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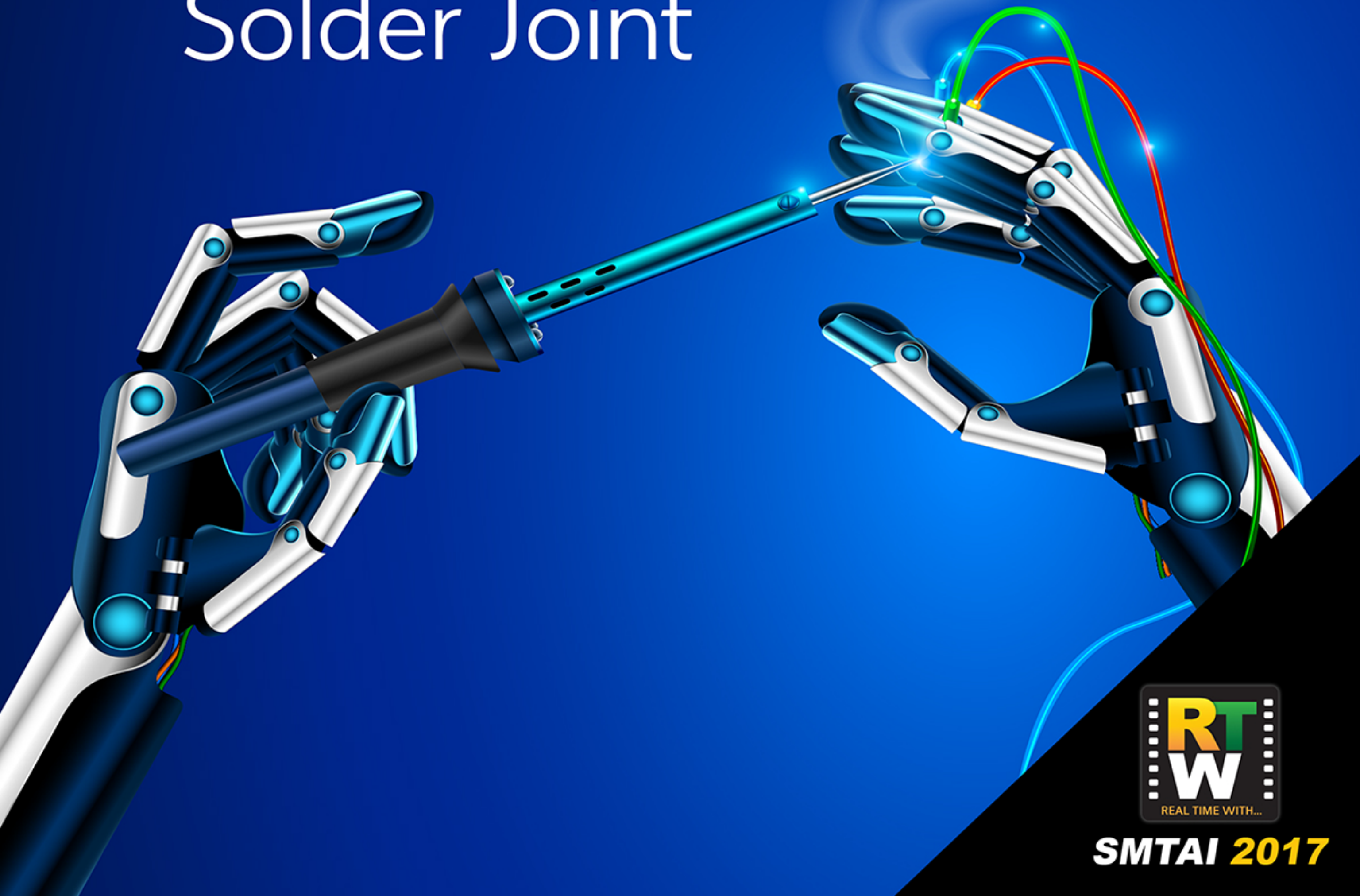
Achieving the Perfect Solder Joint

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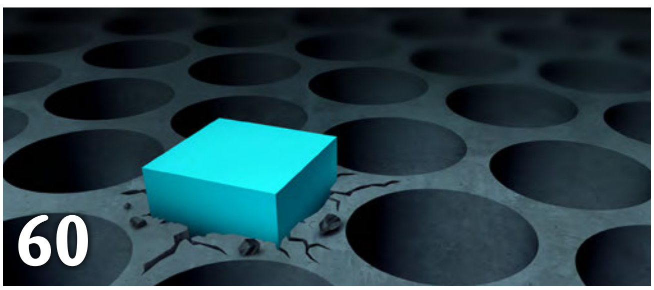

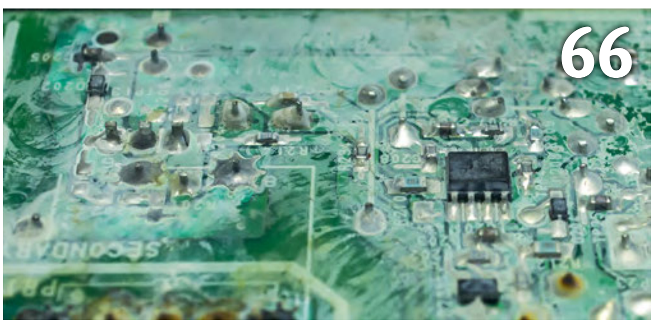

Solder Joints

This month, *SMT Magazine* looks into the many perspectives and challenges in creating perfect solder joints, and presents parameters and strategies that can help assemblers improve their soldering process to achieve reliability.

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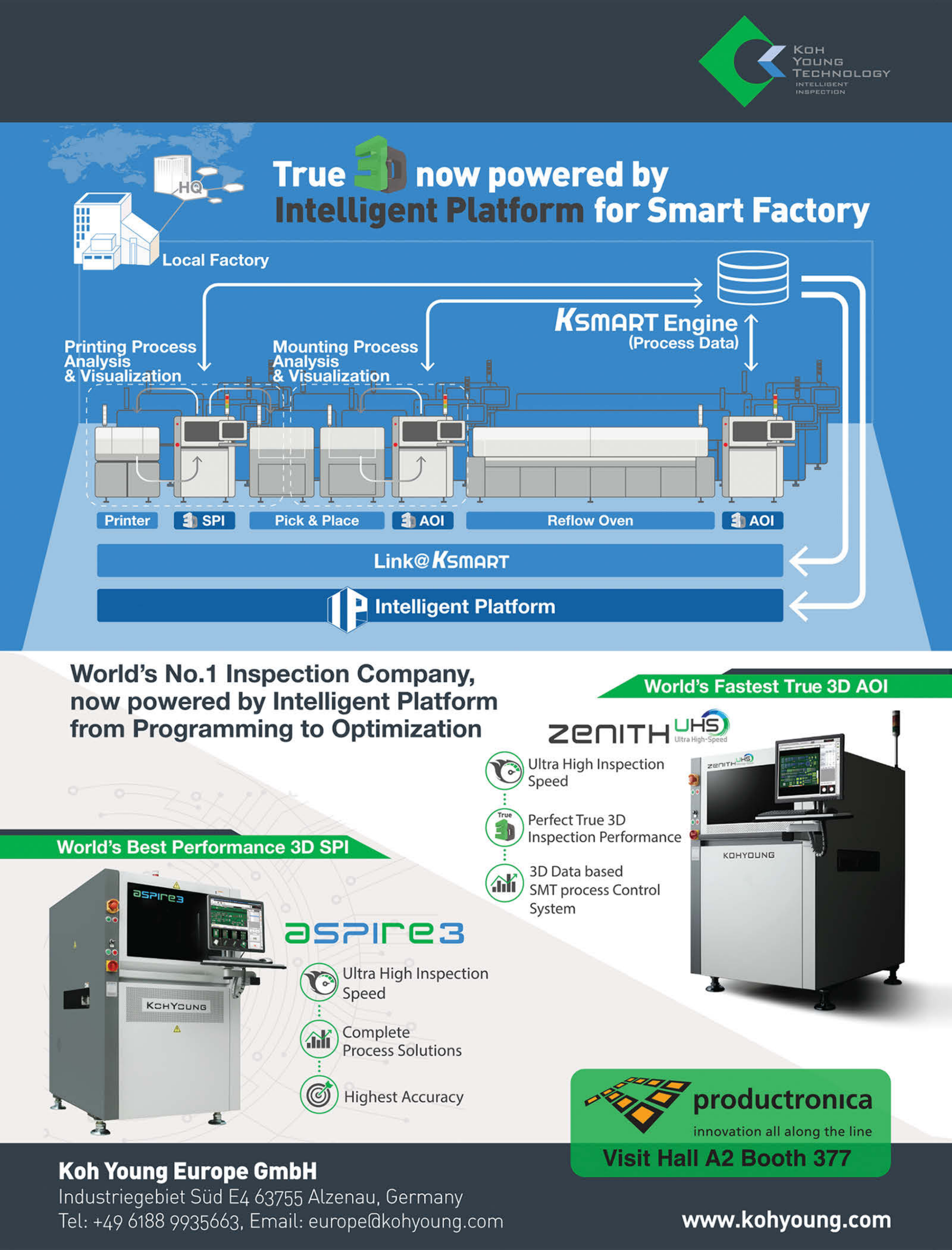

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Creating the Perfect Solder Joint

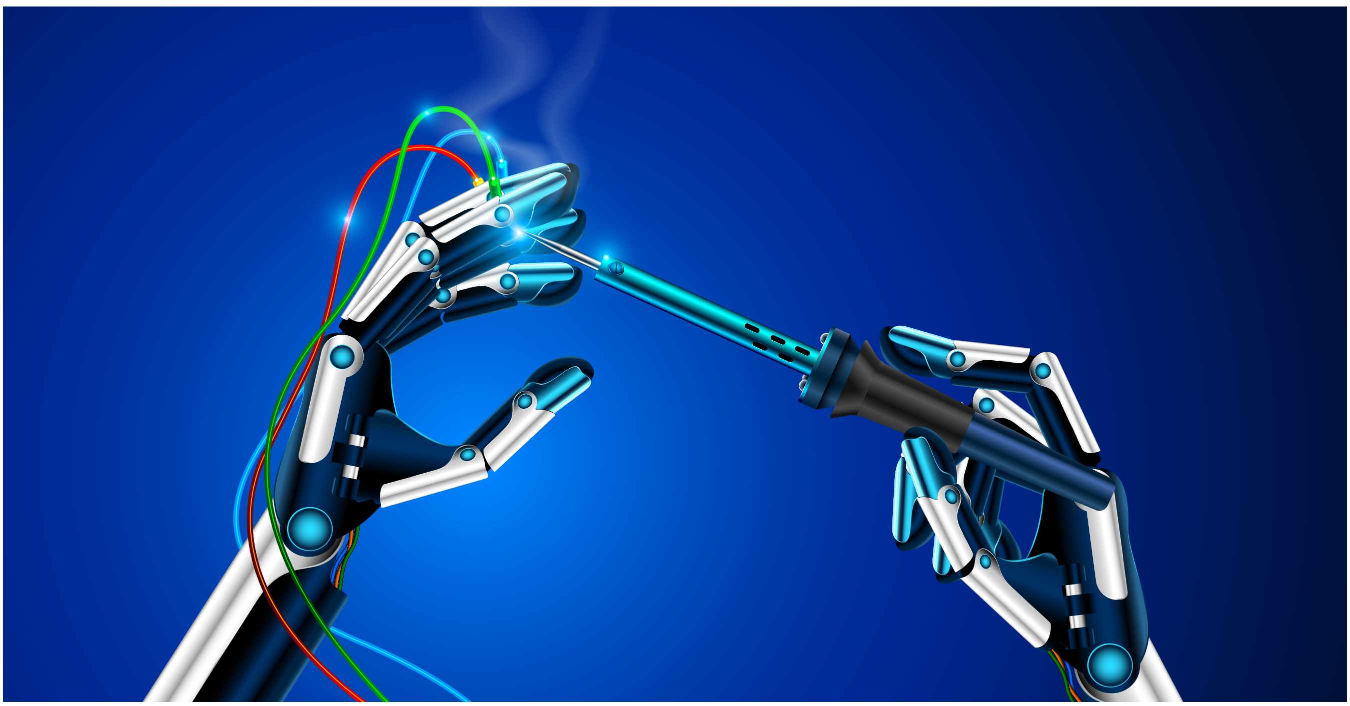
by Stephen Las Marias
I-CONNECT007

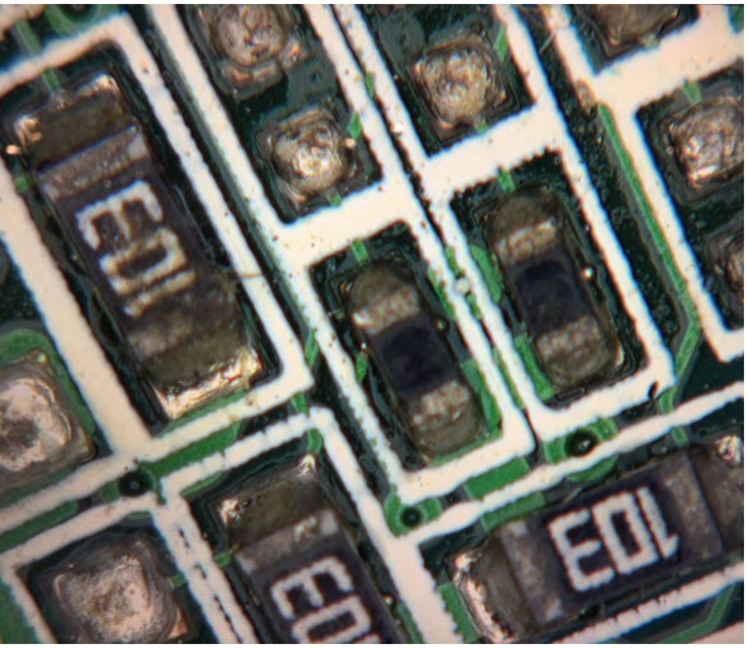
What are the characteristics of a good solder joint? Generally, from a visual standpoint, they should be smooth, bright, shiny, clean, and have a nice concave solder fillet. At least, these characteristics describe solder joints for through-hole components. What about for surface-mount devices? Or bottom terminated components? Moreover, how do you ensure that inside those joints, good intermetallic bonds are formed?

Since all solder joints aren't created equal, the first step is to understand what is expected or required of that joint, according to Rick Short of Indium Corp., during my interview with him at the recent NEPCON South China trade exhibition in Shenzhen, China.

Solder joints play several different roles, and they represent several different opportunities to be a problem, a partial improvement, or a complete improvement. For example, there are solder joints that are necessary for physical strengths, such as holding components, like connectors. We often wiggle and yank our phone jacks—there's a little bit of solder trying to hold all that together, and we keep doing it over the course of ownership of the device. So, those joints must be very robust with regard to physical strength. Other solder joints are merely there to conduct electricity. They don't have much of a harsh life at all, and it is a relatively easy life for them. Other solder joints, meanwhile, are involved in very high heat dissipation demands. They must conduct electricity and heat, and they might also need to address physical strength issues. So, many different opportunities exist for solder joints to either cause you problems or contribute to the success of your finished goods.

Nobody, including myself, wants field failure. I often travel overseas for work, so I definitely don't want the airplane I'm on to experience that "field failure." But going back to our topic on solder joints, I vividly recall that fatal plane crash a few years ago that was main-





ly caused by cracked solder joints in the subassembly unit that controls the rudder. The crash was tragic, but the cause of it is also the reality. I am not sure about the other technical details on the plane, but it had already logged 23,039 flight hours since its manufacture, and 13,610 cycles (an aircraft cycle means takeoff and landing). Just imagine the many hours that these PCB assemblies have been subjected to harsh conditions—component breakdowns are inevitable. Which is why the reliability of PCB assemblies remains very critical.

In our recent survey on soldering, we identified many challenges to address during the soldering process to ensure good solder joints. These include solder paste selection, thermal issues and reflow profiles, voiding, and component size variations, to name a few.

So for this month's issue of *SMT Magazine,* we talked to a lot of stakeholders in the soldering process to know more about the challenges from their perspectives, and the strategies that could help improve the process and achieve that perfect solder joint.

In our first feature, we have Indium Corp.'s Brook Sandy-Smith, Metcal's Robert Roush, and MC Assembly's Andrew Nunenkamp and Vince Burns in a wide-ranging discussion on the many aspects of soldering, from the solder paste, to automation, inspection, and the challenges in achieving reliable, well-made solder joints.

With the continuing trend towards miniaturization, and the move to design increasingly more components into ever-shrinking PCB real estate, visual inspection is no longer viable for board assemblies with these tiny components. Therefore, for this month's issue, I interviewed Vi TECHNOLOGY's Olivier Pirou to learn more about the developments in the SPI and AOI space to help manufacturers address their inspection issues.

From a reflow oven standpoint, Rehm Thermal Systems' Ralf Wagenfuehr shares the latest technologies they are incorporating in their systems to eliminate soldering issues, including voiding.

Enrique Moreno of JBC Soldering, meanwhile, highlights hand soldering technologies and strategies to create good solder joints.

I was also able to interview Jonas Sigfrid Sjoberg of Indium at NEPCON South China to find out how they are helping customers address their soldering issues.

Next, we have an article from Dr. Reza Ghaffarian, of the Jet Propulsion Laboratory, discussing the impact of surface finishes on the reliability of solder joints.

SMT Magazine is not complete without the expert opinions of our columnists in their respective industries. Read what Dr. Jennie Hwang, Michael Ford, and Tom Borkes have to say this month.

Last, but not least, I interviewed Mentor's Sven Patrik Eriksson about the critical challenges in getting meaningful data from the factory floor, manufacturers' journey to Industry 4.0, and the best approach towards its adoption.

I hope you enjoy this month's issue of *SMT Magazine*. Stay tuned next month as we talk about the PCB assembly challenges presented by HDI boards. **SMT**

Stephen Las Marias is managing editor of *SMT Magazine.* He has been a technology editor for more than 12 years covering electronics, components, and industrial automation systems.

The Role of Bismuth (Bi) in Electronics, Part 1

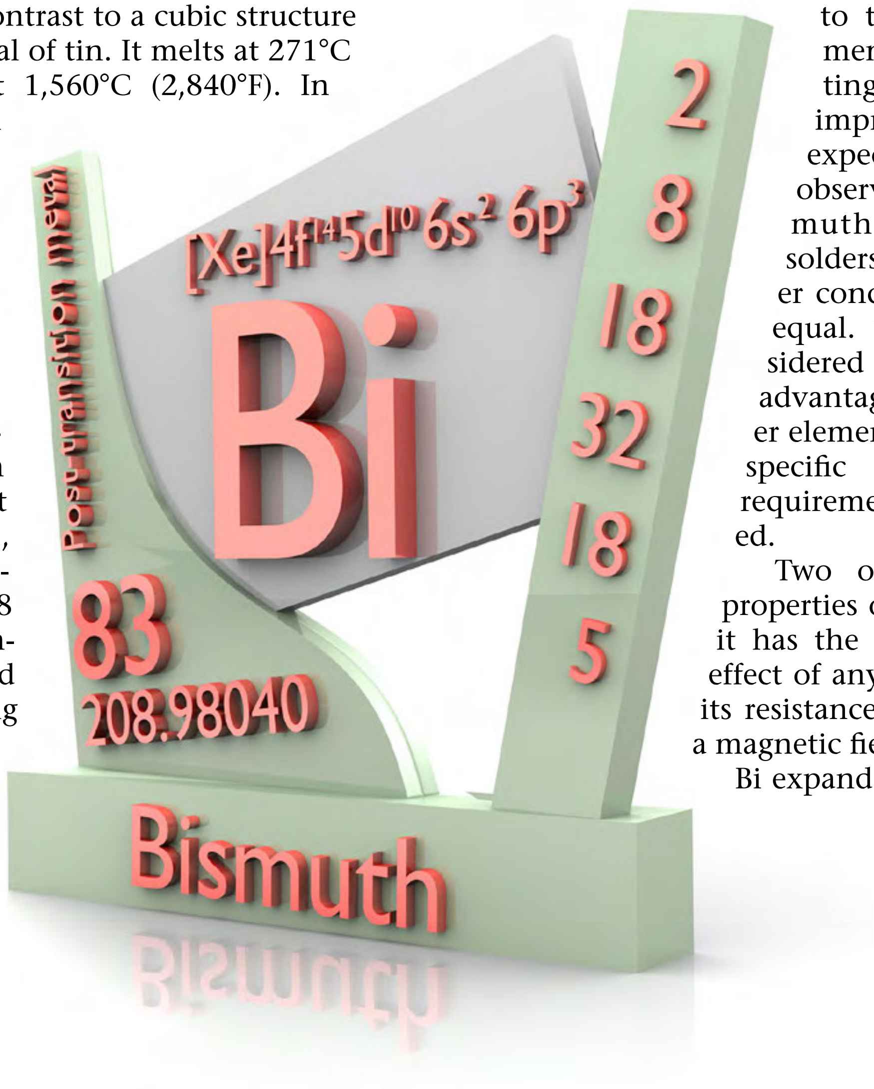
by Dr. Jennie S. Hwang
H-TECHNOLOGIES GROUP

Following the prelude for this series (SMT Magazine, August 2017), we now sequentially address the topics as outlined therein.

Elemental Properties

Bismuth (atomic number 83 and atomic weight 208) is classified as a metal. It normally appears as grayish white with reddish tinge and can be grown into colorful iridescent crystals. It is soft, but brittle. It has rhombohedral crystal structure in contrast to a cubic structure of lead and tetrahedral of tin. It melts at 271°C (520°F) and boils at 1,560°C (2,840°F). In comparison with tin and lead, its density (9.80g/cm^3) is higher than Sn (7.31g/cm^3) and lower than Pb (11.34g/cm^3).

With respect to conductivity, the electrical conductivity of bismuth is measured at 0.8 (10^4 Ohm^{-1} cm^{-1}) versus tin at 9.1 and lead at 4.8, and the thermal conductivity is around 8 (w/m-k, 300°K) compared to tin's 66 and lead's 35. Among metals, bismuth's electrical and thermal conductivity are the lowest. The coefficient of thermal expansion (CTE) is also lower than that of tin or lead, at 13.4 x 10^{-6}/C (Sn=22.0, Pb=28.9). The lower CTE can be leveraged as a useful property to design a proper CTE of solder materials.



