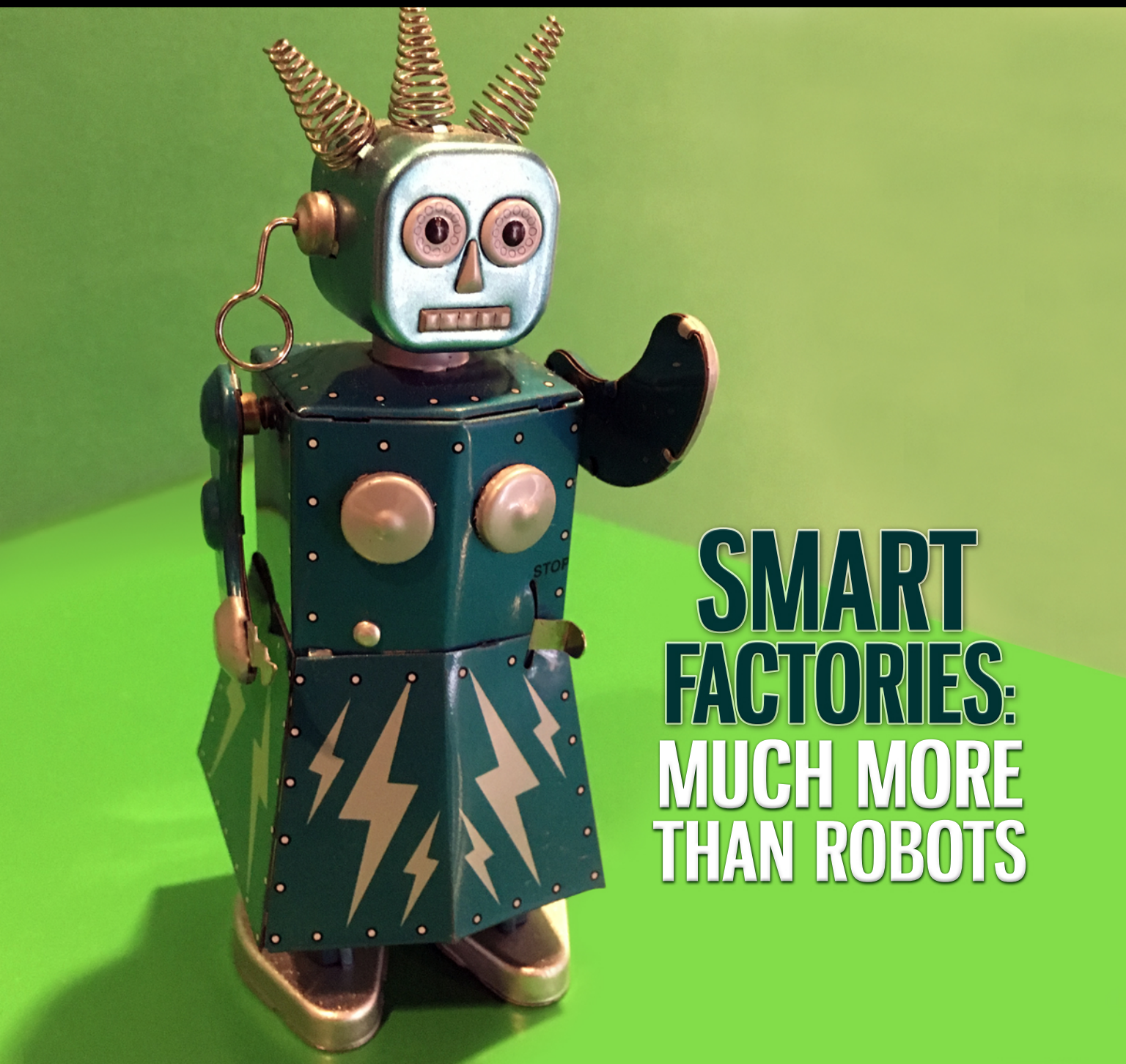
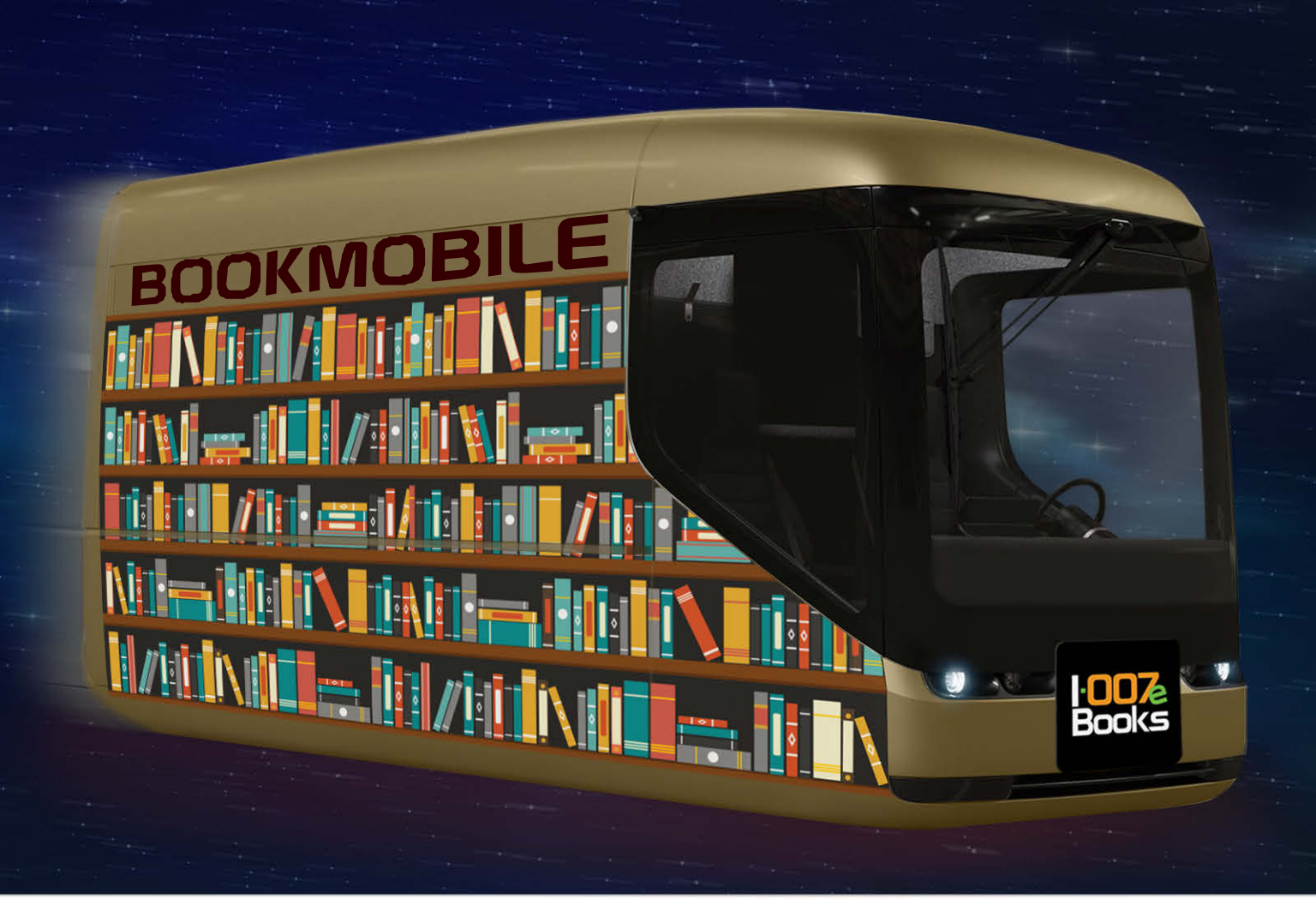
MARCH 2019

