NOVEMBER 2021

PCB007 MAGAZINE

I-Connect007
GOOD FOR THE INDUSTRY

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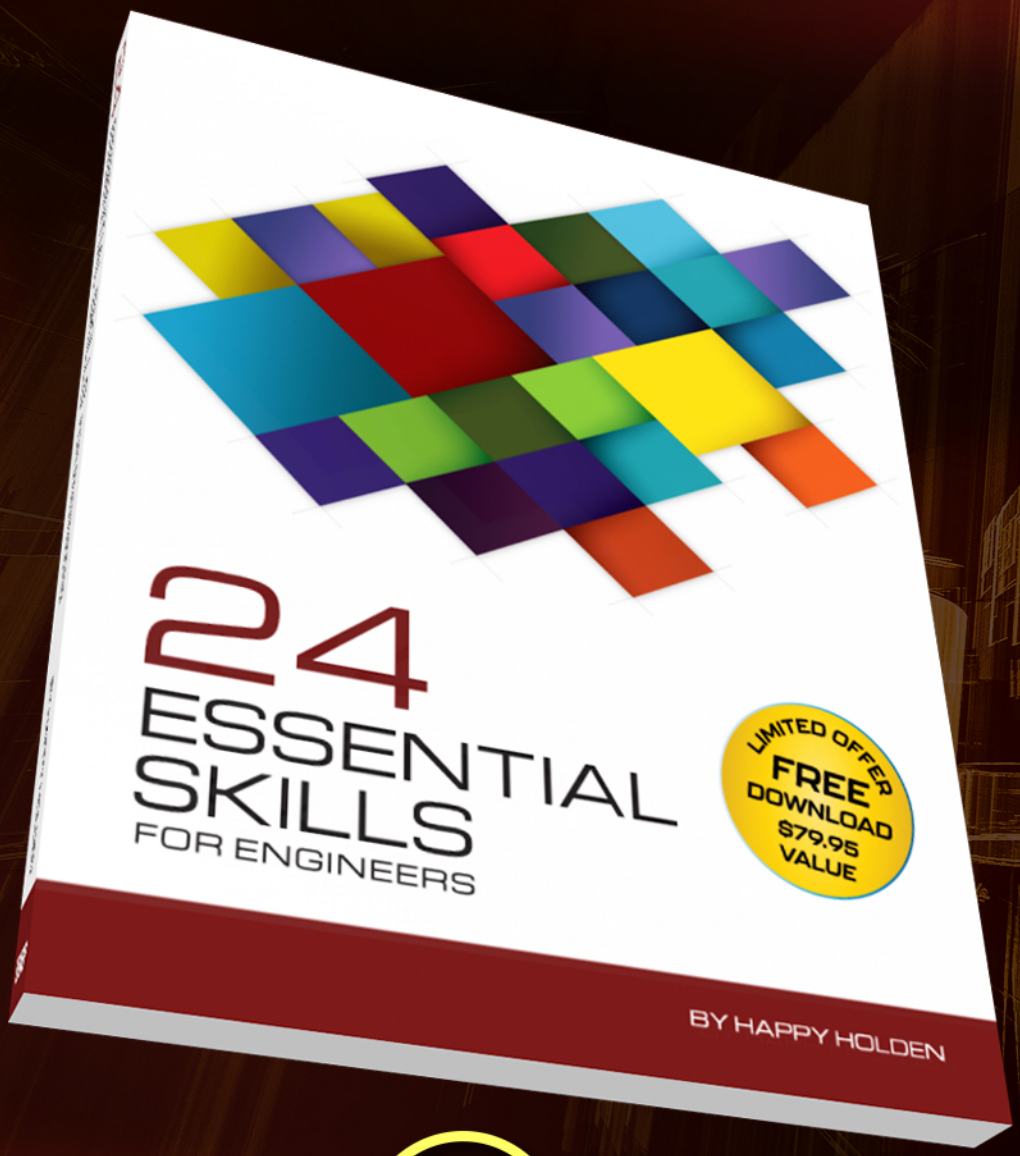

PCB007 MAGAZINE

Test and Inspection

With new inspection technologies and methods, along with AI and advancing data collection, fabricators have new options to consider in their inspection practices. In this issue we look at how new capabilities drive on-floor best practices, and how new best practices are influencing equipment design.

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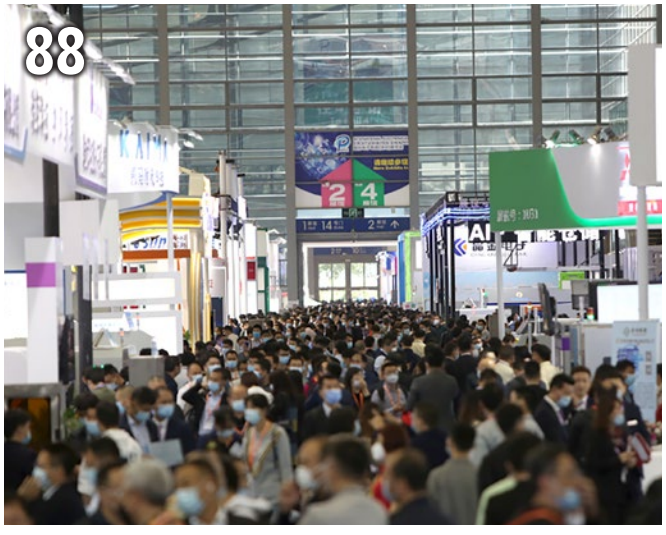

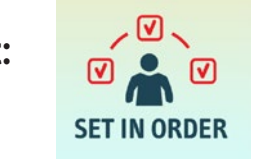

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Test and Measurement:
Drawing Inspiration from IC Design

Nolan's Notes

by Nolan Johnson, I-CONNECT007

I try not to sound like an "old-timer" but I've spent my entire career in the electronics manufacturing industry. Sometimes, "old-timer" stories just slip out. When I was first coming up in this industry, I worked as a software engineer at a CAE software developer. This was during the early years of the CAD tool industry and, while I was a junior engineer, I got to work on some of the first tools in the CAE space (see? There I go...). For example, I worked with the engineering team that developed Mentor Graphics' ChipGraph, Mentor's first IC design tool. Back then, the feature sizes on silicon were in the low mils—right where the cutting-edge dimensions for PCBs are now.

Given the dimensions, does this mean that today's PCB challenges are comparable to semiconductors, then?

Semiconductors are usually manufactured in clean room environments. But PCBs? Not necessarily, even at these cutting-edge dimensions. The software tools do not tackle the design process in the same manner, either. There is a different dynamic in the two disciplines, to be sure. For example, chip designs are built in quantity; the designs are developed from the very beginning to be manufactured en masse. For many, many applications. The circuit board, however, is usually the only unique part of the circuit board subassembly; and is solely responsible for making the components work together. The board, in other words, is both the glue and programming interface.

Back "in the day," semiconductor designs were typically run through LVS (layout versus schematic) and other simulation and verification tools to ensure the semiconductor design was a complete and faithful representation of the schematic. Given the costs for an IC fab run—multiple tens of thousands of dollars back then and even much more now—the pressure was on to deliver first-light on the first rev. Still is, for that matter.

In addition, semiconductor manufacturing is more, let's say, elite. There are relatively few OEMs, and the setup for each chip at the fab is very expensive, so long production runs, consequently, are the intended outcome.

PCBs are not quite the same. Each design and each revision within the design is unique. In today's dynamic supply chain situation, it's possible that there may be multiple versions of the same design and rev just to accommodate which parts packages are available at the time of manufacture. The OEMs are much more diverse, as are the PCB fabricators. What all this means is that the onus is on the PCB fab to ensure the design is manufacturable, where the semiconductor fabs avoided that process altogether.

And that situation leads us to this month's topic: test and measurement. With new inspection technologies and methods, along with AI and advancing data collection, fabricators have new options to consider in their inspection practices. In this issue we look at how new capabilities drive on-floor best practices, and how new best practices are influencing equipment design.

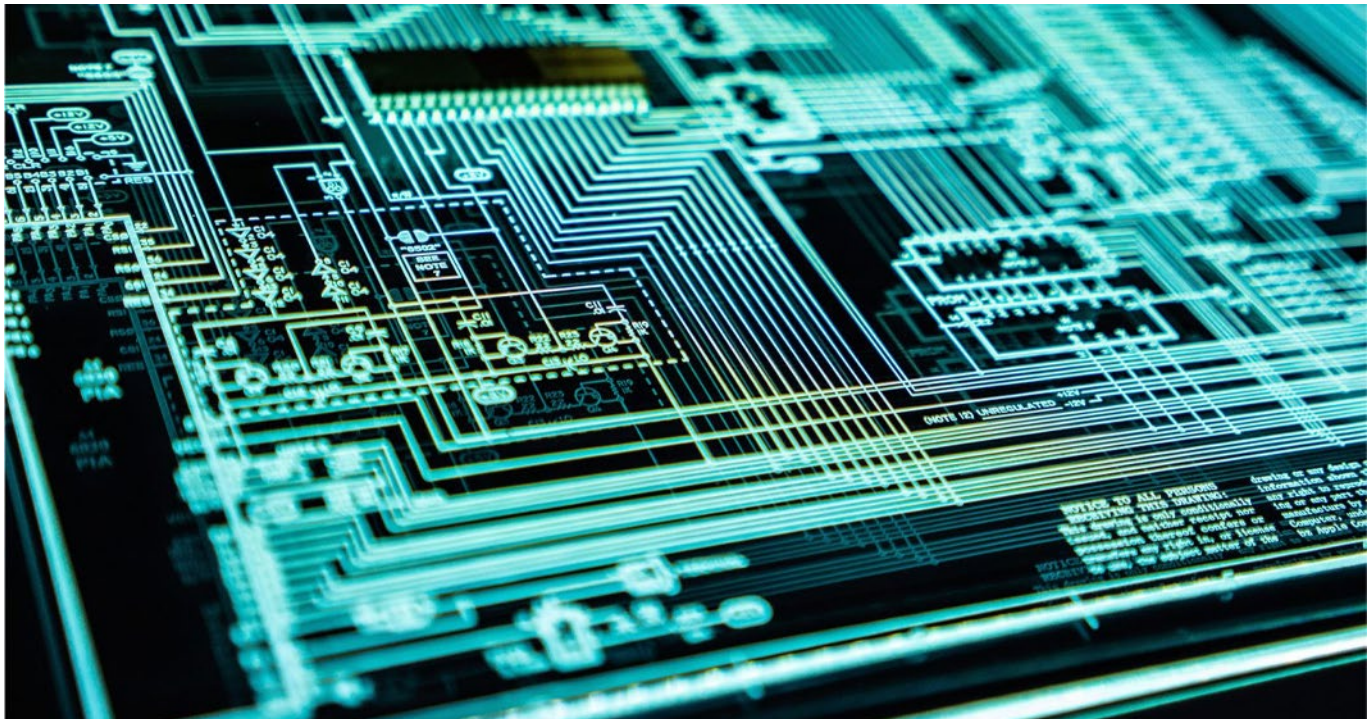
What has changed as the dimensions have gotten smaller? How does test data start to influence feedback and feedforward loops on the fabrication floor? Are there testing techniques that need to be evolved?

In this issue, Todd Kolmodin delivers an interview that takes us "Far Beyond Opens and Shorts" and we explore "Fascinating Opportunities in Flying Probe Testing" with atg and Mycronic. Summit's Gerry Partida discusses some new and powerful methods for prequalifiying manufacturing challenges, and Charlie Capers outlines test and measurements' competitive advantages as well as the cost of doing business. Aster's William Webb contributes a piece on DFT and test coverage in the digital factory environment, and Alex Stepinski brings his insight on linking data and process to improve both manufacturing and the inspection processes required.

Finally, we bring you our cadre of columnists, and a dispatch from the PCB007 China office—an interview with the HKPCA China show officials.

As I look back over the topics in this magazine, I can't help but notice that many of these conversations are starting to look more preventative, more simulation-based, more like what IC verification tools were doing "back in the day." There may be differences in how the design-to-manufacture processes work, but it sure looks like that same sort of rigor is emerging in the PCB sector. **PCB007**

Nolan Johnson is managing editor of *PCB007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To contact Johnson, click here.



Test and Inspection: Far Beyond Opens and Shorts

Feature Interview by Andy Shaughnessy and Happy Holden
I-CONNECT007

Gardien Vice President Todd Kolmodin talks about test and inspection market drivers from his perspective as a test service provider. Andy Shaughnessy and Happy Holden go down the "microvia rabbit hole" with Todd, as well as explore how OEM design requirements are driving test and inspection functionality and processes. When board layer counts and feature densities force longer test times, the tradeoffs to profitability for manufacturers become time and accuracy. Minimizing time while maximizing accuracy calls for new methods, which Kolmodin explains.

Andy Shaughnessy: Todd, will you give us an overview of test and inspection?

Todd Kolmodin: We're seeing that the way to compete right now is bundling. In test and inspection, you have requirements from a customer now that are far beyond just what I need to test the board for opens and shorts.

When the requirements now come in, we want the open and shorts. That's the "throw it on the table" given. But then they say, "We have some buried passives, some impedance, then some buried inductives, and HiPot; we have all these things that are added on there. Maybe they've moved into high voltage design. They want 4-wire Kelvin high-resolution testing. They want buried resistive testing because the Ohmega™-ply layered technology has really matured, and a lot of people are doing it. We test both in sub part innerlayer or final and we can figure out internal matrices of buried series resistance, parallel resistance, and combinational resistance.

We have integrated multiple tests into the same equipment and it's a way we can stay competitive and provide a one-stop test service or quality assurance service without having to buy all kinds of equipment. There are people buying grid testers and flying probes and then you're buying TDR equipment and

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machines for doing inductions and such like that. That's how we're seeing it.

Shaughnessy: What do you see going on with test and inspection? The good, the bad, the challenging?

Kolmodin: We're seeing more requirements from some of the manufacturers and that has forced us to invent ways to do things differently. Some of our equipment now can provide the TDR, the standard test, the buried inductance testing, buried capacitance testing, and buried resistive testing all on one machine so you don't need a lot of other equipment. You have to go this way to stay competitive because you can only cut your margins so far; after a while you won't compete anymore and you still need to pay your employees.

Todd Kolmodin

We are seeing some onshoring again. We are seeing a lot more of the hotshot stuff under ITAR agreements, and some of the military applications. Overall, I think we're getting stronger again but the function for success is definitely automation. I'm speaking for test in general, not just us.

Happy Holden: Todd, are you testing bare boards or assembled boards?

Kolmodin: With very small exceptions, it's all bare board level.

Holden: So, the test is getting more complex because the printed circuit itself is getting more complex with newer technologies?

Kolmodin: Exactly. Your standard 8-, 10-, 12-, 16-, and 20-layer boards—we see them up to 30+ when you get into backplane. These engineers figured out some time ago how they can bury certain components in the board using different types of material.

The problem is when you have some of it buried in the board and some buried components behave like electrical faults. As a resistive network, it could be higher than the continuity threshold required. Similarly, if you have capacitance built in, you could get charge time and leakage which will screw up the results of a standard test. You must be able to provide both tests in one session. It gets tricky.

Holden: I don't think a lot of designers realize that the very fast opens and shorts testers are not necessarily measuring any kind of resistance. They have a relatively large window to differentiate an open from a short.

Kolmodin: The standard electrical testers, be it a fixture tester or a flying probe, have metering systems and you tell them this board generically—for the basic opens and shorts test to make it easy—is I have this many networks and an endpoint-to-endpoint resistive value that should not exceed 10 ohms. It then measures, and if it's over 10 ohms, you fail. It's the same thing with leakage; no networks or adjacent networks should have any leakage. The isolation between the two should be 10 megohms or higher. If it's less, that's considered a leak.

We're adding different metering systems. You might have one machine that has three different meters—one for doing standard opens and shorts, one to do inductance, and one to do capacitance. Right now, you can't buy a machine off the shelf that can do all that. We're working on integrating that into a machine so all the meters are there and it does it all. As an equipment supplier, you've got to be there

because otherwise you're going to have problems competing later.

Shaughnessy: Do you typically start off working with the OEM or an EMS provider?

Kolmodin: Usually the OEMs are going to contract to the manufacturers. I'm not saying that we don't interface with the OEMs but a lot of times we're the third one down the line. There's always a strong communication line between us and the manufacturer.

Shaughnessy: Interesting. Some companies just don't really have a test strategy. They think it's expensive but the potential is there to save you from blowing a lot of money downstream. How do you convince someone of its value?

Kolmodin: The question is: Are you adding value to the board? We're not necessarily a value add but an insurance policy. Nowadays nobody wants to skip tests because there's too much involved in the manufacture. We're not talking double-sided or four layers anymore so it's really not cost effective to skip test because rolling the dice can be extremely painful.

When we talk to a customer, we ask them about their cost of test, and it's remarkable to discover that some have no idea. They have a test department, but they have no idea what it costs, or they have a very incorrect idea of what they're doing. That is a challenge for us to make our case for value add or ROI.

It's important for manufacturing products such as plating lines, presses, and drills to stay current with the technology. I'll see someone force a board into an antiquated or semi-obsolete test department and wonder why it stays there for three days because they can't get it tested. It's a good argument for paying someone to take that headache away, someone who already understands it. It's about outsourcing vs. not outsourcing. Some manufacturers love the idea because it takes all that capital and headache away. Others feel they can do it better internally, so that's just the way it works.

Shaughnessy: We hear in our surveys and interviews that, especially the designers, are being told you should own the design. Others say, "Well, not really; it's not my problem necessarily."

Kolmodin: That's the challenge electrical test has had for years because what happens is the designers prepare to design a board, they have a system and components, and they lay it out. But they don't have a sense for what will happen, what pain points the manufacturer will have, or what costs will be associated with their requirements. And then there's test as well.

My argument is this: "The technology is available to improve your design. It may have some finite restrictions on it and may impact the cost of your final board or the ability to perform all the requirements that you have." The disconnect has been between designing at the OEM side and manufacturing and test. I think a test strategy needs to have multiple groups involved. Obviously, the ultimate solution is to have the test guys and OEMs in the same group so there's that understanding of manufacturing and test and measurement; otherwise, you have those disconnects as you go forward.

Shaughnessy: What advice would you give designers regarding tests? What are some of the common problems, and what should they do or not do regarding DFT?

Kolmodin: If they have a manufacturer, they definitely should get feedback on capability.

From the manufacturing side, they need to have information from their test and measurement group on how to feed that back to the OEM so the OEM knows, "We can't put 10.5 micro packs in this area back-to-back because there's no way in hell we're going to be able to test it." That type of feedback is the most difficult.

You would have to create a test pass one and a test pass two which gives you 100% coverage, but the drawback is time. Instead of four hours in tests, now we need a day as each board needs two passes because they are not designed to test quickly. Meanwhile, downstream processes want the board "right now."

If designers want a signature analysis from a buried resistive value in an innerlayer, they need to port that signal on the surface of the board where it's accessible. Otherwise, it either must be tested at the innerlayer level or sub-part level, which then increases the cycle time of manufacturing. If they put an IO to it on the outside of the board, it can all be tested at final, which can be a very good time saver, but the drawback is that when you wait until the end and you have a problem with a buried network or something similar, you can't fix it.

Shaughnessy: Are you seeing AI in the tools? Do you think it's going to have a bigger role in test and inspection?

Kolmodin: I see it with robotics—load, unload, things like that. But I think there's a place for that in there. It's still rudimentary, but the way our flying probers measure and remember—it's not so much a science-fiction world anymore. It's not just the PCB industry, but other industries also going in that direction. I do see a place for it in the future.

Holden: Have you seen more requests for high voltage, especially where we're thinking about the automotive prototypes in electric vehicles in which the boards are going to be under 800 volts or higher?

Kolmodin: Yes. The military has a high-voltage test which represents much of their power supply stuff. We see insulation resistance test which is basically a high-voltage test on certain networks or planes on the board. It's usually high-voltage networks.

It's similar to HiPot, but not the same. HiPot test applies a voltage, ramps it up to 500 to 1,000 V or higher, then holds it at that voltage and looks for leaks. Insulation resistance test is where we look at two planes, maybe two networks, and we do the same thing. We ramp it up to 500 or 1,000 V, or we see 3,000. It's doing the same thing—holding that voltage high—but it's also making sure that the insulative resistance between the two networks is at a value or higher, just like an isolation test in circuits. It's just a very high-voltage isolation test called IR. If you had asked me the same question five years ago, I would have said we don't see that too much, but we are seeing it now. HiPot has always been around, but this high-voltage insulation stuff? We see it a lot and we should incorporate that into a test where we're doing our standard opens and shorts test.

Holden: Have people been requesting micro-ohm measurements when they have stacked vias?

Kolmodin: That's the 4-wire Kelvin test that we do. The theory behind it is easy. You put a probe on two sides of a via and you measure it. The problem is when you've got stacked vias and sub parts; copper will give you a resistance per inch, like 9.81 ohms per inch or so, theoretically. But we're dealing in micro- and milliohms for resistive values if it's a microvia stack.

Holden: Are you seeing increasing requirements for tighter TDR measurements? Some of the military guys, because of the new ICs, want TDR measurements within 2% of the window, rather than 10%.

Kolmodin: Ten percent is standard for us, but we see it down to the 5% range at times. Even the standard 10% is not really sufficient. We see some of the big OEMs come down to 5% tolerances. For us, it's not a big thing. The machines can do it, but the real challenge is at the manufacturer. For example, the military

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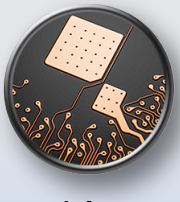

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Holden: Have they solved the problems with OSP so that it doesn't foul up the probe tips?

Kolmodin: OSP is one of the most difficult finishes out there; the main way to get around that is to test before OSP. Otherwise—even before flying probes, even with grid testers or fixture testers—trying to probe a pad with organic coating on it is an absolute nightmare. Usually, you won't get through it and you will have overflow opens and all that. The best thing is to get it from the process prior to OSP in the test, and back into organic coat before you start oxidizing the pads. If the organic coating is to be applied, the best way to test is after your critical process or measurements are done. I don't know a way around that one, really.

Holden: When I was at HP, we were not getting test probes on the surface or test pads, so we came up with a bead probe, which is just expanding the trace and putting solder paste on it so your probe could have a place that wasn't covered with solder mask and didn't affect the electrical impedance. If you have accurate flying probe or bed of nails, you could probably hit these small pads in traces.

Kolmodin: It was a challenge back then. But now that you mention it, when designers decide to use wire bond, direct probing is out of the question. You can't do it. Tell a prober to hit it but after that you've basically destroyed the bonding surface no matter how light you hit it.

You must come up with another way. You must short out the wire bond area, and test somewhere else to check for continuity and shorts. But they would fan out something in the design level if you got wire bond, test IOs. Wire bond is common in some of that product nowadays, especially high-speed and flex, and that is something I would recommend to designers.

Holden: There's a potentially big uptick in electronics, which is good news for young engineers because there is plenty of job security. But the uptick means more complexity from the semiconductor guys and that doesn't necessarily make it easy for us.

Kolmodin: I agree. It has grown leaps and bounds in the 35 years that I've been in this industry. With the acceleration of that curve, I imagine the next five or 10 years will be pretty amazing.

Holden: Especially with electric vehicles. With electronics replacing all those mechanical transmissions, axles, and differentials, that's good news for fabricators and assemblers. But if you don't have the capital budget to keep up with it, that's bad news.

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Kolmodin: That's where I ask about the value of in-house vs. outsource. Do you want to keep investing in capital, or do you want to bring in an expert team that's always on top of it all? It might be a few extra pennies here and there, but it sure saves you having to put multiple millions of dollars into equipment every three years, because the acceleration of this technology curve in ICs and printed circuits is faster than what you can amortize your equipment.

Holden: I had a testing challenge with some innerlayers using gold wire bond showing some shorts. Then we would laminate them, mark the boards, and send them out into assembly. Eventually these boards would be tagged and rejected, and we would run over to look at the card. They all said, "Too much time," which meant testing could not find the bad component and the time being spent on it exceeded the value of board. If we have a whisker short on the bare board and it's been laminated in, the tester can't discover it. To the test department, it's too much time. And too much time doesn't point to the actual problem on printed circuit board. It's a profit center decision.

Kolmodin: Right. We call that whisker a micro short. We developed an algorithm and technology with our equipment called micro short detection, which is basically those slimmer shorts on an innerlayer from a clearance to a plane or something like that. If you do your normal voltage test you will actually fry that thing. The tiny whisker will pop like a fuse but won't be detected as a short because it was gone so fast. The problem is that it leaves a metallurgical signature that could actually cause a latent short down the road, which is what Happy was saying.

Holden: Yeah, the data said that was just passing the problem down.

Kolmodin: Especially with the density and spacing that you have on these innerlayers. You've got metal there and you might burn it open for the moment but, left over time, heat, shrinkage, expansion, and some funky metallurgical stuff goes on in there where you can actually grow that short back. It's expensive from an assembly side when you have a $3,000 board out there that fails.

Getting a return is always bad news but a lot of times OEMs aren't going to spend the time to destructively analyze the board or remove a component to say, "Okay, we have to actually go down to a bare board level problem." They'll just send the board back to the manufacturer, marked as failed, and let the manufacturer's lab deal with it. But we do see some of the bigger OEMs and assemblers wanting root cause of analysis.

Holden: I think test will become a bigger thing with EV because I've found automotive to be far more critical about reliability and performance. If you have a single failure, you really have to jump through hoops to the root cause because they're worried about the warranty costs.

Kolmodin: Oh, sure.

Holden: If these things come back under warranty, that's a big expense.

Kolmodin: Just from a mechanical standpoint, we saw the horrors of the Takata airbag recall and that was huge. We're right at the time of year where the new model year comes out, so if they've got a component problem in a car, that's a huge recall, and that's big money.

Shaughnessy: Todd, thanks for speaking with us today. It was a good discussion.

Kolmodin: You're welcome. **PCB007**

Todd Kolmodin is an I-Connect007 columnist. To contact Kolmodin or read past columns, click here.

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Fascinating Opportunities in Flying Probe Testing

Feature Interview by Pete Starkey
I-CONNECT007

Pete Starkey visits with Peter Brandt, director of sales, Europe and Japan for atg Luther & Maelzer, who reflects upon joining the Mycronic group, discusses market and technology trends in testing, and what to expect from atg at this year's productronica.

Pete Starkey: Recently, atg Luther & Maelzer was acquired by Mycronic. How will atg Luther & Maelzer integrate into the Mycronic group?

Peter Brandt: As of June, atg became a member of the Mycronic shareholding group headquartered in Sweden and we are now part of this big European technology company. Mycronic was our first choice during the transfer process. We talked to several potential buyers, and in the end, we were very lucky to be acquired by Mycronic because they are a technology leader in the assembly and loaded board business. They produce pick-and-place systems, bonding systems, and digital mask writers. They know exactly how it works in the world of investment products. It's nice that we are talking about the same issues when doing a forecast for the next year or when you need capital equipment.

You don't always know; do you sell this machine, do you get the order next year, or it is canceled? We have more or less the same base market, but we can keep atg Luther & Maelzer as our own complete sales channel because Mycronic is located in the assembly and loaded board industry, and we are in the bare board industry. This means with our supply and our supporting chain—like our agents, distributors, and our complete service and sales organization—we keep it like it is. We are part of a technology company, but we can transfer our production, sales, and service; everything else stays the same because there is no actual consolidation process.

The size of Mycronic in relation to atg is also very good. We are approximately 10% of the revenue of Mycronic, which provides us with a strong financial background when we must finance machines, need bank warranties, or something like this. On the other hand, we are already a significant part of the business unit of Mycronic.

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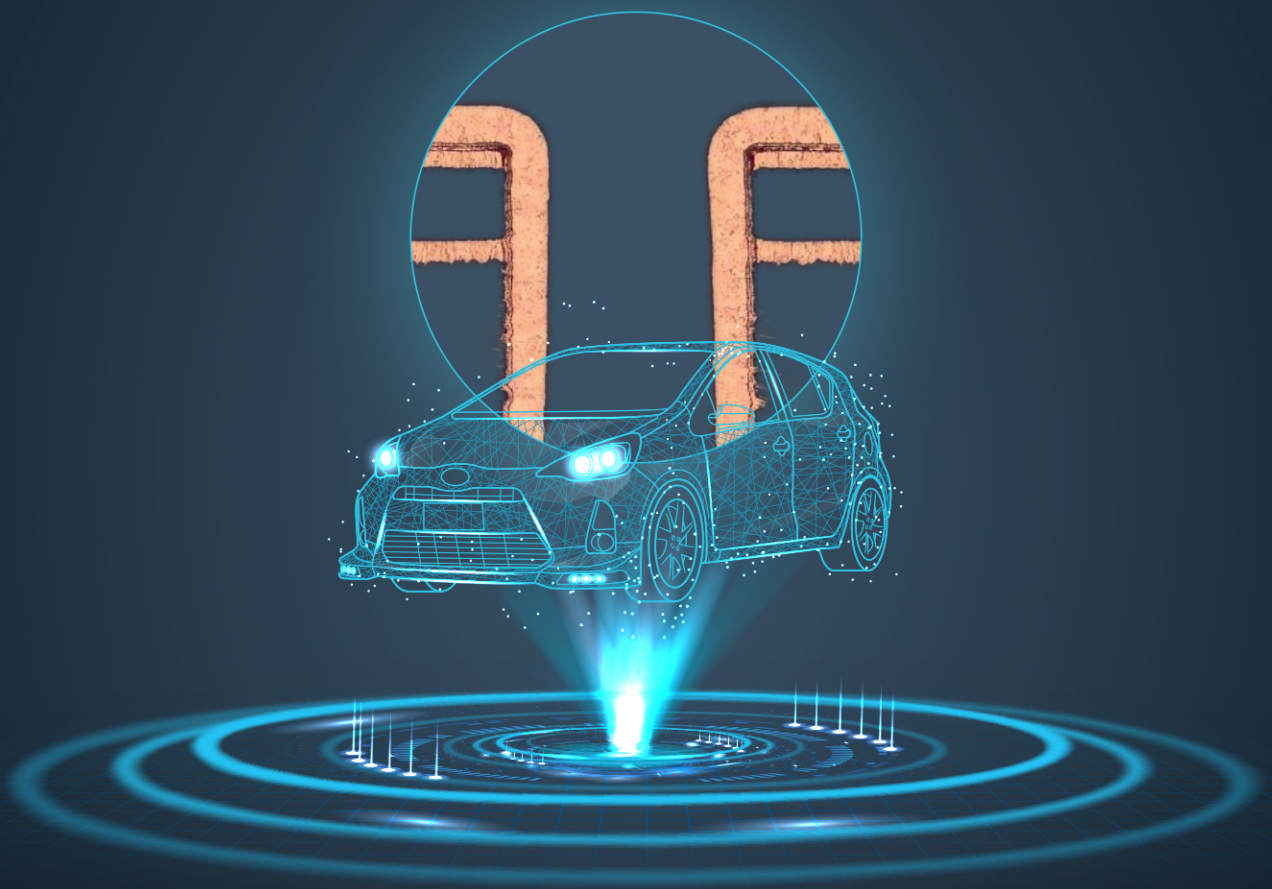

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Starkey: Could you comment on global and regional trends you are seeing in the market as they relate to testing?

