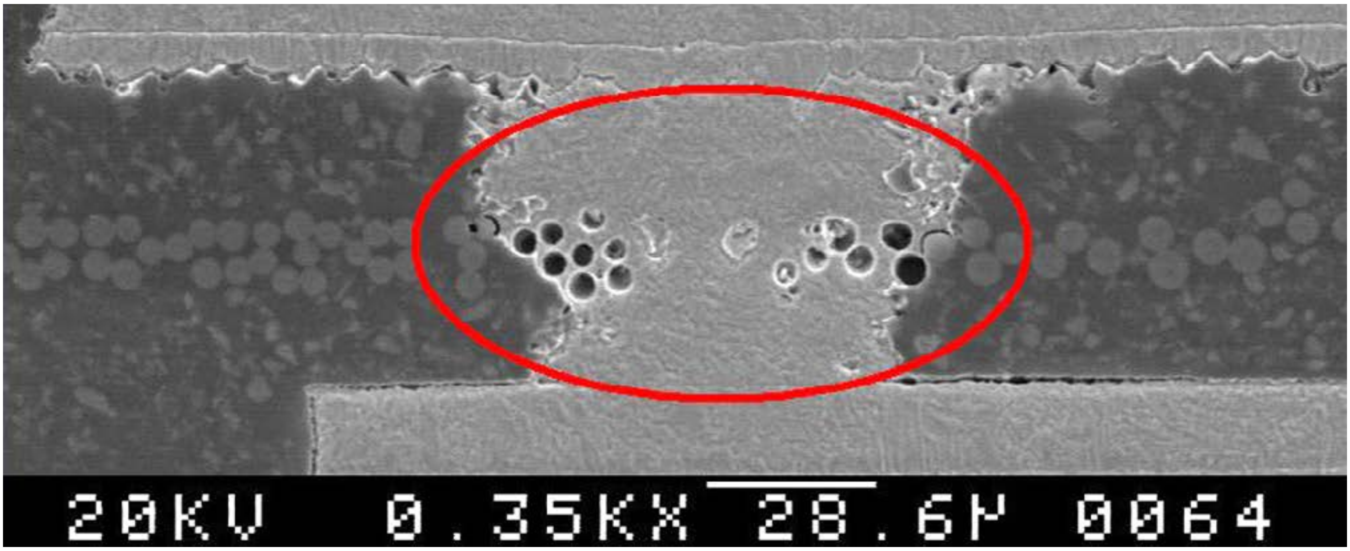


Figure 4.

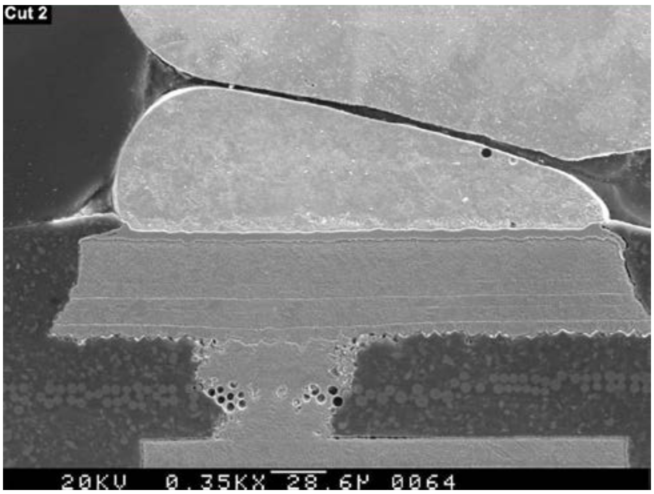


Figure 5.

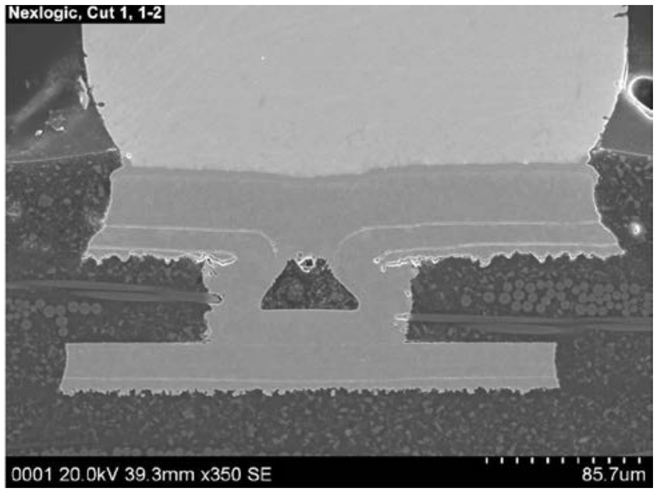


Figure 6.

are shown with a head-on-pillow defect, which causes an intermittent connection. An intermittent connection refers to a faulty connection existing between and among a BGA's balls. This is among the top and most prevalent issues associated with BGAs and micro-BGAs, which is preventable if OEMs select their EMS providers properly with due diligence.

Forensics is also known as "destructive inspection." In this case, an assembled board is cut apart along with its components so that inspectors can look inside it via SEM or scanning electron microscope and/or cross-section image to start their detective work. Cross-sectioning is a key part of this failure analysis. It provides the physical evidence of failure mode and site location along with empirical measurement, as well as isolates suspected versus non-suspected devices.

Forensic analysis uncovers an innumerable number of defects or failures that conventional inspection cannot. At the board level, it investigates thickness of Cu plating on the through-holes and vias; if it's a gold immersion surface board, it verifies out the thickness of the gold plating to determine whether or not the ade-

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quate amount of gold has been deposited, as per fabrication specs.

On an electroless-nickel immersion gold (ENIG) surface board, forensic analysis provides the assurances the nickel—which is the base plating before the gold is deposited—is performing according to the spec sheet. Also, it pinpoints infinitesimally minute fractures within solder joints as well as cracks within a via hole barrel. These details are not visible at the 300–400x magnification level, but with SEM, those details are magnified upwards to the 2,000x level. Plus, in some instances, black pads or the acute corrosion of a board's nickel-plating layer can be viewed very clearly.

As mentioned above, intermittent connections represent a major issue associated with BGAs, micro-BGAs and PoP, which are widely used in today's PCBs. Forensic analysis locates these inter-metallic failures. It can determine the distance between gold plating and the solder ball in the event BGA balls are detached after assembly. These are the occasions where BGA is not working properly unless you press hard on the device and then it starts working again.

Forensics also gets a good view of solder thermal fatigue when testing for solder joint failure. Solder thermal fatigue occurs in the field when the product is used in excessive heat, especially containing BGAs or flip chip devices. Those fatigue cracks begin slowly and over time grow to get detached from the surface of the board due to the excessive heat. This is especially true if the BGA isn't designed properly or if it's an analog circuit and heat dissipation isn't incorporated at the board design level. In some cases, there can exist a coefficient of thermal expansion (CTE) mismatch between packages that contributes to this failure.

"Solder thermal fatigue occurs in the field when the product is used in excessive heat, especially containing BGAs or flip chip devices. Those fatigue cracks begin slowly and over time grow to get detached from the surface of the board due to the excessive heat."

Sometimes pinpointing defects like this using conventional AOI and X-ray may or may not identify all solder fatigue failures associated with a given package. For instance, the failure or failures could be due to organic, metallic or any other kind, like solder joint detachment and even tin whisker growth, which at times AOI and X-ray don't recognize, because it is developed over time and may not be present at the time of initial assembly.

Also, in some cases, the solder bridging of flip chip devices have leakage failures. Due to solder or flux, especially when the device uses underfill, a flip chip device leaks current after thermal cycling. Therefore, current doesn't get to the proper ball of the BGA and a non-acceptable noise creeps into the design at certain levels. Destructive analysis or forensics via SEM can reveal the voids due to the fact that air gaps are created inside the solder due to poor plating, as shown in Figure 3.

After thermal cycling, a high-powered optical microscope can be used to verify other issues, such as delamination or bulk solder extrusion. As a result of thermal cycling, a solder can leak out to such areas as vias, thereby reducing the amount of solder needed to optimize a BGA's solder joint.

Summary

OEMs are assured their next-generation designs can receive the utmost advanced inspection now that conventional technologies partner with forensics analysis to perform the most comprehensive inspection possible. Even as the industry moves to smaller form factors and three to four packages are mounted on top of each other, OEM concern over maintaining high reliability for their systems and sub-systems is considerably alleviated thanks to both conventional and forensics inspections. **SMT**

Zulki Khan is the founder and president of NexLogic Technologies, Inc. To read past columns, or to contact the author, [click here](#).

IPC APEX EXPO 2014: The Opening Keynote Session

by Peter Starkey
I-CONNECT007 TECHNICAL EDITOR

Images contributed by Michael Weinhold

We will rock you! A grand Las Vegas opening to the 2014 IPC APEX EXPO included a spectacular show by dance troupe Speed of Life, complete with silver paint, angel wings, rollerblades and stilts. The approximately five-minute performance heralded the appearance of IPC President John Mitchell, who welcomed a packed house in the Mandalay Bay Convention Center, and declared the event's theme: New Ideas for New Horizons.

John Mitchell

Steve Pudles

Mitchell began by taking a few minutes to commend the success of the new IPC Validation Services initiative, and to present a certificate to IEC Electronics as the first company to be admitted to the Qualified Manufacturers Listing. After acknowledging the winners of the Best Technical Papers awards, Mitchell handed off to IPC Chairman Steve Pudles, who took the stage to introduce the keynote presenter, Dr. Peter Diamandis, co-founder and chairman of the X-Prize Foundation and co-founder of Singularity University.

Dr. Diamandis' provocative and inspirational presentation, "Creating a World of Abundance: Exponential Technologies Causing Disruptive Innovations," contained some sometimes frightening observations on the potential for future technology and other emerging market forces to dramatically influence living standards. Compared with human society's historical "local and linear" process of communication and development, where progress happened one step at a time, and the transfer of knowledge was limited by the distance a man could walk in a day, we are now in a world where progress is happening exponentially, and knowledge can be transferred anywhere in the world in a split second. He demonstrated how, in a company, these changes were accelerating disruptive stress—or disruptive opportunity depending on management's attitude to innovation. Agility is critically important. Companies commonly have experts who effectively block innovation by finding lots of ways an objective could not be achieved, and Dr. Diamandis despaired of organisations that start off with a mission and then back off because they decide it is too risky.

Nominating Kodak as the definitive example of a company worth billions that failed to recognise the disruptive opportunity presented by the digital camera in 1996—actually invented by one of its own people—and found itself overtaken by new technology and bankrupt in 2012, Dr. Diamandis noted that in contrast, in 2012, Facebook made a multi-billion-dollar takeover of Instagram, a young company of 13 employees. The life-span of a typical company is now of the order of 15 years, and he predicted that 40% of existing Fortune 500 companies would be out of business within the next 10 years.

Returning to the theme of local-and-linear thinking, Dr. Diamandis explained the philosophy of Singularity University in the study of exponential technology—with the example that thirty linear steps would gain a distance of thirty metres, whereas thirty exponential steps would circle the world twenty-six times. And Moore's Law exemplified the exponential growth in computing power, to almost inestimable levels in the future.

Near-infinite computing power could open up new dimensions in artificial intelligence—the ability to look beyond plain logic, even recognise the subtleties of irony, cynicism and humour, and understand what answer is relevant. Couple this with robotics, where a paradigm change is well underway, and truly intelligent machines are already a reality, as demonstrated in Dr. Diamandis' video of the view from the passenger seat as Google's autonomous car negotiated a slalom course at high speed. 3D printing is another area of exponential development, with amazing engineering capabilities. Breakthroughs in genome sequencing have enabled developments in synthetic biology to the extent that printed DNA molecules have been produced.

It was clear that the rate of innovation is exploding, and innovation is coming from everywhere. True breakthroughs generally come from unexpected directions. Dr. Diamandis made it plain that any company relying only on innovation from within was probably going nowhere and that to limit risk was to accept a future of, at best, incremental improvement.

Diamandis is a great believer in crowdsourcing. Lindberg flew the Atlantic to claim a $25,000 prize. Diamandis had a longstanding ambition to get into space. How? By throwing out the challenge to the world and offering a $10 million X-Prize as the incentive, which resulted in 26 teams spending a total of $100 million. "Set a target and challenge the world to solve the problem. Winner takes all—no second prizes!" He believes the world's biggest problems present the world's biggest business opportunities.

A question from the floor related to schoolchildren having little interest in taking up careers in science and engineering: How to inspire them? Dr. Diamandis suggested the answer was to make the scientists and engineers the rock stars, and to encourage the young people to perceive them as role models. The question he posed was, "How about a competition for the youngest person ever to travel to the space station?"

What is the next X-Prize challenge? Healthcare—to develop a hand-held universal medical diagnostic device. And after that, to achieve global literacy, even in the most impoverished areas.


Dr. Peter Diamandis

Dr. Diamandis' closed by declaring, "The only constant is change, and the rate of change is increasing. The next twenty years are going to be transformational. There's lots of change ahead, and the rate of change is increasing beyond our ability to project it!"

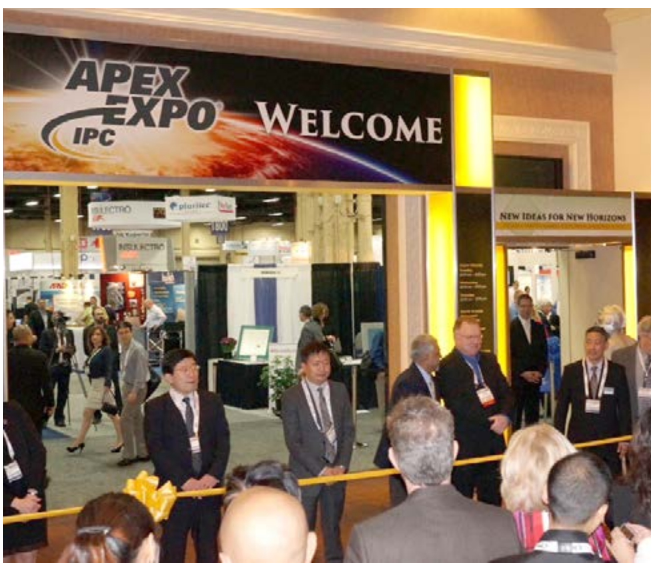
IPC APEX EXPO 2014: Publisher's Report

by Ray Rasmussen
I-CONNECT007

A sold-out show, record conference attendance and solid floor visitors made for a good show and conference at this year's IPC APEX EXPO in Las Vegas.

Here are some of my highlights.

Mentor introduced a major new software suite designed to remove the information barriers created by disparate systems. The software streamlines the design-to-fab-to-assembly information flow. Not being a user of software for design, fab or assembly, I can't speak to the software's effectiveness but, conceptually, it's a great idea and one that's been talked about for years. In fact, IPC hosted a meeting over a decade ago, which was well attended, and dealt with the communications issues in the supply chain. Think of how far along we'd be if that effort had gained traction. It's definitely a move in the right direction.