I-Connect007

PCB007 MAGAZINE



SMART FACTORIES: MUCH MORE THAN ROBOTS



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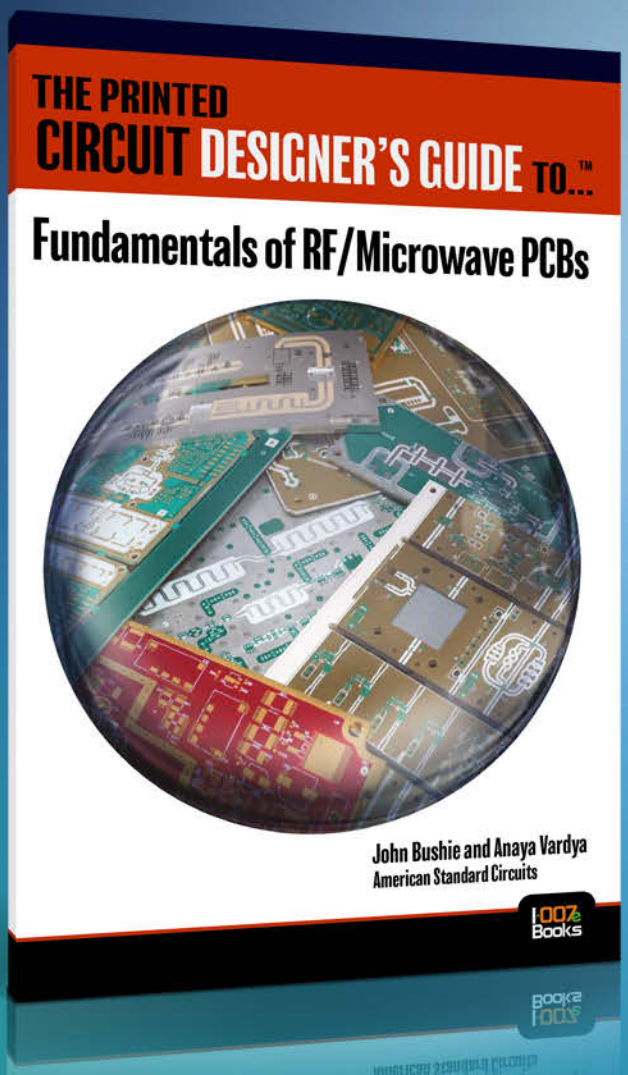

