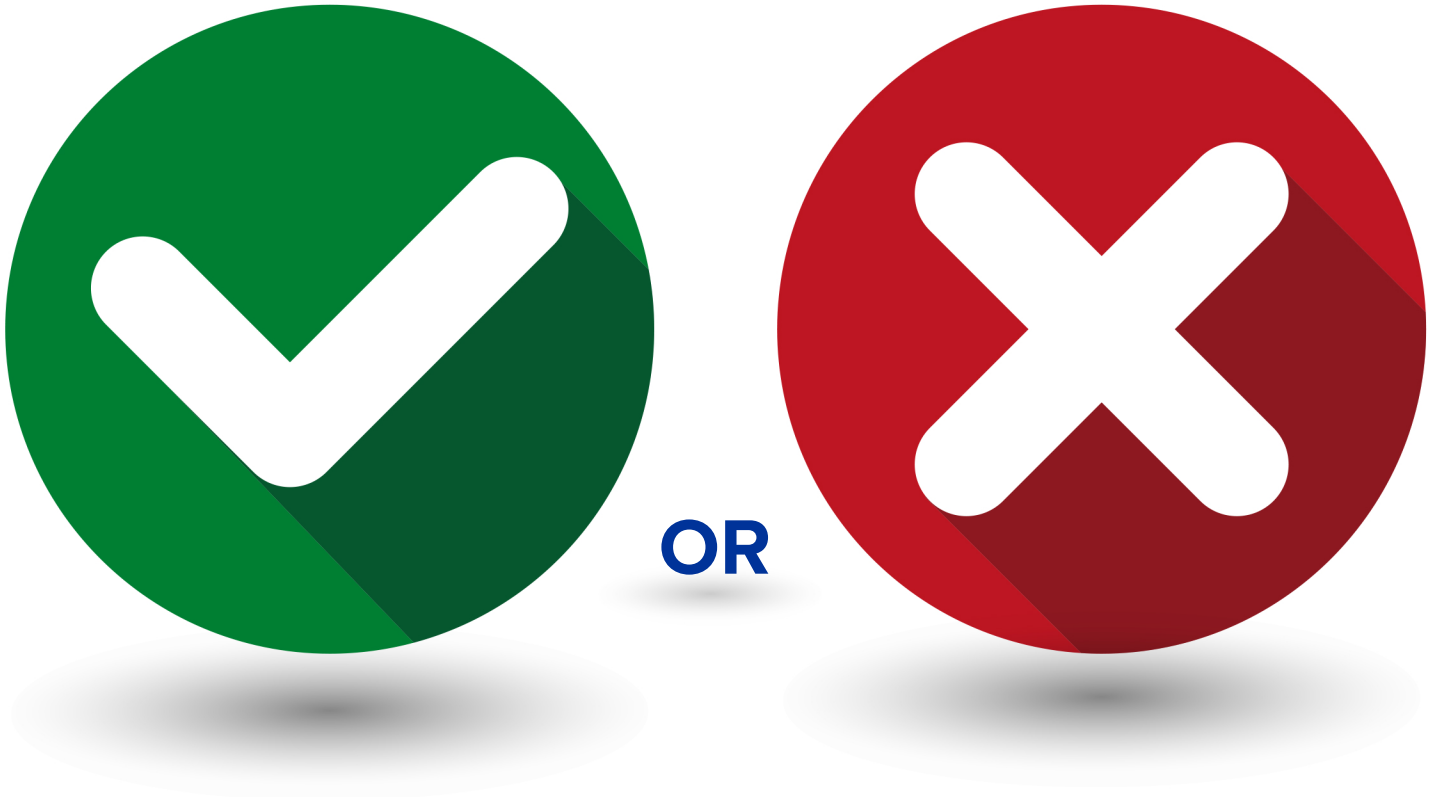
NOVEMBER 2021

I-Connect007 SMT007 MAGAZINE



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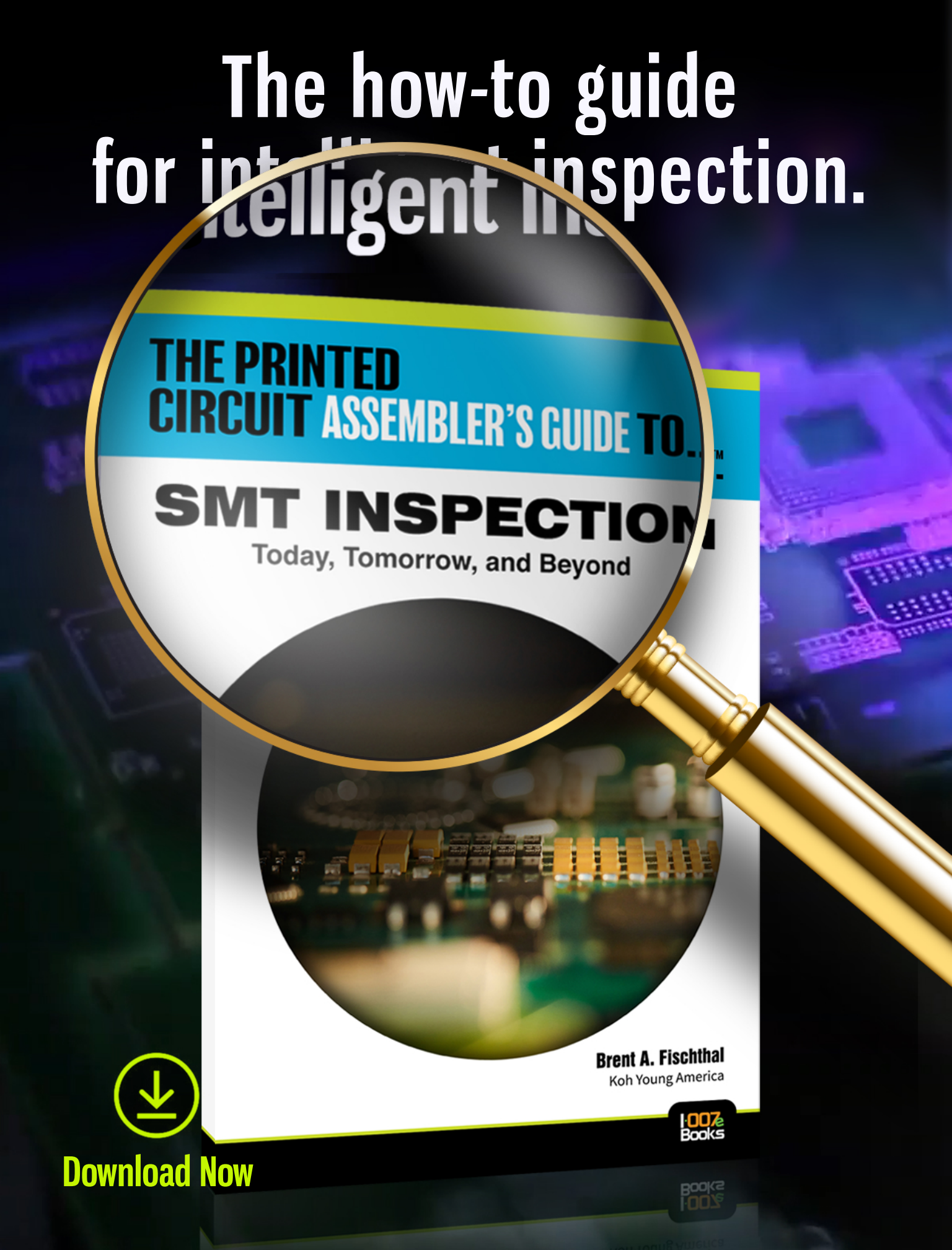

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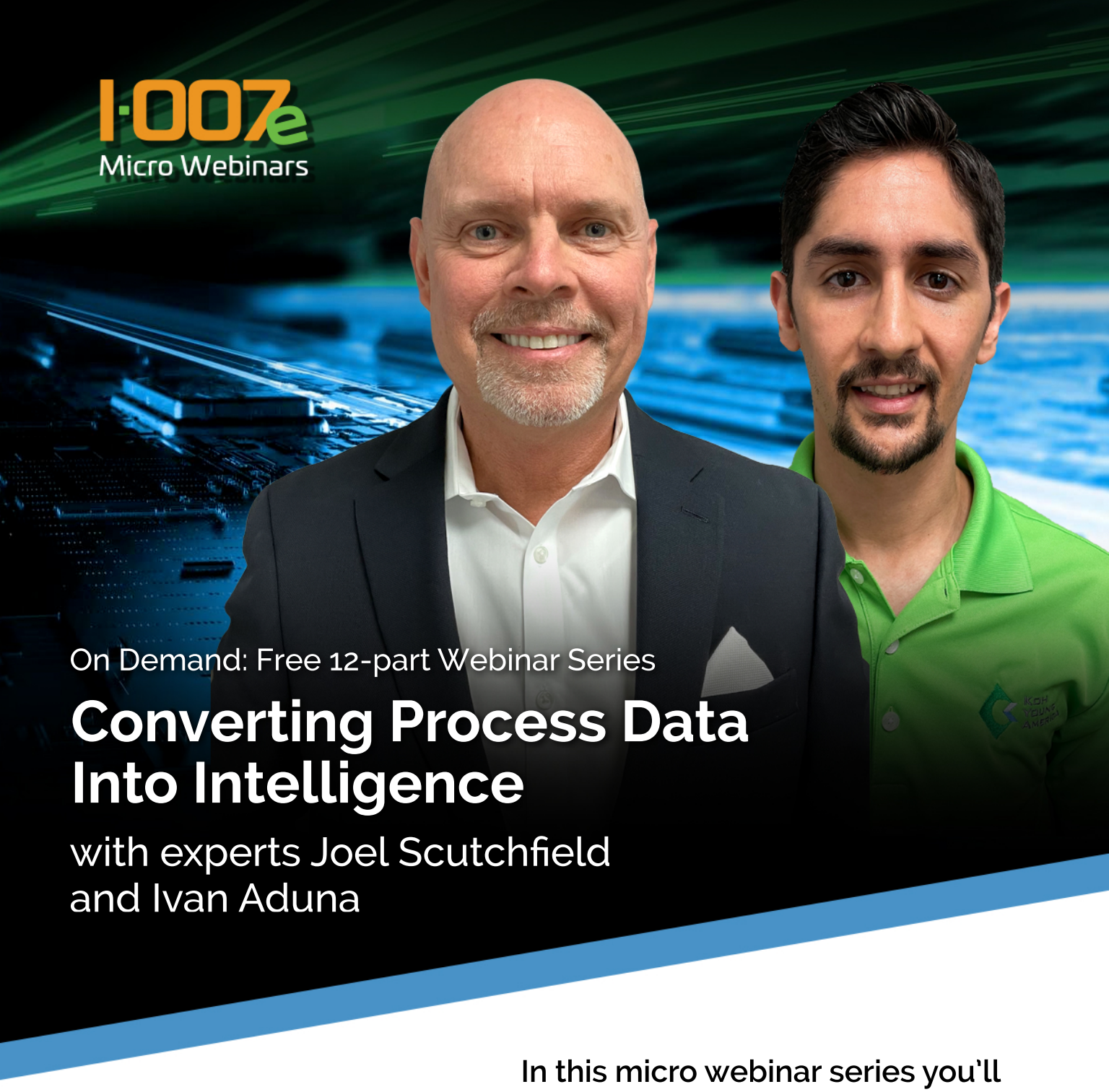

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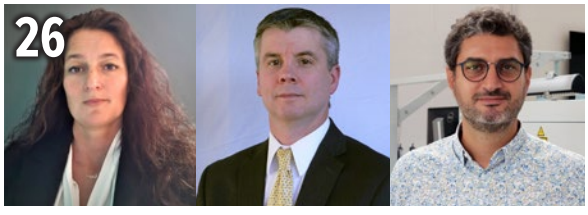
Test and Inspection

With new inspection technologies and methods, along with AI and advancing data collection, EMS companies 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 manufacturing challenges are influencing equipment design.

FEATURES



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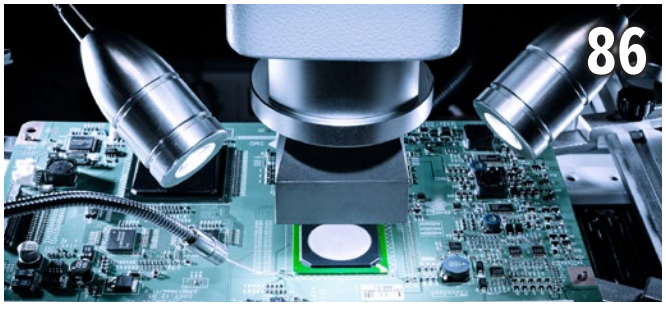

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Test and Inspection: Take a Good Look

Nolan's Notes

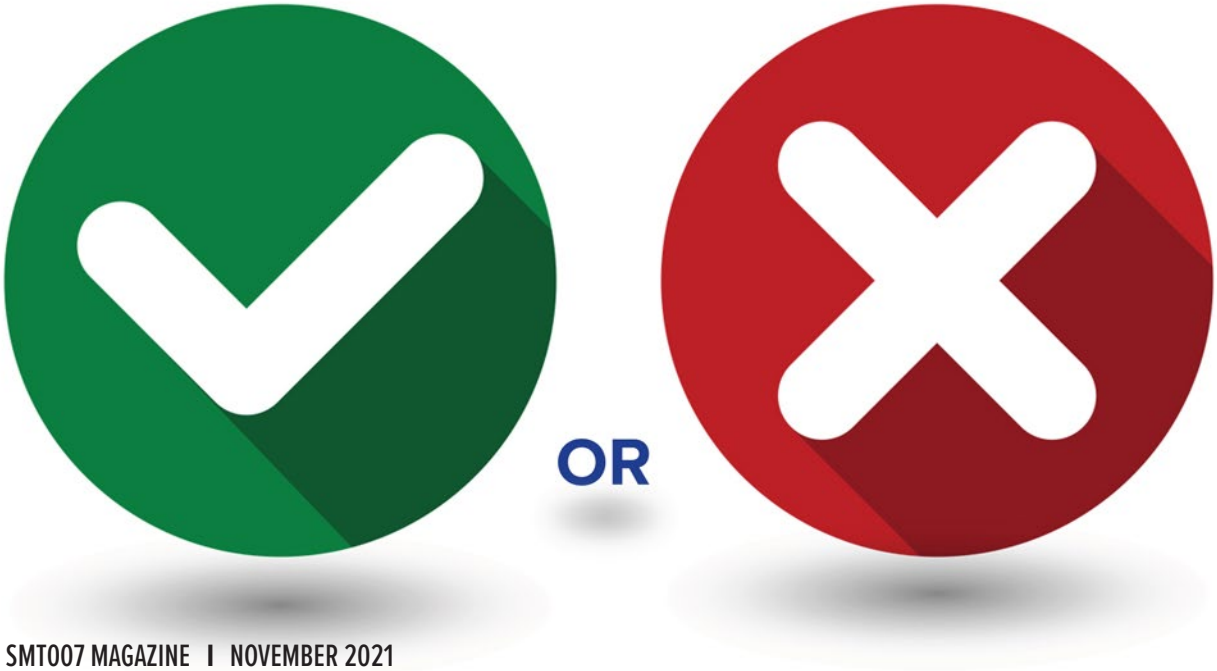
by Nolan Johnson, I-CONNECT007

It's been a confluence of factors over the past three months. First, the gradual reopening (of the whole world, it would seem) made it possible to leave the house and move more freely about.

I live in the Pacific Northwest of the United States, and vaccination programs have been largely effective. The state of Washington is fifth on the list of those with the highest rates of immunization; Oregon, just over the river from me, is #12. The Oregon state officials project that 85% herd immunity will happen within the state sometime in late December. The effect, of course, is that the virus finds fewer susceptible host bodies, thereby slowing its ability to jump from host to host. And the more the spread slows, the more we get back to a regular life. This comes just as the warm, dry weather transitions to wet and dreary.

Earlier this week, in a casual phone conversation, an industry colleague said, "Working in this industry, as we all have, it becomes the norm to be moving at high speed. The slowdown that came from hunkering down was good, but I'm ready to be on the move again." I share that sentiment wholeheartedly.

So much so that I must admit to binging behavior. Over the last eight weeks, I've made road trips on seven weekends. I've been able to reacquaint myself with the sensation of sailing on Puget Sound. I've reintroduced myself to the high desert of central Oregon on horseback. I've run the whitewater outside Bend and floated on the lazy river winding through the city's downtown. And I've been to a handful of live, outdoor music festivals up and down the Interstate-5 corridor. I must say, it's been good to get out.



Like my colleague, returning to the road for work has been a pleasant experience. With two trips under my belt in the last two months, and SMTA International just over the horizon in November, it's good to get conversational again. Turns out I wasn't alone. Trade show and conference attendance may still be down from pre-pandemic numbers, but the people at the events are there with a purpose. It is my impression that the show floor conversations are not idle chit-chat, but discussions with a clear purpose as they share the latest in both customer needs and supplier solutions.

Which brings me to this month's magazine where we are talking about the importance of test and inspection. And what a talk it's been. Interviews are our specialty, and that was wholeheartedly apparent for this issue.

First, we spoke with the experts to see just what's going on currently with test and inspection. Bert Horner and Bob Neves wanted to talk about test strategies. We then got updates about IPC standards work from Jonathon Vermillion and Eric Camden, who shared committee work regarding IPC-J-STD-001 and revisions in the past three years.

To continue the conversation, we interviewed the folks from Koh Young regarding new developments in equipment and features; Keysight's Christopher Cain on artificial intelligence implementation; and Phil Kinner shared news of some new products as well as an update on the MacDermid Alpha/Electrolube merger.

Our ever-faithful columnists keep our magazine pages lively. Just browsing through their topics: Michael Ford writes on the costs of legacy thinking; Emmalee Gagnon looks at new feeder design to eliminate placement errors; Bob Wettermann brings his expertise to bear on rework; and Ron Lasky continues his continuous improvement column with the fictional Maggie Benson.

There are just two months left in 2021, and it's been an interesting year. We've made our focus that of continuous improvement. How did we do? I would love to hear from you. I'm packing my bags and heading out to trade shows, starting with SMTA International in early November. I'll be on the show floor, microphone in hand, and I'm ready to talk... and to listen.

But from my vantage point, I want to create content that generates industry conversation. We also take pride in bringing you the latest information. When you read our magazines, we want you to see yourselves in the pages, in the conversations, and in the future of your business.

I'll see you there. **SMT007**

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 Strategies and Pain Points

Feature Interview by the I-Connect007 Editorial Team

Bert Horner of The Test Connection, Inc., a test engineering service provider, shares his insights on the trends and challenges for test and inspection. He centers his discussion around common challenges in the industry, and the importance of setting up your test and inspection strategy.

Barry Matties: Bert, thanks for joining us today. The Test Connection is a generational business, correct?

Bert Horner: Yes. We celebrate our 41st year this year.

Matties: Congratulations. That's fantastic. Your father started the business?

Horner: Yes, sir. In 1980.

Matties: That's wonderful. From those many years, what trends are you seeing in terms of repeating defects in manufacturing, or what your test data is revealing? What are the common mistakes?

Horner: We've seen the bar chart until we're all sick in the stomach of seeing shorts and opens. Solder splashes are probably the most common. The other issues are orientation and wrong value passives. Then it goes over to the lower levels where they say the device is the wrong one and is not performing up to spec. They're the low opportunities of electrical tests. One thing we see with electrical test—when you get through the AOI and the X-ray, and you're getting into flying probe and in-circuit ICT—is the bed-of-nails ICT. We're encroaching on some functional and design test. That helps justify the cost of a bed-of-nails fixture or a flying probe. More people are incorporating what we call cluster or functional testing at those test solutions.

Matties: What challenges do you see fabricators generally having in test and inspection?

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Horner: We see some challenges with design for test. The biggest challenge is giving access to the key points and understanding a test strategy prior to the assembly being built. We feel there's a lack of communication among design, manufacturing, and test that creates an opportunity for test engineering to put their wishes into the design. There's a disconnect between the internal and external test engineering groups and the design group.

Bert Horner

Matties: Are there differences between test strategies based on the EMS provider that you're using, or is there a standard that designers should be following?

Horner: There's not really a standard to follow other than understanding what your EMS partner must support. What solutions do they have? Do they have an X-ray? Do they have an AOI? Do they have an in-circuit tester? Do they have a flying prober? Understanding what your partner has and what they have available for test and inspection needs to be communicated upstream or the design group needs to specify it: "This is a test strategy based on this AOI, this X-ray, and this electrical test."

Matties: So, not only does the design layout person need to be an SI and stackup expert, now they must be an authority on test strategies as well.

Horner: They must have a good understanding of what they're trying to accomplish. We see a lot of designers working with a project engineer, and sometimes that role falls onto a project engineer or a program manager of a specific project. That understanding needs to be somewhere down the food chain where the design is in a soft stage and they're coming up with a plan.

Matties: Now, going back to those common problems, such as splashing, opens, and shorts, what feedback or data do you provide to the manufacturers that will help them improve their process, or is there such a cycle?

Horner: For our test services, we incorporate a summary where, by serial number, they can see what the common faults are. If they have some quality management system (QMS) at the contract house, they're reading in the data, and they can see trends quickly. But we do a summary when we're testing product under contract test services.

Nolan Johnson: Bert, where does a project manager, project engineer, or designer go to find out? Where are their resources for design for test?

Horner: Most test partners have created their own, and they're all based on a very similar design for tests guidelines, whether it's bed-of-nails, flying probe, or boundary scan. There are some common papers for most partners (we're one of them), and we have a boundary scan, an ICT, and a flying probe guideline for design for tests. There are also products in the market. ASTER Technologies has TestWay. Mentor has Text Expert. These are tools that are encroaching on that schematic level review, where everybody has a solution that looks for access. Whether they use it is a different question, but we are seeing people in the market look at the schematic level design for test: Automated Tool, TestWay, Test Expert. I know we have both products here, and when you're looking at the schematic level, you're seeing where the controllability of a circuit is, where you have access, and you have control of a circuit so you can isolate down on to a net, a pin, and a device.

Johnson: Are these tools a bit like using a DRC checker after the fact?

Horner: No, they're more upfront. While the electrical engineer is laying out a schematic, even before they lay out a board, they can be putting DFT into the card and it's catching it before it goes out to a PCB layout. You can identify key nets and net pins that you must have access to. So, when you have circuitry where you have RF, high-speed digital, or microwave, and you can't put in test points or control circuits, at least on the peripheral circuitry, you can get access. You may have to only do more of a functional test on those high-speed areas that you can't pick up using traditional ICT flying probe and even boundary skin.

Andy Shaughnessy: Bert, what advice would you give designers regarding DFT? There doesn't seem to be a lot of classes on DFT. What would you recommend to designers?

Horner: The simple answer is to get to know your friendly test engineer. They don't bite. But if they can incorporate some basic design for test rules; that's a good start. Normally you find out if you can get 60% to 80% testability put into the card automatically. The other solution, and this is where some of those automated tools become very popular, is to do predictive coverage. If they say, "I'm using AOI to cover this part of the circuitry, I have flying probe covering this part of the circuitry, and I have X-ray covering this part of the circuitry and boundaries scan covering this circuitry," they may find the overall test strategy is 100%.

It's a question of which test solution is going to cover which response. It's got to be where it's going to pick up the responsibility to cov-

er it. Like bypass caps using an AOI solution to pick up that electrical test, we're not going to cover that. Maybe on certain types of BGAs boundary scan, an X-ray may be a solution that you don't have nodal access to because flying probe and AOI may not be able to pick up those coverage or points.

Matties: I heard you were talking about the schematic. So, the earlier you can be involved in the design, the better?

Horner: Right. Again, it's getting the test engineer involved in the design sequence, even if it's just to supply the design-for-test rules to the designer so they can put it into their libraries and their models when they're laying out a board. Some of that stuff can be automatically incorporated. If you can get 60–80% of that done up front, then when the EMS and the test engineers are involved in setting up the test strategy on that particular assembly, it can be set up for success.

Matties: Bert, you provide test services to whoever wants it. Where does outsourcing fit in on test strategies and how does that help an EMS provider?

From an OEM point of view, the design-for-test review up front can help the designer incorporate the testability at the earlier stages.

Horner: From an OEM point of view, the design-for-test review up front can help the designer incorporate the testability at the earlier stages. At the EMS level, the test engineer or the test development service can offer guidance on a test strategy. Most EMS providers are armed with a knowledge base of test engineering, whether they have an in-house guru or they have a fairly competent staff able to do that. But as far as incorporating a third party like ourselves, we get involved in the earliest stages, even at time of quote, where we're spelling out test plans and test strategies. It's not uncommon for us to say, "Hey, give us a preliminary or a predictive test coverage," at the time of quote.

Matties: Are you working with the OEM at that point, or are you working with the designer or EMS company? Where's the first contact made?