Its lower surface tension (378mN/m, 270°C) than tin (574mN/m, 232°C) and lead (465mN/m, 327°C) is also a useful property, contributing to the improvement in wetting ability. This improvement is expected to be observed in bismuth-containing solders with other conditions being equal. This is considered a significant advantage over other elements when the specific performance requirement is needed.

Two other unique properties of Bi are that it has the greatest Hall effect of any metals (i.e., its resistance increases in a magnetic field), and that Bi expands upon solid-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Atomic Number	83
Atomic Weight	209
Density	9.80 g/cc (20°C)
Density	10.1 g/cc (M.P.)
Melting Point	271.3°C
Boiling Point	1565°C
Surface tension	388 mN/m(M.P.)
CTE	13.3/°C
Volume Expansion	3.32% on Solidification
Thermal Conductivity	0.020 cal/cm^3/cm/°C/sec
Crystal Structure	Rhombohedral

Table 1: Physical properties of bismuth (Bi).

ification by 3.32%.

Overall, bismuth's versatile properties make it an intriguing element to design alloys.

Table 1 summarizes the properties of bismuth.

Natural Resources

The level of natural resources of bismuth is about the same as Ag. Elemental bismuth may occur naturally, although its sulfide and oxide form important commercial ores.

It is found most in Australia, Bolivia, Canada, China, Japan, Korea, Peru, Mexico, and USA. However, Bolivia, Australia and China are the only lands where native Bi is available. Due to its lack of wide presence in the native state, bismuth is usually associated with copper, lead, tin, tungsten, silver and gold ores. Yet in China, a major proportion is associated with tungsten.

Bismuth has always been produced mainly as a byproduct, and its price historically reflected the cost of recovery and the balance between production and demand.

The world mine production in 2016 stands at approximately 10,000–11,000 metric tons, with major contributions from China, Vietnam and Mexico, and the world reserves at 370,000 metric tons (Source: USGS). The United States ceased production of primary refined bismuth in 1997 and is highly import-dependent for its supply.

Bi Safety Data

Bismuth is widely recognized by the scientific community as one of the safest elements available. In practical terms, it has been regarded as non-toxic. Its only regulated uses are in pharmaceutical and cosmetic applications. It was approved by US EPA/NSF for substitution of Pb in free-cutting brasses for drinking water fittings in the U.S. A number of literatures cover the studies of Bi and Bi-compound safety.

Table 2 lists the relative rank of toxicity per U.S. OSHA – PEL.

Application Areas

Bi-compounds have been used for burn bandage dressings, antiseptic powders, and the treatment of venereal diseases. As reported, other pharmaceutical areas engaging Bi-compounds include its use as a pre-treatment to reduce the lethal toxicity of several forms of cancer therapy and the use as an additive to special polymers for bone implants. In addition, Bi-Ge oxide crystals have their place in diagnostic devices by its virtue of neutralizing lethal gamma rays and improving overall imaging quality.

In the chemical world, Bi catalysts are widely used in industrial organic chemistry, and Bi-compounds are popular pigments for health and beauty care. Toys and industrial applications that require non-toxic yellow to red or green pigments also rely on Bi compounds. For example, bismuth oxychloride pigment's brilliance and luster is an effective ingredient to generate the pearlescent effect in lipsticks, nail polishes and make-up powders. Another compound, Bi citrate, is found to contribute to im-

Element	PEL (mg/m^3)
Bi	None
Zn	5
Sn	2
Cu	1
Sb	0.5
In	0.1
Ag	0.1

Table 2.

proved hair dyes. Additionally, bismuth is used in metallic paints and glass coloration products, as well as in heat/energy absorption coatings, such as solar panels.

For metal industry, Bi has been successfully used as a lubricant to steel and aluminum, improving the machinability of free-cutting steels and aluminum. In galvanizing, Bi in place of Pb has been used to increase fluidity of the bath and wettability of steel. This Bi function makes the lead-free galvanizing possible. Then there are "green bullets." U.S. Army engineers have been trying to develop lead-free, combat-ready cartridges since the early 2000s. Reportedly, more than 1,000 indoor military shooting ranges have closed because of the Pb-contamination problem and the resulting high airborne Pb-level. For this purpose, Bi is found to be a successful replacement for Pb.

For electronic applications, Bi-compounds are found to effectively improve and alter the properties of ceramic materials, such as lowering the processing temperature and improving the properties of varistors (zinc oxide). Bismuth telluride, a semiconductor, is found to be an excellent thermoelectric material.

Additionally, bismuth has been used in electronic solders, which will be the subsequent topics of this series. **SMT**

Dr. Jennie Hwang, an international businesswoman, speaker, and business and technology advisor, is a pioneer and long-standing contributor to SMT manufacturing since its inception, as well as to the lead-free electronics implementation. Among her many awards and honors, she is inducted to the International Hall of Fame – Women in Technology, elected to the National Academy of Engineering, named an R&D-Stars-to-Watch and awarded YWCA Achievement Award. Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., SCM Corp, IEM Corp., she is currently CEO of H-Technologies Group, providing business, technology and manufacturing solutions. She serves as Chairman of Assessment Board of DoD Army Research Laboratory, Commerce Department's Export Council, National Materials and Manufacturing Board, various national panels/committees, international leadership positions, and on the board of Fortune-500 NYSE companies and civic and university boards. She is the author of 475+ publications and several books, and a speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees as well as Harvard Business School Executive Program and Columbia University Corporate Governance Program. Further info: www.JennieHwang.com.

Vermes Highlights Piezo Technology in Microdispensing

Juergen Staedtler, CEO of Vermes Microdispensing GmbH, talks with I-Connect007 Managing Editor Stephen Las Marias about their latest innovations in microdispensing, and how their piezo technology is addressing the trend towards miniaturization in PCB assemblies.

Staedtler also discusses how microdispensing can complement solder paste printing in the SMT line.

Watch the interview here.

Achieving the Perfect Solder Joint:
The Many Perspectives on Soldering

by Stephen Las Marias
I-CONNECT007

For this month's issue of *SMT Magazine,* I-Connect007's editorial team brought several experts together for a teleconference call recently to discuss the many aspects of soldering, from solder paste, to automation, inspection, and the challenges in achieving the perfect solder joint.

In attendance were Indium Corporation's Brook Sandy-Smith, technical support engineer; Metcal's Robert Roush, product support engineer; and from MC Assembly, Andrew Nunenkamp, director of engineering, and Vince Burns, quality engineer and an IPC Certified Trainer.

We also talked about the strategies and parameters to consider to ensure reliable, good solder joints.

The Challenges

The first topic in the discussion is the challenge in achieving the perfect solder joint. When it comes to soldering and soldering materials, Sandy-Smith comments that the question she hears the most is regarding the type of flux that can be used to wet to unusual surfaces.

"Many times when people are soldering, they're not just soldering to a PCB with a suitable surface finish. In these cases, we often get questions about soldering to unconventional surfaces. When people are doing regular SMT assembly, I frequently get questions about what to do if the components are oxidized or if the surface finish on the component is difficult to solder to."

Roush, on the other hand, says many of their customers are very concerned about process control and throughput, and the balance between the two. Customers want to make sure that they're getting as much product through at a reasonable rate, but that they also want to ensure that they're minimizing scrap.

"They want to make sure that they're producing a quality product at the end. They're looking for guidance on training or advice on solder tip geometry selection and that type of thing. It really comes down to all the little pro-


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cess variables heading into forming that solder joint that we get the most questions for," says Roush. "There's just been such a trend in the industry for products to become denser, with more components in such a small amount of area that the boards and the thermal loads have just dramatically shifted over the years, and they're looking for more performance to be able to give off thermal energy into the joint to form something strong and reliable in a reasonable time. We get many requests for trying to optimize the tip geometries or temperature selection or one of the other factors going into it to really improve that process. There's only so much control they have over it. The tip geometry selection and solder, type of materials they're soldering to, and then the training of the operator all goes into this big mix. In the end, they're hoping that they're getting a good solder joint. So that's really what they're looking for.

Brook Sandy-Smith

"Probably the second most asked about trend is traceability. There's been a huge push in the last couple of years, especially among contract manufacturers (CM), to be able to provide traceability information to their customers for those solder joints. So, it's really that next generation of how to collect this data and do something with it."

One of the soldering trends nowadays is the move towards automated hand soldering. So, is this a method for improving joints? Roush says with all the variables associated with just the idiosyncrasies of operators—variation on the skill and experience level—a robot levels that playing field.

"What you can't replicate on a robot, at this point, is knowing when something is going wrong or there's an activity or a problem that crops up," he explains. "The robot is relatively dumb in that respect and it's just going to do exactly what you program in it. If its conditions change, for example, there's a bad batch of boards or there's something wrong with a component that's being put down, the robot won't know any better and will just continue to execute the program. So, I don't think they're going to totally replace it, but I see it more of a complement and a way to increase throughput."

But on whether automated hand soldering provides a better solder joint, there are definitely tradeoffs, according to Roush.

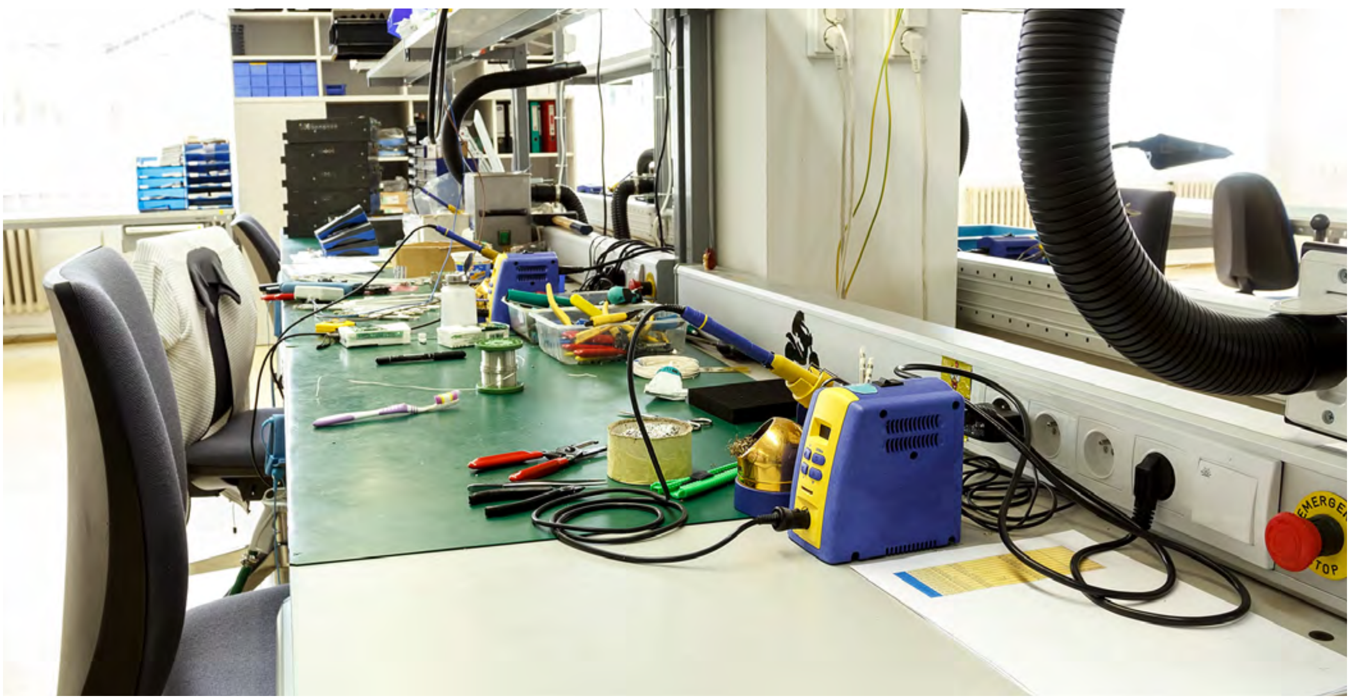
"There's some fantastic operators out there that are like machines, and they do a fantastic job of soldering. But I think that the challenge with robotic soldering is that for 99% of what's out there in the market, you have to program it on the safe side, and your tendency is to give it more time on the joints than may be necessary because you want to make sure that the joint is formed properly, because no one's watching it. So, the time on joint may be four or five seconds and you only need it to be there three; that increases the amount of time it takes to produce the board, and you're putting more thermal energy into the joint than you really need to, which can then impact IMC formation," says Roush.

One of the latest technologies from Metcal, the Connection Validation soldering station, provides operators with real-time, closed loop feedback to indicate intermetallic compound formation—the key to a good solder joint. With the CV, Roush says the power supplies are attached to a robot and have an application, and whether it's a hand soldering or robotic soldering application, the feedback from the unit will basically indicate to the operator or to the robot to move on to the next joint as the IMC is formed. "So, there's no real danger there of staying on the joint too long or dwelling too long on a single joint," he says.

From a contract manufacturers' standpoint, MC Assembly's Nunenkamp says there are pros and cons for all product development using robotic soldering irons and hand soldering irons. "Lack of a one-size-fits-all solution is part of the challenge. What Robert was referencing is spot on from the idiosyncrasies of the impact of an operator to the robot," he explains. "I have certain scenarios that I cannot put on that robot because I don't have the ability or the volume for it to be successful. I need to have trained solderers to successfully make those solder joints. We see volume-driven environments and Class 3 requirements are challenging robotics to be consistent, but then you have the visual validation factors as well or an automated system that can hopefully perform that inspection as well and meet IPC requirements. So, it's all about the tooling, the fixturing and the alignment pieces that come with the robotics. We had a high volume product that worked very well on the robot. Some of the variations that we run into though is if a no-clean solder is required, we have to change over requirements or needs for additional equipment then.

"So, in a contract manufacturer's world, it really depends on the size of the customers' need and their design. We have other scenarios that we're looking at right now, for example, that require some very detailed soldering efforts that are very inconsistent when you put it on and depend on the people to do it. We could get some more consistency out of the robot once we get tooling in place and design of fixturing and supporting the components that you need in play. It is a significant investment to go that route. There are pros and cons in each direction and the application is really depending on that answer. So, if we're building high-volume cellphones, you would have a different conversation, but if we're building lower-mix, medium-mix or low-volume products to mid-volume products, then we have a little different approach to it."

From an assembler's point of view, the greatest challenge when it comes to solder joints is, according to Nunenkamp, is physically getting the IPC knowledge to the point of making the right judgment call on quality rather than personal preference. "The insufficient viewpoint, the non-wetting calls, the things that are considered defects in the world of IPC are getting that trained eye and knowledge instilled in the people that we need so that they can create the good solder joints and then can agree with the inspector's eyes as well," Nunenkamp explains. "Obviously, driving inspections back to the operator that's making the joints is our preference so that we don't double up our effort, but that's really one of our largest challenges. Then, I think the other piece of the puzzle is getting them to use the tools that are made available and adequate for the job. The thermal energy that Robert talked about is one of those challenges that continues to be around, but you might use a pre-heater, you might use an alter-



nate heating mechanism to get that thermal energy that you need in the actual product before you start soldering, or during the soldering operation as well. Their previous experiences can plague it a little bit right where they've never had to do this before or they've only done this in a leaded environment. We're now going to a lead-free environment with a couple other copper layers in the circuit board or a challenging thermal component, and really getting that innovation in the soldering development process versus the way they've always done it before is the challenge.

Solder Paste Printing vs. Jetting

For volume production, assemblers still prefer solder paste printing. "The majority of it is screened down," says Nunenkamp. "We have looked at the ability to dispense solder; it's been a finite example that hasn't been needed across the board. I would say right now, we're about 99– 100% screening. At this point, our jetting focus would be for design-specific requirements or possibly in a rapid prototyping environment where stencil cost isn't insurmountable today and the management of stencils isn't significant because the infrastructure's been in place for years. Our stencil supplier is around the corner, the next driveway over, so locale and accessibility to the stencils isn't a significant issue for dry versus a jetting need—unless a design or prototyping solution would drive that, and that would have to be really a volume driven prototyping effort that from a timing perspective won't allow for stencil creation or things like that where we have enough process development executed and knowledge base developed in our stencil."


Robert Roush

"We have products that are developed for jetting and it's been a hot topic in the last few years. However, I haven't seen it as quickly adopted as I thought it would, and I think it's because it's targeted toward very tiny deposits," explains Sandy-Smith. "In 80% of assemblies, if customers are switching from tin-lead to lead-free, they're not using aperture sizes that are that small, not even less than 12 mil squares. So, you don't find any challenge with stencil printing and there isn't a push to move to jetting, but for customers trying to print very small things, I see jetting being considered. The other interesting application for jetting is finding jet heads in SPI systems, so that when you find an insufficient deposit, the jetting head inside the SPI machine can add a little bit of paste where it is needed. I think jetting is a great application right now, but I think it's going to take some time for the miniaturization of printed circuit boards to really push us to using it on a wide scale."

"Another consideration from a solder joint standpoint is that with more oxidation and finer powders, reflow has a more pitfalls or it's more challenging," says Sandy-Smith. "So, with finer and finer deposit sizes and smaller and smaller components, there might also be limits that we can reach as far as solder joints becoming so small. You might not be able to use air reflow or it might change other processes, so the issue is not just how you deposit the solder paste."

Customer Collaboration is Key

Close cooperation or collaboration between customers and suppliers always yield the best results in the SMT industry. Sandy-Smith agrees. "That's most of what I do. I test our solder paste fairly rigorously when we have a new solder paste so that I can make sure we get the product and process recommendations out to our customer base," she says.

"From a very basic standpoint, when the goal is to form a good solder joint, it's critical to have clean surfaces that are not oxidized. It's critical to have a flux that will stand up to the thermal profile that you're expecting to put it through, and it's also critical to keep all the surfaces oxide-free so the best metallurgical connection can be formed. It is important to choose the right alloy to meet your process and the temperature limits that you want to conform with. These three things are really important when I'm thinking about which prod-

uct to choose for a customer. For most lead-free assemblies, there are few basic materials that really work well. The other big question to ask is whether you're going with a no-clean process. Where you process the paste and the amount of thermal energy put into it is going to render the flux benign. If you're planning to wash off the residue, you should still use a no-clean paste and wash it. There are also water-soluble pastes that that can be washed off with just water."

Customers often follow the components manufacturers' recommendations at the starting point in their board designs—for instance, how a land pattern should be put on the board for a particular component. This results in a manufacturing challenge for the assemblers. "We have to be innovative on our manufacturing capability or ability to make solder joints for them because they want the smallest pad possible or they want the least voids possible in the bottom terminated components because that affects the performance of those components," says Nunenkamp. "So, what can we do from a manufacturing perspective to ensure that happens? Do we innovate in the pad design, and adjust our process and really narrow our process window so that we're successful every single time? Those are the types of things that they expect from us. Just getting that quality solder joint to fill its size and consistency is our target. So, if you can give them feedback upfront, we're going to have a little bit better possibility. We utilize software rules to give that feedback and identify a rule set that would provide consistency for us or highlight the nuances of those small solder joints that Brook was mentioning. The other day, I found a board that was going to give us 7.8 mil solder pads, which is going to provide challenges in our stenciling process. They don't want to change the pad design, so I have to alert them that I have to change my stencil thickness to support that release properties and adequate soldering requirements. Those are the types of things that we can give design feedback on to ensure success and quality products in really a timely manner for our customers."

"The other day, I found a board that was going to give us 7.8 mil solder pads, which is going to provide challenges in our stenciling process."

"I would agree with that," says Sandy-Smith. "Many times, if you look at the root cause from a design choice that was made, the issue stems from the board designer and it's something that they can't change. So that's what pushed us to develop materials that go above and beyond to really fix QFN voiding or BGA warpage-induced defects. For instance, in the case of a bottom terminated component like a QFN, if there are plated vias in the pad that are very large and they're not plugged, the right amount of solder paste can be put down, but the paste will flow into the vias and end up with very high voiding in that part. Aside from adding more solder paste in this case, there isn't really a way to get rid of the voiding. If you could go back to choose a different via design, you could fix the voiding issue entirely. But if you can't change that design, then you have to find material solutions that go above and beyond in order to reach the goals that you want."

Vias, and Other DFM Challenges

Speaking of vias, designers most of the time put the via in the pad and don't bother to even think or ask questions about what happens to the solder paste during reflow.

"There are times where someone came to me complaining of high voiding just on this one component, so we did a lot of research or we got them set up with a low-voiding material. Then, when we looked at the actual X-rays and found that there were huge vias that pulled the solder away from the solder joint," says Sandy-Smith. "Often, people don't realize that they need to do a cross-section because it's hard to measure stand-off height for these components without doing destructive analysis. Because everything is underneath the component with bottom termination components, people don't think three-dimensionally about them. It's easy to miss these kinds of failures because they're not as apparent—you can't see them with your naked eye. I think there's a big gap between the way the designer is thinking about the design because they're very concerned about the way the connections are being made inside of the board with all of that complexity. I don't think they're always thinking ahead to designing for manufacturability."


Andrew Nunenkamp

"We talk to a lot of process engineers as we're developing our tools and one of the things that's really become interesting for us is that the electronics assembly process, with some exceptions, is not really a discipline when it comes to engineering," says Roush. "What you tend to talk to are either electricals or mechanicals that have been learning bits of the other person's profession, and there's a lot of interaction going on. So, the mechanicals may understand how to physically assemble stuff, but there's some electrical considerations that they're not maybe aware of or that they've forgotten. There's really been a blending of these process engineers where it's predominately mostly during the on-the-job training (OJT) where they've got to figure this out as they go along; if they're lucky, they've had somebody who's dragged them along in their learning process. What's really been interesting is we've talked to people over the last couple years and heard what's going on and how they're solving the problems, and their approach to solving that problem."

Burns notes that they have seen the same issues across a variety of customers when it comes to BGAs and bottom termination components.