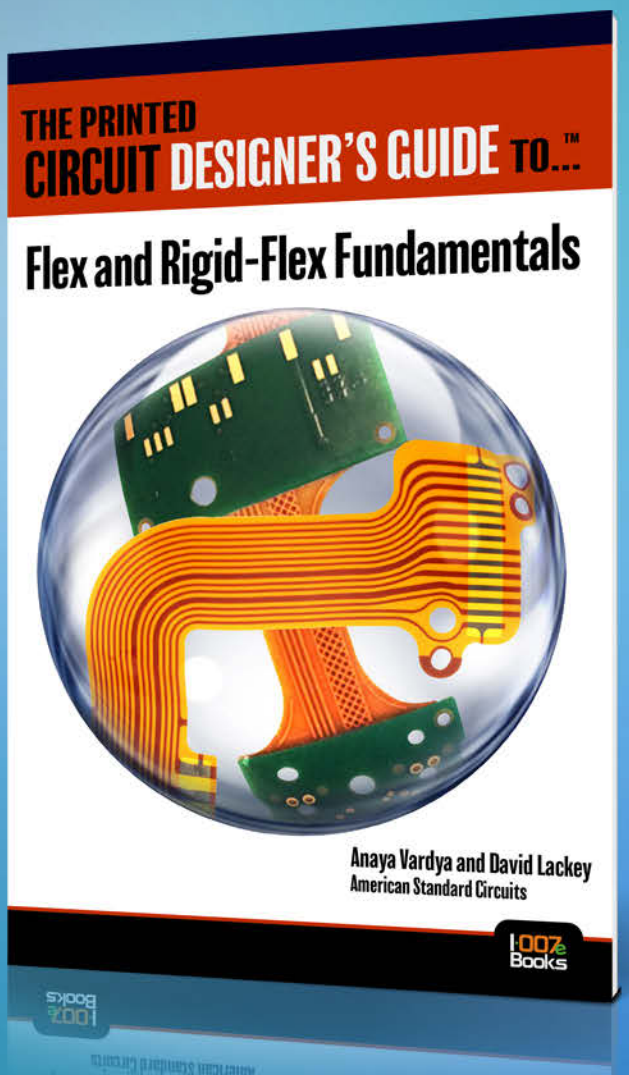

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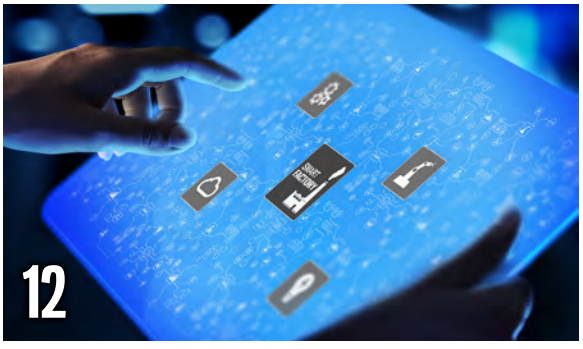

Smart Factories

The acceptance of smart factories is a global movement across multiple industries. In electronics manufacturing specifically, China seems to be a key leader in the move to Industry 4.0. What stands out about the Chinese transition is that automation—robotics, in particular—is a surprisingly small part of the whole solution.

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Smart Factories: More Than Robots

Nolan's Notes

by Nolan Johnson, I-CONNECT007

The acceptance of smart factories is a global movement across multiple industries. In electronics manufacturing specifically, China seems to be a key leader in the move to Industry 4.0. Once seen as an industrial heavyweight that depended on a huge labor pool, the environment in China has transformed. Chinese culture has a history of adaptability, and China's industry-leading implementation of Industry 4.0 concepts is demonstrating that essential skill to the globe once again. What stands out about the Chinese transition is that automation—robotics, in particular—is a surprisingly small part of the whole solution. Don't get me wrong, automation is a crucial component, but automation alone is not the objective.

This issue's focus on smart factories brought out a number of perspectives from our columnists and other contributors. Together, this issue reads like a roundtable discussion on smart factories from various inside-the-industry voices. Even materials and chemistries are aligning with a move toward further automation, which allows equipment manufacturers to capture and store more data, and software layers to perform more detailed analysis, prediction, and optimization. CFX, Hermes, JARA, and other machine-to-machine protocols might be all the buzz right now, but when it comes to Industry 4.0 in printed circuit fabrication, the work will involve the entire supply chain.