Horner: Both at the EMS provider and the OEM. The designer, if they're handing that off and they don't have a particular EMS provider picked, or even if they do have one picked, they will leverage somebody like us and incorporate that test plan at time of review. And at the EMS level, at time of quote, we're also being incorporated in a boundary scan and flying probe, or we do AOI and flying probe, which are predictive coverage. So, we're brought in on both levels.

Matties: And how important is the cost factor and the testing strategy?

Horner: It costs a little bit of money to set up a test strategy, but you save money downstream. So, if you're going to build 100 boards, you may be looking at the test plan and test strategy and the testability review and be a little concerned on the pricing. But when you have a bone pile of half, a third, or even 10% of the boards and there's not a test solution to detect where the fault is, what's that product worth at that level?

Matties: Right. It's a balancing act, for sure.

Horner: Balance is having a budget to say, "Our test plan up front is going to cost us this much

money to build the boards and test them." You should have some percentage of that set aside for setting it up for success. The tools, like ASTER and Mentor, are very powerful if you have the right person using them. That can be priceless to have the right people working that tool, guiding your designers, and putting that into the project management hands to go to EMS provider one, two or three, where you're looking at cost factors. You need that knowledge base. You must couple it with a design for manufacturing. Often, you're seeing concerns on access to a board. That's probably the easiest thing to attack. But understand the controllability and setting up the test strategy on the board at the electrical level, I think, is so much more important than just raw access. We're seeing EMS providers, though, who are not always set up for success by their OEM customers.

And that's putting it nicely. But they're taking the solution of their assemblies and designs that they're getting and they're creating a test strategy around it. Sometimes it works fabulously, and sometimes it falls a little short.

Matties: So, the after the fact test strategies are hit-or-miss?

Horner: Yes. You can see a big swing of the bat and you can either hit a home run or strike out.

Matties: Right. Now, as the boards continue to become smaller and more complex, what impact is that having on test strategies and the equipment that the EMS providers, assemblers, and test services need to have in-house?

Horner: You're seeing a generational gap. Ten years ago, equipment that might have assem-

bled well back then may fall short with the newer technologies, such as the 0201s, the 01005s. The physical size challenge that you have putting the control access onto the board, interconnecting with connectors and stuff like that, is really a testing challenge.

Ten years ago, equipment that might have assembled well back then may fall short with the newer technologies, such as the 0201s, the 01005s.

Johnson: Bert, you're talking about having somebody who is a competent expert at running those test planning tools. It sounds like that's a make-or-break situation for more complex designs. Do you need to have that expertise on your staff or can you hire somebody who is just project-based? That seems like a critical part of the project, and yet maybe not a lot of people are doing it.

Horner: The simple answer is you can pick up or outsource. We can do it, and some of my industry competitors offer that as a solution. Back in the '80s and '90s, most companies had an in-house test engineer doing electrical reviews manually. They were looking over schematics, putting in their red pencils, and putting in what they thought were needed. As designs are changing more quickly, access is eroding; there's that challenge of one person handling maybe a whole corporation of product. So, the bandwidth is narrowing with that in-house.

There's a challenge with keeping it all in-house. That's why, if you have maybe not the highest-level test engineer, but somebody who understands the philosophy of tests and some of the inspection limitations that the contract manufacturer has that you're partnering with, they can be very successful using these automated tools like ASTER or Mentor. There are automated tools that can fill the gap and process things a lot faster with nice reporting capabilities that you can share with the design team, whether it's the electrical engineer or the PCB layout.

Matties: Well, it's not going to get any easier, is it?

Horner: No, it's not. As we're moving more onto complex chips, placing of those devices is going to be more critical because now it's incorporating more of the functionality of the assembly at one device or a couple of devices. So, placing those devices on a smaller PCB is going to drive cost and drive defects onto a card.

Johnson: Components are getting smaller, traces and features on the boards are getting smaller, but are test points getting smaller?

Horner: Yes, they are. When I first started, I used to get growls and frowns when we asked for ICT 30- or 35-mil test targets. Now we're down to 20-mil test targets for ICT bed-of-nails, and that's where you're getting the growls. On the flying probe, anywhere from 12- to 3-mil test targets are becoming popular. That's why the technology gap between systems that are 10 years old and newer systems are really starting to age in the technology that's out there. So, not to say that an older flying probe can't test product, it's just that if you're building more complex, smaller devices, you could be running into a technology challenge.

Matties: Who ultimately owns the test strategy?

Horner: If I'm putting my name on a product, I think the OEM would have to own it. But if you're talking about a manufacturing process

test, one can make a good argument that the EMS provider would have to own that part of it, because it is a process.

Matties: Well, my thought and inclination it's the OEM because they're the ones who have to approve the expense around it.

Horner: Yes, but it's also their name being put on the product. When you buy your watch or your laptop from vendor A, you're either going to say, "This is a great laptop I bought," or, "This is a great car I'm driving because it was built correctly, or this function works." So, if you're having brand recognition and having the last say, "Brand X is..." or "Brand A is not good," that's where I think one should look. The cost is a huge factor in that, and the last thing you want to do is over-test something. That runs up the cost.

Matties: When you start talking about brand, it's also the manufacturer's reputation that's at risk to their OEM customer because they must build and provide a product that is going to meet specification. While you talked about opens and shorts, that's maybe a different testing, like solder paste inspection or in-process testing.

Horner: I was picking on AOI, but yes. Understanding where SPI and AOI and these inspection mechanisms in place can help prevent faults downstream is key.

Matties: How does your organization fit into that type of testing and inspection strategy?

Horner: The Test Connection has been more of an electrical test solution. In the last three to five years, we have become involved in in-

spection. We have partnerships with some of the larger AOI companies, SPI companies like Mirtec. We also have some X-ray partnerships with Creative Electron and Dage, which allows us to offer solutions in that spectrum of tests and inspection. We see many EMS providers, though, having more of a role in that level of inspection rather than outsourcing partnerships. Let's face it, it is a more intimate part of your manufacturing process where you're looking at solder paste and the component placement on the board before you get into the electrical test and even functional test.

Matties: Exactly. That's something you're not going to outsource because it's happening in real time.

Horner: Yes. That's a big piece of setting up your test and inspection strategy. If you don't have the right tools or people in place, you're going to be paying for it in post-assembly processes. And whether you're electrically or functionally testing it, that can be quite expensive.

Matties: If they don't have those in the process, then your service becomes more of a sorting device, good vs. bad, because at that point, it's just too late to do anything.

Horner: The last thing you want to have is a large bone pile where you run the risk of losing inventory of product because it's behind in revisions, because it sat too long. So, you run the risk of a higher dog bone rate of assemblies.

Matties: Do you see AI becoming a more central role in test and inspection?

Horner: It's coming, but it's not here yet. There are companies putting effort into that predictive and real time feedback, looking for trends at earlier stages with the Industry 4.0 model. With the IPC pushing on that also, it's coming. I think we're seeing it more on the inspection side. Electrical test is coming, but it's not quite here yet.

Matties: How important is simulation in your testing strategy?

Horner: On functional tests, it's probably more important because it's a roadmap. So, with that part of functionality incorporated into the in-circuit tests and some flying probe, you need to know what you're looking for when you test it. The simulation will give you a good roadmap to see what is really expected of that test, especially if you're simulating a board and you're looking at where could it possibly heat up or where certain fallout could happen on the performance of a particular function of a board. That's huge. The inspection not so much, because it's more of an observance, but the electrical, functional, and some of the manufacturing process tests. Some flying probing encroaches on that functional test.

I see it more so in the ICT bed-of-nails; it's ICT plus. Somebody says, "Oh, they're spending money toward a fixture." They say it like it's a bad word. "I'm going to spend $10,000 for this fixture. Can we make these measurements?" Well, now you're starting to encroach on some functionality, which is nice because now you're not putting all your eggs in one basket where you're doing a custom bench top, or a rack, a type of functional test, or a system level tests. You're able to do some of that at the earlier stages of the board assembly process where you're doing it at an ICT, and you're able to have a high level of confidence that as you take it off the ICT, you go over to the next process or next test level; first, you're not testing for the same thing twice; second, it was cheaper to do it at ICT than it was to try to incorporate it into a more expensive rack, a more expensive bench test, or more of a manual test.

If you're building hundreds and thousands of boards, obviously automation comes into that. Your costs could be up front with automation,

so all that relates back to where simulation can drive a test strategy also.

Matties: You're just making a stronger case that more planning up front saves you scrap in the end. What advice would you give to the EMS provider for this test and inspection issue?

Horner: Have confidence in your test and inspection solutions. As technology moves forward, budget for newer and more powerful tools. Unfortunately, that's the nature of the business. It's a very capital-intensive industry we're in.

Matties: If I'm an EMS provider or assembly house and I'm reading this interview, what actions or takeaways should I be concerned with?

Horner: Not only look at it for design for manufacturing but look at it for design for test. Even at the quote stages when we're quoting a project, we don't just look at how big or small the technology that we're going to use to test. We're seeing if it's feasible. There are times when we have to no-bid a job because the solutions that they're requesting are not good solutions. Or we'll make a counter offer. If somebody says, "I want a bed-of-nails electrical test," and you don't have a good access on the assembly, then we'll look at flying probe and say, "You may want to look at this solution," or, "Can we put DFT into the card?"

Matties: Bert, thank you for your sharing your insights, we certainly appreciate your time today.

Horner: Thank you. SMT007

Bert Horner is president and lead of business development at The Test Connection, Inc.

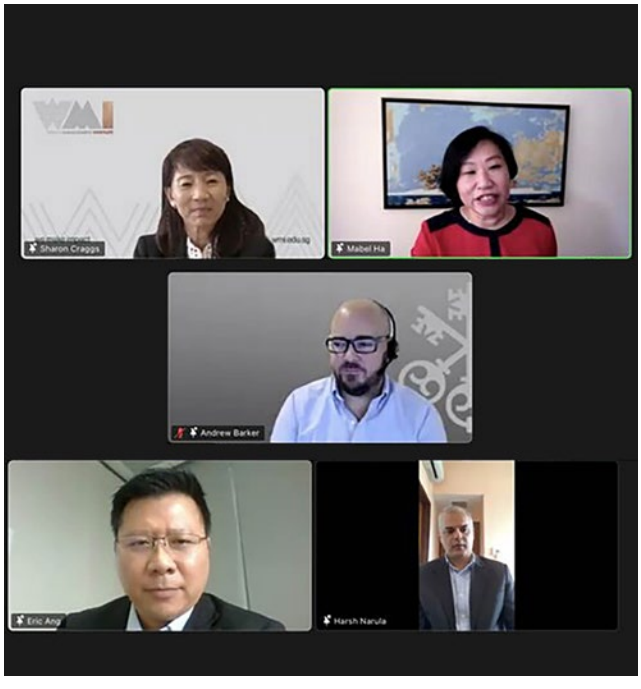
Anti-Money Laundering Prototype Using AI and Machine Learning Launched

The Wealth Management Institute (WMI) in collaboration with Nanyang Technological University Singapore (NTU Singapore), UBS and leading financial institutions in Singapore, embarked on a research project to develop new capabilities utilising artificial intelligence (AI) and machine learning to improve detection of money laundering.

The research focused on the use of artificial intelligence and machine learning to augment the capability of existing systems and human intelligence, ascertain patterns in data and complex transactions to enable financial institutions to better detect unusual money flows and transactions that may be signs of money laundering.

It also showcased the use of secure privacy preserving architecture where underlying data stays with individual banks while data models are extracted, enabling cross-bank AML analytics and intelligence. The deployment of such technologies with powerful data analytics capabilities can help provide financial crime teams across financial institutions the technological tools necessary to widen their surveillance.

(Source: Nanyang Technology)



Three Pages That Changed the World (Kind Of)

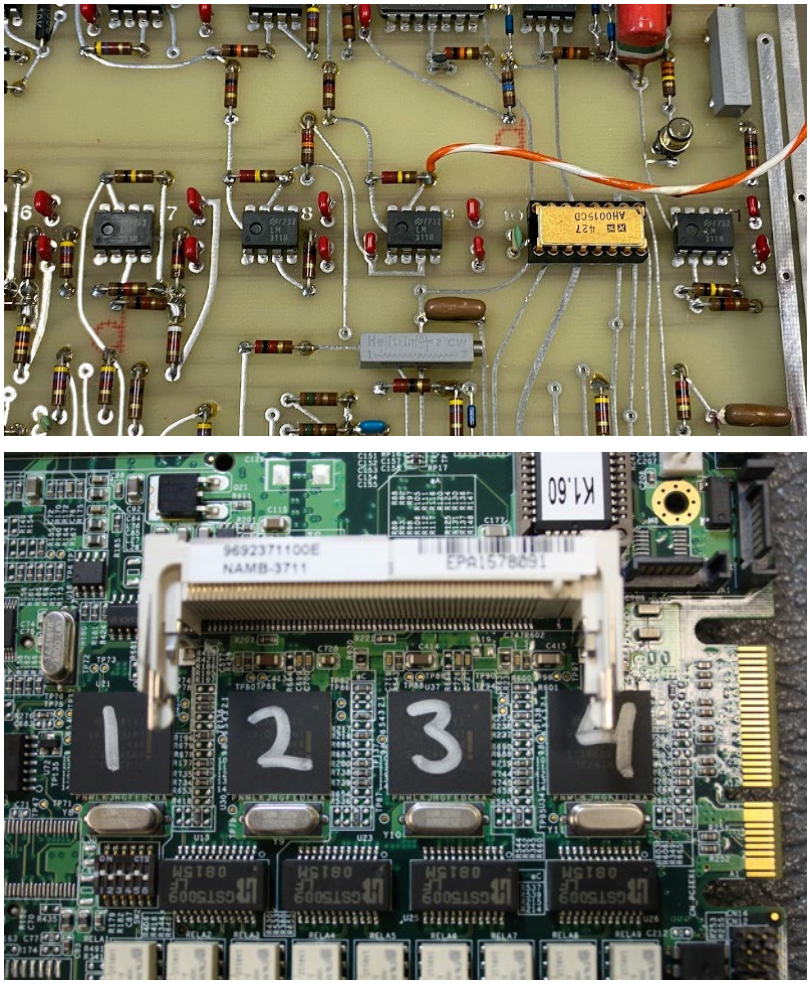
Feature Article by Eric Camden
FORESITE, INC.

If I may begin this article with the tired trope of using a dictionary definition for "objective evidence" from a scientific perspective: "To be termed scientific, a method of inquiry must be based on gathering observable, empirical, and measurable evidence subject to specific principles of reasoning. A scientific method consists of the collection of data through observation and experimentation, and the formulation and testing of hypotheses."[1]

Applying this definition to J-STD-001H, Section 8.0 (the titular three pages) we get an idea of what it takes to meet this new requirement. There has been much gnashing of teeth and furrowing of brows since the historical ROSE testing limits of 1.56 µg/cm^2 of sodium chloride equivalence was removed from the J-STD-001 back in 2020.

This position is quite understandable as that has been the only industry accepted standard for measuring PCBA ionic cleanliness since the 1970s. Let's pause here and think about that last phrase. The criteria was developed in the 1970s when assemblies were built with rosin fluxes containing ~35% solids and were subsequently cleaned with ozone depleting chemicals. This was a time of gas guzzling land yachts and muscle cars, bell bottoms, platform shoes, and porkchop sideburns. We have moved past most of those (sadly for those sweet sideburns), but as other electronic technologies changed, the testing criteria did not. Think about how much has changed since the 1970s in terms of PCBAs, their components, and how they are built.

Figures 1 and 2 give you a rough idea of the astronomical leaps the industry has made in both processing power and miniaturization.



Figures 1 and 2: PCBAs from the 1970s and today[2].

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But in all that time, and with all the changes our industry has gone through, the acceptance criteria had not changed before 2020. Of course, one could argue that, even still, the criteria wasn't so much changed as it was removed completely.

Beyond that, we also need to remember what the most important part of this whole discussion might be: the ROSE test was never intended to be used for determining what a qualified manufacturing process is. The idea was to only use it as a process monitoring tool during production to detect gross changes. It didn't take long for most assembly houses to start using the ROSE test for process qualification because, quite honestly, in most cases it wasn't hard to pass. That passing result gave you a warm fuzzy feeling about your process and it met a published industry standard. Everything was great, right? Well, maybe, maybe not.

That is one of the biggest issues with using the old acceptance criteria on far more technologically advanced assemblies. You passed the test but what did it mean without objective evidence specific to your process and material set? For decades, a lot of manufacturers never thought about that part of the equation. Contract manufacturers just kept building product, and in some cases, they were not clean enough to be used in the intended end use environment. This often manifested in electrical leakage-related failures as shown in Figure 3 of an assembly that passed the ROSE test.

The assembly in Figure 3 used a manual solder operation for the plated through-hole (PTH) connector pins. This was the only part of the process that was leaving high levels of ionics, but when that was averaged out across the full surface area, it was not detected as an issue.

This would be a great time to bring up the topic of full board extractions vs. localized cleanliness analysis in areas of concern or sensitive components—but I digress. The point is if this company had done more testing up front to determine what a golden board ROSE test result should have been, instead of blindly adopting 1.56 µg/cm^2, this might have been detected before it became a much larger issue. To end my soliloquy on the past, I'll just say we can do better and that is where the new J-STD-001H comes in.

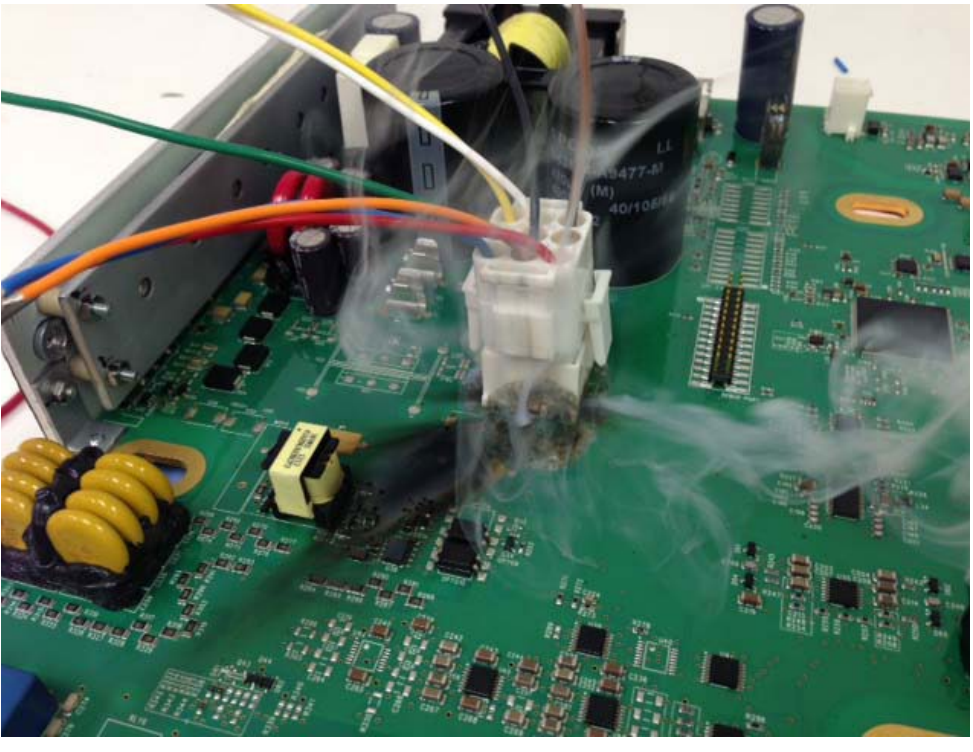

Figure 3: Passed ROSE test.

Creating objective evidence to meet the new standard isn't as difficult to achieve as some seem to think. The underlying data may already exist in some form to satisfy the new requirement. I think this part of the process is being overlooked by many, but it is right there in black and white within the standard. J-STD-001H Section 8.1 lays out three ways to create objective evidence. The second note references historical evidence, looking at returns, warranty service records, failure analysis results, etc., that show the issues for those failures aren't related to cleanliness

and/or ionic residues. This is a way to meet the standard without even doing any new analysis. This falls under the "if it ain't broke, don't fix it" category.

At no time has anyone empirically said that 1.56 µg/cm^2 isn't a valid number for your product and process, it just needs to be proven that it works at weeding out dirty boards. The third note is to perform electrical testing on live product under elevated heat and humidity conditions, using normal operating power. In my opinion this is the most important test when determining the impact of ionic cleanliness on field operation. The first note is what is throwing a lot of assemblers, as it requires surface insulation resistance (SIR) analysis that uses some sort of test board, most often the IPC B-52 CRET board, using the actual product equipment and material set. That includes bare board solder mask, metallization, SMT paste flux, and any fluxes used for PTH soldering. The idea is to mimic the final product as closely as possible and see if the assembly process yields a product that is not adversely impacted when subjected to elevated heat and humidity. This is often coupled with ion chromatography analysis to determine the acceptable amount of residue after assembly. You can also use ROSE in combination with the SIR analysis once you have a proven process. It is very important to use your in-house ROSE tester to determine what your acceptance criteria is if the plan is to use that for process monitoring.

SIR is the requirement for new product acceptance since obviously you won't have historical evidence at that point. There is a fantastic document, IPC WP-019B, that goes into great detail on how we got to this point and even more importantly, how to go forward. Full disclosure, I am referenced as a subject matter expect (SME) in the document but can assure you I had only the smallest input. I'm sure the real contributing SMEs would agree with that as well. Honestly this article could have been one sentence, "Re: Cleanliness, see WP-019B, the end." Not sure why I am just now thinking of that, actually. Could have saved us all some time.

It is very telling that the WP-019B uses 28 pages to explain three pages in the J-STD. Cleanliness is that important. Within the WP-019 documents there are multiple examples of how to create objective evidence, and when you need to requalify your process, based on minor and major changes, with many examples based on the size of the CM. Here in our lab, we have been recommending something like this for many years.

If you plan to use ROSE testing for process monitoring, at a minimum you need to do a rough correlation study. I say rough correlation because there isn't a 1:1 comparison between ROSE and IC testing. ROSE testing measures the amount of material that can become soluble during the test and gives you a resistivity measurement; IC tells you exactly what the ions are and in what amount. What you can do is build a lot of 50 boards (or some statistically relevant number) and then test 25 with IC and the remaining 25 with ROSE and see what the average is. If the ROSE average falls under the 1.56 µg/cm^2 great; if not, also great. If you have historical data that says you don't have issues with contamination and your ROSE tester gives you an average of 20 or 200 µg/cm^2 that

ROSE testing measures the amount of material that can become soluble during the test and gives you a resistivity measurement; IC tells you exactly what the ions are and in what amount.

is the number you need to use for that specific assembly.

That brings up another important point: you need to qualify each product individually due to differences in component architecture/density and thermal mass. Each board has its own unique set of parameters that can and most likely will yield a different result in the ROSE tester. This is similar to why I say you should never profile an empty reflow oven when switching paste types. It's not a bad idea to do that for calibration/verification of an oven, but when you fill that oven with boards the thermal load will have an impact that should be measured on a fully populated assembly at critical locations. Just as the 1.56 µg/cm^2 cleanliness criteria was a bad idea to use on all assemblies, it is an equally bad idea to use a bare board to verify a reflow profile and then apply that recipe to all boards built with that paste. A little off topic, but still important when trying to achieve a qualified manufacturing process.

I fully believe that removing the 1.56 µg/cm^2 criteria will improve overall quality and reliability of electronics as time goes on, as it forces us all to take a much closer look at how residues impact the products being built today. I also believe that it's not as difficult as some may think. I know for sure that the information on how to create the objective evidence is readily available in the J-STD-001H Section 8.0 and WP-019B. As I have said many times, you are responsible for the quality and reliability of your own processes but this revision from the IPC will go a long way in helping you increase both. **SMT007**

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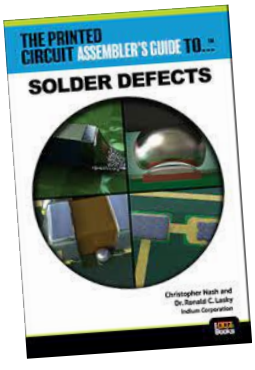
1. Objective Evidence, eduquest.net, February 7, 2000.

2. How CERN Made High Quality Electronics in the 1970s, Hackaday.

Eric Camden is lead investigator at Foresite, Inc.

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.