"As a CM, a lot of times we'll catch those things because we're looking for it as we know the issue. So, if we catch it during our review upfront, then we can talk to the designers and try to get them to change those designs. Sometimes we're successful and sometimes we're not, but part of that issue goes back to the basic education of the engineers. How many engineers, either electrical or mechanical, study solder and the flow properties of solder when they go through school? You know, getting their bachelor's degree even at that level. There's not a whole lot of understanding necessarily by the engineers that 'Hey, this solder is going to flow somewhere and it's going to go down this hole.' They may not even think about it until they get that OJT and that education in the field. It would go a long way toward getting the design engineers educated upfront in the properties of the materials that are going to be involved in this system, because they don't have any clue or they don't even think about," Burns explains.

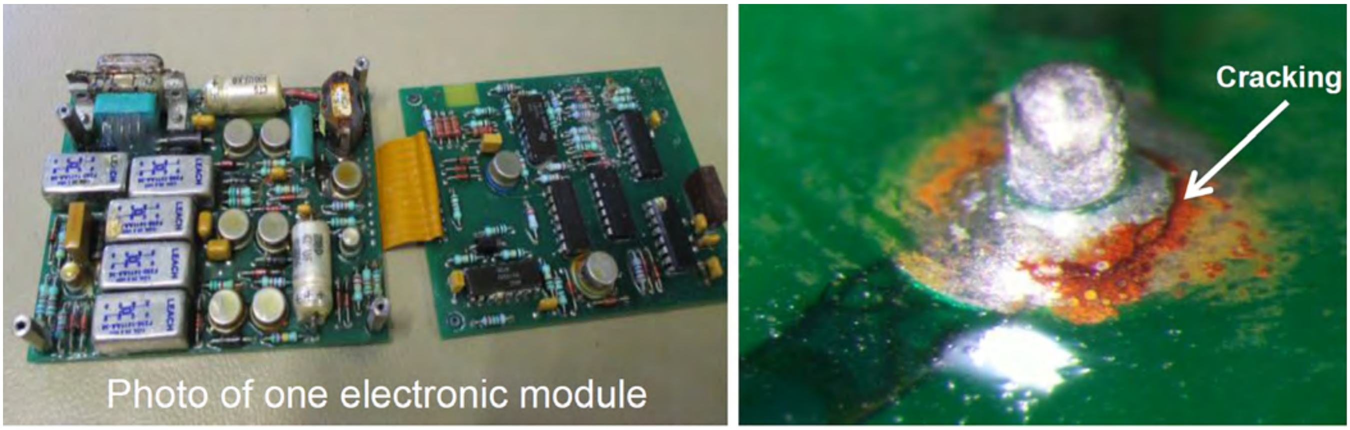
"Some of these new circuit components are purposely warped before you actually apply heat, and then they relax into a flat state once they've had heat. Some of these new packages are extremely challenging and getting more so," says Roush. "I know that the designers' incentive is to pack more density in there and get more processing out of smaller spaces, but where we come in to play in that realm is rework. You know, they've spent all this time in development and then they say 'Well, we can't launch it until you can prove that you can fix it,' and there's quite a few hoops you end up jumping through at the end of the day to get it to work where you're manipulating custom stencils, or sometimes, we've had to go out and design entire machinery just to be able to support some of the applications out there because we know that when our customers come back to us and say, 'We're trying to rework this component and no one else can do it' or 'There's just not a solution in the factory.' It takes a lot longer to get the part's acceptance in the industry, and that's really the challenge. We've done it over the past couple years where we've done evaluations, and I'm just now seeing them show up on boards. It's taken that long to get the acceptance and I think part of it is that you can work out all that you know. How do you run through the oven and the materials and everything else, but when it goes wrong on that rare occasion, how do you rework it when you have to start from scratch? It's not an easy solution all the time."

The challenge is not only with the surface-mount components that are getting even smaller. "We also have the other end of it where we have the through-hole side and parts that are bigger and boards that have multiple ground planes," says Burns. "When you get into very, very thick boards with a lot of ground connections, power planes and a whole separate set of issues with the heat profile and the thermal transfer, you need to get an adequate solder connection. We've had some instances where we've tried to hand-solder things and there's so much thermal mass that it makes it virtually impossible. So, a designer adding the thermal mass and the thermal planes for the circuits to operate correctly doesn't always lend to good solder connections or ease of process for soldering. We try and automate the things as much as we can through wave solder or through selective soldering process, just to give us the advantage of the mechanical push of the solder up through the holes in addition to the heat. But the thermal planes are a huge issue. The other issue on that is the same concept that you get with the pad geometry in surface-mounts. You have to make certain that the hole side, the diameter of the hole and the diameter of the leads aren't too close together so that you have enough room to physically allow the solder to move through the hole."

Roush says pre-heat helps to address the issues with dealing with thick boards. "Redesigning some of the tips, we've spent a lot of time in the past few months really looking at that as we've done testing in other areas, and found that through the course of the matter, getting barrel fill in the through-hole is really an ongoing issue. We've had customers who had never cross-sectioned their boards and they thought they were doing a pretty good job, and realized that they were actually not getting the barrel fill they thought they were getting. I think, sometimes it comes down to a little patience from an operator's standpoint. We've found that because they can see the top where they're going to feed the solder in if they're using wire and it looks like it's re-flowing, they're not patient enough to let the thermal energy go all the way down to the bottom of the barrel before they start feeding solder and then when it backs up they think it must be full," he explains. "There's a little patience involved in that, which doesn't necessarily come through until you have enough experience to realize that you've got to get that energy all the way through the barrel and the corresponding pin location. But pre-heat definitely helps and then re-looking at how the tip designs are done. I know the tendency is to use a small selection of tips to do a majority of the jobs, but in those applications, redesigning or doing something that's a little outside the box or custom to that application may help get more thermal energy in there more efficiently. We've seen a growing trend of that. We've seen that we've guided customers into different tip selections because they're doing that through-hole application and they weren't patient enough and they needed more energy to get there, and that was the end solution. It's a combination of tip geometry, asking them to just wait even a fraction of a second longer than they think they really need to, to allow that thermal energy to soak through."

> **"One of the main points we touch on in the soldering classes that I teach is being patient."**

Burns agrees. "Patience is a big thing. One of the main points we touch on in the soldering classes that I teach is being patient. I can give you an example but sometimes even that doesn't matter when it comes to some of these designs. We had a board out here that the operator couldn't get to flow, so I walked down and watched the process. In this case, we had two different soldering systems, and we were using the highest thermal energy tips we have from one of the systems. Two tips at the same time on the board. After about 40 seconds, we could get solder to flow through the hole. So, a significant amount of patience, a lot of time, a lot of



Electronic module of the rudder travel limiter unit. (Source: National Transportation Safety Committee, Indonesia)

effort, and it just wasn't happening. So that's the kind of design issue that we're dealing with. The tools are fantastic for what they do, but the thermal mass of this board is so heavy that there's just nothing we can do with it."

To address the issue, Burns says they used a selective soldering system. "With the selective solder system, you have a lot more advantage because you have the heat of the solder pot plus you can push the solder through the hole. That was our solution in this case. But if we have to rework those, we'll have huge problems. The components that are on this don't allow us to use a pre-heat system just because of the design of the component. Flipping the board over and doing the bottom side just is not effective," he explains.

Ensuring Solder Joint Reliability

Sometimes, the reliability of the solder joints is what stands between life and death. In a plane crash a few years ago, the investigators found out after a year of investigation that the main contributor of the crash were cracked solder joints on a PCB of the rudder travel limiter unit. The cracked solder joints resulted in a loss of electrical continuity to the rudder system, leading to its failure, and the fatal plane crash.

"I'm familiar with that case," says Roush. "As a point of fact, I have pictures of it and pictures of the solder joint, and the example I'm looking at looks like it's a through-hole component and you can see the joint, but if you look at the actual solder fillet that's supposed to have been formed, it's not formed correctly. So, it looks like improper assembly and then improper inspection. They didn't solder it right and then they didn't catch it in inspection. A combination of things happened. It's a poor-looking solder joint and I don't think anyone who's done any length of soldering would have found that acceptable. So, it just goes to show that keeping to the basics a lot of times of forming a good solder joint are what can solve the problems."

"I think it's critical to choose a material that fits your application and then process it properly, which seems like a no-brainer, but the inspection is also critical," says Sandy-Smith.

"I agree with all the comments I've just heard," notes Burns. "From our perspective, ideally the automated processes are going to work properly; we select the right materials, we select the process, we select the profiles, we run everything and it works fine. Then we do inspect to a point depending on what the product is. If it's aviation, anything aerospace or anything critical, typically we have 100% visual inspection at that point. A lot of the commercial products, not so much because if you inspect, you have a lot of costs and a lot of time, but any of the critical systems are inspected 100%. The other end of it is training of the operators that are doing the hand soldering. You have to have people that are trained to solder correctly and to recognize what a good and a bad solder connection really is, including your inspectors. So, if your operators are all trained properly and your systems are working properly, that type of thing should be an extreme rarity." SMT

MilAero007 Highlights

Cirtronics Enhances Inspection Capabilities

EMS firm Cirtronics Corp. has selected Nordson DAGE for its Quadra 5 flexible X-ray inspection solution.

Saab and Adani to Collaborate on Aerospace and Defense Projects in India

Defense and security company Saab and Indian infrastructure conglomerate Adani Group announce a collaboration plan within aerospace and defense in India, aligned with the Government of India's Make in India initiative.

Jabil First Customer for Nano Dimension's Commercial 3D Printer

Nano Dimension Ltd's wholly owned subsidiary Nano Dimension Technologies Ltd has signed an agreement with Jabil Inc., its first commercial customer.

Sypris Posts 17% Growth in Q2 Revenue

Revenue for Sypris Solutions increased by 16.8% sequentially to $21.2 million for the quarter, while gross margin expanded to 7.5% from a loss of 3.8% in the first quarter of 2017.

Raytheon Partners with Ducommun to Build Naval Strike Missile Fire Control Systems

Raytheon Company has selected Ducommun to build fire control systems for the Naval Strike Missile, or NSM, an advanced weapon that Raytheon is offering for the U.S. Navy's over-the-horizon requirement for its littoral combat ships and future frigates.

Stadium Group Acquires PowerPax UK

Stadium Group announces that it has acquired the business and assets of PowerPax UK Limited.

Sparton Reports Positive Fiscal 2017 Q4 Results

Sparton Corp. has announced consolidated net sales of $104.4 million for the fourth quarter ended July 2, 2017.

Plexus Completes Fourth Annual B.E.S.T. Competition

Plexus has announced the completion of its annual Bringing Employee Successes Together (B.E.S.T.) Competition.

VirTex to Host Manufacturing Day Event

VirTex is excited to announce that they will take an active role in this year's industry recognized Manufacturing Day. They will be part of an organized network of manufacturers to open their doors to showcase visitor's manufacturing, engineering, and innovation in action, inspiring the next generation to learn from a truly visual experience.

Moving Toward the Zero-Defect Line: An Interview with ViTECHNOLOGY's Olivier Pirou

by Stephen Las Marias
I-CONNECT007

For this month's issue of *SMT Magazine,* I interviewed Olivier Pirou, Chief Operating Officer of Vi TECHNOLOGY, during the NEPCON South China exhibition in Shenzhen to learn more about achieving the perfect solder joint from the point of view of an inspection systems provider, and how manufacturers can strategize to achieve a zero-defect line.

Stephen Las Marias: Olivier, from your perspective as an inspection technology provider, what should a perfect solder joint look like?

Olivier Pirou: We have an IPC standard describing what is the acceptable quality level of a soldered joint, and more generally speaking, what is a good printed circuit assembly. Beyond the quality aspects, especially in very stringent environments such as automotive or harsh industrial conditions, your solder joint will need to be the most reliable possible. It's a combination of geometrical features, and mechanical structure of the long-term reliabilities in a joint.

Las Marias: What are the parameters for perfect and/or reliable solder joints?

Pirou: Many parameters are involved in the printing process, the pick-and-place process, the reflow process, to make the perfect assembly. All those conditions are even getting more complex, where a lot of different materials are involved, being consumables or component supplies, and operating conditions within the factories that are different from one to another.

The approach that Vi TECHNOLOGY is taking to enable the zero-defect line – we should probably say the Six Sigma line – is to make sure that each individual process operates within controlled process limits.

For that, we need outstanding Quality sensors, I would call them, after each process—the printing process, the pick-and-place process, and the reflow process, to make sure that all the relevant parameters are monitored, all the

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processes have a closed loop to make sure that any deviations in the process are caught before the defect appears, and that this is sufficiently agile for the line operator and line supervisor to use. By outstanding quality sensors, we also mean an SPI/AOI inspection that has no noise: no machine noise (often referred to as false calls) or human noise often referred to as (false accepts)

In addition to making sure that each individual process is and stays within control, we add a smart layer that is the combination of information of quality sensors to remove the noise and ultimately add onto the test and quality coverage.

This is really what we're aiming at quite successfully with our 3D SPI, 3D AOI and SIGMA LINK Suite —offering quality sensor excellence through very easy to use and automated equipment, capturing the entire defect spectrum of the processes, making sure that we take most of the correlation between printing, pick-and-place, and reflow process to operates within the Six Sigma boundaries.

Las Marias: Is it like the Industry 4.0 approach?

Pirou: Exactly. With Industry 4.0, you have the combination of horizontal and vertical communication. What we just described is the horizontal approach. Then you have the vertical integration, which ensures that if any of the deviation is occurring within the line, you have a strict control of what needs to happen. If something goes wrong, you have the connection with the MES to decide. The idea is, within that information hub, to link up horizontally in the line and vertically towards MES or other customer systems to have smarter operations

Las Marias: Olivier, what soldering problems continue to persist?

Pirou: Miniaturization is in there. The printing process has its challenges with the increasing miniaturization, and more complex assembly processes, so we still see soldering issues. 3D SPI today is making even more sense in this type of environment. But the same is true for pick-and-place and reflow because the components that are placed are very different from one another. These, and various applications that are requiring, even for the end customer, increased integration. The end device is getting smaller as well, and on top of all that, the Z-dimension is getting even more important—even critical—in some environments. Critical measures for X, Y, theta, and Z in the automotive environment, for instance, are very important. The automated optical metrology has never been so justified.

Las Marias: Is having an X-ray capability important nowadays?

Pirou: Indeed, it's getting important. It always has been important in the failure analysis, but most of the problems are consequences of up-front processes that have not been under control. To us, making sure that all individual processes are operating within the limits, that were set to have a good assembly, are essential. In that case, you can probably avoid a lot of downstream controls. Seeing the voids at X-ray doesn't help very much. The real key is to avoid voiding.

But the X-ray can build redundancy in the quality control chain especially when it is intelligently coupled with AOI or SPI technologies. But again, we believe that it's a process-by-process approach combined to have greater control. We don't believe that there is one single point inspection strategy or electrical test strategy that would replace or be superior to all the others.

Las Marias: Definitely, collaboration is important.

Pirou: Collaboration is important. You see the whole industry moving to greater connection. there's this Industry 4.0 global initiative that now leads all equipment manufacturers to link together.

Las Marias: Olivier, can you explain some of the latest innovations from Vi TECHNOLOGY that would help customers ensure that their solder paste and solder joints are reliable or perfect?

Pirou: Sure. As you know, with our PI Series system, we're leading the way in fully automated 3D solder paste inspection. I think PI really offers superior value in terms of ease of use with unmatched metrology capabilities. Because beyond the quality of the metrology, of the machine, what we embed in that is really the ease of use. It's an auto-programming machine. We're going also in that direction for 3DAOI. Because most of the players will go to a fully-automated line, nobody really cares to program an SPI machine or an AOI machine or an X-ray machine. If it's auto-programmed, if the limits are well set, if we have a mechanism to stay within process limit boundaries, it would save a lot of time and cost to our customers and, at the end of the day, increase quality.

"If it's auto-programmed, if the limits are well set, if we have a mechanism to stay within process limit boundaries, it would save a lot of time and cost to our customers and, at the end of the day, increase quality."

This is what we do with PI. Of course, the same applies to the 3D AOI that we've introduced last year. The main innovation that we've brought to NEPCON is Sigma Line, and this is the correlation between 3D SPI and 3D AOI, to make sure that we have a mechanism to auto-adjust tolerances between all inspection sensors in the line.

Las Marias: It's like one, smart loop?

Pirou: Yes. Closed loop at the process steps, and a smarter loop linking all the quality sensors together in the line, which are 3D SPI, 3D AOI, pre-reflow, and post-reflow.

Las Marias: There are still companies who are using 2D AOI and 2D SPI. How do you encourage them, and what is the justification for them, to move to 3D technology?

Pirou: At the end of the day, it's all about customer requirements and test coverage. There is not always a reason to exclude 2D to 3D. All the players are using mathematical algorithms that are a combination of both. 3D is a great enabler to simplify programming and to expand test coverage, but this shouldn't be at the expense of a lower 2D capability. If you take the example of, for instance, the lighting automotive industry, they have very critical 2D measurements to make sure that the optical path of the LED is well aligned. A centroid is compared to other features on the board, being a point, being a line, or whatever, with advanced metrology capabilities, you can achieve the accuracy and the reliability required for such applications. As I said, the best technologies today are combining the best of both worlds to serve the customer requirements for what is critical to the process and critical to the end-user application.

"If you take the example of, for instance, the lighting automotive industry, they have very critical 2D measurements to make sure that the optical path of the LED is well aligned."

Las Marias: Over the past few years, we've talked to a lot of people and companies, and everyone's very optimistic. They're saying that last year there was a downturn, but at the end of last year it started picking up, and this year growth is continuing. Are you also experiencing it on your side?

Pirou: Yes. We see, as far as inspection is concerned, that this is one of the best ways today to guarantee quality at individual process steps. This is creating value for customers. Everybody wants to move towards the Six Sigma line. Inspection is a great enabler, and yes, we see that we are one of the few to really contribute to that better yield enhancement with customers.

Las Marias: Is there anything else we should be talking about?

Pirou: Moving towards the Six Sigma line in an ever-smarter factory is a very exiting topic. The world is moving fast in that direction which makes our industry much more interesting.

Las Marias: Thank you very much, Olivier.

Pirou: Thank you for your time. **SMT**

Gary Tanel Discusses How SMTA Helps the Industry Evolve

At the recent SMTA International 2017 exhibition in Rosemont, Illinois, Gary Tanel, president of the SMTA Dallas Chapter, speaks with I-Connect007 Publisher Barry Matties on a myriad of topics, including the goal of the SMTA as an industry association, and how it is helping the industry evolve.

They also discussed challenges and strategies in bringing more young people to the industry, as well as why they should be involved with the SMTA.

Tanel, who has been the president of the Dallas Chapter since 1994, also talks about their chapter, their activities, and how it is helping individual members grow their interpersonal and leadership skills.

Watch the interview here.


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Counterfeit: A Quality Conundrum

by Michael Ford
AEGIS SOFTWARE

There is an imminent, critical challenge facing every manufacturer in the industry. The rise in the ingress of counterfeit materials into the supply chain has made them prolific, though yet, the extent is understated. What needs to be faced now is the need for incoming inspection, but at what cost to industry, and does anyone remember how to do it?

Going back 20 years, the incoming inspection of materials was common throughout the electronics assembly industry. At that time, component material and production technologies were relatively new, with sizes beginning to diminish, led by design pressure, which gave rise to what we would now regard as frequent failures. Having to repair or replace circuit boards after assembly, or later once assembled on the main production lines, was a very expensive challenge. I saw numerous cases of production lines where epidemic rates of material-related quality issues had been detected, and it was decided to simply remove the defective products from the line so that the line could continue while the products were being re-worked. Unfortunately, the re-work rate was often longer than the rate at which defects were discovered, resulting in significant stock-piles. Once, to compound the problem, visitors were due to be touring the plant the next day. Local companies selling very large black sheets saw their sales sky-rocket, as defective products in the factory were hidden in every place conceivable.

The situation was not a one-off. This was daily life at so many manufacturing sites back in the "wild West" days. To be fair, faulty materials were not the only contributor to defect rates that were so bad, a quality manager today wouldn't allow the factory to produce a single thing. Assembly processes, especially SMT,


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itself a relatively new technology, were also quite variable in those days. Materials, however, were the one thing that could not be controlled or addressed by industrial engineering practice. The solution, as we would say today, was to "left-shift" the problem into the material receiving operation. There, materials could be measured and inspected as they were booked into the factory, so as to engender confidence that they would be fit for production and not contribute to assembly line failures.

> **The solution, as we would say today, was to "left-shift" the problem into the material receiving operation.**

In fact, a great deal of testing also ended up being introduced at many stages in the production flow, as the final assembly line became the one thing in the factory that must not stop, as it would cause delivery issues to customers. Increased forms of in-line testing and inspection, including automated methods such as ICT, AOI, etc., became commonplace and continue to be regarded as essential. Segmentation of production areas, each with associated buffer stock, also became common. The increased cost to manufacturing was quite severe and contributed in no small way to manufacturing moving overseas to areas where the labor needed to perform all of these enhanced tasks was cheaper.

In the wild West, however, action still needed to be taken to reduce the costs of test and inspection as much as possible to keep what little remained competitive. As far as incoming inspection was concerned, manufacturers started to extend relationships with material suppliers to provide guidance on expected quality levels and provide help and training in sampling and testing so that suppliers could take ownership of the quality of their materials. Once a degree of control was established, contracts were put into place with responsibility for material defects to be placed with the supplier, relieving manufacturing progressively of incoming inspection tasks. The impact on the business of manufacturing was significant, which went beyond the labor saving.

With reliable material quality and supply, buffer stocks could be reduced and handling decreased. The age of efficient, Kanban and just in time (JIT) material delivery was enabled. Traceability was positioned as the police force of the supply-chain, as it could in theory assign responsibility for material defects found in manufacturing and beyond, back to the material supplier. In some cases, this happened successfully for those who took traceability seriously, utilizing the specialist software tools needed for complex production processes from multiple vendors with huge bills of materials. With relationships and trust in place between material suppliers and manufacturers, incoming material inspection has become almost redundant, providing significant cost reduction, which has already helped to tip the balance for the on-shore business case for manufacturing.

That is, until now.