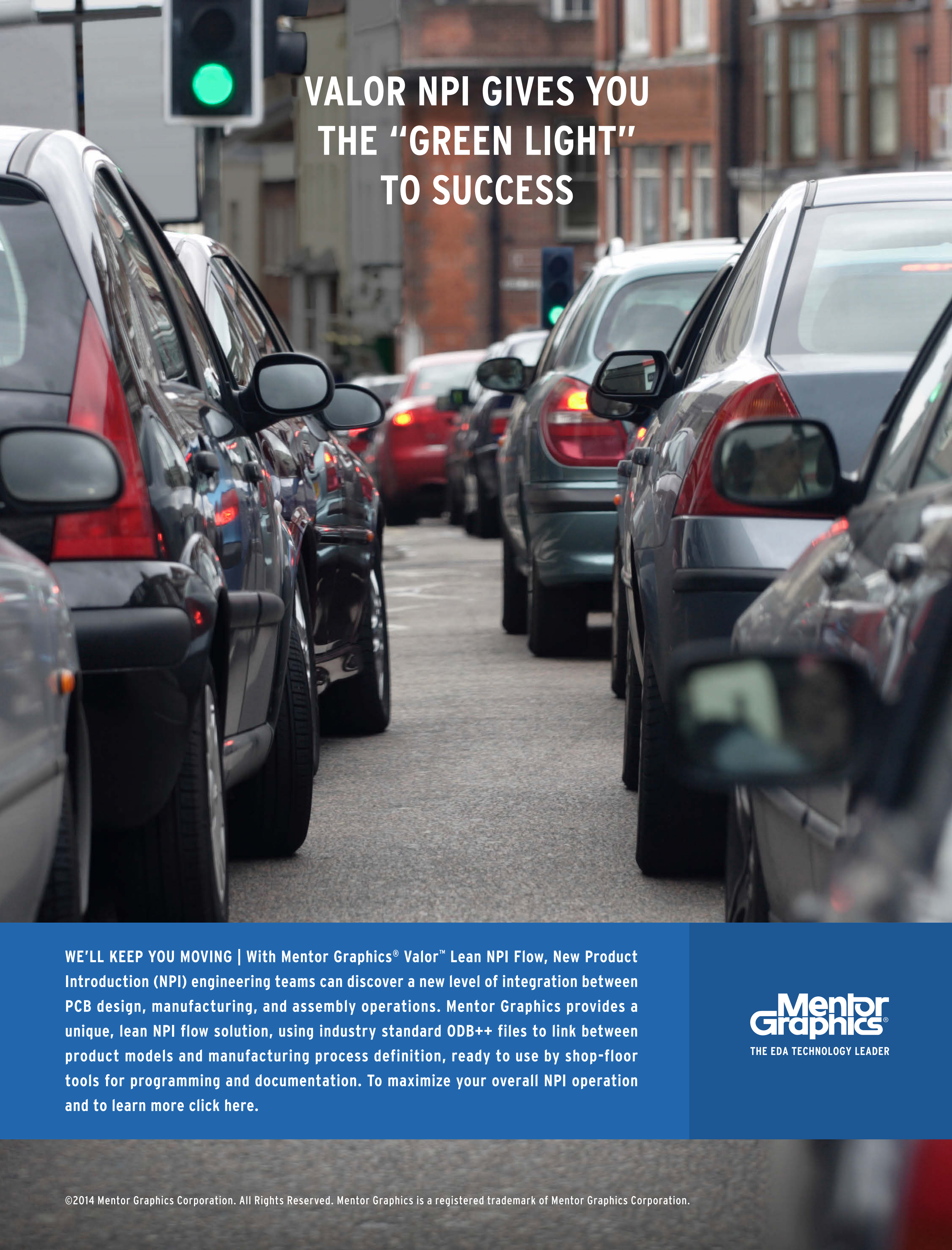


The *Printed Circuit Handbook, 7th Edition* is in the works. Editor Clyde Coombs came out of retirement to tackle the latest update of the PCB industry bible. First published in 1967, Coombs says this edition will likely contain up to 20% new content with all chapters getting significant updates, as needed, from some of the industry's leading experts. It's a labor of love for Coombs, who spent much of his career at HP in their PCB facilities. He says the book effort helps him stay connected with the industry.

Printed electronics, in its first-ever all-day session at an IPC event, offered a series of presentations from materials suppliers as well as PE makers, demonstrating the interest this technology is generating. In addition to the conference, an entire day was dedicated to standards development efforts. Marc Carter stated that IPC is working with organizations around the globe to develop the standards needed for this rapidly evolving industry. Currently, all of the standards IPC is working on are co-authored with JPCA. At this point in time, IPC is a leader in the development of PE standards for PE materials.

Walt Custer gave quite an upbeat assessment in his state-of-the-market report. All indications point to a year of good industry growth for most regions. The U.S. should see solid growth while Europe may see some growth, but will likely remain flat. Of course, one area of concern is the situation in the Ukraine. Although not big electronics industry players (Ukraine and Russia), the crisis could rattle markets around the world.

The sold-out show itself was very good; exhibitors were pretty happy. Their feelings were likely a direct result of the conference attendance, which translated into solid show-floor attendance. It will interesting to see how it goes next year when we're back in San Diego.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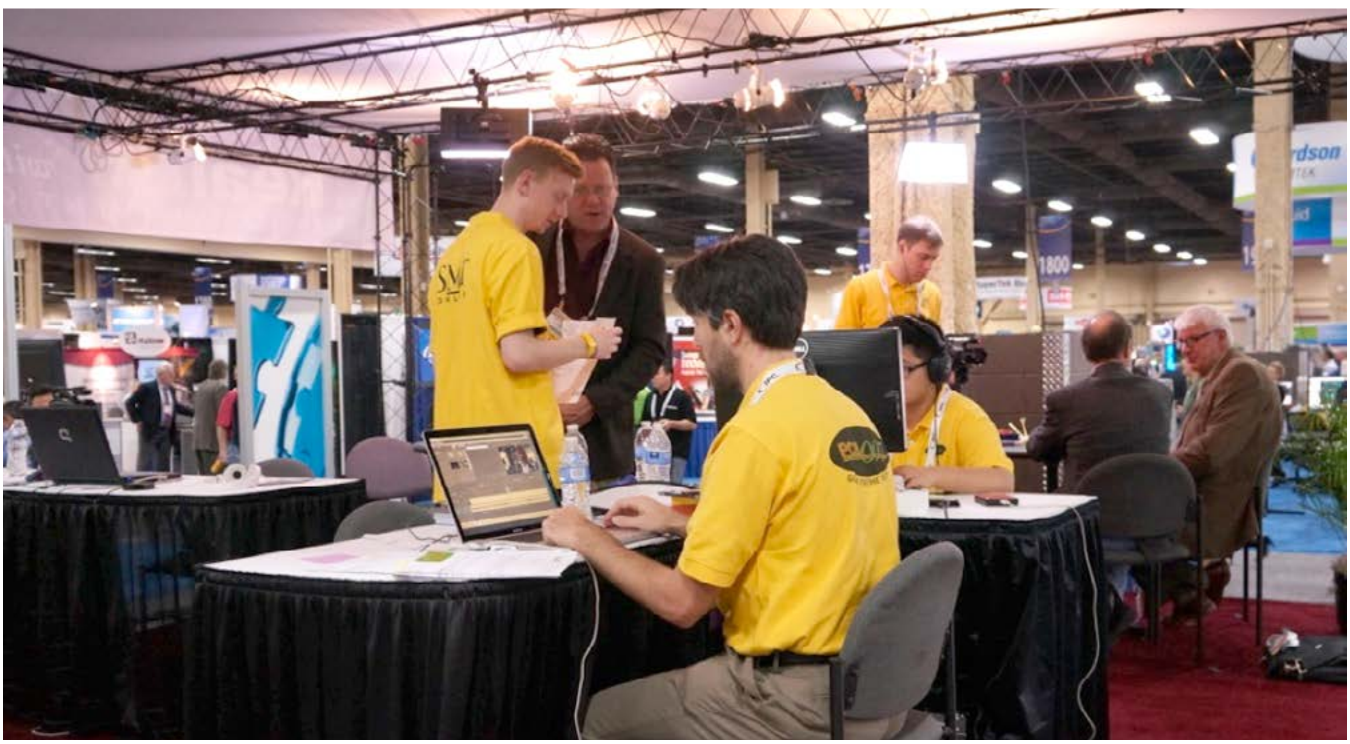
Editor's Notes IPC APEX EXPO

by Lisa Lucke
MANAGING EDITOR, *THE PCB MAGAZINE*
CO-MANAGING EDITOR, *SMT MAGAZINE*

If you attended IPC APEX EXPO 2014 in Las Vegas last week, you'll know that it was a packed house for the most part, and offered something for everyone, from equipment on the show floor (many with "SOLD" signs) to technical conferences, standards meetings and of course, our *Real Time with…* video program. Our I-Connect007 team churned out more than 130 interviews with industry leaders, reps, fabricators, and designers, along with a handful of panel discussions that featured a moderated format aimed at generating lively discussion on key issues facing the industry, like onshoring, data file formats, the future of flex, and more. If you haven't seen it yet, check out our *Real Time with…* video index by clicking here. Most of the video interviews and panels are viewable now, and in the coming days, weeks and months, these videos will be featured in our newsletters and monthly magazines, and of course on our website. To subscribe to any of our publications, click here.

See you in San Diego in 2015!



Designers Step up at Design Forum

by Andy Shaughnessy
MANAGING EDITOR, *THE PCB DESIGN MAGAZINE*
CO-MANAGING EDITOR, *SMT MAGAZINE*

After two years in San Diego, the Design Forum was back on familiar turf this year as IPC APEX EXPO returned to Mandalay Bay Hotel and Convention Center in Las Vegas.

Forum speakers included Greg Munie of IPC, Karen McConnell of Northrop Grumman, Gary Carter of Fujitsu, Dieter Bergman of IPC, Mark Laing of Mentor Graphics, Humair Mandavia of Zuken USA, and Ben Jordan of Altium.

Although busy doing our *Real Time with...* video interviews much of the time, I managed to catch some of the sessions. Carter's discussion of the IPC-2581 data transfer standard was well received, and, of course, it led to some good back-and-forth during the Q&A period.

While sitting in on the Design Forum, Guest Editor Kelly Dack met first-time attendee Halil Yaslak, a PCB designer with Aselsan, a defense company in Ankara, Turkey. We talked him into doing a video interview. Yaslak was one of the younger designers at the Design Forum, but he's a heavy hitter; he took home first place honors at the 2012 Mentor Technology Awards for a 26-layer HDI board. He's definitely someone to watch and we look forward to seeing him next year if he's able to make the long journey again.

When the forum was over, most speakers and attendees trooped over to Rainer Thuringer's Professional Development class on optimizing high-speed design. Thuringer is chairman of the FED, a German organization that represents electronics designers and manufacturers. With a Ph.D. in physics, Thuringer has a unique viewpoint. He stresses the critical demand for finding "new blood," as well as the EMS community's need to focus upstream, on the challenges facing PCB designers and design engineers.

Altium's Ben Jordan also moderated our panel discussion on data transfer standards, which is always a contentious topic. As Ucamco's Karel Tavernier joked beforehand, "No daggers?" Tavernier's company owns the Gerber standard, and he joined Mentor's Dave Wiens, who represented

Designers Step up at Design Forum *Continues*

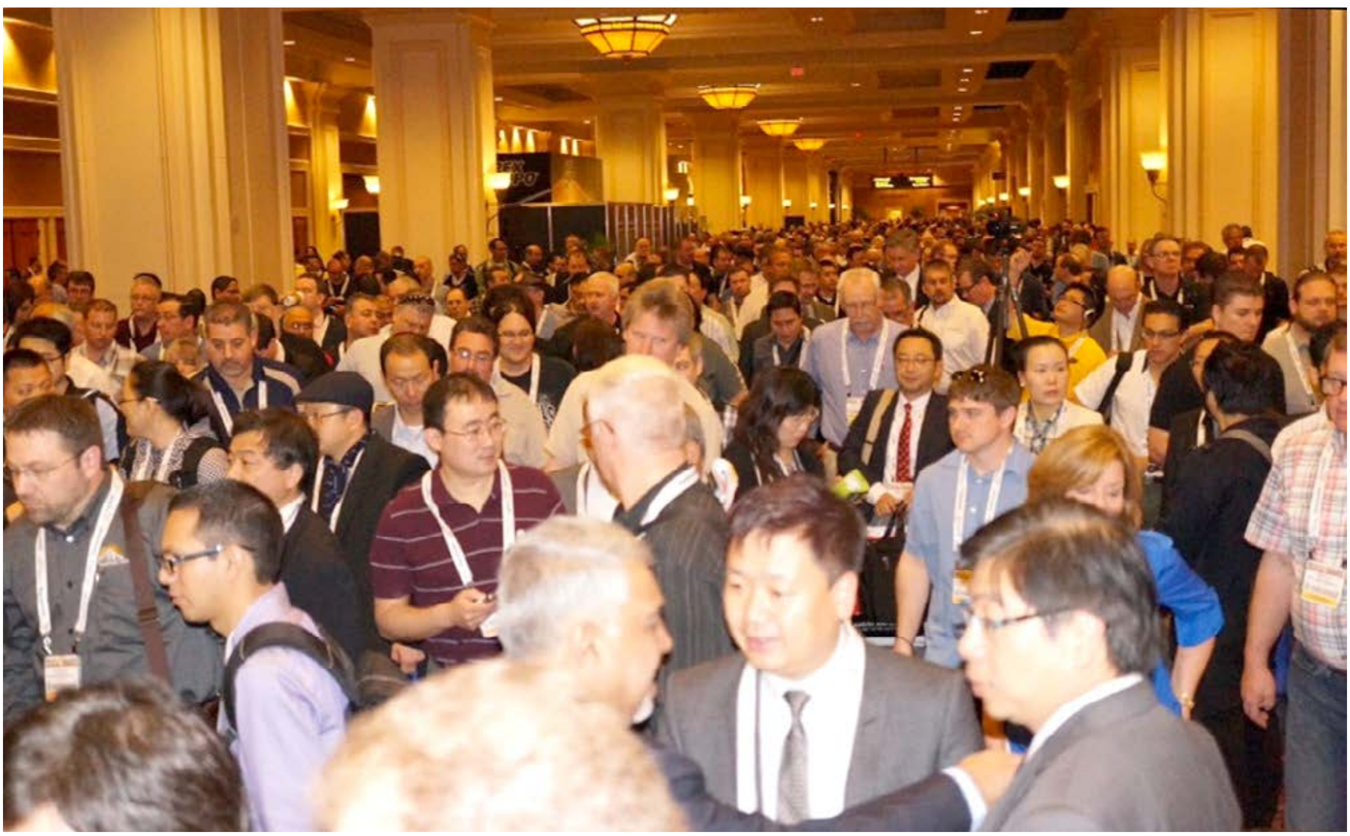
ODB++, and Hemant Shah of Cadence Design Systems, who is active in developing the IPC-2581 standard.

These panelists kept the marketing to a minimum and addressed the facts surrounding this hot-button issue. We shot a variety of these panels, but the data standard panel drew the biggest crowd; each format attracted its own entourage. But no panelists were injured during the filming of this panel.

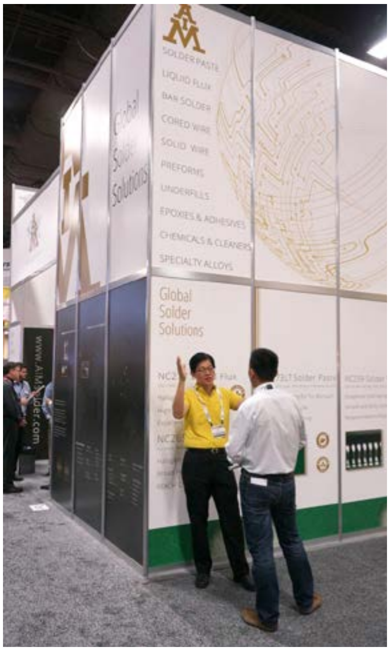
In other news, Rick Hartley announced that he is really, truly retiring from L-3 Avionics this year. But he'll continue to teach design classes and stay active in the PCB community. He just won't have to get up to an alarm clock anymore, which sounds like a plan.

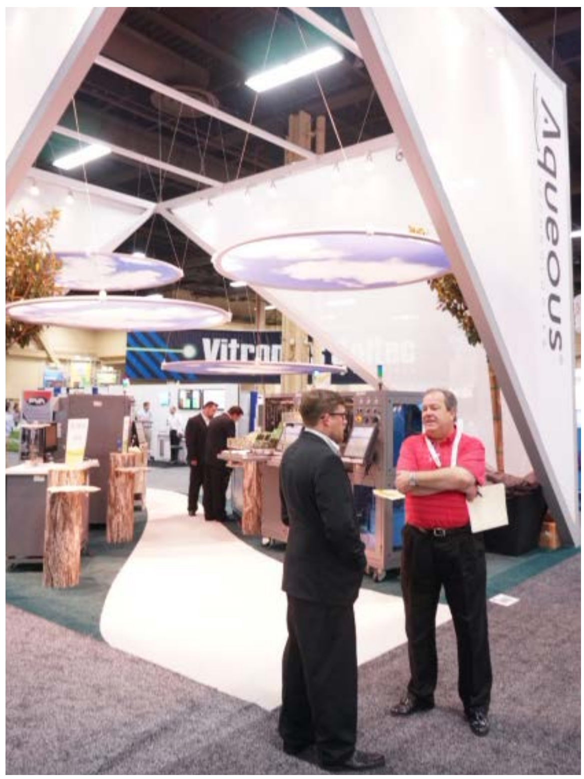
Overall, the Design Forum and IPC APEX EXPO went off without a hitch. Our booth was packed all week, with interviews set for every 15 minutes. And we saw solid traffic in the aisles the first two days, and OK traffic on the last day. Next year, the show moves back to (hopefully) sunny San Diego. See you in the Gaslamp Quarter!