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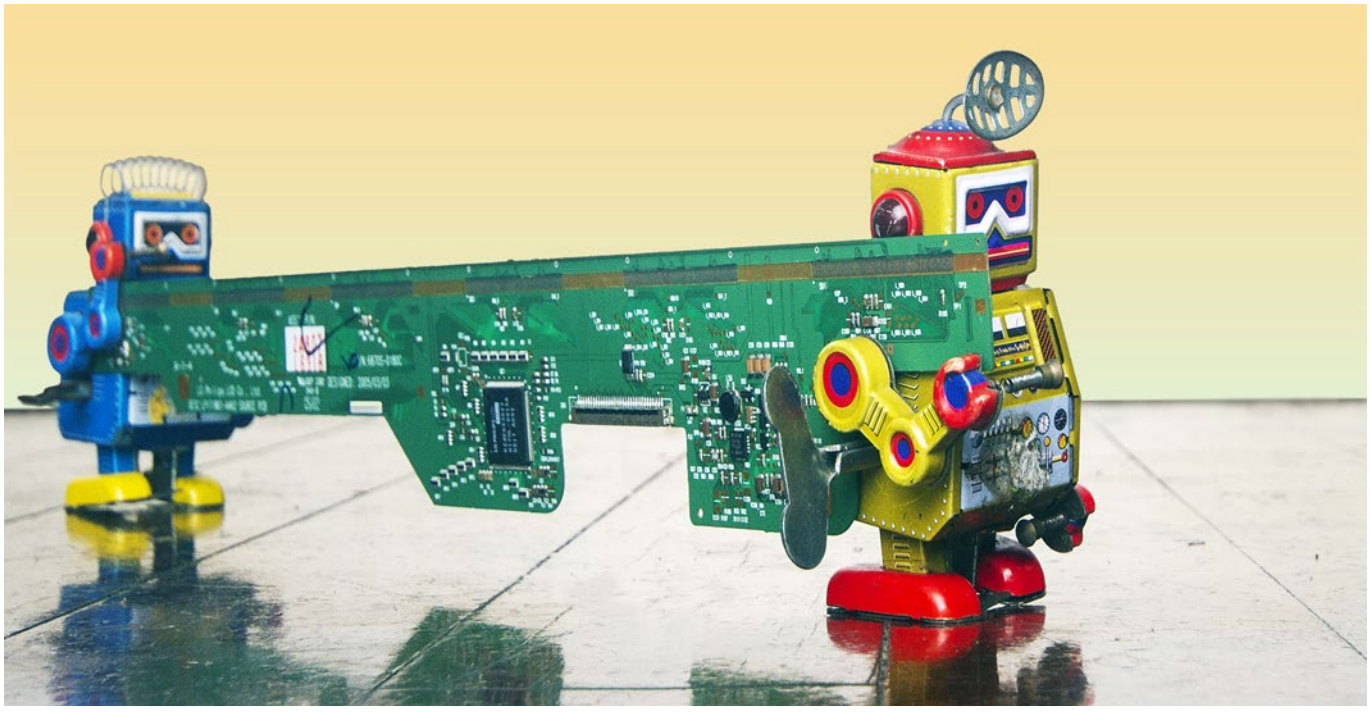

Where AI Meets Test and Inspection

Feature Interview by Nolan Johnson
I-CONNECT007

Nolan Johnson interviews three members of the Mycronic team about test and inspection, data collection, and how the implementation of artificial intelligence continues to evolve. In this conversation, Johnson speaks with Alexia Vey, inspection products product manager; Yan Manissadjian, a member of the marketing department; and Jesse Dowd, vice president of global sales.

Nolan Johnson: Let's talk about test and inspection, especially the implementation of AI in the process. But before we do, would you explore the customer pain points you're working to solve at Mycronic?

Yan Manissadjian: You mentioned AI and that's really a burning issue. Not AI for the sake of AI, but for making our systems, our equipment, and our technology more user-friendly, more automated, faster to be used, and able to be implemented in any kind of production line. Here, AI has all its value, and we are really putting a lot of effort into that. Our SPI has been developed upon machine learning technologies, and we started integrating AI in our AOI software two years ago to simplify programming. Our customers are seeing the value of that daily, with an easier and faster SPI and AOI programming, and this confirms we are making progress in that direction. User friendliness, ease of use, and fast implementation are hot topics for our customers.

Johnson: It sounds like that has been a primary focus of the development work here in the past couple of years. Is that true, Alexia?

Alexia Vey: Exactly. Especially for AOI. SPI, of course, is easier than AOI. We just inspect some little things. We directly introduced a very user-friendly SPI machine seven years ago. The effort for the past few years has been more focused on AOI programming, which is a more complicated subject. This is our focus. Over

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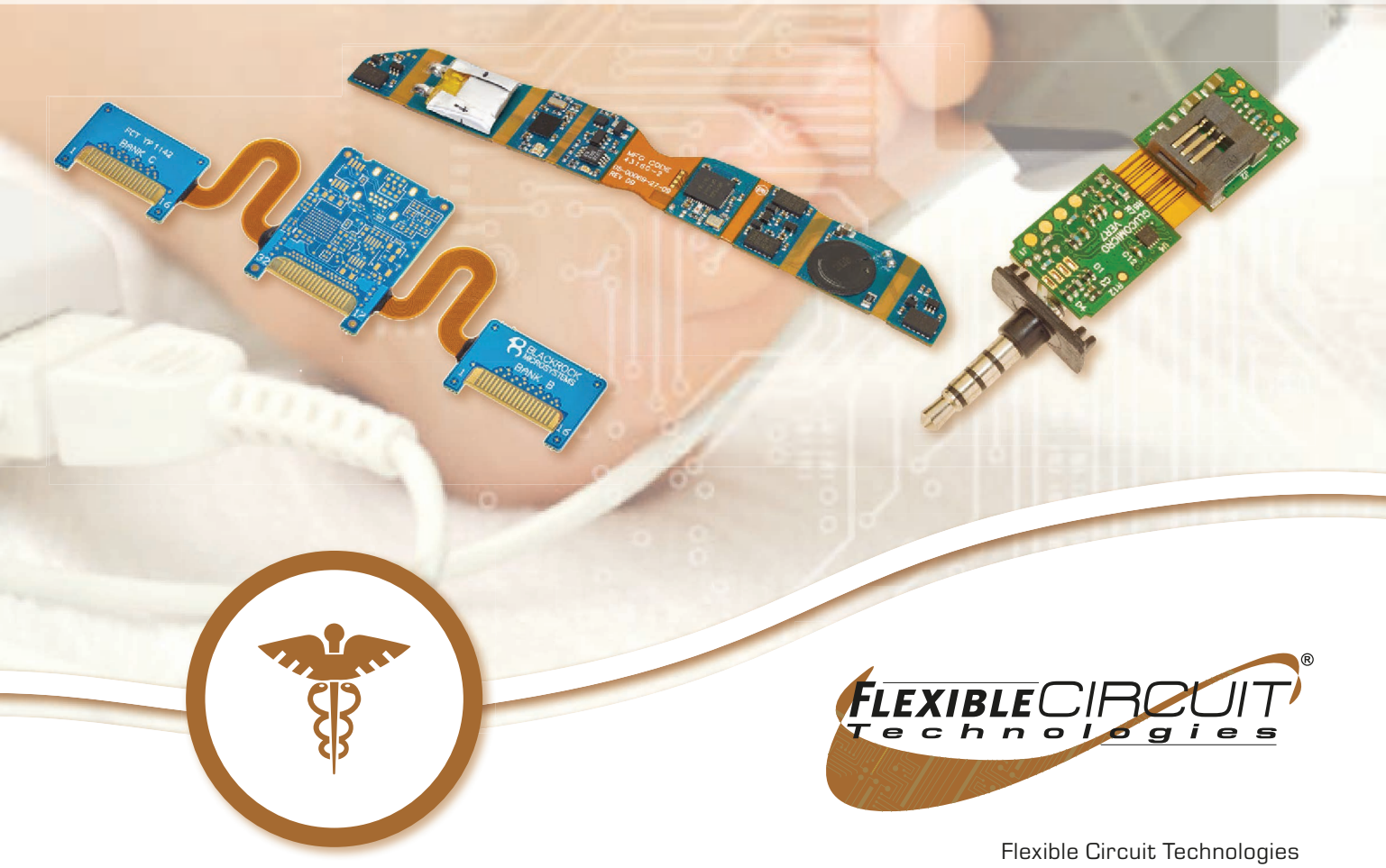

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Alexia Vey

the years, we have increased the test coverage with the introduction of 3D, of course, but we have reached a point where the test coverage is complete, and our customers are now looking to spend less time creating and fine tuning their AOI programs.

Johnson: That's probably where the user interface, user-friendly artificial intelligence applications come into play, helping the staff spend less time for set up.

Vey: Yes, and we also have to take into account the sometimes high level of operator turnover that our customers face. Consequently, EMS providers are requesting AOI systems that need less experience and skills from the operators to be programmed, so we need to adapt to this. Of course, to be profitable, customers want to spend less time on the AOI programming or fine tuning and, last but not least, they need to get rid of all the false calls as well.

Johnson: One goal in product development is to create machines that help implement the new best practices for a manufacturing environment. AI is starting to play into that: the operators are less technical, less skilled, and less experienced. So, that experience—that skill set—needs to be captured somewhere. If it's not in the brain of the operator, then it needs to be in the system itself. Does that ring true to you?

Vey: Yes, exactly. We tend to guide more and more the user, the programmer, in fact. The production operator interface is already clear and easy to use, so now we focus on the programming side. The trend, I would say, is to guide the user.

Jesse Dowd: I think it's an economics decision: "We would like to be more efficient with our changeovers. We have multiple machines on the line." The more common the programming environment is, the better. That's great and that's certainly a good economics argument. But I think something we're hearing, at least from some of our customers, is the shortage of skilled labor. How do you get the people that can really keep your line running, keep your customers happy, deal with the next thing your customer is asking you to do? I think they need machines that can be easy to use and solve some of the problems on their own with minimal human interaction. I think that's valuable, and it's certainly on people's minds today.

Johnson: How does Mycronic define AI? What's the implementation to you?

Vey: There are two different kinds of AI. You have the machine learning, and you have the deep learning. We have started to implement the machine learning. These are very advanced algorithms, which work automatically. Today for example, we can present any SMT component to the software and the software will recognize the body and the leads without any human input. Our SPI can "read" a bare board and automatically locate and identify the fiducials, the copper pads, and even compensate for the warpage, all on its own. This is the first customer benefit brought in by AI that we ex-

tensively use on our inspection systems. But AI capabilities go beyond advanced machine vision, and we are already working on some advanced AI applications that will further revolutionize the implementation of inspection.

Johnson: In the beginning, inspection setup and learning used a board or a finished assembly as the gold standard. You created a reference image of that, and then as long as everything matched that, it passed. Right?

Vey: No!

Johnson: Alexia, you're wagging your finger at me for that comment (laughs). Talk about how it should be.

Vey: Mycronic has always refused to follow this image comparison system. This is the reason why our AOI has always been, and still is, one of the most stable AOI systems on the market. Because if you only compare images, then you are not robust to all the variations between PCBs, between PCB suppliers, and between components, and this will generate false calls. There are some systems where you teach the golden board one time, then you run your batch; it's fine, but one month after that you run another batch and it's not working anymore. The reason is simple: this is due to all the supply variations, and we must cope with it. The way we have addressed this issue is by not comparing images, but by having an algorithm-based system.

We do not use a golden board because it does not exist in reality. No customer can place components perfectly. Instead, we teach the system what it should find, and then we check that it finds it. But we teach it in a vectoral way, which means that the system receives more information on the theoretical model than necessary, but then it can adapt to the variations. Of course, I mean, this was more the 2D part, but since we introduced 3D, the algorithm got so much simpler, because you don't have to question whether the reflection you see is the component, some solder, or something else. With 3D, the component is here or it's not present, with no image comparison at all. I know that not all AOI manufacturers have this strategy, but we went to this strategy and history has shown us that this was the right choice. Just think of all our key accounts who have been using our AOI technology for more than 10 years on multi-lines with the same library, with extremely stable results.

Johnson: Tell me about the results information that gets provided back. How accurate is it in spotting false positives or false errors? Does the system become more accurate and more precise over time for your users?

Vey: Yes. We usually have a strategy of a central library for all products. This way, you have a learning curve, and after a few products, your library stability increases. You will get fewer false calls. Some high runners in the automotive sector with very high-test coverage have managed to have more than 95% FPY with our system.

Johnson: When you're talking about the components in the library, are you talking about the board assemblies as a component, or the individual chips that are going on the board?

Vey: The individual chips. We create a library model for each individual package type.

Dowd: There are a couple of layers to this technology. Within the AOI and the SPI equipment, we have what we like to call a vision engine, which we have been developing for years to do this analysis. It has proven to be strong in the industry; where we have deployed it, it has been beneficial to our customers. And in the traditional ways of inspection, right? Preventing defects or detecting defects and helping reliably weed them out and not get stuck with too many false positives.

Jesse Dowd

As we've evolved this AI piece, I see it as applying to the business and helping the customers in two ways. One is, of course, within the inspection process, building this more robust set of data for analysis to say, "Hey, that's good; that's bad." Continually building the intelligence of that database is critical. It's really exciting to think about how we can make the inspection process better, and then using the AI algorithms and this sort of thing.

With the idea of having this capable vision engine and this AI to build up data over time, we can better use our increasing data knowledge to make more throughput, higher yield, and a better quality electronic assembly that is more reliable. These are things that customers care about. Having the vision and the engine to start with inspection and then continuing to migrate that out into the rest of our portfolio of products is really very exciting. I think the customers are going to get some real benefits from that in the coming years.

Johnson: There are some new emerging marketplaces globally; automotive is a great example. The amount of electronics going into cars is changing the pie chart of who the big players and the minor players are in electronics design and purchasing components. How is Mycronic responding to that shift? How does that change what you're doing for your equipment design?

Vey: Surprisingly, not that much. A few years ago, we saw the trends of component size reduction. But now, it seems that we have reached a limit where we can't reduce anymore. Some boards are getting denser, this is true. The final product at the end does not really change the game for the SMT process and inspection process, I believe.

Dowd: I think some combination of throughput, yield, and reliability is really driving everybody. That certainly varies depending upon application and market. Sure, autonomous vehicles and mobile robotics are pushing the electronics out in the world. Interacting with people and all of that certainly creates interest in reliability and high quality. The flexibility of manufacturing and the throughput and yield results remain important. But on balance, I agree with Alexia. It's not a sea change in what we see for the electronics assembly and what's valued by the customers.

Some of the things that we are talking with our customers about, i.e., the component shortages, has them asking, "How can I recover from that quickly? In the past, I could find a substitute part. Maybe it's an equivalent pad on the board, and I don't have to change the design and go. But now, oh boy, I can't find that part. So, what do I do? How can I quickly change my board or change all of my programming and continue to keep my production going?"

Johnson: And provide the ability to take results data and aggregate that into meaningful analysis for management?

Dowd: That's right. You can probably argue the accumulation of that data builds more of the ability to detect defects or anticipate any problems. I think it really creates the possibility to

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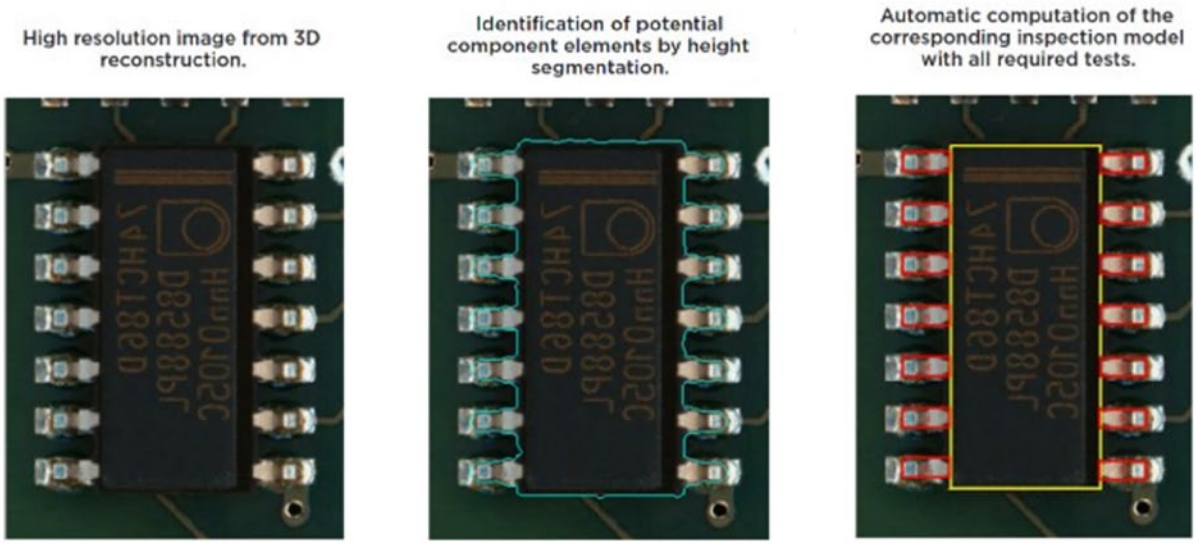


increase the quality and the reliability of their output, of their electronics as they are built.

Johnson: That's an interesting perspective. We're still at a place where even with the work to automate, the critical factor is still the human operator, the process engineer.

Dowd: Let's say I'm an automotive manufacturer, and I've got three production lines running in three different places. Right now, technically, the process engineer can exercise some judgment, "When I inspect that joint, I like to see the fillet like this. I like to see it a little shinier." It's certainly experiential based, and it's certainly valuable. Not to diminish their expertise, but I could easily make the case that it's introducing variability into my three lines. Now, if they're all running on the same AI engine, then whatever was detected is going to be consistent on all three lines. Maybe it's not about eliminating the human, but it's about making a more standard, predictable, and consistent judgment on what we see and how we (or the customer) will react to it.

Johnson: What advice would you give to manufacturing lines that are looking to make inspection better? How does Mycronic view the return on investment, the value add?

Vey: I think process control is the key here. You do not buy an AOI or an SPI just to flag, "There is a defect." You buy some inspection machines to improve the quality of your final product, and to do that, you need to improve your process. This is the reason why we have introduced a feedback or forward loop between SPI and AOI. This is to control not every step, but the full line. We have the chance to have one machine at the very beginning of the line and one at the end. This is first to avoid scrapping boards unnecessarily, to gain money at the end, and to take no risk on the final product quality.

Johnson: So, the concept is that there is a feed forward loop, and information from earlier inspection or processing could help flag for the final inspection equipment to pay particular attention to this area on this board, because of what we saw in the earlier data?

Vey: That's exactly what it is. I will give you a simple example on the SPI. The SPI will detect a very small breach between leads. Some of the customers will say, "No, I don't want to take the risk. I scrub the board." Some will say, "I'm pretty sure that this breach will disappear in the oven, so I will let it go." But who will make the final judgment? This is definitely the AOI and the operator in the review after we're through. In this kind of case, we can set the SPI limits so that the little breaches do not stop the line. We continue but we check at the end of the line that we are sure that we

don't detect any breach and any defect. This, combined with a more long-term SPC system where we can correlate all the solder joint related defects, so it's solder joint, bridges, and coplanarity defects, then you can adjust the tolerances on both SPI and AOI machines to catch only what is needed.

Manissadjian: There is another way to look at inspection from the customer point of view. Inspection machines are not producing; but they can be seen as high-level quality checkpoints. They are also the sensors of an SMT line. They not only capture defects at the board level, but they also reveal problems at the process level. If you manage to gain 1% of first pass yield, that can be translated into bottom line improvement directly. Our customers that operate SPI and AOI together with MYPro Link process control software, which is fed in real time by SPI and AOI data, have all the actionable information to help them improve not only the inspection process, but also the pick-and-place process, the paste printing process, or the oven process.

Here lies a big part of the value add of inspection. Those customers, who thought that their printing process was so perfect that they didn't need an SPI, take an SPI just to make a trial, and they say, "Oh wow! I didn't know it was so bad before." We've heard that so many times, and that's the very first added value we can see, but then this also translates into much deeper process improvements, and it has a direct impact on the overall financial performance of that production line.

Dowd: Some of these trends you were talking about earlier, Nolan, if you buy at all the idea that the reliability is both economic and brand image, if you buy at all that increasing reliability of the electronics in the field over time is important in some of these trends, then we have the ability to see, in detail, the quality of the few parts in the process. We can provide information into the line process itself because we're making other machines as well to

Yan Manissadjian

improve the quality and reliability. I think that links it together for me.

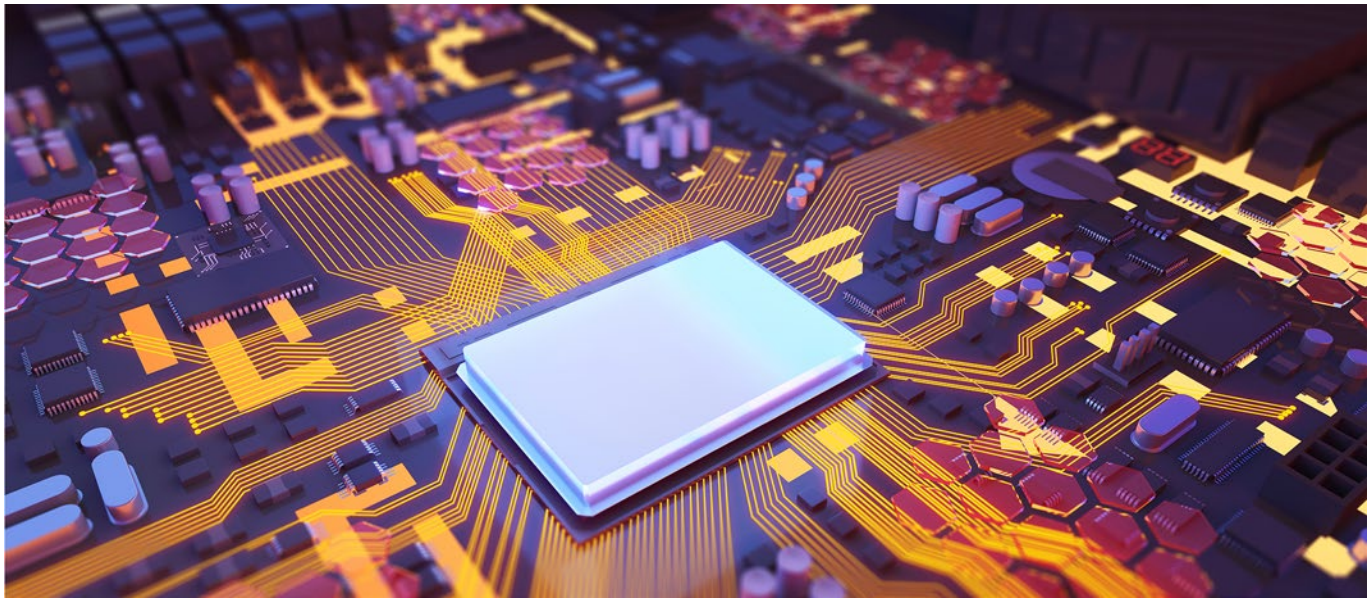
Johnson: MES systems are also an integration channel. Can we talk about connecting to them?

Vey: There are two emerging protocols released. We have the Hermes protocol, which is machine-to-machine, and the CFX protocol, which becomes the standard to communicate from a machine up to the MES, and from the MES down to the machines. I see a trend to standardize the communication between machines, and between machines and MES. I think this is a very good trend for every player in the line, including the MES. Now that the IPC-CFX protocol is coming. I see it being increasingly demanded in the market.

Johnson: This has been really good information. Thank you.

Dowd: We really appreciate your time with us, and the opportunity.

Manissadjian: Thank you, Nolan. SMT007



Market Changes Require Re-evaluating Your Testing Processes

Feature Interview by Nolan Johnson
I-CONNECT007

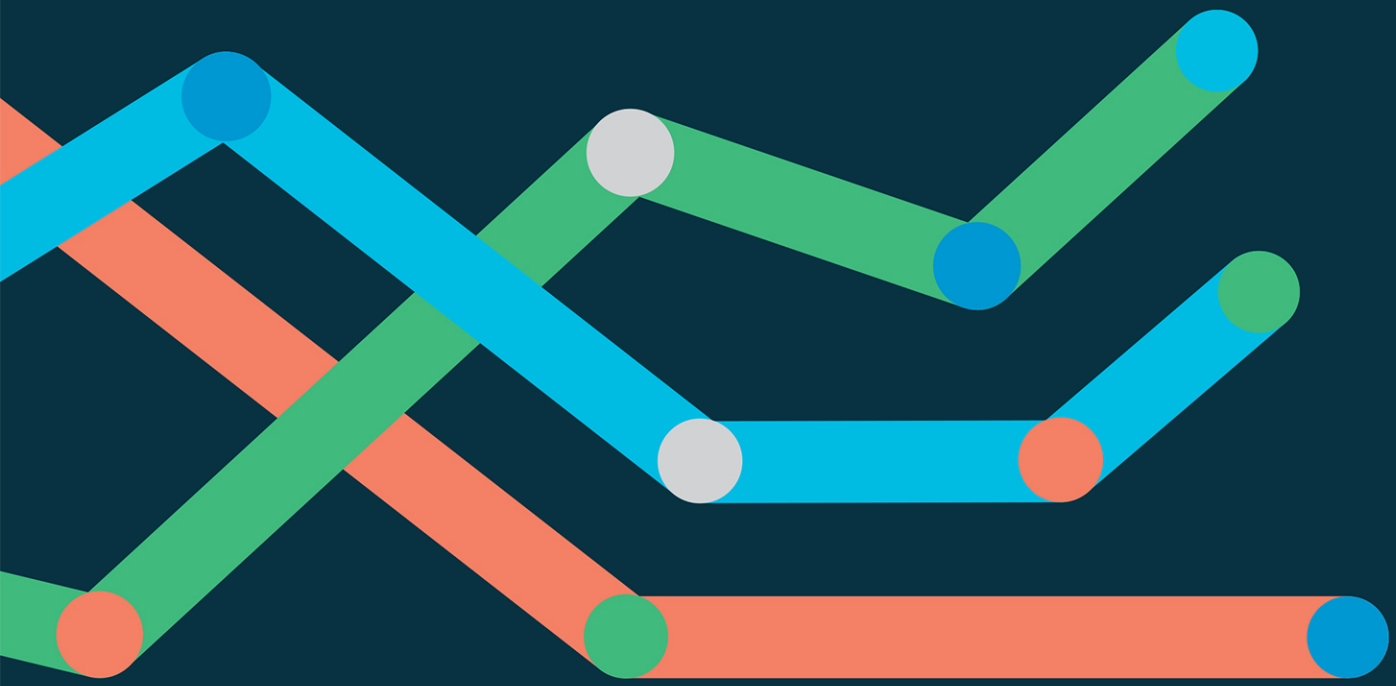
Nolan Johnson dives into test and inspection with Bob Neves of Microtek Laboratories China. From his perspective running a test lab, Neves shares his view on the current issues for contract manufacturers regarding test and inspection. Over the course of this conversation, Neves discusses the effect of the current supply chain on testing practices, factory automation, the collection an analysis of data, and more. For all the automation and data collection possible, Neves points out, it still comes back to the people.