It is discretely known by many key companies in the industry that the incidence of finding counterfeit materials in products is rapidly on the rise. They can be re-marked integrated circuits or passive components, even laminates within PCBs. Today's counterfeiters are smart, buying used machinery on the open market for the cleaning, marking and re-packaging of discarded, obsolete, life-tested or inferior materials. Some of the tampering can be visible to a trained eye; odds are, however, that some cannot. The growth of this issue, it is said, could potentially destabilize trust within the industry. The use of effective traceability throughout the manufacturing process is a key weapon against counterfeit supply, as any instance where a counterfeit material is discovered during internal testing, inspection, or even in a failed product in the market, can be traced back, without doubt, to the source. Though this insurance is in place, the disruptive effect of counterfeit materials and the loss of confidence in quality has not been addressed, leading to the re-visit of

the question of "left-shift," that is the reinstatement or increase in the level of incoming inspection.

There are two problems associated with this. Firstly, there is the cost of labor. Adding indirect costs to manufacturing, after having enjoyed a good period of time without them, is going to be hard to accept. Then, there is the requirement of the skill and experience levels of those people who specify, manage and perform the tests. Even if we could find experienced people today, the cost of hiring engineers with degrees who know about the various statistic dependent sampling rules and test result interpretation is going to be significant. In-house experience is likely near to zero. It will be an uphill battle. To do nothing, however, would be like a ticking time-bomb. To raise the issue openly and vocally would invite a loss of confidence from customers. To put into place an active solution within manufacturing is a compelling alternative, so long as there is a positive cost justification. In other words, the ROI is not just based on what disaster may or may not someday happen.

"We are, after all, in 2017, so we should be looking for a smarter, modern solution to this problem."

We are, after all, in 2017, so we should be looking for a smarter, modern solution to this problem. Rather than looking at each individual element of the problem separately, it is better to create an overall specification for a material logistics system that will satisfy all of the key needs of the business. On the shopping list needs to be incoming inspection support, material logistics management and traceability. Especially in the electronics assembly industry, the solution needs to include support and understanding of complex processes, achieved by connection to automated processes, such as SMT machines, robots and associated inspection and test equipment. The combined singular solution then yields a net benefit for manufacturing, rather than representing an additional cost. Justification of the complete solution is then so much easier than trying to get disparate solutions working together in an attempt to address the business-critical need for quality.

To find a holistic, singular solution for the entire shopping list is the goal. In electronics assembly, a great deal more than 80% of materials are placed today with SMT machines, which are very complex with respect to the way materials are used and consumed, especially when considering dual lanes, multiple modules and materials that exist in multiple instances. These same issues actually also apply to the latest assembly process robots, as well as some manual processes.

To gather accurate traceability data requires precise communication with the machines themselves. Of course, machines in isolation don't usually understand what the materials are, other than their shape, so continuous reference to a material identification, logistics, and management system is required, including the unique identification of each instance of a material carrier. It sounds like a lot of work, until you consider the values that can be gained. Typically, using Lean material logistics, shop-floor material stocks can be reduced by between 75% and 95%. With accurate accountability of material usage and spoilage, unexpected material shortages can be eliminated, leading in most cases to a vast reduction of buffer stock in the warehouse, which can double the number of material turns.

The saving of material investment, plus the ability to utilize the process and material traceability data for active quality management already yields a significantly short ROI. It is therefore not necessary to justify investment in the software by talking only about potential disasters. With the built-in specialist support for incoming inspection, where the rules and guides are already a part of the software, performing the various tests and inspections can now be done with a regular production operator skill level, trained only to follow the easy-to-use guides.

The materials are already uniquely labeled. The infrastructure is in place to manage any deviations or defects in material performance.

There are now two active tools against counterfeit materials in manufacturing, made possible in a way that brings business benefits every day, plus, has the potential value of being able to avoid catastrophic quality events due to counterfeit materials, quickly and quietly managing any minimal consequences that may have occurred. This is the smart way to move forward. It is time to become aware of the latest modern smart software for manufacturing out there. The default options of enterprise resource planning (ERP), and perhaps a simple manufacturing execution system (MES), will not provide the specialist tools needed in this new world that we made for ourselves. Look around now for your smart logistics solution that addresses what some say is the most serious threat to the industry that there has ever been. Look also into your own life—the flights you take, the car journeys you embark on, the medical devices you depend on in times of need, the controllers of the nuclear power plant that is supplying your electricity, and all the other electronic aids that are now an integrated part of your life. To what degree of tolerance are you willing to accept the risk and consequences of counterfeit materials? **SMT**

Michael Ford is the European marketing director for Aegis Software.

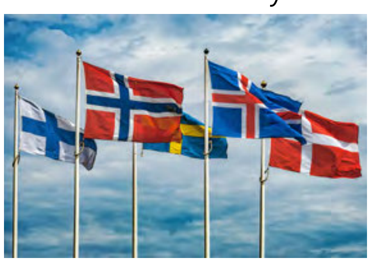
What's Up in Scandinavia's EMS Industry?

By Dieter G. Weiss, Weiss Engineering

Scandinavia, consisting of Denmark, Norway, Sweden, and Finland is relatively small in regard to the overall European EMS revenues, and counts for less than 6% of the total European EMS production value. Nevertheless, more than 160 companies offer EMS services in Scandinavia, not counting companies who only manufacture cable harnesses or just do design work, box building, and after-sales services. Even so, there are some larger companies with several different manufacturing locations.

By far, the biggest EMS hub in Scandin via is Sweden, with nearly 50% of all EMS companies. Finland and Denmark are nearly equal regarding the number of companies, and Norway has about half of the number of EMS providers compared to Denmark. If one looks at the revenues, Finland is double that of Denmark; while Norway's EMS revenues are more than 30% than that of Denmark.

Talking about growth rates, it becomes tricky. Many people convert all numbers into U.S. dollars. Whereas, this might be a way to compare the countries on a global scale, it does not necessarily reflect what the situation in the individual country is. The US dollar is not the center of the world and neither is the euro. In Scandinavia, only Finland has converted its currency 17 years ago to euro. All other Scandinavian countries still have their individual currencies such as the Norsk krone, the Svenska krona and the Dansk krone. The Dansk krone has been stable to the euro over the last three years, but the Svenska krona changed nearly 9.5% to the euro from 2013 to 2016, and the Norsk krone even 19% at the same time.



Therefore, it is not a wonder that EMS manufacturers in Norway had a decline in revenues of more than 4% calculated in euro in 2016 compared to 2015, but in Norsk krone, it was just minus 0.5%. In Sweden, a decline of more than 2% in euro even turned into a plus of 0.5% when looked at in local currency. The same is valid for Great Britain and Switzerland, where negative growth in euro converted to a positive change in local currency.

The worrying point of the Scandinavian EMS industry is that in Norway, 50% of all companies reported losses in 2015 as well as in 2016, and the average profit after tax fell to a low of 0.3% of revenues. In Sweden, Finland and Denmark, 25% of all companies reported losses. At least in Sweden, profitability was better and even improved compared to 2015.

Choosing Solder Processes: Getting it Right

A Conversation with Rehm's Ralf Wagenfuehr

by Stephen Las Marias
I-CONNECT007

To find out more about achieving the perfect solder joint, I interviewed Ralf Wagenfuehr, plant manager at Rehm Thermal Systems, during the recent NEPCON South China exhibition in Shenzhen to get his insights on this issue from the perspective of a reflow oven supplier.

Stephen Las Marias: Ralf, why do you think solder joints are among the key factors in PCB defects?

Ralf Wagenfuehr: It all comes down to the solder joint. It's getting (the components) connected to the board. The other factors are based on the suppliers, the components, the PCBs, etc. I think the solder joint is the main purpose of the whole SMT industry. Everything else is easy to control, but bringing them together, it is important to have the correct parameters in there.

Las Marias: How would you define or characterize a perfect solder joint?

Wagenfuehr: A perfect solder joint, we believe, can be only achieved in the nitrogen atmosphere. You don't look only at when it's connected, you have to look at the next 10 years, where the end-user is using the product continuously. The perfect solder joint is reliable, and I think the important thing is it has a clear surface, that it's not impacted, and that there are no corrosions, among other things. While a good connection on the surface is very important, you also must make sure the joints are stable.

Las Marias: Why do you need a nitrogen environment?

Wagenfuehr: In a nitrogen environment, you can exclude oxygen already, so mostly, you would achieve better wetting. Sure, it depends on the paste, but I believe reliable solder joints can be achieved under a nitrogen atmosphere. That's why we designed nitrogen ovens.

Las Marias: What are the parameters to consider for achieving the perfect solder joint?

Wagenfuehr: The main ingredient is the solder paste, and it is important for material surfaces. You have different components and different surfaces for different customer requests. That's why choosing the right paste for the right components is one of the most important things.

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Next is the customer's temperature ranges for the components in PCBs. There's a wide range of applications. Some cannot have nitrogen, some need nitrogen. The solder paste is very important, but connecting the components to the board is a process that influences the long-term reliability of the parts themselves.

Las Marias: It's important that the paste supplier, the assembler, equipment supplier, and customer are all working together.

Wagenfuehr: Yes, that's very important. If you choose the wrong surface finish, then you will have defects built in from the beginning. That will cause defects on a long-term view. Of course, most people are already considering this. But I think it's very important to have the right paste.

Las Marias: Ralf, what are the other soldering issues from your perspective?

Wagenfuehr: Wrong profiling is one. We still see people doing wrong profiling. Wrong designs and wrong storages are the other issues. Design has a big influence. We have a lot of engineers working together, we have a lot of components, solder paste, solder pads, so the design (of the board) has a really big impact. Wrong storage (of solder paste) is also one of the biggest culprits.

Las Marias: Why is voiding a big issue right now?

Wagenfuehr: Things are getting more compact, and the power usage is getting higher. We have more applications running on a smaller surface. That means everything is consuming more power, even on the PCB. Of course, in applications such as automotive, medical, and other critical industries, it can cost lives. You don't want a PCB to break down on the airplane when you're in it. Your mobile phone breaks down, it's a quality issue; you can make a decision in the future. But for other things, you only have one chance to make it right. As things become smaller, more compact, with more built-in functions into the circuits, and into the components, it is important to have less soldering voids.

Las Marias: How do you help customers address their voiding problem?

Wagenfuehr: We have the main systems, including our condensation soldering, our vacuum soldering, and vacuum reflow. But we also have a whole process chain that we can support. Our customers call us not only for voiding but mainly also for this, and how we can support them is through our process chain. Here, the design is one of the main factors for the voiding. The design often is the wrong choice. Things cannot escape, and air cannot escape. The soldier joint is the wrong size, or has the wrong pad. We have to design it with some holes so air can escape from the solder pad. Of course, the printing process is very important. How we pressurize the components on the solder pad itself is very important. We have done studies, and we figured that with an improved process, you can nearly achieve around 20% or less in higher applications, but of course, if you can control all your factors with our systems, you can go down to 2% voiding.

Las Marias: What are the key considerations to achieve this?

Wagenfuehr: Atmosphere is one of the factors that have an impact on the process. For instance, you have less oxygen when the solder melts. It's important to have the right surrounding atmosphere. The process must be seen as a whole process chain to avoid voiding. We have trained process engineers at all locations, and we can support on the process chain as well. This is why Rehm is very strong—not only for making machines, but by being able to support the process chain as well.

Las Marias: Finally, Ralf, what are some of the latest innovations from Rehm that will help address this voiding challenge?

Wagenfuehr: We have the condensation soldering system for very high-reliability applications. We have four different kinds of series for each market, so two condensation soldering machines with vacuum. For industries that do not have the possibilities for condensation sol-

dering, where the limitation is the cycle times, then we have vacuum reflow, which features a built-in vacuum into the reflow process, after the peak zone. Here, we can get the escaped voids down to 2%. Those are the products we have in terms of equipment. But our team knows about the process also, and that's also another factor. So, when you buy with Rehm, you get not only the machine, but the whole support in your production. We are happy to do this to our customers.

Las Marias: Do you have any other final comments?

Wagenfuehr: I think the paste and the component suppliers should collaborate more for the industry to develop in the same direction. Of course, this will help everybody to have faster development and understand the emphasis in the machinery industry. Sure, we want to be the most sellable oven, but I think it's also important that the customer can choose and know who the right supplier is for them and the right component, and the right paste supplier. They often choose wrongly and choose ingredients that aren't right for the process, and make the wrong product. Maybe more communication between all the suppliers will open collaboration that will be helpful.

Las Marias: Communication and collaboration are key.

Wagenfuehr: Yes, correct.

Las Marias: Thank you very much, Ralf.

Wagenfuehr: Thank you. **SMT**

AIM's Dr. Mehran Maalekian Speaks on New Alloys for Harsh Environments

Dr. Mehran Maalekian, R&D Manager at AIM Solder, speaks with I-Connect007 Managing Editor Andy Shaughnessy about new alloys that are targeted for high-temperature and demanding applications, particularly in harsh environments, where standard lead-free alloy such as SAC will not perform as well.

[Watch the interview here.]

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Analyzing Material Cost in Today's Global Economy—Hit the "Pause" Button

by Tom Borkes
THE JEFFERSON INSTITUTE

This month's column was planned to conclude a series that analyzed the cost of material in today's global economy. The first three discussed the competitive importance of material cost considering it is generally 70–90% of the total electronic product cost.[1–3]

It was recognized that differences in the cost of material that are based solely on the geographic location of where the product is being assembled frequently occur. Further, for a given purchase volume, any increased shipping and distributor overhead costs do not justify the magnitude of these differences.[4]

The conclusion was that material price variation to these levels—in some cases from 20% to 50+%—could only be explained by one of two reasons:

1. Certain affluent markets are simply willing to pay more (i.e., what the market will bear).
2. For political reasons (i.e., manipulating material pricing to funnel the value-added product assembly activity and the associated jobs to regions that are common to the material manufacturers).

This is an audacious claim that needs to be confirmed with data. That was the original intent of this column. Toward that end, many U.S. agencies and NGOs (non-government organizations) were contacted for data… still waiting. Hopefully, we will be able to take our finger off the pause button and hit "play" next month.

Regardless, there are a few important points to be made while awaiting the data:

1. In a free global market economy, a company can sell their products at any price they choose. They can even choose to provide those products to some customers at preferred pricing, unless there is an international agreement to the contrary. It would be good to know this, wouldn't it? I'm not speaking of a material price preference given because a customer offers a higher level of business activity to a material supplier (i.e., annual purchase volume, or any other traditional business reason). I'm referring to component manufacturers and/or distributors increasing prices to "non-local" companies for the reasons stated above, perhaps with their government's encouragement, or worse, direction.

2. If this is the case, what is the remedy for electronic product assembly operations that are subject to the high side of this material cost disparity, for whatever reason? The remedy is to manufacture these components locally. We need to challenge the industry similarly to how we do to the re-shoring effort for assembling products. So, regardless of the offshore material pricing motivations, this level of national vertical integration would make the material price manipulation question moot.

3. Three questions require answers:
   a. Does this mean manufacturing electronic components in the States—resistors, capacitors, coils, inductors, ICs, etc.?
   b. Do we have an educational system to support this ground shaking shift in manufacturing thinking?
   c. Can we do this competitively?

In order, the answers are: yes, no, and yes, if we can change the answer to the second question to "yes."

All roads lead to education!

"If your plan is for one year, plant rice. If your plan is for ten years, plant trees. If your plan is for one hundred years, educate children." —Confucius

Forget about a planning horizon of one year. In today's Western, free-market business climate, one year is a long time. Unfortunately, in many cases, our totally near-term, profit-now culture obsesses almost exclusively on the results for the next quarter—stockholders demand it. In many cases, the investment community has become one of the traders—those who buy and sell with little regard for a company's long-term prospects.

This pressure on management leads to a series of decisions and actions that are not conducive to long-term success, just the near-term stock price. The mentality of, "We must ship," even if it means issuing a work order to build 1,100 units to be assured of getting 1,000 that pass functional test, so be it.

So, in addition to building products, we become proficient in building bone yards.

In our ardor to make the numbers, understanding the root cause of a consistent yield loss—whether it be client induced (design) or production induced (statistically incapable or out of control of the assembly processes)—often gets relegated to the bottom of our production priority list. At the top of the list, unfortunately, is the mindset to keep the machines running—at all costs!

However, with a properly educated workforce, the big data available on the production floor provides an opportunity not only to do root cause defect analysis, but also to do it in real time. In some cases, corrective action can occur without the need for human intervention through meta-process control (sometimes called Factory 4.0).[5]

It takes management virtue to resist the pressure imposed by this short-term thinking.

In a way, it is analogous to the difference between batch assembly—where product is pushed through the factory, and continuous flow manufacturing—where product is pulled through the factory. Virtue is required to transition one's thinking to acceptance of having production operators on the line who are idle while waiting for upstream work, rather than building as many units as possible at each work station and batch moving the work in process from one work station to the next.

If you are a process engineer, the cost of the material for which you are developing an assembly process doesn't concern you. Why should it? As an individual, you are evaluated on assembly throughput (the sister of machine utilization) and yield. This mindset is a consequence of an organizational structure that can be likened to a field of silos—each silo is a department. "Hey, it's the procurement department's job to purchase the material, not mine!"

This all changes if the organizational model is product team-based (*SMT Magazine* columns December 2016 to March 2017), rather than department-based.

However, as an engineering student I was not educated in material purchasing. There was no class called "Material Procurement 101." How can I be concerned with something of which I have little knowledge? Looking back, wouldn't it have been an advantage for me to been taught about real world material procurement as part of my traditional Economics 101 class?[6]

Passing through the looking glass from the academic world to the real world, we are like children looking for manufacturing wisdom. I remember during the emergence of SMT in the early 1980s, the floodgates opened and everyone was racing for the SMT assembly Holy Grail.

People would approach me at conferences and ask, "What is the best pick-and-place machine to buy?" In other words, "Just tell me the answer. Save me the details." Of course, the answer then, as it is now is that there is no single answer. The devil is in the details.

Toward that end, in our decision-making class we suggest one important criterion in the judgment process is to employ an objective way to develop a figure of merit for each of the choices that are in front of us. Specifically, to develop a weighted averaging matrix:

1. List all the variables that affect the decision.
2. Weight each one's relative importance to your interests.
3. Rate each of the candidates with respect to one another.
4. Multiply the rating by the weighting factor in each category and sum the products to arrive at an option's figure of merit.

Finally, our species has the distinct advantage of storing and sharing information. We didn't have to develop the optimum time/temperature reflow profile for 63/37, tin/lead solder.

The manufacturers who wanted us to buy their solder paste and reflow ovens did this. They based recommendations on the empirical work they did in achieving a solder joint grain structure with the preferred intermetallic that led to the most robust component-to-circuit board attachment.

Even then, blind faith in the experts' recommendations could be misleading and dangerous. As stencil apertures got smaller and the volume of paste we printed decreased significantly, we ran into process problems (paste sphere oxidation) created by recommended by too slow soak reflow profiles.[7]

Judgment once again becomes the operative term—unfortunately, it is not a skill that is currently developed in our educational system. But, nonetheless, it is an essential attribute on the competitive field of the real world.

At least that's what I think. What do YOU say? I'd like to hear your thoughts, reactions and opinions.

Next month, we hope to have the statistics needed to support the component pricing disparity claim. **SMT**

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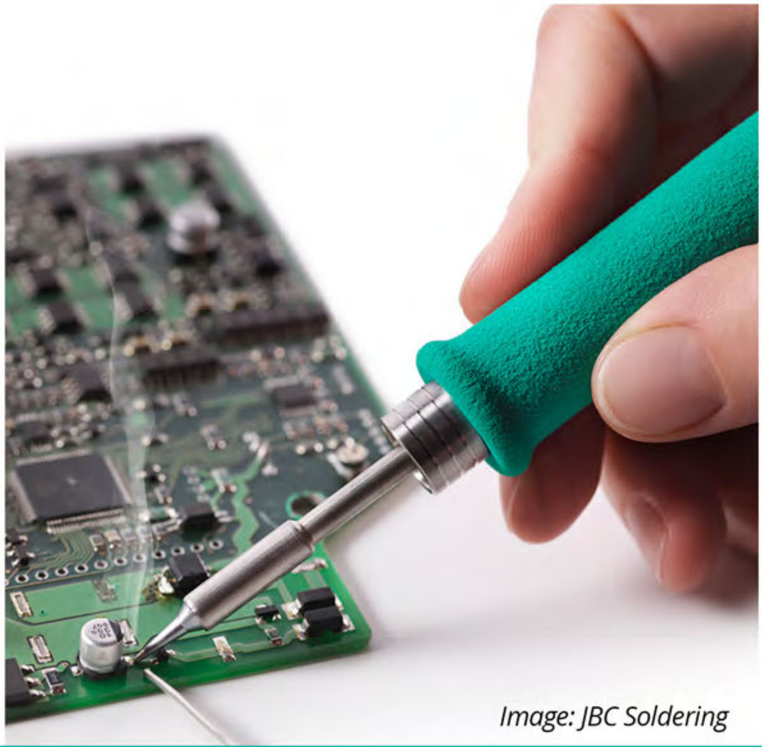
Tom Borkes is the founder of the Jefferson Project and the forthcoming Jefferson Institute of Technology. To read past columns or to contact Borkes, click here.



Soldering Tip:
Key to Good Solder Joints

by Stephen Las Marias
I-CONNECT007

For more than 85 years, JBC Soldering has been providing soldering and rework tools for the electronics manufacturing industry. Headquartered in Barcelona, Spain, the company also has branches in St. Louis, Missouri, in the USA; Guadalajara, Mexico; Hong Kong; and Shanghai, China.

In an interview with *SMT Magazine* at the recent NEPCON South China event in Shenzhen, Enrique Moreno, technical support engineer, discusses the key parameters to consider during hand soldering to achieve the perfect solder joint.

Stephen Las Marias: Solder joint defects are among the key problems in PCB assembly. Why do you think so?

Enrique Moreno: Mainly, the problem with hand soldering on PCBs comes with the bigger planes, and most especially with barrel filling. Good thermal transfer is important to make a good solder joint. Maybe this can be solved with high temperature on the tip, but then the intermetallic formation of the solder joint can be too big. You can have problems on the mechanical strength of the solder joint. Later, it may crack, leading to product defects.