Ben Jordan and Andy Shaughnessy



IPC APEX EXPO 2014 Show Review LAS VEGAS, NEVADA





IPC APEX EXPO 2014
Show Review
LAS VEGAS, NEVADA

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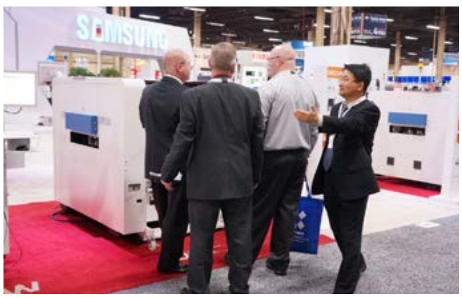

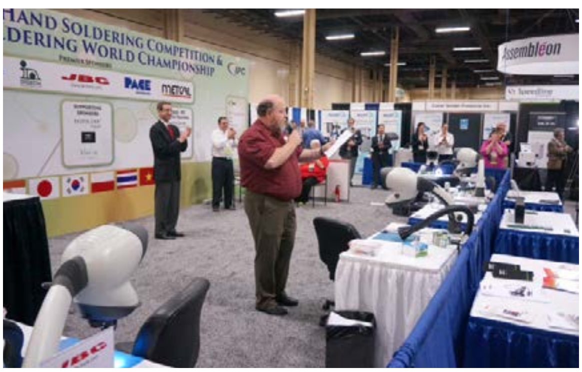

Conformal Coating over No-Clean Flux

by Karl Seelig and Timothy O'Neill
AIM

SUMMARY: As the proliferation of modern-day electronics continues to drive miniaturization and functionality, electronic designers and assemblers face the issue of environmental exposure and uncommon applications never previously contemplated.

This reality, coupled with the goal of reducing the environmental and health implications of the production and disposal of these devices, has forced manufacturers to reconsider the materials used in production.

Furthermore, the need to increase package density and reduce costs has led to the rapid deployment of leadless packages such as the QFN, POP, LGA, and micro-BGA. In many cases, the manufacturers of these devices will recommend the use of no-clean fluxes due to concerns over the ability to consistently remove flux residues from under and around these devices.

These concerns, along with the need to implement a tin whisker mitigation strategy and/or increase environmental tolerance, have led to the conundrum of applying conformal coating over no-clean residues.

The AIM R&D team has united with OEM electronics and conformal coating manufacturers in an attempt to characterize the different coating technologies currently available. In this study, various coating materials were tested with different chemistries of no-clean fluxes. Results demonstrate possible combinations meeting the mission profile of the assembly with consideration for the assemblers' capabilities and cost objectives.

Conformal coating of PCBs has garnered serious attention in all phases of PCB design and manufacturing. Manufacturers and engineers industry-wide are exploring the capabilities, costs, and limitations of this technique. The driving factor is the deployment of electronics into more diverse and harsh environments as demand for functionality and interoperability

grows. These systems are being introduced to conditions that would have been considered unsuitable for electronics a short time ago, including condensing environments and dust environments. Some of the known benefits of coating include:

- Reducing entrapped surface contamination to contact power or ground areas
- Tin whisker mitigation

Having engaged multiple conformal coating manufacturers, there is a common recommendation for the application of conformal coating; that is that the substrate be cleaned prior to application, regardless of the type of coating to be applied. These same manufacturers will also admit that many of their customers are coating over no-clean flux residues for a variety of reasons. The most common being:

- Cost of cleaning
- Throughput requirements
- Incomplete removal of ionic contamination under and around low-standoff devices
- Tin whisker mitigation

Analyzing final working environment is crucial to a successful outcome and should be the first consideration in determining the appropriate assembly process. One should determine if applying coating will: a) achieve the desired outcome b) be practical given the nature of the assembly and the assembler's capabilities. Assuming coating is appropriate the materials to be used need to be vetted.

Acrylics
Thermoplastics dissolved in solvents – no cross-linking

Strengths	Weaknesses
Air Dry	VOC Bearing Solvents
Easy Solvent Rework	Poor Solvent Resistance
Good Moisture Barrier	Flammable
Ease of Use	Soften in High Temp

Urethanes
Cure through cross-linking

Strengths	Weaknesses
Solvent Resistant	Some contain VOC's
Humidity Resistant	Rework
Abrasion Resistant	Cure rate environmentally dependent
Dielectric Properties	Worker health risks

Silicones
Cure through moisture cross-linking

Strengths	Weaknesses
Humidity Resistant	Abrasion
Moisture Resistant	Workplace contamination
Flexibility	
Temperature Tolerant	

Epoxies
Usually two-part systems

Strengths	Weaknesses
Humidity Resistant	Two-Part
Moisture Resistant	Rework
Abrasion Resistant	Pot life
Dielectric Properties	

Acrylated Urethane
UV Curable Urethane

Strengths	Weaknesses
Protective Properties	Capital Investment
Through Put	Rework
Environment Impact	Shadowing
UV Inspection	

Charts 1-5.

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13	Legacy Electronics 14	15	Former Assets of Blackberry 16	17	18	19
20	Exelis 21	22	Jabil #45 23	24	25	26
27	28	i3 Technologies #1 & #2 29	30	MAY 1	2	

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In this study, we will address the findings of an in-depth analysis of various types of conformal coatings and how they perform in combination with a variety of no-clean flux residues.

The following industry test standards were applied:

- IPC J-Std-004 SIR testing
- IPC CC-830 - Qualification and Performance of Electrical Insulating Compound for Printed Wiring Assemblies
- ASTM – D3359 - Standard Test Methods for Measuring Adhesion by Tape Test

The three standards applied to this study will determine the SIR values and adhesion properties of each material in combination. These figures were compared with supplier-provided data on the individual materials to determine if characteristics were measurably enhanced or degraded when combined. The classes of conformal coating materials tested are outlined in Charts 1-5.

All of the samples tested passed IPC SIR testing without issue. An example of the data generated found below:

Pass-Fail Criteria IPC J-STD-004B §3.4.1.4.1

- All measurements on all test patterns shall be exceed the 100 MΩ
- No evidence electrochemical migration that reduces conductor spacing by more than 20%. No corrosion of the conductors

Test Results

1. Test data, chart attached, pass
2. Presence of dendrites: No
3. Maximum percent reduction of spacing: 0%.
4. Presence of discoloration between conductors: No
5. Presence of water spots: No
6. Presence of subsurface metal migration: No

Original test data available upon request.

Results are shown in Charts 6–8:

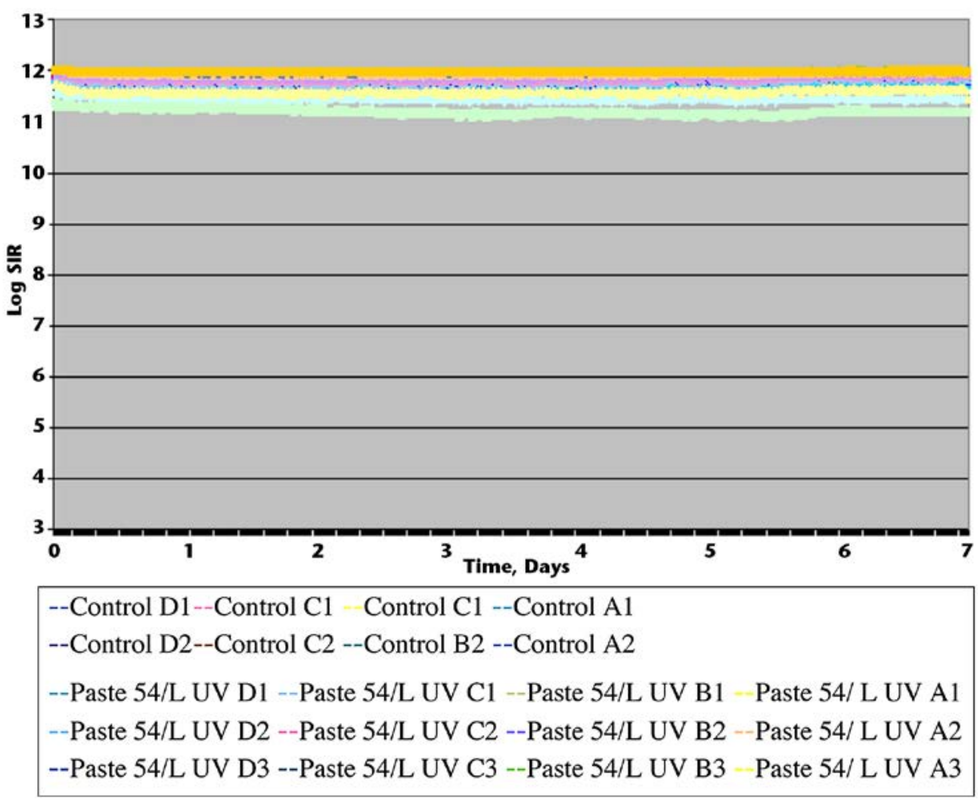

Chart 6: "L" UV Cure Coated, "Paste 54" (Sn-Pb), "Control".

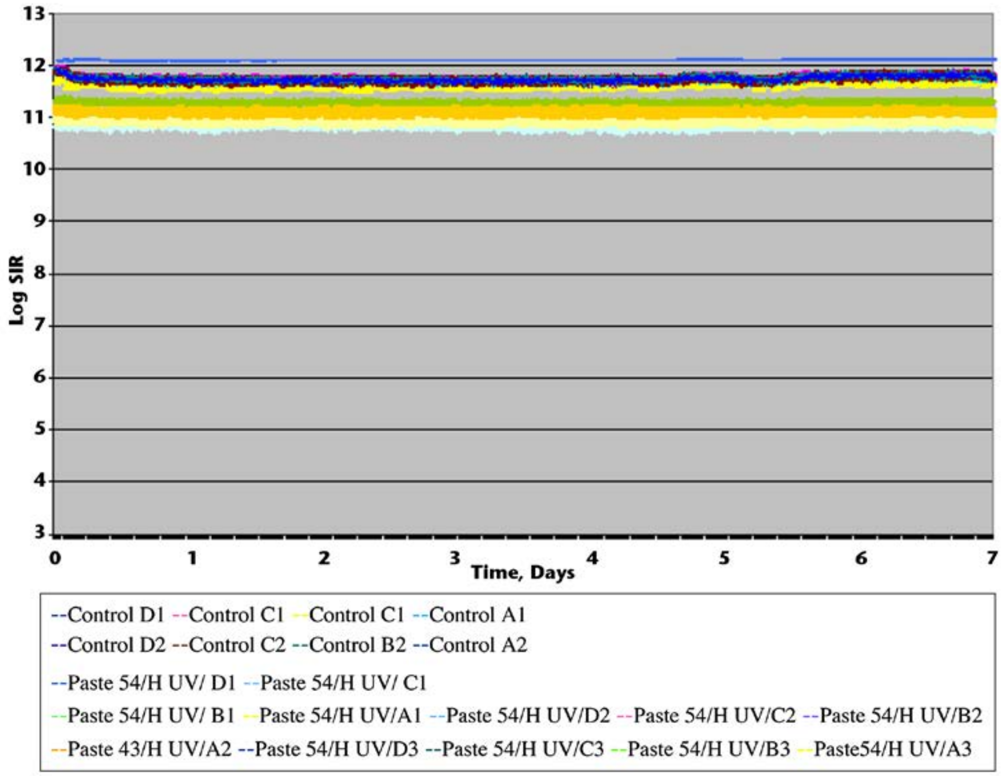

Chart 7: "H" UV Cure Coated, "Paste 54" (SAC305), Control.

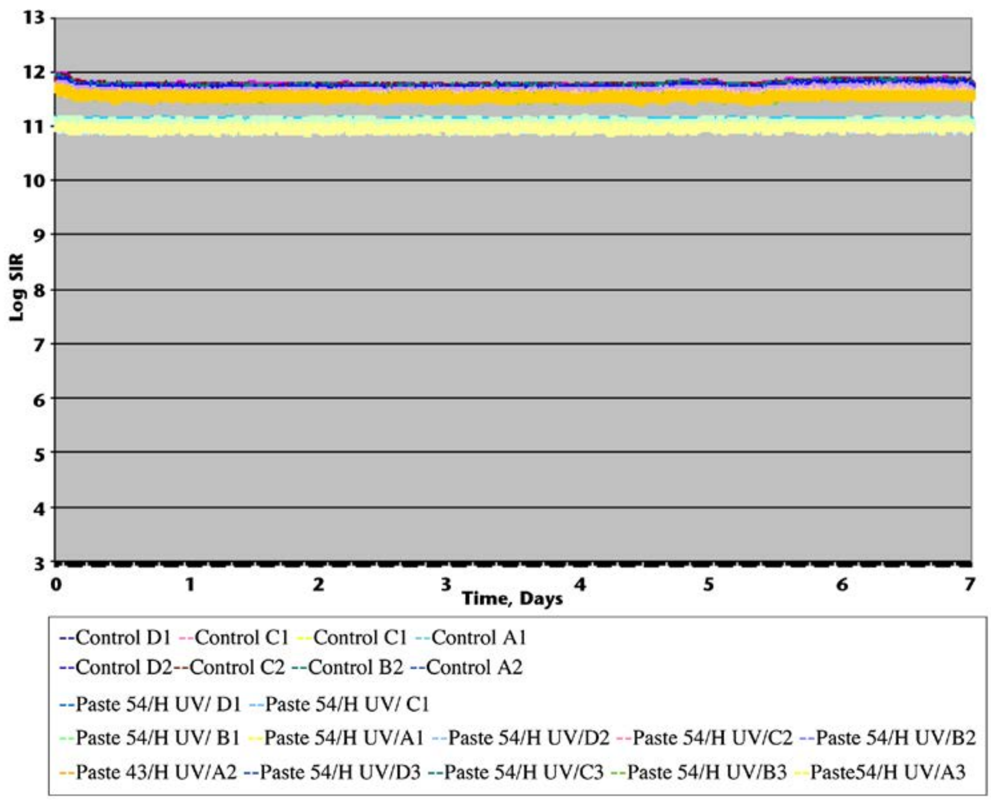

Chart 8: "H" UV Cure Coated, "Paste 54" (Sn-Pb), Control.

Adhesion testing/thermal shock testing was originally conducted on Practical Component SABER test assemblies; however, after multiple tests it was determined that the required data could be collected using standard B-24 test coupons. In addition to a considerable cost savings, it eliminated variables that could have clouded the results including the presence of ionics, mold release agents and coating thickness variability.

The findings of the adhesion testing yielded both favorable and unexpected results. The balance of this work focuses on solder paste. We did not test wire solder residues and all liquid fluxes where the conformal coating wet and adhered to the substrate at the time of coating/curing passed all subsequent tests.

Initial testing of thermal shock at -60°C +125°C showed gross delamination. Initially, it was thought the failure was due to movement of the flux residue having softened at 125°C. Further examination revealed that there was a cohesive failure of the flux residue, wherein the flux remained firmly adhered to the PCB substrate and to the coating, but failed internally (Figure 10). This phenomenon was present on all coatings in varying degrees (other than silicone). In general, UV materials performed the worst, with solvent-based acrylics better and silicones the best, with no delamination. A failure was considered any evidence of delamination. It was not determined if delaminated coating that remained contiguous was still effective in protecting the underlying substrate.

Ultimately, we found the modulus of the coating is directly correlated to cold temperature failure. The CTE mismatch of the residue and a high modulus coating were enough to fracture the cold hardened flux residue. Flux medium used in solder paste is typically a resin-based material and after reflow, the residue is hard. The colder the environment is, the harder the residue. To test this theory, we varied the residue and the coatings using harder and softer materials. UV curable silicone having the lowest modulus of the materials tested and UV cure urethane the highest. We also tested a paste that is not resin based with residue that is waxy rather than hard. As depicted below, reducing the modulus of either the coating or the residue eliminated the delamination failure.