Brandt: We see an improving market in the package and substrate business. This is mainly an improvement in the Asian markets, like in China or Korea, and partially in Japan, which is for our flying probe. There are big challenges regarding accuracy and measurement methods for our flying probe. But this is a high-volume business. This means we only participate in smaller production quantities, because you can say 99.9% of this market for electrical testing will be covered by dedicated testers, using high-density, and high-cost fixtures. This technology is a market driver in the case of fine pitch density, and we see that this technology will jump step by step into the regular PCB market, not just the short term. But we see more and more substrate applications in PCB. We call it substrate-like PCB products (SLP). Our standard PCB high volume flying probe for machines is a growing business.

Starkey: Sure. I think it's very clear that there is a blurring of the boundary between the printed circuit board side and the substrate and component packaging side. This is affecting a lot of the design and manufacturing technologies as well. It's clear that because of your involvement in that part of the industry, it's acting as a technology driver for the development of your equipment.

Brandt: With this technology from the substrate market or from the HDI mobile phone market, we get more applications for different and advanced measurement methods. Twenty years ago, when you'd try to sell a flying probe machine to your customer, they would ask you about continuity and short measurement. That's all. Now, when you're going to the U.S. (North American) market, a big part of the business is for the aerospace and defense industry, and they are asking for a class

Peter Brandt

3 approval for the measurement technique. For us, this means all these machines need a high speed, high voltage resistance testing for the short measurement, where a customer can select thresholds up to the G-Ohm level or voltage level up to 500 or more. In addition, we have a chance with a high voltage short measurement where we can add on a high voltage breakdown test.

During the charging of the net, we monitor the loading curve, and in case of a high voltage breakdown, the system stops and will monitor this kind of defect. It's also a kind of leakage test in the high voltage test. We always add more features for the measurement methods. The advantage of the flying probe is that you can define all the parameters by yourself. You can change the voltage, the current, the threshold level—everything can be selected by the customer and can be monitored for future quality approvals.

Starkey: Are all these features incorporated into a standard machine, or do you need a specially adapted version of the machine for special tests?

Brandt: All these additional measurement methods are available in our flying probe machines because we have a basic electronic unit—a unit with the same software and electronic components for all our flying probes. We have this technology for our existing A7a and A8a technology, and with this is our state-of-the-art, latest generation of the direct linear motor drives technologies in the A9. It's also in the A9 automation technology which released this year. This is our newest technology. With these high voltage features for the quality of shorts, we are getting more requests for four-wire measurement options that can recognize thin plating defects in through-holes or latent test measurements where you can detect dish downs, cracks, mouse bites, or the quite new measurement technology—a back drill test where you can detect remaining stripes or partial stripes in back drill holds. All these different measurement methods can be integrated optionally in these flying probe testers.

Starkey: When I first encountered your equipment, we were looking at low-voltage resistance testing: if the resistance exceeded a specific value, or if the resistance was less than the specified value. Then we got shorts and opens and when we looked for them with a magnifying glass, we could actually see them. But a lot of the defects that you can identify are beyond the capability of the human eye, even with a good magnifying glass. Just going back to the sort of physical measurements, if we look at the mechanical side, what sizes and fixtures are you able to contact accurately and consistently with the flying probe tester?

Brandt: The standard or the limit of the standard product line for flying probe means standard A7, A8, or A9 automation; a standard pad size dimension for two wire probe test is around 50 microns. This means two mil. This is a standard for all flying probe machines. When you want to go less than 50 micron in a pad size you need some requirements to do it. Then you have to check the parameters. It means you have to keep the machine in a stable environment, especially for temperature. You have to integrate a glass calibration plate instead of an FR-4 calibration plate. You will take fine pitch probes instead of standard probes. Then it depends in which direction you want to go.

When you have a PCB test system, like A9 or A9a, then the limit of the technology is somewhere in the range of 30- to 35-micron pad size. If you want to go less in smaller pad dimensions in the direction of 20 to 15 microns, then you have to go in the direction of our S technologies—S2 or S3—in the substrate market and package boards. This is a dedicated business, but you never know, sooner or later it will also move from the substrate market. This technology, this kind of production capability, is also in the standard printed circuit board. We have to prepare for this.

Starkey: You mentioned you have to make sure the environment is stable and the calibration is precise. What are the real characteristics of a printed circuit board to consider when you determine accuracy? How intelligent can your positioning systems be?

Brandt: We always use an optical alignment system in all our equipment and in most of the flying probes in the market. The operator selects optical scan marks on the top and bottom sides, and with the optical scan marks they're able to compensate for the shrinkage and offset problems. Here you can compensate tolerances from the production in relation to the real data of the board production; I would say at least in the range of ±2-3%. This means for a big board size you can compensate different alignment of offsets in the range of three to five millimeters all over the board. Only this kind of optical alignment check of the complete board will guarantee that you always contact in the middle of the test point.

This is a must. If you are not hitting the test points, you get an open. Or if you have,

for example, very soft surfaces, then you risk touching the point at the edge. You will get a big hit mark. With this kind of technology, especially if you have big server boards, for example, there are a lot of layers inside. There's a big dimension. You need an optical calibration and some partial improvement of the calibration over these long sizes to optimize positioning independently from top and bottom to always hit the pad in the center. Only with this capability do you get approval from the quality manager.

Starkey: Sure. Give me an example of what you consider to be "long."

Brandt: For us, big panel sizes are always the server and back panel boards, which are larger than 24 x 21 inches. We have different machines with an A7-16 to reach panel sizes up to one meter long with a dimension of one meter by 600 mm, or one meter by 800 mm. The biggest machine we ever produced was a 24-head flying probe machine with a test area of 1.5 meters by one meter. This is the biggest machine we have ever produced. This is not a standard machine, but one we produce on customer demand.

Starkey: It's one thing to produce the machine to test it and another thing to actually manufacture the product that you're going to test.

Brandt: These are niche products. We produce a maximum of one machine per month, and a maximum of 10 of these oversized machines per year. In comparison, we produce approximately four to six automatic flying probes per month. So, when you talk about the tendencies of the market as future demand from the customer, this is more in the direction of automation. The owners are looking for reliable workers, not only here in the European or U.S. markets, but also in Asia. They now convert all their manual machines to automatic machines.

Starkey: Peter, in the past, flying probe systems were never really considered for testing volume production. You already mentioned, in certain applications like the production of smartphones, that because they're produced in very large volumes, you could produce a specialist grid test fixture for testing that sort of product. But for the more general state-of-the-art circuit board product, the current leading-edge design density really exceeds the mechanical capability and cost-effectiveness of classical grid testing. The focus has been on flying probe testing and that's demanded improvements in probing speeds and automated panel handling. What sort of throughputs are currently achievable?

Brandt: When you look at the typical consumable application in North America or in Europe, or some high-density applications in Asia, you can approximately—if you have a test board with 5,000 test points, multilayer board—reach a one-minute cycle time on the flying probe machine. Depending on the measurement parameters, you can reach around 50, 100, or sometimes 150 boards in one hour, which is not in the range of a grid system, because the grid system is still able to reach

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several hundreds, but it's already going in this direction.

You see how long it will take sometimes, depending on the density and the size, to set up a fixture. This means the set-up fixture, if it's a double density fixture, and you want to test the BGA on the board. You have a big pin tilt, and sometimes it takes hours to get the reliable fixtures. You don't need this with the flying probe machine. In that case, to do every parameter in consideration, when you have quantities up to 1,000 to 5,000 you should think about the flying probe machines. With package boards or HDI mobile phone boards, if you reach quantities of 100,000 or more, then you still need the fixtures. But today's flying probe using standard measurement parameters, 1,000 boards or even more, is not a problem from an economic point of view.

Starkey: Peter, we're approaching productronica. Provided the authorities don't impose any travel restrictions, I plan to attend. What can I expect to see at the atg booth?

Brandt: At the atg booth this year you will see two machines. You will see a standard A7 machine which has been in our portfolio for seven to eight years. This is our standard manual machine, and the first time in the world where we will exhibit our new automation, so you will see the A9 with the automation function inside. It's our latest technology. It's a machine where you can load manually production panels up to 21 x 24 inches. In parallel, you have an automation unit handling with a double shuttle. This means your product change time is nearly zero seconds, and with this automation you can handle product sizes of 480 x 420 millimeters.

We also have another manual A9 machine at atg Italy, our distributor there. Last but not least, we have a new A5 machine in the booth from our distributor Adeon. Hopefully this year we'll have four test systems at the productronica show.

Starkey: Thank you, Peter. **PCB007**

I-Connect007 Launches *Real Time with... American Standard Circuits* Event

I-Connect007 is pleased to announce *Real Time with... American Standard Circuits,* the first-of-its-kind event featuring three in-depth discussions and a virtual tour of American Standard Circuits' factory. Inspired by their three wildly successful books in I-Connect007's The Printed Circuit Designer's Guide to... series (*Flex and Rigid-Flex Fundamentals, Fundamentals of RF/Microwave PCBs and Thermal Management: A Fabricator's Perspective*), this project is a comprehensive knowledge base for the reader interested in learning about high-tech circuit board manufacturing. These discussions augment the book series, offering a deeper dive into the respective technology segments.

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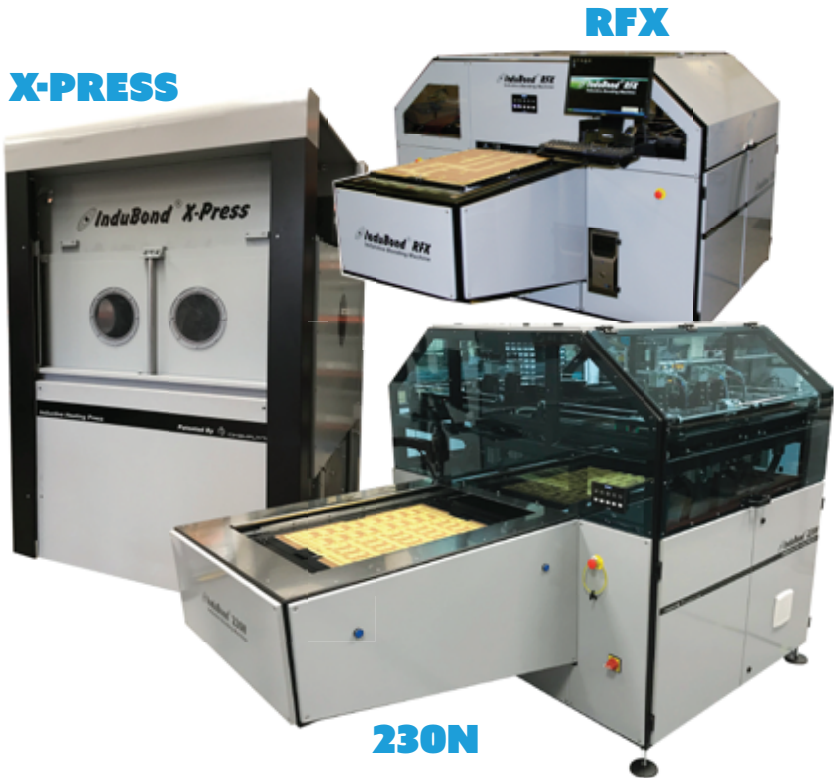

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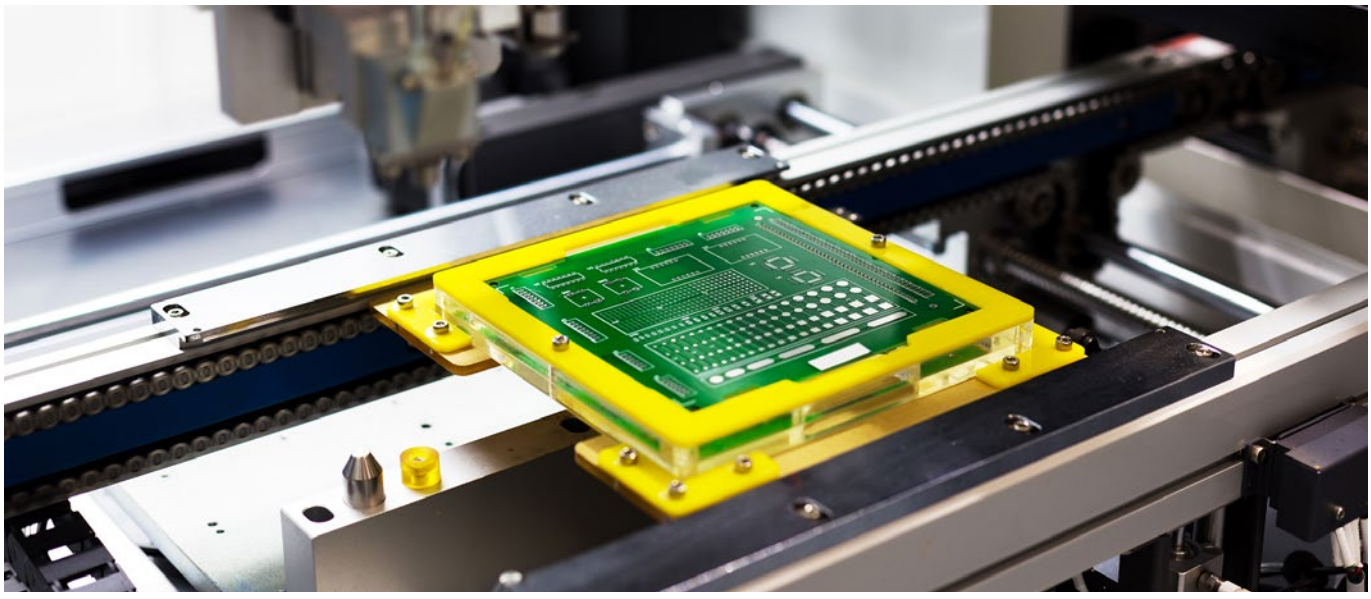

New Methods for Quantifying PCB Design Weaknesses and Manufacturing Challenges

Feature Interview by Nolan Johnson
I-CONNECT007

Nolan Johnson recently spoke with Summit Interconnect's Gerry Partida about disruptive new methods for analyzing and quantifying potential manufacturing challenges in designs while still in the design phase.

Nolan Johnson: Gerry, what's the background for the new methods we're about to discuss?

Gerry Partida: The industry is at a new point in evolving how we look at building boards. Our industry has historically built boards and then tried to find a test for them. Then, when they found a test for it, they figured out that it needed to be analyzed before they built the board. We did this with electrical test. We built boards and down the road, as people started asking, "Why am I buying bad boards? We should electrically test them," electrical test was introduced, reluctantly, into the test part of manufacturing printed circuit boards by suppliers or fabricators. Then they embraced it. But when we started testing boards, we did comparison tests. We would build a bunch of boards, put the first one on a tester, tell it to self-learn, and compare all the boards to the first board. If they all matched, they all shipped as matched boards, but if they had the same defect, they all shipped with the same defect. This did happen.

It wasn't for another 10 or 15 years that we took extracted netlist from the CAD software and compared it to the Gerber data that would be used to fabricate the board, to find out whether everything was corrected before we started manufacturing. We would find that there was a problem, and we would fix it or get new data. Then when we knew we had a match, we started to manufacture the boards and downloaded the program to the tester. But this was an evolution of about 15 to 25 years. It depends on what point of view you take from it.

We've done the same thing with microvias. We've been building microvias. There are datasheets that talk about the modulus and the CTE expansion after reflow, before Tg, and after Tg,

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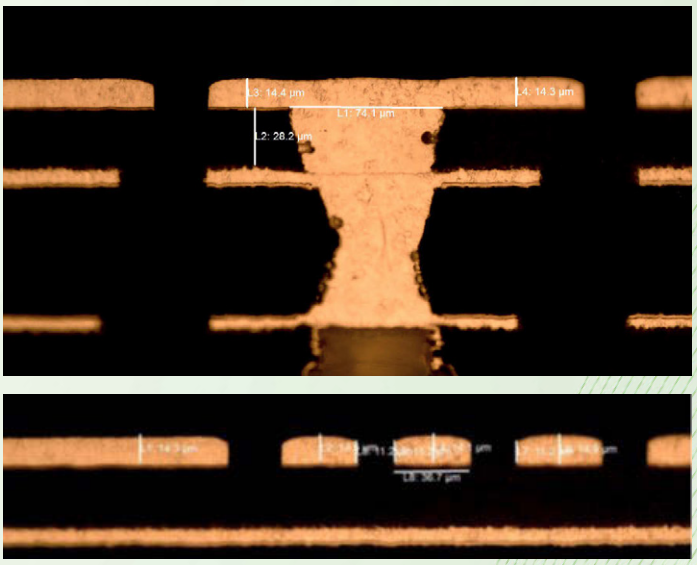

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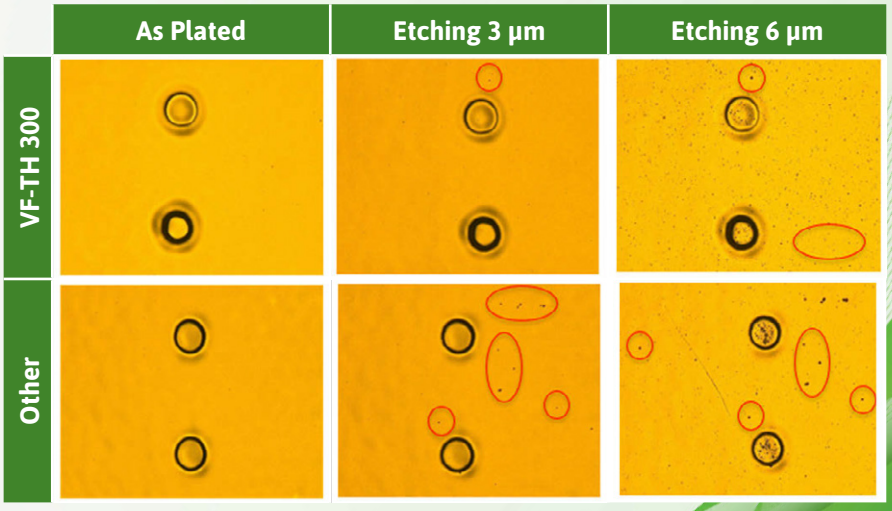

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Gerry Partida

but no one really would do any math or science behind it. The PCB fabricator would just build the boards and ship them. Sometimes there are assembly problems, and the industry says, "There's something going on with microvias. Three-stack and four-stack are not as safe as a single microvia and staggering them." Everybody is trying to find out how strong or how weak they are. Most people were finding out at assembly because the standard IPC-6012 performance specs in the evaluation couldn't identify a weak microvia very well. So, we came up with the OM tester, which is using the IPC-TM 650 2.6.27 test method, which actually takes a coupon with the same structures that are in the board and simulates reflow on the coupon before we ship the boards.

If that structure, which is in the board that we're trying to ship, can survive reflow in a tester, then we know that the boards are more than likely going to pass and survive reflow and assembly. This works great. It will tell fabricators that if we process everything right, the board is going to be reliable through reflow. However, after a couple years of having the tester, we discovered we did everything right, but occasionally it wasn't working. They were failing 6X reflow. Utilizing our extensive experience in microvia fabrication, our portfolio of reliability testing data, materials expertise and software tools, we can simulate the stack-up; you can actually input the microvia structure and the data output will tell you if it can survive six reflows or not.

We're now doing that same evolution that we did for electrical tests with microvias, where we can analyze and simulate if it's going to work before we fabricate. If we find something that will appear to work, or if not, we can share and help understand between our customer and ourselves: What is the risk if we do this? Build the boards and then test it for reliability by reflow simulation and resistance testing, and make it match. That's where we have gone to this next stage of evolution, which is as important as netlist compare and downloading. I think that's where we're at with this method.

Johnson: That makes sense. Does that trigger changes in the design to get better reliability? How does that dialogue happen?

Partida: That dialogue is evolving as well. As a fabricator, if somebody hands you a drawing in a stackup and you say, "That won't work, and I've even asked some people I've proven it on with their boards, that it would only last three reflows. But if we change the material, change the design, we can get it to 10X reflow." Then they say, "Okay, let's rebuild and change the design. Let's do that." I asked them the question, then said, "Just give me your gut first reaction when I ask you this question." They say, "Shoot. If I told you the day you gave me the print that these boards would fail if we tried to build them, what would you do?" He immediately responded, "We would have found another fabricator."

Johnson: That's the wrong answer, isn't it? The customer is sweeping fundamental issues with their design under the rug.

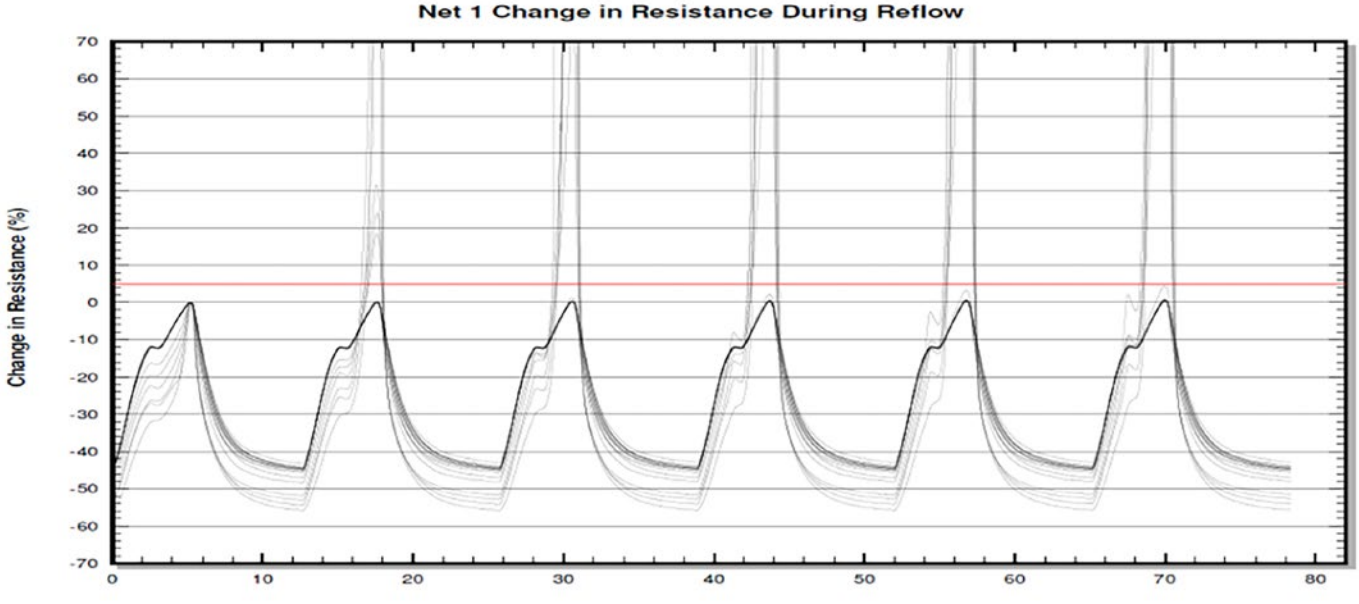
Partida: That's correct. I'm trying to help them understand that this is what we see. In other words, "If we try to do this, it's not going to work. Our experience and tools say it's not going to work. It's based on science." And it sounds like, well, this is magical. You put this information in, and it will tell you it will not work, but how do you know that it's going to work in the real world?

I have two years of D Coupon testing data. I'll give you an example: 47 net, 47 failed, one passed. Our data said, "It will fail at 3.1 reflow cycles." The OM tester will tell you that one reflow cycle, I might fail that." I put in the spreadsheet, every net at what refill cycle to fill it at. Our output says 3.1 reflows to failure; when I averaged out the 47 failures, it came out to 2.95 reflows to failure.

Johnson: That's pretty accurate. If you get enough of those examples, you start to really trust the analysis. This starts to change the traditional test and inspection dynamic. You're moving away from having to inspect and test what you've done and, instead, moving into, to use a Happy Holden term, predictive engineering.

Partida: That's a great term. That's the evolution here. We can look and find out whether this is a good idea to build it because if it says it works, it can calculate correctly, and it seems to, then we know with assurance that our build is going to work. If it doesn't work, we probably didn't do something right in our process. It's manufactured circuit boards, you can do something wrong, and it's not reliable. It's that revolutionary. I think this changes how we build boards in our industry and how we formulate the conversation with the customer: "Listen, I have a stackup, but I need to talk to you without you just running off to the next supplier who'll say, 'Yes, I can build it.' Listen to the science."

There's an education we can do in the industry, this predictive engineering, that it's really demonstrating just that. If we can show that we can make safer and more reliable boards, then it's a benefit to us fabricators that we're can say, "Hey, it's not me. It's your design," after we've spent all the time building it. We can just start off on the right foot. And it calculates other things that are not our problem that we're not going to see. It will identify challenges in the resin flow that leave pathways for CAF failures which are going to happen years



OM tester resistance change greater than 5% non-conforming if above red line.

later. It doesn't happen in my factory, and I'll never identify it, but it will make those products safer in the field, in the future. Where we always thought we could use this resin and this thickness, we might need a little bit more resin, making things thicker than we've been doing for years—the designers, the fabricators—but it's awareness that you're leaving pathways for CAF, and you can put more resin and fill it in and eliminate that. We've always used thinner ones. Well, maybe we shouldn't have been doing that.

Johnson: For quite some time, IC design has been working with manufacturing simulation processes. PCB design, however, maybe not so much. How is that going to change?

Partida: Yeah, there's a lot of education that needs to be reinforced, and we must dedicate it to the designers to understand fabrication, fabricators to understand what the designers need and want. There are a lot of excellent guidelines within the IPC design guidelines that most people don't know about; they don't read them. They are three or four revisions behind, in understanding what the finished performance specs are when we finished the circuit board. I did a lunch-and-learn here today at PCB West, and I took 15 topics that designers may not know there's an actual rule in IPC and made them aware that when you bend these rules, just let us know because you may have bent a rule and we can't build your board to the compliance you're stating. It's just education. There's a lot that our industry needs to do. We have the EDA software more in the hands of the actual EE rather than a designer who's got 30 or 40 years, who's retiring with his expertise and knowledge not to violate certain rules.

There are a lot of excellent guidelines within the IPC design guidelines that most people don't know about; they don't read them.

It's very easy in EDA software to do stuff because it's convenient, easy, and quick—but not compliant. You've just made the board less reliable and we're going to have lower yields. I reviewed some of those types of rules and it reinforces that we need a lot more education and engagement between the design activities and the fabricator so we can help each other, and so the designers design PCBs that we don't need to ask questions, that jobs don't go on hold. We get much higher yields, and it's very impactful across the whole electronic supply chain. We get designs where people just turn on the auto-router, set it to 3.5 mil line and space, and just let it rip. It will make three-and-a-half mil space in the design, but it could have been a four-mil design board.

The design is just done once. Even when they rolled a revision, they're not rerouting, they're just adding a component here or there. It's not really a full reroute of the whole design. But when you change the spacing in a design from three to four and spend an extra week or two building it, any time one of the cores is etched, the yields go up, there's less loss. You're going to get more product on time at full quantity. It's just that if you invest that time in the design phase, the yields just skyrocket in manufacturing.

Johnson: There's room here to use some forethought in the design phase to make sure what you're designing will be manufacturable, that you can have better yields. Does that extra design effort take the pressure off test and inspection?