A case in point comes from a statement from Bill Cardoso speaking about Creative Electron's work with AI. Cardoso said, "Inspection is graduating. Inspection for 20–30 years has been a cost center. In this new generation of connected equipment—thanks to Industry 4.0, CFX, and other initiatives—it is graduating into a data center." Cardoso continued, "AI is critical for giving pass/fail decisions instead of just giving them an image they have to figure out…instead of giving the customers data, we like to give them information that they can act on."

Pressing the point that Industry 4.0 will transform the entire chain, consider this. If a major contract manufacturer implements Industry 4.0, they will pressure their suppliers—fabricators included—to implement Industry 4.0. Once a PCB fabricator follows suit, then the fabricator's suppliers must do so as well. And once the major participants have made the switch, smaller firms will need to respond or risk being left out of the conversation. This transformation has already begun.

With all of this systemic retooling, it's an understandable concern that jobs will shift; the age-old concern that robots will leave us all out of work

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remains. But where operators were a primary job function in the past, engineers and technicians will be increasingly required in manufacturing to fill the gap. To achieve Industry 4.0, machines will manage the automation and staff will use their analytical skills more than their hands. After all, people are also inherently adaptable to their environments. It's no wonder that educational programs are strongly on the mind of industry leaders and organizations.

In this issue, we start with "The Smart Factory IQ Test" where you can quiz your conceptual Industry 4.0 knowledge based on an often-cited whitepaper published by Deloitte on the smart factory.

Next, Barry Matties visits Ventec International Group's China-based facility. Laminate isn't considered a high-mix, low-volume business—especially in China—but that's exactly their approach.

Dr. John Mitchell, IPC president and CEO, introduces the IPC Education Foundation in his column, which is a 501c(3) organization to assist students and the emerging workforce.

Returning to China, we bring you a report from the recent HKPCA & IPC Show in Hong Kong. Mr. Hu Yang provides an overview of how the Chinese domestic market is developing and changing the fabrication industry.

Tara Dunn shares an example of doing business that serves as a great metaphor and reminder. The real smarts in any factory are—and will continue to be—the people who perform the most complex, heuristic analyses of all. Read her column titled "Old-fashioned Networking."

From people to technology, I-Connect007 Technical Editor Happy Holden and factory automation pioneer posts an overview of the "Hardware and Software in Smart Factories."

Somehow, Steve Williams brings together Star Trek, The Jetsons, and "Maximum Overdrive" in his discussion of the rise of the fourth industrial revolution. In "The New Frontier of Manufacturing," Williams takes a broader view, discussing the key elements making up Industry 4.0 technologies.

The PCB Norsemen consider smart factory technologies and the move into implementation around the globe. They specifically mentioned, "A growing trend is for even more traditional factories to have connected equipment…China is now making a significant amount of investments in AI and smart automation for PCB manufacturing and other related applications."

In "Optimizing the OSP Processes for High Performance," Michael Carano discusses organic solderability preservatives (OSPs). Given that the estimate is that 45% of all the PCBs produced annually use OSPs, this is a dominant finish type.

"Testing Todd" Kolmodin dives into creating "Confidence in Inspection" in his column. Kolmodin discusses third-party inspection, which seems to be gaining ground in the high-growth, high-reliability sectors, such as aerospace and medical. In an emerging smart factory environment, the rise of third-party inspection seems to be a natural evolution.

Wrapping it all up, we bring you "The Travelling Engineer, Part 1." Columnist Mark Ladle shares an anecdote about his initial experiences traveling overseas as a field engineer. As Industry 4.0 transforms the manufacturing workforce, the role of the field engineer will continue to become more important.

So, there you have it—the intersection of smart factories and the emergence of Asia as an early adopter. You can share your smart factory opinions and experiences with I-Connect007 by emailing us at editorial@iconnect007.com. **PCB007**

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

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The Smart Factory IQ Test

Feature by Nolan Johnson
I-CONNECT007

Let's see how prepared you are to talk about Industry 4.0. The following 12-question test will measure how much you know about smart factory concepts and philosophies [1]. Since the concept of a smart factory is larger than the electronics manufacturing industry and encompasses the entire supply chain, the terms and concepts here are also more global in nature.

Questions

1. To realize the digital supply network needed for smart factories, manufacturers must:

a. Introduce horizontal integration through multiple organizational systems
b. Implement vertical integration through manufacturing
c. Integrate throughout the entire value chain
d. All of the above

2. True or False: A smart factory implementation relies on shop floor automation exclusively.

3. True or False: The ability to adjust to and learn from data in real time can make the smart factory more responsive, proactive, and predictive, and enables the organization to avoid operational downtime and other productivity challenges.