We also noted that solvent-based acrylic coatings outperformed UV cured urethane materials although it was product specific. It is believed that the solvent would facilitate a more intimate bond between the residue and the coating lessening the adverse effect of the CTE.

We went a step further to determine what the lowest temperature a resin-based no-clean paste and acrylic or acrylate/urethane coating can withstand before suffering delamination. The results of these tests were scattered, but none of the material sets were capable of withstanding more than -35°C for more than 10 cycles.

With this information, it would seem the simple solution to this problem would be to incorporate a softer residue solder paste to remedy the delamination issue. Unfortunately, there is a significant impact to the SIR characteristics as detailed below in Figure 1.

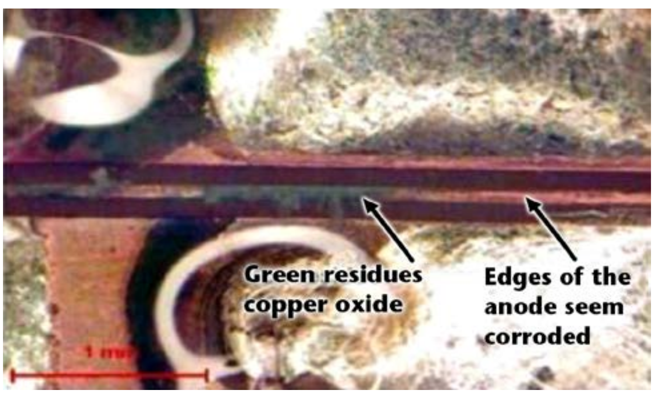

Figure 1: Moisture absorption after conformal coat.

UV Curable Urethane Hybrids	TG	Paste A	Paste B	Paste C	Comment
A	40	1	1	1	Complete delamination, combination with Paste C was the worst
B	25	3	1	4	Delamination but not global
C	3	4	3	4	Wetting issues, slight delamination
D	-60	5	5	5	Perfect, no delamination

Figure 2: Results: 1 to 5 (worst to best).

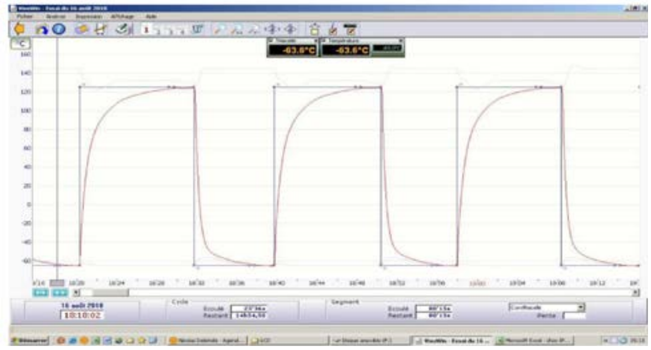

Figure 3: Profile.

The results indicated that the silicon did not delaminate. Delamination is easy to see in the test as shown in the following images. The following profile was used.

However, if the solder paste is a low/no residue nitrogen reflow solder paste delamination does not occur.

The photographs in Figures 8–13 identify the hard flux issue with delamination of a harder urethane coating.

Conformal coatings are not hermetic with all the materials tested having varying degrees of moisture vapor transmission. In this case, whereas moisture enters the coating, the softer residue solder paste absorbs the moisture and creates a "pressure cooker" of corrosion and electrical failures (Figure 15).

Pictured in Figure 14 are SIR test results showing the beginnings of dendrites. These were run in 85°C/85Rh. SIR testing was also run at 40°C and 90 Rh. This test showed less failures

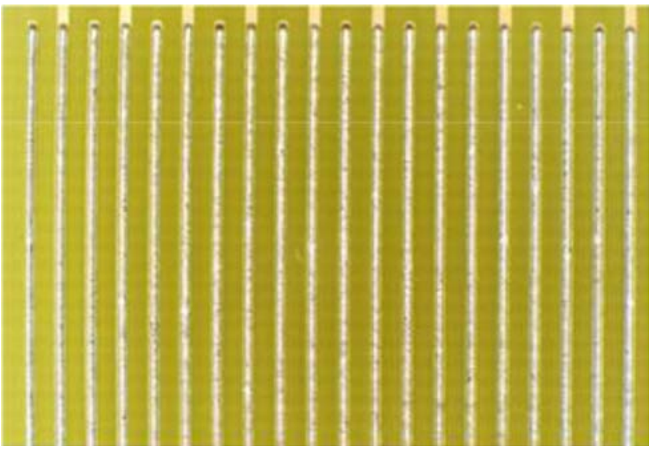

Figure 4: Pre-shock.

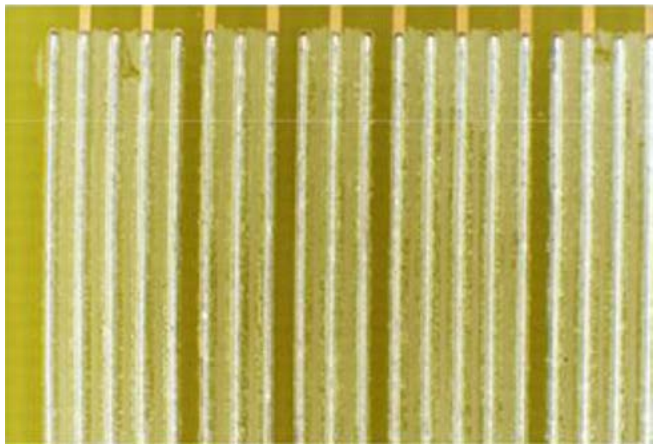

Figure 5: Paste 55 Post-T shock delamination.

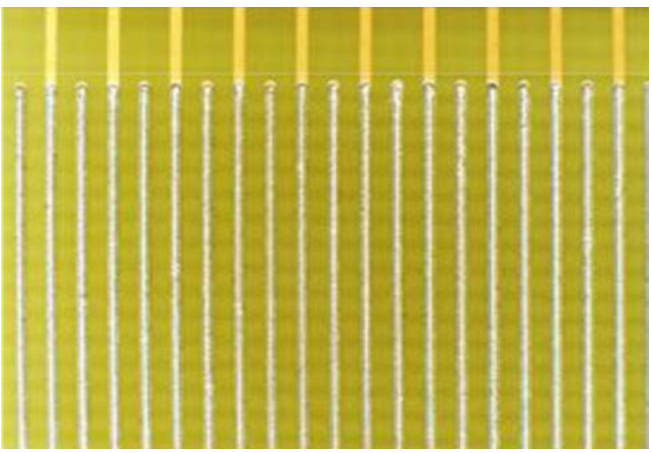

Figure 6: Paste 16 (low/no residue) pre-T shock.

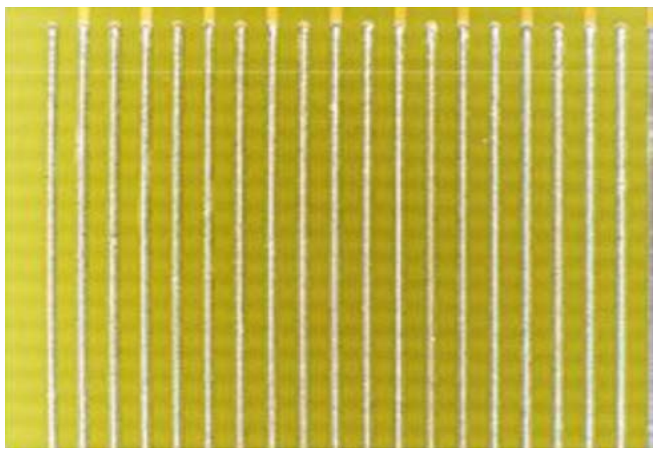

Figure 7: Paste 16 post-T shock/no defects.

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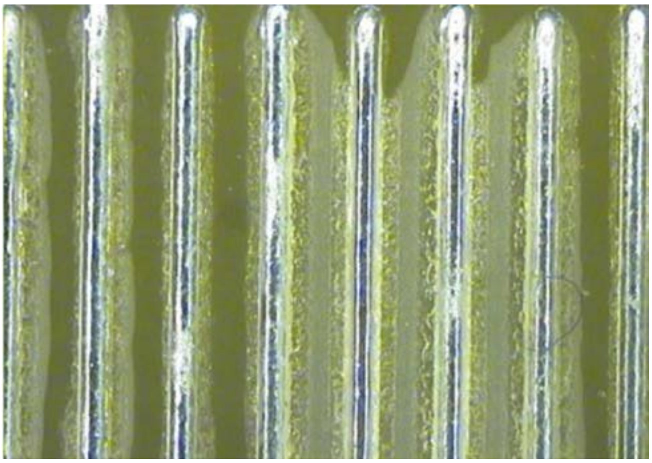

Figure 8: Delaminated after thermal shock testing.

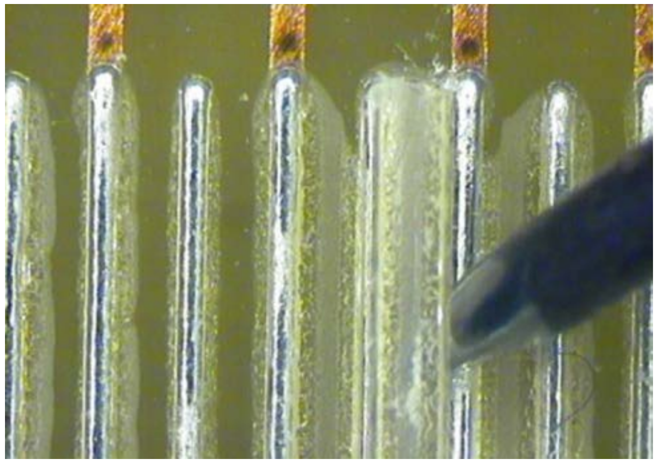

Figure 9: Delamination lifting off board.

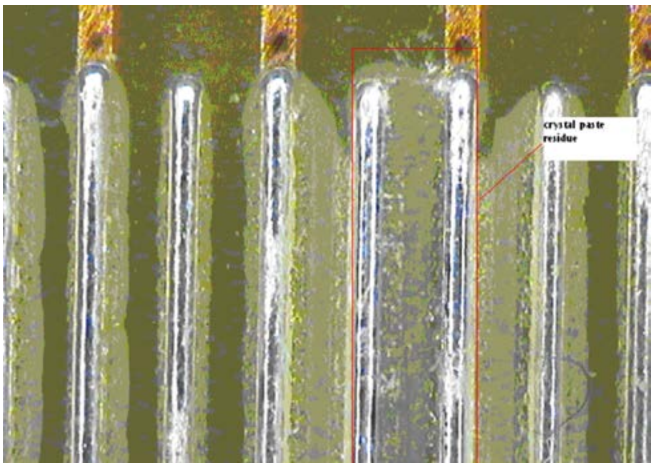

Figure 10: The crystal flux residue left on the board.

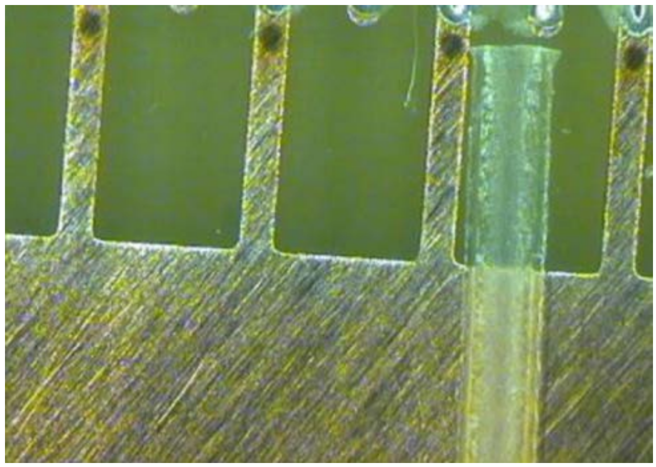

Figure 11: Crystal flux residue stuck to the coating.

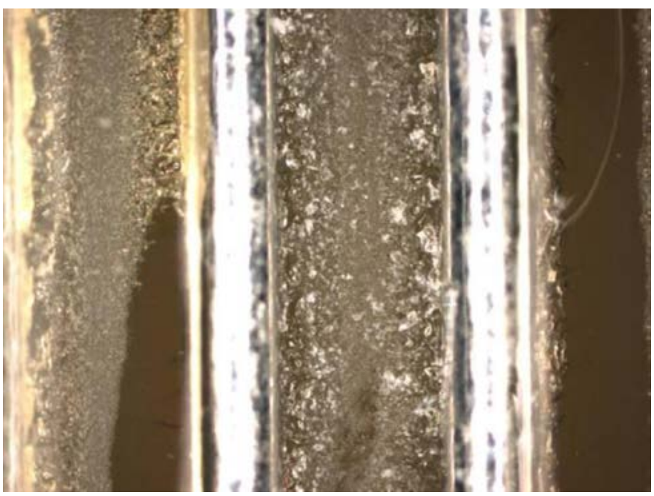

Figure 12: Close up of delamination.

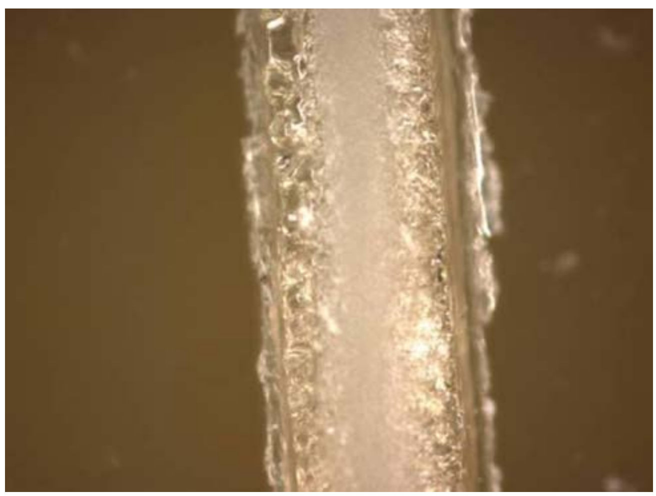

Figure 13: Close up of delamination.

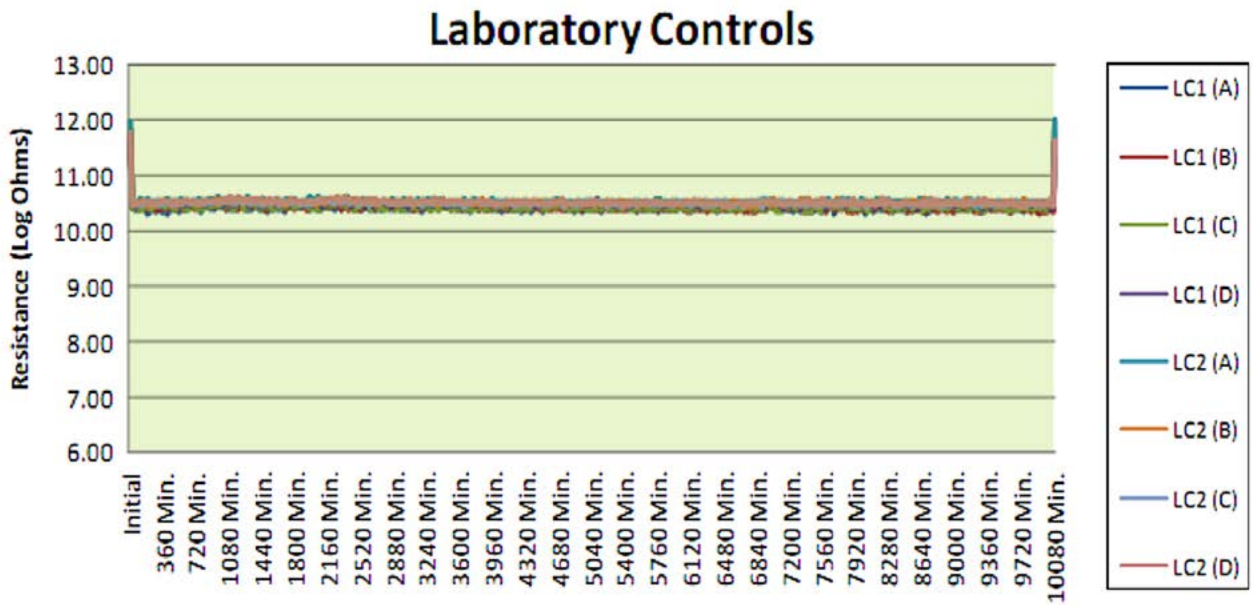

Figure 14: IPC 2.6.3.7 SIR test (paste material coated with conformal coating).