Partida: Yes. What happens when you push the envelope of finer lines and spaces, defects are

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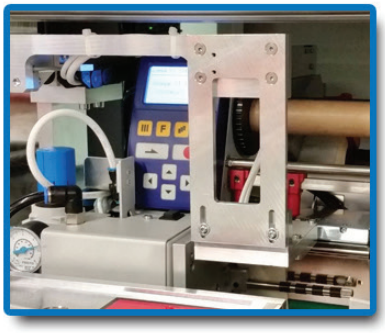

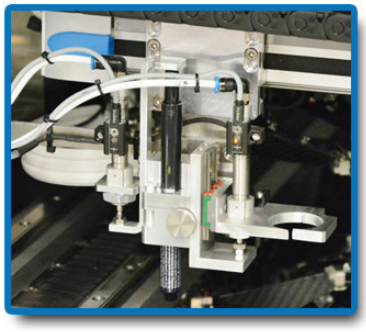

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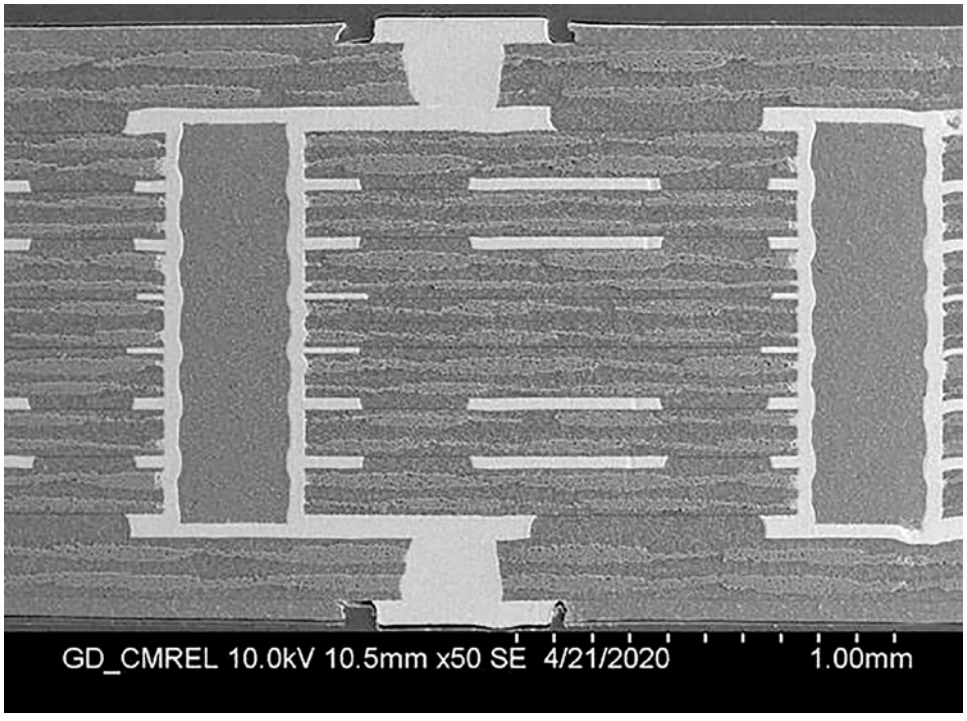

Image of microvia separation 400X and with SEMs.

showing up. And when defects show up, some can be reworked, some are just false alarms, but if you go from one or none at AOI (identifying defects on a core) to 40 or 50, because things are finer, there are more false alarms and there are more actual things that can be reworked, things will get missed. Then the final product is just a scrap board and we run more.

Johnson: The people who need to be paying particular attention to this really seem to be the design teams, working with their fabricators to make sure that they're getting analysis information, long term feedback to ensure a more reliable, higher yield, a more profitable board. Maybe we're starting to change how we do business a little bit. What advice do you have for the designers?

Partida: It's collaboration. The complexity of current designs will benefit from collaboration between the fabricator and design. The fabricator can give guidance, improve yields. I worked with one customer who had a double-blind [via] that ended up into a buried that had five laser vias working its way out with a laser via that passed the buried via structure.

Johnson: Is there a catch?

Partida: No. The overall area was smaller than what it had to do and how they made the board. We went through the stackup for nine months. I said, "You cannot stack six laser vias. It's not going to work." I explained why. They staggered them. They did what they were supposed to. We went through the design three times. We went through part numbers three times completely, and we found little minor things that could help. They had a ground plane where they dog-boned the laser via. They said, "Okay, the impedance is a three-and-a-half mil line on the ground plane." I said, "There are things to understand about a board shop. Etchers over-etch, platers over-plate. On this layer when that's plated and over-etched, those three-and-a-half mil lines may disappear, but the track length is less than the two pad sizes combined. So, there really is no impedance. Could you change it from a three-and-a-half to an eight-mil wide trace? Then there's no way we're going to etch it out."

The EE said, "You're right, absolutely. Go ahead and change these layers and this layer and that layer." We went through and changed everything we could, and where we needed to when they were outside the components, we went to a larger via and land sizes so there wouldn't be any failures there. We only used a small feature when we had to. When we built these boards, it's complex, there's two double blinds that go to a buried. There are five lasers on the way out, six total lasers down. We built

them in two of our factories; one built two, the other one built one, and all three of these boards were built in four weeks and delivered. A lot of it was the collaboration we did regarding what can we do in the design to simplify and reduce the opportunities for failure, so we have a more successful build. It was all collaboration.

Johnson: What's the customer's mindset about the analysis? Do you have to educate them on what that's all about? Do you have to twist their arms or are they starting to welcome this?

Partida: It's been embraced very easily. When I see a stackup, and I'm concerned about the microvia reliability, we do a whole bunch of things to analyze it. I do the analysis and show that the graph says it doesn't make six reflows. I say, "Hey, we should have a conversation." It's education, a little bit of shock value, and we've steered away from the rocks into safer waters in the design, and we're able to have a build that works.

Johnson: That sure creates a compelling event for your customer, that graph, that shock value. Obviously, there's a payoff for them. As a fabricator, how is this monetizing for you?

Partida: When it comes to the question, how do you monetize or approach this concept, there is value in the upfront expertise involved in this process, and that's how we see it being employed. Expect that, with customer knowledge and consent, it works its way into being one of the non-recurring engineering (NRE) costs.

Johnson: Do you see a longer-term impact?

Partida: I'm glad to have this conversation. I think this is something that should be shared in the industry. The industry will benefit from cost avoidance by finding out that the design is not optimal to get through assembly. We can have optimal designs before we start fabricating. It will have greater success for a customer's reduced respins. Although it does seem like we're going to build fewer boards, the more successful companies are, the longer they will be in the industry and be successful. This pays forward with that cost avoidance.

Johnson: Gerry, thanks. This has been a great interview. **PCB007**

Gerry Partida is director of technology at Summit Interconnect.

Better Electronics Start with Better Training

One World, One Industry

by Dr. John Mitchell, IPC PRESIDENT AND CEO

While I've often heard the term "skills gap" used as a catch-all for training issues, it always seemed like an oversimplification of the problem. A skills gap problem implies that the skills the industry possesses are different than the skills the industry needs. The workforce challenges we are seeing today extend beyond a skills gap to also encompass the identification and onboarding of new talent, providing ongoing, job-based training to existing workers, and a means of upskilling to utilize the latest techniques and technologies. IPC is committed to addressing all aspects of the workforce challenge by collaborating with our membership and the industry.

According to a study from Deloitte and The Manufacturing Institute, the U.S. manufacturing skills gap could leave as many as 2.1 million jobs unfilled by 2030[1], costing the U.S. economy more than $1 trillion in 2030 alone. Finding skilled workers is becoming more difficult on a daily basis, as competition for talent increases. While many may equate this program solely to the operator level, the industry is experiencing this same challenge for middle- and high-skill jobs as well. The IPC Workforce Development Program seeks to address the various challenges facing the industry at each skill level.

Finding New Talent

The IPC Education Foundation (IPCEF), in conjunction with the IPC Education Team and industry volunteers and partners are actively

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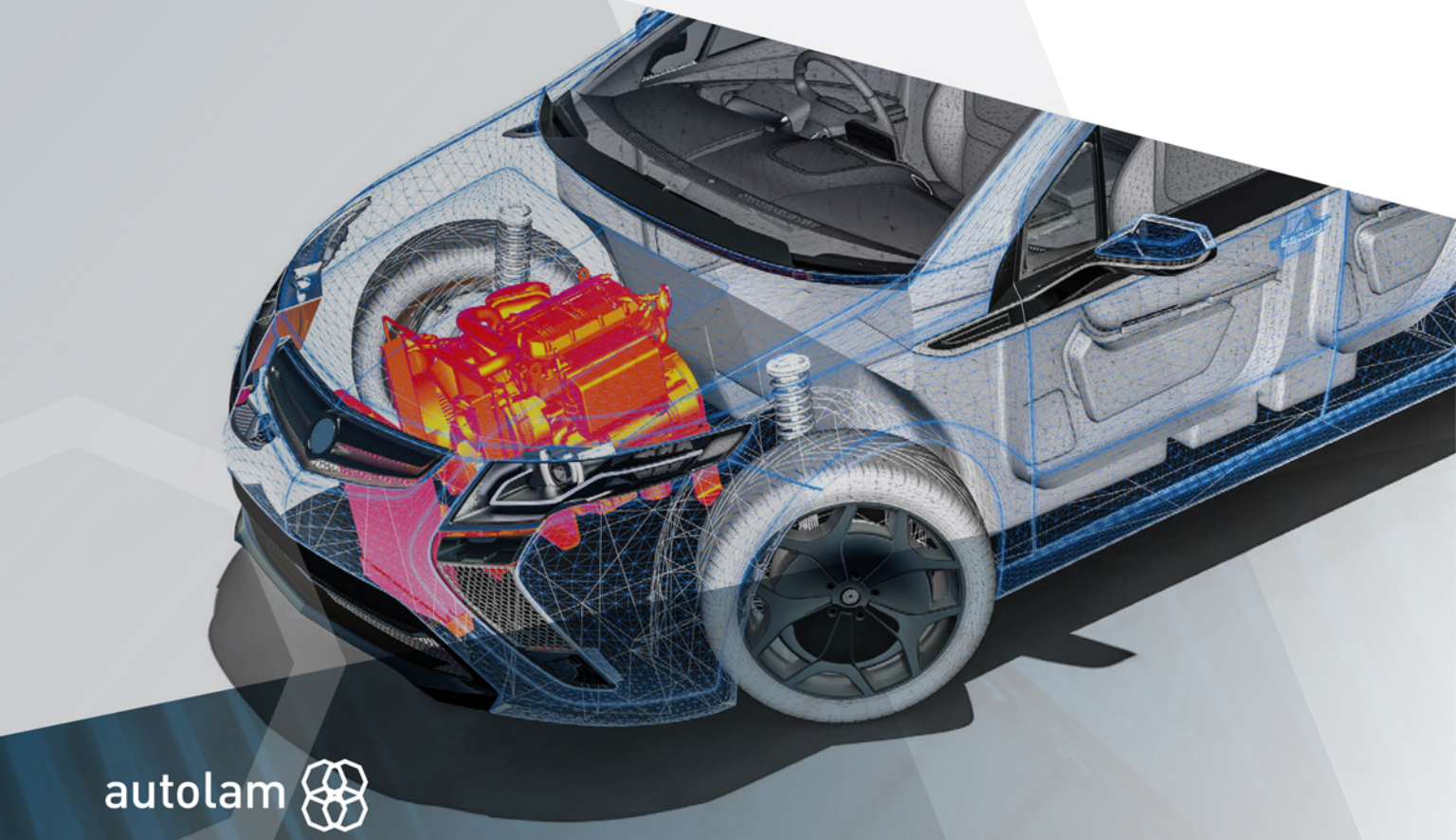

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working on identifying and driving new talent into the industry. A variety of pipeline programs are in use or in development to increase interest in a career in electronics by providing accurate information to students, parents, teachers, and guidance counselors at the high school level.

We are also collaborating with schools to develop and offer basic skill training classroom curricula and online programs covering basic electronics skills. In the near future, we will be offering these students the opportunity to gain IPC badges and credentials that identify their competencies for potential employers. A key goal of this initiative is to spark an interest in electronics careers and increase the electronics industry's chances for obtaining new talent. IPCEF is already working with member companies that have generously volunteered to offer tours to students and a firsthand look at the high-tech environment in their local facilities. We are looking to expand this program to help connect students who go through these programs with potential jobs in the industry.

We are looking to expand this program to help connect students who go through these programs with potential jobs in the industry.

Onboarding Training Programs

Finding new talent is just the first step. Onboarding training programs are the foundation of a quality training system. IPC is working with industry to develop engaging, effective, and efficient onboarding programs that help bring new workers up to full productivity quickly, while also increasing knowledge retention. But onboarding talent is not the end of the line. To retain talent in the industry we must turn jobs into careers. We can accomplish this by identifying career pathways and growth opportunities and providing programs to help our workers achieve their full potential. In a tight labor market, it can be difficult to sell a candidate on starting as an operator and remaining as an operator. Through the Workforce Development program, IPC seeks to help employers identify the members of their team with the most potential, and guide them into more advanced roles, helping the industry with the jobs they need today while building a base of talent for the future.

The rate of technological innovation is growing at an exponential rate. This requires a new approach to the challenge of continually upskilling our existing talent. Upskilling programs help organizations improve productivity and employee morale, creating an environment where employees continuously learn, grow, and feel valued.

Organizations that have implemented the IPC Workforce Development program report that staff members learn more in less time (some identified a 50% decrease in training times) and retain what they learned. We continue to work closely with industry subject matter experts to ensure that we provide engaging educational experiences that focus on the right information taught to the right depth and in the right context.

One of the first career pathways tackled by IPC was PCB designers. PCB designers were retiring at an alarming rate and the industry didn't have the proper mechanisms in place to train new talent. IPC created a series of programs that lasted six to eight weeks, with entry level, mid-level, and advanced/specialized programs that cover the spectrum of PCB design knowledge and skill. These programs blend the convenience of online distance learning with the practicality of a project-based curriculum. Every week, students are tasked with completing a real-world design project that applies the skills they learned. They then receive feedback

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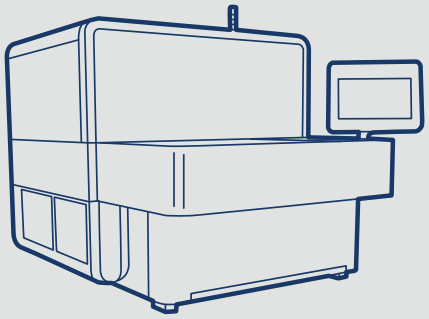

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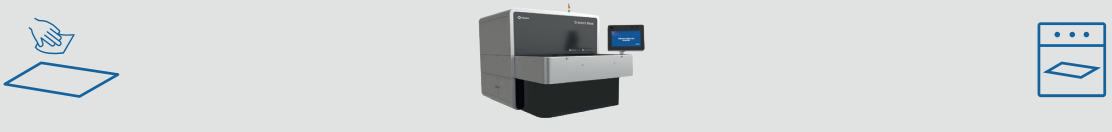

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and coaching from our expert instructors. This is just one aspect of the IPC Workforce Development program.

Available in self-paced and instructor-led options, IPC's Electronics Workforce Training courses are designed to meet the growing needs of a rapidly changing industry, while providing flexibility and reducing training costs. In addition to PCB design, other courses include:

- Electronics Assembly for Operators
- Electronics Assembly for Engineers
- Wire Harness Assembly for Operators
- IPC-A-610 for Operators
- IPC-J-STD-001 for Operators
- ESD Control for Electronics Assembly
- CFX courses, and many more

With a variety of courses available, we are directly addressing the critical issues of pipeline, onboarding, and staff retention in a way we hope attracts the best and brightest to our industry. For information on how we can help you meet your education and training needs, visit training.ipc.org. **PCB007**

References

1. U.S. Manufacturing Skills Gap Could Leave As Many As 2.1 Million Jobs Unfilled by 2030, Deloitte.com, May 4, 2021.

Dr. John Mitchell is president and CEO of IPC. To read past columns or contact him, click here.

Additive Reality:

Drop Your (Solder) Mask, it's Sampling Time

by Luca Gautero

Many countries nowadays are relaxing restrictions in public places. During the pandemic, supermarkets have provided continuous support for our needs, even though most of us have reduced our grocery visits to a minimum. In the future, we might come back to enjoy an occasional free sampling ("If it has a toothpick in it, it's free!" BH Simpson by Matt Groening), and our taste buds will provide us with accurate information about what we buy. Why this initial digression? Inkjet printing equipment around the world is printing solder mask on PCB half fabricates. This effort goes under the name of "sampling." Major PCB manufacturers have been asking either equipment or material suppliers (or both) to provide a solder mask coated sample with inkjet technology to make cross comparisons.

The world may not yet know the capabilities of this technology, though; it is a fair assumption that in almost every PCB manufacturing company someone has seen a solder mask coated by inkjet printing on a design and a board of their choice.

On one hand, this is the best way to demonstrate the technology; on the other hand, it is a collective waste of time. This last statement is a strong one, though one single sentence easily sustains it: There are no standards for inkjet printing of solder mask. This means that the presumed "next best thing" happens: a board is qualified with a comparison to traditional technology.

Through my columns so far, it has been shown several times that a printed solder mask can have the same pattern as a traditional solder mask coating, though its cross section is largely different. The dome shape of a dam cross section or the slow ramp from edge toward full thickness is nothing alike a vertical wall. Even more, it will never resemble the steep slope idealized by the traditional solder mask coating technology.

To read the entire column, which first appeared in the I-Connect007 newsletter, click here.

Luca Gautero is product manager at SUSS MicroTec (Netherlands) B.V.

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Test and Inspection: Competitive Advantage and Cost of Doing Business


Charlie Capers

Feature Interview by Nolan Johnson
I-CONNECT007

In this interview, Charlie Capers of Zentech breaks down the changing requirements he's seeing in test and inspection in the industry, and the growing importance of investing in testing for the future growth and success of your company.

Nolan Johnson: Charlie, test strategies seem to be all over the place.

Charlie Capers: Everybody does everything a little differently. It depends on your shop, your processes, the size of your shop, and the volume of the stuff you're doing.

Johnson: What seems to be emerging is increased activity with the IPC J-standard; the shifts in how you approach ROSE testing, in addition to the customer-driven and OEM-driven demands that are changing for testing inspection regarding finished product. This is especially true for military and medical, which are starting to demand them.

Capers: Yes. Those are the top ones.

Johnson: As you move toward automation, isn't there an increased need for test and inspection as a part of process control?

Capers: Yes. Maybe in larger shops, I would believe that. They go hand in hand. When you collect statistics on defects, you will start to see a trend that says, for example, we've got a lot of shorts and opens, meaning that our solder paste process is not tight. If you're collecting statistics and really studying them, you will see trends in your processes. It's part of the AS9100 too; you must collect your statistical data and review it every year.

Johnson: The trick is how to make it meaningful. Turning that not just into data but into intelligence and analysis seems to be where the gap is right now.

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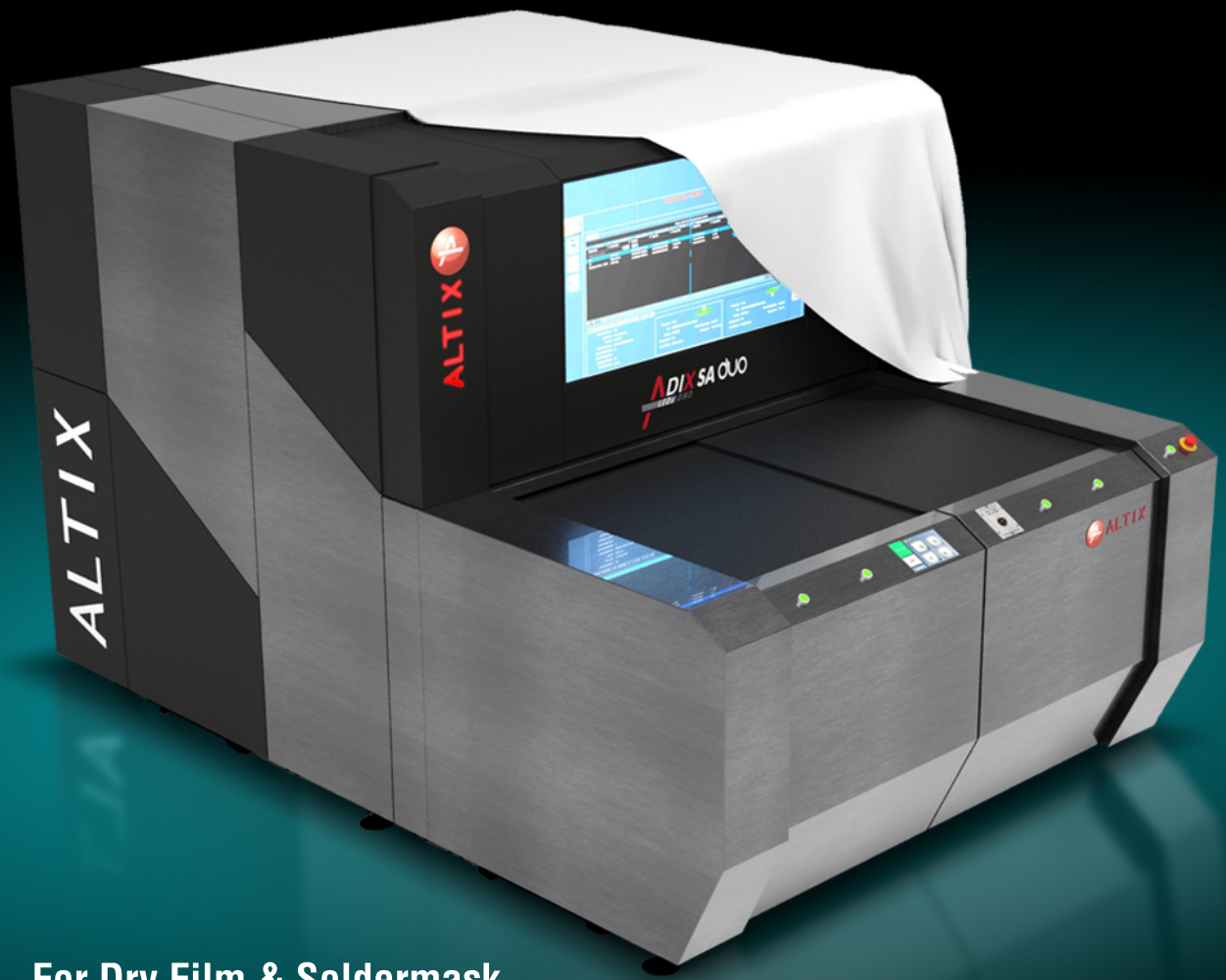

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Capers: Yes. I would agree with that. You can collect data all day long. You can look at it and see you're having issues, but unless you dig deep and ask why the issues in this particular area or with this particular defect are there, then all the data collection is kind of useless—but we do it anyway.

Johnson: From where you sit, have you seen any interesting work to turn that into usable intelligence?

Capers: We are currently using it for our internal records, and for our requirement of AS9100. If you dig deep, you could probably say something like, "Operator number 13 is screwing up left and right." But is it a personnel issue? Is it a process issue? Is it a machine issue? What is it? At our size, we probably have the capability, but not the resources, to dig deep into that type of stuff.

Johnson: How do you get software tools to the smaller firms, which make up the bulk of the active companies in the U.S.?

Capers: The tools are not only the software; it's capital equipment that helps ensure your processes are good. You could have every certification in the world: plaques, trophies, and all of this, for all the good work you do. But at the end of the day, it comes down to price, and everything else is expected. After putting money into AXI, ICT, AOI, flying probe and all those good things, it would be nice to be able to recoup that money. These days, though, it's assumed that you will be doing all these processes.

Twenty years ago, maybe you could buy an AOI machine and be able to charge for that service. For ICT and flying probe test, we must charge because there's a development cost involved with it. For flying probe testing, you must program the machine and debug the program to make sure it runs correctly. For ICT, of course, you must program the machine, but you also must procure a test fixture to put on that machine, a bed-of-nails test fixture. There are costs involved in that. In our little world, we must pass those through. For big production, I'm sure it's just built into the price of "we're going to build you a million boards and this is what it's going to cost, and we're going to guarantee everything." It's a different world.

Johnson: If you're having to invest in this kind of equipment because your customers are demanding it, how do you finance that? How do you make the ROI for that equipment so that it's making a profit for you?

Capers: There are two parts. Let's just take flying probe, for instance: the equipment itself and the personnel to run it. The equipment is probably $150,000 to $200,000, and then you need the personnel to run it. That's another annual salary. So, the ROI on that must be realized over years. I don't think you're going to see a direct ROI. You'll see an indirect ROI by the volume of business that possibly increases because you have this capability that a customer wants done in-house; they don't like using an outside service. The ROI is not something you can directly measure. I think it's measured in volume of business and just the overall relationship and processes.

When people come through and do a tour of the facility or audit the facility, they will want to see all this equipment in place. If they don't, then you don't get that box checked. If you want the business, you almost have to have it in place.

Johnson: It's almost like having a building. If you don't have a building, you're not going to get any business.

Capers: Exactly. It's a CapEx investment, but at the same time, you're not going to have a direct ROI that you're going to be able to quantify.

Johnson: How are requirements changing from your customers when it comes to test and inspection? Is it just more of the same, or do you need to put in additional testing you weren't doing before? How do you respond to what they're asking for right now?

Capers: First, let's talk about customers who don't have requirements. You can tell them we are going to do 3D AOI to make sure that everything looks good on their boards. Most small commercial-type customers say that's great. If you're building thousands of boards, you're going to be sampling. So, you're not going to be doing 100%. Then you get the very tough customers.

One of my customers is very particular about our processes and how we build their products because they're expensive. We're not talking about $20 boards; we're talking about $20,000

boards. They want to make sure everything's done up front.

Because when they put this board in their equipment, it's going to work. They're a little more stringent on the requirements. They like things in place, like solder paste inspection; 3D AOI is a given these days, in my opinion. Flying probe test is almost a given as well. For the manufacturer, it ensures after all these other process steps, it gives them peace of mind that their processes are tight and they're building boards without shorts, without opens, and everything like that. It helps identify defects before they make it out the door.

Anytime something comes back in the door, it's going to cost you money to fix, remedy, refund, or credit it. We're trying to avoid stuff coming back in the door. We even do incoming inspection on materials that come in the back door to make sure that, if they're sending us a 10K resistor, it measures 10K before we stick it in inventory.

Anytime something comes back in the door, it's going to cost you money to fix, remedy, refund, or credit it. We're trying to avoid stuff coming back in the door.

The rest of the testing—AOI and flying probe test—are just things to ensure that your in-house processes are consistent. The two most important things that an EMS company can do is SPI solder paste inspection on the front end before they place parts on a board and then AOI to make sure that everything that's happened—from solder paste to pick-and-place to reflow—when it makes it over to AOI, it should catch any defect that those machines are designed to do.

Johnson: What does everything else add?

Capers: Just more layers of protection and assurance. Usually, if you can get through solder paste inspection and AOI, you've got a high probability that your boards are good. ICT becomes a requirement from a customer if that's what they want and what they want to pay for. We can build it into the quote; we just need to know exactly what you need. Usually there's additional test time for a flying probe and ICT if they want that. Since we're talking about test and inspection, there are other things that we can do. For instance, we do environmental stress testing to make sure that the products can withstand the extreme cold to extreme heat. We test them after they come out of the temperature chamber. Military is extremely hard. Commercial is pretty easy, if you ask me.

Johnson: The more complex customers are obviously looking for more thorough test and inspection, which means you must have that onsite. Does that trickle down to your less-demanding customers? Does that just become a part of the process, or do you reserve that for when you're getting paid for it?

Capers: We reserve it for when we're getting paid. AOI is a given, like I said, it's just something we do. We can either do 100% AOI or we can sample depending on the customer. If it's a military-type product, it's going to get 100% AOI. It gets a little more attention than the cheap $15 assemblies. It's because you don't want those boards to come back. If you must scrap for any reason, it's going to cost you much more vs. scrapping a $20 board, which you can throw in the dumpster.

Johnson: What do you see of most strategic importance when it comes to investing in test and inspection for the next year or two?

Capers: If you walk around the show floor at IPC APEX EXPO, you will see a lot of empha-

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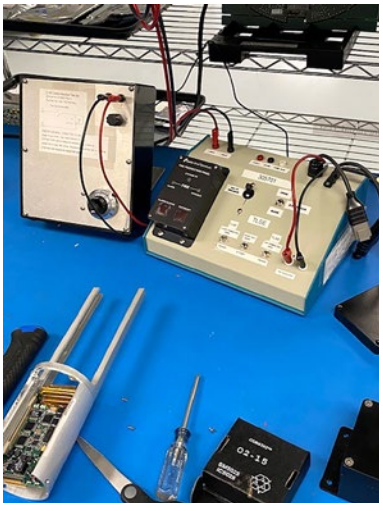

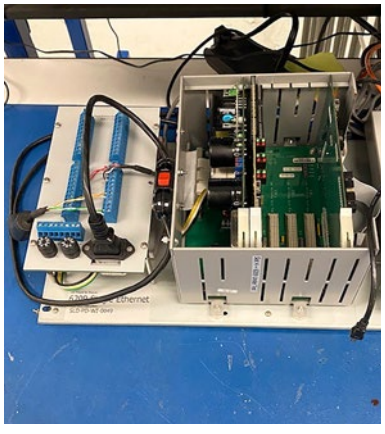

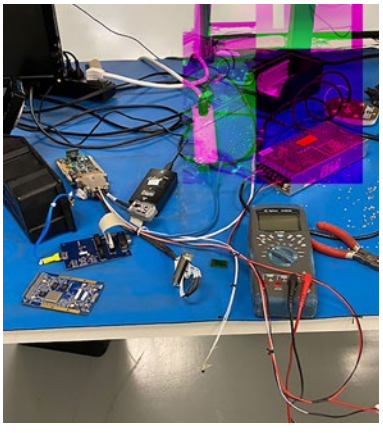

sis on AOI and 3D AOI. Perhaps AXI depending on what you're doing and the volumes you are doing. You don't see a lot of exhibitors with their flying probes because they've been around for years. But I see the emphasis on solder paste inspection. AOI has always been big at the shows. I think those are the areas where people are focused. Even savvy customers that know a little bit are going to be looking for key things like 3D AOI, solder paste, and 3D solder paste inspection.

Johnson: What advice would you give to the design teams who are putting together the designs to help make them as successful as possible going through fab and assembly, regarding test?

Capers: To design a bare board, have the shop build it, and do flying probe test based on your netlist, that's easy to do. Now, when you're talking about bed-of-nails testing or flying probe testing on the finished assembly, it is a little more difficult. My advice is to talk to who you intend to use, to build and test your boards, see what the requirements are, what their testers are capable of, and whether it will be a bed-of-nails or a flying probe tester. There are some parameters that they need to know. They can make sure that their board is close to 100% testable because with most boards that you see, nobody takes any of this into consideration.