4. In a proactive smart factory system, employees and systems can anticipate and act before issues arise, rather than reacting to them after they occur. Which feature is NOT a factor in delivering a proactive smart factory system:

a. Identifying anomalies, restocking, and replenishing
b. Destructive process testing
c. Predictively addressing quality issues
d. Monitoring safety and maintenance concerns

5. True or False: AI, cognitive computing, and machine learning have made it possible for smart factories to override human operator decisions on the shop floor.

6. Which of the following factors makes this the right time for smart factory implementations?

a. Manufacturing has grown increasingly global, fragmenting production and spreading it across multiple geographies
b. Smart, digital technologies have ushered in a new set of competitors who leverage the digitization to enter new markets
c. IT is beginning to take data from automation and turn it into insight and action
d. Skilled talent shortages are forcing manufacturers to mitigate risk and reconfigure staffing to do more with fewer staff
e. A and C
f. B and D
g. All of the above

7. Undertaking a smart factory journey can address a number of business practices. Which is NOT one of those practices:

a. Asset efficiency
b. Sustainability
c. Improved company picnics
d. Better profitability
e. Labor force stability

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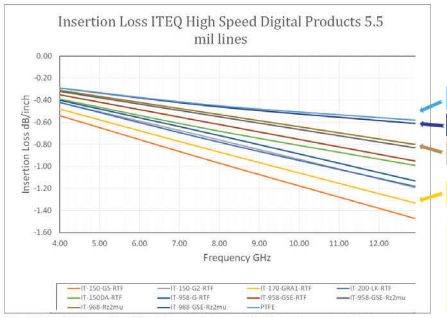

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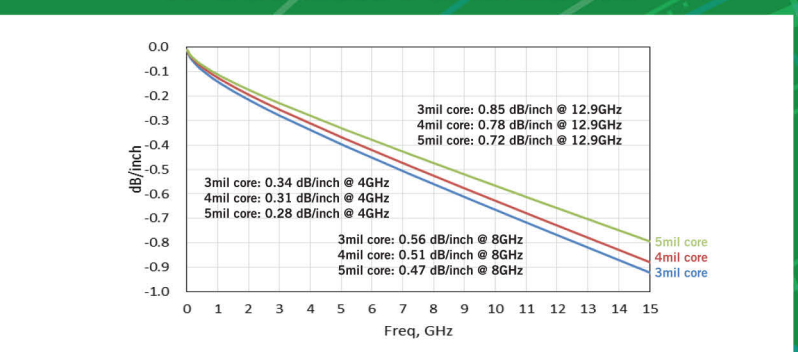

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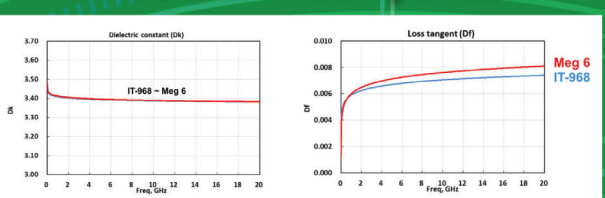

GHz	10		12.9		16		20	
Parameter	Df	Dk	Df	Dk	Df	Dk	Df	Dk
IT-968	0.0071	3.39	0.0072	3.39	0.0073	3.38	0.0074	3.38
M6	0.0076	3.39	0.0078	3.39	0.0079	3.38	0.0081	3.38
%	7.95	0.04	8.52	0.04	8.98	0.03	9.45	0.02

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Property	Test Method	IT-968	IT-968 SE
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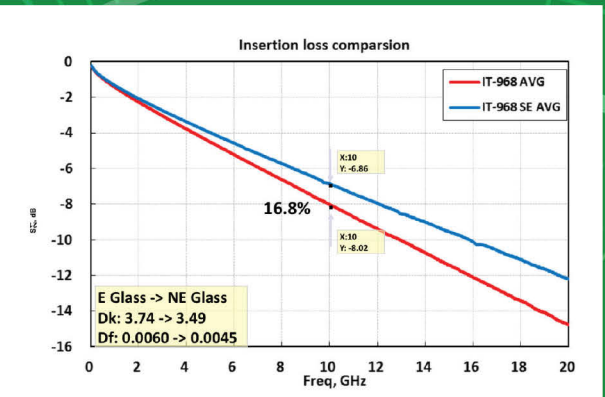
T-288 (w/ 1 Oz Cu, min)	TMA	120+	120+
Td-5%(°C)	TGA 5% loss	390+	390+
CTE (%), 50-260°C	TMA	2.2	2.2
Peel strength (lb/inch)	1 oz	6	6
Water Absorption	D-24/23	< 0.1	< 0.1
Dk , 1 GHz 2-10 GHz	IPC TM-650 2.5.5.9 IPC TM-650 2.5.5.13	3.8 3.8-3.7	3.4 3.4-3.3
Df , 1 GHz 2-10 GHz	IPC TM-650 2.5.5.9 IPC TM-650 2.5.5.13	0.0032 0.0038-0.0050	0.0028 0.0031-0.0040

E-Glass vs Low Dk Glass



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8. True or False: Smart factory automation achieves agile operation with off-the-shelf automation and control systems industry-wide.