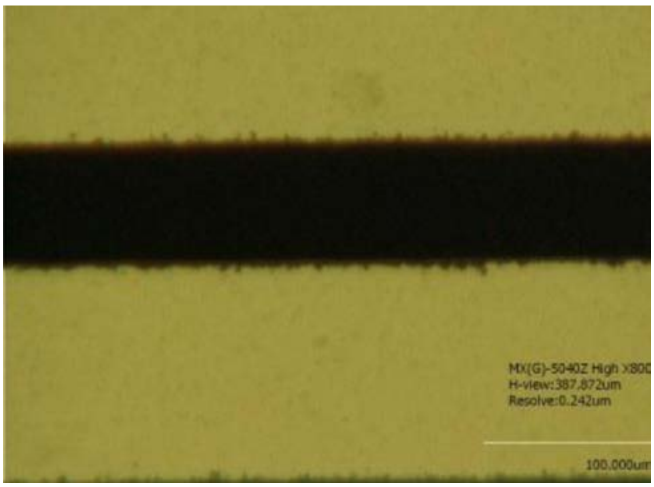

Figure 15: Comb pattern with dendrites.

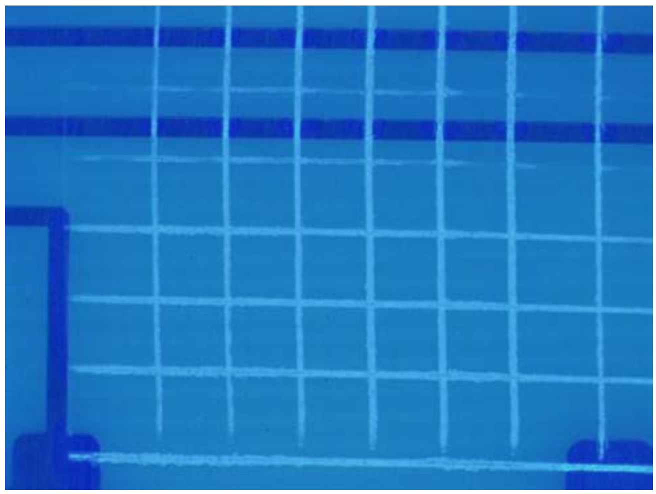

Figure 16: Black light/good adhesion.

compared to the 85°C/ 85Rh. Figure 15 shows a comb pattern that was run at 85°C/85Rh. The dendrites are starting to grow. Adhesion to board and flux residues can also be determined by using a crosshatch cut and applying tape to check adhesion as shown in Figures 16 and 17.

Conclusion

This article is a consolidation of hundreds of tests and material combinations. The matrix of residues and available coatings would be too large to contemplate. The data has been edited to present key findings of collected information and provide practical guidance for engineers considering deploying this technique for their assemblies.

Based on our findings, we have concluded that conformal coatings can safely be used over no-clean flux chemistry for many types of assemblies. It is imperative that compatibility

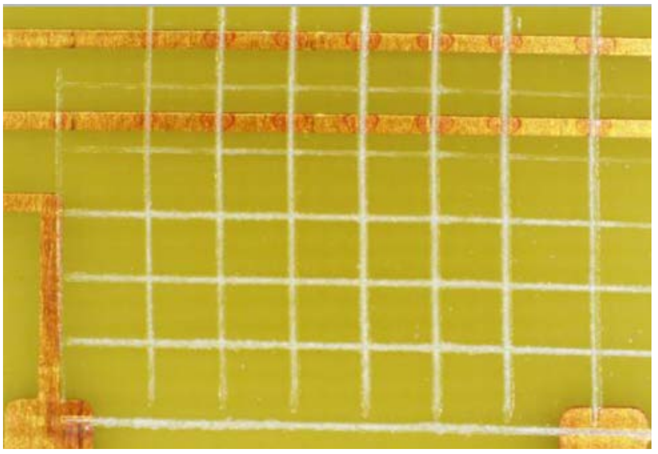

Figure 17: White light/good adhesion.

testing be performed to ensure the coating provides the intended protection and meets the mission profile of the assembly.

The incorporation of low-standoff devices and the ability to completely remove water soluble organic residues is driving more assemblers to consider a no-clean process. The risk assessment of water soluble versus no clean in these applications consistently favors no clean. The cost savings in decommissioning the wash process and equipment is another major reason for migrating to no-clean chemistries.

Finally, as conformal coating continues to be the only accepted practice for tin whisker mitigation, along with the looming expiration of the RoHS exemption, we predict no-clean chemistries and the subsequent coating of the resulting residues will become increasingly prevalent over time. **SMT**

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Tim O'Neill is regional manager at AIM. He can be reached at toneill@aimsolder.com.

SMTonline Market News Highlights

U.S. Circuit Board & Component Manufacturing Report

Despite revenue declines in almost every year of the last five years, robust growth in 2010, due to a rebound in demand, led to an expected average annual growth of 1.6%; however, revenue is still expected to decline 2.7% in 2014, hitting $43.9 billion.

February Conference Board Employment Trends Index Up

"February's job report and the ongoing improvement in the Employment Trends Index should provide some relief for those concerned about weakness in the U.S. economy and labor market," said Gad Levanon, director of Macroeconomic Research at The Conference Board. "

Healthcare Cloud Computing Market: $6.5B by 2018

This report studies the North American healthcare cloud computing market over the forecast period of 2013–2018. This market was valued at $1.75 million in 2013 and is poised to grow at a CAGR of 29.8% from 2013–2018, to reach $6.45 million by 2018.

Global 3D Printing Market: CAGR of 16.8% by 2019

According to a new market report published by Transparency Market Research Global 3D printing (Polyjet, FDM, SLS, SLA) Market—Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2013–2019, the global 3D printing market was worth U.S. $2.2 million in 2012 and is expected to reach U.S. $7.24 million in 2019, growing at a CAGR of 16.8% from 2013–2019.

Mobile DRAM Revenue Down Slightly in 4Q13

The mobile memory industry's worldwide revenue reached $3.039 billion in the fourth quarter of 2013, bringing the yearly total to $11.826 billion, representing 34.3% of DRAM industry value. Looking ahead to the first quarter of 2014, a 7.4% QoQ decrease in smartphone shipments is forecast, while tablet sales are expected to be weak as well.

3D Printing Market Experiencing Rapid Growth

The 3D printing market has seen rapid growth in recent years due to its increasing applications across different sectors Such as consumer products and electronics, automotive, medical, industrial, and aerospace. Decreasing cost of 3D printers and its increasing adoption across the government and education sectors is further expected to spur the demand in the coming years.

IDC: PC Shipments See Continued Decline Through 2018

Worldwide PC shipments fell by -9.8% in 2013, slightly better than a projected decline of -10.1%, but still the most severe contraction on record, according to the International Data Corporation (IDC) Worldwide Quarterly PC Tracker. Fourth quarter results were slightly better than expected, but the outlook for emerging markets has deteriorated as competition from other devices and economic pressures mount.

Wearable Devices Market to Reach $30.2B in 2018

BCC Research reveals in its new report, "Wearable Computing: Technologies, Applications, and Global Markets," the global market for wearable computing devices is expected to grow to $30.2 billion by 2018, with a five-year compound annual growth rate (CAGR) of 43.4%.

Growth of 65% for Digital Power Supplies & Power ICs

The global market for digital power is undergoing explosive growth, with revenues for digital power supplies and digital power integrated circuits (ICs) each projected to jump almost 65% in 2014, according to a new report from IHS Technology.

Global Lithium-Ion Battery Market Soars to $24.2B

Lithium-ion battery is used in a variety of markets, such as consumer electronics, automotive, and industrial. Trends are favorable for growth across the industry; however, significant differences in growth potential among the application markets and regions exist.

Protecting Your Supply Chain from Counterfeits and Liability

by Todd Kramer
SECURE COMPONENTS LLC

For a few years now, it has been clear that many contractors are not adding new suppliers to their approved vendors' lists the way they once did. In adopting this policy, they fail to recognize the value of trustworthy, independent distributors. By neglecting the advantages that independent distributors can offer to the supply chain, these firms potentially do themselves a grave disservice. Despite contemporary rhetoric, trustworthy independent distributors are an essential part of the landscape of modern procurement.

In the procurement departments of modern firms, it is common knowledge that line-down situations do occur. While, in a perfect world, this would not be the case, it is an unfortunate business reality. When OEMs, OCMs, and authorized distributors cannot provide parts, procurement personnel are faced with a few choices. They can go without procuring components, leading to slowing or even halting production. Alternatively, they can attempt to locate and purchase the needed parts on the open market from independent distributors, choosing one of two options when doing so: They can purchase through "trusted suppliers" or through suppliers that have not been audited by either their organization or any accredited third-party assessments. For the purposes of this column, the latter category of distributors will be termed "un-vetted suppliers," as they have not been vetted by a government organization, nor have they been certified to an internationally accredited counterfeit avoidance standard. The use of these un-vetted suppliers could potentially come with serious consequences. Recognizing

Figure 1: SAE International—the ultimate knowledge source for mobility engineering.

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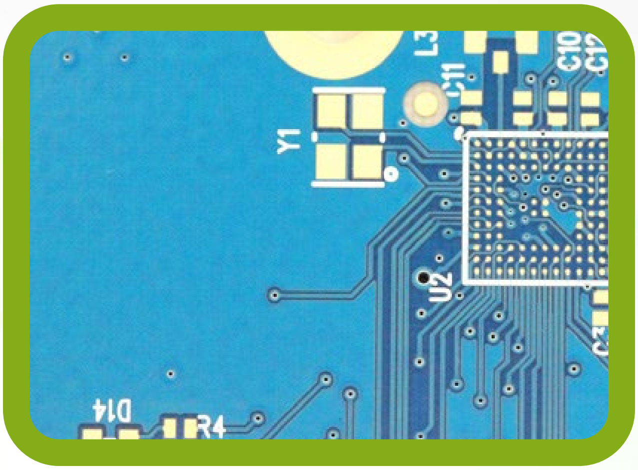

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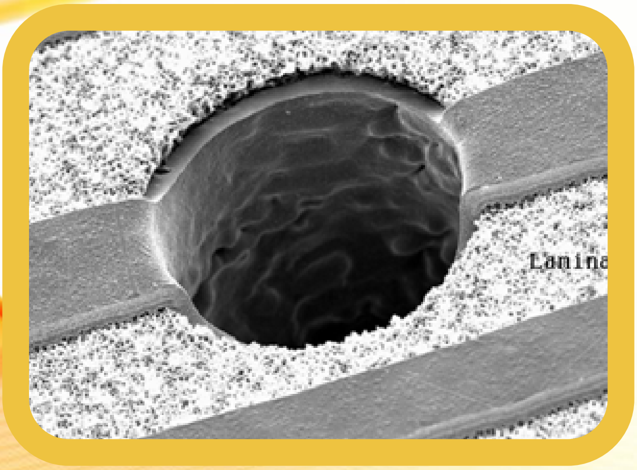

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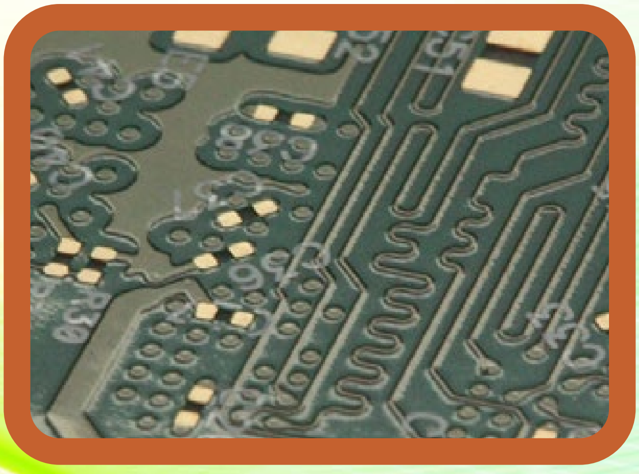

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ADVANCED PCB SOLUTIONS

www.candorind.com | sales@candorind.com | (416) 736-6306 the impact of utilizing such suppliers, in December of 2011, the National Defense Authorization Act (NDAA), Section 818 was signed into law. This law requires defense contractors and subcontractors to:

"Establish qualification requirements…pursuant to which the Department may identify trusted suppliers that have appropriate policies and procedures in place to detect and avoid counterfeit electronic parts and suspect counterfeit electronic parts[1]."

Additionally, in situations where OEMs, OCMs, and authorized distributors are unable to supply needed parts, NDAA Section 818 authorizes, "department contractors and subcontractors to identify and use additional trusted suppliers, provided that—

(i) The standards and processes for identifying such trusted suppliers comply with established industry standards;
(ii) The contractor or subcontractor assumes responsibility for the authenticity of parts provided by such suppliers as provided in paragraph (2); and
(iii) The selection of such trusted suppliers is subject to review and audit by appropriate Department officials[2]."

After Section 818 was signed into law in December of 2011, many contractors and subcontractors questioned whether independent distributors still had a place in the aerospace industry. With the passing of this new law which required the use of trusted suppliers, could independent distributors still be used? If they were, how would a firm be able to contend that the independent distributor could safely be considered a trusted supplier?

While this law is a step in the right direction with regard to counterfeit mitigation, it contains a serious ambiguity: the term "trusted supplier" is left undefined. This failure to define it created confusion, which is one of the last things that the industry needs at the moment. In order to better interpret the term, one can consult a number of industry resources, such as the SAE International AS6081, AS5553-A and ARP6178 Recommended Practice documents. Additionally, the Defense Logistics Agency's Qualified Testing Suppliers List (QTSL) contains suppliers who have been audited and approved by the DLA to sell microcircuits directly to them, in which components are only available from an "other than authorized" source of supply.

There is no doubt the term trusted supplier needs to be better defined—an industry-wide standard definition would be the ideal. However, as such a definition has not yet been provided by any regulatory organization. Procurement professionals must use the available resources to develop an understanding of who is a trusted supplier. This is very important, as failure to use a trusted supplier can result in serious liability.

Both the AS5553-A and AS6081 Counterfeit Avoidance Standards have been promulgated on an international level and adopted by the DoD. AS5553-A pertains specifically to manufacturers who engage independent distributors to procure components that are not available from the original manufacturer or their authorized distributor. AS6081 pertains to the manner and process by which independent distributors go about procuring parts from other than authorized sources.

A manufacturer who is certified to AS5553-A has developed and demonstrated a counterfeit avoidance plan which has been subject to rigorous review by an independent certifying body. An independent distributor who is certified to AS6081 has similarly demonstrated an adoption of and adherence to the robust counterfeit avoidance standard. AS6081 includes a standardized table, detailing the sample size and degree of authenticity testing required for components procured from other than authorized sources.

Since AS5553-A and AS6081 have been adopted by the DoD, it stands to reason that manufacturers who rely on contractors who are certified to AS5553-A and distributors who are certified to AS6081 have met the trusted suppliers threshold.

Importantly, Section B.1.3.2 of AS5553-A states that "using the results of audits performed by other private sector or Government organizations is an acceptable alternative to second- or third-party auditing provided the auditing process, attributes, and auditor qualifications are evaluated and deemed adequate to assure compliance with this document and/or other invoked requirements." The ability to rely on audits performed by third parties accomplishes two important things. First, it gives the manufacturer confidence that the independent distributor they have engaged and trusted to find components has been vetted and certified by a third party. Second, it relieves the manufacturer of the cost and burden of sending their audit team to each and every supplier they use.

Figure 2:
The DoD has adopted SAE AS6081 & AS5553-A.

Another place industry can look to in their search to work exclusively with trusted suppliers is the aforementioned QTSL program, which works in a fashion similar to AS6081 and also requires that components be authenticated via testing. DLA Land & Maritime has conducted on-site audits of independent distributors to determine which sources of supply have the quality management system, counterfeit avoidance plan and infrastructure in place to keep counterfeit components out of its supply chain.

As of this writing, 14 independent distributors have been qualified by DLA for QTSL. Manufacturers seeking to comply with NDAA Section 818 could turn to this list to satisfy the trusted supplier requirement of the law by working with QTSL-approved suppliers. Recall that AS5553-A allows manufacturers to use the results of audits performed by private sector or government organizations. Therefore, the prime contractor or manufacturer could utilize the audit performed by DLA—thereby saving time and money.