When they just throw it over the wall and then say, "Wow, we only got 75% coverage on our test." We reply, "You know, 25% of it is not testable because you didn't have that in mind when you were doing this thing." So, talk to your suppliers and if you're just throwing it over the wall and hoping for the best, good luck to you. But if you're building, especially high-volume production and even on some of the lower volume military stuff, these designers know what they're doing. They follow all the rules. My point is, if you're anticipating that you want full ICT test or flying probe test, you must make your product testable. You can't just throw a bunch of stuff out there and expect somebody to make it work for you.

If you really care about your products and you want them to be tested 100% reliable, there are some things you can do. That's why we have all these nice little acronyms, like DFT, DFA. Design for test is huge, but a lot of people don't really pay much attention to it. Especially design for assembly.

Johnson: All right. I think you gave me a very meaty discussion. Thank you.

Capers: I hope this will be of some use. **PCB007**

Charlie Capers is vice president/general manager of Zentech Dallas.

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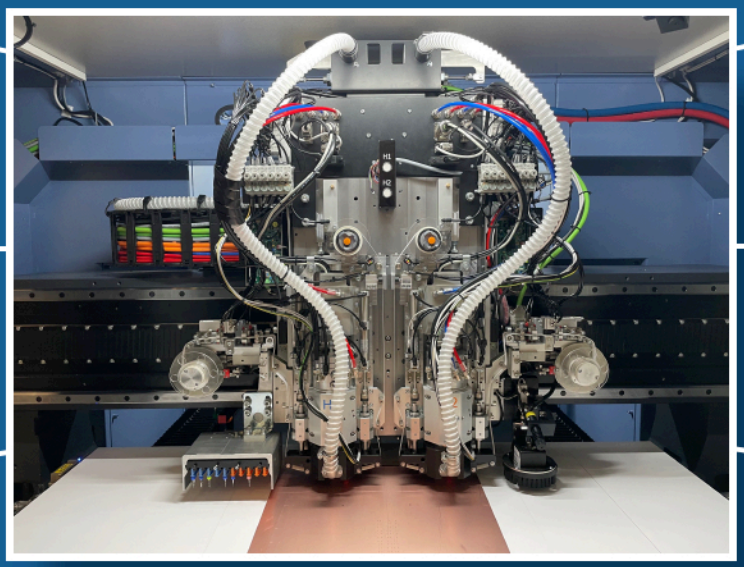

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Supplier Highlights

Trouble in Your Tank: Case Study—Interconnect Defects and a Few Other Problems ▸

For this month's edition, we are taking a slightly different approach—that of presenting an actual case study. However, the basic principles of these columns continue.

LPKF Names Dr. Klaus Fiedler New CEO ▸

Dr. Klaus Fiedler will become the new chief executive officer of LPKF Laser & Electronics AG. The supervisory board of the SDAX-listed technology company has appointed the top manager to join CFO Christian Witt in the management board, effective 1 April 2022 or earlier, with a three-year contract term.

ILFA Places Multi-Million Order for UCE Machines with Viking Test Ltd. ▸

Modernization at Hanover-based PCB manufacturer ILFA is progressing steadily: with the placement of an order worth a total of several million euros, the leading English supplier of PCB services and machine equipment Viking Test Ltd. has been contracted to supply state-of-the-art wet machines from the Asian market leader UCE for production.

ACB Group Invests in atg's Flying Probe Test System from ADEON Technologies ▸

Following a comprehensive investment plan for the ACB Group, the group's subsidiary Atlantec took delivery and installation of the brand new A9 system from atg Luther & Maelzer through its distributor, ADEON Technologies. The ACB group has a long-term experience with the flying probe electrical test systems from atg-LM.

Ventec Completes Asset Purchase Agreement with Holders Technology in Germany & UK ▸

Ventec International Group Co., Ltd., is pleased to announce that it has finalized an asset purchase agreement with Holders Technology in Europe.

Atotech, AT&S Announce Project to Optimize Energy Efficiency and Meet Climate Goals ▸

Atotech and AT&S have announced a joint collaboration project with the goal of reducing energy consumption and optimizing energy efficiency of the AT&S production processes in the plating lines manufactured by Atotech.

Luminovo Acquires PCB Platform Provider Electronic Fellows ▸

Luminovo, Munich-based software company building products to digitize the electronics value chain, acquires the Wiesbaden-based startup Electronic Fellows.

High Density Packaging User Group Announces Uyemura Membership ▸

High Density Packaging (HDP) User Group is pleased to announce that Uyemura International has become a member.

RBP Chemical Technology Appoints New Executive Vice President ▸

RBP Chemical Technology, Inc. is adding to its leadership team with the appointment of Dan Carey as executive vice president.

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Design to Production Flow:

DFT and Test Coverage Using Industry 4.0 Principles to Produce Good Products

Feature Article by William Webb
ASTER TECHNOLOGIES

Achieving design for test (DFT) can be challenging for both design and test groups as sometimes both expect that the other will be the one to manage DFT. The design and test groups might be in the same organization, or they could be an OEM vs. an EMS company. It works best if both the design and test groups are engaged in the process of DFT and trying to achieve the goal of the best test coverage and lowest rate of field returns.

Traditionally, design and test have operated in silos where there was not always the best communication, and at some point, the design was given to the test department to perform DFT. Often, due to project timelines and people working in different geographic regions, this means if some DFT concern was found, it may have been too late to address and resolve the issue. It is too late to wait until a board has gone through layout to begin DFT, as this needs to happen at the time of schematic capture, when the logic design is taking place, and before the board has gone for routing and layout. There are critical items that can be examined at the schematic capture phase to ensure that the board will be as testable as possible. A continuous feedback loop into DFT and test coverage understanding is key to producing defect-free products at a minimum cost.

Companies must deliver good products to their customers, defect-free and at minimum cost. The challenge is how to detect or prevent defects from occurring so that only good

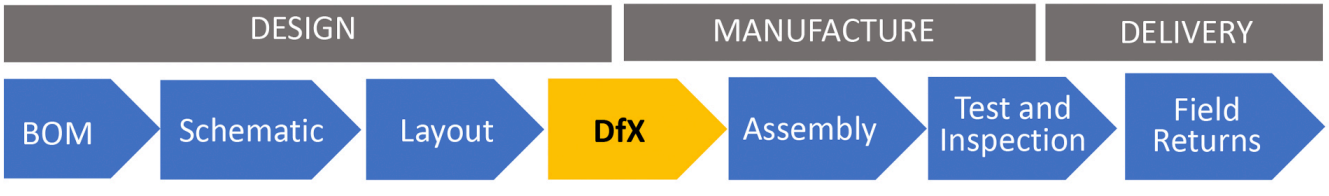

Figure 1: Traditional workflow: Longer, more expensive and obsolete.

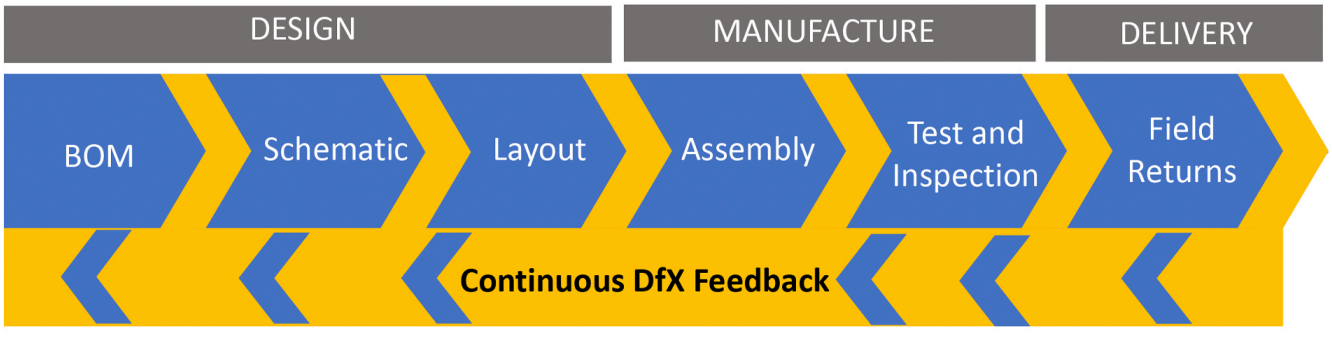

Figure 2: EMS 4.0 workflow: Improved decision-making, faster time-to-market, cheaper and better quality. Lean design, test and manufacturing deliver defect-free products at lower cost.

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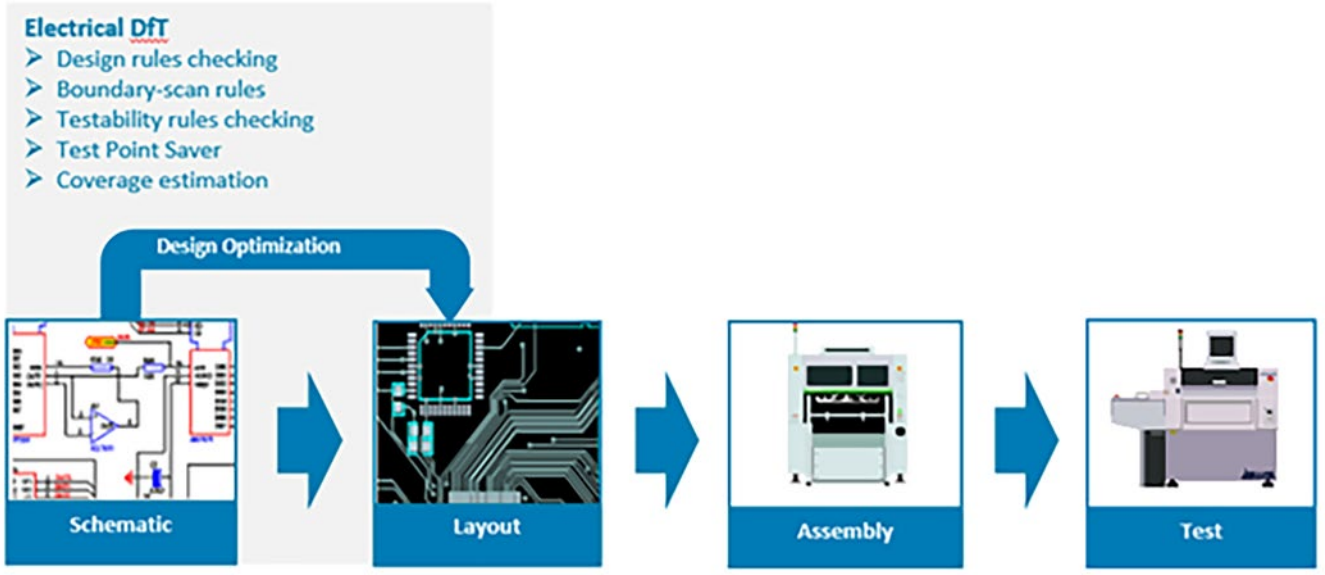

Figure 3: Electrical DFT and test point requirements.

products are shipped to the customer. Traditional DFT tools usually work only from the layout stage, which is too late in the whole process. Design data must be analyzed at the earliest stage possible in the product life cycle by importing schematic design data.

Electrical DFT rules violations should be identified and rectified prior to commitment to board layout, to prevent costly design respins. These rules can include standard and customer-specific checks relating to company requirements. With a centralized knowledge database, the same problems will never be repeated.

Test point requirements must also be identified pre-layout, during the schematic capture stage. This reduces the need for unnecessary test access, saving on PCB real estate, particularly on high density boards. The test strategy needs to be simulated, including any combination of inspection and test machines, delivering the highest test coverage. This unique com-

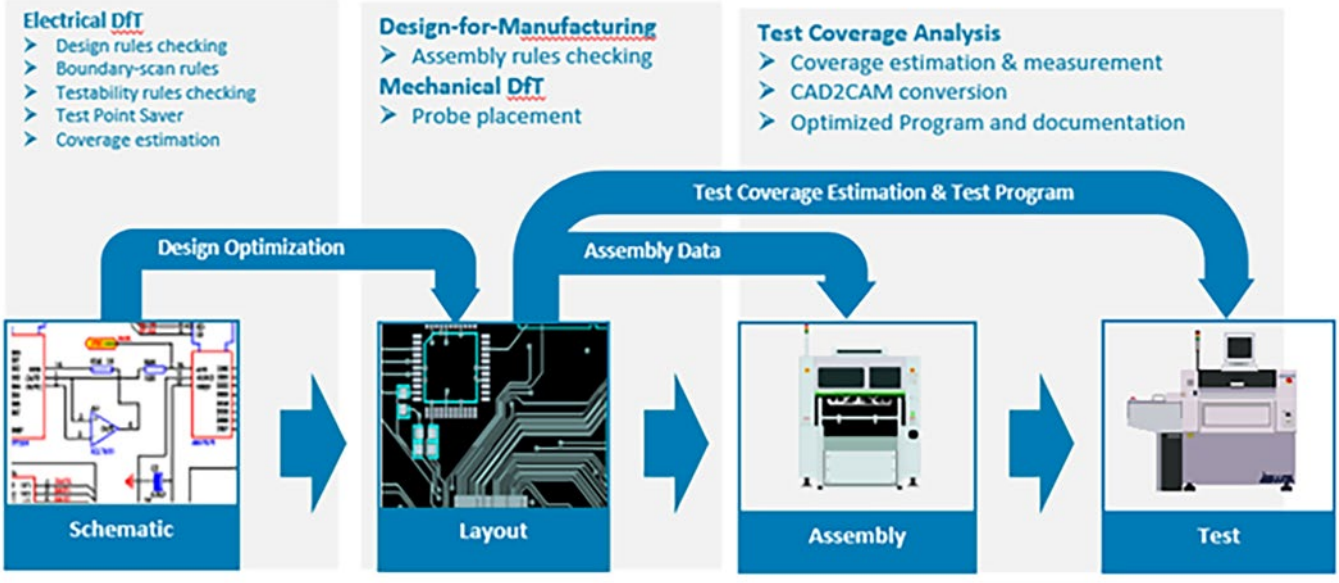

Figure 4: Mechanical accessibility/DFT.

bination provides electrical rules analysis, test point analysis, test strategy optimization, and test cost modeling based purely on schematic information. This, in turn, provides valuable layout guidelines that can be used to optimize the printed circuit board layout.

Once the PCBA layout is completed, a mechanical DFT analysis must be conducted to confirm the nets that require test access are not compromised by solder mask, component outline, adjacent probes constraints, etc.

Production Test Model

The test coverage is the percentage of defects that can be captured by a combination of inspection and test machines. First pass yield (FPY) is the percentage of boards that pass the test. It can no longer be considered a good measure of the production quality. This is easily demonstrated by a test coverage of 0% which will result in a first pass yield of 100%. This leads to the question: Is a board good because it passes the test?

From practical experience, we can ask, "Are all failing products really faulty?" For the same reason we may ask, "Are all products that are shipped good products?" The answer to both questions is no. We cannot assume this without knowing about the extent of the test coverage.

"Slip" is the escape rate. This is a key metric and represents the faulty products that will be shipped to the end customer and can be returned as field failures. Ultimately, the "slip" is how the end-users will measure the final quality. If a PCBA is failing at system test it is because it fell into the escape rate (or slip), and this is usually much higher than expected.

There are two possible reasons why this situation occurs:

- The DPMO (defect parts per million opportunities) figures are higher than expected
- The combined coverage is lower than optimal

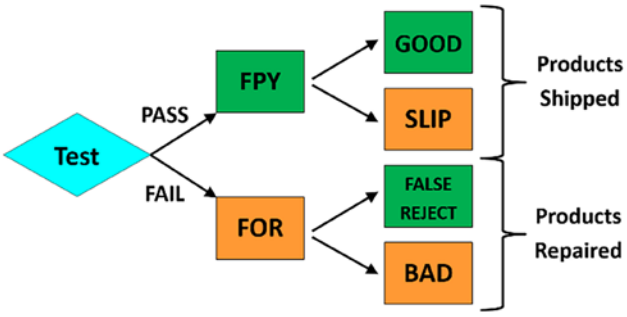

Figure 5: Production model.

Incorrect DPMO figures are probably due to limited defect traceability or incorrect root cause analysis. The unexpected low coverage could also be due to the use of inadequate coverage metrics, such as the confusion between test accessibility and testability.

The key to reducing the slip rate is having a good understanding of the test coverage. By using tools to gain an understanding of the test coverage, and identifying test coverage gaps that need to be filled, the user will be able to reduce the slip as much as possible and, in doing so, reduce the amount of field returns, or bad products, going out the factory door.

Sometimes companies need to have return on investment (ROI) justification on the purchase of tools to help achieve this. To respond to that question, it isn't hard to show the justification based on reducing the bad product leaving the factory floor. Retuned product is costly to everyone in time, materials, reputation, etc., so reducing product return is a large cost savings, and easily justifies the cost of tools to help reduce slip and therefore bad products.

As mentioned, the key to understanding how good the process is, and from shipping bad product, is having a good measure of the test coverage. We must be able to measure the effectiveness of the test to a relatable metric from any test strategy whether it be electrical, optical, X-ray, or functional test, etc. We need to consider all the manufacturing defects within the defect universe, including missing compo-

MPSF	PPVSF	PCOLA/SOQ/FAM
Material	Value	Correct
		Live
Placement	Presence	Presence
		Alignment
	Polarity	Orientation
Solder	Solder	Short
		Open
		Quality
Function	Function	Feature
		At-Speed
		Measure

Table 1: Test coverage metrics.

nents, wrong value, misalignment, incorrect polarity, damaged components, open circuits, short circuits, insufficient solder, and excessive solder. We must have test strategies in place that can detect these defects. The ability to detect defects can be expressed by a coverage facet, so that each defect category is aligned with coverage metrics. Table 1 details industry standard metrics that have been defined by Philips Research (MPS), ASTER Technologies (PPVSF), Keysight (PCOLA/SOQ), and iNEMI PCOLA/SOQ/FAM.

These metrics allow the estimation of the theoretical coverage, or measurement of the real coverage, for each unique test strategy or combination of test strategies. No single test strategy can detect all the board defects. It is a combination of complementary test strategies that provide the necessary proper overall test coverage.

When calculating test coverage, it is important to consider the DPMO that reflects the current manufacturing process. This way, the test coverage can be aligned so that better coverage is provided where there is a greater opportunity for defects occurring during manufacturing process.

Industry 4.0: Closing the Loop

The Industry 4.0 philosophy focuses on providing a closed loop to identify where problems exist and facilitate remedial action. This is done by measuring the actual test coverage and comparing it to the theoretical model to ensure compliance and understand gaps. An example of where disparity can occur between the expected test coverage and the achieved test coverage is where the test development and PCBA manufacturing is outsourced. It is imperative that the OEM has complete visibility of what is achieved by their supplier. Otherwise, there is a good chance that an inferior product could be manufactured and shipped to the end customer. High escape rates also have a direct impact on the "no fault found" bone pile. The completed post debug test program should reflect the estimated coverage requirements defined by the OEM.

A product is passed through a test line which, step by step, detects specific types of defects. The production information is stored in a centralized database for traceability purposes. With Industry 4.0, raw data from various machines are aggregated to build and visualize comprehensive information that allows humans to understand the defect universe.

Both defect per million (DPM) and defect per million opportunities (DPMO) are used for determining the overall quality of the unit under test (UUT), produced from the sample quantity inspected. DPM is a measure of manufacturing throughput: how many bad parts slip through the manufacturing process. DPMO is a measure of performance: how many times a manufacturing defect class occurs. DPMO is also an indicator of which manufacturing process needs improvement.

Test strategy and defect occurrences should be linked so that improved test coverage can be targeted toward defects that occur frequently. A lack of coverage on defects that never occur has no real bearing on the final product quality.

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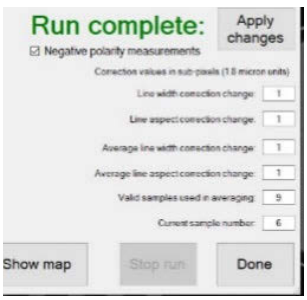

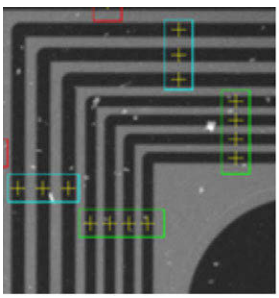

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Conclusion

Using digital simulation, the TestWay software tool creates a virtual copy of the physical world (digital twin). This allows what-if scenarios to be played in the virtual world, to identify the optimal physical flow, using theoretical results to control the real physical world. Once test programs are in place on the shop floor, reading back the actual test coverage to compare to the simulation results is necessary to compare and understand differences and take appropriate action. This EMS 4.0 workflow enables tremendous benefits in time-to-market, cost reduction and quality improvements.

Design, test, OEMs, and EMS companies struggle to provide the DFT at the right time, however integration of a tool like TestWay into the design-to-production flow will greatly aid in creating a testable product that allows for good quality products to be produced. This tool makes good use of Industry 4.0 principles like the digital twin, and big data analysis for DPMO to achieve results. By reducing bad products going out the door (improving the test coverage and reducing the slip rate) as well as the cost savings from reducing test strategy overlap between different strategies (which is often unknown without a tool to identify this), the results can easily provide a cost savings and ROI for the purchase of a software tool such as the above-mentioned. **PCB007**

William Webb is technical director at ASTER Technologies.

Keysight's Massively Parallel Board Test

Feature Interview by Nolan Johnson

Nolan Johnson speaks with Christopher Cain from Keysight Technologies, who is passionate about a relatively new product and the market drivers leading up to the development of this solution.

Nolan Johnson: Keysight announced a relatively new product that performs massively parallel board test and inspection. Let's talk about the market drivers leading up to the development of that solution

Christopher Cain: Absolutely. Our target customers are typically those that do very high-volume electronic assemblies. This solution is meant to test an electronic assembly to make sure that it's been assembled, the parts are functioning, the soldered joints are okay, and it programs. Almost everything today has a processor and associated programming code that must be installed in manufacturing. The first instance of that software is so that the machine does that, and the massively parallel, by its very name, says we can do that on many units, up to 20–at the same time, which is important in industries like consumer electronics, consumer medical products, automotive electronics, and internet of things.

In those markets, they're very driven by yield. These are the high quantity products. They also tend to have lower profit margins, so making sure that they can be manufactured and sold to customers profitably is a very important attribute to them.

Johnson: It sounds like a key area of attention for you in developing a product like this is operator efficiency and high throughput.

Cain: Yes, absolutely. Throughput is the number of units under test in each period of time, and the value of the insights you gain by testing it, as compared to the investment cost, but with the unit in place and operating it.

To read the full article, which appeared in the November issue of *SMT007 Magazine*, click here.

Electronics Industry News and Market Highlights

Siemens Launches Xcelerator as a Service ▸

Siemens is excited to announce the launch of Xcelerator as a Service (XaaS).

Lockheed Martin Ventures, NTT Docomo Ventures Invest in TileDB ▸

TileDB, Inc. a pioneering database company, announced that it has received strategic investments from Lockheed Martin Ventures and NTT Docomo Ventures. The funding will be used to continue key projects and advance the vision and development of the TileDB universal database.

OPPO Ranked First in Global 5G Smartphone Shipments Among Android Manufacturers ▸

Global technology brand, OPPO, announces incredible market growth both locally and internally, cementing the brands commitment to offering its growing consumer base innovative products and enhanced customer service.

Keysight Selected by NIO to Verify 5G and C-V2X Connectivity in Electric Vehicles ▸

Keysight Technologies, Inc., a leading technology company that delivers advanced design and validation solutions to help accelerate innovation to connect and secure the world, announced that NIO, a Chinese manufacturer of battery electric vehicles, has selected Keysight solutions to verify 5G and cellular vehicle to everything (C-V2X) connectivity.

New Report Highlights Strength of U.S. Semiconductor Industry and Continued Challenges ▸

The Semiconductor Industry Association released its annual State of the Industry Report examining the U.S. semiconductor industry's current global position, as well as challenges to—and opportunities for—continued industry growth and innovation.

Qualcomm Leads the Way With IoT-as-a-Service ▸

As digital transformation ecosystem members converge at the third annual Smart Cities Accelerate event in San Diego, Qualcomm Technologies, Inc. is detailing the growth and vision of the Qualcomm® IoT Services Suite.

SEMI Applauds European Chips Act, Aimed at Boosting Semiconductor R&D and Manufacturing ▸

SEMI, the global industry association representing more than 2,400 semiconductor and electronics manufacturing companies worldwide, applauded the proposed European Chips Act legislation aimed at strengthening semiconductor research, development, and manufacturing in Europe.

DRAM Prices Projected to Enter Period of Downswing in 2022 as Demand Lags Behind Supply ▸

DRAM contract prices are likely to exit a bullish period that lasted three quarters and be on the downswing in 4Q21 at a QoQ decline of 3-8%, according to TrendForce's latest investigations.

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Alex Stepinski: A Philosophical View

Feature Interview by the I-Connect007 Editorial Team

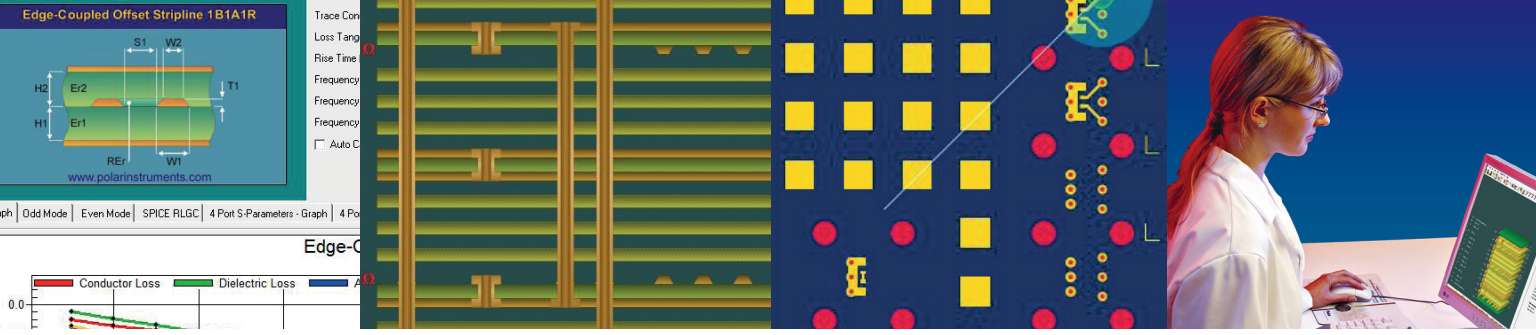
Alex Stepinski gives his thoughts on how test and inspection should be linked and reflects on how the process controls in fabrication are likely to change in the future.

Barry Matties: Alex, as you know, there are two levels of test inspection: product and process. What is your philosophy around test and inspection? I think you have approached it differently.

Alex Stepinski: The industry traditionally has relied on time zero testing. Defects that are 100% there, not latent defects; this is where things started in our industry. As time went on, methods were developed for latent defects. For instance, IBM originally started decades ago doing CAF testing, shorts testing in chambers. They simulated reflow testing in chambers. As a big OEM, this drove reliability to their products.

Gradually, these philosophies spread through the industry and more methods have been developed. Now, we do this OM test method on IPC D coupons for via reliability. The CAF method hasn't improved too much. It's slow and steady, however, it's much more prevalent. But time zero is still what most people do. You generally do reliability through regression. It's not direct measurement, so there's a lot of inferences that need to be made; with the time zero work, you have a probe tester and a fixture tester. It runs against your parameters, whatever they are—whether they're some advanced military parameters, IPC standard parameters, or something special.

This is what people do. My philosophy is to rely less on this and more on sensors throughout the process to measure things non-destructively, then build a model for how you're going to perform, and just validate against the model. It's the next step slowly happening worldwide. For instance, we've had 2D AOI for many years. Sometimes, this is complemented with electrical tests. Now, you start to see more 3D AOI happening. You see them putting more sensors on the AOI equipment for direct measurement. Then, you also have the traditional signal integrity testing. The challenge with that



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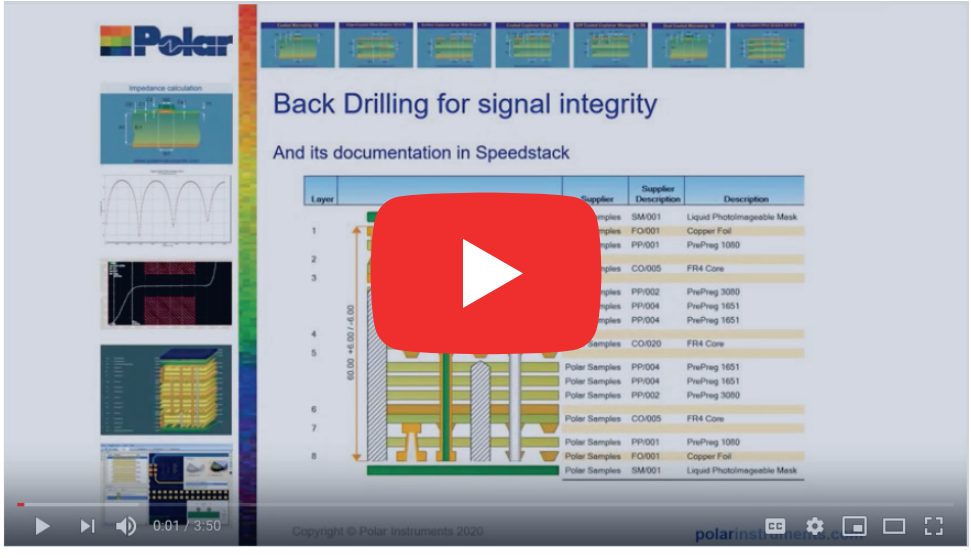

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Alex Stepinski

is it's never been fully industrialized with automation. There are some tools in the market, but you don't see them spread everywhere.

It comes down to whether it's much better to do quick microscopy, or to use a 3D back drilling technology that will sense the location of the plane layers internally.