Las Marias: What are the parameters to consider to make those perfect solder joints?

Moreno: The most important is temperature. If it is too high, the pads will burn; while too low a temperature and the tin will not melt. But also important is how this thermal transfer is done to the PCB. For this, JBC has special tips that allow users to fill those barrels easily. We also have special preheaters that can help them if they need an extra heating system while they are soldering. Users don't need to reach a soldering temperature to 400°C to avoid this huge intermetallic part; they can control the temperature to avoid problems on the PCB.

Good tools are needed. You need a system with good soldering tips, where energy is reactive, not cumulative—imagine a big soldering tip with plenty of heat inside. Temperature and tips change. Regarding thermal transfer, the

Stephen Las Marias talks with Enrique Moreno.

more heat that can reach the component and pin parts, the faster and easier soldering is for the operator.

Also, very critical is the use of the appropriate flux because it takes oxidation off the pins and the pads.

Las Marias: What is the proper temperature to achieve good intermetallic formation?

Moreno: Good intermetallic connection needs to be achieved. The problem is that when it's really high temperature, the intermetallic bonds increases. If you go with lower temperature, the soldering tip's life is longer. Soldering can be done in several different temperatures, so as low a temperature you can select, will help the tip last longer. At the end, of course, it is not that big a difference between 320°C and 350°C in terms of soldering. But the tip life will last longer with 320°C than in 350°C. In this way, we recommend going as low a soldering temperature as you can. Sometimes, we know that operators are under pressure from production, so they increase the temperature to do soldering faster, but the quality and reliability will be compromised. Operators should be trained properly, and they need to be trained in soldering.

Las Marias: After hand soldering, is visual checking enough to know whether the solder joint is good or not?

Moreno: Visual checking is not enough. You cannot see whether intermetallic bonds are being formed just by looking at the solder joint. For example, if you do barrel fill, you need extra equipment such as X-ray inspection machines, where you can see if the barrels are filled or not. Sometimes you could see the top and the bottom of the solder joint, but inside, it is not a good joint.

Las Marias: What can you say about the move towards automated/robotic soldering? Do you see this trend becoming more popular in the future?

Moreno: We are quite sure that automation and robotics will increase. In line with this, JBC just developed new soldering tools for automation including a soldering head, new cartridges, features automatic tip changing, tip cleaning, and automatic fillers—all of them Industry 4.0-enabled.

Las Marias: Who will achieve the perfect solder joint: a robotic soldering system or a highly skilled operator?

Moreno: First, someone needs to tell the robot how to do it. If you don't know how to program this robot to make the perfect solder joint, you are lost. Robots are quite good for repetitive tasks, like in a production environment. But good operators with really good skills can also work in rework environments, where several different tasks need to be done. He can choose the appropriate temperature, appropriate tools, just by looking at the PCB.

Las Marias: Thank you very much, Enrique.

Moreno: Thank you. **SMT**

Electronics Industry News
Market Highlights

NAND Flash Prices to Keep Rising in 3Q17

DRAMeXchange, a division of TrendForce, reports that the NAND Flash market continued to experience tight supply in the second quarter, leading to a price increase of about 3% to 10%.

Thermal Energy Storage Market Size to Reach $12.5B by 2025

The global thermal energy storage market is expected to reach $12.5 billion by 2025, according to a new report by Grand View Research Inc., mainly driven by increasing demand for access to efficient and cost competitive energy sources.

Gartner Releases 'Hype Cycle for the Digital Workplace, 2017'

Digital business execution is requiring more frequent and complex decision making, continuous problem solving, and rapid pattern recognition, all of which require workforce digital dexterity. In most organizations, however, responsibility for helping employees develop the desire and ability to exploit a wide range of transformative technologies—highlighted in the Gartner Inc. Hype Cycle for Digital Workplace, 2017—does not have to rest with any group or individual.

Mobile DRAM Revenue Grew 14.8% Sequentially in Q2

The global mobile DRAM market experienced some recovery during the second quarter, though smartphone sales remained sluggish, according to a new report by DRAMeXchange.

SDN Market to Reach $130B by 2022

The global software defined networking (SDN) market is expected to grow at an astonishing CAGR of around 47% during the period from 2016 to 2022 and reach the market size of more than $130 billion, according to a new report by market analyst Acumen Research and Consulting.

Convergence of Big Data, IoT and AI to Drive Next Generation Applications

Disruptive technology innovations in the information and communication technology space, such as artificial intelligence (AI), Internet of Things (IoT), self-service visualization and structured query language (SQL), have deeply permeated various applications and markets.

Medical IoT Enabled by Convergence of Sensor Technology and Connectivity

Healthcare is facing one of its major turning points in decades, with the digital revolution and its related IoT concept rapidly changing health models.

Concentrating Solar Power Market Size to Reach Nearly $9B by 2025

The global concentrating solar power market is predicted to reach $8.92 billion by 2025, according to a new report by Grand View Research, Inc. Increasing awareness about renewable energy along with government regulations to control growing carbon footprint is further propelling the market growth.

Consumer Trust Is Essential for Mass Adoption of Autonomous Vehicle Technology

Gartner Inc. expects to see multiple launches of autonomous vehicles around 2020, but the full impact of the technology on society and the economy will not begin to emerge until approximately 2025.

Wearable Device Shipments to Reach 430 Million Units Annually by 2022

Fitness trackers and smart watches remain the flag bearers of the wearable market, seeing growth but at a slower pace than estimated earlier, according to a new report from Tractica.

by Stephen Las Marias
I-CONNECT007

Voiding has become a big issue nowadays in electronics assembly. According to studies, voids reduce the life of the solder joint. In particular, voids greater than 50% of the solder joint area decrease the mechanical robustness of the solder joints.

To know more about voiding and its impact on solder joint reliability, I interviewed Jonas Sigfrid Sjoberg, technical manager for Asia at Indium Corp., at the recent NEPCON South China event in Shenzhen. He discussed why voiding has become an important issue in the SMT industry, and how manufacturers can address this issue.

Stephen Las Marias: Why is voiding a such a big problem now in the industry?

Jonas Sigfrid Sjoberg: In the past, the components are not running as often as they are today, so what's happening is that the components are getting much hotter while they are being used. The thermal pads, especially for the QFNs, are there to lead away heat. Many customers, around five years ago, are saying if it's less than 50%, it's okay. Now, they are starting to say they need to have better than 30%, or all the way to 15%. Even down to 10%. It's all about leading away the heat from the components.

We can do things with the process to reduce voiding, but the solder paste that is being used is very critical. It's very important that we educate our customers. We have different pastes for different applications. We don't want to recommend, say, for automotive, a solder paste that we use for mobile phones. It's important to pick the right paste. It also depends on how the flux is formulated. Some give more voids, some less. But the reason for this is they are leading away the heat, and that's why we need to work on the voiding.

Las Marias: Are there market trends that are causing the voids?

Sjoberg: I think it's always been present. It's just that people haven't really been looking for it so much. Now, they are starting to see functional failures or overheating problems. I've been in

Jonas Sigfrid Sjoberg

the industry for almost 25 years, and I think the voids have always been there. It's just that it's getting magnified now as the components are getting hot.

Las Marias: Do you think voiding can still be pushed down to the low single digits?

Sjoberg: For some applications, yes. But I don't feel comfortable, as an engineer, to promise a customer less than 20%, overall. For some applications, it will be below 10%. You will see our marketing information, like for the 8.9HF and 10.1HF, at below 10%. That's for certain applications.

Las Marias: How do you help your customers solve their voiding issues?

Sjoberg: First, give them the right paste. Of course, our product information will give a recommendation on what printer set-up to use and reflow profile to use, but in many cases, we typically do a technical seminar with the customer before they start using the material.

You can give everyone something in writing, but it's much more valuable to explain it face to face. So, we always try to give technical seminar to the customer before they do their evaluation. Some customers don't allow that as they want to do it by themselves, so then we give them our recommended process parameters.

There's certain parameters to reduce voiding. For instance, with our 8.9HF, longer time above liquidus completely reduces voiding—but that doesn't help with all the materials. Some materials might get worse, but most of our materials, when you extend the time above liquidus a little, your voiding level comes down. That's the kind of information we give to our customers.

Las Marias: Educating your customers is critical.

Sjoberg: Yes, it is. It shows our customers that we know more than just selling the solder paste. Customers now are knowledgeable, and they want more information, and we as a company want to be a partner, not as a supplier. Doing that, we get to know what the customers need. If we don't have seminars, if we don't sit down with them face to face, we have no idea what we should develop.

Las Marias: Tell us some of the latest innovations at Indium that target these particular challenges.

Sjoberg: We just launched a new solder paste, and we've had two materials that have been market leaders before, which is 9.1 and 8.9HF; these are what we were typically pushing to automotive. And this is what you see in our slogan, "Avoid the Void." Right now, we are just about to release 10.1HF, which is the next step in voiding. It's not going to be a huge change, but it is going to be a solder paste that might be able to take us down to the single digits without doing it in vacuum soldering.

We also have the material called 10.8HF, which is more targeted to the head-in-pillow and the non-wet issues.

Las Marias: When I was walking around the exhibition hall, I saw reflow ovens saying no voiding or reduced voiding.

Sjoberg: Some of them are starting to promote vacuum soldering. Vacuum soldering, traditionally, is used in the semiconductor industry. Now, the more traditional SMT equipment suppliers are putting in a vacuum chamber in the reflow oven. So, part of the reflow is vacuum and the other part is normal air reflow. With vacuum, yes, you will be able to get almost down to zero percent voiding—depending on the paste and the product.

Las Marias: Are there applications wherein there is acceptable level of voiding that you just can make do with, and are there applications where voiding should be at a certain level only?

Sjoberg: The area where we get the most pressure from is, I would say, automotive, because it is all related to safety and security—we don't want those components to overheat. Automotive is the one pushing the hardest—they want certain specifications, for instance, they are specifying that they have to be only 10% voiding. In the solar industry—solar inverters, typically would be below 20%. In the consumer, we see anywhere between 30% and 50%, but it is coming down. As mobile phones get hotter, I foresee that they will be specifying lower than that as well. It is kind of segment driven, but automotive is the one driving it down, and of course, aerospace.

Las Marias: Is there anything else you think we should be talking about?

Sjoberg: I'd just like to emphasize that we try to do as a company, which I think is very important, is become a partner, because the customers expect us to know more than the solder paste. For our engineers, it is important to understand total costs, because it must be win-win. Of course, I would like to sell a Type 6 SG powder to everyone, because it can do so much more, but it must be a win-win. So, if the customer doesn't need it, we give them what they need. That's one key thing in today's market.

For customers to have higher yields in their process, from a soldering standpoint, it is very important to be able to discuss this with the solder provider. If you start out with the wrong material, it's very difficult to change. So, it is very important that we work with our customers and give them the right materials, and the right expectations—which is why we want to be a partner, not just a supplier.

Las Marias: Thank you very much.

Sjoberg: Thank you. **SMT**

Supply Lines Highlights

Rehm Rigorously Inspects Electronics Components

Rehm relies on the new YXLON Cheetah µHD with 3D computer tomography (CT) for components analysis.

Cogiscan Signs Maxnerva Technology as Partner in Greater China

Cogiscan Inc. has announced a new business partnership with Maxnerva Technology Services Ltd as its sales and distribution partner in Greater China.

Trenton Technology Upgrades to 3D AOI from Nordson YESTECH

Trenton Technology has installed two of Nordson YESTECH's FX-940 ULTRA 3D AOI systems at its Utica, New York facility.

Vision Engineering Founder Rob Freeman Passes Away

Vision Engineering Ltd announces the loss of founder Rob Freeman, MBE, who passed away on August 19, at age 84.

AIM's Flopy Feng Receives Best Presentation Award at the SMTA China South Technology Conference

AIM Solder is pleased to announce that Flopy Feng, technical support engineer, received the award for Best Presentation in his technical session at the SMTA China South Technology Conference in Shenzhen, China.

Heraeus Selects ASM's Mid-Speed Placement Platform for State-of-the-Art SMT Applications Lab

Heraeus has selected ASM Assembly Systems' E by SIPLACE mid-speed placement platform to enhance customer support and benchmarking initiatives within its new Pennsylvania-based state-of-the-art SMT Applications Lab.

SMART Group Launches Guide to QFN/LGA & BTC Process Defects

SMART Group's latest Process Defect Photo Guide, "Guide to QFN/LGA & BTC Process Defects," will be released on October 16.

Nordson VP Robert Veillette to Retire

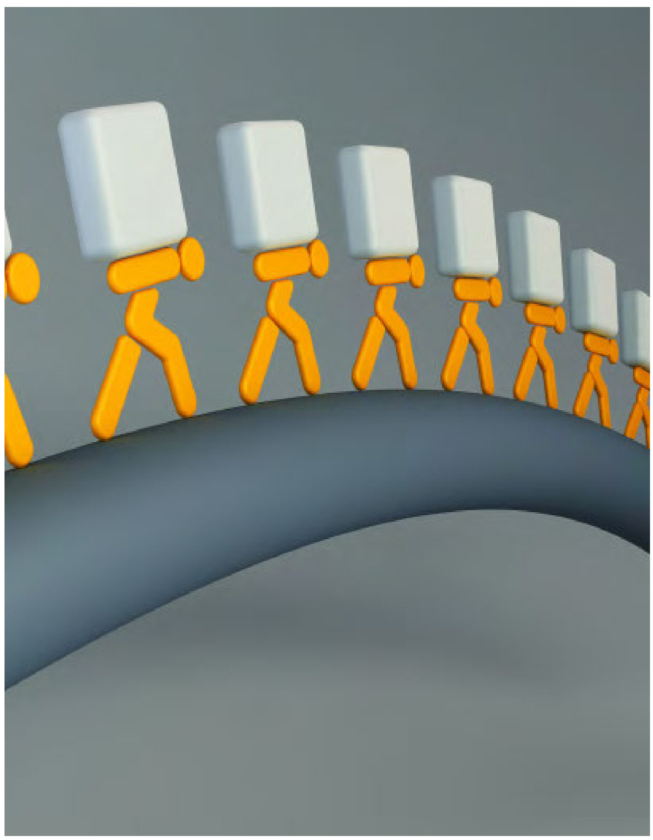
Nordson Corporation's Vice President, General Counsel and Secretary Robert E. Veillette will retire from the company after 32 years of service, effective December 31, 2017.

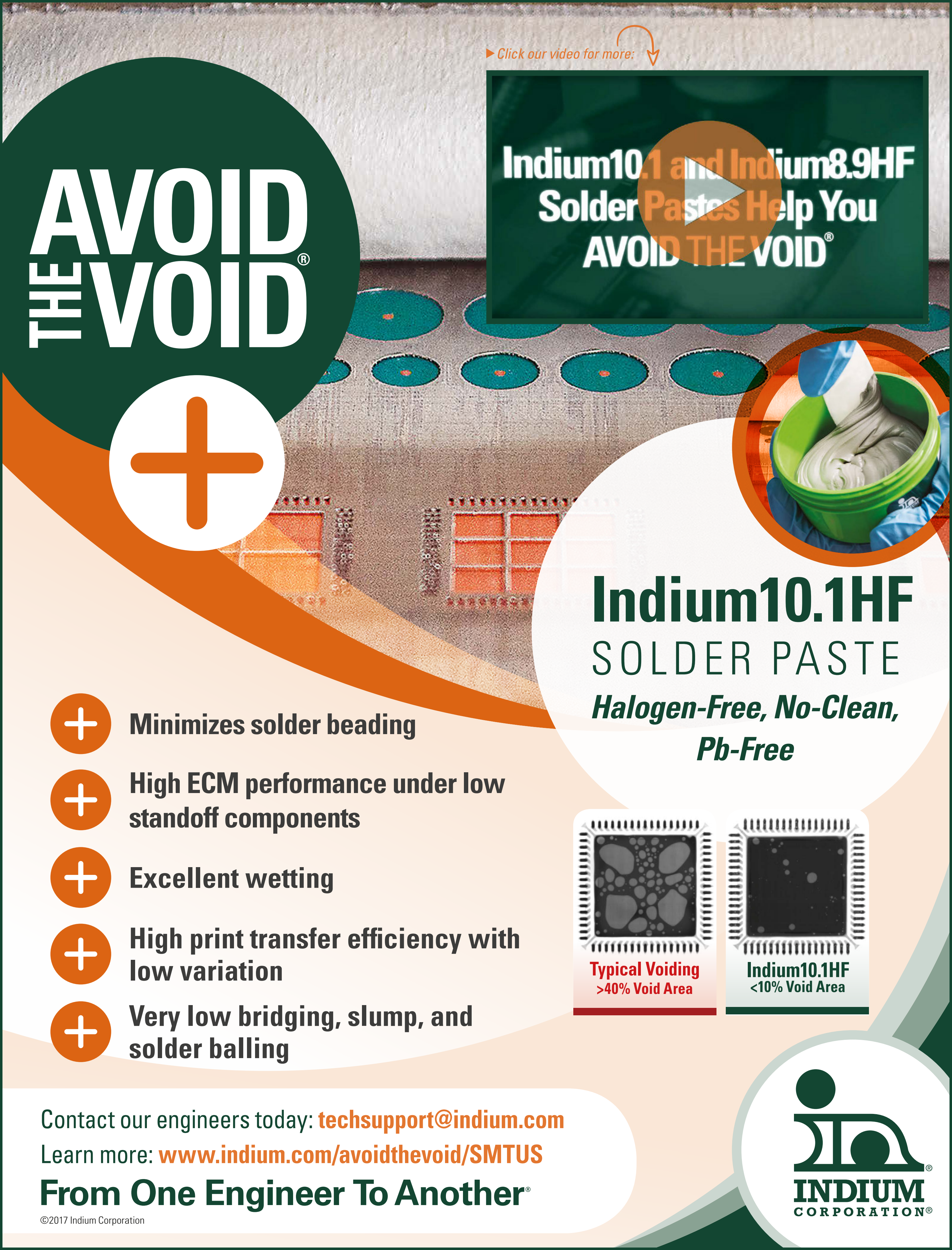
MIRTEC Europe Receives 2017 EM Best of Industry Award for AOI

MIRTEC is the recipient of the 2017 Electronics Maker Best of Industry Award in the category of "Manufacturing Excellence in Automated Optical Inspection (AOI)."

RTW NEPCON South China: Vermes Discusses Piezo Technology in Microdispensing

During the recent NEPCON South China event in Shenzhen, Juergen Staedtler, CEO of Vermes Microdispensing GmbH, discusses their latest innovations in microdispensing, and how their piezo technology is addressing the trend towards miniaturization in PCB assemblies.

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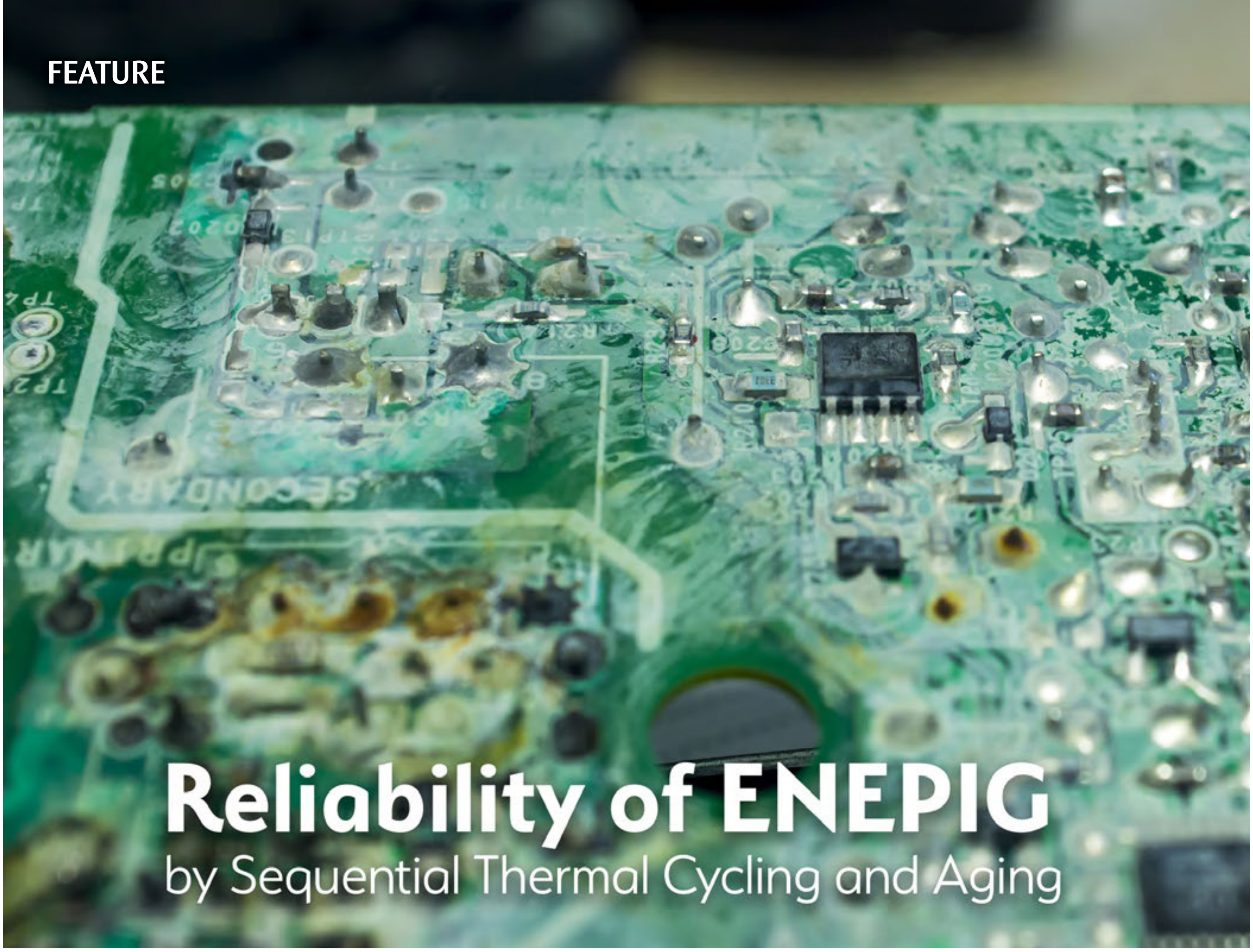

Reliability of ENEPIG
by Sequential Thermal Cycling and Aging

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JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY

Abstract

Electroless nickel/electroless palladium/immersion gold (ENEPIG) surface finish for PCBs has now become a key surface finish that is used for both tin-lead and lead-free solder assemblies. This paper presents the reliability of land grid array (LGA) component packages with 1156 pads assembled with tin-lead solder onto PCBs with an ENEPIG finish and then subjected to thermal cycling and then isothermal aging. To determine thermal cycle reliability, daisy-chain LGA1156 packages were used to enable the monitoring of solder joint failures. The assemblies were built with a vapor phase reflow machine or using a rework station. Then, they were subjected to thermal cycling ranging from -55°C to 125°C. After the completion of 200 thermal cycles, the assemblies were isothermally aged for 324 hours at 125°C to determine the effect of isothermal aging on intermetallic formation and growth, which is one of the concerns for tin-lead solder assemblies. To determine the effect of exposure at temperatures higher than 125°C, the aged samples were subjected to 100 thermal shock cycles between -65°C and 150°C.