Nolan Johnson: Bob, from your perspective, what are the current issues for assembly, as well as fabs as it applies to assembly.

Bob Neves: With fabs, it continues to be between via reliability and the long-term isolation, CAF, or electrochemical migration. Those are the things that never go away. The two primary functions of the printed circuit board are to move current where you want it to go and keep it from where you don't. Those are the two primary functions and tend to be in people's focus.

Microvia technology seems to be changing. Everybody thought microvia were bulletproof, but as microvias structures have become more aggressive and with multiple layers and interconnecting geometries, things started to happen. They're not as bulletproof as they used to be when they were just one or two layers. There's a lot of effort trying to understand what's going on with microvia issues and CAF; it's just a long-term thing. They're the people who need long-term reliability. They're really concerned about it—those in automotive, communications, space—they're all very interested in long-term capital liability.

I've got over 30 humidity chambers at Microtek China with a team of about 12 people and that's all they do; their entire occupation is just doing CAF for customers. The expectations are getting longer and the



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Microtek's thermal shock (RTC) lab.

voltages are getting higher. People are pushing boards more and expecting more from them. This whole move to electrical motivation—whether that's, cars, trains, airplanes, bikes—everything is all run at higher voltages. You have the microprocessor guys that are down at 3.3 V, and now you have all this electric motivation that's running in the hundreds of volts.

There is a real disparity between the needs of both of those groups. I don't think the designers get that; they just design boards, but you just can't use the same rules for the 3.3 V as you can for the 800 V board.

On the SMT side, they're stepping up a level. You have the solderability and surface contamination issues. Obviously, you have component issues, but I'm not really qualified to talk about it because we don't do much with components. My experience is starting with the solder joint and working down. I don't have much experience above the solder joint, but I know component attachment using lead-free technologies is stressful on the substrate materials as well as the repair and rework they undergo.

Component shortages are causing people to do things with components that they wouldn't normally do. Normally, they would throw questionable components away. Now, they are trying to fix them rather than take a component off, throw it away, and put on a new one. There might not be a new one, so they're salvaging. They're taking components off of boards that are scrap and putting them on good boards. A lot of weird things are happening now, due to supply chain issues, that weren't happening before.

Johnson: So, for both fab and assembly, there are similar ongoing issues?

Neves: Yes, other issues in addition to the supply chain issues. And we're seeing that in the PCBs too. People aren't getting exactly what they expect. There's a lot of substituting both officially and unofficially. People accept glass or solder mask from suppliers that they wouldn't normally use, or substitute materials like copper-clad laminate because most of the production is coming from offshore and it's currently sitting on a ship off Long Beach, California, for example.

Johnson: Right, with the other 70 or 80 freighters out there. That might be the biggest emerging challenge: components, rework, and salvage. How do you test and inspect that?

Neves: There are not a lot of procedures out there. This is new and people aren't talking about it. They're not saying, "I'm using components off old boards, scrap boards, or this and that." People just want product. They don't care how they get it. I don't think this is really something that's being openly talked about a lot, but I'm sure it's happening.

Johnson: Since there aren't really any standardized procedures, what are you seeing? Is this something showing up in the work you're doing? It would seem to me that functional

testing with salvage components would be important for every finished product with salvaged components.

Neves: Sure. But, again, that's today's number. You really don't understand what the long-term reliability is because you're undergoing more rework procedures than you would normally do. The board, the component, and other things are being subjected to processes and heats—not necessarily saying they're bad—but they're just not typical for the process that people have qualified to. They qualified a product to a specific process and then a bandwidth around that process. But now, with the component shortages, people are doing things outside that bandwidth and the best they can hope is do that functional test and say, "Yeah, it works today," but there's really a question of, "Is it going to work in one, five, or 10 years?" We really don't have that information, and nobody will invest the time, money, and energy to figure that out because this is likely a temporary issue. They will just bury it and deal with the problems as they come up. That's my opinion; I don't have any hard data to back that up, but that's just my take on things.

Johnson: So, what questions should OEMs and EMS providers be asking?

Neves: You need to ask the questions to assess the additional risk that's coming up from all these interesting things that are happening due to the supply chain issues. People are looking at secondary markets to source components. They're changing components and all sorts of things that will obviously affect the product. But is it going to affect the product in a way that is an acceptable risk? That's the question to be asked.

Johnson: There's this move toward increased automation, smart factory, that sort of thing. Along with that is talk of increased inspection in the middle of the line as a part of the automation. Is that real? Is that valuable? Is that unnecessary?

Neves: The one thing that's hard to quantify is that when you have humans in the process, there's a lot of things they see that don't get quantified by automation. They notice things. The human brain works in such a way that you can notice things happening that you may not be able to program into an AI, or into an automated process of doing things. You're expecting things to go the same way when you have an automated process, and where you try to control the variables. Then, you expect them to go the same way as before the automation and you have so many inputs, but a human can process a lot more inputs than just the cameras and other data input can.

I think you lose some intuitiveness when you pull the human out of the process. So, the idea of having more inline inspections is to add intuitiveness back in. It's a double check just to make sure we didn't miss anything because we're not covering everything a human would cover as far as inputs are concerned. Let's add more inspection to make sure that we verify that we're not losing something by taking away some of the inputs that the human would notice.

Johnson: I'm looking at some survey data here, on capital expenditures in this case, from the EMS providers. I asked them, "What is driving your capital expenditure plans for 2022?" Tied for first place was market opportunities and additional capacity. Automation is in second place, followed by additional capabilities. So far, nobody has said that they're adding additional capabilities. It's all market opportunities and capacity.

Neves: Right, it's reducing cost and increasing revenue. Let me put my IPC hat on for a second and say that the IPC popped in with CFX at just the right time, and it's really taken off. I think that's an industry standard that has taken

Bob Neves

off, been adopted, and is creating positiveness on the EMS side of things, in the automation arena. Vendors seem to be jumping into it and putting it on their machines. You're seeing this integration with machines talking to each other to make them better and more intelligent.

Johnson: Because there is so much data, is that data ultimately useful to you and your role as an independent third party? Can you make use of that data?

Neves: Not really. As third-party testers, we're risk reduction people. The testing we do to IPC standards and the company standards is to show that the company has done its due diligence to limit liability. They're not looking to us to dive into attributes of the process. They're looking to us for help in quantifying a product's expected reliability. The CFX standard is assisting manufacturers with gathering all this data about process, process improvement, process control, and consistency.

Johnson: Can you envision a future where your test results actually feed back into that digital twin?

Neves: Oh, they do, if they're designed to do so. But, most of what we do is compliance. It's a barrier to getting your product accepted. It's a requirement, like filing taxes. I would say that's probably 80% of what I do. The other 20% is interesting because I have people come to me and say, "Okay, I want to find what material is right. I want to find what processes are right. I want to look at product design or look at the design of microvias and see which stackup works better.

Those are the interesting things for me to do, and that makes up 20% of my business. Those investigations go back into the process—how the board is designed, or how it's manufactured.

Johnson: For the 20% that's doing R&D-oriented testing, is that population of the industry growing, shrinking, or does it seem to be staying pretty stable?

Neves: It's pretty stable. I think it's usually driven by need. Somebody needs something new or a new customer comes along. It's people who identify a problem or have a severe issue, and they really want to come back and resolve it. People aren't being proactive about doing testing. Again, it's just a cost center. There's no way to provide direct, tangible improvement, whereas with investment in automation or anything else, you can do the math. You can say, "If I spend this, that will save you here." When times are lean and people have to cut costs, my business goes up as internal cost centers are downsized and services like mine are used instead.

Johnson: What advice do you have for the contract manufacturers regarding getting more out of testing and inspection?

Neves: If I had to say anything that would be of value, it's that the current situation is requiring you to change your supply base. Do things you wouldn't normally do, take some time, and un-

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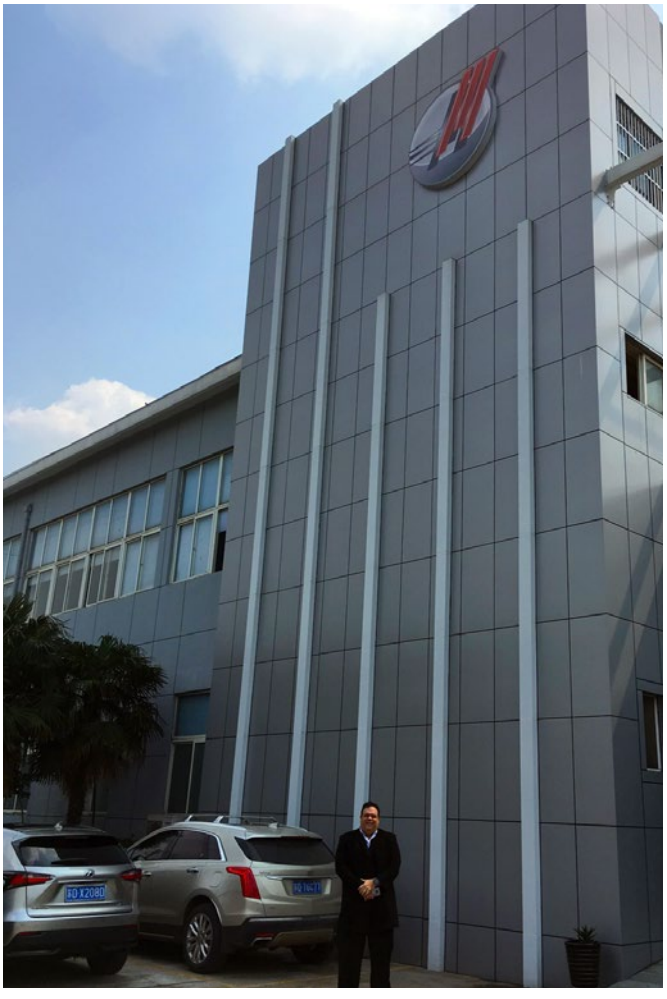

Bob Neves at Microtek's Changzhou facility.

derstand what these things are really doing to the process. Spend your testing dollars wisely.

Your people are doing tests and inspection, whether that's their role or you understand it. They're watching the process and the machines. They're watching the components and looking at the trays. As you pull people out, you're limited to the inputs that the machines have, whether it's cameras, test beds, or whatever it happens to be. You're limited to just those inputs. There's no intuitiveness to it. You set up what your inputs are, the upper and lower control limits, and that's all you get. You lose a little piece of that insight when the humans are removed.

To me, the key concern with going automated is that most people just slap on more testing: "Let's just test more." That's the approach people are taking, and it's a good one. It's just that you have to carefully understand what you're losing by pulling the humans out.

Johnson: With more automation, more testing, and the limitations of what automated equipment can do for testing, the how of presenting the results back to the operator, the engineer, or the product manager becomes crucial—turning the data into analysis.

Neves: Correct. It's overwhelming. You have an Excel spreadsheet with 100,000 data points in it. How do you turn that into something that a manager, who has very little understanding of the actual process, can decide on? Having data is not an end-all. You have to take the data, summarize it, and present it in a way that is easily understandable for people who don't understand the process intuitively.

Johnson: Right, you have to cook it.

Neves: It's just like the old SPC charts we used to put on the wall. Are you collecting the right detail, the right frequency, the right amount of depth? If you're looking at the ocean, and you're only checking the first three feet, what does that tell you? "Sure, it's wet. It's good down three feet." But you're not seeing the whole thing.

For the board manufacturers, there's some automation, but I think the EMS guys are the ones who have pushed the automation forward. Boards are still basically made the same way I made them eons ago. There's less human handling between the processes, but I wouldn't call that full automation. I would just call that smart design. "I put my two machines right next to each other. I put a little conveyor between the two. Right, yeah, wow." I don't know if that's automation, whereas with the EMS guys, that really has changed.

Johnson: Bob, thanks for all the insight. **SMT007**

Bob Neves is chairman/CTO of Microtek Laboratories China, and vice chair of the board at IPC.

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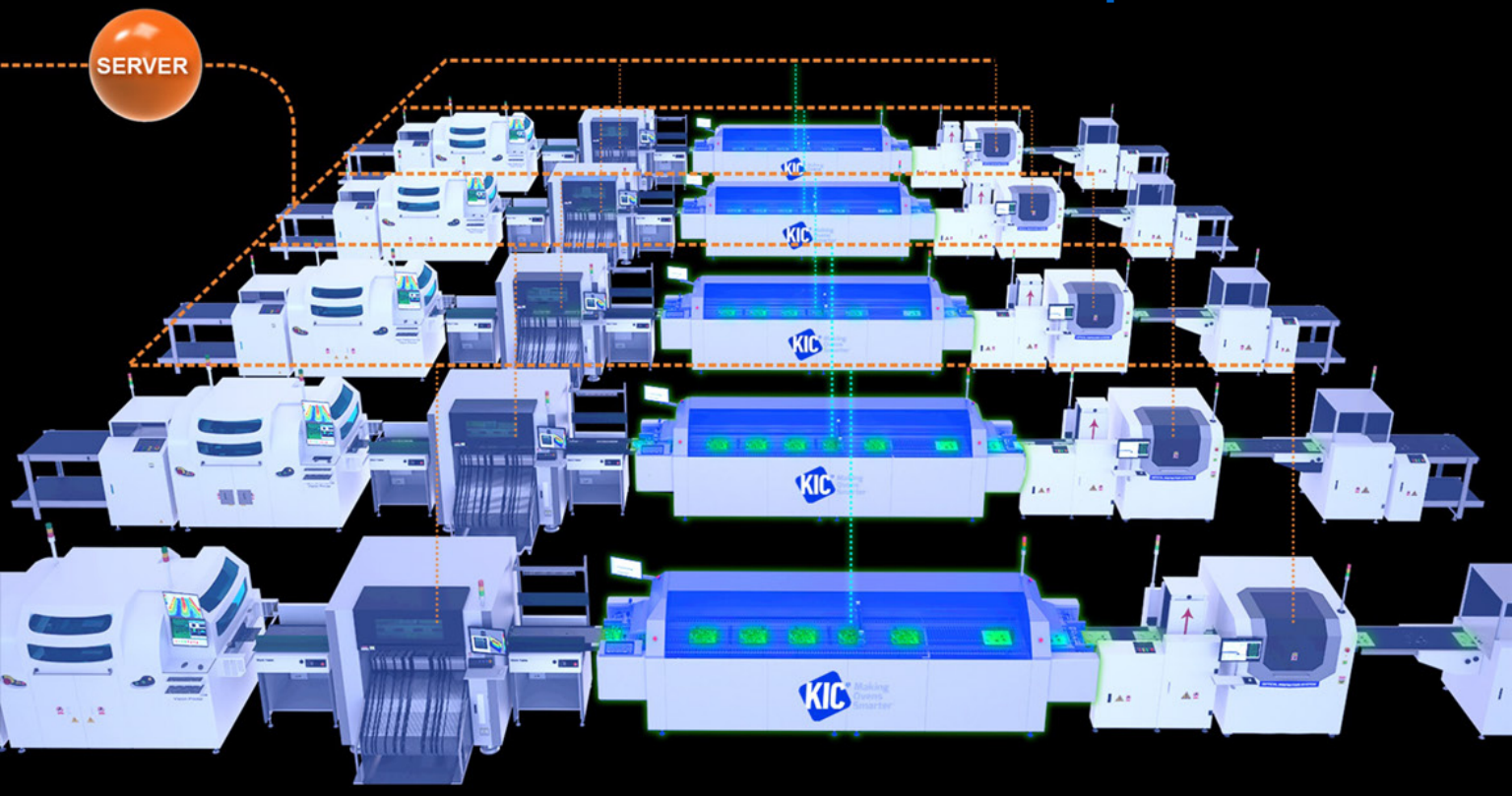

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Explore the Depths of Your Dispensing Process

Feature Article by Axel Lindloff, Heriberto Cuevas, and Brent A. Fischthal
KOH YOUNG

Past missions to the "final frontier" might have been more successful if the coating on the electronic assemblies had been measured using our novel inspection technology for the dispensing process. While this is just a hypothetical statement, it is highly likely that in a harsh environment like outer space, some effects such as crystal growth and surface contamination can occur. As such, sealing the electronics assembly from environmental contaminants is particularly important because any debris or moisture can form the breeding ground for crystal dendrite growth.

Harsh environments are not limited to space; electronics need protection on earth too. Consider the engine compartment of your vehicle, or the drive in an offshore wind turbine, the motor on an e-bike, or your mobile device. The assemblies must be protected to prevent damage from environmental elements; yet the protection process itself can become the challenge or even the reason for product failure in the field.

On an unprotected electronics assembly, debris and moisture form a conductive mixture that shortens the insulation distances and causes failure. Moisture also causes corrosion. Conformal coating is intended to protect the assembly from these dangers. However, if the debris or moisture is captured within the conformal coating, the danger lies dormant under the supposed protection. Bubbles and air pockets are also predetermined breaking points in the protective layer. Koh Young now provides a solution to these failure opportunities with its proprietary dispensing process inspection (DPI) solution called Neptune (see Inspection Solutions sidebar on page 44).

Failure Modes

Conformal coatings isolate and protect electronics from moisture, debris, corrosion, and shock, and add mechanical stability to reduce failures and improve reliability in harsh en-

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vironments like automotive, LED, military, aerospace, medical, mobile, and more applications. But what if the coating is too thin or defective? Failure may result.

Here are some common failure modes detectable by the inspection machine:

- When entrapped air or solvents skin over—often caused during the drying process or multilayer coating application—bubbles become entrapped before settling out. The inspection machine can detect bubbles measuring length or percentage of the affected area.
- Cracks leave an area exposed and less protected from moisture and dust. This usually happens when the curing temperature is too high or when curing occurs too quickly. If combined with a thick coating application, it causes fracturing of the coating into sections. If a crack turns in a bigger affected area, it can become a delamination problem, which can also be created by a circuit board cleanliness issue.
- Conformal coating thickness can present two problems, one related to a too-thick coating, and the other related to a thin coating layer. For these scenarios, measuring thickness—which is one of the main advantages of using LIFT technology—this system can find common defects caused by an incorrect coating thickness. These include capillary flow, de-wetting, and uneven coating—a challenging defect to detect with traditional, often destructive, measuring technologies.

Inspection Solutions

Traditional laser-confocal or electron microscopes only measure three-dimensional shapes and cannot inspect transparent materials. The microscope penetration depth is too shallow, and the processing time is quite lengthy, so measuring transparent materials is a significant challenge due to the laser's shallow penetration depth and elapsed time. UV-based systems also gauge material thickness in a particular spot, which does not deliver the accuracy and repeatability needed.

Neptune T

This system uses non-destructive 3D inspection technology to examine the thickness of transparent and semi-transparent materials like coatings, underfill, and epoxy used on a PCB. This ensures the conformal coating used to protect the delicate circuitry is applied correctly and will ensure the device operates as it should. Expanding on its capabilities, the system has advanced with the next phase in its development. This is to inspect batch and inline conformal coating inspection systems using data aggregation and data-driven process.

Neptune C+

Neptune C+ allows manufacturers to identify defects with 2D, 3D, and cross-section views. The system measures materials for coverage, thickness, and consistency with user-defined threshold settings. Instead of measuring IC leads with a point method, which can yield unreliable results, the Neptune Series measures the actual coating thickness to satisfy demanding quality standards.

LIFT (Laser Interferometry for Fluid Tomography)

With the help of laser interferometry for fluid tomography (LIFT), the layer thickness of transparent media is determined within seconds. This tech-

- A bad coating application can leave particles in orbit that may result in a short circuit or can reduce the PCB protection from environmental contaminants like dust, moisture, and corrosive vapors. In some products, conformal coating is applied to give some structural integrity.

If there is not a good detection of coating defects, PCBs, as a part of a final assembly, can have a reduced lifetime, or even worse, a malfunction during regular operation. Consider some modules in a car, composed of several PCBs requiring strong bonds, protected by conformal coating against vibration and mechanical shocks. If this protection is inadequate or defective, it could cause an accident because of an electronic module malfunction that was supposedly protected by a coating.

Critical reliability issues have driven the need for advancements in measuring thickness. This critical quality assessment tool is something that the inspection equipment series can provide through non-destructive testing at production speed. **SMT007**

Axel Lindloff is a pre-sales application engineer at Koh Young Europe.

Heriberto Cuevas is an application engineering project manager at Koh Young America.

Brent A. Fischthal is senior marketing manager at Koh Young America.

nology delivers non-destructive 3D inspection to precisely measure and inspect fluids. Koh Young's LIFT technology delivers non-destructive 3D inspection to precisely measure and inspect fluids that are wet or dry. Based on low-coherence interferometry, LIFT employs near infrared (NIR) light to capture images through multiple layers of a fluid structure regardless of transparency, providing accurate and reliable 3D inspection across any surface—smooth, uneven, or rough. Using LIFT technology, Neptune allows manufacturers to accurately identify defects without damaging or destroying the product.

Machine Learning

With its machine learning (ML) algorithm, this system accurately measures materials for coverage, thickness, and consistency using user-defined threshold settings. It also inspects bubbles, cracks, and other defects, and inspects "keep out" areas for splash marks. With this proprietary machine learning technology, this system offers enhanced inspection capabilities enabling autonomous inspection without teaching or endless tuning.

Beyond Coatings

Besides coatings, the inspection system measures underfill, epoxy, bonding, glue, and more, delivering accurate measurements of transparent, translucent, and pigmented materials. The system is currently suited for acrylic, silicone, polyurethane, water-based, UV-cure, and hybrid coatings with additional materials being investigated. It handles several types of applications spanning research labs to high-volume electronics inspection.