If you take these methods and integrate them with serialization using QR codes and things like that, you can map a whole panel and find out how thick your prepreg and your cores are, and know the width and height of the features. It's all about taking this information, throwing it into a data lake like they do in many other industries, then running your analytics, forecasting, predicting what will happen, and doing some spot validation.

It's the next phase in the market. Digital transformation is a very common topic in many industries, but not so much in PCB. There's a lot of other sensors out there as well. There are gravimetric techniques that can be used. We hardly use any gravimetric tools to do process control. There are imaging methods to look at roughness on the surface, to make sure things are clean. These things have all been developed for other industries, and you see us just starting to incorporate them.

Matties: Who drives this in the organization? It's not going to be the quality manager, and it's probably not a skill set that already exists inside a fabricator. You're special in that you went out to create something new, fresh, and innovative, whereas everybody else is in a business cycle, if you will. How do they exchange that mentality, and what do they need to do?

Stepinski: From my perspective, this is generally a low-margin business and that's a fundamental challenge. R&D is expensive, and there always needs to be some dedicated R&D resources to evaluate these technologies. There is some R&D overseas; one of the biggest PCB shops with R&D is AT&S, with a large organization based in Austria.

But you must have a certain scale to afford the R&D resources. It could be a challenge for smaller shops, and there isn't really a blueprint yet in the market. Once you have a case study, everybody can copy it. That seems to be what we do in the PCB industry for anything. I think we just need to get a case study that people have access to, and it will propagate because it's a copy-paste thing.

Matties: To make the change into this approach, the payoff obviously must be there. How do you measure that? How do they justify that?

Stepinski: In my experience there's a very good internal rate of return on many of these investments. It comes down to just knowing all your costs. In our industry we're often still 50 years in the past, buying things on price; we don't look at the total cost of quality in many cases. That is because of a lack of knowledge about the process, insufficient understanding of where all the costs are coming from, and all the different subroutines that happen because of poor quality. If you look at the whole picture and think of it holistically, there are a lot of small investments that can be deployed; even in small PCB shops high returns can be achieved that prevent scrap.

When I mentioned earlier about the philosophy and everything being a data lake upfront, that's nothing too special. A lot of industries are doing it right now. Cloud computing costs have come way down. It's not a big deal to buy yourself some cloud space, start one process at a time, and start building up your data lake. Start with the highest net present value (NPV) investments, and gradually work your way down. Next thing you know, you're a digital company, and you can forecast.

Because I've recently gone to school for this, I'm extremely indoctrinated, plus I built a factory recently that was quite advanced, so my perspective may be a little bit different than brownfield sites and people who aren't going to these types of courses right now.

Nolan Johnson: People have been boxed into their thinking. Isn't that part of the challenge, philosophically, with process control, and test and inspection?

Stepinski: There are a lot of forces in the market right now. One of the main forces affecting PCB fab is digital transformation. In the next 10 years, we're going to see a lot more automation, but the software side is really the big thing that's going to change. We see it other markets right now too.

I would encourage all PCB shops to get a free Coursera account; pay $100 and take some courses in digital transformation. Learn Python and how to apply it to your business. Do some data engineering, data science. Start now, because the people who do this first are going to be those who stay in the long term. That's my feeling on this.

Johnson: You talked a lot about non-destructive sensors, measurement from inside the process, not on the board or the finished product itself, right?

Stepinski: Yes.

Johnson: That's a shift in thinking, I think, for a board fab. If your processes are right, then the product that's coming out is right.

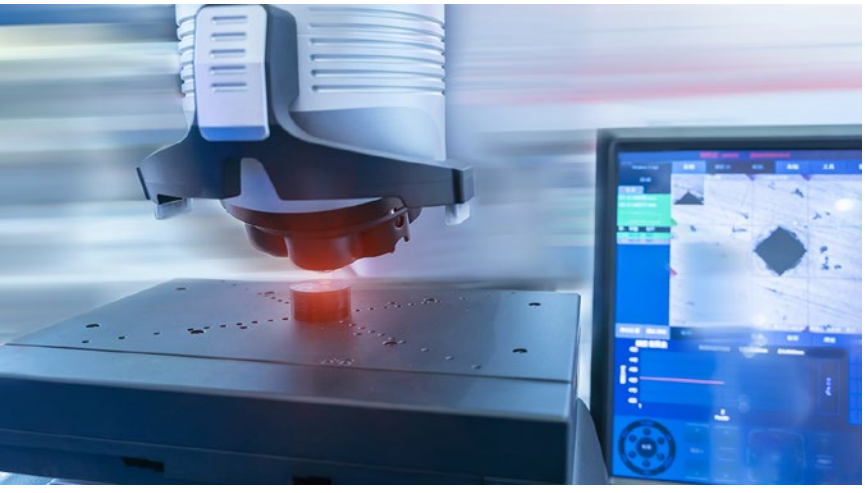
Stepinski: Theoretically. This is, in large part, driven by legacy specifications. Fabs are going to use methods that the customers accept. If you go out of line with this, you're a fool because your management will put the hammer down, and the customer is not going to accept product. At the end of the day, though, this is a big fallacy. It makes a lot of sense to develop other methods. The challenge is the legacy data that says, "We measure things this way," so you must have additional labor to do those other things.

In my experience, there are a few things that should be used with the process; 3D microscopy is a big one. You can avoid cross-sections in process by doing a lot of 3D microscopy, and then just using the cross-sections for final acceptance. There are offsetting benefits there.

In my experience, there are a few things that should be used with the process; 3D microscopy is a big one.

If you can make agreements with your customers to use the 3D microscopy, the 3D back drilling, and things like that to model your signal integrity, then just sample at the end and do a regression; this also makes a lot of sense in an existing shop. But the headwinds are associated with legacy specifications. That's really what it comes down to—that and the culture of our market and of our industry.

Johnson: You were doing some things differently at the fab you recently built. You had



some 3D microscopy onsite; how did that change the ability to track your quality? Did you get the results you expected?

Stepinski: The use of those tools gave us a different perspective on the manufacturing process. That factory was able to eliminate the stacked microvia failures and hit tolerances that had not previously been hit in the market by leveraging those tools to build the quality in; and continue to do so.

Johnson: There's a correlation, then, between test and inspection, and the processes?

Stepinski: Yes. The important thing is to have a data link. This is the new buzzword for our market. Very few shops have this. Maybe a few in Asia, but in the U.S., we're missing this right now. A data link allows you to have a repository for all this information so you can correlate things together, do analytics, and be able to come up with very good sampling plans that minimize your overall costs, raise the quality level, and add value to the customer. I think it's a big opportunity and it's not a hard thing. Because it's common in other industries, there are a lot of other prior learning and resources that you could leverage to accomplish this.

Happy Holden: I agree. We need to have good AI case studies because it's not easy to originate all the ideas. But it's a lot easier to take something that's working—somebody else's idea—and apply it or brainstorm it.

Stepinski: There are a lot of components to artificial intelligence to make it successful. The first is the inherent process capability, how much process variation is there. You can't do artificial intelligence with garbage equipment. It just doesn't work out. You need a sufficient level of process control in order to know that when you optimize something, the process hasn't changed.

The next step is the data engineering, making sure that the data coming to you is good and in the right format to do something with it. Typically, in these kinds of artificial intelligence practices, that's the biggest component. After process engineering, it's the biggest software component. Once you get through that, then you're into the data science, and that's the core algorithm to figure out what's going on. It's probably the smallest piece of the puzzle. Then you follow that with the analytics and the feedback.

You need all those things to make it work. Can you do it beyond registration? Absolutely. You can do it with plating, and with etching. But you need to get the first piece working, and know that the process is capable. You have to do your studies and identify this, because artificial intelligence requires a good Cp to have a good Cpk. If you have a poor Cp, you won't have a good Cpk. Just basic statistics, right?

So that's what it's for; it's going to give you the best Cpk for the native capability of the equipment if it's all executed properly. I think this is a great opportunity in the market. There is a lot of potential everywhere to add more value and it reduces costs without the new tool CapEx if the Cp is already there.

Matties: As you were hitting ratios and such that others haven't achieved, that created a new market opportunity where customers started coming to you because of your capa-

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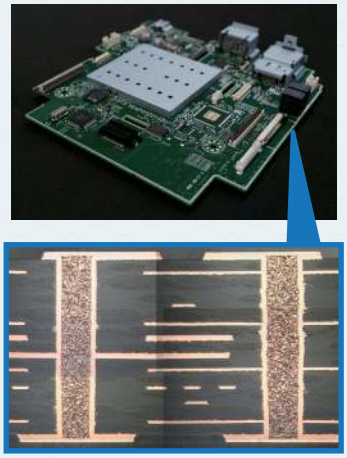

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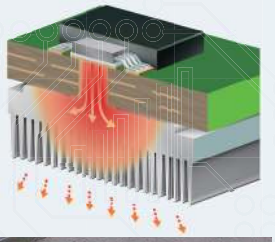

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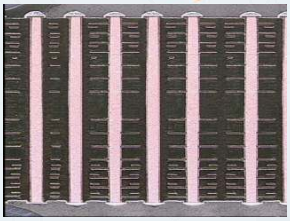
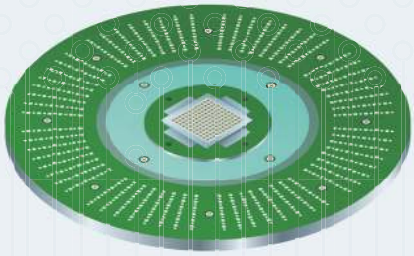
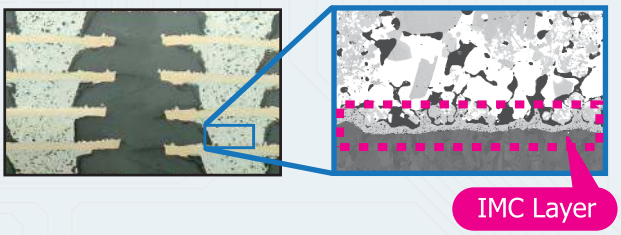


Metalizing Paste - TLPS Type
MP Series

Board-to-Board and Inner Layer Interconnect Materials

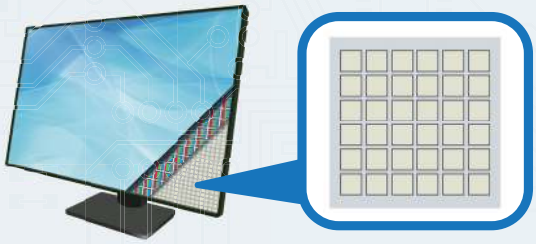


MP Series forming IMC layer

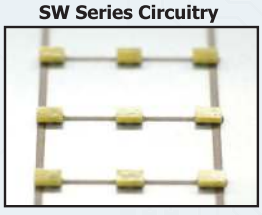


Circuitry Paste
SW Series

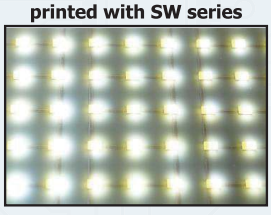
For Circuitry of LED Backlight Display



LED lights connected by SW Series Circuitry



LED powered by circuits printed with SW series



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bility and your tight process control. That's got to be a big measure of ROI. It's not just your yield, but it's also the market opportunity that you create by putting yourself in an advanced processing position. You saw that, no doubt.

Stepinski: Yes. These types of techniques are very common in other industries, like tuning things on the fly based on sensor measurements and improving your modeling. It's just something that really hasn't been in our market, for whatever reason. It seems like it's a low-margin business; there's not enough R&D funding. This is where we ended up as an industry. I mean, even the pizza delivery industry is more advanced. They have digital tools to tell you when the pizza will be done. We're just starting this stuff in PCB.

I mean, even the pizza delivery industry is more advanced. They have digital tools to tell you when the pizza will be done.

Matties: If we were to look at a brownfield site, where should the fabricator start? Is there a self-audit or some next step that they need to take to understand where they're at, what the opportunities are?

Stepinski: It comes down to looking at what you are and are not controlling, what data you have to use, and how you can connect what you have. That's the first step. I think you can rely a lot on the suppliers for this. If you just convened with your suppliers and said, "We want to have a more digital factory. We want to move forward into the 2020s here and join the digital revolution. A little late, but we're here. How can you guys help us?" That's the first step, because that's where all the research has been done right now, at the supplier's side.

You'll find the AOI equipment actually uses artificial intelligence. They have unsupervised learning algorithms that group things together. You can say, "There are 500 pictures that have one speck of black stuff on them that appears to be oxidation. It's not a real defect." It groups them together, so you can say, "I'm going to not inspect this family. I'm not going to verify this family of defects, but I am going to verify the 11 that look like they're nicks and see if they are really nicks."

These tools are already in place to some extent, but do the shops optimize this and develop their procedures? I think the suppliers are further ahead than the board shops.

Johnson: What do you see as the tipping point for the industry?

Stepinski: I don't think that there have ever been big tipping points in our industry. I think it's always been quite slow. But what you see now are some of the bigger companies based out of Asia who are going in this direction. There's a lot of Industry 4.0 going on there, but it's mass production oriented, for the most part.

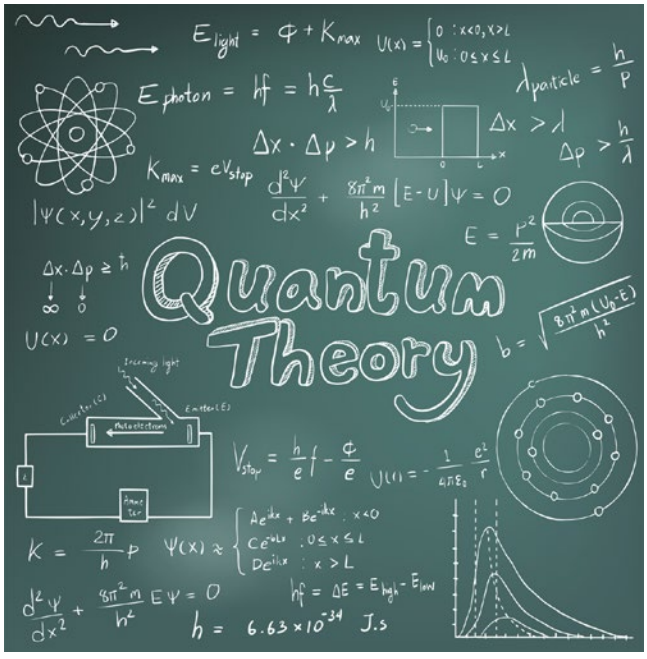
In Europe, you see some R&D developing these processes for higher mix, but a little slower. We see some market growth in Europe, which may result in more investment as well, to improve this. Once you have these case studies, then the suppliers are the ones who distribute the knowledge. They don't take ideas from their clients. They just say, "Hey, we did a big project." Everybody hears, "Hey, this company did this." You have something that we could use, and there's a little more background to it, and they can help you develop it. They give you a little head start.

I think that is what will happen, but it will be a slow osmosis into the market of these things. My recommendation is not to wait for the slow osmosis. Get ahead of it. Take some classes on Coursera, go to the Hanover Fair in April (or

something like that), and see what kind of sensors are in the market. Talk to people and figure out how to start incorporating into your equipment.

Johnson: You mentioned that a lot of the Industry 4.0 adoption is happening in the large volume facilities, but you've also proven recently that lot size one is possible using these same techniques.

Stepinski: Lot size one really comes down to a different equipment set. When you're doing production scale, you have large amounts of data, and you can tune things in very tightly.



With lot size one, typically you have to augment with test vehicles and things like that. It depends on what lot size one means. Does lot size one mean it's the first time I've ever built something with these parameters? Or is lot size one similar, part of a product family, or a platform of products that you're historically building? It might be part number 78, but I already built 77 part numbers with similar conditions, and then you can correlate throughout the product family and know what your recipes are.

Lot size one isn't necessarily lot size one. If it's the first time you've built a technology, that's really lot size one. Then you can augment with test vehicles, so you must look at it a little bit differently, I think. If it's all similar products and it's all within your DFM guidelines that you've qualified, it's not that hard.

Matties: Isn't lot size one where you can customize each panel or board as it's going through, based on the sensors, so every board could be slightly different because of variation?

Stepinski: Yes, but this is a little bit like quantum theory too, with the measurement of something compared to the ability to change, so you have to finish something to know the result, and then how do you change it at that point? This is quantum theory engineering, and that's the challenge with lot size one. With lot size one, feedback is not the right way. You must have feedforward, and that's a different control methodology.

Matties: There are some areas where you can do it, like registration, or optimizing the hole through the board.

Stepinski: Yes, corrections.

Matties: That's probably where we'd need to start?

Stepinski: Usually the most cost-effective method isn't to change the artwork; it's to change the process variables. This is typically the most cost effective. But it requires a capable process. You change the conveyor speed by 2.3% for this lot. But then you can't have the whole machine on one conveyor drive. You need to have it broken up into smaller conveyor drives, so the next panel gets reduced by 3%. You don't have to run out the whole line to do it. You have to look at the equipment design to do this; vertical is obviously even better for these situations.

Holden: Where does culture and the tipping point intersect?

Stepinski: The culture of the industry is driven by the history of the industry. It's a low-margin industry that's been low-capital investment for 20 years in the U.S. market. You don't have the staff in place, you don't have the mentality to go and do these projects. The biggest challenge is for the project manager: coordinating the right resources together, probably heavy supplier dependence, and a nice R&D team to do all this homework, get everything built the right way, and modify the existing factories. It's a hell of a project. The expertise to do all this is scattered.

Matties: Do you think there's an age issue in terms of leadership or ownership? If you start looking at the ownership or leadership, they've been at this for 20 or 30 years. They're just not ready to take on the challenge.

Stepinski: That is part of the problem as well. These factories need a fresh approach. It happens more overseas because they have better demographics, honestly. We have an older bias, and that doesn't help things. Also, a lot of this is fairly new. It hasn't been going on for that long.

Matties: That's why I was asking if they even have the job title or the skill set on staff, or is this something that they will need to rethink, to create this new position and new hire with that specific knowledge to come in and transform a factory?

Stepinski: There are two ways: you can outsource it, or you can do it yourself. There are outsourcing companies now available to help facilitate all this. But at the same time, I remember sitting in class one day and one of the professors had a consulting firm on the side. He lost his whole firm in one day because somebody in Switzerland hired them all for more money and they all jumped ship together. This is the challenge. It's very volatile when there's so much demand for the skills and people and this is what happens.

Matties: You've already mentioned that we're working on razor-thin margins. It's really a catch-22 here. They have to stay in business, they have to fund it, and they have to modify the way that they're thinking, all at the same time. As you mentioned, a lot of headwinds.

Stepinski: They need to have enough confidence in the investment that they're willing to finance it to get the results down the road. That's what it comes down to.

The future is about measuring things in process, taking the data into a data lake, doing analytics on it to model what's going to happen in the future, and make any adjustments as needed.

Johnson: Alex, thank you for taking the time.

Stepinski: Yes, it was nice to talk.

Matties: Always a great conversation with you, Alex. We greatly appreciate it. **PCB007**

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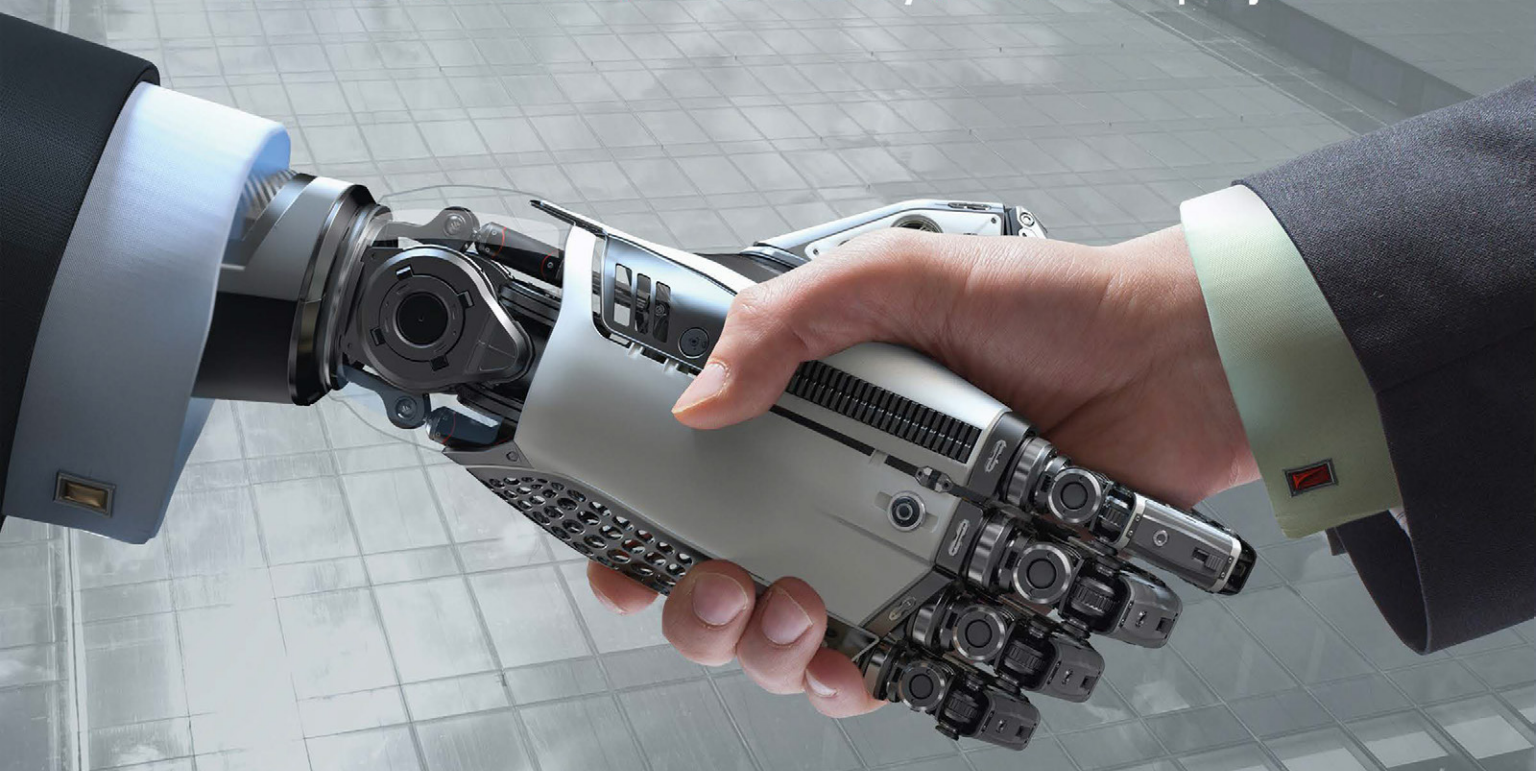

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Induction Lamination

Happy's Tech Talk

by Happy Holden, I-CONNECT007

Multilayers have been around about as long as the printed circuit. The industry has always used heated hydraulic lamination presses to produce these multilayers, with the introduction of vacuum assist in the 1980s. But recently, with the encouragement of Green-Source Fabrication, induction lamination has been perfected by Chemplate Materials of Spain. Chemplate had introduced the use of induction-pinning by optical alignment of innerlayers for multilayer stackup in the early 2000s. This was to go with another innovative way to laminate innerlayers together—the Italian CEDAL resistance-foil vacuum-press, which had some early adopters.

The induction vacuum lamination press (InduBond® X-Press) from Chemplate (Figure 1) is a very compact machine. That stems from its innovative use of magnetic flux to induce heating in the stainless-steel caul plates of the multilayer stackup vs. electric, steam, or hot-oil heating of the press platens.

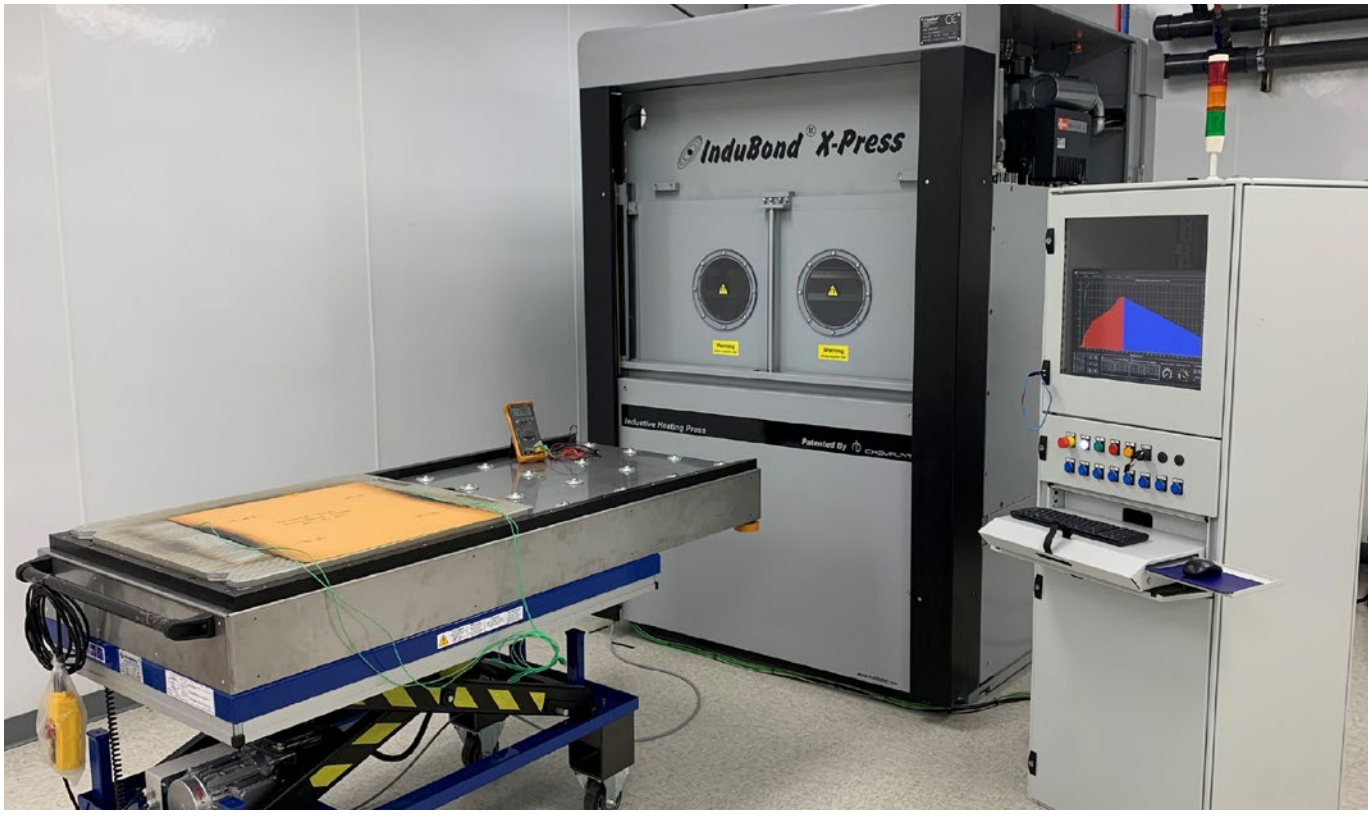

Figure 1: New technology using magnetism to produce heat to laminate PCB materials in record time and with uniform temperatures. (Source: Chemplate[1])

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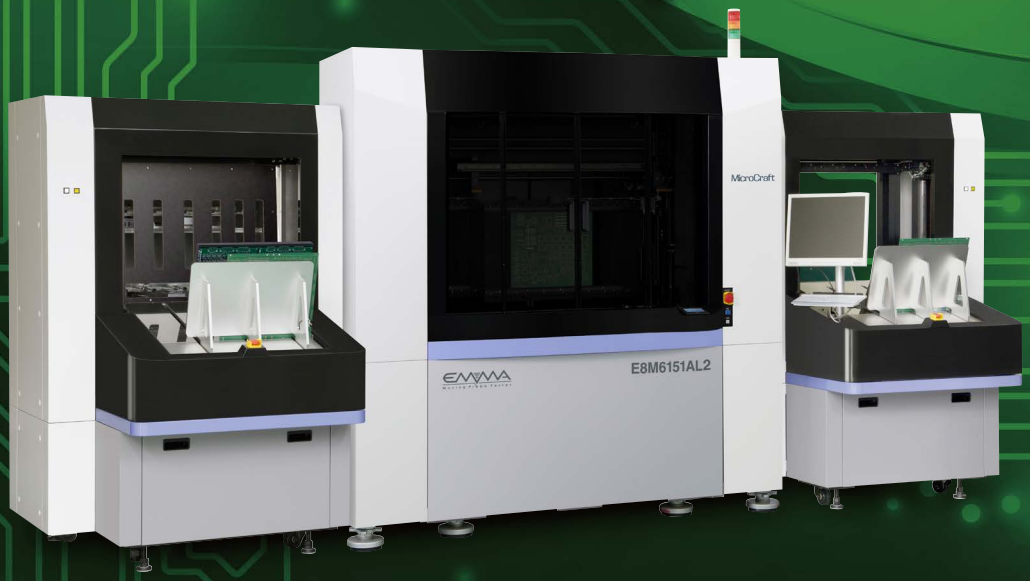

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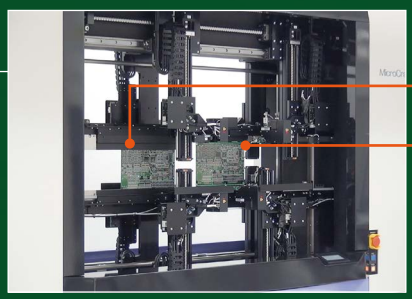

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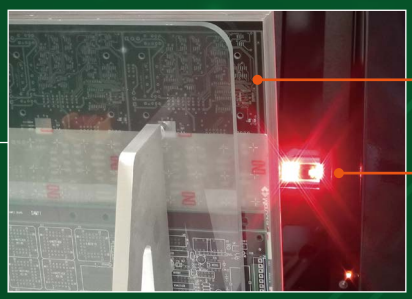

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In the October 2019 edition of *PCB007 Magazine*[1], Victor Lazaro Gallego explained, "The novelty of this new technology, however, is that the thermal energy (heat) to cure the resin composites is produced directly at each of the stainless-steel separator plates that are between each multilayer panel in the press stacks. This thermal energy is transferred at the same time—with the same temperature magnitude and without any thermal conduction delays—to every panel of the lamination press stack. As the energy is induced very homogenously, the heat distribution has the highest uniformity possible in every position and direction of the press stack (X-, Y-, and Z-axes). Therefore, all the layers of laminates inside the press reach the same temperature at the same time; there are no thermal transfer delays. Because the heat is produced only at each stainless-steel separator plate of the stack, the technology can achieve extremely high temperatures and very rapid ramp-up rates with very high energy efficiency."