Several characterization methods were used to ensure the integrity of solder joints. These included nondestructive evaluation by X-ray, daisy-chain monitoring at thermal cycle/aging intervals, and destructive characterization by cross-sectioning. The cycled/aged samples were cross-sectioned and characterized by optical and scanning electron microscopy (SEM). Assembly processes and SEM photomicrographs showing damage progression and IMC/microstructural changes, as well as elemental analyses by X-ray energy dispersive spectroscopy (EDS), were also presented.

Introduction

The IPC standards team has helped in easing the implementation of ENEPIG surface finish for PCBs by releasing a standard with a large characterization database[1,2]. This data and that generated by industry[3] generally concentrated only on the basic testing approaches and mostly for

lead-free solders and testing of individual solder ball attachments rather than the advanced ball grid arrays (BGAs) electronic packaging assemblies and for tin-lead solder. It is extremely difficult to correlate test results from the shear of individual balls to the assemblies of BGAs. Reliability testing using BGA packages, especially land grid arrays, with tin-lead solder is lacking. In addition, controversy exists regarding the reliability/compatibility of ENEPIG with tin-lead solder[4], as there are more consistent positive test results for the lead-free solder joints[5]. A hot air solder level (HASL) finish, which is commonly used for the tin-lead solder, lacks the flatness requirement for the fine pitch ball grid arrays (FBGAs).

"A hot air solder level (HASL) finish, which is commonly used for the tin-lead solder, lacks the flatness requirement for the fine pitch ball grid arrays (FBGAs)."

The significance of the PCB surface finish on assembly reliability was recognized by the IPC 9701 standard team in its early development, when the team was narrowing the requirements for the tin-lead solder joint testing for the BGA packaging technologies. The team limited the use of the PCB finishes to solder preservative (OSP) and HASL to minimize the potential for premature failures by using other finishes. Such restriction was implemented to avoid significant cost and schedule burden on smaller facilities, which generally lack knowledge and experience on the nuances of unique surface finishes such as electroless nickel/immersion gold (ENIG). This specification allowed unique surface finishes only for comparison to the baseline finish. The A revision, which also includes recommendations for Pb-free solders, allowed only the use of an OSP finish since the tin-lead HASL was not compatible to Pb-free solders. Other surface finishes including silver (Ag) and tin (Sn) were acceptable only for a manufacturer's internal data comparison. Also, an ENIG finish could be used for an internal data comparison; however, it was warned that the risk of introducing unintended brittle failure (black pad) could occur. The ENEPIG was not introduced at this time; therefore, this specification does not discuss this specific surface finish.

With the industry implementation of Restriction of Hazardous Substances (RoHS), the use of a tin-lead HASL finish for PCB with excellent solderability and solder joint reliability has diminished even though this still is the dominant finish for high-reliability applications with tin-lead solder. The process consists of immersing PCBs in a tin-lead alloy followed by solder removal using air knives, which blow hot air across the surface of the PCB [to remove excess solder]. The lead-free HASL finish has gained some interest for RoHS use, but it suffers from increased copper dissolution and lacks the flatness requirement needed for finer pitch array packages. An ENIG finish provides the flatness requirements with excellent solderability, but it suffers from the "black pad" potential failure and lacks gold wire bondability that is required for hybrid (wire and solder) technologies[6].

ENEPIG has provided the best solution for the black pad defect by depositing an additional layer of electroless palladium over nickel. The palladium is not etched away during the gold plating process so the potential for the oxidation of nickel (black pad) is eliminated. However, ENEPIG is costlier than ENIG. ENEPIG also provides excellent solder joint reliability for lead-free solder joints, but industry debates continue on its reliability with tin-lead solder assembly.

The IPC-4556 specification for ENEPIG is very comprehensive and includes a wealth of information. The thickness specification for ENEPIG specified as: 1) Nickel: 3 to 6 µm (118.1 to 236.2 µin), 2) Palladium: 0.05 to 0.15 µm (2 to 12 µin), and 3) Gold: a minimum thickness of 0.030 µm (1.2 µin). All measurements are to be taken on a nominal pad size of 1.5 mm x 1.5 mm (0.060 in x 0.060 in) or equivalent area. The new amendment sets an upper limit for the gold thickness at 2.8 µin (0.7 µm) to discourage requests for a much higher immersion gold value and avoid its negative effect on reliability. A higher gold thickness will increase dwell time in the gold bath resulting in nickel corrosion under the palladium layer.

This investigation addresses the reliability from an assembly perspective and more realistic thermal cycles and aging environmental conditions. ENEPIG is yet to be widely accepted for high-reliability applications with tin-lead solder assembly. First, technology trends for LGA are discussed followed by an example of the difficulty of reflow for HASL with PCB surface finish compared to ENEPIG finish. Then, briefly discussed is assembly on a PCB with ENEPIG finish using two advanced area array packages, one an LGA with 1156 solder joints and the other one with CLGA 1272 (ceramic LGA) LGAs. The LGAs were subjected to 200 thermal cycles (-55°C to 125°C). Optical and SEM photomicrographs showing solder interface conditions after 200 thermal cycles (TC) are presented and were compared to samples that were subject to additional 324 hours of aging at 125°C. Furthermore, these were compared to those that were subjected to an additional 100 thermal shock cycles (-65°C to 150°C). The article concludes with a summary and recommendations for the next steps of investigation.

LGA and Advanced Packaging Trends

This article focuses on the second-level (board-level) solder joint reliability and intermetallic formation of LGA1156. Figure 1 categorizes single-chip microelectronics packaging technologies into three key technologies[7,8]:

- Plastic ball grid arrays (PBGAs) including flip-chip die version (FCBGA), land grid array (LGA) with solder balls, quad flat no lead (QFN) and new versions
- Ceramic ball grid array (CBGA), ceramic column grid arrays (CGAs), and ceramic LGA version[9]
- Chip-scale packages, smaller footprint versions of BGA, and wafer level packages (WLPs)

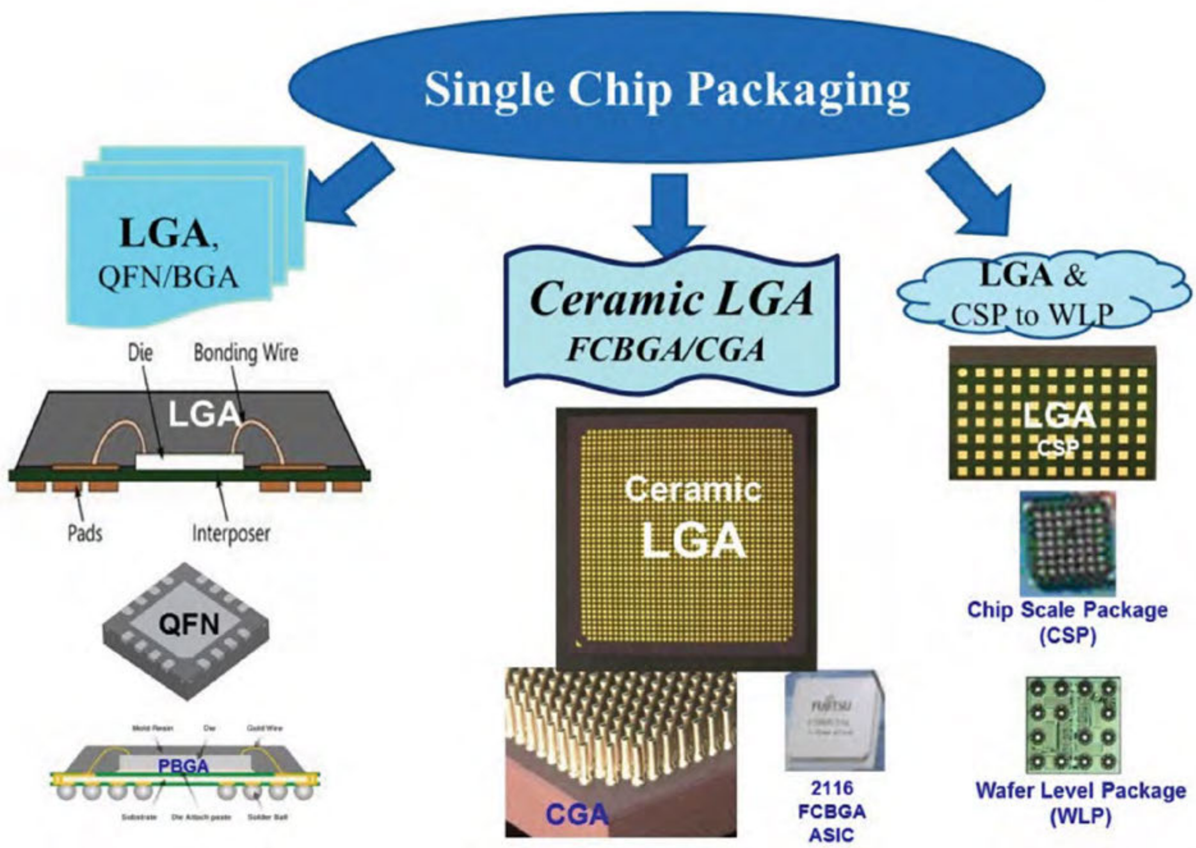

Figure 1: Single chip packaging technologies covers three main categories. LGA exists in all three categories.

PBGAs and CSPs are now widely used for many commercial electronics applications, including portable and telecommunication products. BGAs with 0.8–1.27 mm pitches are implemented for high-reliability applications and generally demand more stringent thermal and mechanical cycling requirements. The plastic BGAs introduced in the late 1980s and implemented with great caution in the early 1990s, further evolved in the mid-1990s to the CSP (also known as a fine-pitch BGA) having a much finer pitch from 0.4 mm down to 0.3 mm. Recently, fan-out and fan-in wafer level packages have gained significant interest. LGA packages cover a range of counterpart packages from fine pitch CSP to large pitch and high I/O BGAs. Similar to ball array versions, LGAs are surface-mountable.

There are no solder balls in LGAs, only land pattern terminations like QFNs. Interconnections are formed using solder paste and reflow during surface mount assembly—reducing the assembly height. This allows for a thinner assembly needed for mobile and computing products, especially the RF application that requires lower parasitic noise. LGAs are the preferred packages for applications that require an ideal combination of low device sizes and profiles, and superior thermal and electrical performance. LGAs have negligible internal stray parasitic elements associated with their external solder pads and closeness to PCBs which enable an extremely low thermal resistance to the device. This enables maximum heat transfer from the die to the package pads. However, thermal cycle reliability has an inverse exponential relationship with solder joint height. Therefore, there is a possible significant reduction in solder joint reliability. FEA modeling projects lower cycles-to-failure trends for LGAs compare to BGAs, which are also verified by testing[10].

HASL Finish Limitation for WLP1600, 0.3 mm Pitch

A test vehicle with various BGAs, sizes, and pitches was designed to determine assembly challenges for mix pitch and sizes as well as their reliability. Two PCB surface finishes were considered—one standard tin-lead HASL and the other with ENEPIG. The most challenging packages for PCB surface finishes and assemblies were the following two sizes and pitches.

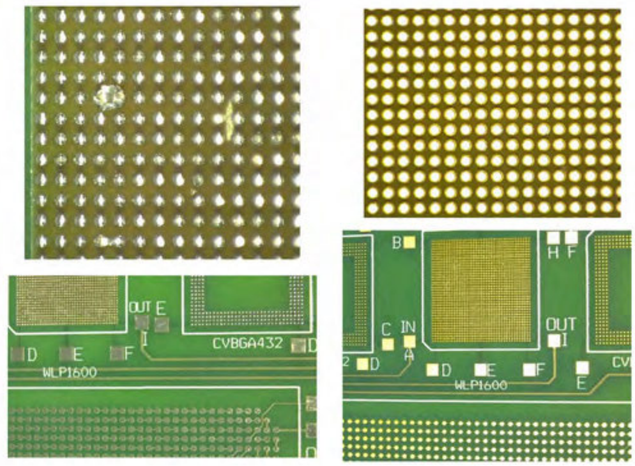

Figure 2: The images of HASL (left) and ENEPIG (right) PCB finishes. The HASL finish is unacceptable for WLP1600 with 0.3 mm pitch, whereas ENEPIG is acceptable.

- Two FPBGAs with 0.4 mm pitch and 13 mm^2 body size. One of the CVBGA432 components had SnPb solder balls whereas the other had Pb-free SAC305 solder balls.
- Two daisy-chain WLPs with 0.3 mm pitch and 12 mm^2 body size. The WLP1600 had Pb-free SAC305 solder balls.

Figure 2 shows a section of the PCB that compares the images of daisy-chained pad patterns for ENEPIG and HASL. The baseline for the pitch of 1.00 mm is also included. The enlarged sections of WLP1600 are shown for both surface finish conditions illustrated irregularity in HASL, and regularity in ENEPIG surface finishes. The HASL shows solder shorts covering four pads. Even the solder dome formation is non-uniform. The ENEPIG finish, however, shows excellent consistency for 0.3 mm pitch and higher. So, the ENEPIG is a clear winner. For 0.4 mm pitch, the HASL finish is more consistent even though solder dome formation is still a common feature.

ENEPIG: LGA1156 Assembly and Inspection

To determine the effects of ENEPIG surface finish under a severe thermal stress condition,

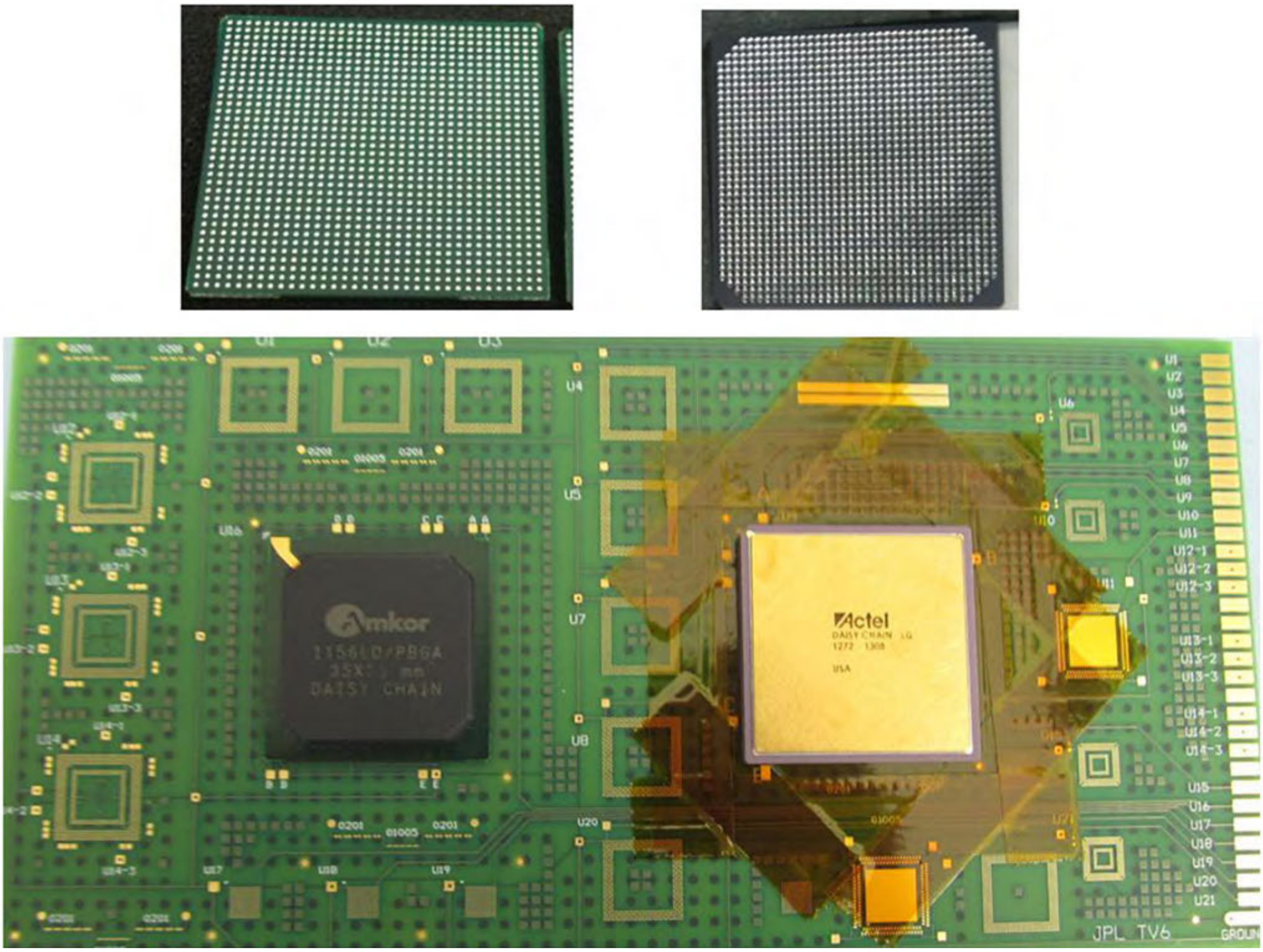

Figure 3: ENEPIG PCB surface finish for the assembly of plastic LGA with 1156 pads (left top) and ceramic LGA (right top). LGA1156 with ceramic version were assembled onto ENEPIG PCB finish (bottom).

LGAs were used for assembly onto PCBs that also added additional manufacturing challenges. A printed circuit board was designed to accommodate a plastic LGA1156 package, as well other packages that are beyond the scope of this article. The ENEPIG thicknesses were defined per IPC-4556, Jan. 2013 release: electroless Ni, 118–236 µin; electroless Pd, 2–12 µin; and immersion Au, 1.2 µin minimum.

The LGA1156 had daisy-chain patterns for checking opens after assembly and for opens during the reliability evaluation. High I/O LGA daisy-chain patterns on ENEPIG PCB finish not only enabled solder joint reliability evaluation, it also provided another verification method for the condition of interconnections after assembly. The PCB daisy-chain patterns were designed to match LGA designed packages to make a complete resistance loop after the package was assembled onto the PCB. Three key parameters were evaluated before being ready to commit to a larger number of assemblies for reliability evaluation.

Generally, after LGA1156 and PCB were baked for moisture removal, tin-lead eutectic solder paste was applied on LGA1156 pads and reflowed to form solder domes on their pad. Ceramic packages were required to repeat the process to achieve the desired height of solder dome. After solder paste application on the PCB pads, the LGA1156 was placed onto the PCB and prepared for assembly. Figure 3 shows a photo of the bumped plastic and ceramic LGAs (1156 and 1272 I/Os) and the final assembly. The test

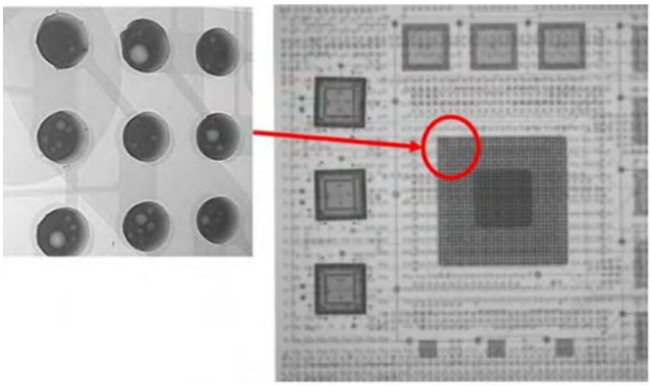

Figure 4: X-ray photomicrograph images of a section of a test vehicle with plastic LGA1156 showing solder joint voids.

vehicle was assembled using a vapor-phase reflow machine.

The real-time 2D X-ray of the two package assemblies revealed no shorts or excessive solder balling and are acceptable. This build was repeated one more time and achieved acceptable quality results. Figure 4 shows the overall X-ray of the side with the LGA1156. It also shows the corner solder joints at a higher magnification. The X-ray shows the internal configurations of the LGA and the fine pitch packages. During real-time examination of the X-ray images at higher magnifications, there were no apparent unusual solder anomalies except the existence of large voids.

ENEPIG Microstructure after 200 TC (-55°C/+125°C) for LGA1156

LGA1156 assemblies on ENEPIG finished PCB were subjected to thermal cycling followed by isothermal aging prior to cross-sectioning for microstructural changes. LGA1156 assemblies were subjected to thermal cycling in the range of -55°C to +125°C with a 2–5°C/min (target 3°C/min) heating/cooling rate. After 200 thermal cycles, one of the LGA packages was cut in half diagonally for cross-sectioning. Figure 5 shows cross-sectional images of a LGA1156 with the package dimensional values including die size, die thickness, and solder joint height length. Images include both optical and scanning electron microscopy (SEM).