Inspection systems used in electronics manufacturing could traditionally detect the presence of coating. However, the systems could not inspect the thickness at production speed.This missing element meant some PCBs passed through the production line wit out the correct protective layer. **SMT007**

The Costs of Legacy Thinking

Smart Factory Insights

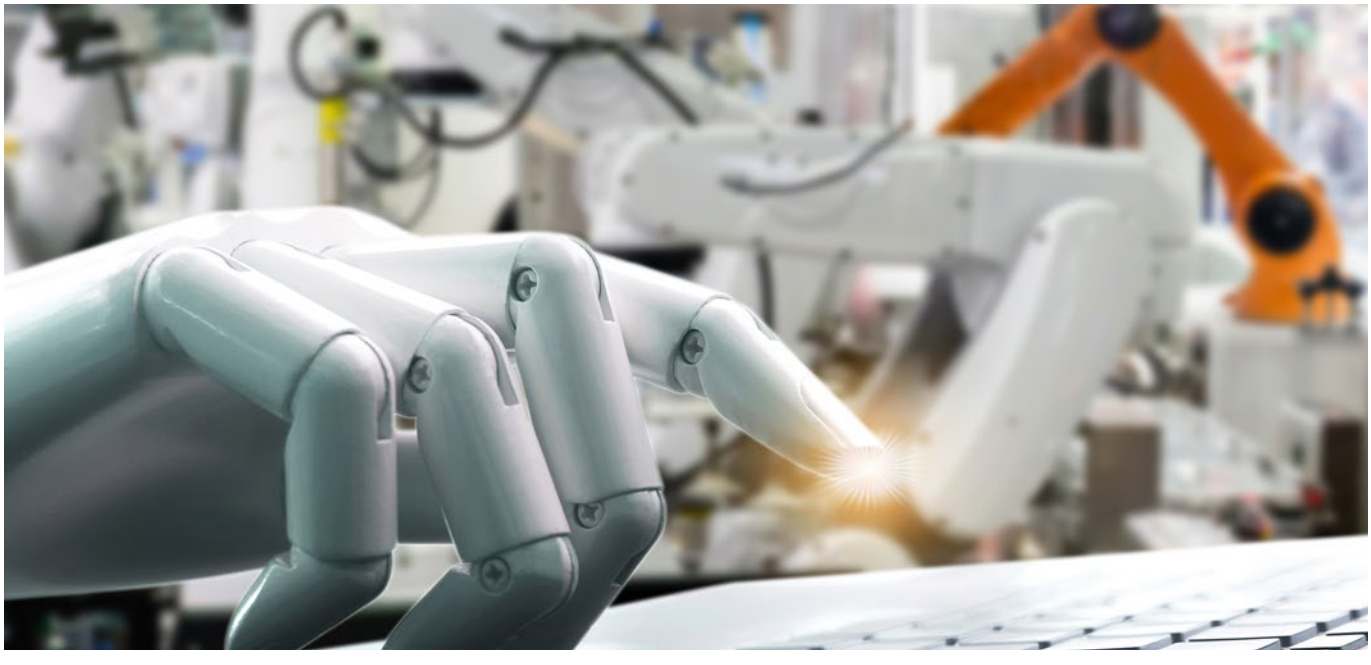
by Michael Ford, AEGIS SOFTWARE

As humans, we learn facts, gain impressions, create solutions, put practices into place, and move onto our next challenge. Over time, our intent is to create a legacy of value, but in many cases, we are creating legacies in a different sense. Our knowledge, experience, and creations age or become superseded, but there is resistance to replace or update. An increasing gap develops between perception and reality. Younger, more agile peers take advantage, get ahead, and we look away, thinking that they don't know what they are doing. Though a natural human phenomenon, decision-makers in manufacturing today need to bear this mind more than ever.

As a civilization, we have achieved so much—men on the moon, supercomputing power in the palm of our hands, and we've even made the planet just a little bit warmer. In manufacturing, we benefit from faster, more flexible automation; smaller, lighter materials; greater throughputs; near-perfect quality; and decreased costs, with a supply-chain to die for.

Our intent was to create excellence. Being in control in manufacturing is paramount, having removed as many unknown sources as possible of variation and change. Practices put in place address challenges that once plagued operations, and that maximized benefits and profit. It has meant we took our eyes off the ball.

The world is going through another fundamental change. In fact, this time, a few different interacting changes, are occurring at the same time. Whether it is global or local poli-



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tics, a pandemic, or bad weather, the message is finally getting across that there really are fundamental challenges ahead, not the least within manufacturing, which of course, brings new opportunities.

In the manufacturing world, the advancement of software within inspection, test, and assembly machines, as well as operational and business solutions such as MES, MOM, and ERP, has been radical over recent years. It is more difficult to see the progress of software changes as compared to machine hardware technology, which you can see and for which there are clear specifications. Most of the software value is not visible, with thousands of elements that contribute, which are not, however, practical to detail and explain. Even the human interface, the shopwindow of software, has shrunk in significance. Advancement of software brings more automation of decision-making, and even "creativity," but less human interaction and involvement. One manufacturer was unhappy when they upgraded their product design data import from Gerber to the use of IPC-2581. Instead of a screen full of options and configurations needed to cope with the randomness of Gerber and the myriad associated supporting files, there was just one button, labelled "Import 2581." The feeling of being in control on behalf of the user is replaced by the cleverness within the software and the data format itself. Which do we think is the quicker and most reliable?

It is more difficult to see the progress of software changes as compared to machine hardware technology, which you can see and for which there are clear specifications.

More and more, we see advanced technologies being embedded within software. Incredible improvements in factory management, active quality, supply-chain, and even image sensors and inspection algorithms, often go unnoticed and are taken for granted, certainly lacking appreciation of value. Vendors often attempt to recreate that feeling of interaction, making eye-catching game-ready graphical displays in the hope that people will notice that the software is there and doing something.

Against this backdrop, it is difficult to assess progression and therefore the need for modern software, to make confident, justified decisions that create changes in current manufacturing practices. The purchase and use of software very often is based on information and perceptions dating from many years ago. Even in a period of months, values from software become significantly enhanced. Another factor, however, is that not all vendors are keeping pace, and setting the state of the art for the industry. Vendors are also subject to the same difficulties in making paradigm-changing choices in the development of their products. We see many large software platforms, popular in the industry, date back decades since their initial creation, which will never be able to evolve quickly enough. Progressive vendors have reinvented solutions that take advantage of the latest technologies, such as standardized IIoT messaging, and use it to create previously unachievable functionality and automation. It is essential to regularly reset perceptions and take a fresh look into which software solutions have really evolved and which companies are driving the industry, helping manufacturing adapt and recover, knowing that perceptions of limitations from years ago have long since been addressed. Today's software technology, architecture, and reliability is a long way ahead of what you might expect.

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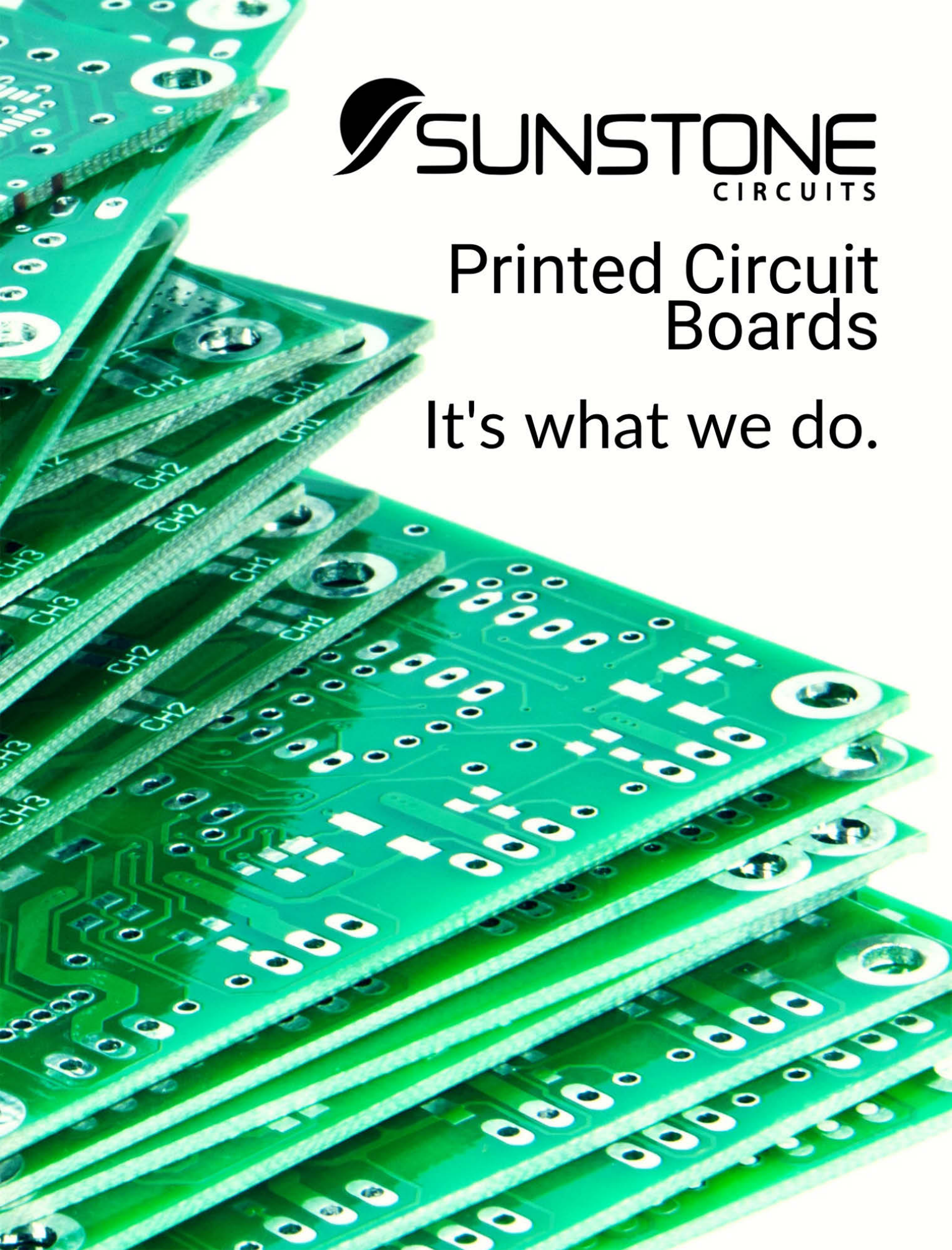


As most manufacturers now scramble around for materials, machines, and spare parts, as well as skilled and experienced labor, remember that the most modern software from machine vendors, MES providers, and others are likely to be far more advanced than you realize, which reflects on the ability to cope much more easily with the business-related changes and limitations that are being forced upon us all. The argument that any change, including that of new software, brings its own variations and challenges, as well as thinking that it may be too late now as the global challenges are already with us, are not valid. The amount of control and visibility that the latest software provides is at least an order of magnitude greater than the work and effort to introduce the software.

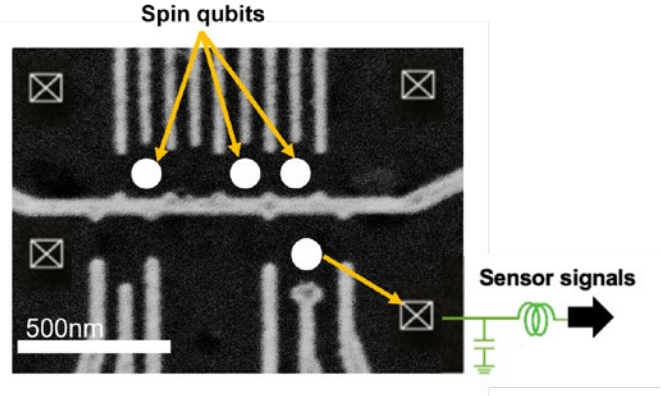
As for global challenges coming to an end, many think that is unrealistic, both in terms of dealing with ongoing consequences of what has happened already—for example, with the pandemic—as well as worsening factors such as climate change and potentially political issues, which are forcing rapid change in government policy, risk management, and customer demand choices. The worst and the best are yet to come. The most modern software is your friend and ally as we face the future together. **SMT007**

Michael Ford is the senior director of emerging industry strategy for Aegis Software. To read past columns or contact Ford, click here.

Cutting Through the Noise: AI Enables High-fidelity Quantum Computing

Researchers led by the Institute of Scientific and Industrial Research (SANKEN) at Osaka University have trained a deep neural network to correctly determine the output state of quantum bits, despite environmental noise. The team's novel approach may allow quantum computers to become much more widely used.

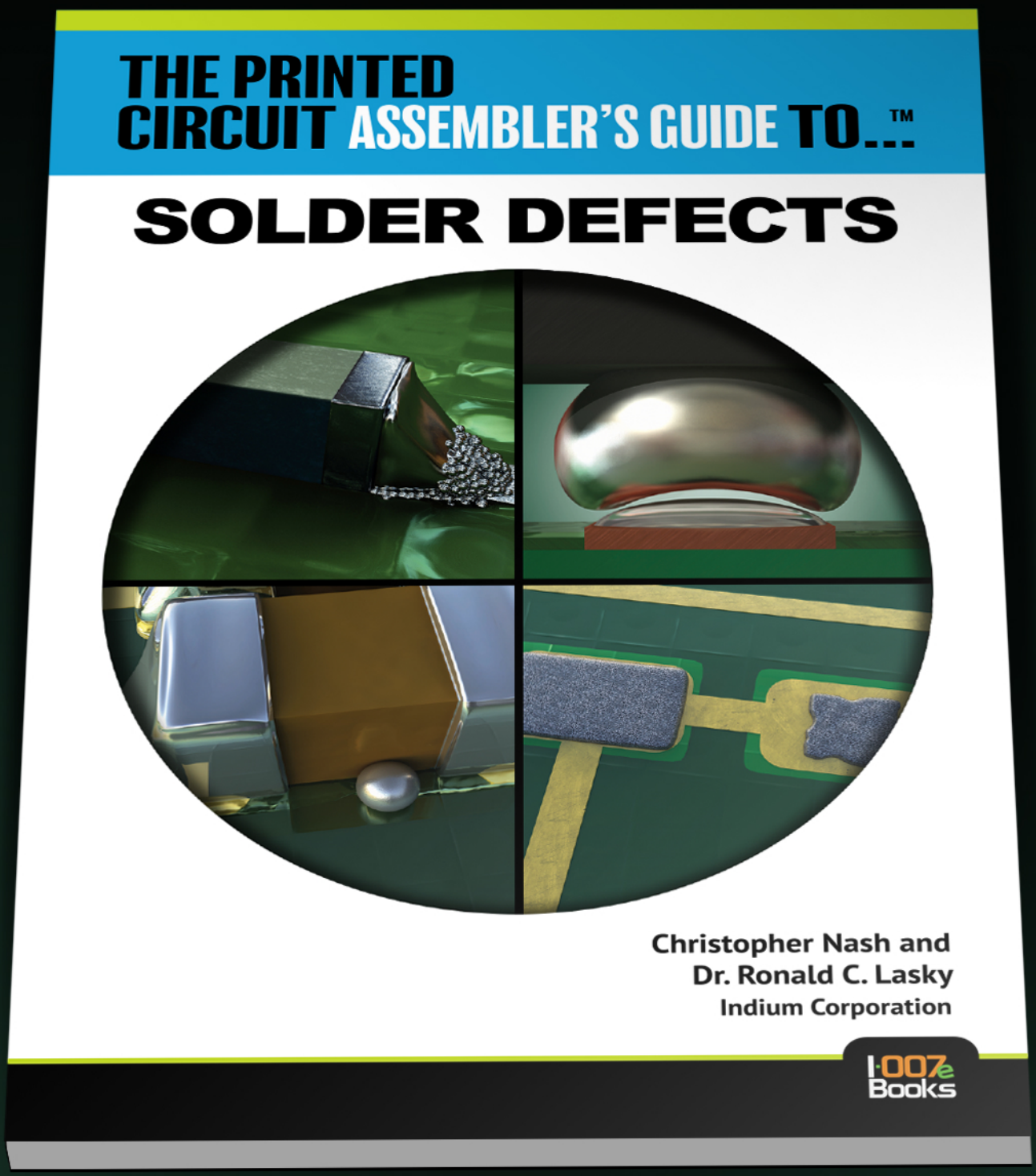
Modern computers are based on binary logic, in which each bit is constrained to be either a 1 or a 0. But thanks to the weird rules of quantum mechanics, new experimental systems can achieve increased computing power by allowing quantum bits, also called qubits, to be in "superpositions" of 1 and 0. For example, the spins of electrons confined to tiny islands called quantum dots can be oriented both up and down simultaneously. However, when the final state of a bit is read out, it reverts to the classical behavior of being one orientation or the other. To make quantum computing reliable enough for consumer use, new systems will need to be created that can accurately record the output of each qubit even if there is a lot of noise in the signal.



Now, a team of scientists led by SANKEN used a machine learning method called a deep neural network to discern the signal created by the spin orientation of electrons on quantum dots. "We developed a classifier based on deep neural network to precisely measure a qubit state even with noisy signals," co-author Takafumi Fujita explains.

In the experimental system, only electrons with a particular spin orientation can leave a quantum dot. When this happens, a temporary "blip" of increased voltage is created. The team trained the machine learning algorithm to pick out these signals from among the noise. The deep neural network they used had a convolutional neural network to identify the important signal features, combined with a recurrent neural network to monitor the time-series data.

(Source: Osaka University)



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Electronics Industry News and Market Highlights

SIA Welcomes White House Meeting on Semiconductor Supply Chain ▸

The Semiconductor Industry Association (SIA) released the following statement from President and CEO John Neuffer regarding a meeting at the White House between Biden Administration officials and leaders in the semiconductor industry supply chain to discuss the global chip shortage and actions needed to strengthen America's semiconductor supply chains.

Ansys, Rockwell Automation Optimize Industrial Operations With Expanded Digital Twin Connectivity ▸

Ansys and Rockwell Automation are expanding digital twin connectivity to industrial control systems, enabling users to optimize the design, deployment, and performance of industrial operations.

Siemens Launches Xcelerator as a Service ▸

Siemens announced the launch of Xcelerator as a Service (XaaS).

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.

Scientists Demonstrate Pathway to Forerunner of Rugged Nanotubes ▸

Scientists have identified a chemical pathway to an innovative insulating nanomaterial that could lead to large-scale industrial production for a variety of uses—including in spacesuits and military vehicles.

BT, Oracle to Accelerate Delivery of New 5G Services in the UK ▸

BT Group—the UK's largest mobile and broadband provider—has selected Oracle Communications Cloud Native Converged Policy Management to optimize its network resources and bring new 5G offerings to market faster.

University of Bayreuth Uses New LPKF ProtoLaser R4 ▸

Researchers in engineering sciences at the University of Bayreuth now have a unique laser device equipped with an ultrashort-pulse laser source for material processing available to them.

Nano One, Euro Manganese Develop Applications for Lithium-Ion Battery Cathode Materials ▸

Nano One and Euro Manganese have entered into a Joint Development Agreement.

Qualcomm Shares Vision of IoT Services Suite ▸

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.

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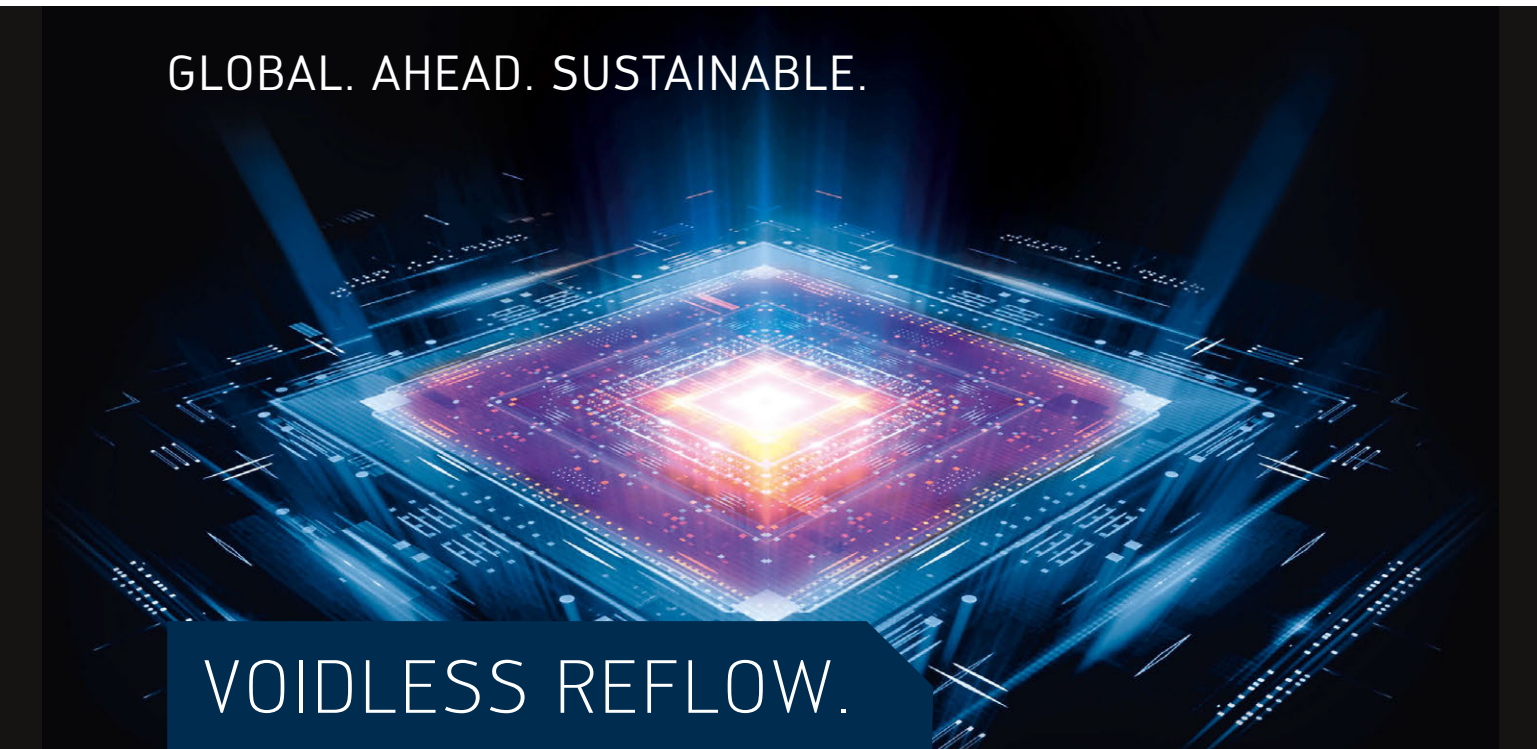

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Research and Development Leads to Biogreen Coatings

Feature Interview by Nolan Johnson
I-CONNECT007

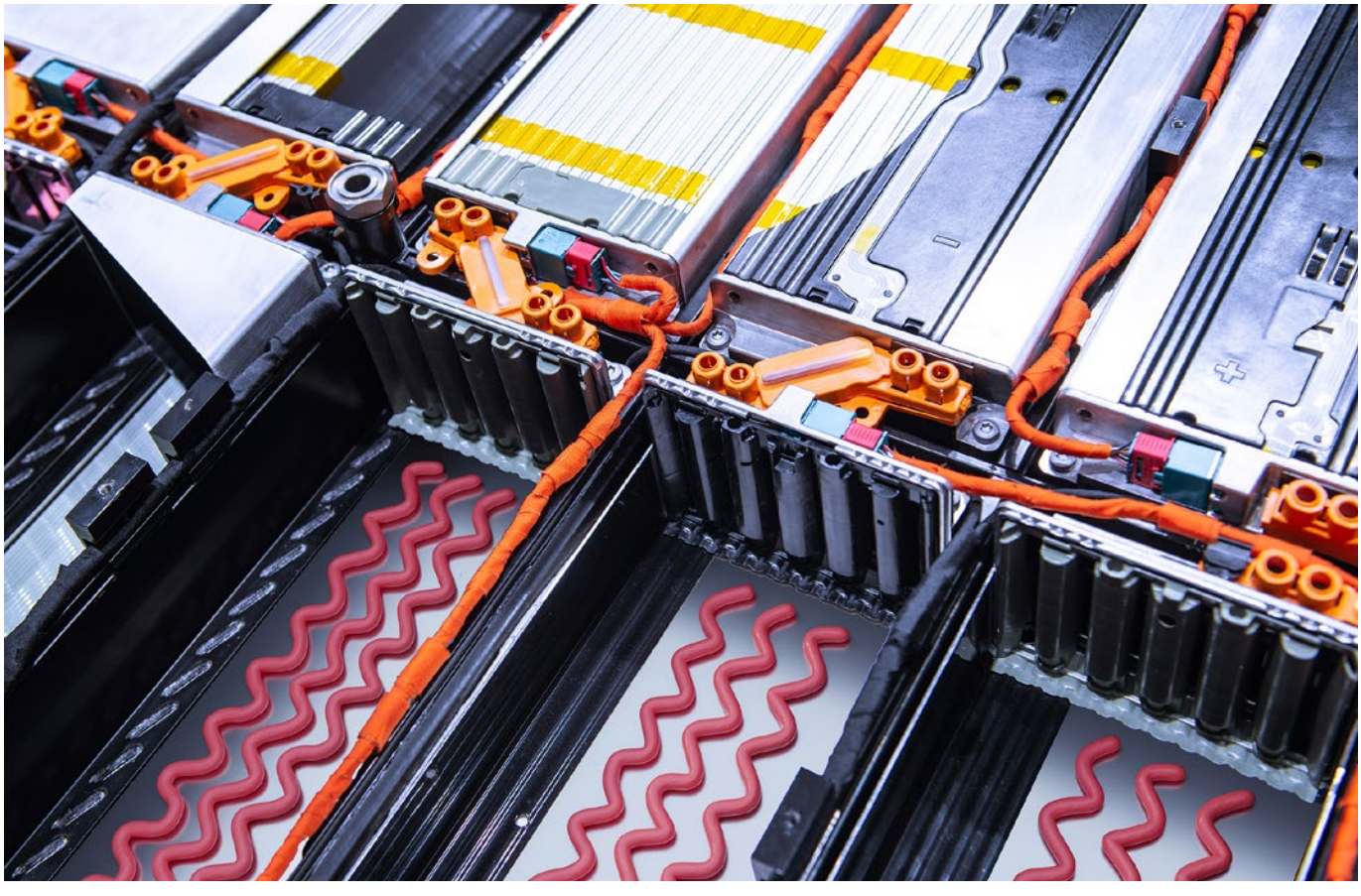
Electrolube's Phil Kinner previews the company's newest products, which will be on display at the upcoming productronica show.