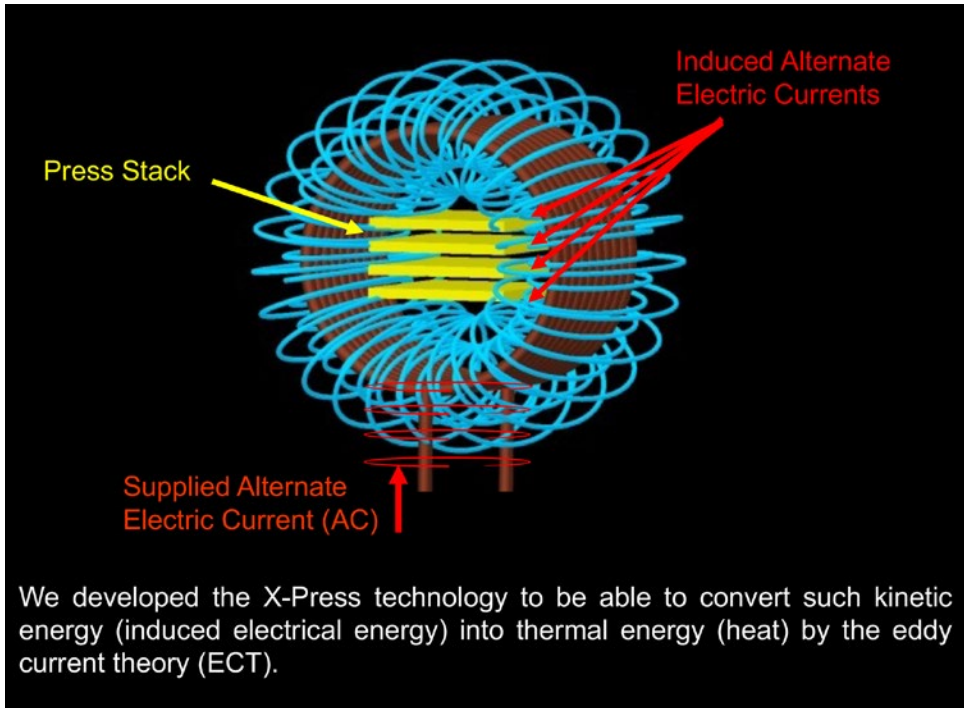

Figure 2: Stainless steel press stack separation plates as the secondary coil to induce heat. (Source: Chemplate)

Principle of Operation

Electromagnetism is generated when an electric current move through an electrical coil, as is defined by the Biot-Savart Law[2]. A magnetic field generated on the inside of the coil and looping around the coil perpendicular to the current in the coil is associated with the electric current in the coil.

This phenomenon also works in reverse. When a magnetic field is created by an electric current moving in a coil, an electric current can be made to flow and can induce electric currents in a secondary coil, if the magnetic field is placed in proper alignment to the primary coil.

For a multilayer stackup, the properly aligned stainless-steel caul-plate is working as a one turn coil in a short circuit for the induced currents (Figure 2). The induced magnetic field converts such energy on each stainless-steel separator plate (induced electric energy) into thermal energy (heat) by the eddy current loss theory[3].

Saving Energy, Time, and Money

Not having hot, massive platens to heat up and be maintained at high temperatures means that the energy usage is going to be minimized (reported to be ~10% of a hot press) and insulation materials will not be not required, since the separator plates themselves are the source of heat. A dummy panel with the same materials and physical properties as the laminate is embedded with a temperature sensor to track the temperature of the stack in real-time (Figure 3).

To better illustrate the efficiency of this new technology, Chemplate took thermogra-

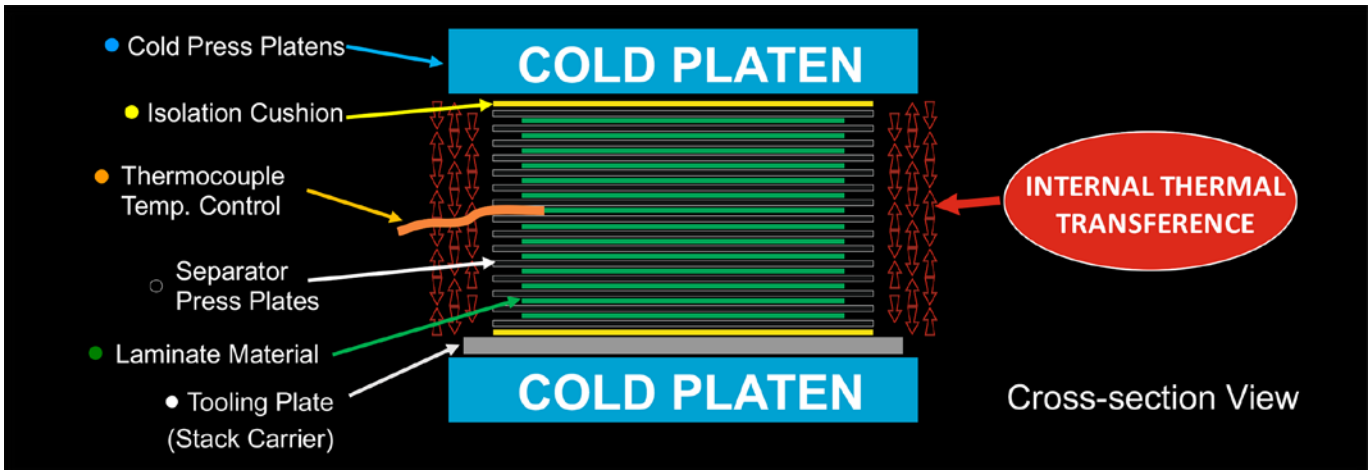

Figure 3: The InduBond X-press schematic cross-section view with constructions. (Source: Chemplate)

phy on one of the platens from conventional press technology, and another thermography of the new magnetic press technology (Figure 4). The left side shows the hot platen heat distribution where the platen surface and the sides are hot while the center (press stack) is cooler and needs more time to transfer the heat through the press stack materials. The right side shows that platens are at almost ambient room temperature while the center of the press stack is hot and uniform in temperature.

Energy Efficiency

In the article by Gallego, he provides a detailed analysis of how the induction process requires lower energy, more uniformly distributed and at a faster rate than does conventional press technology. A stackup mass of M_2 (4 kg) and M_3 (4 kg) heated from room temperature, 25°C (77°F) to 220°C (430°F) with induction energy requires only 702 K-joules, while a hot press with 70 kg platens will require 12,987 K-joules, nearly 18.5 times more energy. With two hot platens, more hot platens will increase the energy load.

The heat transfer is so efficient and uniform that 30 multilayers can be applied to a single opening, vs. the need for multiple daylight openings with smaller stack in conventional lamination (Figure 4).

Profile Programming

The lamination press profile is normally composed of the combination of three different profiles in a unique timeline: temperature, pressure, and vacuum (see controls in Figure 1).

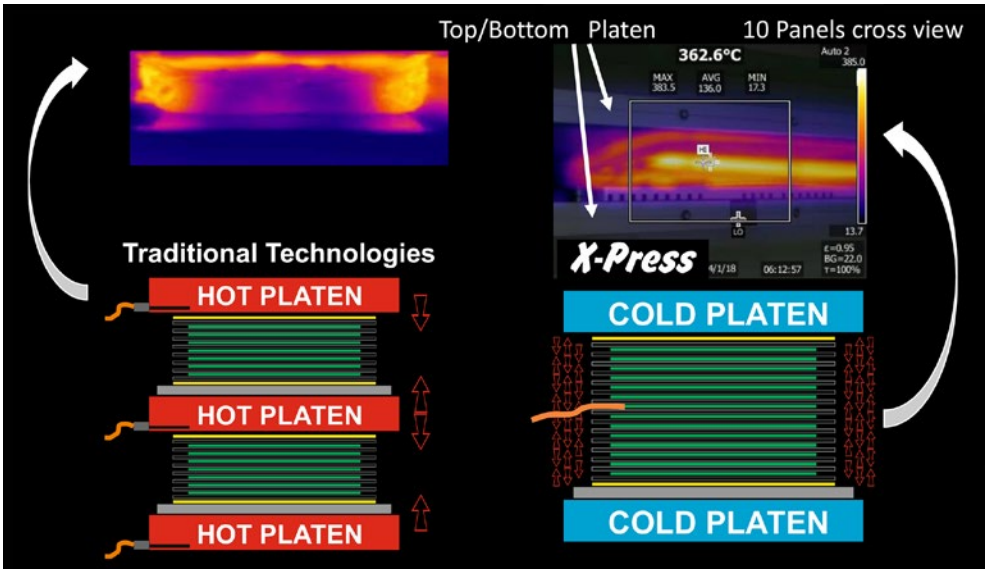

Figure 4: The thermography comparison of traditional hot-platen lamination compared to cold-platen, electromagnetic lamination. (Source: Chemplate)

Point	Conventional Technology	Electromagnetic Inductance Technology
Heat Transfer Efficiency	Must heat up the platens (large thermal mass) to transfer temperature from the outside to the inside of the press stacks by thermal conduction. This is true no matter which heating method the standard technologies use (electrical heaters, thermal oil or steam). Consequently, the material in contact with the hot platens will have a different temperature profile than the inside of the press stack as there are big heating delays. The large mass of platens result in a very high thermal inertia that complicates the thermal dynamics to be dealt with.	Induces heat directly into the separator plates, which is a much smaller mass compared to the platens. Plus, they are located right next to the material to be laminated, resulting in low thermal inertia, no thermal delays, and much-improved thermal uniformity along the three axes (X,Y,& Z) of the press stack. Heat is induced equally by the electromagnetic field in every separator plate simultaneously, which ensures controlled, real-time temperature transfer through the entire press stack.
Temperature and Ramp-up Limitations	Standard system using thermal oil or heaters are faced with big limitations in reaching high temperatures at high heating rates.	Induces the heat directly into the material to be laminated with direct and immediate thermal transfer. And with a much smaller mass to heat up, it is possible to reach higher temperatures (500ºC or 932ºF) and very high heating rates (>20ºC/min, or 36ºF/min).
Accurate Measurement and Control	Temperature control is based on the thermal transfer of energy from the outside (big mass platens) to the inside of the press stack through the highly thermally isolated materials (panels). As a result, temperature control in the panels becomes a question of an empirical or experimental process that can lead to dimensional distortions and lamination quality defects in the panels.	Uses a temperature sensor inside of the laminating panels that allows real-time temperature measurement and direct energy delivery (no delays) to the panels. The lamination profile is configured in the software (temperature, pressure, vacuum and time). The InduBond X-Press will apply the same profiles to each panel of the press stack at the same time-not an empirical or experimental process.
Energy Efficiency	Poor energy efficiency because the system heats up very large mass of the platens that are mechanically (and thermally) linked to the whole heavy machine structure, resulting in a huge loss of energy to the environment.	High energy efficiency because the energy is delivered right to the materials without heating up the big mass platens; thus, there is no energy leakage. It will use an average of 10% what traditional hot presses will use.
Footprint and Environment	Standard system occupy large spaces. Heaters and their connection and control systems (piping) require space for installation and safety. A large industrial infrastructure accompanies oil heaters, and they require large amounts of oil that must be heated and held in reserve for use on demand.	InduBond X-Press Technology dramatically reduces the floor space requirements and is clean, "green" technology that requires no oil, thermal papers or thermal maintenance.

Table 1: Summary of the differences between standard heating methods and the electromagnetic inductance-based system. (Source: Chemplate)

The process engineer or operator creates a temperature profile following what the laminate or prepreg manufacturer recommends on the datasheet of the material. Once this profile is transferred to the InduBond system, the computer, control, temperature sensors, and power driver work together to make the real temperature of the material track the programmed temperature profile very precisely. The software does the same for all other settings, such as vacuum, hydraulic pressure, lamination pressure, and all other process parameters. All the data during the lamination process is logged in a database and associated with a dedicated work order.

Once the heating section of the cycle is over, the vacuum chamber is pressurized. The developed cooling system creates a specific loop of airflow with a specific ΔT that crosses through the edges of the press stack separator plates. When the cold air touches the separator stainless steel, energy is exchanged. In other words, the air takes heat from the plates increasing the air temperature while the separator plates become a bit cooler. The air is then pulled by the blowers and conducted to a water/air exchanger that cools down the air again before the blowers push it back to pass through the press stack again. The system recirculates the air inside the chamber.

Summary

Table 1 provides a comparison of electromagnetic inductance lamination with conventional external heating lamination technologies. **PCB007**

References

1. Multilayer Press Technology Using Magnetism to Produce Lamination Heat, by Victor Gallego, *PCB007 Magazine,* October 2019.
2. Biot-Savart Law, gsu.edu.
3. Eddy Current Loss, circuitglobe.com.

Happy Holden has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa/Westwood, Merix, Foxconn, and Gentex. He is currently a contributing technical editor with I-Connect007, and the author of *Automation and Advanced Procedures in PCB Fabrication,* and *24 Essential Skills for Engineers.* To contact Holden or read past columns, click here.

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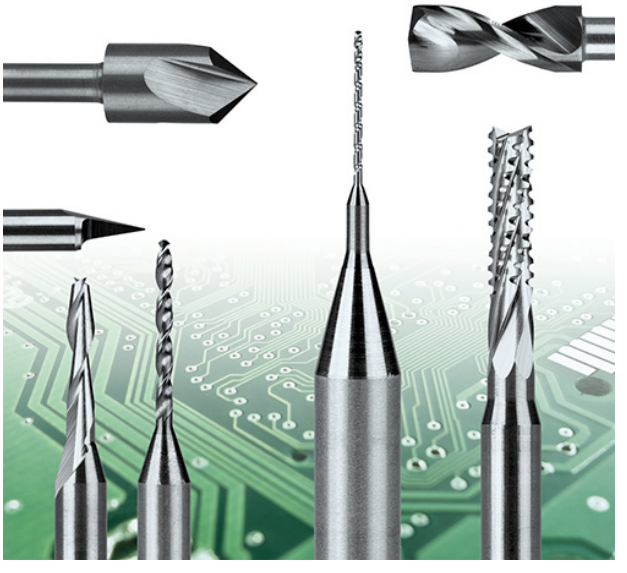

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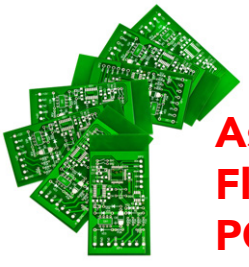

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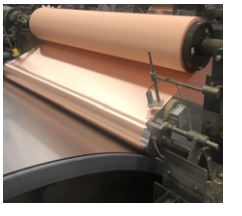

The Significance of IPC ENIG Specification 4552 Revision B

The Plating Forum

by George Milad, UYEMURA

The ENIG Specification 4552 was issued in 2002. Since then, it has undergone a series of amendments and revisions to meet ever-changing industry requirements. Although it started as a thickness specification that did not reference lead-free soldering or nickel corrosion, its latest iteration, 4552B, addresses all aspects of nickel corrosion.

The IPC Specification 4552B was issued in April 2021 as a performance specification. It is already having a profound effect on how the industry (suppliers, manufacturers, and end users) views the ENIG surface finish. The document is a revision of its predecessor, 4552A, issued in 2017. Revision 4552A addressed nickel corrosion for the first time. It described the corrosion defects as viewed in a cross-section at 1000X magnification by coining the terms "spike," "spreader spike," and "black band." It also addressed the level of corrosion and defined three levels. The levels were based on depth of defect and frequency of occurrence in the field of view at 1000X magnification.

ENIG Specification 4552A went a long way in defining the defect and its evaluation. The way the specification read was that if a single Level 3 defect was encountered, the product was deemed "rejectable." Rejecting a production lot due to a single occurrence of a Level 3 defect in the 1000X field of view did not make any sense. There had to be a method to determine the frequency of occurrence or prevalence of corrosion in the board. This was addressed in the revised ENIG specification 4552B.

In revision 4552B, the term "product rating" was introduced. Product rating is a way to assess the frequency of occurrence or prevalence of the corrosion defect. Product rating is determined by assessing the defect levels of multiple cross-section locations (seven for a through-hole and five for a single pad).

To arrive at a product rating, a cross-section of the board is examined at lower magnification (200X) where multiple holes are within the field of view. The specification then states that holes or pads with the most prevalent defects are to be evaluated at 1000X (Table 2). The results are tabulated, and a product rating value is extrapolated depending on the frequency of each of the levels.

This is a significant development in corrosion evaluation. Now there is a standardized method for corrosion evaluation that produces a product rating number. Specification 4552B

Corrosion Level	Description	Disposition
Level 1	<10 defects with <20% depth penetration	Acceptable
Level 2	defects more than Level 1 and less than Level 3	This level required resolution
Level 3	>10 defects with >20% depth penetration, at least 5 with >40% penetration	This level is rejectable

Table 1: Revision 4552A addresses corrosion effects.

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Product Rating	Corrosion investigation	Disposition
0	Defect-free, zero evidence of corrosion	Acceptable
1	>60% of evaluated locations show Level 0 or Level 1	Acceptable: This level of corrosion will not degrade solder joint integrity
2	Corrosion defects and frequency > Product Rating 1 but < Product Rating 3	Acceptable: Provided that solderability meets requirements per section 3.9
3	>40% of evaluated locations show Level 3 defects	Nonconforming: This level of corrosion will degrade solder joint reliability

Table 2: Revision 4552B assesses the frequency of occurrence or prevalence of the corrosion defect.

also addressed the disposition of the extent of corrosion.

4552B contains details on how to calibrate and qualify XRF thickness measuring equipment. It also describes how to generate "guard bands" for instruments that do not meet statistically acceptable repeatability.

4552B added a method to measure the phosphorous content of the EN deposit. The method uses energy dispersive X-ray florescence (EDXRF). Here, a number is generated for % phosphorous in the EN deposit. This number is a good indicator of the EN bath performance over its life as measured by MTOs (metal turnovers). The number can also be used to establish a correlation between the occurrence of corrosion and the % phosphorous content of the EN deposit.

With this methodology, manufacturers can gain a good understanding of the defect. They can track it, attempt to define a root cause, and eventually eliminate the defect. Products can be shipped with confidence, knowing that the product will not be rejected for ENIG corrosion.

Buyers can request that the manufacturer perform corrosion testing per 4552B and supply support documentation that the product is corrosion-free, or with an acceptable level of corrosion that will not cause solderability issues.

Suppliers now have a way to evaluate the performance of products in the field. They can increase the robustness of their products and service to ensure that customers can produce acceptable ENIG finishes in different manufacturing environments. Manufacturing sites vary dramatically in level of engineering support, lab support, plater experience, equipment, QC capability, etc.

Specific examples of increasing product robustness include:

- A modified catalyst that will produce a uniform catalyzed surface
- A more corrosion-resistant electroless nickel
- A non-aggressive immersion gold
- A reduction-assisted immersion gold

For technical service, the supplier must have a team of service engineers that are well versed on nickel corrosion and are supported by an analytical lab with capable personnel that can produce product rating numbers and % phosphorous as specified in 4552B.

The revised ENIG Specification 4552B gave the industry a tool by which manufacturers, buyers, CMs, and suppliers can measure the extent of ENIG corrosion. With this measurement tool, the problem of ENIG corrosion is well on its way to be eliminated.

"You can't fix a problem that you can't measure." **PCB007**

George Milad is the national accounts manager for technology at Uyemura. To read past columns or contact Milad, click here.

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MilAero007 Highlights

Learn How to Avoid Solder Defects With New Book Authored by Indium Corporation ▸

The Printed Circuit Assembler's Guide to... Solder Defects—the latest title in the I-007eBook library—is specifically dedicated to educating the printed circuit board assembly sector and serves as a valuable resource for people seeking the most relevant information available.

Circuit Chronicles: Effective Spokes in the Wheel of QMS ▸

What is a quality management system (QMS)? Over the years I've had it explained to me and exposed to many different definitions and forms of what a QMS is. By the way it wasn't always called a quality management system, and not many of those seemed to stick.

U.S. Defense Department Awards $8.9 Million for Further R&D on Lead-Free Electronics in Aerospace and Defense Sectors ▸

The U.S. Defense Department (DoD) is taking another step toward understanding and embracing the use of lead-free electronics in high-performance defense areas by allocating another round of funding to a public-private research effort.

Boeing's Latest 737-9 ecoDemonstrator Testing Crane A&Es New Long-range Sensing ▸

Crane Aerospace & Electronics, a segment of Crane Co., has been selected to feature its new Long-Range Wireless Tire Pressure Sensors on Boeing's 2021 737-9 ecoDemonstrator program.

HawkEye 360's Third Satellite Cluster Begins Commercial Operations ▸

The third cluster of satellites launched by HawkEye 360 Inc., the world's first commercial company to pioneer radio frequency (RF) data and analytics from space-based satellites, has achieved initial operating capability and has begun to deliver RF data and insights to clients.

Creation Technologies Completes Acquisition of IEC Electronics ▸

Creation Technologies, an end-to-end, scalable global electronic manufacturing services provider, announced that it has completed the acquisition of IEC Electronics Corp.

Raytheon Missiles & Defense, Northrop Grumman Successfully Test Fire Hypersonic Weapon ▸

Raytheon Missiles & Defense, a Raytheon Technologies business, in partnership with Northrop Grumman, successfully completed the first flight test of a scramjet-powered Hypersonic Air-breathing Weapon Concept (HAWC) for DARPA and the U.S. Air Force.

Celestica Partners with ECM to Bring Patented Technology Solutions to the Aerospace, Defense Market ▸

Celestica Inc., at the AUSA 2021 Exposition announced it has partnered with ECM, a software and technology firm that is changing the global electric motor and generator industries to bring ECM's patented printed circuit board stator solution to the Aerospace and Defense (A&D) market.

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The New Electrical Test: Riding the Wave

Testing Todd

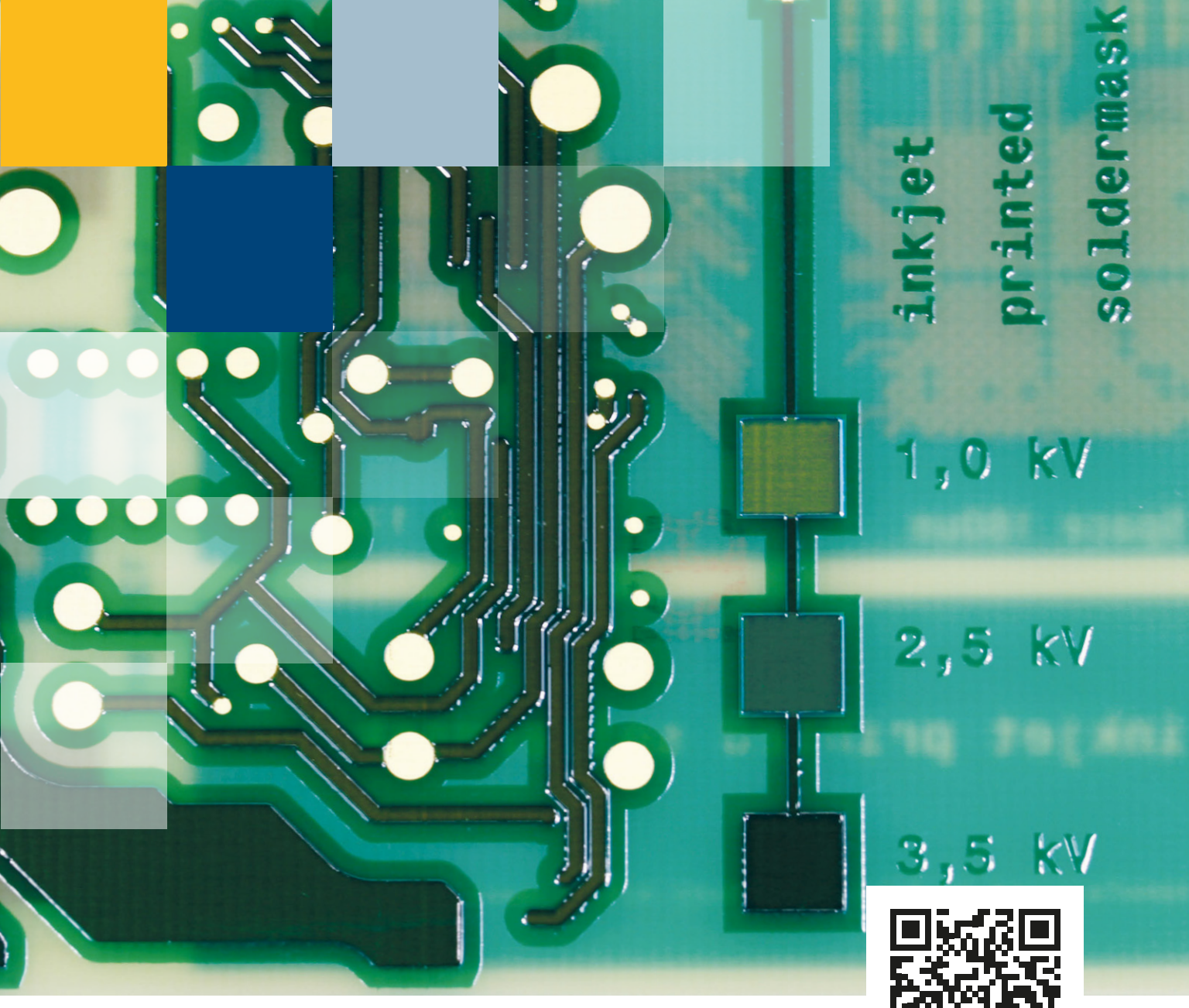
by Todd Kolmodin, GARDIEN SERVICES USA

Many years ago, when electrical test (ET) was necessary on a bare printed circuit board (PCB) you would build a dedicated fixture with spring pins and mount the box fixture to a machine interface and perform the test. However, back then there were no preconfigured netlists, and the machines were only capable of "learning" the board. This was known as the "self-learn" or "learn comparison" test. At the time, all you could do is prove that all the boards of the test lot were the same. The risk was that if there was a film defect and all boards had the same fault, the test would still pass even though all boards were defective.

As ET evolved, test machines gained the capability to save learned programs. Although still a "learn," we gained the ability to compare lot to lot for consistency. It wasn't the best solution but for the day, we worked with what we had.

As evolution progressed, the front-end systems began development of ET-related modules that could provide CNC drill files and programs that would support a handful of the test machines available. This was monumental as the self-learn was replaced by predetermined intelligence of the PCB. This raised the confidence level of electrical test significantly and unintentional scrap of product due to undetectable defects was greatly reduced.

Fast forward to today and electrical test, or test and measurement, has made significant advances. No longer self-learning (in most cases), ET now includes a battery of test options. It is not just "opens and shorts" but TDR, IR, buried passives, 4-wire Kelvin, and even buried inductance.



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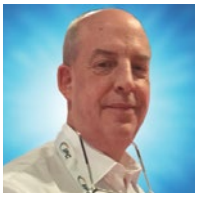
An advanced test floor may resemble an ICU with all the equipment around for these test options. You have machines for basic opens and shorts, TDR, inductance, HiPot, and IR. This can become costly to operate and maintain. Many OEMs are now requiring these tests as basic criteria for acceptance. All this equipment requires space and, of course, money.

The key to success is to do more with less. This is the 5S discipline at work. Today, the larger test facilities and equipment manufacturers are working to combine the requirements to single points of service. To streamline and provide cost effectiveness, these tests are being combined into single machines. Imagine a machine that can provide standard opens and shorts testing but can also provide buried passive testing, HiPot, 4-wire Kelvin, IR, and inductance testing from one platform. It is available right now. No more need for multiple test stations, machines, and extra operators. In the July 2021 issue of *PCB007 Magazine,* my column, "The PCB Limbo—How Low Can You Go," we discussed that price pressure is common and we must progress to maintain margins that keep us in business. The solution is machine combination testing which reduces operation and labor cost. We must make what we have do more.

The next progression is AI and automation. Systems are now available that communicate with internal databases that validate machine abilities, maintenance status, calibration status, and historic test data for any given part. If a machine is overdue for maintenance or calibration, the system disallows operation of that machine until remediation is completed for the point of error. Further, competence and training can be incorporated so that any operator who is not trained in a particular test method or type will be disallowed to continue.

These are just some of the newer competencies available with production systems of today. Speak with your service provider to see if they are doing more with what they have. It is the wave of the future and the best way to save money while enjoying the total benefits of what is now available to you. **PCB007**



Todd Kolmodin is VP of quality for Gardien Services USA and an expert in electrical test and reliability issues. To read past columns or contact Kolmodin, click here.

'Thermal Switches' Dynamically Moderate Heat of Electronic Devices

Purdue University engineers have developed a "thermal switch" made up of compressible graphene foam, that dynamically adjusts to temperatures both inside and outside the device to maintain consistent thermal management.

Graphene foam is a commercially available product, built from nanoscopic particles of carbon deposited in a specific pattern, with small voids of air in between. When the foam is uncompressed, it acts as an insulator, with the air pockets keeping the heat in place. But when the foam is physically compressed, the air escapes, and more heat is conducted out through the foam. Depending on how much the foam is compressed, the amount of heat transfer can be precisely dialed in.