9. Industry 4.0 includes which of the following digital and physical technologies:

a. Analytics
b. Web browsers
c. Robotics
d. High-performance computing
e. Augmented reality
f. AI and cognitive technologies
g. Buggy whips
h. Advanced materials

10. True or False: Organizational change management will be a simple, matter-of-fact affair since smart factories will result in a net loss of manufacturing jobs.

11. True or False: Cybersecurity becomes a greater concern precisely because a smart factory is highly connected.

12. True or False: The most effective way to implement a smart factory is to start with a greenfield ground-up/build-out.

Answers

1. D.

2. False. A true smart factory is a more holistic endeavor, moving beyond the shop floor toward influencing the enterprise and broader ecosystem. The smart factory is integral to the broader digital supply network and has multiple facets that manufacturers can leverage to adapt to the changing marketplace more effectively.

3. True.

4. B. While valuable, destructive testing is a post-facto analysis—not a factor in predictive analysis.

5. False. The ability to evolve and adapt, coupled with powerful data processing and storage capabilities, allows manufacturers to move beyond task automation toward more complex, connected processes.

6. G.

7. C. While improved social events may be a secondary effect, it probably benefits from these first-order benefits: increased profitability and reduced costs.

8. False. One of the most important features of the smart factory–agility–also presents manufacturers with multiple options to leverage digital and physical technologies depending on their specific needs. There is no single smart factory configuration, nor is there a single path to successfully achieving a smart factory solution.

9. Everything except B and G. Web browsers may be a fundamental part of accessing data, but strictly speaking, they do predate Industry 4.0. Buggy whips are clearly not Industry 4.0, although they serve as a reminder of what might happen to businesses that do not embrace Industry 4.0 concepts and systems.

10. False. While there may indeed be fewer operations positions in a smart factory, other roles are expected to be augmented by the new capabilities, such as pre-manufacturing engineering positions. New roles will likely emerge as well.

11. True. Every connection is a potential hack point. This exposure only increases as connectivity and data start moving outside the walls of the manufacturer, and up and down the manufacturing supply chain.

12. False. While that may be one way to do it, most existing facilities aren't in a position to simply build new. It can be more effective to start small, testing each new concept and then scaling based on your specific lessons learned. Scaling can proceed from a single asset to a production line, the factory, and/or a network of factories.

Your Rating

1-4: Time to read up. If you scored less than four, then much of the current industry transformation is getting past you.

5-8: Pretty good. You have an awareness, so that's a good start. We suggest you get even more information through further reading. Whether your factory moves to smart factory methods or not, as a professional in this industry, you will need to be informed to remain employable.

9-12: Looks like you're doing your research! If you're preparing for an Industry 4.0 implementation in your factory, keep it up. **PCB007**

Reference

1. Deloitte University Press. 2017. "The Smart Factory: Responsive, Adaptive, Connected Manufacturing–A Deloitte Series on Industry 4.0, Digital Manufacturing Enterprises, and Digital Supply Networks."

Mauro Dallora

DSG: Breaking Ground on the Smart Factory Revolution

by Barry Matties
I-CONNECT007

In 2006, Dongguan Somacis Graphic (DSG) PCB Co. Ltd. took on the challenge of building a PCB manufacturing facility from the ground up in Dongguan, China. Mauro Dallora and the leadership at DSG have since made some serious changes to become a leading Industry 4.0 smart factory.

To accomplish this new manufacturing model, Mauro and his team are retooling and expanding the entire factory. Plans have been made, smart systems have been mapped out, state-of-the-art equipment has been ordered, and the ground has been broken.

After visiting DSG eight years ago, Mauro takes the I-Connect007 team on a tour through the DSG facility and lays out the company's strategy for becoming an Industry 4.0 smart factory while explaining the current ongoing major expansion.

Read about the tour and our interviews with DSG leadership in the March issue of *SMT007 Magazine.*

Ventec Focuses on High-mix Manufacturing

Feature by Barry Matties
I-CONNECT007

The I-Connect007 team recently toured Ventec International Group's Suzhou factory where a modern, flexible manufacturing concept designed for fast delivery is enhancing their established volume manufacturing of specialty, high-reliability epoxy laminates and prepregs. The ongoing investment in the facility to offer flexible world-class high-mix manufacturing capabilities for polyimide, thermal management, low-loss, and signal integrity material solutions supports Ventec's growth strategy in these specialty niches with fast global deliveries.