Nolan Johnson: Electrolube (MacDermid Alpha Electronics Solutions) will be at productronica; give us a teaser.

Phil Kinner: This is the first show that we've been to in a while, and we have a couple of new products we are launching. One is a thermal gap filler, designed in China by our Chinese team with a thermal conductivity of 6 watts per meter K, which is really decent. We also have a new conformal coating with a high degree of bio-renewable source materials. Wherever possible, we sourced raw materials from renewable sources, which has less impact on the environment and improved product performance. Improved performance was what we were aiming for, and the bio-renewable aspect was a bonus.

Johnson: What should readers know about the gap filler you're taking to productronica?

Kinner: For a reasonably high thermal connectivity, it has low viscosity, is easy to use,



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and is less abrasive on dispensing equipment than previous generations of material have been. Those are the main features of the products.


Phil Kinner

Johnson: How is that thermal gap filler applied?

Kinner: Typically, it's a two-component material. It will be dispensed with a robotic dispensing system, but it's also available in side-by-side cartridges for manual applications if required.

Johnson: With the new coating, is the goal to have better performance, with the added benefit to customers of making your entire supply chain green and bio-friendly? How did that come to be?

Kinner: Yes. We do a lot of work looking at harsh environments testing. We have been doing a lot of work with the National Physical Laboratory in England, particularly in condensation testing. We did pretty well compared to our peers, but one of the things that stood out was we knew we could do better. That really set us in the direction of, "Here's the problem. How do we get better performance?" In listening to customers, we learned that UV curing is always of interest because it helps with single piece flow, minimizes energy consumption, and speeds up time to handling, which are always good things. So, we set about making a material that would answer those fundamental issues. The performance was driven by the end application. Internally, we had decided to test a lot of renewable raw materials. We know that performance is okay or better than some of the petroleum-derived alternatives, so whenever we can, our intention is to use renewably sourced materials.

Our "How can we deliver better performance?" project came together. We can make it UV-curable, and we can get a high degree of bio-renewable materials into the system. As far as the question about certified organic, for one of the raw materials, we are relying on information from our supplier. We've seen data that shows the percentage of carbon-14, and from that you can calculate how much of it really is renewable. One of the other raw materials must be from an organic source. There's no other way of getting it.

Johnson: That one's easy.

Kinner: Yes. We did our best to fact check the supply chain and we have that data available for anyone who is interested in it; not that people wouldn't believe us.

Johnson: At the same time, you've mentioned that the performance is better. Were you primarily driven to get a green coating because of a customer specification or was it the drive for improved performance?

Kinner: It was by design, and we knew that we could do it. It's a win in both regards. If you're just interested in performance, this material has it in abundance. If you want the green aspect, then that's there too. I've yet to see anyone request it, but that's been our history. We tend not to wait until customers ask for things before we make them available. With all the geopolitics that we've seen during the pandemic, the recent fires in California, Europe, Australia and other places, the media has been highlighting climate change. If there's an opportunity to use bio-renewable sources, then why wouldn't you? If you can get the performance, why wouldn't you do it?

Johnson: What has been the customer reaction to the renewable and green characteristics of this new product?

Kinner: A couple of customers have evaluated the material and the feedback has been outstanding. They found that the performance is as we described it, which is their primary interest. The green aspect is nice to have, but what we're really doing is future-proofing it because it's nice to qualify material. Then, two years down the road, the government says, "You need to do your bit for the environment," and it's covered. It's not something they're necessarily thinking about, but it's definitely nice to have. However, the key thing is the performance and that is better. Every generation of these materials has been a little bit better than the previous one. That's continued here.

Johnson: You will have both these products at productronica.

Kinner: Yes, we will.

Johnson: I presume then that we'll be seeing them at IPC APEX EXPO also?

Kinner: Yes, definitely, we will be exhibiting with MacDermid Alpha Electronics Solutions and these are key launches for us.

Johnson: Travel restrictions allowing, of course.

Kinner: Double vaccinated people are allowed back into the U.S. starting in November. So, fingers crossed, we'll be there.

Johnson: But for those in the industry who are interested in looking at these products, they will be able to find them there.

Kinner: They will be able to find them there, they can see the presentations, and we'll be there to answer any questions.

Johnson: Great. Any comment on the MacDermid Alpha acquisition of Electrolube?

Kinner: It's interesting, being acquired by such a big company, getting access to wider R&D groups and getting a different perspective. For many years, a lot of problems were always the solder paste guys or the flux guys. Now they're our guys. That's an interesting perspective and I think there will be some interesting collaboration that results from it.

For many years, a lot of problems were always the solder paste guys or the flux guys. Now they're our guys.

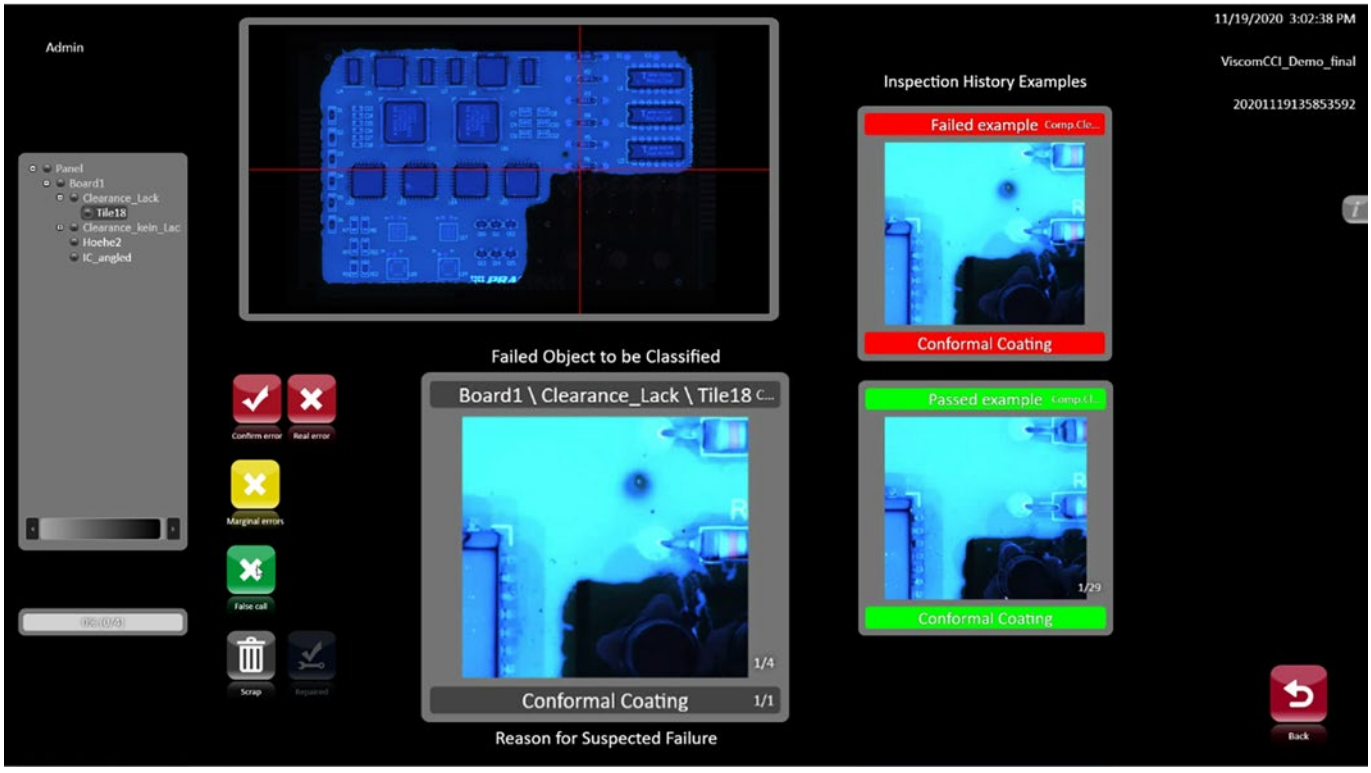
Johnson: Is that sort of dynamic showing up in the company culture?

Kinner: I think the company culture will follow. We're all naturally inquisitive and when it comes to finding solutions to problems, it's always been part of our DNA to get as far toward the root causes as we can. What we're really seeing is we have colleagues with the same inclinations; together, we're able to get even further toward the root causes of the issues. I'm confident there will be some really cool new products; it's been extremely interesting and really beneficial, so far.

Johnson: Very good. It will be interesting to see what happens over time.

Kinner: Absolutely. Very exciting. SMT007

Phil Kinner is the head of R&D at Electrolube, and an I-Connect007 columnist. To read past columns or contact Kinner, click here. Download your free copy of Electrolube's book, *The Printed Circuit Assembler's Guide to... Conformal Coatings for Harsh Environments,* and watch the micro webinar series "Coatings Uncoated!"



Conformal Coatings and Legacy X-rays

Feature Interview by Nolan Johnson
I-CONNECT007

Viscom President Ed Moll talks about test and inspection, specifically the company's X-ray technologies and current state-of-the-art conformal coating inspection.

Nolan Johnson: Ed, what's happening in the test and inspection marketplace? What are the pain points for customers, and where is that driving the market?

Ed Moll: It depends on the product line, whether its solder paste inspection, optical inspection, or X-ray inspection; a new recent trend would be conformal coating inspection. We are doing quite a bit of work in conformal coating inspection, which is being driven by the auto manufacturers requiring that those who are doing conformal coating are collecting data, not just visually inspecting, using a black light, and determining that it's good. They want to see some actual data. That's been a growth factor over the last several years.

Another area of high activity is replacing aging X-ray machines that many of the contract manufacturers and OEMs have been using for many years. The Agilent machines are now 20+ years old. Many customers have kept their machines running by cannibalizing parts from other machines. To address that we have introduced a new line of inline X-ray machines to provide a go-forward solution. The customers who see the machine are very impressed because they're used to looking at 20-year-old technology and the strides that have been made in digital flat panels in the last few years are creating eye-popping images now at high production line speeds.

Our products can handle boards up to 26 inches wide by up to 63 inches long and they can weigh up to 15 kilos (33 pounds). We already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have applications for it. We are doing demos in our office in Atlanta, and of course, at Viscom in Hanover, Germany, our corporate headquarters. We are very confident this new addition to our product line will be well received in the marketplace.

Johnson: Let's start with conformal coatings. Often, inspection is simply looking for coverage of the board. But automotive applications have more detailed expectations. Are those expectations changing the data-gathering for automotive?

Moll: Basically, it's the same as when you're doing any optical inspection. The conformal coating inspection machine will clearly show that the conformal coating is in areas that it should be while making sure that it's not in the keep-out areas. We use angular cameras to look at the sides of the components. Rather than just looking at it from the top-down view, we're looking at it from the side and that's the kind of information that customers want. If you just have an operator looking at it and he says it's good, fills out the tracking paperwork, and off it goes, there's no traceability.

The Viscom iX7059 offers reliable inspection for heavy, solid, and encased components.

Johnson: Does this play into inter-machine operability?

Ed Moll

Moll: All our in-line machines are Industry 4.0, CFX, and Hermes compatible.

Johnson: For Industry 4.0, taking that data and turning it into analysis or operational knowledge seems to be the next step. How is Viscom making that data more available?

Moll: For example, we have software for artificial intelligence where we're collecting images to build up a history that will also help the operator with his classification. In other words, it's based on the classified data that we've already collected. The software will assist the operator when classifying a flagged image.

Johnson: Let's talk about X-ray replacements. I was fascinated by the new X-ray technology. What makes the new equipment better for current Agilent users?

Moll: One of the main items would be the flat panel detectors. The image quality that's coming from the flat panel detectors accomplishes two things. It makes it easier for the algorithms to work because the images are much clearer, and the images that transfer to the classification station are very crisp and sharp. The operators who are performing the classification can clearly make good choices. The other advantage over these older machines is the cycle time; the cycle times are going to be much faster. You will get a better image in less time, for better results.

Johnson: Better image, faster time, therefore, a better throughput. It helps with the capacity. You're not a bottleneck any more in the manufacturing line.

Moll: Right. For example, someone who might be running three of these older machines can replace them with one or two machines, so they don't need to buy one for one.

Johnson: That certainly helps overall, with everything from footprint to throughput, from capacity to investment, and operating costs.

Moll: The operating costs would be less in one big respect: you're not paying a yearly license fee for your software updates. Viscom software updates are free for life. If it's an upgrade where we must replace some hardware, a frame grabber, or something else to take advantage of the software update, you must pay for the hardware. But the software update itself is free and with those older machines, they were charging quite a substantial licensing fee every year and expensive maintenance contracts. Now with these new machines, we can offer maintenance contracts, but there's certainly no reason that an owner of the equipment can't maintain it himself. It's not that hard.

Johnson: One of the things that I'm hearing as a common theme is that test and inspection is a necessary evil. It's something that they do because their customers demand it of them. They increase their investment or put in new equipment because they have customers who expect them to do a more thorough job in some way. What is your take?

Moll: Well, how do you put a price tag on making your customer happy? What is that worth? I realize that there are many who say testing doesn't add any value. However, what does it cost if you have a field return or a field failure where that antilock brake didn't work because you didn't do your inspection properly? How do you put a price tag on that? From our point of view, there's a lot of value add, but I do know that some people feel it's just a necessary evil. I strongly disagree.

Johnson: Ed, thank you very much. I appreciate this. SMT007

International Team Improves Efficiency of Liquid Metal Batteries

Climate protection means increasingly turning to renewable energies. But in order to store the energy produced by solar, wind and other regenerative processes, sophisticated systems are required. Today's storage options are still too expensive and hardly or even impossible to recycle. Scientists at HZDR's Institute of Fluid Dynamics have been working on liquid metal batteries for several years and are now in the European vanguard. Together with the Massachusetts Institute of Technology (MIT), HZDR's scientist Dr. Norbert Weber has managed to decisively optimize a novel lithium lead battery. Thanks to an improved electrolyte formulation, the team was able to increase the power efficiency to nearly 100% and the energy density by 45% at the same time.

The batteries are exposed to a working temperature of more than 400° C so that the metals are present in liquid form. Lithium, which is located at the top of the battery is separated from the heavy lead on the bottom by a molten salt layer. The membrane functions as a kind of additional, second dividing wall between the metals lithium and lead and thus reinforces the molten salt by preventing unwanted chemical processes that would irreversibly damage the battery.

(Source: HZDR)

Supplier Highlights

Omron Automation Americas Launches Next Generation 3D AOI ▸

Introducing the Omron VT-S10 series 3D AOI, the first PCB inspection system that uses innovative, multi-direction, multi-colour imaging, MPS 3D hardware and advanced AI to reduce false calls, improve first-pass yields, and optimize defect detection.

Cogiscan, iTAC to Demonstrate SMT Factory Digitalization Solutions at productronica ▸

Cogiscan, a connectivity and TTC solutions provider for the electronics manufacturing industry, is proud to join iTAC Software AG for Productronica 2021 in Hall A3 at Booth 161.

L3Harris Selects Aegis' Platform for 20 Manufacturing Locations with Over 5,500 Users ▸

Aegis Software, a global provider of Manufacturing Execution Software (MES), has signed an enterprise agreement with L3Harris Technologies to support 20 manufacturing sites and more than 5,500 end users with the Aegis' FactoryLogix® platform.

Sanmina Strengthens Focus on Extensive Optical, RF and Microelectronics Capabilities ▸

Sanmina Corporation announced that it is strengthening its focus on its extensive optical, radio frequency (RF) and microelectronics (microE) design and manufacturing capabilities to capitalize on growing demand for highly integrated technology products.

Indium Corporation Mourns the Loss of Board Chairman William N. Macartney III ▸

It is with great sadness that Indium Corporation announces the passing of Chairman William (Bill) N. Macartney III on September 14, 2021.

CalcuQuote Adds NAC Semi to Quoting System for EMS ▸

CalcuQuote customers will benefit from the inclusion of NAC Semi, a global electronic component design service and distributor into the CalcuQuote ecosystem designed for electronics contract manufacturers.

Totech Europe Displaying Dry Storage Solutions at productronica 2021 ▸

Moisture management specialist Totech EU will feature a wide range of electronics dry storage and logistics solutions at November's productronica at stand A3-277.

Mycronic to Showcase Enhanced Process Control Solutions for Flexible PCB Assembly at productronica ▸

As a leading global partner for integrated PCB assembly solutions, Mycronic will continue to demonstrate the benefits of the flexible factory at productronica in Munich, November 16-19, 2021.

MIRTEC to Exhibit Complete Line of Automotive Pin Inspection Solutions at productronica 2021 ▸

MIRTEC will showcase its cutting-edge INTELLI-PRO AI Based Smart Factory Automation Solution and GENSYS-PIN Automotive Pin Inspection System in booth #461, Hall A2 at the 2021 productronica exhibition.

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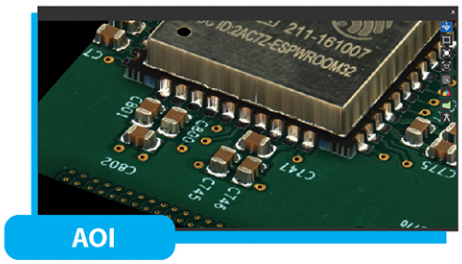

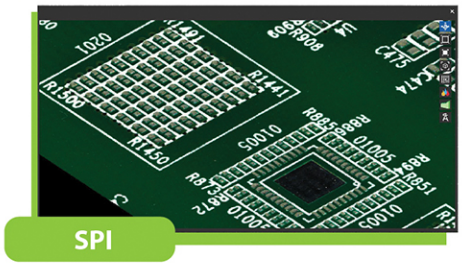

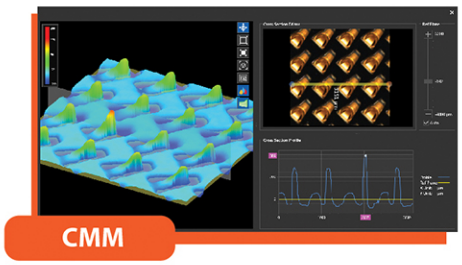

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New Feeder Design for Eliminating Errors Prior to Placement

The Mannifest

by Emmalee Gagnon, MANNCORP

As new technology and methods have emerged, companies in the electronics manufacturing field now have new options to consider for improving their best practices. These practices have helped influence the design of new equipment with ground-breaking capabilities. One recent industry advancement is the design of feeders with built-in OLED screens. This innovation helps create a pre-inspection stage that allows for operators to review components before they enter the machine. By having pre-inspection capability at the feeder stage, companies running in-house equipment can avoid manufacturing hiccups before they occur—providing better turnover and less downtime.

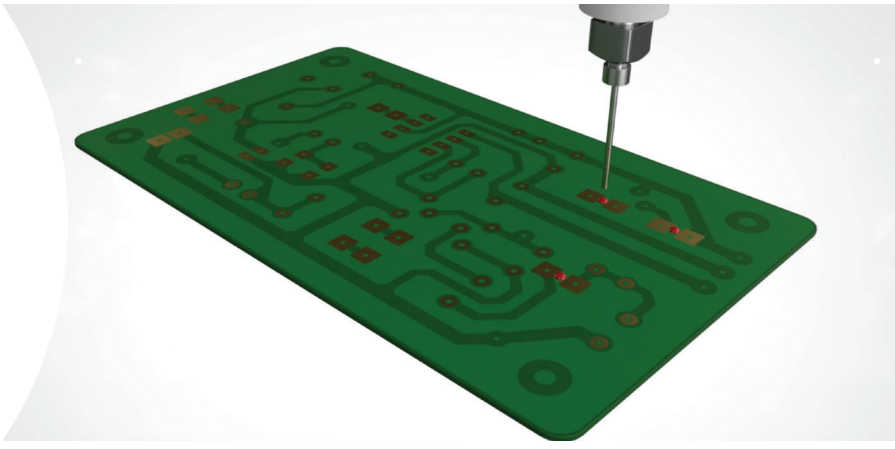
Avoid Production Mistakes: Innovative Feeders with Built-in Displays

Before feeders with built-in displays hit the market, it was up to operators to use component counters for determining the reel information. Now, that information is stored directly and constantly updated within the feeder itself. These new feeders allow operators to review component quantities on reels, feed-

Figure 1: View component quantities, feeder slot locations, part numbers and values, and more on the built-in display.

alpha

f(x)



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er slot locations, part numbers, part values, and more—all while the machine is in use or offline.

Being able to view this vital information on the feeder itself will help solve problems before they occur. For example, if a reel has two of the same packages with different values, they will look the same, and the pick-and-place machine will not be able to tell them apart. An inspection machine may or may not be able to tell the difference. The result could be misplaced components. This pre-inspection stage adds an extra level of insurance that the correct parts will be placed accurately from the onset, fixing problems before reaching the inspection stage.

Being able to view this vital information on the feeder itself will help solve problems before they occur.

Highlights of this new feeder type include:

- Component reel information is now stored/updated in the feeder
- OLED displays allow for easy monitoring of the component consumption status
- The feeder has an internal battery, so data will always be available in both online (connected to machine) and offline (standalone) modes
- Vision library names are displayed (for example 0201, SOIC16, QFP44, etc.) and the feeder stores the lot and date codes of components

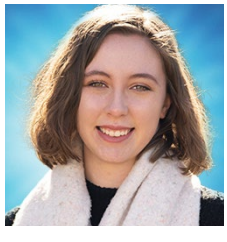
The Real-World Impact of the Improved Feeder Design

With operators being able to view important information at a glance, there will be fewer chances for mistakes. This is especially helpful if/when onboarding new employees who may be less familiar with the equipment, components, and the system. The innovative on-feeder display reduces chances of:

1. Placement errors on boards: Operators will see if the component is correct or incorrect before the part is placed, helping cut down on wasted PCBs.
2. Putting multiple feeders in the wrong slots: Operators will know what the part number is and which slot it goes into, eliminating the need to cross reference a feeder ID with the program.
3. Costly shortages and equipment downtime: The remaining part quantity is tracked and easily viewable, ensuring enough parts will be available to run the entire job in question.

A Small Change to Your Production Line for a Large Impact

Due to the scarcity of components and machine operators this year, equipment designers have risen to the unique challenges in the industry and provided this updated feeder design to reduce the amount of resources companies must devote to inspection and rework. These feeders are available and compatible with select pick-and-place machines released in the third quarter of 2021. By adding this pre-inspection technology to your equipment line, operators will be able to eliminate errors prior to placement, reduce the amount of work done during final testing and inspection, and save much needed time and resources. **SMT007**



Emmalee Gagnon writes about SMT-related topics and customer stories for Manncorp. To read past columns or contact Gagnon, click here.

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IPC-J-STD-001: The State of the Standard

Feature Article by Jonathon Vermillion
BALL AEROSPACE

One of the most frequent questions I was asked during the last year was about the biggest changes in revision H of the IPC J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies. The J-STD-001 is the material and process requirements used for manufacturing of electronic assemblies.

The latest revision of the J-Standard was mostly completed online with working group meetings. There were more than 1,700 comments submitted to the H revision, including those from the IPC-A-610 Task Group. While some of these were editorial or overcome by events (OBE), there were still quite a few for a mostly all volunteer task group. We achieved the first draft industry review (FDIR) milestone right after IPC APEX EXPO 2020. One month later, we were all caught in the grips of a lockdown and a pandemic, and we planned to transition to online meetings. There was similar push at our day jobs, which made sense. It worked out well; we split up comments and worked as a team. I researched the technical comments, while co-chairperson Milea Kammer dispositioned the editorials. Technical comments must go to the task group for resolution, as it takes a two-thirds group vote to close a comment. Sometimes we have comments that can't be accepted or dismissed. In that case, we might assign a working group to the issue. We usually find that when we can't reach consensus, we either don't have enough information or we haven't talked it out enough.

In 2015, it was recognized that the long-standing cleanliness provisions of J-STD-001 Section 8 were no longer adequate for modern electronics and that a new approach was needed. A group of cleaning subject matter experts (SMEs), dubbed the Rhino team, were assembled to create the new protocol. This group of SMEs was led by Doug Pauls of Collins Aerospace, a long-time leader in cleaning materials and processes in the IPC. He said "tiger" was overused and he always had a fondness for the rhino, a particular animal of the Serengeti. The team was tasked to come up with a better way of characterizing acceptable/unac-


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ceptable residues on electronic assemblies and the effects of the residues, and to address both clean and no-clean electronics. This SME team (or A-Team) met two to three times a month over the course of three years, resulting in the approach published in J-STD-001, Revision G, Amendment 1. Because this was such a dramatic change from what manufacturers were used to, the Rhino team also generated a detailed white paper, explaining the changes. IPC-WP-019A was the resulting document. When IPC-J-STD-001 went to Revision H, WP-019 (Rev B) was also revised to keep the language current. In addition, several members of the Rhino team have hosted half-day and full-day professional development (PD) course to help people understand the changes.

Several members of the Rhino team have hosted half-day and full-day professional development (PD) course to help people understand the changes.