The Purdue researchers measured the thermal conductance by sandwiching a 1.2-millimeter-thick sample of graphene foam in between a heater and heat sink, and placed the system under an infrared microscope to measure the temperature and heat flow. When fully compressing the foam to a thickness of 0.2 millimeters, the thermal conductance went up by a factor of 8.

Researchers also conducted an experiment in a chamber at Purdue's Flex Lab that can create specific environmental conditions, and achieved similar results with ambient temperatures from 0° C (32° F) to 30°C (86° F).

(Source: Purdue University)

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2/3 of electronic industry companies have difficulty finding production workers.[1]

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[1] IPC. (2017). Findings on the Skills Gap in U.S. Electronics Manufacturing.

2021 International Electronics Circuit Exhibition (Shenzhen) Coming December 8–10

Article by Tulip Gu

Editor's note: This report, was originally published in PCB007 China Magazine and translated to English for our readers. It outlines what attendees can expect at the upcoming HKPCA International Electronics Circuit Exhibition.

With less than two months before the opening of the 2021 International Electronics Circuit Exhibition, *PCB007 China* conducted an interview with the exhibition organizer, HKPCA, to talk about the preparations for this year's show and preview the highlights of the exhibition.

2021 International Electronics Circuit Exhibition (Shenzhen) will be held in Shenzhen World Exhibition & Convention Center (Bao'an) December 8–10. This exhibition is organized by Hong Kong Printed Circuit Association (HKPCA) and China Printed Circuit Association (CPCA). The theme will be "5G Connecting the World." More than 600 manufacturers will gather at the scene to showcase their innovative equipment and cutting-edge technology in the field of circuit boards and electronic assembly driven by 5G Internet of Things. It is an annual event that cannot be missed by the PCB industry.

Q: The 2021 International Electronics Circuit Exhibition (Shenzhen) will be held soon. The exhibition will be moved to Shenzhen World Exhibition & Convention Center (Bao'an) and will cover Halls 5-8 (four halls in total). The exhibition area will reach 80,000 square meters. What new supporting services will the new exhibition hall have?

A: Shenzhen World Exhibition & Convention Center contains more than 150 conference rooms of different sizes and types, which can meet the needs of various conferences held at the same time. The exhibition center is equipped with a catering area of 50,000 square meters. Exhibitors and visitors can eat without going out of the exhibition center, and choose a variety of catering services such as tea break, fast food, and a large banquet, according to their personal needs. In addition, the exhibition center has two-story underground parking area as well as a ground-level parking area.

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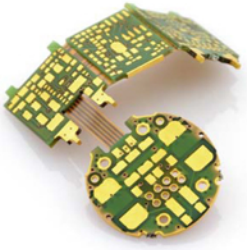

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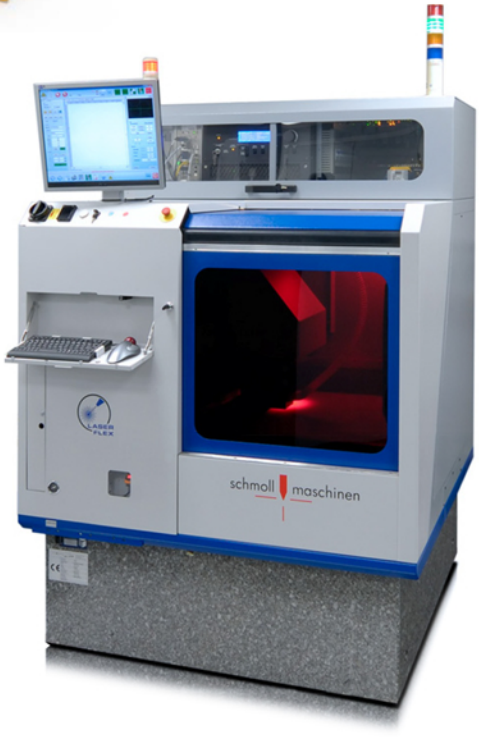

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Q: What should exhibitors pay attention to? For the attendees, what are the highlights to be expected?

A: It is suggested that exhibitors can make use of the promotional activities of the organizer and the exhibition hall to get exposure to professional visitors before or during the exhibition, in order to make their brand more exposed and attract more professionals to their booths; and to improve the exhibition efficiency.

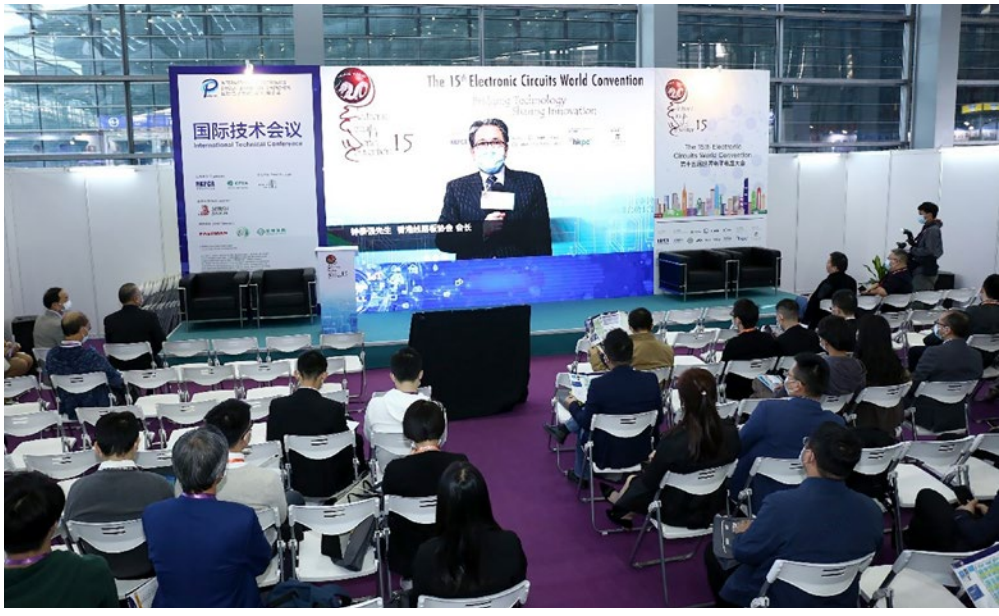
For industry visitors, this exhibition is definitely a year-end event that cannot be missed. This year, the exhibition will present the historically largest and strongest lineup of exhibitors. The highlights are as follows:

- **New pavilion, new experience:** It is the first time the exhibition will move to Shenzhen World Exhibition & Convention Center (Bao'an). Hall 5, 6, 7, and 8 will be put into use. There will be four halls in total, with nearly 4,100 booths and an exhibition area of 80,000 square meters.
- **Strong lineup of exhibitors,** gathering more than 600 industry giants and start-ups, including: TTM, Topsearch, Founder, Elec & Eltek, China Eagle, Allfavor, MSL PCB, WKK, Atotech, Harvar, DuPont, Schmoll, Jadason, Orbotech, Han's CNC, C Sun, Protek, World Wide Group, Universal PCB, Boffotto, Joint Stars, Machvision, Zhengye, ISOLA, JHD, Lauffer, SCREEN, Kingboard, Process Automation, Taliang, Kunshan Dongwei, Daidalos, Chaohua Tech, San-Eikagaku, Magneto, Accutech, Keyence, Inovance, ZWSOFT, Inno Laser, BU-Laser, LEAD, G. WEIKE, WUJO HIGH-TECH, Zhongde Nawei, Jiuyao, Blihe, WangHong, Rockent, Glorysoft, ROKAE, OPTON, VEGA, etc. They will display innovative equipment and cutting-edge technologies in the field of circuit boards and electronic assembly driven by 5G Internet of Things. The exhibition is the best platform for the industry to discover products/technologies and expand business.
- **Exciting concurrent events:** The International Technology Conference, which was very popular in previous years, will be a gathering of authorities and market leaders in the industry to share the latest market trends and cutting-edge technologies. This will help to get new market opportunities and new opportunities. The Golf Tournament allows people in the industry to talk freely and strengthen contacts in a relaxed atmosphere.
- **Celebrating the 20th anniversary of the exhibition:** The conference will hold a special 20th Anniversary event at the exhibition site. We hope to review the journey of the exhibition and look forward to the future with the industry in a warm atmosphere. The event is under planning. Please kindly wait for more details.
- **The Virtual Exhibition** will continue, creating a business platform without time and geographical restrictions: The Virtual Exhibition has been highly praised since it was launched in 2020. It provided people in the industry with a new exhibition experience. This year's Virtual Exhibition will continue to be launched to help the industry break the restrictions of region and time, and establish extensive business cooperation.

Q: Could you brief us about the powerful guests and keynote speeches at this year's International Technology Conference?

A: The International Technology Conference will bring together dozens of corporate executives and technical experts to share the latest market trends, research, and innovative technologies. The topics are rich and brilliant, which aim to help participants get practical knowledge and advanced ideas to enhance business development in order to cope with

the increasingly complex challenges the industry is facing, and to meet the development of 5G era. You can get the detailed agenda and speaker list from the exhibition www.HKPCAshow.org or the official WeChat account "PCB_SMT."



Q: The size of the exhibition area shows that industry enterprises are actively participating in the exhibition, and various new products and new technologies emerge at the exhibition. What are the highlights of the exhibition?

A: This year's exhibition will still be divided into seven exhibition areas, namely circuit board manufacturer area, electronic assembly area, environmental protection and cleaning area, intelligent automation area, equipment supplier area, raw material supplier area, and Japan and South Korea area, showing the innovative equipment and cutting-edge technology in the field of circuit boards and electronic assembly driven by 5G interconnection of things. It is the best one-stop platform to discover products/technologies in the industry and to do business development.

To enable the audience to effectively plan the itinerary before the exhibition and quickly find the products and technologies they need, before the exhibition, we launched the Show Preview. The audience can get to know the innovative equipment and technology, and get the 600+ exhibitors list as well as the introduction of the current events by visiting the official WeChat account "PCB_SMT."

Q: Compared with last year's show, what are the new online exhibition functions, the advantages, and the effects? How will you create more functions during and after the exhibition to bring added value to the exhibition?

A: The Virtual Exhibition was highly praised by the industry after it was launched last year. It will be launched in mid-to-late November this year and will last until the end of December. We will create a new exhibition experience of "Online + offline," which will have several core functions:

- The Virtual Exhibition will have "PC version" and "WeChat version" to meet the needs of different people.
- Exhibitor showcase: Exhibitors can upload company introduction, products, videos, pictures, etc., through the platform to show the company strength and product advantages, and attract online visitors from all over the world.
- Audience browsing: Visitors can view the products and technologies of the manufacturers without time and geographical restrictions, and invite their favorite exhibitors to communicate and explore more cooperation opportunities.
- Business match-making function: Visitors and exhibitors can invite exhibitors through the platform and communicate with them online.

Q: This year, a large number of R&D forces have also emerged in China in the fields of IC carrier boards. In view of this, what are the

technical hotspots in exhibitions and seminars worth mentioning, and what role will they play in promoting the development of PCB industry in the future?

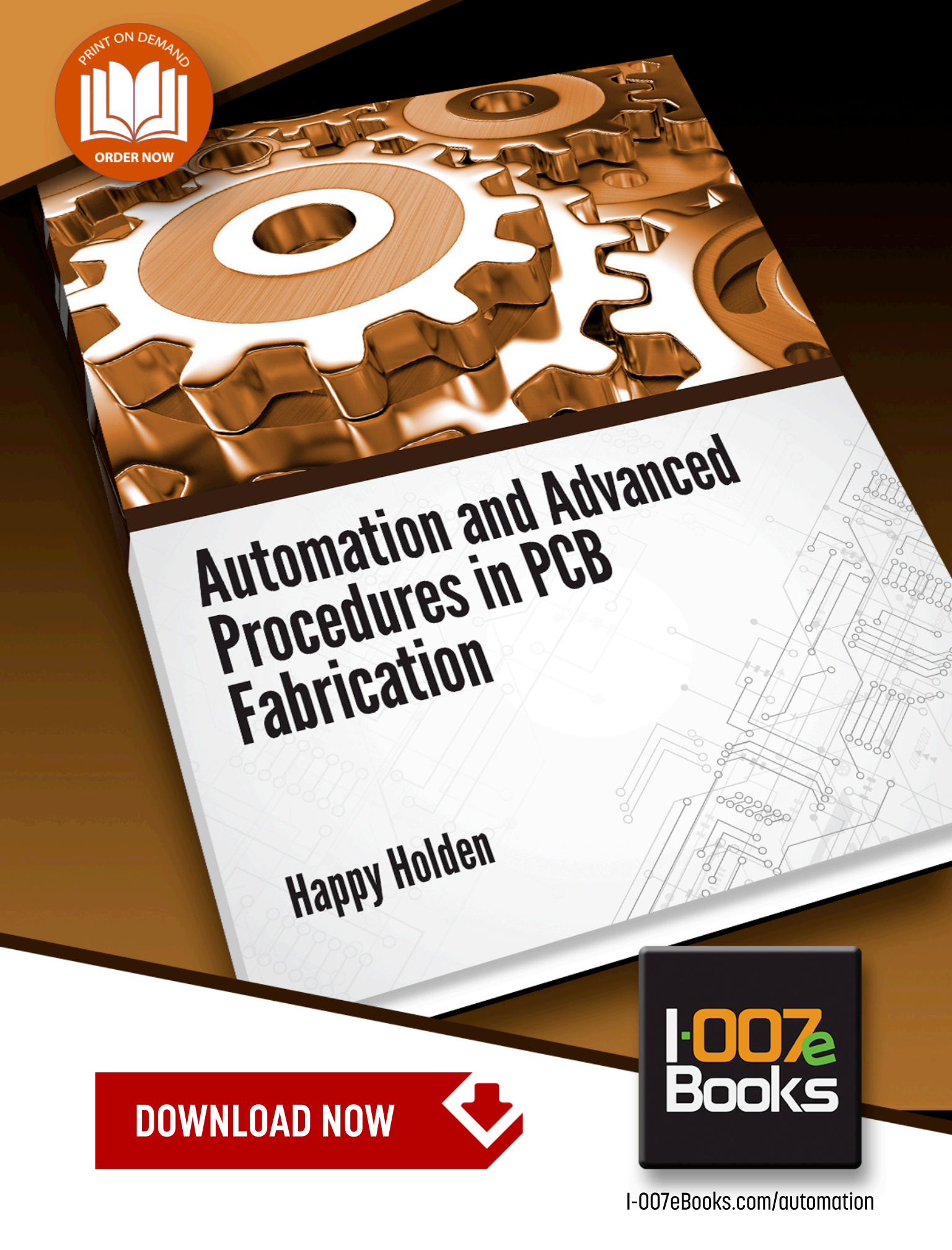
A: In the field of chip manufacturing, the changing packaging technology, and the more high-speed and high-frequency applications brought by 5G era, have driven the carrier industry to take off. With the theme of "5G Connecting the World," this exhibition brings together industry giants and start-ups to display innovative equipment, technologies and solutions covering the whole supply chain of the circuit board and electronic assembly industry, to help the industry accelerate the integration and innovation with 5G and sustainable development.

From the perspective of carrier classification, the technology used by flip chip BGA has had strong growth momentum in recent years. It can achieve narrow line width and line spacing, relatively more layers, and can support some high-order packaging. In addition, many module class carrier applications are related to mobile phones and consumer products. Especially for 5G high-frequency transmission, it needs new modules. These two types of carrier boards will be the focus of development in the next few years. The development of the carrier board industry will promote PCB industry to integrate into the whole semiconductor industry chain.

Q: What is the global PCB development application fields and technical trends worthy of special attention in the industry?

A: With the effectiveness of vaccination, herd immunity, and other measures, the global economy has gradually recovered in 2021. With the increase of industrial procurement, the global PCB industry will continue to grow. 2021 is also the opening year of China's "14th Five-Year Plan." The long-term goal of 2035 is to accelerate the promotion of digital industrialization, cultivate and expand emerging digital industries such as artificial intelligence, big data, blockchain, cloud computing and cybersecurity, etc., enhancing the industrial level of communication equipment, core electronic components as well as key software. It is aimed to build 5G-based application scenarios and industrial ecology by carrying out pilot demonstrations in key fields such as intelligent transportation, intelligent logistics, intelligent energy, and intelligent medical treatment.

Under the environment of accelerating digital industrialization, the electronics industry is facing different opportunities from the past.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The whole circuit board industry presents a new turning point, and the carrier board has achieved double-digit growth. In computer-related categories, especially high-end computer categories, PCB production technology has changed to high complexity packaging technology. HDI board technology is not limited to mobile phones, but is more widely used in automotive, server, memory storage, laptop, tablet, and other product fields.

Since 2020, the carrier board market has grown rapidly as a whole. The manufacturing of carrier boards is mainly concentrated in Asia. According to the carrier board investment plans announced by domestic and foreign enterprises, the investment amount has exceeded US $10 billion. There is a great demand for carrier boards in the future. The technology and market of carrier boards deserve everyone's attention. **PCB007**

BYU Researchers Create World's Most Power-Efficient High-Speed ADC Microchip

Dr. Wood Chiang, BYU professor of electrical and computer engineering, and his team have just built the world's most power-efficient high-speed analog-to-digital converter (ADC) microchip. An ADC is a tiny piece of technology present in almost every electronic piece of equipment that converts analog signals (like a radio wave) to a digital signal.

The ADC created by Chiang, Ph.D. student Eric Swindlehurst and their colleagues consumes only 21 milli-Watts of power at 10GHz for ultra-wideband wireless communications; current ADCs consume hundreds of milli-Watts or even Watts of power at comparable speeds. The BYU-made ADC has the highest power efficiency currently available in the world—a record it holds by a substantial margin.

"Many research groups worldwide focus on ADCs; it's like a competition of who can build the world's fastest and most fuel-efficient car," Chiang said. "It is very difficult to beat everyone else around the world, but we managed to do just that."

The central challenge facing researchers like Chiang is that increasingly higher bandwidths within communications system devices means circuits that consume more power. Chiang, Swindlehurst and their team set out to solve the problem by focusing on a key part of the ADC circuit called the DAC. (Confusing, right? Yes, there is a central piece on an ADC called a DAC and it stands for the opposite: digital-to-analog converter.) (Source: BYU)

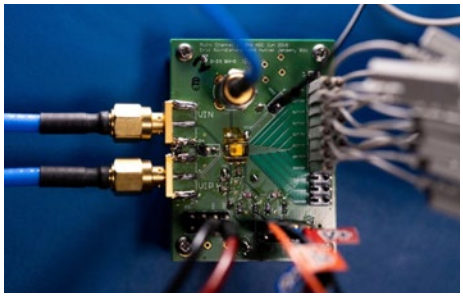

Photo: The analog-to-digital converter or ADC microchip created by Professor Wood Chiang, Ph.D. student Eric Swindlehust and their team of researchers. (Photo by Jaren Wilkey/BYU Photo)

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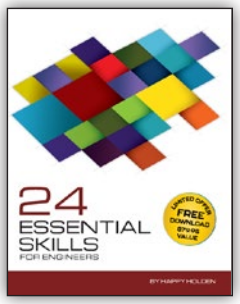
TOP TEN

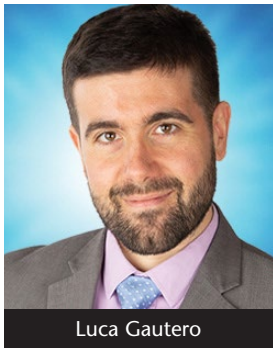
EDITOR'S PICKS



24 Essential Skills for Engineers: The Story Behind the Book

In this interview with I-Connect007's own Happy Holden about his newest book, 24 Essential Skills for Engineers, which he wrote over the span of his career, he highlights some particular moments from his time working at HP and as CTO of Foxconn which inspired many of the book's chapters. Happy explains why he covered engineering skills as well as "soft skills" such as problem-solving and communication—skills which are keys to succeeding as an engineer.

Additive Reality: Solder Mask Patterning at the Edge Between Drops and Bricks


Luca Gautero

The digital form of the inkjet printing technology goes through files containing a rasterized image; these bitmaps, in their simplest form, contain information about presence (or absence) of drops. Additionally, the resolution brings in the drops pitch.

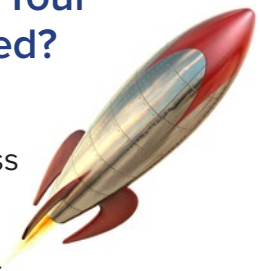
The Right Approach: Leadership 101—The Law of the Inner Circle

Good leadership always makes a difference; unfortunately, so does bad leadership. This leadership truth continues as we will be talking about the 11th of the 21 Irrefutable Laws of Leadership.

The Big Picture: Part 2, Geopolitics and the PCB Supply Chain

Since my last column on this topic was so popular, I figured I should double down on it. If you've been living under a rock, let me tell you to stay there. China is currently undergoing a spate of power issues due to a perfect storm of trade feuds, electricity price capping, insane coal prices, and high consumer demand. Hold on to your mast because this one's going to be a wild ride.

Testing Todd: Is Your Process Cluttered? Supercharge It!

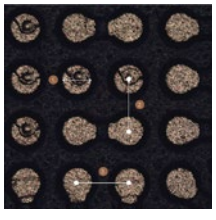


Recently I came across a posting on social media regarding process development in the eyes of Elon Musk. Although there are many philosophies regarding process development, I found Elon's insight particularly interesting. Let's design a process, shall we?

Summit Interconnect Partners with Lindsay Goldberg for Its Next Stage of Growth

Summit Interconnect announced that affiliates of Lindsay Goldberg—a leading private investment firm that focuses on partnering with families, founders and management teams—have completed a majority investment in the Company in partnership with the Company's President and CEO, Shane Whiteside, and other members of the Company's management team.

PCB Technologies Develops Substrate Integration for Miniaturization



In the endless pursuit of miniaturization of microelectronic devices, aimed at their enhanced functionality and reliability in parallel to higher endurance, PCB Technologies has developed the ultimate substrate integration relevant for various applications.

The Plating Forum: The IPC Surface Finish Specifications

Specifications are reference documents to be called out by OEM board designers in specifying the attributes of a surface finish. Designers may take exception with one or more items in the specification to ensure that the product meets the requirements of its intended use. The term AAUBUS (As Agreed Upon Between User and Supplier) is part of any specification.

It's Only Common Sense: Get Off Death Row, Part 3—Finding, Hiring, and Keeping Good People

Dan Beaulieu

In the early 1970s, I was a program coordinator for Maine Electronics, a division of Rockwell International. As I got to know more about the job, the product, and the company, I fell in love. Rockwell was building important products, from the Minuteman missile to the F-111 fighter, the Viking; later, we were a prime for the Space Shuttle. I fell in love with the work.

SÜSS MicroTec Continues to Grow, Has Record Order Entry in 3Q

According to preliminary figures, technology company SÜSS MicroTec SE has received ca. EUR 101 million incoming orders during the third quarter of 2021.

Career Opportunities

Is your team growing?

Find industry-experienced candidates at I-Connect007.

For just $750, your 200-word, full-column ad will appear in the Career Opportunities section of all three of our monthly magazines, reaching circuit board designers, fabricators, assemblers, OEMs, suppliers and the academic community.

In addition, your ad will:

- be featured in at least one of our newsletters
- appear on our jobConnect007.com board, which is promoted in every newsletter
- appear in our monthly Careers Guide, emailed to 26,000 potential candidates

Potential candidates can click on your ad and submit a resume directly to the email address you provide, or be directed to the URL of your choice.

No contract required. Just send over your copy and company logo and we'll do the rest!

Contact barb@iconnect007.com to get your ad posted today!

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Career Opportunities

schmoll maschinen
... one step ahead.

Service Engineer

Schmoll Laser and Direct Imaging

Reports to: Field Service Manager
Location: North America

SUMMARY:
Provide expert-level service on multiple laser drilling and direct imaging product lines. Maintain high customer satisfaction, timeliness, accuracy, efficiency, cost effectiveness, and safety.

DUTIES AND RESPONSIBILITIES:
- Install, commission, and maintain Schmoll products at customer sites. Perform modifications and retrofits as needed.
- Troubleshoot, diagnose, and calibrate products via telephone or at customer sites.
- Handle a wide variety of problems, issues, and inquiries.
- Provide training for customers and others in the effective operation, calibration, and maintenance of all products.
- Lead the project management team for retrofit/upgrade requests and recommendations for Schmoll equipment until the end of commissioning and final payment.
- Assist customers with potential optimization of their machine operations and work with clients on application improvements.

QUALIFICATIONS:
- Must possess a valid driver's license, clean driving record, major credit card (for business travel), and passport.
- Ability to read and interpret technical documentation, compile reports, and compose routine correspondence, define problems, collect data, and draw a valid solution.
- Must be able to travel extensively, partly international, to support customer needs. While Burkle makes every attempt to avoid Sunday and Friday evening travel, sometimes it is required.

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MacDermid Alpha ELECTRONICS SOLUTIONS

Technical Marketing Specialist

Waterbury, CT

JOB DESCRIPTION:
Responsible for providing technical knowledge and support to marketing communications professionals. Cross training and acting as liaison between the Innovation and the Marketing Communications teams for both Circuitry Solutions and Semiconductor Solutions.

Chemist 1

Waterbury, CT

JOB DESCRIPTION:
Perform analysis—both chemical and mechanical—of customer-supplied samples. These include both structural and chemical testing using various instruments such as SEM, Instron, ICP, and titration methods. Perform various failure analysis functions, including, but not limited to, chemical analysis, SEM analysis of customer parts, and cross-section evaluation.

Applications Manager

Waterbury, CT/New England Region

JOB DESCRIPTION:
Applications Manager in the Electronics Specialties/Circuitry Solutions group to provide applications process knowledge, training and technical support of new products leading to sales revenue growth. Requires working through the existing sales and technical service organizations to leverage this knowledge globally. Experience in multilayer bonding along with dry film and solder mask adhesion processes a plus.

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Career Opportunities

Sales Manager

New Business Development (m/w/d) – Sales Territory: Germany

CML Group is a global leader in the Printed Circuit Board industry, specialized in PCB manufacturing and sustainable PCB supply solutions. Our products are made to the highest quality and reliability standards, including automotive requirements.

For the expansion of our target markets, we need you to generate new business, drive new projects from RFQ stage and manage the customer relationship.

Your responsibilities:

- Develop new customers and build long-term customer relationships
- Understand the customer requirements and acquire new contract enquiries from all market sectors
- Proactive market and customer research
- Identify new potential electronic industry sectors
- Result-oriented sales management including support and consulting on new projects
- Independent management and organization of your accounts
- Price and contract negotiations with customers and contractual partners

Your profile:

- Several years of professional experience in sales and key account management
- Knowledge of printed circuit board production/ industry would be an advantage
- Fluent in Business English and willingness to travel internationally
- Flexible and an open-minded mentality
- Strong communication skills, team player
- Self-motivated, well-organized, professional
- Your home base is in Germany

Interested? Looking forward to your application!
Please send your application to hr@cmit.support.
For more information visit
www.cml-globalsolutions.com

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Customer Service Representative, UK

We are looking to expand our UK Customer Service/ Internal Sales team. As Customer Service Representative you will provide great sales and customer service support and respond to the needs of clients from industries including Aerospace, Defence, Automotive and Pharmaceutical. Duties include:

- Maintain & develop relationships with new and existing customers
- Make rapid, accurate cost calculations and provide quotations
- Accurately input customer orders through bespoke MRP System
- Liaise with colleagues at Chinese HQ and other Overseas Business Units to manage domestic and international requirements
- Assist sales team with reporting, sales analysis and other items at their request

Skills and abilities required for the role:

The ideal candidate is a proactive self-starter with a strong customer service background. Friendly, approachable, and confident, you should have a good phone mannerism and be computer literate.

- Previous experience in a Customer Service background, ideally management or supervisor role
- Experience with MRP Systems
- Good working knowledge of Microsoft Office Tools such as Outlook, Excel etc.

What's on Offer:

- Excellent salary & benefits commensurate with experience

This is a fantastic opportunity to become part of a successful brand and leading team with excellent benefits.

Please forward your resume to HR@ventec-europe.com

apply now

Career Opportunities

Printed Circuits, a fast-growing printed circuit board fabricator, offers:

- Excellent opportunities for advancement and growth
- Dynamic manufacturing environment
- Excellent health, dental and other benefits
- Annual profit-sharing plan
- Signing bonus
- Additional incentives at the leadership level
- Clean facility with state-of-the-art manufacturing equipment
- Highly collaborative corporate and manufacturing culture that values employee contributions

Laminator Technician

Nature of Duties/Responsibilities

- Layup cover lay
- Layup rigid flex
- Layup multilayer/CU core boards
- Oxide treat/cobra treatment of all layers/CU cores
- Shear flex layer edges
- Rout of machine panel edges and buff
- Remove oxide/cobra treatment (strip panels)
- Serialize panels
- Pre-tac Kapton windows on flex layers (bikini process)
- Layup Kapton bonds
- Prep materials: B-stage, Kapton, release sheet
- Breakdown: flex layers, and caps
- Power scrub: boards, layers, and caps
- Laminate insulators, stiffeners, and heatsinks
- Plasma cleans and dry flex layers B-stage (Dry)
- Booking layers and materials, ready for lamination process
- Other duties as deemed necessary by supervisor

Education/Experience

- High school diploma or GED
- Must be a team player
- Must demonstrate the ability to read and write English and complete simple mathematical equations
- Must be able to follow strict policy and OSHA guidelines
- Must be able to lift 50 lbs
- Must have attention to detail

Wet Process/Plating Technician

Position is 3rd shift (11:00PM to 7:30AM, Sunday through Friday)

Purpose

To carry out departmental activities which result in producing quality product that conforms to customer requirements. To operate and maintain a safe working environment.