After a quick 20-minute high-speed train ride from Shanghai to Suzhou, we arrived at Ventec's headquarters and lamination production facility. The facility also houses their highly active R&D center. Ventec, now a publicly traded company on the Taipei Stock Exchange, was founded in 2000. Since that time, they have established a global presence with additional manufacturing locations, service centers, and sales offices in key locations across Asia, Europe, and America.

In Suzhou, Ventec COO Mark Goodwin gave us a tour of the highly flexible manufacturing facility. When it comes to laminate production, you don't usually think of it as a high-mix, low-volume business—especially in China—but that's exactly how Ventec sees it. The factory is tooled with equipment capable of meeting their customer's everchanging delivery needs.

When we asked Goodwin about their strategy, he explained it very simply. Read on to also hear Goodwin's thoughts on supply chain integrity, UL testing and approval, standards, and the impact of Brexit.

Mark Goodwin

Mark Goodwin: Our strategy is to make the right products available to customers quickly. It doesn't work to have great products with long lead times to deliver them; customers lose interest. Thus, our whole strategy is not just to bring new products to the specialty sectors within the market, but to deliver them fast in relatively small quantities. We have presses down to 10

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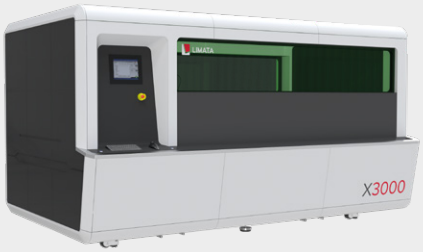

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Barry Matties: Ventec started in 2000 and the growth has been phenomenal.

Goodwin: I've been involved since 2006, and have been responsible for EMEA and the Americas where our growth has been strong.

Matties: How are you doing in Asia?

Goodwin: That's growing as well. You can see from some of the information we've shared with you today that our traditional FR-4 laminate business in certain sectors is being diluted, which is quite deliberate. We have focused our growth on specialty products that are being demanded by the market. Other sectors are shrinking as a percentage of our business but are staying stable in volume. The dicey FR-4 business is really being diluted as we're steering that towards our thermal management and signal integrity products, and polyimides—all of the specialties.

Matties: And you are seeing growth in all of those.

Goodwin: Yes.

Matties: Is this a market-driven factor or a business choice that you're making?

Goodwin: It's both, but it's driven by a strategy that we don't want to be the biggest laminator in the world; we want to be first and we want to be fast. We also want to be flexible in terms of delivery to customers and competitive in price. You need all of those things. It's no good having a great product but no delivery and a price point people can't live with. You have to have all three: price, availability, and performance.

Laminate breakdown system.

Matties: One of the advantages that Ventec enjoys is the distribution network that's built in. Talk a little bit about that.

Goodwin: For me, it's all about customer intimacy. We know our customers very well. We're really close to our customers, and increasingly so with our OEM activity; we're close to our customers' customers as well. That is important with the new products—signal integrity, tec-speed 20.0 for 5G applications, etc.—it's an OEM sell, so we're gaining some traction there. It will take some time because we're coming up against well-established competitors, but we have a drop-in product with tec-speed 20.0. In my opinion, it will come; something will give. Everybody told me we'd never get established in the polyimide business, but look where we are now; we're the market leader in Europe and the world leaders in terms of product quality.

We make very clean laminates and prepregs, and you've seen some state-of-the-art equipment today walking around the factory including specialist filtration and a high degree of automated optical inspection on our prepreg treaters. They find and catch any inclusions before pressing laminates, but it is also part of a feedback loop driving the quality and the cleanliness of the product forward and making it better. That's the more important part.

Matties: It's the feedback loop?

Goodwin: Correct. We have an industrial process. There is a risk inherent in the process of putting some inclusions into the prepreg from raw materials and processes. The first thing is to catch it. Then, you have to improve it and make less to catch, but catch what you do make. Ventec has fewer inclusions than its competitors, and that's the AOI feedback loop in action, which is critical to continuous improvement and has also driven our end-user space qualifications in Europe.

Matties: It's about quality, price, and delivery.

Goodwin: Supply chain integrity is another big thing in some of the markets where we're operating. I think it's going to become increasingly important in general, and specifically in the automotive, aerospace, and medical sectors. Automotive is a sector you will see some fairly strong activity in from Ventec in 2019. We are already well established in the aerospace business. We control our own supply chain, ensuring there's no opportunity for product substitutions, mix-ups, or counterfeits. In traditional supply chains with third-party distributors, things can happen. I'm sure there are some deliberate things that go on, but mostly the things that can happen aren't deliberate. But the fact is you can't end up with somebody else's product in the Ventec supply chain be-

Thermal impedance tester.

Thermal impedance testing.

cause we don't distribute, sell, handle, or manage anybody else's product.