One final tool contractors and manufacturers may use to help determine whether a supplier rises to the level of a trusted supplier is the SAE ARP6178 Fraudulent/Counterfeit Electronic Parts; Tool for Risk Assessment of Distributors. This tool provides a framework for evaluating whether a potential supplier has the requisite quality management system and counterfeit avoidance plan in place to protect your supply chain.

The risk assessment tool "was developed from best practices identified by procuring organizations and was developed with the intent of supplementing the information and requirements of AS5553-A and AS6081 aerospace standards[3]." ARP6178 encourages on-site audits of potential suppliers and includes a Pre-Visit Assessment Survey, which can be used as an initial gauge to determine whether a potential supplier warrants a site visit. In sum, ARP6178 is a tool which can be used to help determine whether a potential supplier merits consideration as a trusted supplier.

Finally, industry should supplement their use of objective tools and standards like those mentioned above with some common sense. Highly trustworthy independent distributors tend to act in a transparent fashion, keeping their customers informed throughout the purchasing process. When looking for a trustworthy independent distributor, transparency and the willingness to act as a partner to your purchasing and sourcing teams, rather than a simple broker, are important qualities to consider. **SMT**

References:

1. NDAA Section 818 C.3.C.
2. NDAA Section 818 C.3.D.
3. SAE ARP6178, Foreword.

Todd Kramer is CEO of Secure Components LLC, an AS6081 & AS9120 certified independent distributor of electronic and mechanical components to the aerospace, defense, and high-reliability industries. Kramer is an active member of organizations such as SAE G-19C, the current chairman of U.S. National Committee (USNC/IECQ) and the International Working Group 06 (Counterfeit Avoidance). To contact Kramer or to read past columns, click here.

Mil/Aero007 News Highlights

Ducommun Gains TOW Missiles Contract from Raytheon

Ducommun Incorporated has received a follow-on award from Raytheon Company to continue providing complex wiring harnesses and printed circuit card assemblies for the tube-launched, optically-tracked, wireless-guided (TOW) weapon system. The contract extends the Company's support of the program through 2014.

Nortech's 17% Sales Rise Driven by New Programs

Nortech Systems Incorporated, a leading provider of full-service EMS, has reported net sales of $29.3 million for the fourth quarter ended December 31, 2013, a 17% increase compared with net sales of $25 million for the fourth quarter of 2012.

MC Assembly Achieves AS 9100 Rev C Certification

This certification, which provides a common set of quality requirements across the global aerospace community, accredits MC Assembly's Quality Management System compliance to the aerospace requirements to manufacture and service PCB assemblies, sub-assemblies, and final assemblies.

Sypris' Electronics Group Posts 20% Revenue Drop

Revenue for the Electronics Group was $10 million in the fourth quarter of 2013 compared to $12 million in the prior year period, reflecting lower product sales to overseas customers and budgetary and funding uncertainties within the U.S. DoD.

Advantage Eyes Special Nuclear Materials Project

In a recent statement, President and CEO Jody Singleton declared, "Advantage will be honored if awarded a contract and we will be proud to bring our unique capabilities in gamma spectroscopy threat detection as well as the benefits of the small size, light weight and exceptional power management features we typically employ in instrumentation development.

MINT Region to Increase Defense Spending by $20B

ReportsnReports.com adds "Future of the MINT Defense Industry—Market Attractiveness, Competitive Landscape and Forecasts to 2019" research report to its store. It says the MINT defense industry is expected to become one of the most attractive defense markets in review period. The Mexico, Indonesia, Nigeria, and Turkey (MINT) region is expected to increase its defense spending from US $40.6 billion to US $61.1 billion over the forecast period, according the new report.

Orbit Reports Sales Drop in Q4, FY 2013

Mitchell Binder, president and CEO, stated, "2013 was a difficult year for our company resulting from challenging business conditions in the defense industry. Like most companies in our industry, including large defense prime contractors, as well as short sales cycle defense contractors like Orbit, our revenues declined from the prior year as reorders on many of our legacy products were delayed..."

Military Communications Market to Reach $30B by 2022

"Managing bandwidth in increasingly congested spectrum will be a key challenge in meeting future demands for data-centric military communications," observed Asif Anwar, director of the ADS service. "This is leading to the use of higher frequencies, particularly evident in the military satellite communications segment with adoption of Ka-band."

DoD Releases 2015 Budget Proposal of $495.6 Billion

President Obama has sent Congress a proposed defense budget of $495.6 billion in discretionary budget authority to fund base defense programs in fiscal year 2015. The request is $0.4 billion less than the enacted FY 2014 appropriation and is consistent with the current budget caps.

India Becomes Largest Defense Market for U.S.

"We are seeing trade patterns fundamentally change for the dominant players," said Ben Moores, the study's author. "The most notable change is the spectacular level of imports from India. China, Indonesia, Egypt, and Taiwan all saw imports increase by one billion. When we look at India, those figures were $5.9 billion. By 2015, our forecasts show that number jumping to $8.16 billion."

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A SHORT SCOOP

Screen Printing Solutions for Small Die and Precision

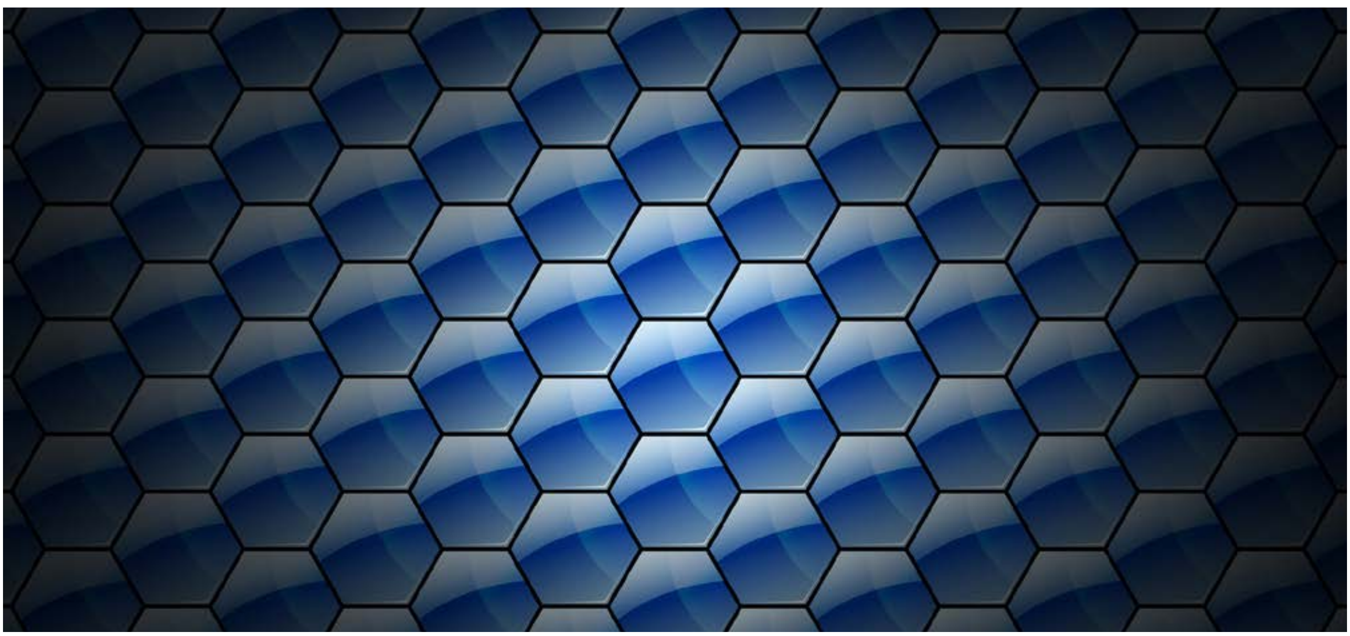
by Rachel Miller-Short
PHOTO STENCIL LLC

The Short Scoop this month discusses one of our more demanding customer applications. As discussed in previous articles, when selecting stencils, the trick is choosing the right tool for the right job; but sometimes the need for tailoring a stencil for a specific application can take a bit more engineering time and several iterations to get the desired results.

As a case study, consider this: Recently, a customer was trying to print solder fillets on gold Kovar tabs. The Kovar tab measured just 0.063 +/- 0.002 x 0.125 +/- 0.002 inches. The tab was finish plated with 150 µin (minimum) of nickel and then over-plated with 100 µin (minimum) of gold. When the component was attached, the solder fillet needed to align precisely with the tab and the solder reflow had to be perfect. For this demanding application, there could be no gas pockets or voids anywhere on the fillet, which meant that ensuring sufficient venting for flux residue from under the part was a priority. The plan was to use a stencil and a squeegee to transfer the solder onto the fillet. However, getting a successful plot was extremely difficult.

Previously, the customer had been processing the parts by hand-soldering them onto the assembly. At this point in their manufacturing process, they decided to use machine placement for a more accurate and repeatable result and to speed throughput to accommodate increasing volumes.

The stencils they had been working with had six apertures distributed over the large pad for the Kovar tab (slug). Using the initial design configuration of apertures to print the solder paste did not allow sufficient solder paste solvent to escape during reflow. This lack of adequate solvent escape was causing voids under the Kovar tab as well as poor solder fillets on the edge of the Kovar tab during reflow. Both of these defects were unacceptable conditions for the exacting assembly standards required for the end product.



SCREEN PRINTING SOLUTIONS FOR SMALL DIE AND PRECISION *continues*

In the customer's own words, "We had set extremely high standards because the fillet of the solder on this part needed to be perfect. We had tried many stencils and made many plots, but they all resulted in failures."

The solution included two important elements: (1) an aperture design that employs a honeycomb type structure, and (2) ground plane aperture designs for quad flatpack no-lead (QFN) stencil printing, which solves a similar problem with small part attachment with a large ground attachment.

First, a hybrid electroformed stencil was chosen with a squeegee printing surface that is perfectly flat compared to woven wire knuckles used on woven screen mesh products. This flat, electroformed structure is stable and does not stretch during usage like woven wire mesh and, being an electroformed stencil, it can be tailored to precise thicknesses and is able to release paste from the screen more reliably than a laser cut tool. A variety of mesh patterns can be designed to cover large application areas. Shapes such as rectangles, squares, circles, ovals, and hexagon mesh shapes are used and eliminate the angular variations that are seen in competing woven mesh products. In this case, the engineered mesh design was central to the success of the Kovar tab attach for the customer.

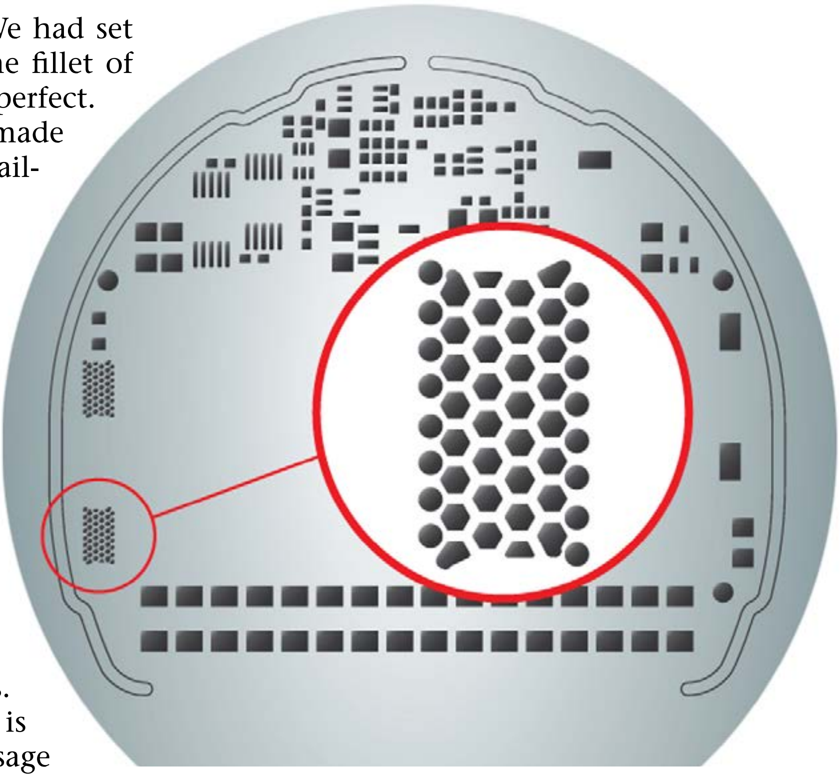


Figure 1: Board with honeycomb pattern magnified.

The next challenge was printing solder paste for QFN devices, which present several assembly problems. QFNs have a metal pad on the underside of the part for grounding and heat conduction. The packages are very small and light. The QFN leads and ground plane conductor are flat and in the same plane on the bottom of the package. Printing solder paste 1–1 with the ground plane can cause the QFN to float during reflow due to the surface tension of the liquid solder which can cause miss-registration of the leads on the QFN and the pads on the PCB.

QFN float can be controlled by reducing the amount of solder paste printed on the ground plane. Typically a 50–60% reduction will solve the QFN float problem. However, the aperture reduction must be done judiciously since at some point, starving the part of solder becomes an issue. A window pane aperture is recommended for most cases of QFN attachment which allows the solder paste volatiles to easily escape during reflow without moving the QFN device.

The result was an adaptation of an Accu-Screen stencil with which could be created a uniquely designed stencil with a honey-comb aperture pattern that would evenly dispense the solder paste and allow for out-gassing during reflow, providing a uniform solder fillet around the Kovar tab. The apertures would be 6-sided and arranged in an array. **SMT**

Rachel Short is vice president of sales and marketing at Photo Stencil LLC. To read past columns, click here.

SMTonline Supplier/New Product News Highlights

Optimum Design Acquires Viscom X-ray Inspection System

Zero Defects International, regional sales representative for Viscom Americas, announces the sale and installation of a Viscom Model 8011 X-ray at Optimum Design. Based in Pleasanton, California, Optimum Design conducted a rigorous and comprehensive review of all available systems prior to selecting Viscom.

Microtek Welcomes Obitz as Laboratory Director

The company announces the hiring and appointment of Debora (Debby) Obitz as laboratory director of its new Microtek Laboratories—East facility located in Linthicum Heights, Maryland. She brings with her over 30 years of experience at a senior laboratory management level and is very active in numerous IPC technical committees and task groups.

Dymax Honored by Connecticut for Outstanding Service

Dymax Corporation was recently recognized by the Connecticut Economic Resource Center (CERC) for the company's outstanding service and commitment to the state. The company, along with 19 other Connecticut companies, projects, programs, and leaders, was singled out for its contribution to Connecticut's economy.

MC Assembly Achieves AS 9100 Rev C Certification

This certification, which provides a common set of quality requirements across the global aerospace community, accredits MC Assembly's Quality Management System compliance to the aerospace requirements to manufacture and service printed circuit board assemblies, sub-assemblies, and final assemblies.

Super Dry Unveils Nitrogen-free Baking & Storage

Moisture specialist Super Dry will feature its broad range of desiccant cabinets at this year's IPC APEX EXPO in Las Vegas, Nevada. Visitors to booth #425 will learn the processing and financial benefits of replacing costly nitrogen and eliminating high temperature baking for the protection of moisture sensitive components and PCBs.

Indium Adds Teo to Sales & Marketing Team

Indium Corporation announces that Tony Teo has been hired as associate director for sales and marketing for the Asia-Pacific region, including China. His primary responsibility is to continue the successful and profitable growth of Indium Corporation's business in Asia by investing in staff training, supporting new product development, enhancing branding efforts, and training staff.

Ellsworth Nets Distributor of the Year Award from Lord

"We are honored to receive the Lord Product Assembly Adhesives Distributor of the Year Award again this year," said Roger Lee, VP and GM of Ellsworth Adhesives North America. "We highly value our longstanding relationship with LORD and their commitment to product and market development and their related focus on their distribution channel."

Computrol Installs Third Essemtec Tucano Stencil Printer

"Computrol purchased another Essemtec Tucano stencil printer due to its large print area, easy setup and consistent results," said James Spencer, Computrol's engineering manager. "The two printers that we currently have in service have performed exceptionally well and the service from Essemtec has been great."