Most of the information included in the overhaul are a reaffirmation of Chapter 3, "Materials, Components and Equipment Requirements," but also addressed many questions that were not addressed in previous revisions of the standard, such as: What requalification is needed for a change in materials or processes? What is a major change, what is a minor change? How is no-clean manufacturing addressed in a section focused on cleaning?

The single biggest change in the new protocol is that prior to the new protocol, the use of the Resistivity of Solvent Extract (ROSE) test was used as the arbiter between acceptably clean and unacceptably dirty, using a metric of 1.56 micrograms of sodium chloride equivalence per square centimeter. The new protocols declared that test as an obsolete practice for determining acceptably clean or unacceptably dirty but could still be used for process control. It was recognized that replacing ROSE for product acceptance with another test would likely be a long process.

Some of the confusion comes from what is in the white paper and what is in the released revision H. The approval of J-STD-001 G Amendment 1 was supported by WP-019A, and J-STD-001 H was supported by WP-019B.

One thing missing from the new cleaning section is, "For assemblies soldered with ROL0 or ROL1 fluxes and tested by Static Extraction Method, contamination shall [D1D2D3] (Defect all classes) be less than 1.56 micrograms/cm^2 sodium chloride (NaCl) equivalent ionic or ionizable flux residue." That number is no longer there. I thought it was an odd number (even though it's an even number) but most of that has to do with its Imperial English equivalent: 10 micrograms/in^2. That's the number I remember the requirement as being. Most people mention that it has been in use as long as they have been in electronics, so for me that would be the late 1970s. Also, I really didn't worry about cleaning requirements at that time for a few reasons. First, I wasn't a process control engineer, I was an assembler. Also, we used high solid rosin fluxes and a vapor degreaser with a great fluorocarbon cleaner. Our assemblies also had very large electrical clearances. We hadn't heard of surface mount components at that time. The vapor degreaser worked great; I was sad to hear it was depleting the ozone and we had to get rid of it.

I just recently implemented the 3 Sigma test methodology based on empirical data of acceptable hardware. That upper control limit (UCL) that we came up with was significantly less than the old requirement. I was concerned with the change at first but if your process is in control then you will pass the test 99.73% of the time (at least that's what I told our lead polymerics technician). What we had feared

for so long really wasn't that big a deal. I recommend reading the WP-019B and Chapter 8 of the J-STD-001, to confirm that it's not as bad as people may think.

I will try to address the changes in layman's terms. You must have objective evidence that what you are doing is producing acceptable hardware. It gives you three options:

1. Surface insulation resistance (SIR) testing, testing of cleaning test boards and sometimes called test vehicles, IAW IPC-9202 and IPC-9203. SIR testing uses a grid in hard to clean areas to test for damaging contaminants building up over time with increased temperature and humidity. Ion chromatography (IC) testing could be used to assist in identifying possible contaminants left behind.
2. "If it ain't broke don't fix it." What you are doing has been documented as safe and effective for your service environment on delivered hardware over time (See J-STD-001 - Appendix C).
3. Custom testing that simulates the service environment. Troubleshoot any failures to determine if residues caused the failure.

- Rework processes (solder, flux, heat) need to be included
- Once you do this you don't need to requalify until you change something called out in 8.3
- Determine your UCL (the WP-019 is helpful); document your process
- What to do if you exceed your UCL?
- What if you change something?

Those are covered well in 8.2.3 and 8.3. The best advice I can give is to read WP-019B, because it gives examples to help determine what works for you.

Some of the other major changes to revision H were:

- Clarification on the word lead as an attachment and lead (Pb) the element that may be found in solder. The homograph (words that are spelled the same but having different meanings) could be confusing for other translations of the J-STD-001. It was proposed that the term lead (a part attachment) would remain unchanged, and lead (the element) would be lead (Pb) or Pb-free as needed. This has now become a common change in multiple IPC documents as they are updated.
- Clarification of voiding from the process not being followed, compared to normal voids that naturally occur. This was very helpful because there was some confusion on the subject, so Appendix D was incorporated to clarify this issue. Team Skeleton, led by the outgoing chairs, Dan Foster and Kathy Johnston, worked this task.
- Addition of new SMT parts. Inductors wrapped around terminal posts (quad package). SMT electrolytic capacitor (AKA V-Chip) or sometimes a crystal called Vertical Cylindrical Cans with outward L-shaped leads. Flat unformed leads (not powered) criteria for ribbon cables. Center terminations on SMT chip components.
- Modification to flat and round gull wing leads for toe overhang and heel fillet requirements. Data was presented by Udo Welzel (co-chairperson of the Auto Addendum) for a proposal to change the heel fillet requirement to one-half the lead thickness for Product Class 3. The concern here was the leads were relatively thick and additional solder needed to meet the requirement could result in a weakened solder joint as shown in thermal cycle testing. Also, the contact area of the lead on the land and toe overhang were tweaked to help address some issues.
- You may notice that the International Space Station symbol is gone. It was only

editorial in the first place. The Space Addendum (SA) group does not know what needs to be mitigated until the latest revision is released. For example, that group determined that the heel fillet requirement for gull wing parts should be left at one lead thickness. That may have caused some confusion if the symbol was missing from the root document. Also, there are more addendums being released. The Auto Addendum (AA) is very popular, and they will be building more hardware than the Space Addendum group (for now at least).

More addendums to the J-STD-001 are being released. The Auto Addendum is very popular and will build more hardware than the Space Addendum group (for now at least). Whereas the Space Addendum is used for hardware exposed to vibration and extreme thermal cyclic service environments (i.e., spacecraft, critical military) the Auto Addendum is focused on automotive electronics and their unique processes and applications.

Currently we are accepting comments for revision J. We have a December 5 deadline for comments to be addressed at IPC APEX EXPO 2022. We have working groups addressing such issues as "lead, wire, conductor" and where they are used, as well as criteria for solder cup wetting/fill. We have a team looking to consolidate the minimum electrical clearance (MEC) and give examples, stating that it's always a defect when it's violated. We will be meeting face to face at APEX and I look forward to seeing everyone there. If you haven't participated in the past, we are always looking for ways to make the documents better for everyone, so please join us. **SMT007**

Jonathon Vermillion is principle M&P engineer at Ball Aerospace co-chair of the J-STD-001 Task Group.

All-nitride Superconducting Qubit Made on a Silicon Substrate

Researchers at the National Institute of Information and Communications Technology, in collaboration with researchers at the National Institute of Advanced Industrial Science and Technology and the Tokai National Higher Education and Research System Nagoya University have succeeded in developing an all-nitride superconducting qubit using epitaxial growth on a silicon substrate that does not use aluminum as the conductive material.

This qubit uses niobium nitride (NbN) with a superconducting transition temperature of 16 K (-257 °C) as the electrode material, and aluminum nitride (AlN) for the insulating layer of the Josephson junction. It is a new type of qubit made of all-nitride materials grown epitaxially on a silicon substrate and free of any amorphous oxides, which are a major noise source.

By realizing this new material qubit on a silicon substrate, long coherence times have been obtained: an energy relaxation time (T1) of 16 microseconds and a phase relaxation time (T2) of 22 microseconds as the mean values. This is about 32 times T1 and about 44 times T2 of nitride superconducting qubits grown on a conventional magnesium oxide substrate.

By using niobium nitride as a superconductor, it is possible to construct a superconducting quantum circuit that operates more stably, and it is expected to contribute to the development of quantum computers and quantum nodes as basic elements of quantum computation. We will continue to work on optimizing the circuit structure and fabrication process, and we will proceed with research and development to further extend the coherence time and realize large-scale integration.

(Source: NICT)

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MilAero007 Highlights

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.

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.

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.

U.S. Defense Department Awards $8.9M 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.

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.

Collins Aerospace's MS-177 ISR Sensor Now Supporting Global Hawk Operational Missions ▸

The U.S Air Force (USAF) recently completed its first RQ-4B Global Hawk Block 30 unmanned aerial system (UAS) operational mission carrying Collins Aerospace's MS-177 multi-spectral imaging (MSI) sensor.

Scientists Demonstrate Pathway to Forerunner of Rugged Nanotubes ▸

Scientists have identified a chemical pathway to an innovative insulating nanomaterial that could lead to large-scale industrial production for a variety of uses–including in spacesuits and military vehicles.

Successful C-130 Test Flight Moves Collins Aerospace's EVS System ▸

Collins Aerospace successfully completed a test flight proving the effectiveness of its Enhanced Vision System (EVS) on a C130J aircraft. EVS has, for many years, increased situational awareness on commercial and business aircraft.

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Keysight's Massively Parallel Board Test

Feature Interview by Nolan Johnson
I-CONNECT007

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: We're talking about best practices and strategies for testing and inspection. The motivation for this was a relatively new product Keysight announced that performs massively parallel board test and inspection. Let's talk about the market drivers leading up to the development of that solution. What are the pain points the customer faces? And how is the industry changing to make room for massively parallel testing inspection?

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

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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.

Christopher Cain

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, 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.

Johnson: It sounds like this is an Asian market product. Is that correct?

Cain: Five or ten years ago, I would have agreed with that, but today is different. We're selling this in every region: Europe, the Americas, and Asia, of course. We're seeing a shift in manufacturing. Asia continues to expand, but we see regional manufacturing take hold in every region of the world—North America, South America, Europe—and shifting in different parts of Asia. There is tremendous expansion into places like Thailand, Vietnam, and the Philippines, as well as China.

Johnson: Let's drill down on that. With this interest in massively parallel work, what are customers looking for that is consistent across the regions? And what is unique about the different regions?

Cain: There are some consistencies because some of these are global companies with a consistency of operation to ensure business efficiency. And then you see some variations, some areas of focus and specialty. But overall, for electronic products in general, it's becoming much more regionally diversified.

They're looking at the total balance of the cost of producing electronic assemblies that are not necessarily dictated by the labor that goes into it as much as maybe 10 or 20 years ago; it's the cost and transporting of the materials. You have customers demanding a relatively fast turn between order and delivery of a product. So, especially in the areas of things like automotive, it isn't just a mega factory.

In one area of the world, it's mega factories. Elsewhere, especially with the move to electric vehicles and other very highly electronic products, you see regional manufacturing being set up so those vehicles aren't in a container on a ship in transport. That's a lot of capital and time spent. They would rather assemble those, then transport those quickly to the end customer, and sell them.

Johnson: You mentioned earlier about consumer-type products being a great fit for this equipment and now you're mentioning automotive. Those two things dovetail. Are automotive applications a primary driver for this sort of high-volume low-mix?

Cain: It's one of the primary drivers. As I mentioned, consumer electronics are the infusion of almost everything at this point. Look at the

computational power of a smart thermostat—that would have been a nice desktop computer 10 or 15 years ago. It's fully connected to the internet; it's the transformation of interconnected communication, especially wireless devices, into a much larger infrastructure typically controlled by software, or it is used downstream for analytics. The electronics that go into a vehicle are anything but simple, especially for autonomous driving. Some of the most seriously complex computational horsepower available today goes into an autonomous vehicle. I'm not saying those are super high volume yet, but the amount of computational power electronics, the number of sensors, the complexity of sensors, the complexity of assemblies, all go into what we take for granted.

Johnson: In developing this product, overcoming those challenges, what came out of the R&D? What became the primary features or attributes of this equipment?

Cain: One of the things decided early on was automation, which is two-fold and plays into the question that you asked me earlier about platforms, factory automation, and data interplay. There is physical automation; and data automation, which leads to data analytics insights, especially if you get to predictive and prescriptive insights, because those feed back into a method to make sure that what you measure is helping you improve.

One of my favorite quotes is from Lord Kelvin, who said, in essence, "If you cannot measure it, you cannot improve it." There is a lot of work that goes into the scientific process, analytics, and knowing root cause; then you act and continuously improve. We established a platform that could enable customers to do that, starting with physical automation, while thoroughly putting the hooks in for data automation to make sure that customers could use the information that is gathered, to gain insights and act quickly to improve yields, improve their time to market, and to be first in market. Those are things these high-volume electronics customers hold very dear.

Johnson: It seems to be at a critical juncture. We have Industry 4.0 infrastructure and data protocols that capture data, add a process, and can communicate that from machine to machine up and down your line or elsewhere in your facility. That information is available, but only as raw data. Now we need to process that data to turn it into actionable, meaningful control and guidance, whether that means fine-tuning process windows automatically between machines, or providing management-usable information back to the operators and supervisors. I'm sure there is some interesting R&D going on there.

Cain: Yes. There are two primary forms to physically automate. One is to do a conveyor system. That's well-known and used in the industry. The other is to use islands of robotics to load and unload printed circuit assemblies as they get manufactured. We do both. This particular system uses a guided rail for automation and there are things like IPC CFX, Hermes, and other standards we fully comply with. Those standards then make these systems plug and play into the larger context. These are not islands unto themselves; they're part of a whole chain of equipment that other vendors create, and at the end, that customers create themselves to essentially manufacture and verify that what they're manufacturing is indeed ready to send to customers.

We've also been investing in an analytics platform for manufacturing called PathWave Manufacturing Analytics, which has been deeply integrated into this massively parallel test platform and other manufacturing test platforms that we make. It is also built to be integrated with any test platform—anything that produces data.

Industry standards continue to evolve, so we aren't as concerned about the format. We will take it all. If we don't have a way to convert

it to a common use, we will create one. What helps is to think about your data, your need to be agnostic to the format. You are right that after data translation, there is a big difference between data, insights, and actions. We've developed quite the domain expertise in what works, and what doesn't work. What does it mean when this result happens? We put together data on its platform and then add in, algorithmically, our expertise.

We've developed quite the domain expertise in what works, and what doesn't work.

For example, you know if you get a stream of tested boards going by and you know these are all bed-of-nails contact points. Your audience is probably familiar with that, and one of the things, especially with printed circuit boards bed-of-nails contact points, is they get dirty in the bed of nails and the probes wear out. Then your contacts can start to fail, and that creates a measurement failure. It's very common. When people start to see a measurement fail consistently, one of the first things they do is to ask if it's the probing. Do I need to replace or clean the probes now? The problem occurs if you wait until it fails; then your line is down.

Now imagine if, through analytics, you could see through the data that the measurements were starting to come off what they normally would be. You need to be careful and note the difference between passing and failing, but if you notice the passing cases are slowly getting worse and you combine that with domain expertise, you might see an indication that maybe a probe is getting dirty or will probably start to fail. You could send a predictive alert: "You might want to take a look at this probe at the next shift, change, clean, or fix it at the next opportunity where the line doesn't have to go down." Now the value of giving people that proactive information is huge because it results in zero downtime.

It also starts with good, solid measurement data. It's terrible to predict the future with noisy data.

Johnson: That's part of what you're driving toward, to look at the data and not only figure out what is what, but if it tests pass and fail data. What is product specific data and what is machine maintenance data? You could be looking at data and realize you have a hotspot of failures in one corner of the board. Is that manufacturing or is that measurement?

Cain: Or is it a batch of parts? It could be a lot of things. Is it process related? Is it correlated to a specific set of operators? Yes, and so it's very helpful to not just collect the data on one island of information, but correlate it to multiple sources, like who was the operator running the tester, which fixture was on the tester, and which tester it was. How does that compare to others testing the same product at nearly the same time? Those are all very interesting points to correlate the data; that gives you some insight into the root cause, so you take action and do better.

Johnson: Do you see that analysis as something that your products should be delivering or should this kind of analysis be considered higher level? Does the analysis go to somebody else who is specializing in the management and process control for the line? Where do you see the industry evolving to?

Cain: It's at a fun state where there are many options; to be honest, a lot of people are quite rightly doing it themselves because the tools and capabilities are not that hard to obtain. And that's not a bad way to do it, but there are pockets where you can purchase a premade solution,

which allows you to focus on your core competencies and core value add. You want to leverage competencies from others. That's part of the trick and everybody is learning that for their business at this point. What we're trying to do is to help them on that journey, and frankly, we're taking the journey ourselves and learning.

Near term, we want to make sure our customers are successful now. But at the same time, we want to raise the bar in a big way, long term. We are trying to pick and choose where we fit and where we can add value to our customers. We feel the right formula for us to do this is to leverage the data science and computational power available today with our domain expertise.

Now, we can't do that in every domain. We already talked to some customers and said, "Well, maybe we don't have the domain expertise. Maybe you do or somebody else does." They've asked if they can use our platform. We said, "Yes, and there are also all these other platforms you can use." There's a lot available, so the best thing is to experiment and learn to accelerate the process. Keep in mind what you are trying to improve and are you measuring it? Are you really improving?

A lot of people are playing with the tools and a lot of people can do data analytics. But when we find anomalies and you ask the data scientists what the anomaly means, they would say, "I don't know, you tell me."

Johnson: I think that analysis is the area to have the most innovation in the future.

Cain: Yes. When we designed this massively parallel platform, we made sure that it plugged and played very nicely with both physical automation and data analytics automation. We also left the choice open on what people want to make massively parallel; we purposely chose sub-assemblies' capabilities that we knew were very scalable. While we did some ourselves, like the interconnect or what we called the switch fabric between the test fixture to the system, we left some open to the users by providing a PXI infrastructure in the form of a PXI chassis in the system. It's a standardized interface that is scalable in terms of the measurement. There are multiple types of instruments available, including the i7090 measurement card itself, which we designed to fit into a 3U PXI module.

Johnson: Test and inspection is seen as a necessary evil, a cost of doing business, not as a contributor to the profit margins in any way. How is Keysight turning that around so that customers see this as an investment that returns and adds to their margin?

Cain: You must not become a bottleneck in the workflow if you try to apply a traditional board test system that can test up to four boards at once: "On these units that are lower complexity but higher volume, they may be built on a panel of 64. Can you test those four at a time?" "Yeah, absolutely, that's no problem." We had a case where a customer had something like that, and it was taking 120 seconds to test. On our massively parallel program, it took less than 20 seconds.

Instead of having a bunch of testers per line, now you need, maybe one, for multiple lines,

depending on your flow through your line. That gives you not only efficiency in the capital cost, but in manufacturing. What's interesting is that there is much more emphasis on physical space taken. The most precious commodity at most electronic factories is floor space.

The most precious commodity at most electronic factories is floor space.

We help customers with that return on investment. Typically, that's measured in time, or by the cost of the system. But we're delivering a return on investment, in many cases, in less than a year. Compared to the amortization period that finance typically uses, which is five or even seven years, that's not bad for a piece of capital equipment. That means after that period (less than one year), after getting back the return on investment made on the i7090, test costs now become profit margin.

Johnson: Of course, you face some interesting challenges with this sort of an application being very parallel. You mentioned that some of the value add to a facility could be fewer test machines, which would normally indicate a bottleneck, but when you're doing the kind of preventative maintenance, analysis, and early warning, it's no longer a bottleneck. It is a throughput.

Cain: That's correct. Throughput and yield. We've helped manufacturers achieve literally greater than 99% yield. That is not easy in printed circuit assemblies. It's doable, but that is not simple. They require a huge investment of continuous improvement.

Johnson: Where do customers start to improve yield?

Cain: Most people will say that they have 90% yield. Of course, yield is a funny thing as it depends on where you measure it. Are you measuring it at the point that the boards were coming, ready to be turned on or tested? As an assembly? There are other test stages prior to that. There's no doubt about that, and there are test stages after that, but if you look at the point where they come out of the reflow oven, or they have most of the parts assembled and soldered onto the board on a printed circuit assembly, most people would probably have a realistic yield of 70–80%, and that's not too bad. Now they'll say it's higher, because they'll measure it at a later stage. For 98%, that means, likely, one out of 400 boards failed. You must wait a half hour for that to occur and if you think about that, that's a high volume into factoring a line.

Again, not everybody needs to get to that yield. We're not trying to get everybody to 99%, because that requires a very large investment, and it must match your business outcome. We're just trying to give them the tools to match their situation.

Johnson: It's interesting about getting 99% yield because once you're doing that, it usually comes with even tighter tolerance, and results more centered in the process window, which then sets you up for longevity of your product in the field. It's just a better-quality product overall.

Cain: Correct. Some companies specialize in that kind of perspective. That's how they're differentiating in the market. You must pick the business outcomes that are most important to your business. What are the tools you will use to get there quicker and sustain it at a very efficient level?

Johnson: What advice do you have for those who are manufacturing and might need massively parallel testing? Also, what advice do you have for the manufacturers who are look-

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ing at test and inspection of a more high-mix, low-volume configuration?

Cain: First, I'd say design for manufacturability and design for scale are super important. I don't think you can under-invest in those, to be honest. Now, you still want to be paid back. You don't want to waste your time and money because you don't have any to waste, but there are the benefits. The leverage you get by designing for manufacturability, designing for yield, and designing for the outcomes you want to achieve is huge.

Johnson: With that answer, though, you just pointed the finger at the OEM design team to set up manufacturing to succeed, right?

Cain: Yes, which in a lot of cases has become a challenge because as the industry has matured, electronics (and in most cases) OEMs, are not the same company manufacturing. It's contract manufacturing or outsourced, and there's nothing wrong with that; you just must work hard to span that bridge. It's not to say that the OEM must become an expert on a task, but they must know the questions to ask. I've seen customers get extremely high yield. There is a very deep partnership, not a vendor relationship, but a partnership between the OEM and the CM. The other thing is to be sure you're measuring the right things at the right point in time. There's not a simple formula, unfortunately, for that; there are many ways to do it. You must experiment and try things. I encourage people to run experiments, learn from them, and then in an agile fashion, make it better.

I'm increasingly seeing other workflows in a lot of industries become very tuned to this agile Lean process. To me, analytics is the embodiment of W. Edwards Deming and Lean manufacturing processes which use feedback loops in processes such as PDCA. I love continuously improving feedback loops.

Johnson: What advice would you have around test and inspection to make it generally better than it is?

Cain: Here's an example. We have an automation system that we designed over a decade ago. It wasn't publicly available. It was designed purposely to create test automation, to move sub-assemblies, which in our case were electronic test and measurement instruments like vector network analyzers. As they were being assembled, it would take that unit and move it from one test stage to the next. Previously, the reason we did that is we had racks full of instruments and these racks would be developed to test the product. With the next variant, we have another rack of instruments testing the product. One day, about 15 years ago, we measured the utilization of that equipment, and we were shocked how low most of it was.

We were running out of space, which is a common thing for a lot of manufacturers, and we knew we had to do something. So, we reinvented how we performed tests by creating a set of test stages so that any one of them doesn't completely test a unit. It tests only part of it, but we designed it to maximize the utilization of the equipment. Then, to make that work efficiently instead of having operators running around like crazy, we put a machine and automation to move the equipment around automatically. Now, the approach is to take a step back when you're in a high-mix environment. Utilization in space usually ends up being a bigger driver, and so you must rethink the test problem: instead of optimizing to test a unit you optimize to test the flow.

Johnson: Fantastic, great. Thank you for taking the time.

Cain: Sure, I enjoyed this. SMT007

Christopher Cain is VP/GM for Electronic Industrial Products at Keysight Technologies.

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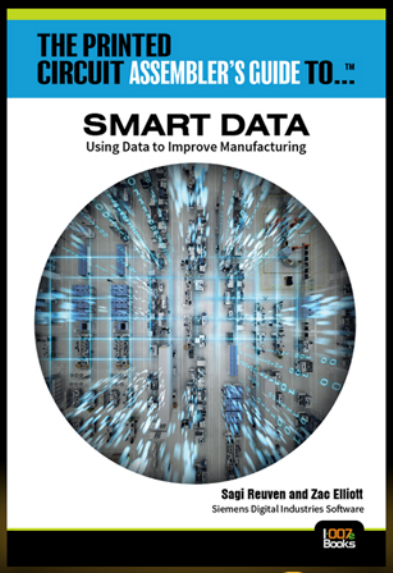

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Methods for Underfilled Component Rework

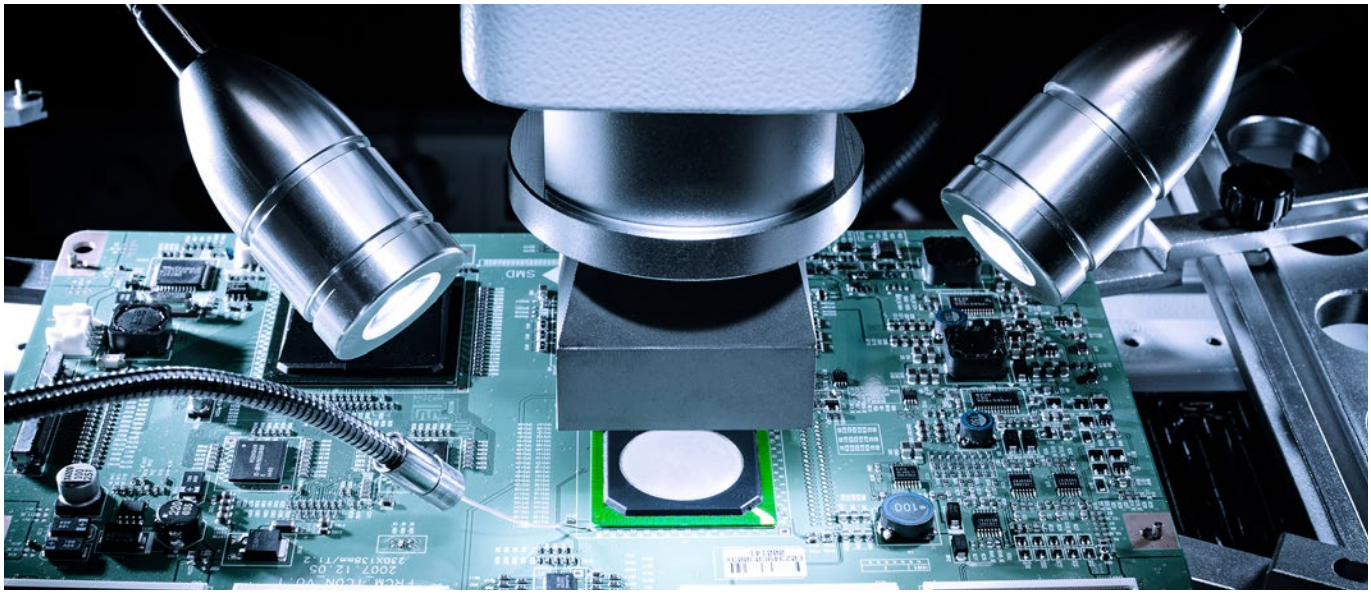
Knocking Down the Bone Pile

by Bob Wettermann, BEST INC.