Figure 6 shows representative optical and SEM images at high magnification providing details on microstructural features after 200 thermal cycles (-55°C to +125°C). The observation of no cracks confirms the result from the

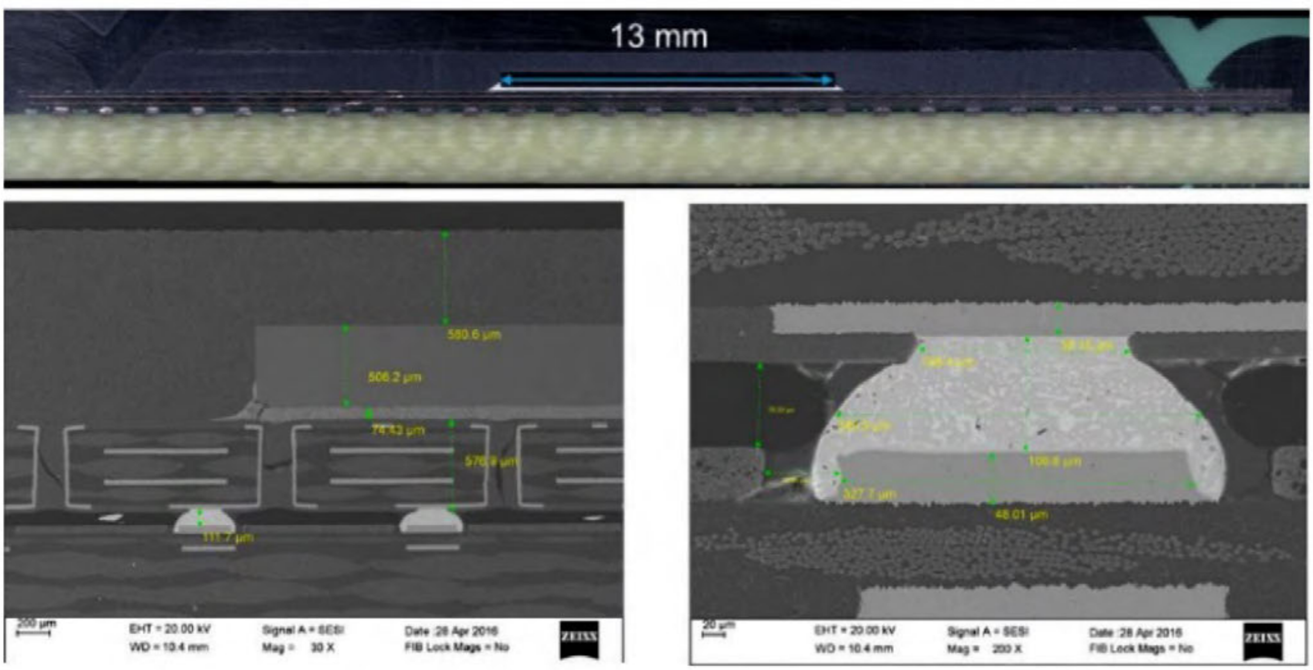

Figure 5: Representative photomicrographs of LGA1156 after thermal cycling showing die size relative to the package.

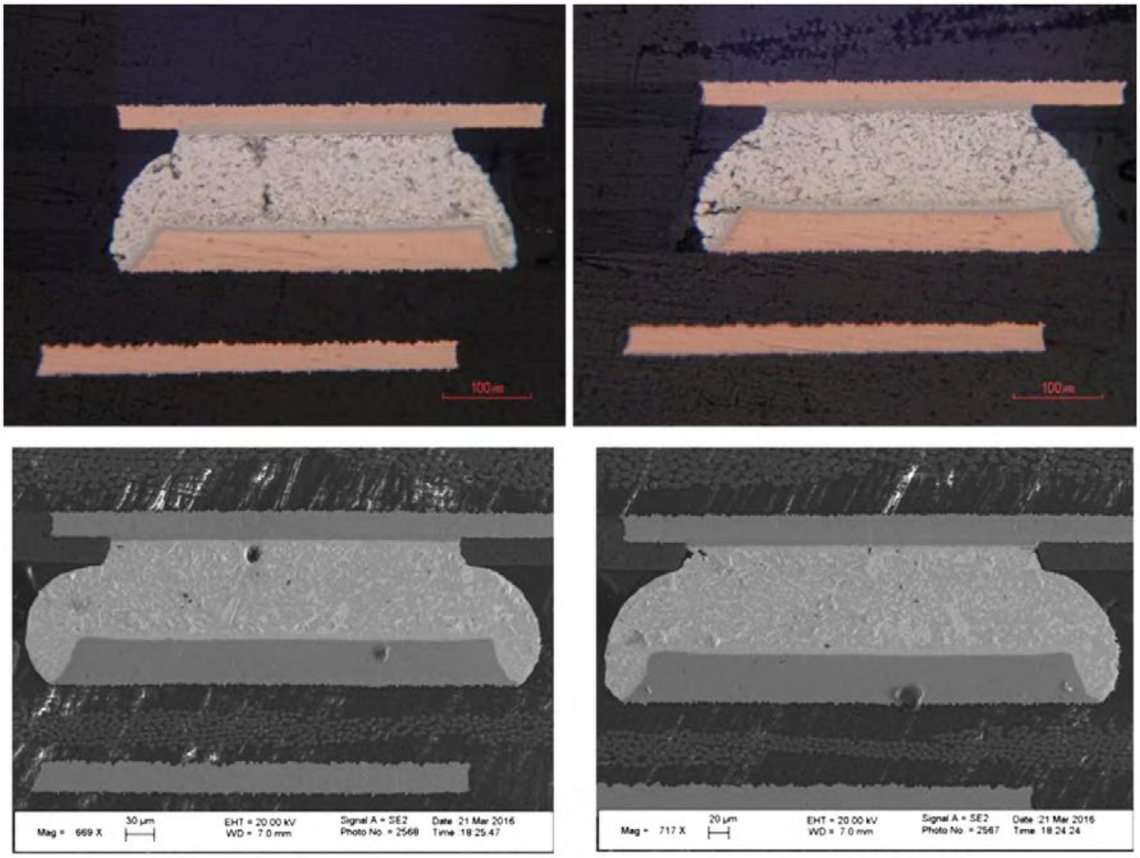

Figure 6: Representative optical and SEM images of LGA1156 solder joints at 200 thermal cycles (-55°C to 125°C). Acceptable LGA solder joint quality with non-solder mask defined (NSMD) or pad defined configurations are also apparent.

daisy-chain resistance measurement that also showed no increase in resistance after 200 thermal cycles. Generally, more than 20% resistance increases, within a short time increasing to mega ohm resistance, are associated with cracking and opens in the solder joints.

Characterization of the solder/ENEPIG interface is critical to be established after cycling, but before a subsequent isothermal aging for comparison. Figure 7 illustrates representative SEM images with SEM EDX/EDS (energy dispersive x-ray) elemental analysis (e.g., showing existence of Ni, Cu, Sn, and Pb) at the solder interface after 200 thermal cycles (-55°C to +125°C).

200 TC (-55°C/+125°C) + 324 hr Aging (125°C) for LGA1156

To determine microstructural changes due to isothermal aging, thermally cycled LGA1156, as well as the half of the unused samples from the microsectioned parts were subjected to isothermal aging at 125°C for 324 hours. A section from the cut sample was purposely used to eliminate the contribution of manufacturing variables on the ENEPIG/solder interface intermetallic growth. This enabled only the contribution of isothermal aging for direct comparison of the microstructural changes at the interface before and after aging. Note that this approach cannot be used for thermal cycling since half of the package induced a different CTE mismatch than a full size assembled package. The test results could not have captured the effect of the CTE mismatches. Figure 8 compares representative SEM images of samples before and after isothermal aging. No significant changes appear at this magnification due to the additional 324 hours isothermal aging.

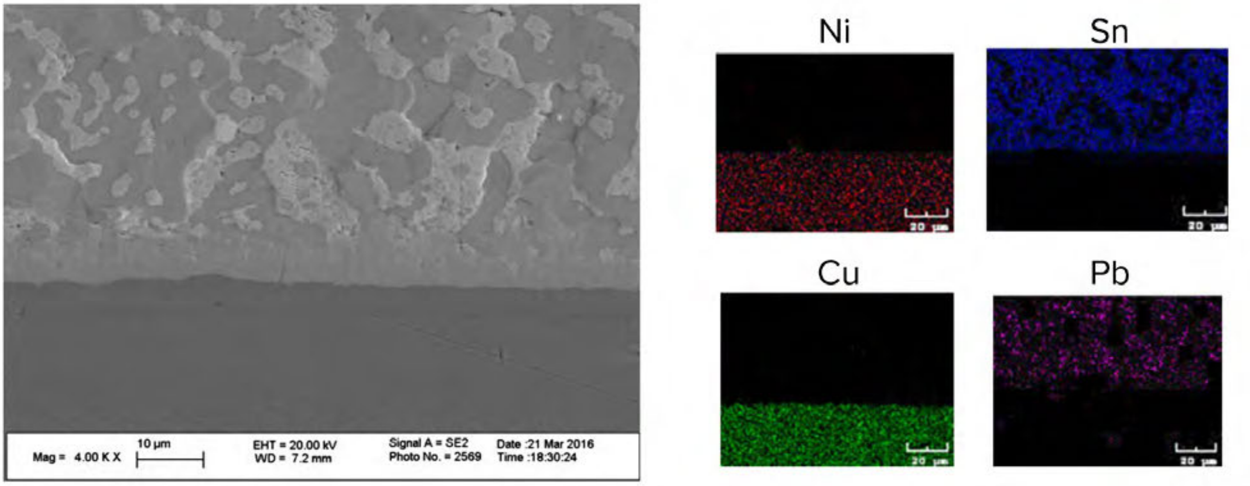

Figure 7: Representative SEM images with SEM EDS elemental analysis (e.g., showing existence of Ni, Cu, Sn, and Pb) at the solder interface after 200 thermal cycles (-55°C to +125°C).

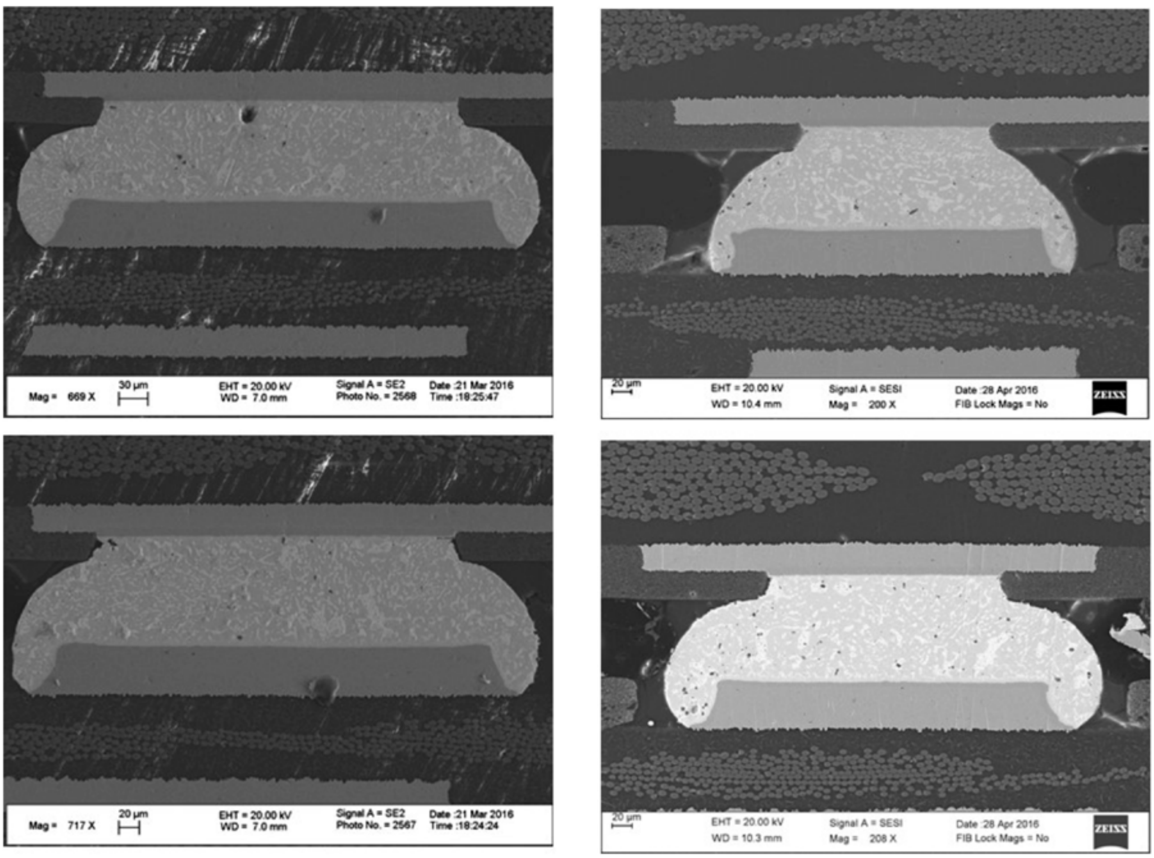

Figure 8: Representative SEM photomicrographs of LGA1156 solder conditions under the die after 200 thermal cycles (–55°C/+125°C), (left), and after subsequent 324 hours of isothermal aging at 125°C (right). Samples were the same—half used after TC—and the other half was used for subsequent aging, polishing, and SEM imaging.

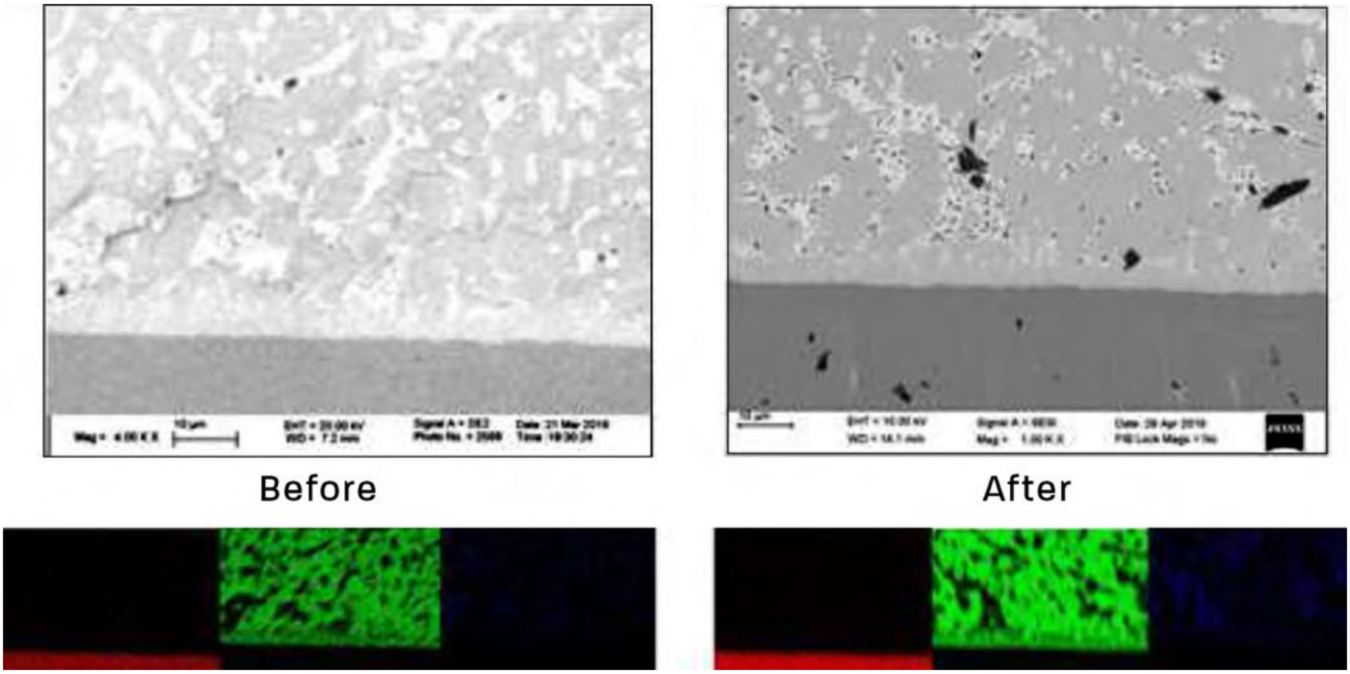

Figure 9: Representative SEM photomicrographs with EDS elemental analysis of LGA1156 solder conditions after 200 thermal cycles (-55°C/+125°C), left, and after subsequent 324 hours of isothermal aging at 125°C (right). Samples were the same—half used after TC—and another half used for subsequent aging, polishing, and SEM imaging, and elemental analysis.

Higher magnification was required to determine microstructural changes at the solder/ENEPIG interface. Figure 9 compares the higher magnification SEM images after 200 TC and after additional 324 hours of aging. It also includes the EDX/EDS elemental mapping analyses performed at the solder/ENEPIG interface showing the key elements to be tin and lead distribution. Grain growth is apparent, which is normal for aging. There is no abrupt change due to isothermal aging.

200 TC (- 55°C/+125°C) + 100 TS (-65°C/+150°C) for LGA1156

To determine the effect of higher temperature cycling ranges on interface microstructural changes, the thermally cycled LGA1156 assemblies (200 TC, -55°C/+125°C) were subjected to 100 more severe thermal shock cycles (TS, -65°C/+150°C). Contrary to the thermal cycle condition, which was performed in one chamber, the thermal shock cycle used two chambers and test vehicles were shuttled between the hot and cold chambers. A representative thermal cycle profile is shown in Figure 10. Only three TVs were subjected to this thermal shock cycle regime. All TVs failed between 20 and 60 cycles, but continued to 100 TS to possibly cause further opening of the solder joints. The one with an open after 60 TS was selected for cross-sectioning and the microstructural evaluation of solder and ENEPIG interface.

Figure 11 shows representative SEM images of the LGA assembly after 200 TC +100 TS. The cross-sections cover the areas with microvia, which was one layer down to provide daisy-chain pairs for continuity test. Figure 12 shows the SEM microstructure with EDS elemental analysis detailing the microstructural changes at the solder/ENEPIG interface.

Finally, three SEM images, with their EDS elemental analyses, comparing the effect of additional aging and thermal shock cycles are shown in Figure 13. They cover SEM images after 200 TC, after 200 TC plus 324 hours of aging at 125°C, and after 200TC plus 100TS. No apparent anomalies were observed.

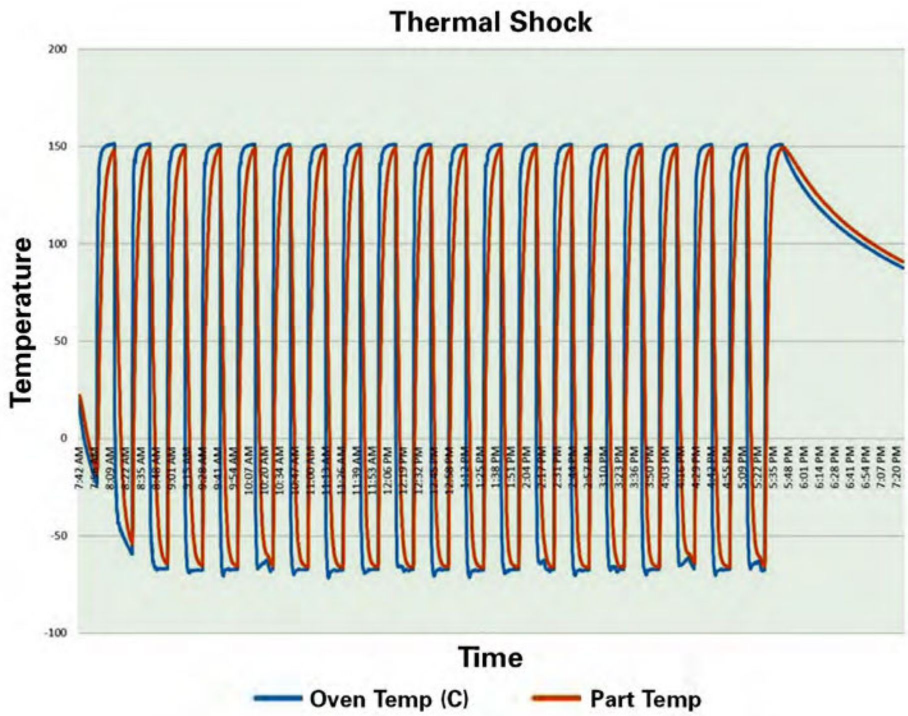

Figure 10: A representative thermal shock cycle profile (-65°C/+150°C).

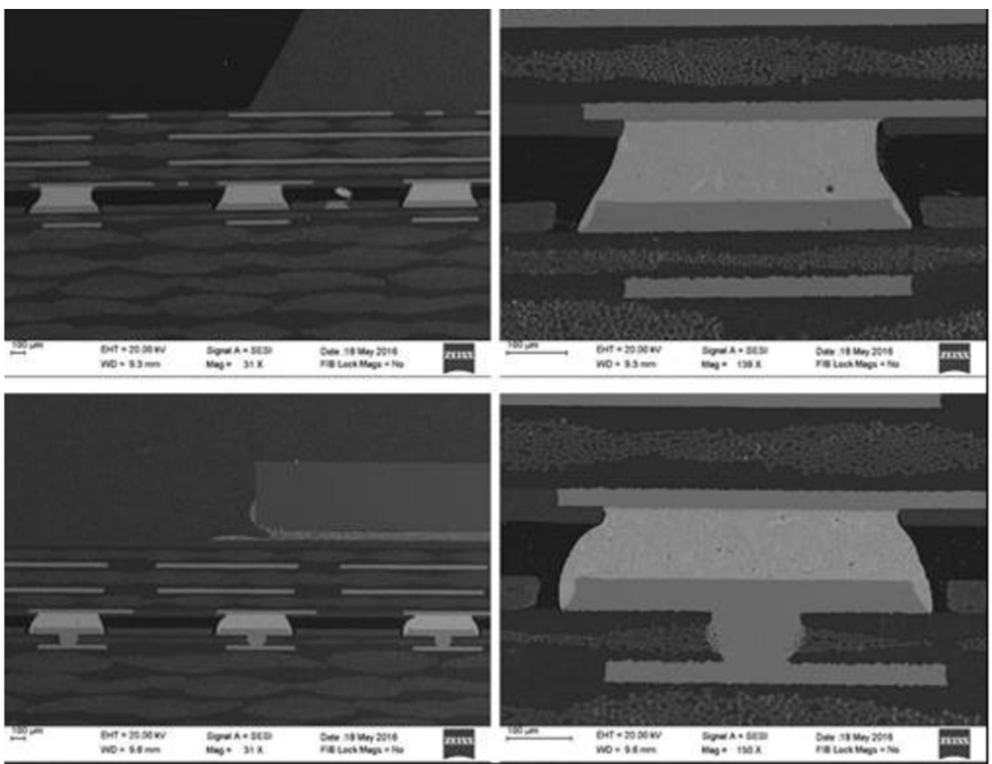

Figure 11: Representative SEM photomicrograph images of LGA1156 solder conditions under the die and over the via after 200 thermal cycles (-55°C/+125°C) and an additional 100 thermal shock cycles (-65°C/+150°C).