XJTAG Hosts Free Workshops in South Africa

The hands-on introductory workshop provides a comprehensive overview to JTAG boundary scan and the IEEE 1149.x standard. The one-day sessions will take place May 19 and 21 in Midrand, and are of particular interest to engineers in design, development, test, and production.

Electrolube Develops New VOC-free Conformal Coating

As an ISO 14001 specialist chemicals manufacturer committed to innovation, safety, and environmental responsibility, Electrolube has developed a new acrylic conformal coating, USTFA, for the American market to enable users to reduce their site's VOC emissions. Over the past few years, U.S. federal and state agencies have been establishing limitations and regulations of VOC content found in thousands of chemical products.

Expanding Your Comfort Zone

by Michael Ford
MENTOR GRAPHICS, VALOR DIVISION

In the engineering world, there is increasing pressure to be a specialist, especially in technical roles. Does this intense focus on specialisation work against us, however, when we consider the wider requirements of the business? How can we bring added value to specialist roles, such as PCB layout designer or SMT machine programmer, which are key elements of the wider production introduction team, without getting distracted from specific objectives?

Software tools help us focus excellence in a specific role, but software must now add more benefit from team environments, even when derived from a widely spread collaborative flow, and bring a step change improvement in performance without the cost of distraction from our specialist operations.

As technology continues to evolve, there is always more to learn, whether it is how to better design a PCB or how to better prepare programs for SMT machines. These are not new tasks, but people performing them are continuously pushed to achieve greater efficiencies and performance. What often happens is that we end up with certain roles that are very specialized in focus, experience, and outlook. Software tools have grown up around these kinds of roles, providing added value, guidance and management, and in effect, promoting the specialisation itself. The issue, then, is how to effectively connect these specialist roles into a team or collaborative flow. Can we afford to distract people from their core strengths by asking them to acquire some level of expertise in areas that are related to their tasks, but outside of their direct role? How can we optimise teamwork as part of a flow without losing our focus on individual key goals?

Let's take, for example, the PCB layout designer, a specialist on the design team who uses software to create PCB layouts. This role involves the use of specialised skills and experience, taking physical and electrical requirements from the schematic diagrams and laying out circuits on a PCB. Several cycles of PCB prototypes may be needed during the design phase to correct issues from the electrical design, the physical form and fit of a PCB into a product, and mistakes in the layout itself. Specialist design tools provide support in these areas, enabling the skills of the layout designer to be maximised.

Product design is the first step in the flow for new product introduction (NPI). Once complete, the design is passed to the fabrication stage and then on to assembly. In each of these manufacturing disciplines, there are also experts in their fields, engi-

EXPANDING YOUR COMFORT ZONE *continues*

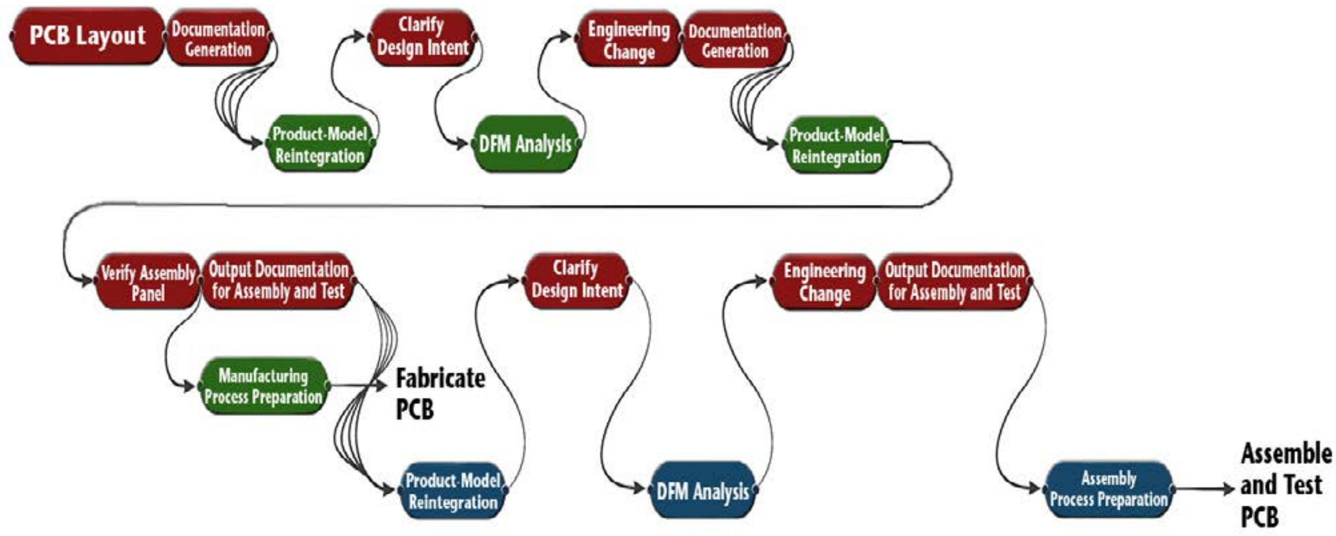


Figure 1: The traditional NPI flow from design to manufacturing for new PCBs.

neers who understand their processes and specialist technologies. They are also likely to have one or more software tools, to assist them with the interpretation of the data they receive from design, which they need to check, and in many cases to reconstruct so that their process will work efficiently with the required yield.

It is most often the case that issues from the design that could cause serious problems during the manufacturing setup will be picked up. In the best case for PCB fabrication, there is usually the scope to request that the PCB design is changed to accommodate issues or limitations of the manufacturing process. This can trigger whole repeated cycles of layout design refinement, testing, output generation and re-engineering for manufacturing, but it solves the problem. More risky, however, is when it is agreed that the fabricators can change the PCB design locally by themselves to avoid this cycle. The problem is again solved, although with many issues going through this process, the designer has lost a great deal of control of the consistency of his product. This is compounded when multiple fabricators are used, together with inevitable differences in ways that each apply their solutions

Obviously, the greater the level of detail and completeness of the product model coming out of design, the easier it is for process engineering to confirm that the product is fit for their operation and to get the processes set up. Industry standard formats such as ODB++ create a complete and detailed product model such that the need for data reconstruction is avoided.

The assembly process does not usually have the luxury of being able to negotiate design respins. The physical PCBs are already made in quantity. Again, however, tools are used to assess the data from design, and again, assumptions and adjustments are made to make sure that the product fits to the assembly platforms to be used. Each assembler will again have similar issues and is likely to resolve them in different ways.

These manufacturing engineers have a lot of responsibility on their shoulders. They are on the front line, preparing complex manufacturing processes that will produce quality products. The manufacturing process, however, is often significantly separated from the PCB layout process, even though this is their key source of data through the NPI flow. There has been a lot of frustration historically among manufacturing engineers about why the designers make the same mistakes time after time. Issues occur with fabrication, assembly, test access, fiducials, pads, tracks, component spacing, and many more. All of these issues happen over and over again, which could simply be avoided. In OEMs, direct emails and phone calls get little response. Design is on another continent, speaking a different language, in another time zone, and, by the way, the design team have long moved on to other projects. In an EMS scenario it is worse, because there is a commercial contract between the designer and manufacturer, with clear definitions of responsibilities of costs should anything go wrong.

The individual teams of people, who are supposedly working together in a flow, to introduce a new product into manufacturing, cannot actually spare the time to learn from each other. The PCB designer sometimes doesn't understand the technologies and requirements around fabrication or assembly. After all, different issues come from different engineering people, sites, and companies all the time, and there is no apparent consistency to someone who is not an expert in the field. It is not for the designer to be the mediator. The designer lives and works within his design tool, which justifiably governs his world view. The breakthrough here is to bring qualified information and know-how from the manufacturing process preparation teams directly into the designers' world, to expose opportunities for improvements in a way that the designer can understand and action. Concurrent design for manufacturing (DFM) tools that can model manufacturing requirements and present them natively within the design tool provide a way for the designer, with virtually no cost, to accommodate complex manufacturing requirements without having to understand the technology behind them. The value comes from the rule-set built into the DFM software, the process of extraction of the know-how from the engineering processes, and the fact that it is right inside the designer's native environment.

The PCB layout designer is happy, with a huge reduction of distractions from emails, phone calls, and demands for respins. Very little additional effort has resulted in a huge gain. The PCB layout is now qualified against manufacturing requirements. The fabrication and assembly people are also happy. The product model they now receive from design feeds straight into their process preparation tools, enabling them to simply get on and plan their processes and execution. There is, of course, a little piece of extra work for them to do, that is, to contribute information for the setting of the DFM rules, which is the feedback to design with the model of their requirements. These configurations should evolve continuously,

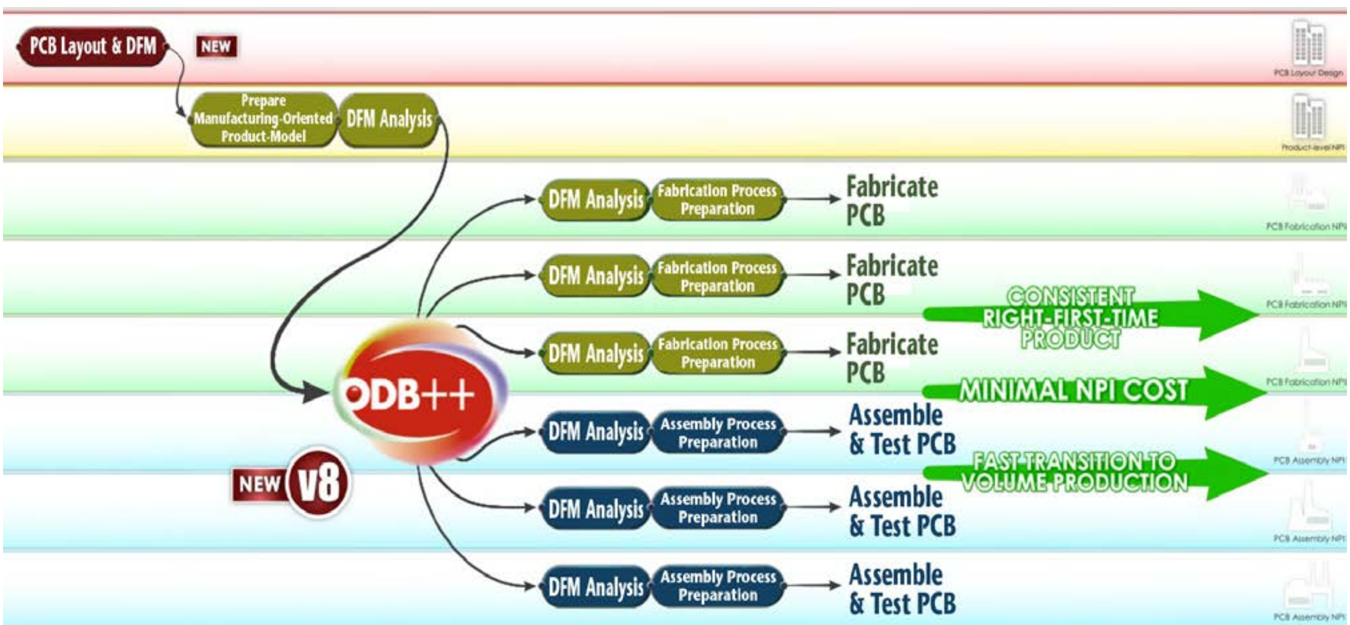


Figure 2: The lean NPI flow.

enhancing rules for better performance and quality, as well as following any changes to the processes. This ongoing work is asynchronous to the product models being introduced, representing a very worthwhile investment of their time and expertise versus a significant reduction of their day-to-day repetitive work-load for each product.

We now have a lean NPI flow (Figure 2). Lean, because the waste of time and effort for everyone involved in the flow is virtually eliminated. Compatible tools supporting the lean NPI flow, work together at design, fabrication, and assembly, working through, for example, ODB++.

The premise of this flow is that we expand the scope of specialists to work outside of their comfort zones by establishing a process flow with feedback loop that enables each specialist area to help the other, without straying outside of their area of expertise and excellence. With Lean NPI, the designer can perform a more comprehensive task, including DFM, but without having to be a manufacturing expert. The business impact of this flow is very significant, bringing products to market in a fraction of the time and cost previously needed, mainly through the reduction of respins and elimination of needless data reconstruction. Justification for the introduction of the complete set of lean NPI tools is not hard to find.

This is a great example of how software is evolving, not only providing the specialist support of key functions, but also bringing members of a team together who until now have been unable to communicate and help each other effectively. **SMT**

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

ZULKI'S PCB NUGGETS

Tighter Scrutiny Needed for PCB Cleaning Agents

by Zulki Khan
NEXLOGIC TECHNOLOGIES INC.

PCB cleanliness on the assembly floor is now getting more attention, due to tiny residues and contaminants being left on assemblies after new, advanced assembly processes. Cleaning methodologies, testing, analysis, and special chemistries are being taken to a new level to assure customers of ultraclean boards to avoid costly latent issues.

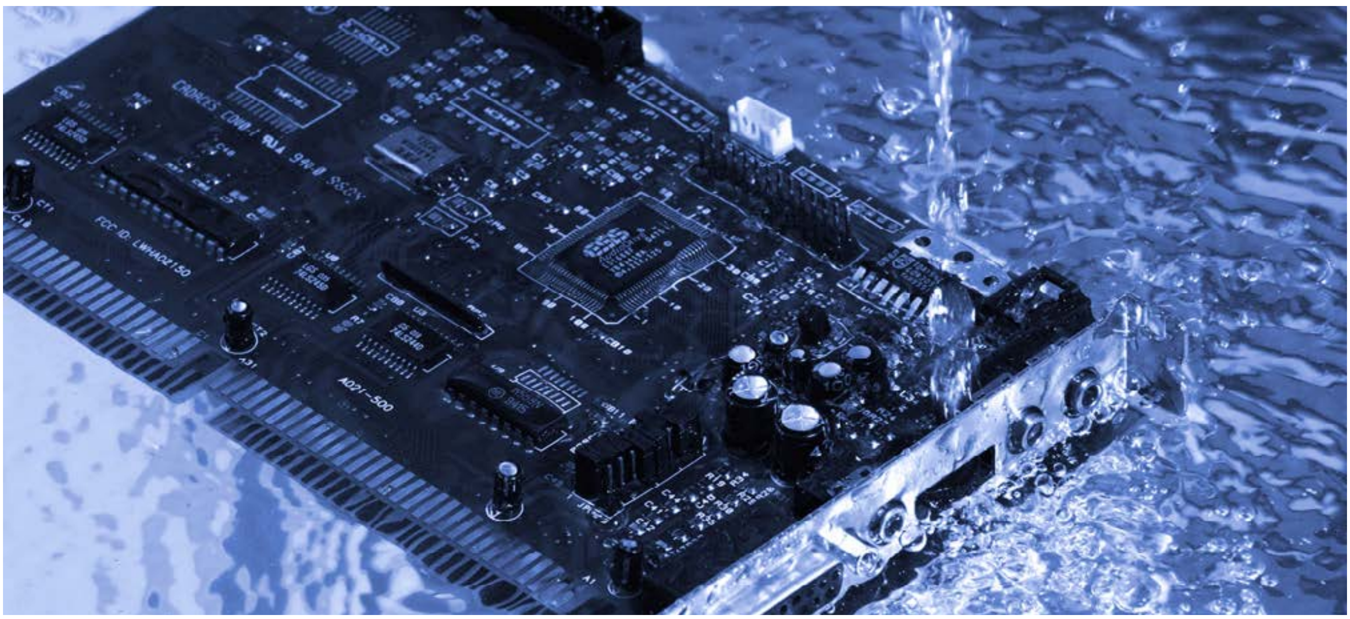
Board cleanliness is especially critical for mil/aero and medical applications. The right types (and amounts) of cleaning agents must remove flux residues to assure the integrity of processes such as bonding and conformal coating. During the coating process, if residues result in poor wetting or delamination, they can cause assembly failures and ultimately lead to field failures.

In today's assemblies, there are growing numbers of advanced packages like land grid arrays (LGAs), fine pitch BGAs, micro BGAs, micro CSPs, and the list goes on. Packages such as LGAs are flush to the board, and they have bumps, not balls or spheres, like BGAs.