Products such as engine control modules, drones, smartphones, and other handheld communication devices, which are designed for high reliability and require high processing power, often have a BGA or CSP package as the processor. Underfill has been a solution at the package level protecting these devices from the coefficient of thermal expansion (CTE) mismatch between the device and PCB or between the die and the component substrate for flip chip packages. Stress caused by CTE mismatch redistributes the stress from the bottom of the solder spheres to the entire component. Underfill also provides for a mechanical bond between these surfaces while providing very good protection for the solder joints against both mechanical and thermal strains as the product experiences vibration, drops, or thermal shocks.

Underfill is typically constructed from either an epoxy-based or other polymeric-based material and is dispensed in a controlled fashion underneath the component. Through capillary action and under increased temperature, the underfill makes its way underneath the component. It is typically cured by either thermal or thermo-sonic energy.

The downside of using underfill is that it causes the rework process to be extremely difficult. While some underfills are categorized as "reworkable" this does not mean that the underfill removal process is not without extreme challenges. There are several problems which arise from removing an underfilled component regardless of whether it is "reworkable" or "non-reworkable." The problems are fairly numerous when the underfill is heated and moves around, breaking the bond between board and



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component. Some of the most common problems include:

- Twisting motion to break board/device bond during the component removal process may damage board or neighboring devices
- Using a sharp tool to "cut" the underfill so the component can be removed may damage neighboring components or the PCB
- Mechanically scraping or cutting away the underfill may cause damage to PCB or neighboring components
- The mechanical bond of the underfill to the PCB may cause the lifting of pads, laminate damage, or solder mask damage (Figure 1)
- The time-consuming nature of removing the underfill makes the rework process beyond economic repair
- Heating the solder underneath the BGA/CSP/QFN to a liquidus temperature for removal causes the underfill to begin to reflow, "pushing" solder out from the designated pad areas
- Neighboring underfilled components can be pushed off their pads during the removal process

There are numerous methods which can be used to rework these underfilled devices. Each method has both advantages as well as drawbacks.

The method used most often for reworking underfilled devices involves the use of a heat source to reflow the BGA while simultaneously creating a parting line in the underfill between the component and the PCB. This will release the component from the pads on the PCB, as the softened material still adheres to both the component and the board. Either the BGA rework system has a twisting motion to get the component removed or a bimetallic reflow nozzle "grabs" the suspect component for removal. After component removal, the site is dressed using a hot air source along with a tool

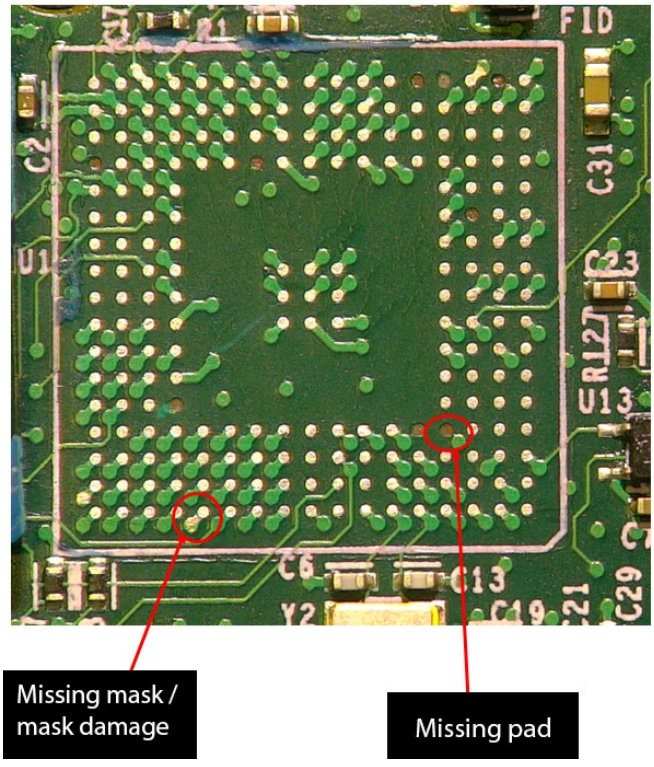

Figure 1: BGA site location after removal of underfilled BGA indicating both pad lifting and mask damage.

such as a solder extractor or a hobby knife, or by utilizing a specific soldering iron chisel tip along with solder braid. If no BGA rework station is available, then a non-controlled heat source such as a heat gun can be used to remove the component from the board followed by clean up. These processes require care and skill by the operator to not damage the board or neighboring components.

Another method which can be used to remove the BGA by breaking the adhesive force of the underfill is via a softening agent. A solvent-based chemical—formulated by the underfill vendor—comes into contact with the underfill and softens it. This allows for easier removal of the underfill, thereby reducing the likelihood of component, mask, or pad damage. One of the drawbacks to this methodology is being able to get the softening agent to all areas of the underfill, as the hardened underfill blocks the liquid from getting to all areas. Furthermore, depending on how

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aggressive it is, the liquid can damage components and device markings as well as other coatings. Post softening agent application cleaning is also a challenge as analytical testing needs to be part of the process qualification. In many cases, the reliability risks imposed by this method are not worth the process time-saving rewards.

A further removal method of the component relies on laser ablation. In this method a directed laser source is programmed to scan the surface area of the laser back and forth to disintegrate or ablate the component, underfill, and some cases, the solder balls. At low laser flux (low laser energy density, w/cm^2), the material is heated by the absorbed laser energy and sublimates. The laser beam is pulsed, electronically controlled, and the beam steered to not destroy neighboring components. This method is useful in applications where either the vibration of the board in precision milling presents too high a reliability risk or when either the component or board warpage is extreme.

A more recent addition to the underfilled BGA/CSP removal process list of alternatives is the use of a precision mill to cut away the device. Typically, "non-reworkable" underfill

Figure 2: Laser-ablated BGA, half height of the component.

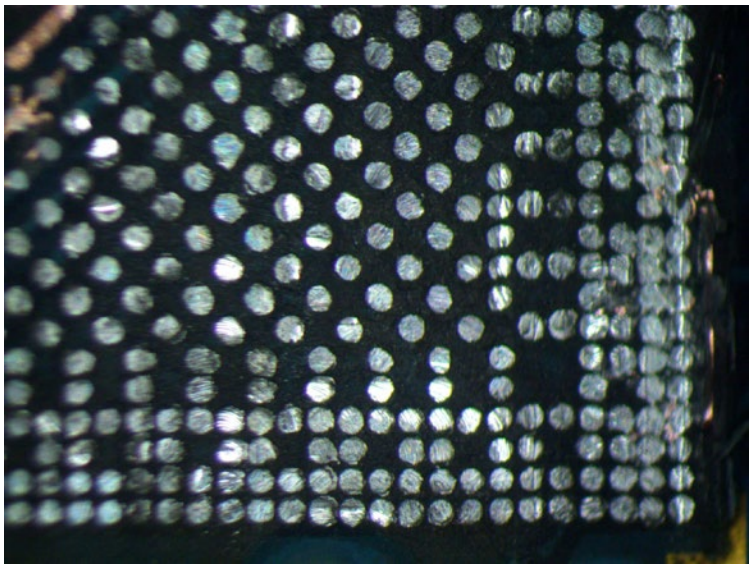

Figure 3: Pads after milling off underfilled BGA.

along with the component and solder is milled off the board. The board is fixtured properly to retain a flat surface, typically with the use of a vacuum fixture. Height sensors make sure the mill does not drive too far down into the board and damage it. Vacuum is also supplied near the cutting area to keep debris off the PCB. As reflow temperatures are not reached, lesser board damage results. The resulting vibration of the milling process and its effect on the board need to be investigated for the end use operating environment.

There are numerous methods for reworking underfilled area array and bottom terminated components. A skilled, experienced rework technician with several methods, including the machinery, available to them will determine the highest yielding method in the fastest amount of time. **SMT007**

Bob Wettermann is the principal of BEST Inc., a contract rework and repair facility in Chicago. For more information, contact info@solder.net. To read past columns or contact Wettermann, click here.

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Taking a Team Approach

Maggie Benson's Journey

by Ronald C. Lasky, INDIUM CORPORATION

Editor's note: Indium Corporation's Ron Lasky continues this series of columns about Maggie Benson, a fictional character, to demonstrate continuous improvement and education in SMT assembly.

Maggie was working in her office, deep in concentration, when she was startled by the phone ringing. It was her mentor, Professor Patty Coleman from Ivy University. Maggie reached to answer the phone.

"Hi Prof...," Maggie started, "Patty."

"Well, Maggie, we still need a little work on you calling me Patty," Patty said, chuckling. "I am calling to thank you again for taking my family to Mount Ascutney to view the Milky Way. Rob, our boys, and I really enjoyed it. I didn't consider that the new moon might be the best time for viewing. It was also neat to see Venus. I was unaware that Venus is in the Western sky after sundown because it is closer to the sun than the earth."

Maggie was beaming. At last, she knew something Professor Coleman didn't!

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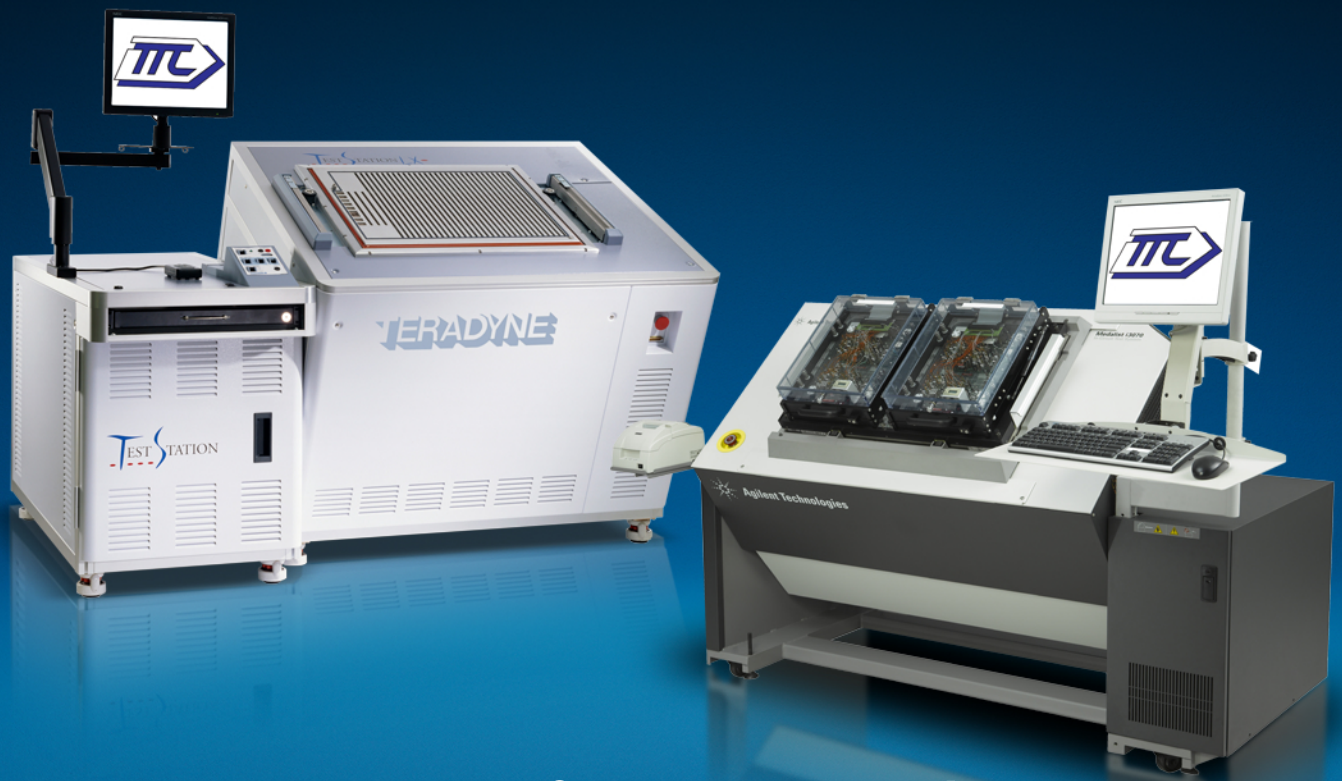

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Figure 1: Maggie recommends a lightweight, inexpensive telescope such as these. (Source: Wikimedia Commons)

Patty continued, "We brought binoculars to Ascutney, but you suggested a telescope instead if it's one that you don't have to lug up a mountain. I was hoping to get one for our sons. Could you recommend one?"

"I think a scope like mine is ideal. It has a six-inch mirror which allows serious viewing yet is small enough to handle. Also, the cost is less than $1,000," Maggie explained.

Maggie sent Patty a link to a similar telescope as hers (Figure 1) and to some astrophotos that a scope like this could take.

Three days later...

Maggie, John, Frank Emory, and Chuck Tower sat in Patty Coleman's spacious university office with plans to review their progress in keeping the lines running during lunch hour.

"So, what's the scoop?" Patty asked.

"Well, it was a resounding success," Maggie stated. "John and Chuck will explain."

Chuck, feeling a little uncertain and after a short awkward silence, let John begin.

"We had an all-hands meeting and announced that everyone would get a $3 per hour raise if the company could keep the lines running during the lunch half-hour," John said. "Frank explained how we lost much more than a half-hour of production time during lunch. It was actually closer to an hour and 15 minutes."

"How was it accepted?" Patty asked.

"At first, we received a lot of skepticism, but as people offered suggestions, the meeting became more and more positive," John continued.

"Let me guess. The first complaint was that the workers wanted to eat lunch together?" Patty asked.

John whispered into Chuck's ear to answer a "yes" to Patty's question.

"As the meeting went on, more suggestions were offered as to how to keep the line running during lunch with the fewest people. One big breakthrough happened when staff who do not work on the line offered to pitch in and help during the lunch hour," Chuck began, hesitatingly.

"What I think is really great is that you let the workers offer suggestions, instead of telling them what to do," Patty said in a complimentary tone.

"It gets better; let Chuck continue," Maggie suggested.

"At the meeting, we organized a group of people to set up a plan, and within a week it was implemented," Chuck said.

"And the results were?" Patty asked.

"We set up a skeleton crew for each line to keep it running during lunch hour. With the staff who don't normally run the line volunteering now, each worker only misses lunch with their friends about once every other week. In addition to the focus on uptime, many people offered helpful suggestions on how to improve uptime in general," Chuck elaborated.

"So how is it working?" Patty asked.

"Let me take this one," Frank said. "Uptime skyrocketed to just over 45%. The financials are mind-blowing. As a reminder, with uptime at 30%, we were at a little less than $2.8 mil-

Title of Run	Total Sales	Unit Profit	# Units	Total Profit	Δ to Baseline
BE with 40% UT with $2/hr Raise NE	$45,405,244.50	$ 13.44	393,119	$5,285,134.66	
BE with 45% UT with $3/hr Raise All	$50,097,201.00	$ 13.45	433,742	$5,833,222.25	$548,087.59

Table 1: The profit picture at 40% and 45% uptime.

lion profit per line. With our plan to get uptime to 40% with the line running during lunch and give the workers a $3 per hour raise, we went to about $5.3 million per line (Table 1). We took a gamble and told everyone, not just the line workers, that we will give them a $3 per hour raise if they can keep the line running during lunch. So, with the uptime at 45% and the $3 raise, the profits went up to over $5.8 million per line."

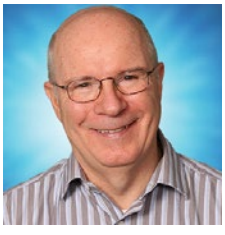
Maggie added, "Having the staff work on the line and offer suggestions was tremendous for bonding and was a great morale booster. In addition, we increased our Christmas bonus program and made it strongly dependent on profitability. So, all the workers now look at the company financials, which are posted monthly. In addition, lunchtime is still a fulfilling social experience."

As the group walked out of the office, Patty's smile disappeared, only to be replaced with a scowl.

Epilogue

Why is Patty scowling? And what is your process uptime improvement plan? Do you keep your lines up during lunch?

Cheers, —Dr. Ron



Ronald C. Lasky is an instructional professor of engineering for the Thayer School of Engineering at Dartmouth College, and senior technologist at Indium Corporation. To read past columns, or contact Lasky, click here. Dr. Lasky is the author of *The Printed Circuit Assembler's Guide to... Solder Defects.*

Making Self-driving Cars Human-friendly

Leeds scientists investigating how to better understand human behaviour in traffic say that neuroscientific theories of how the brain makes decisions can be used in automated vehicle technology to improve safety and make them more human-friendly.

The researchers set out to determine whether a decision-making model called drift diffusion could predict when pedestrians would cross a road in front of approaching cars, and whether it could be used in scenarios where the car gives way to the pedestrian, either with or without explicit signals. This prediction capability will allow the autonomous vehicle to communicate more effectively with pedestrians, in terms of its movements in traffic and any external signals such as flashing lights, to maximise traffic flow and decrease uncertainty.

Drift diffusion models assume that people reach decisions after accumulation of sensory evidence up to a threshold at which the decision is made.

To test their model, the team used virtual reality to place trial participants in different road-crossing scenarios in the University's unique HIKER (Highly Immersive Kinematic Experimental Research) pedestrian simulator. Study participants' movements were tracked in high detail while walking freely inside a stereoscopic 3D virtual scene, showing a road with oncoming vehicles. The participants' task was to cross the road as soon as they felt safe to do so.

(Source: University of Leeds)

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

TOP TEN

EDITOR'S PICKS

Siemens Global Webinar: Data-Driven Manufacturing in the Electronics Industry

Pete Starkey had the opportunity to attend the second in the series of Siemens global webinars on data-driven manufacturing in the electronics industry, this time focused on data acquisition and analysis, discussing challenges and methodologies and detailing hardware and software solutions, exemplified by real-world illustrations of successful implementation.

X-Rayted Files: Radiation's Effects on Electronic Components

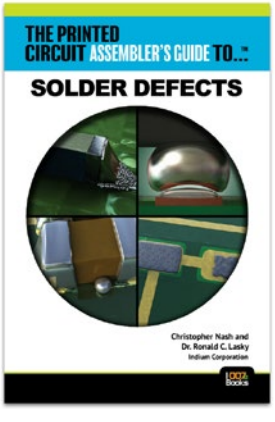
Whether it's from naturally occurring sources or induced by modern human ingenuity, electronic components, like everything else, are subject to regular exposure to radiation. It is vital to understand the various sources of radiation exposure as well as their likely effects on today's microelectronics and the devices they make possible.

I-Connect007 Launches New Micro Webinar Series: 'Converting Process Data Into Intelligence' Presented by the Experts at Koh Young

In this engaging, 12-part micro webinar series, Koh Young topic experts Joel Scutchfield and Ivan Aduna examine 3D inspection, AI, CFX, connectivity and smart factory success.

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

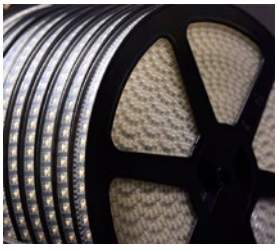
The Printed Circuit Assembler's Guide to... Solder Defects—the latest title in the I-007eBook library—is specifically dedicated to educating the printed circuit board assembly sector and serves as a valuable resource for people seeking the most relevant information available.



Driving Lean Manufacturing with Digitalization

Reducing waste in the manufacturing process is always a challenge, especially when it comes to new product introductions (NPI). It is a key pain point for manufacturers, as waste leads to delays, unexpected costs, quality issues, and lost profit. Waste isn't always about material that must be discarded—it can also include idle workers and equipment, unused material, and inefficient planning processes.

BOMs and the Supply Chain from an Assembler's Point of View



Duane Benson of Screaming Circuits speaks with Nolan Johnson about issues assemblers encounter with BOMs and part shortages. Duane gives advice on how to avoid some common pitfalls.

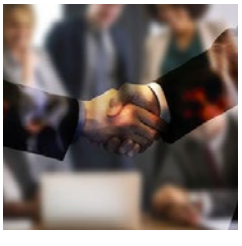
A Multi-Tenant PLM Software Solution

To better understand how bill of materials and business operations software can interact, we reached out to George Lewis, vice president of corporate strategy for Arena, a PTC Business.

SMTA Welcomes New Board Members

The SMTA is pleased to announce its election results for the Global Board of Directors for the term beginning October 4, 2021. Jason Keeping, Celestica, Inc.; Adam Klett, L3Harris Technologies; Cheryl Tulkoff, National Instruments Corporation; and Kirk Van Dreel, Plexus Corp., have been newly elected to the Board of Directors.

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.

Intuitive Machines Chooses Tempo Automation to Return U.S. to Moon's Surface

Tempo Automation, a software-accelerated electronics manufacturer, announced that Intuitive Machines, a provider of space products and services, has chosen Tempo Automation to speed up the rate of innovation of its flight- and space-rated circuit boards.

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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.

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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
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- 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.

apply now

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.

apply now

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.

apply now

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.

apply now

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.

apply now

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.

apply now

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.

apply now

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 micro-electronics 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.

apply now

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

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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.*

apply now

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.

apply now

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.

apply now

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.

apply now

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

apply now

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.

apply now

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.

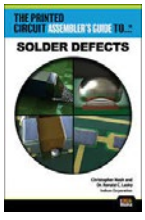
If interested, please submit your resume to HR@eagle-elec.com indicating 'Process Engineer' in the subject line.

apply now

Watch and Learn!

Our latest micro webinar series examines 3D inspection, AI, CFX, connectivity and smart factory success in 12 easy-to-digest segments. Designed to complement Koh Young's I-007eBook, *The Printed Circuit Assembler's Guide to...SMT Inspection, Today, Tomorrow and Beyond,* the presenters share highly focused educational information on the use of data gathered during the inspection process.

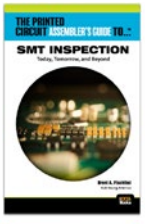
I-007e Books: The Printed Circuit Assembler's Guide to...



Solder Defects

by Christopher Nash and Dr. Ronald C. Lasky, Indium Corporation

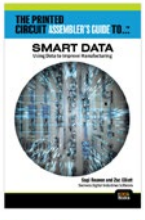
This book is specifically dedicated to educating the printed circuit board assembly sector and serves as a valuable resource for people seeking the most relevant information available.



SMT Inspection: Today, Tomorrow, and Beyond

by Brent Fischthal, Koh Young America

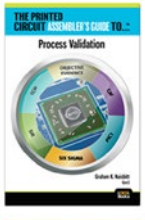
An in-depth insight into new and exciting true 3D inspection technology is provided in this book, along with a look into the future of leveraging big data management and autonomous manufacturing for a smarter factory.



Smart Data: Using Data to Improve Manufacturing

by Sagi Reuven and Zac Elliott, Siemens Digital Industries Software

Manufacturers need to ensure their factory operations work properly, but analyzing data is simply not enough. Companies must take efficiency and waste-reduction efforts to the next phase using big data and advanced analytics to diagnose and correct process flaws.



Process Validation

by Graham K. Naisbitt, Gen3

This book explores how establishing acceptable electrochemical reliability can be achieved by using both CAF and SIR testing. This is a must-read for those in the industry who are concerned about ECM and want to adopt a better and more rigorous approach to ensuring electrochemical reliability.

Advanced Manufacturing in the Digital Age

by Oren Manor, Siemens Digital Industries Software

A must-read for anyone looking for a holistic, systematic approach to leverage new and emerging technologies. The benefits are clear: fewer machine failures, reduced scrap and downtime issues, and improved throughput and productivity.

Our library is open 24/7/365. Visit us at: I-007eBooks.com

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