Nature of Duties/Responsibilities

- Load and unload electroplating equipment
- Fasten circuit boards to racks and cathode bars
- Immerse work pieces in series of cleaning, plating and rinsing tanks, following timed cycles manually or using hoists
- Carry work pieces between departments through electroplating processes
- Set temperature and maintains proper liquid levels in the plating tanks
- Remove work pieces from racks, and examine work pieces for plating defects, such as nodules, thin plating or burned plating
- Place work pieces on racks to be moved to next operation
- Check completed boards
- Drain solutions from and clean and refill tanks; fill anode baskets as needed
- Remove buildup of plating metal from racks using chemical bath

Education and Experience

- High school diploma or GED required
- Good organizational skills and the ability to follow instructions
- Ability to maintain a regular and reliable attendance record
- Must be able to work independently and learn quickly
- Organized, self-motivated, and action-oriented, with the ability to adapt quickly to new challenges/opportunities
- Prior plating experience a plus

Production Scheduler

Main Responsibilities

- Development and deployment of a level-loaded production plan
- Establish manufacturing plan which results in "best possible" use of resources to maximize asset utilization
- Analyze production capacity of manufacturing processes, equipment and human resource requirements needed to produce required products
- Plan operation manufacturing sequences in weekly time segments utilizing production labor standards
- Maintain, align, and communicate regularly with internal suppliers/customers and customer service on key order metrics as per their requirements
- Frequently compare current and anticipated orders with available inventory and creates replenishment plan
- Maintain master distribution schedule for the assigned facility, revise as needed and alert appropriate staff of schedule changes or delays
- Participate in periodic forecasting meetings
- Lead or participate in planning and status meetings with production, shipping, purchasing, customer service and/or other related departments
- Follow all good manufacturing practices (GMPs)
- Answer company communications, fax, copy and file paperwork

Education and Experience

- High school diploma or GED
- Experience in manufacturing preferred/3 years in scheduling
- Resourceful and good problem-solving skills
- Ability to make high pressure decisions
- Excellent written and verbal communication skills
- Strong computer skills including ERP, Excel, Word, MS Office
- Detailed and meticulous with good organizational skills
- Must be articulate, tactful and professional at all times
- Self-motivated

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Career Opportunities

Fuji America Corporation is a rapidly growing electronics assembly equipment distributor. We support the factories of the future and smart factories globally. We offer an exciting and challenging career for a software support engineer and an applications engineer who want to join our growing company.

Software Support Engineer

As a software support engineer for Fuji America Corporation, you will be a customer-facing technical advisor with the opportunity to solve technically complex problems for our proprietary software. As a trusted advisor to our customers, you will have influence over a broad range of solutions that create business value. As a valued member on our team, the software support engineer will use advanced troubleshooting methods and tools to solve technically complex problems. These highly complex, escalated problems require broad and in-depth product knowledge, as well as exceptional troubleshooting skills.

- Field installation of proprietary software/ automation equipment throughout North America
- Field troubleshoot, repair, training, and process support of proprietary software
- Provide remote and on-site technical support
- Troubleshoot Windows 10/Windows server installing, configuration, and support
- Networking experience—setting up and supporting networks.
- Exposure and/or experience with Oracle or Microsoft SQL server databases
- Strong verbal communication skills with both customer and other technical depts.
- Flexibility to travel and perform job assignments on short notice
- Strong aptitude with current computing applications and networking processes

Experience

- Bachelor of Science in computer science or related field preferred

Applications Engineer

As an applications engineer, you will be responsible for doing cycle time and studies in preparation to make recommendations of Fuji products for customers' applications. Support implementation of activities within the technical center such as customer visits, demonstrations, evaluations, testing, inspection of Fuji products, including peripheral equipment from other vendors.

- Assist sales representatives in technical aspects relating to machine and software functions and utilization.
- Assist sales representatives and customers with providing CTA (Cycle Time Analysis) to them for recommending Fuji products to customers' specific applications. This includes the sFAB machine as well as all other SMT machines.
- Schedule and perform product demonstrations on all available types of equipment and software to potential and existing customers.
- Test and evaluate existing as well as new technologies on equipment and software performance and reliability.
- Assist in the coordination of any new FAC projects by utilizing your full potential.
- Responsible for the setup of the equipment and its demonstration for various trade shows.
- Assist FAC staff in any technical issues which may require attention.
- Assist in the coordination of design and manufacture of customs tooling for placement equipment.
- Perform inventory checks every six months according to the schedule and manner regulated by the company, if applicable.

Experience

- Minimum five years programming/computer experience
- Bachelor's degree preferred

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Career Opportunities

PCB Field Engineer–North America Operations

ICAPE Group is a European leader for printed circuits boards and custom-made electro-mechanical parts. Headquartered in Paris, France, we have over 500 employees located in more than 70 countries serving our +2500 customers.

To support our growth in the American market, we are looking for a PCB Field Engineer.

You will work in our North America technical center, including our U.S. technical laboratory, and will be responsible for providing technical and quality support to our American sales team.

You will have direct customer contact during all phases of the sales process and provide follow-on support as required.

RESPONSIBILITIES INCLUDE

- Feasibility recommendations
- Fabricator questions and liaison
- Quality resolutions
- Technical explanation (for the customer) of proposals, laboratory analysis or technology challenges

REQUIREMENTS

- Engineering degree or equivalent industry experience
- 5 years' experience with PCB manufacturing (including CAM)
- Excellent technical understanding of PCBs
- Experience with quality tools (FAI, PPAP and 8-D)
- Good communication skills (written and oral)

Communication skills are essential to assist the customer with navigation of the complex process of matching the PCB to the application.

SALARY

Competitive, based on profile and experience. Position is full time in Indianapolis, Ind.

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Prototron Circuits

Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB shop, is looking for sales representatives for all territories.

Reasons you should work with Prototron:

- Serving the PCB industry for over 30 years
- Solid reputation for on-time delivery (99% on-time)
- Excellent quality
- Production quality quick-turn services in as little as 24 hours
- AS9100
- MIL-PRF- 31032
- ITAR
- Global sourcing
- Engineering consultation
- Completely customer focused team

Interested? Let's have a talk.
Call Dan Beaulieu at
207-649-0879
or email to
danbbeaulieu@aol.com

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Career Opportunities

The Test Connection, Inc.

Rewarding Careers

Take advantage of the opportunities we are offering for careers with a growing test engineering firm. We currently have several openings at every stage of our operation.

The Test Connection, Inc. is a test engineering firm. We are family owned and operated with solid growth goals and strategies. We have an established workforce with seasoned professionals who are committed to meeting the demands of high-quality, low-cost and fast delivery.

TTCI is an Equal Opportunity Employer. We offer careers that include skills-based compensation. We are always looking for talented, experienced test engineers, test technicians, quote technicians, electronics interns, and front office staff to further our customer-oriented mission.

Associate Electronics Technician/ Engineer (ATE-MD)

TTCI is adding electronics technician/engineer to our team for production test support.

- Candidates would operate the test systems and inspect circuit card assemblies (CCA) and will work under the direction of engineering staff, following established procedures to accomplish assigned tasks.
- Test, troubleshoot, repair, and modify developmental and production electronics.
- Working knowledge of theories of electronics, electrical circuitry, engineering mathematics, electronic and electrical testing desired.
- Advancement opportunities available.
- Must be a US citizen or resident.

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Test Engineer (TE-MD)

In this role, you will specialize in the development of in-circuit test (ICT) sets for Keysight 3070 (formerly HP) and/or Teradyne (formerly GenRad) TestStation/228X test systems.

- Candidates must have at least three years of experience with in-circuit test equipment. A candidate would develop and debug our test systems and install in-circuit test sets remotely online or at customer's manufacturing locations nationwide.
- Candidates would also help support production testing and implement Engineering Change Orders and program enhancements, library model generation, perform testing and failure analysis of assembled boards, and other related tasks.
- Some travel required and these positions are available in the Hunt Valley, Md., office.

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Sr. Test Engineer (STE-MD)

- Candidate would specialize in the development of in-circuit test (ICT) sets for Keysight 3070 (formerly Agilent & HP), Teradyne/ GenRad, and Flying Probe test systems.
- Strong candidates will have more than five years of experience with in-circuit test equipment. Some experience with flying probe test equipment is preferred. A candidate would develop, and debug on our test systems and install in-circuit test sets remotely online or at customer's manufacturing locations nationwide.
- Proficient working knowledge of Flash/ISP programming, MAC Address and Boundary Scan required. The candidate would also help support production testing implementing Engineering Change Orders and program enhancements, library model generation, perform testing and failure analysis of assembled boards, and other related tasks. An understanding of stand-alone boundary scan and flying probe desired.
- Some travel required. Positions are available in the Hunt Valley, Md., office.

Contact us today to learn about the rewarding careers we are offering. Please email resumes with a short message describing your relevant experience and any questions to careers@ttci.com. Please, no phone calls.

We proudly serve customers nationwide and around the world.

TTCI is an ITAR registered and JCP DD2345 certified company that is NIST 800-171 compliant.

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Career Opportunities

EAGLE electronics Inc.

MANUFACTURERS OF QUALITY PRINTED CIRCUIT BOARDS

Maintenance Technician

Inspects work-related conditions to determine compliance with prescribed operating and safety standards. Operates power-driven machinery and uses equipment and tools commonly used to maintain facilities and equipment. Replace filters, belts, and additional parts for repairs and preventive maintenance. Moves objects weighing up to 150 lbs. using a hand truck or pulley. Cleans work area and equipment. Works with cleaning fluids, agents, chemicals, and paints using protective gear. Works at elevations greater than ten feet, climbing ladders, while repairing or maintaining building structures and equipment. Assists skilled maintenance technicians/workers in more complex tasks and possible after-hours emergency repairs. Must meet scheduling and attendance requirements.

apply now

Plating Operator

Plating operator for printed circuit boards. No experience necessary, will train. Must be able to work with chemicals, lift up to 50 pounds, and have good math skills. Minimum high school/GED or equivalent. All shifts (1st, 2nd, 3rd), 8 hours per day minimum, Monday thru Friday. Saturday and Sunday work is common allowing for steady overtime pay.

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EAGLE electronics Inc.

MANUFACTURERS OF QUALITY PRINTED CIRCUIT BOARDS

Water Treatment Operator

Responsible for operating waste treatment plant, our operation that converts wastewater in drains and sewers into a form that's metal free to release into the environment.

Control equipment and monitor processes that remove metals from wastewater. Run tests to make sure that the processes are working correctly. Keep records of water quality and pH. Operate and maintain the pumps and motors that move water and wastewater through filtration systems. Read meters and gauges to make sure plant equipment is working properly. Take samples and run tests to determine the quality of the water being produced. Adjust the amount of chemicals being added to the water and keep records that document compliance.

apply now

Drilling Operator

Drilling operator for printed circuit boards. Minimum 2 years of experience. Minimum high school/GED or equivalent.

All Shifts (1st, 2nd, 3rd), 8 hours per day minimum, Monday thru Friday. Saturday and Sunday work is common allowing for overtime pay.

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Career Opportunities

MivaTek Global

Product Manager

MivaTek Global is preparing for a major market and product offering expansion. Miva's new NG3 and DART technologies have been released to expand the capabilities of Miva's industry-leading LED DMD direct write systems in PCB and Microelectronics. MivaTek Global is looking for a technology leader that can be involved guiding this major development.

The product manager role will serve as liaison between the external market and the internal design team. Leadership level involvement in the direction of new and existing products will require a diverse skill set. Key role functions include:

- **Sales Support:** Recommend customer solutions through adaptions to Miva products
- **Design:** Be the voice of the customer for new product development
- **Quality:** Verify and standardize product performance testing and implementation
- **Training:** Conduct virtual and on-site training
- **Travel:** Product testing at customer and factory locations

Use your 8 plus years of experience in either the PCB or Microelectronic industry to make a difference with the leader in LED DMD direct imaging technology. Direct imaging, CAM, AOI, or drilling experience is a plus but not required.

For consideration, send your resume to N.Hogan@MivaTek.Global. For more information on the company see www.MivaTek.Global or www.Mivatec.com.

apply now

MivaTek Global

Field Service Technician

MivaTek Global is focused on providing a quality customer service experience to our current and future customers in the printed circuit board and microelectronic industries. We are looking for bright and talented people who share that mindset and are energized by hard work who are looking to be part of our continued growth.

Do you enjoy diagnosing machines and processes to determine how to solve our customers' challenges? Your 5 years working with direct imaging machinery, capital equipment, or PCBs will be leveraged as you support our customers in the field and from your home office. Each day is different, you may be:

- Installing a direct imaging machine
- Diagnosing customer issues from both your home office and customer site
- Upgrading a used machine
- Performing preventive maintenance
- Providing virtual and on-site training
- Updating documentation

Do you have 3 years' experience working with direct imaging or capital equipment? Enjoy travel? Want to make a difference to our customers? Send your resume to N.Hogan@MivaTek.Global for consideration.

More About Us

MivaTek Global is a distributor of Miva Technologies' imaging systems. We currently have 55 installations in the Americas and have machine installations in China, Singapore, Korea, and India.

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Career Opportunities

ARLON ELECTRONIC MATERIALS

Arlon EMD, located in Rancho Cucamonga, California, is currently interviewing candidates for open positions in:

- **Engineering**
- **Quality**
- **Various Manufacturing**

All interested candidates should contact Arlon's HR department at 909-987-9533 or email resumes to careers.ranch@arlonemd.com.

Arlon is a major manufacturer of specialty high-performance laminate and prepreg materials for use in a wide variety of printed circuit board applications. Arlon specializes in thermoset resin technology, including polyimide, high Tg multifunctional epoxy, and low loss thermoset laminate and prepreg systems. These resin systems are available on a variety of substrates, including woven glass and non-woven aramid. Typical applications for these materials include advanced commercial and military electronics such as avionics, semiconductor testing, heat sink bonding, High Density Interconnect (HDI) and microvia PCBs (i.e. in mobile communication products).

Our facility employs state of the art production equipment engineered to provide cost-effective and flexible manufacturing capacity allowing us to respond quickly to customer requirements while meeting the most stringent quality and tolerance demands. Our manufacturing site is ISO 9001: 2015 registered, and through rigorous quality control practices and commitment to continual improvement, we are dedicated to meeting and exceeding our customers' requirements.

For additional information please visit our website at www.arlonemd.com

apply now

KOH YOUNG TECHNOLOGY

Logistics Assistant

Koh Young America is looking for a Logistics Assistant to assist and oversee our supply chain operations. Working alongside a Logistics Specialist, you will coordinate processes to ensure smooth operations using a variety of channels to maximize efficiency. You must be an excellent communicator and negotiator well-versed in supply chain management principles and practices. Also, you should be meticulous with a focus on customer satisfaction. These attributes are ideally complemented by a Bachelor's in Supply Chain Management or equivalent professional experience in the manufacturing industry.

This position is in our Duluth, Georgia, headquarters, where we serve our customers within North and South America. We offer health, dental, vision, and life Insurance with no employee premiums, including dependent coverage. Additionally, we provide a 401K retirement plan with company matching, plus a generous PTO policy with paid holidays.

Koh Young Technology, founded in 2002 in Seoul, South Korea, is the world leader in 3D measurement and inspection technology used in the production of microelectronics assemblies. Using patented 3D technology, Koh Young provides best-in-class products in Solder Paste Inspection (SPI) and Automated Optical Inspection (AOI) for electronics manufacturers worldwide.

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Career Opportunities

Manncorp™

SMT Operator
Hatboro, PA

Manncorp, a leader in the electronics assembly industry, is looking for a **surface-mount technology (SMT) operator** to join their growing team in Hatboro, PA!

The **SMT operator** will be part of a collaborative team and operate the latest Manncorp equipment in our brand-new demonstration center.

Duties and Responsibilities:

- Set up and operate automated SMT assembly equipment
- Prepare component kits for manufacturing
- Perform visual inspection of SMT assembly
- Participate in directing the expansion and further development of our SMT capabilities
- Some mechanical assembly of lighting fixtures
- Assist Manncorp sales with customer demos

Requirements and Qualifications:

- Prior experience with SMT equipment or equivalent technical degree preferred; will consider recent graduates or those new to the industry
- Windows computer knowledge required
- Strong mechanical and electrical troubleshooting skills
- Experience programming machinery or demonstrated willingness to learn
- Positive self-starter attitude with a good work ethic
- Ability to work with minimal supervision
- Ability to lift up to 50 lbs. repetitively

We Offer:

- Competitive pay
- Medical and dental insurance
- Retirement fund matching
- Continued training as the industry develops

apply now

Manncorp™

SMT Field Technician
Hatboro, PA

Manncorp, a leader in the electronics assembly industry, is looking for an additional SMT Field Technician to join our existing East Coast team and install and support our wide array of SMT equipment.

Duties and Responsibilities:

- Manage on-site equipment installation and customer training
- Provide post-installation service and support, including troubleshooting and diagnosing technical problems by phone, email, or on-site visit
- Assist with demonstrations of equipment to potential customers
- Build and maintain positive relationships with customers
- Participate in the ongoing development and improvement of both our machines and the customer experience we offer

Requirements and Qualifications:

- Prior experience with SMT equipment, or equivalent technical degree
- Proven strong mechanical and electrical troubleshooting skills
- Proficiency in reading and verifying electrical, pneumatic, and mechanical schematics/drawings
- Travel and overnight stays
- Ability to arrange and schedule service trips

We Offer:

- Health and dental insurance
- Retirement fund matching
- Continuing training as the industry develops

apply now

Career Opportunities

SIEMENS

Siemens EDA
Sr. Applications Engineer

Support consultative sales efforts at world's leading semiconductor and electronic equipment manufacturers. You will be responsible for securing EM Analysis & Simulation technical wins with the industry-leading HyperLynx Analysis product family as part of the Xpedition Enterprise design flow.

Will deliver technical presentations, conduct product demonstrations and benchmarks, and participate in the development of account sales strategies leading to market share gains.

- PCB design competency required
- BEE, MSEE preferred
- Prior experience with Signal Integrity, Power Integrity, EM & SPICE circuit analysis tools
- Experience with HyperLynx, Ansys, Keysight and/or Sigrity
- A minimum of 5 years' hands-on experience with EM Analysis & Simulation, printed circuit board design, engineering technology or similar field
- Moderate domestic travel required
- Possess passion to learn and perform at the cutting edge of technology
- Desire to broaden exposure to the business aspects of the technical design world
- Possess a demonstrated ability to build strong rapport and credibility with customer organizations while maintaining an internal network of contacts
- Enjoy contributing to the success of a phenomenal team

***Qualified applicants will not require employer-sponsored work authorization now or in the future for employment in the United States. Qualified Applicants must be legally authorized for employment in the United States.*

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U.S. CIRCUIT

Plating Supervisor

Escondido, California-based PCB fabricator U.S. Circuit is now hiring for the position of plating supervisor. Candidate must have a minimum of five years' experience working in a wet process environment. Must have good communication skills, bilingual is a plus. Must have working knowledge of a plating lab and hands-on experience running an electrolytic plating line. Responsibilities include, but are not limited to, scheduling work, enforcing safety rules, scheduling/maintaining equipment and maintenance of records.

Competitive benefits package. Pay will be commensurate with experience.

Mail to:
mfariba@uscircuit.com

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Career Opportunities

BLACKFOX
Premier Training & Certification

IPC Instructor

Longmont, CO; Phoenix, AZ; U.S.-based remote

Independent contractor, possible full-time employment

Job Description

This position is responsible for delivering effective electronics manufacturing training, including IPC Certification, to students from the electronics manufacturing industry. IPC instructors primarily train and certify operators, inspectors, engineers, and other trainers to one of six IPC Certification Programs: IPC-A-600, IPC-A-610, IPC/WHMA-A-620, IPC J-STD-001, IPC 7711/7721, and IPC-6012.

IPC instructors will conduct training at one of our public training centers or will travel directly to the customer's facility. A candidate's close proximity to Longmont, CO, or Phoenix, AZ, is a plus. Several IPC Certification Courses can be taught remotely and require no travel.

Qualifications

Candidates must have a minimum of five years of electronics manufacturing experience. This experience can include printed circuit board fabrication, circuit board assembly, and/or wire and cable harness assembly. Soldering experience of through-hole and/or surface-mount components is highly preferred.

Candidate must have IPC training experience, either currently or in the past. A current and valid certified IPC trainer certificate holder is highly preferred.

Applicants must have the ability to work with little to no supervision and make appropriate and professional decisions.

Send resumes to Sharon Montana-Beard at sharonm@blackfox.com.

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American Standard Circuits
Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

Summary of Functions

The CAD/CAM engineer is responsible for reviewing customer supplied data and drawings, performing design rule checks and creating manufacturing data, programs, and tools required for the manufacture of PCB.

Essential Duties and Responsibilities

- Import customer data into various CAM systems.
- Perform design rule checks and edit data to comply with manufacturing guidelines.
- Create array configurations, route, and test programs, penalization and output data for production use.
- Work with process engineers to evaluate and provide strategy for advanced processing as needed.
- Itemize and correspond to design issues with customers.
- Other duties as assigned.

Organizational Relationship

Reports to the engineering manager. Coordinates activities with all departments, especially manufacturing.

Qualifications

- A college degree or 5 years' experience is required. Good communication skills and the ability to work well with people is essential.
- Printed circuit board manufacturing knowledge.
- Experience using CAM tooling software, Orbotech GenFlex®.

Physical Demands

Ability to communicate verbally with management and coworkers is crucial. Regular use of the telephone and e-mail for communication is essential. Sitting for extended periods is common. Hearing and vision within normal ranges is helpful for normal conversations, to receive ordinary information and to prepare documents.

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Career Opportunities

Now Hiring

Director of Process Engineering

A successful and growing printed circuit board manufacturer in Orange County, CA, has an opening for a director of process engineering.

Job Summary:

The director of process engineering leads all engineering activities to produce quality products and meet cost objectives. Responsible for the overall management, direction, and coordination of the engineering processes within the plant.

Duties and Responsibilities:

- Ensures that process engineering meets the business needs of the company as they relate to capabilities, processes, technologies, and capacity.
- Stays current with related manufacturing trends. Develops and enforces a culture of strong engineering discipline, including robust process definition, testing prior to production implementation, change management processes, clear manufacturing instructions, statistical process monitoring and control, proactive error proofing, etc.
- Provides guidance to process engineers in the development of process control plans and the application of advanced quality tools.
- Ensures metrics are in place to monitor performance against the goals and takes appropriate corrective actions as required. Ensures that structured problem-solving techniques are used and that adequate validation is performed for any issues being address or changes being made. Develops and validates new processes prior to incorporating them into the manufacturing operations.
- Strong communication skills to establish priorities, work schedules, allocate resources, complete required information to customers, support quality system, enforce company policies and procedures, and utilize resources to provide the greatest efficiency to meet production objectives.

Education and Experience:

- Master's degree in chemical engineering or engineering is preferred.
- 10+ years process engineering experience in an electronics manufacturing environment, including 5 years in the PCB or similar manufacturing environment.
- 7+ years of process engineering management experience, including 5 years of experience with direct responsibility for meeting production throughput and quality goals.

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Now Hiring

Process Engineering Manager

A successful and growing printed circuit board manufacturer in Orange County, CA, has an opening for a process engineering manager.

Job Summary:

The process engineering manager coordinates all engineering activities to produce quality products and meet cost objectives. Responsible for the overall management, direction, and coordination of the engineering team and leading this team to meet product requirements in support of the production plan.

Duties and Responsibilities:

- Ensures that process engineering meets the business needs of the company as they relate to capabilities, processes, technologies, and capacity.
- Stays current with related manufacturing trends. Develops and enforces a culture of strong engineering discipline, including robust process definition, testing prior to production implementation, change management processes, clear manufacturing instructions, statistical process monitoring and control, proactive error proofing, etc.
- Ensures metrics are in place to monitor performance against the goals and takes appropriate corrective actions as required. Ensures that structured problem-solving techniques are used and that adequate validation is performed for any issues being address or changes being made. Develops and validates new processes prior to incorporating into the manufacturing operations

Education and Experience:

- Bachelor's degree in chemical engineering or engineering is preferred.
- 7+ years process engineering experience in an electronics manufacturing environment, including 3 years in the PCB or similar manufacturing environment.
- 5+ years of process engineering management experience, including 3 years of experience with direct responsibility for meeting production throughput and quality goals.

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Career Opportunities

INSULECTRO

Are You Our Next Superstar?!

Insulectro, the largest national distributor of printed circuit board materials, is looking to add superstars to our dynamic technical and sales teams. We are always looking for good talent to enhance our service level to our customers and drive our purpose to enable our customers build better boards faster. Our nationwide network provides many opportunities for a rewarding career within our company.

We are looking for talent with solid background in the PCB or PE industry and proven sales experience with a drive and attitude that match our company culture. This is a great opportunity to join an industry leader in the PCB and PE world and work with a terrific team driven to be vital in the design and manufacture of future circuits.

View our opportunities at Insulectro Careers (jobvite.com)

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eptac

TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

Opportunities are available in Canada, New England, California, and Chicago. If you love teaching people, choosing the classes and times you want to work, and basically being your own boss, this may be the career for you. EPTAC Corporation is the leading provider of electronics training and IPC certification and we are looking for instructors that have a passion for working with people to develop their skills and knowledge. If you have a background in electronics manufacturing and enthusiasm for education, drop us a line or send us your resume. We would love to chat with you. Ability to travel required. IPC-7711/7721 or IPC-A-620 CIT certification a big plus.

Qualifications and skills

- A love of teaching and enthusiasm to help others learn
- Background in electronics manufacturing
- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

Benefits

- Ability to operate from home. No required in-office schedule
- Flexible schedule. Control your own schedule
- IRA retirement matching contributions after one year of service
- Training and certifications provided and maintained by EPTAC

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Career Opportunities

APCT, Printed Circuit Board Solutions: Opportunities Await

APCT, a leading manufacturer of printed circuit boards, has experienced rapid growth over the past year and has multiple opportunities for highly skilled individuals looking to join a progressive and growing company. APCT is always eager to speak with professionals who understand the value of hard work, quality craftsmanship, and being part of a culture that not only serves the customer but one another.

APCT currently has opportunities in Santa Clara, CA; Orange County, CA; Anaheim, CA; Wallingford, CT; and Austin, TX. Positions available range from manufacturing to quality control, sales, and finance.

We invite you to read about APCT at APCT.com and encourage you to understand our core values of passion, commitment, and trust. If you can embrace these principles and what they entail, then you may be a great match to join our team! Peruse the opportunities by clicking the link below.

Thank you, and we look forward to hearing from you soon.

apply now

Pre-CAM Engineer

Illinois-based PCB fabricator Eagle Electronics is seeking a pre-CAM engineer specific to the printed circuit board manufacturing industry. The pre-CAM Engineer will facilitate creation of the job shop travelers used in the manufacturing process. Candidate will have a minimum of two years of pre-CAM experience and have a minimum education level of an associate degree. This is a first-shift position at our Schaumburg, Illinois, facility. This is not a remote or offsite position.

If interested, please submit your resume to HR@eagle-elec.com indicating 'Pre-CAM Engineer' in the subject line.

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Process Engineer

We are also seeking a process engineer with experience specific to the printed circuit board manufacturing industry. The process engineer will be assigned to specific processes within the manufacturing plant and be given ownership of those processes. The expectation is to make improvements, track and quantify process data, and add new capabilities where applicable. The right candidate will have a minimum of two years of process engineering experience, and a minimum education of bachelor's degree in an engineering field (chemical engineering preferred but not required). This is a first shift position at our Schaumburg, Illinois, facility. This is not a remote or offsite position.

If interested, please submit your resume to HR@eagle-elec.com indicating 'Process Engineer' in the subject line.

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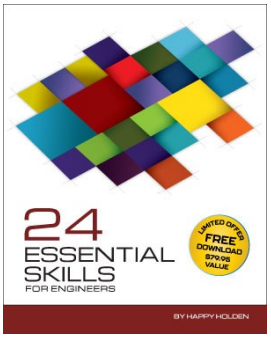
Latest Book from Happy Holden:

24 Essential Skills for Engineers



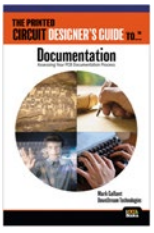
This book is a blueprint of the strategies that Happy has used for decades to overcome engineering challenges. Each chapter is devoted to a skill that engineers do not typically learn in college, such as problem solving, design of experiments, product and process life cycles, Lean manufacturing, and predictive engineering. You won't find all this information in one publication anywhere else. Happy has done all the hard work for you. All you have to do is read this book and take notes. **Get your copy now!**

I-007eBooks The Printed Circuit Designer's Guide to...

Thermal Management: A Fabricator's Perspective

by Anaya Vardya, American Standard Circuits

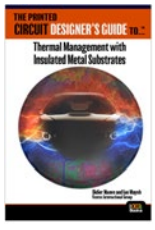
Beat the heat in your designs through thermal management design processes. This book serves as a desk reference on the most current techniques and methods from a PCB fabricator's perspective.



Documentation

by Mark Gallant, Downstream Technologies

When the PCB layout is finished, the designer is still not quite done. The designer's intent must still be communicated to the fabricator through accurate PCB documentation.



Thermal Management with Insulated Metal Substrates

by Didier Mauve and Ian Mayoh, Ventec International Group

Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.

Fundamentals of RF/Microwave PCBs

by John Bushie and Anaya Vardya, American Standard Circuits

Today's designers are challenged more than ever with the task of finding the optimal balance between cost and performance when designing radio frequency/microwave PCBs. This micro eBook provides information needed to understand the unique challenges of RF PCBs.

Flex and Rigid-Flex Fundamentals

by Anaya Vardya and David Lackey, American Standard Circuits

Flexible circuits are rapidly becoming a preferred interconnection technology for electronic products. By their intrinsic nature, FPCBs require a good deal more understanding and planning than their rigid PCB counterparts to be assured of first-pass success.

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