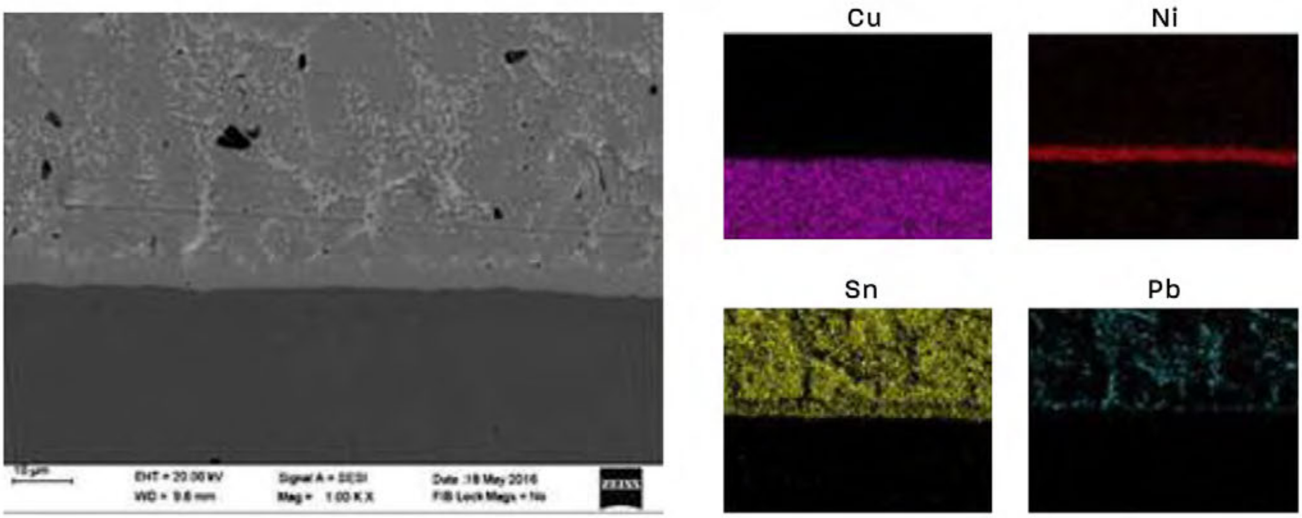

Figure 12: Representative SEM photomicrographs image with EDS elemental analysis of LGA1156 solder conditions after 200 thermal cycles (-55°C/+125°C) and an additional 100 thermal shock cycles (-65°C/+150°C).

Summary

ENEPIG PCB surface finish reliability characteristics for RoHS solder joint assemblies have been the subject of numerous papers showing favorable results. However, reliability data for tin-lead solder is scarce—sometimes showing negative effects on reliability. This paper addressed the ENEPIG with tin-lead for high reliability electronics hardware to see if there were any apparent issues. For this reason, many accelerated thermal cycles and shocks along with isothermal aging were performed using the LGA1156 assemblies to determine the integrity of the solder/ENEPIG interface after each environmental exposure. A summary of findings is listed below:

- After 200 thermal cycles (TC, -55°C to +125°C), no failures were detected by daisy-chain monitoring and no microstructural anomalies occurred at the ENEPIG/solder interfaces
- After 200 TC plus 324 hours of aging at 125°C, the ENEPIG/solder microstructural changes at the interfaces were within normal expectations
- After 200TC plus 100 thermal shock cycles (TS, -65°C to +150°C), the LGA1156 assemblies failed in the daisy-chains showing resistance opens, but no significant degradations were detected at the ENEPIG/solder interfaces by cross-sectioning and SEM elemental evaluation

The preliminary test results showed the acceptance of the ENEPIG PCB finish with tin-lead solder for short-term duration in high-reliability applications. It also revealed the short-term thermal cycle reliability acceptability of LGA1156 assemblies under standard harsh TC (-55°C to +125°C), but not under a more severe thermal shock cycle (TS, -65°C to +150°C).

Acknowledgments

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The author would like to acknowledge the support of the team in this work, especially D. Hunter, A. Mehta, and E. Bradford. The author also extends his appreciation to the program managers of the National Aeronautics and Space Administration Electronics Parts and Packaging (NEPP) Program. SMT

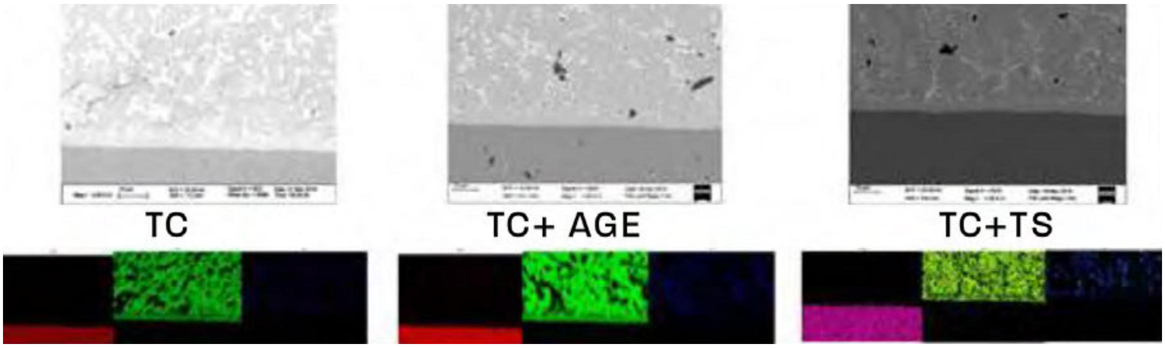

Figure 13: Representative SEM photomicrographs images with EDS elemental analysis of LGA1156 solder conditions after 200 thermal cycles (TC, -55°C/+125°C), (left), 200 TC plus 324 hours aging at 125°C (middle), and a 200 TC plus 100 thermal shock cycles (-65°C/+150°C), right.

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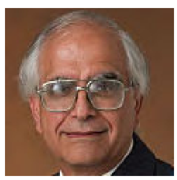

Reza Ghaffarian is principal engineer with the Jet Propulsion Laboratory.

The Root Causes & Solutions for Warped PC Boards

By Duane Benson, Screaming Circuits

There are two primary types of causes of board warping: process related at the fab or assembly shop, and layout related issues.

Determining the root cause is generally a bit of an iterative process. It's tempting to start right off with your fab or assembly partner, but you need some information before giving them a call. You'll need such things as the amount of warpage per inch, board size and thickness. With that, you need to take a good look at your design and consider copper pours, component size and component placement. This article talks about some of the design rules that can contribute to warping.

by Stephen Las Marias
I-CONNECT007

In an interview with *SMT Magazine,* Sven Patrik Eriksson, global technical director of Mentor, a Siemens Business, discusses the critical challenges in getting meaningful, actionable data from the factory floor. He also talks about the manufacturers' journey to Industry 4.0, and the best approach towards its adoption.

Stephen Las Marias: During the past couple of years, there's been much hype, which I think now is already becoming popular, around the Industry 4.0 trend. Do you think the electronics assembly industry is ready for that environment?

Sven Patrik Eriksson: Valor has had products that do Industry 4.0 processes for a long time. For us, this is very exciting because it is about creating solutions using software within the factory. There's a lot of messaging at these exhibitions that you need a lot of new equipment to be able to do this. We think that with our technology, you can bring your current factory towards an Industry 4.0 environment.

Las Marias: During the past couple of years, there's been much hype, which I think now is already becoming popular, around the Industry 4.0 trend. Do you think the electronics assembly industry is ready for that environment?

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Las Marias: What do you think are the critical challenges towards Industry 4.0 adoption?

Eriksson: The big challenge is collecting data. You need to be able to collect data from all the different process stages within your factory, and that is a challenge. Some machines cannot produce any outputs from the system. Others have a very advanced and enriched data that they can export to other control systems. So, it's this blend

of systems that the factories are facing, and how to connect all that into one solution that can use the data and start to analyze that data is the challenge.

Las Marias: Definitely, adopting a new technology such as this would need a significant amount of investment from the manufacturers. How do you think they should justify that investment?

Sven Patrik Eriksson

Eriksson: New machines on the factory floor can be very expensive, going forward. Valor has come up with Valor IoT manufacturing solution, which enables a connection to machines, collects data, and neutralizes that data to a standard way of communicating to any superior application. This is an easier way forward towards Industry 4.0. In terms of justification, I think each customer is different. You need to look at where your issues are and what it really saves you to make an improvement in a certain area.

Las Marias: In a typical electronics assembly line, you've got different machines from different manufacturers. Some of these machines provide data, while others do not. How is your Valor IoT manufacturing solution collecting data from these different machines to provide manufacturers the data that they need?

Eriksson: Over the past 20 years, Valor has developed experience in working very closely with a lot of the leading machine vendors. Communication drivers have now been put into the Valor IoT Manufacturing box. Customers can get all this technology off the shelf. If there are new machines that can produce the file, for example, we have our team that can develop the integration that is needed to also include machines that we may not have outside of the box. So, as long as a machine can produce data that can be processed, we can help the customer.

Las Marias: Will those manufacturers who have equipment that are five or 10 years old, but in perfect working condition, be able to use your box, plug this equipment in, and then see the data that they need coming to them?

Eriksson: If the machine has no certain output, what we can do with this box is connect sensors and scanners around the machine to gain a certain level of control. For example, we can put a scanner in front of the machine or after the machine, or other ways you would like to collect data. That could be an option for older types of machines that don't have the internal option themselves.

Las Marias: What do you think is the best approach towards the adoption of Industry 4.0?

Eriksson: It's a step-by-step process. First, you need to start looking at how you will collect data. Because once you can collect data from your factory, you can start to work with it, and that's what you need to take the next step to Industry 4.0.

We have launched a new Business Intelligence and Analytics (BIA) platform, just for that reason. It gives customers full capability to get out-of-the-box reports to get started quickly. But each customer has their unique needs, so the platform can slice and dice the data as they like.

Las Marias: With all these processes, the amount of data will be huge; how do you make sure that it is meaningful data that you can act upon?

Eriksson: Our new BIA platform is big data-enabled and multi-site enabled, to perform advanced analytics, not just within a factory, but at other factories, and see how it's performing between those; or maybe even analyzing data from the finance system. Most factories want to know how much they are making.

Las Marias: What's the latest development in the Open Manufacturing Language (OML)?

2017 Programs

October 3–4
IPC & WHMA Wire Harness Manufacturing Conference
Conference
Paris, France

October 3–4
IPC Technical Education
Workshop
Paris, France

October 6
Manufacturing Day
National Event
Across the United States

October 10
IMPACT Europe
Meeting
Brussels, Belgium

October 11
Wisdom Wednesday
IPC-2581 and the Perfect BOM
IPC Members Only
Webinar

October 16
IPC Day
Networking Event
Minneapolis, MN

October 17–18
IPC Flexible Circuits-HDI Forum Tutorials and Technical Conference
Conference
Minneapolis, MN, USA

November 7
IPC Day
Networking Event
Raleigh, NC

November 7
IPC Technical Education
held in conjunction with PCB Carolina
Workshop
Raleigh, NC, USA

November 7–9
The Pb-Free Electronics Risk Management (PERM) Council Meeting No. 34
Philips Innovation
Meeting
Andover, MA

November 8
Wisdom Wednesday
Competitive Innovation: Best Practices
IPC Members Only
Webinar

November 14–17
IPC Committee Meetings
held in conjunction with productronica
Meeting
Munich, Germany

November 14–17
IPC Hand Soldering Championship
held in conjunction with productronica
Competition
Munich, Germany

December 6–8
HKPCA International Printed Circuit and Exhibition & APEX South China Fair
Conference
Shenzhen, China

December 13
Wisdom Wednesday
Strategies for Reducing Product Warranty and Liability Risk in Manufacturing Services Agreements
IPC Members Only
Webinar

Eriksson: We're working with a number of customers where we are implementing OML between machines and our software. The OML is growing continuously, and we've seen a gradual increase in interest.

Las Marias: Patrik, is there anything else we should be talking about?

Eriksson: One area that the manufacturers are having issues with is planning the very complex schedule in their factories. With short, smaller batches, and frequent changes, it's getting more and more challenging for the planners to do their planning work. So, we have developed a very unique electronics specific planning tool, and we made it very specific for SMT and the back-end. It's very different from generic planning tools and it is gaining a lot of interest at this moment. You can create changes easily to your schedule, improve production performance on the machines, and minimize the downtime.

Las Marias: And that's because the rate of the product line cycle currently is just six months or one year, then you have to change.

Eriksson: One thing that our customers like about this tool is that before they start production, they know if the material is available to run the whole production. One common problem that factories have is that they run out of the material halfway through, and then they need to re-plan the schedule and the line is stopped for many hours. This is a completely stand-alone product. It integrates with all our other modules, but it can run on its own. It imports data from your systems and machines to simulate the generated schedule.

A product we've had on the market for quite some time is the Lean Material Management Solution. That's another area where companies are seeing the most increase in difficulties. How can they reduce their inventories and still keep the factory running at optimal levels without overstocking on materials? So, since we can have the knowledge about exact consumption of materials on the shop floor, our Lean Material Solution can enable a just-in-time delivery to the machines.

Our customers basically eliminate the material that tends to sit next to the machines. One customer said we turned a waste delivery system into one that delivers fresh fruit. Always fresh product to the line.

Las Marias: That's a good development. Thank you very much for your time, Patrik.

Eriksson: Thank you. **SMT**

Alpha Talks on Solder Dross Reclamation

Mitch Holtzer, director of Americas Reclaim Business of Alpha Assembly Solutions, talks with Managing Editor Andy Shaughnessy about the solder dross reclamation process, and discusses his new role in leading Alpha's reclamation business.

He also discusses the trends he's seeing in solder dross reclamation globally.

[Watch the interview here.]

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- Distill complex technical information into actionable knowledge that users can understand and apply
- Continually develop and maintain product knowledge

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- Bachelor's degree in electronics engineering or equivalent experience
- Sales engineering and/or support engineering experience
- Circuit simulation and/or signal integrity experience
- Understanding of ECAD/ MCAD market segments
- Understanding of micro controllers, SoC architecture and embedded systems market
- Database experience preferred (i.e., MySQL, PostgreSQL, Microsoft Access, SQL, Server, FileMaker, Oracle, Sybase, dBASE, Clipper, FoxPro) etc.
- Experience with PLM/PDM/MRP/ERP software (Program Lifecycle Management) preferred
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- Preparing quotes to modify, rebuild, and/or repair Chemcut equipment

Requirements:

- Associates degree or trade school degree, or four years equivalent HVAC/industrial equipment technical experience
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- Experience with single and three-phase power, low-voltage control circuits and knowledge of AC and DC drives are desirable extra skills

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The technical content specialist will:

- Assist in the development of key content and ensure consistency of message and format across platforms
- Develop a technically-detailed understanding of Indium Corporation materials and offerings to the SAAM industry
- Curate a library of technical conference papers and associated materials, including content related to Indium Corporation materials and their performance
- Assist in the development of, and ensure consistency for SAAM promotional materials, such as product datasheets (PDS), images, brochures, whitepapers and presentations (technical and sales)
- Attend at least one technical conference and its paper session per year

Requirements:

- Technical undergraduate degree (BS in Chemistry/Physics/Metallurgy/Materials Science or Engineering discipline)
- 5 years of work experience in semiconductor assembly or advanced electronics assembly
- Excellent written and spoken English language skills; fluency in Chinese desirable
- Proven ability to work independently with verbal or written instructions

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Southern California Territory Sales Engineer

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This position requires a highly self-motivated, hands on, confident individual of the highest integrity.

Required Skills:
- BA/BS degree-desired, in a technical area is preferred
- Two years of outside/inside sales or manufacturing experience in the PCB manufacturing environment is desired
- Self-motivated self-starter with the ability to initiate and drive business with little supervision
- Independent worker with a strong commitment to customer satisfaction
- Understanding of consumable sales process
- Ability to organize activities and handle multiple projects simultaneously with effective and timely follow-up
- Ability to solve problems and make decisions for which there are no precedents or guidelines and be resourceful in nature
- Positive attitude while operating under pressure and be an independent problem-solver
- Computer skills in Windows, Outlook, Excel, Word and PowerPoint
- Must have a valid driver's license with good driving record

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Throughout the Electronics Industry

Western Regional Equipment Service Technician

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Key responsibilities are to install and service equipment, conduct equipment audit, and provide technical service when appropriate to solve problems.

Required Skills:
- 2+ years of experience in a PCB manufacturing environment or similar
- Willingness to travel
- Positive "whatever it takes" attitude while operating under pressure
- Self-motivated self-starter with the ability to initiate action plans
- Ability to work independently with a strong commitment to customer satisfaction
- Excellent communication and interpersonal skills
- Strong ability to use all resources available to find solutions
- Computer skills with ability to write detailed service and equipment reports in Word
- Understanding of electrical schematics
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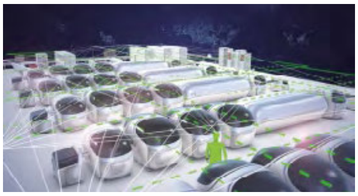
Recent Highlights from SMT007

1 On the Smart Move: Industry 4.0 in Electronics Production

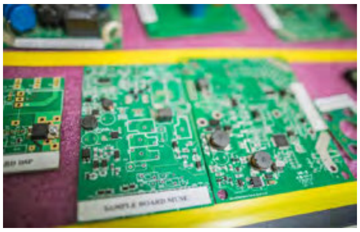


The industrial world is in motion, as we face a revolution in terms of processes, organizational structures, hardware and software in our companies.

2 Should You Entrust Your EMS Provider With Your Supply Chain?

Managing your supply chain can be time consuming and expensive and, more importantly, it can distract you away from other key activities such as sales, marketing and product design.

3 Sourcing PCBA: Can Your EMS Supplier Do More?



Sourcing PCBA doesn't have to be difficult, but there are questions you need to answer.

4 Newbury Electronics to Deliver 'State of the Art' Security Solution to Pen Test Partners

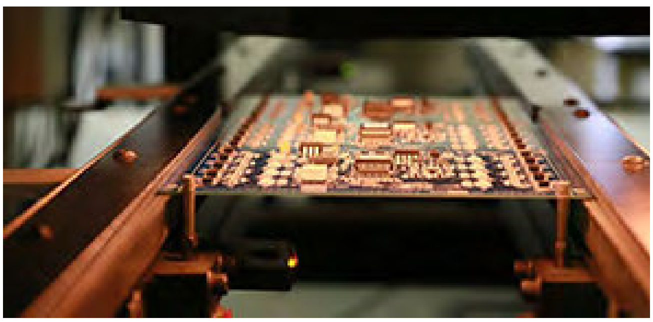
Security testing consultancy, Pen Test Partners, has turned to Newbury Electronics for assistance with one of its most recent security product collaborations.

5 Cemtrex Appoints Former Sony Exec as VP of Advanced Technologies Subsidiary

Cemtrex Inc. has appointed Joe Novelli to VP of Cemtrex Advanced Technologies Inc. to pursue the development and commercialization of proprietary and collaborative Internet of Things (IoT) and wearable technology products.

6 AMI Achieves ISO 13485 Quality Certification

AMI has announced that its quality management system had been certified to the ISO 13485:2003 standard for medical devices.



7 The Past and the Future of the European EMS Industry

The EMS industry in Europe is still in a growth stage of its life cycle.

8 Fabrinet FY2017 Revenue Up 45%

EMS firm Fabrinet has announced GAAP revenue of $370.5 million for the fourth quarter of fiscal year 2017, up by 34% compared to $276.4 million revenue for the comparable period in fiscal year 2016.

9 IPC APEX EXPO 2018 Opening Keynote from Jared Cohen will Highlight Technology's Game Changers

IPC APEX EXPO 2018 will feature Jared Cohen, founder and director of Google Ideas at Google and now CEO of Jigsaw (its successor arm with Alphabet Inc.), former advisor to two U.S. Secretaries of State, author, and member of the Council on Foreign Relations.

10 Valuetronics Q1 FY2018 Net Profit Rose 65%

EMS firm Valuetronics Holdings Ltd posted a net profit growth of 64.8% to HK$48.7 million for the three months ended 30 June 2017 (Q1 FY2018).

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Events

For IPC's Calendar of Events, click here.

For the SMTA Calendar of Events, click here.

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

electronicAsia
October 13–16, 2017
Hong Kong

TPCA Show 2017
October 25–27, 2017
Taipei, Taiwan

productronica 2017
November 14–17, 2017
Munich, Germany

HKPCA/IPC International Printed Circuit & South China Fair
December 6–8, 2017
Shenzhen, China

47th NEPCON JAPAN
January 17–19, 2018
Tokyo Big Sight, Japan

DesignCon 2018
January 30–February 1, 2018
Santa Clara, California, USA

EIPC 2018 Winter Conference
February 1–2, 2018
Lyon, France

IPC APEX EXPO 2018 Conference and Exhibition
February 27–March 1, 2018
San Diego, California, USA

China International PCB & Assembly Show (CPCA Show 2018)
March 20–22, 2018
Shanghai, China

PCB EXPO Thailand
May 10–12, 2018
Bangkok, Thailand

Medical Electronics Symposium 2018
May 16–18, 2018
Dallas, Texas, USA

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The sum and substance of thermal management.

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A look into the latest developments and technologies impacting your processes and systems.