If a small amount of flux remains trapped under the board's surface, it can change the characteristics of impedance, resistivity. This could also change what could have been a perfect eye diagram, and in general, change the optimal level of operation. Ultra cleanliness is even more critical if underfill or conformal coating is applied to a device.

It's difficult to clean such a device after the board has been processed. Therefore, assembly personnel have to be absolutely sure they've taken every possible measure to assure devices and boards are ultraclean. If residues are left in the conformal coating or underfill, then these contaminants are trapped inside the capsule and hinder device performance.

Plus, a vast array of other residues and contaminants can be left on a PCB, as shown in Figure 1. The contaminants may be either ionic or non-ionic contaminants. Ionic contaminants contain molecules that are conductive when the cleaning solution is applied. Ionic residues



TIGHTER SCRUTINY NEEDED FOR PCB CLEANING AGENTS *continues*

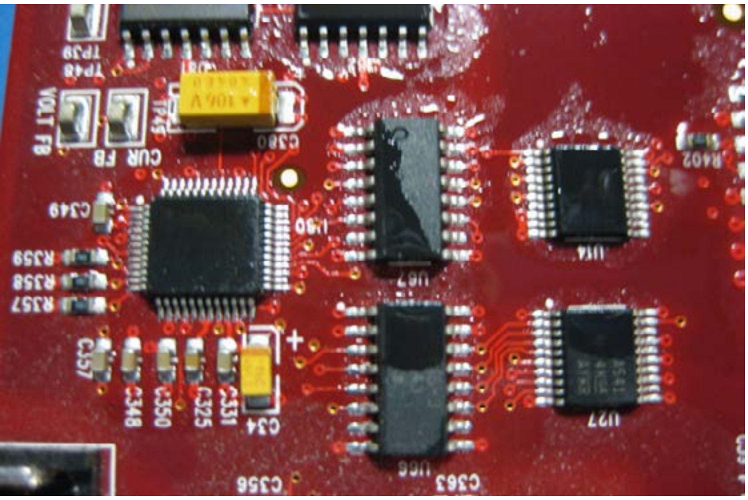


Figure 1: Array of residues and contaminants left on a PCB.

can completely dissociate into negative or positive particles. This changes the overall conductivity of the solution. If water is applied, it becomes ionized and the change becomes either positive or negative.

Ionic residue examples include surfactants, flux activators, perspiration, and plating chemistry, among others. Once one of these residues takes either a positive or negative ion charge, it then changes the cleaning solution's conductivity. Thus, the cleaning process becomes different from what it should be and special care must be given to the type of cleaning technologies used for certain PCB applications.

In terms of non-ionic residues, these aren't conductive, mostly insolvent in nature, and aren't prone to cause problems. They're usually organic species having a role in fabrication and assembly and include mostly resins, oils, greases, or hand lotions. They don't necessarily change the solution conductivity, but they are just resins that need to be cleaned after a board is assembled.

Most assemblies are cleaned using de-ionized or DI water. DI water is generally heated to a temperature in the range of 100–120°F. It usually contains 3–5% chemistry, and the rest is water. Most contaminants are cleaned using de-ionized water.

When it comes to special agents that cannot be cleaned at a specific temperature, in some cases, cleaning agents need to be changed. This involves changing the concentration of the cleaning agent, the wash cycle temperature, and the speed of the rinse cycle to achieve better results. There are different permutations that can be made to make DI water purer and cleaner.

In some cases, there are restrictions where DI water cannot be used for cleaning, because certain components don't react to water very well. Special washing techniques sometimes prescribed by the OEM customer can be used to clean residues, flux remnants, and unneeded paste. But in some cases when those washing techniques are not specified, the assembly house has to use special chemistries, as shown in Figure 2.

Rosin mildly activated (RMA) flux, a hybrid RMA, vapor de-greasing, foaming agent, and rosin flux are among the more prevalent special chemistries. RMA flux is mildly activated and not very aggressive. It contains fewer activators compared to water-soluble fluxes. This is an effective flux if a PCB is mildly contaminated. If too much flux and residues are left after assembly is finished, RMA flux is good. However, due to its multiple types of rosins, it requires a saponifier heated to 100–150°F, meaning it works in a hot environment when it comes to cleaning. RMA provides the option of a final rinse with DI water.

Figure 2: Batch cleaning, used when the assembly provider uses special chemistries.

SMTA
Soldering and Reliability

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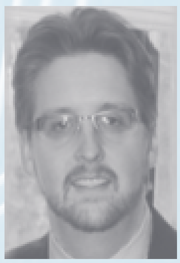
INTERNATIONAL CONFERENCE ON SOLDERING AND RELIABILITY

May 13–15, 2014

Workshops: May 13 • Conference: May 14–15
Toronto Expo & Tech Forum: May 15
Four Points by Sheraton Toronto Airport • Toronto • Ontario, Canada

CONFERENCE OVERVIEW

Electronic products, particularly consumer products have become more complex with greater circuit density, finer lines and spacings and more functionality. Reliability issues continue to be a major concern for industrial, bio-medical, aerospace and automotive applications and require materials, manufacturing, test and quality engineers and scientists to be creative in planning for the future. Challenges such as the use of finer powders in solder paste, the greater need for heat dissipation, the use of novel components and technologies are included. Due to cost considerations, new low silver or silver free alloys are being studied. The use of tailored alloy systems, the variety of alloy choices, and smaller passive components are among the concerns being addressed. Now, a new group of engineers and scientists involved in the design and manufacture of (a) medical devices, and (b) monitoring and control instruments must be ready for the requirements of RoHS recast, also known as RoHS 2. This EU directive officially required that it be made into national laws by January 2, 2013 and these two new categories of electronics must become compliant by July 22, 2014. Soldering and reliability professionals need to come together to share their knowledge and their vision for addressing these challenges.



KEYNOTE ADDRESS May 14, 2014 | 8:50am

A View of the Electronics Industry Process, Reliability, and Materials Research Landscape

Martin Anselm, Ph.D., *Manager AREA Consortium, Universal Instruments Corporation*

Today, the electronic industry's OEMs and CMs are forced to comply with market trends in technologies — due to part availability or cost, and reliability testing for validation. The term "reliability" is often misused, since these tests are evaluation or qualification tests — based upon internal or customer driven standard practices, or on industry accepted standards which do not always provide pass/fail criterion. These tests are employed as best guesses for the reliability of products in the field. This condition is primarily a consequence of limited materials understanding.

We cannot ignore the current state of the economy and the evolution of business practices over the past two decades, paired with significant legislative changes, which contributes to the rate at which leaps in our understanding are being achieved. As a result OEMs and CMs have little time to perform fundamental research and often spend more time in support of individual product needs. As new materials and components become mainstream, manufacturing and "reliability" testing becomes less and less effective in producing predictable results in yield and reliability. The more fundamental research to understand the fundamentals of mechanics of failures, reliability and material properties falls on academia and consortia. Martin will discuss the current mainstream North American research landscape, reviewing some of the research groups in the industry and how each fits into the electronics market. Specific research topics will be used as examples to illustrate value for each program.

TIGHTER SCRUTINY NEEDED FOR PCB CLEANING AGENTS *continues*

The hybrid RMA can also be used for low residues; however, it cannot be washed with DI water. Closed-loop processes are used to keep the discharge to a minimum. This same chemistry can be used repeatedly. But hybrid RMA may not be able to remove all residues and contaminants from components with hard-to-reach areas such as the underside of LGAs or very-fine-pitch BGAs. Hybrid RMA sometimes requires processed chemicals or treated water. It cannot just be directly rinsed; there must be a closed-loop system, and in some cases, a special service may be required to take the water out of the PCB assembly facility to clean it and separate the chemicals.

As for vapor de-greasing, the rinse tank is boiled, creating a vapor atmosphere. The vapor encompasses the board and removes the residues. The advantage is the solvent is recycled. There is low waste, and less floor space is required compared to in-line cleaning. It's a small cleaning unit and less expensive. The solvent could be costly and throughput is not as fast because sometimes only one, two or a few boards can be processed at a time.

Other special chemistries include foaming agents, rosin flux and several others used for extremely contaminated boards. However, the customer should keep several important points in mind. Those include understanding the different types of fluxes available and how suitable they are for their PCB applications, the types of chemistries involved, the percentage of cleanliness their PCBs require, and how well their EMS provider or CM can quantitatively verify their percentage of cleanliness.

Reasons for Cleaning

There are a number of reasons to provide customers with ultra cleanliness, and they all relate to maintaining high reliability. This is especially true for mil/aero and medical electronics applications. For example, intermittent failures can often stem from ionic contamination since it changes solution conductivity. In this case, dendrite growth resulting from ionic contamination can surface and cause shorts and opens. Dendrite growth is comprised of metal filaments that extend across small parts of a board.

Figure 3: Ionic contamination testing required for different contaminants and different applied tests.

Dendrites are similar to tin whiskers that are created by chemical reactions and cause similar issues. Dendrite growth is particularly damaging when components are small and close to each other. For example, fine-pitch micro BGAs, micro CSPs, and other tight geometry packages are highly sensitive to dendrite growths.

Testing

EMS providers must contend with a long list of contaminants, and different tests are required.. The most common is an ion chromatography meter. This system performs a high level of ionic contamination testing, as shown in Figure 3. It can qualify and identify ionic species to a remarkably precise level present on a PCB's surface.

Other prevalent tests include the resistivity of solvent extract (ROSE) test, also known as the solvent extract conductivity (SEC) test, IPC Standard TM650, and surface insulation resistance (SIR). The ROSE concept deals with resistivity. When ionic contamination levels increase, the resistivity of the circuit increases, as well.

ROSE can measure that resistivity to determine the amount of it on the circuitry, and then it instructs the operator on the steps to take to bring that resistivity to a normal and acceptable level. By changing the chemicals used for cleaning, the resistivity is broken down. Thus, a clean surface is created which is acceptable to the customer.

Certain automated devices perform ROSE testing, including Omega, Ionograph, and Zero Ion meters.. Once boards are cleaned, these meters provide results in part per area (PPA) cleanliness to comply with IPC standards.

ROSE testing has certain limitations. It only performs ionic contamination test; not non-ionic. It measures average contamination for an assembly, but doesn't define the source. Certain board parts are more contaminated due to extra touch up or rework. Therefore, there's more flux in those areas compared to other parts not getting as much rework. This means the amount of contamination is different at different board sections. However, ROSE test deals with average assembly contamination and provides average results of the overall surface of the board.

IPC Standard TM650 is the most common test. The board is dipped into a water-based solvent with a great percentage of alcohol at certain temperatures and time periods. Different parameters can be changed in this testing standard. Temperature, as well as alcohol and water concentrations can be changed. Different levels can be checked also. Those measurements include the fluoride, chlorine, bromide, nitrate, phosphates, sulfate, and organic acid. Multiple factors can be measured.

Meanwhile, SIR measures the effectiveness of contaminants remaining on a board. An electrical test runs currents from point-to-point. Those contaminants are measured at certain temperature and humidity levels. When the characteristics are read, the test characterizes residues or fluxes and other contaminants left on a board.

Monitoring and qualifying the degree of cleanliness is absolutely important to make sure final assemblies are acceptable per IPC Class 3. There is some ambiguity in Class 3. However, there are a number of techniques deployed in terms of cleaning the PCBs, many are commonly used in electronics manufacturing in conventional ways.

Other cleaning techniques are in R&D, although newer cleaning products are coming on the market. But the point is cleanliness testing is critical. Ionograph testing and the other methods discussed above can best perform that testing. **SMT**

Zulki Khan is the founder and president of NexLogic Technologies Inc. To read past columns, or to contact the author, click here.

Technology Extends Life Span of Batteries

Technology expert Cary Hayner says his company has developed battery materials that can store about 10 times the amount of energy that a lithium-ion battery does, potentially changing the future of energy storage in products such as cell phones and electric cars.

"This year, 2014, we are focusing on developing our first prototypes that would go into future generations of some of these boutique cell phones," said Hayner, the chief technology officer of SiNode Systems. "These wouldn't be the huge general-consumer type of devices right now."

Hayner joined a four-expert panel to discuss the future of energy storage efficiency which included representatives from Argonne National Labs, SiNode Systems, Navitas Systems, and Intelligent Generation. From cell phones to electric cars to military missile technology, batteries play a crucial role in today's society, according to the experts.

News Highlights from SMTonline this Month

① IPC Strengthening Educational Efforts

Legislative proposals and regulations are having a greater impact on the electronics industry. This has prompted IPC to enhance its outreach efforts to educate policy makers on the industry's economic contributions and priorities to ensure continued growth and open markets.

② Nortech Systems' Board of Directors Welcomes Klein

Nortech Systems, Inc. announced today that William A. Klein has joined its Board of Directors. Klein is currently the CEO of Solarrus Corporation in Huntington Beach, California, a provider of solar energy operation and maintenance services.

③ LACROIX Electronics Forms Joint Venture with AUSY

AUSY and LACROIX Electronics seal their partnership and disclose an unprecedented global industrial solution for the market of electronic equipment conception: An "end-to-end" solution starting with design in R&D centers up to series production, intended for the major industrial world-wide groups.

④ EPTAC Expands IPC Training Centers Across U.S., Canada

EPTAC Corporation has acquired multiple IPC Certification Center licenses for a number of locations across the United States and Canada. This marks a first for an IPC Training Center to expand its delivery and support of electronics training programs to several locations including California, Florida, Minnesota, Missouri, and Connecticut, along with Canada and the Toronto, Ontario market.

5 Congressman Schneider Visits Fuji North America Facility

"My sincerest thanks to Fuji and IPC for hosting today's meeting," said Rep. Schneider. "I greatly appreciate the hard work and attention to detail that goes into manufacturing electronics, which make our lives more connected and our world safer. That's why it's so important that we focus energies on equipping our workforce with the necessary skills to thrive in the twenty-first century economy."

6 Bob Schneider Joins Kimball's Board of Directors

Kimball International, Inc. has announced the appointment of Robert F. "Bob" Schneider to the company's Board of Directors. Schneider currently serves as executive vice president and chief financial officer of Kimball International. His appointment was effective with his election at today's regularly scheduled board meeting.

7 Foxconn Diversifying Away from China; Eyes Indonesia

Foxconn, the world's leading manufacturer of computer components and systems, plans to build high-tech factories in the United States and low-cost plants in Indonesia as the appeal of "made in China" fades into a burden.

8 EMS Quality Benchmark Survey Launched by IPC

Developed with input from quality managers and executives across the global EMS industry, the study covers the industry's most widely used and important quality measurements, including production data, assembly attributes, yields, defect rates (DPMO), customer returns, supplier performance, and many other metrics.

9 IMI Benefits from Expansion; Revenue Up 12.6% in 2013

The company has announced revenues grew 12.6% to US $745 million in 2013 from US $662 million in 2012. Arthur Tan, president and CEO, says, "Our diversification strategy has afforded us extensive global footprint, amplified technical capabilities, and wide-ranging customers, so that despite several challenges we realized higher revenues with corresponding profitability."

10 New Legislation Drives SigmaTron's Earnings Increase

"While SigmaTron posted a positive diluted earnings per share for the third fiscal quarter, we were disappointed with our overall results. The positive earnings were entirely attributable to changes in deferred tax items as a result of new legislation enacted in Mexico," Gary R. Fairhead, president, CEO, and chairman of the board.

EVENTS

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

For the SMTA Calendar of Events, click here.

For the iNEMI Calendar, click here.

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

Printed Electronics Europe 2014
April 1–4, 2014
Berlin, Germany

South East Asia Technical Conference on Electronics Assembly
April 8–10, 2014
Penang, Malaysia

Intermountain (Boise) Expo & Tech Forum
April 17, 2014
Boise, Idaho

Smart Fabrics & Wearable Technology 2014
April 23–25, 2014
San Francisco, California, USA

NEPCON China 2014
April 23–25, 2014
Shanghai, China

Nordic SI Week 2014
May 5–9, 2014
Stockholm, Sweden

Atlanta 18th Annual Expo
May 7, 2014
Duluth, Georgia, USA

International Conference on Soldering and Reliability
May 13–15, 2014
Toronto, Ontario, Canada

Toronto SMTA Expo & Tech Forum
May 15, 2014
Toronto, Ontario, Canada

12th Annual MEPTEC MEMS Technology Symposium
May 22, 2014
San Jose, California, USA

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Test and Inspection of Electronic Assemblies

June:
Thermal Management

July:
Tin Whiskers