Matties: That's an advantage for you and the customer.

Goodwin: I think so. Again, we have some things going on with anticounterfeiting technologies. It's in its very early days, but it's a big driver for us. If implemented, we'll be able to identify our product from a marker within the product—not a mark on the product, but a marker within the product that we're already manufacturing. I'll be able to walk into a factory, look at a piece of material, and tell not only whether it's a Ventec piece of material, but if it is, what lot number it has and how it traveled through our supply chain. We'll start that in the high-value specialties, and then depending on the need and the demand from customers, we can roll it out widely or not depending on whether customers see value in it and are prepared to pay the cost, and customers only pay that cost if they see the value.

Matties: How soon will we see that?

Goodwin: It's difficult to say, but we're starting the project in earnest and plan on making some product in 2019. I'll keep you updated on it, but it's very new.

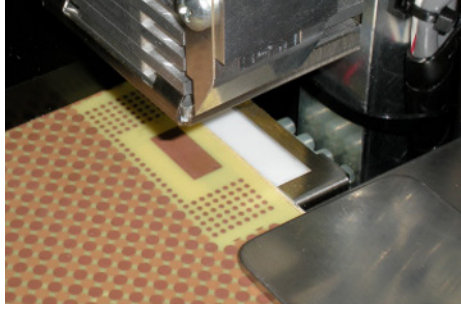
Matties: You have an R&D department here with 50–60 people in this area right now. We were talking a little bit about new products and how you come up with the strategy.

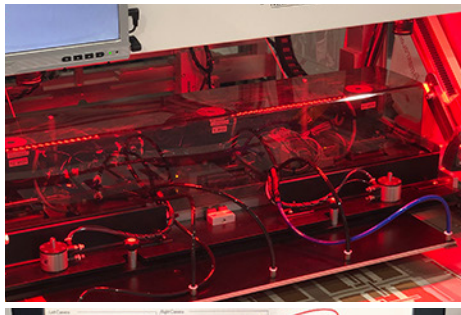
Goodwin: We have some crazy meetings where it's a free-for-all, and ideas come out. They come from the feedback we get from PCB shops, technology roadmaps from OEMs, and extrapolation of those things from our own thinking. In the end, we come up with this mass of ideas. Then, we have to pare that back to something that we can actually develop at an interesting price point for the market and successfully manage through our supply chain.

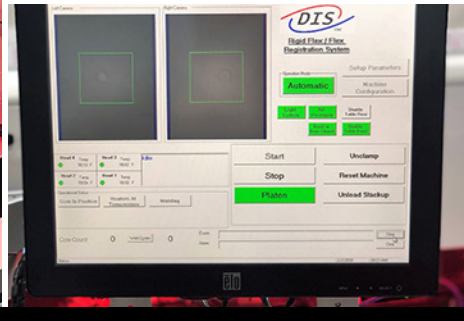
We want it to lead back into our factory where, as we have discussed, we are geared for making high mix, lower volumes of specialty products. We're well placed to do that from a manufacturing perspective. And because we own our own supply chains, we can take inventory decisions and positions globally around the world without having to have serious discussions with third-party distributors about who's going to meet the cost; it's all our cost. We look at the supply chain angle and marketing as part of the product development cost. There's no point in developing products and not having a budget to get them out into the market.

Matties: It's absolutely part of that cost. We talked about the timing too. It takes three to five years, and a large part of that is testing.

Goodwin: UL is a bugbear for us, and they charge a lot of money for what they do. We can argue about the necessity, but it is what it







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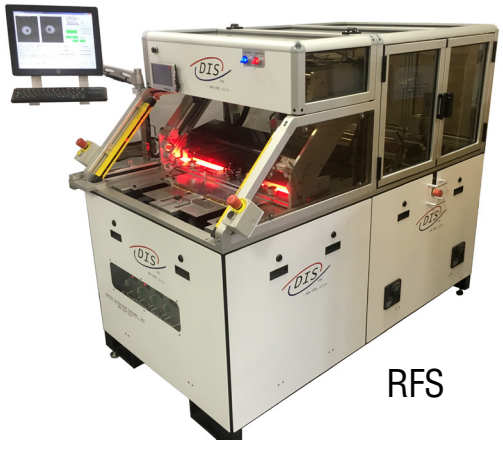

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is. And if you want to sell products in the United States, you have to have UL, but UL testing regimes can be half or more of our product development time, particularly if you want things like their FR-15 and FR-15.1 testing—the long-term thermal aging tests for higher electrical and mechanical RTI values. We have to find quicker ways of qualifying products to UL because the time to market is a huge part of our business. Ventec can develop a product quicker than we can get UL approval on the product.

Matties: The market demands are increasing.

Goodwin: I agree. I can't start the testing regime until the product is developed, and then I have a further window of time. There's nothing I can do. And two to three months is probably okay, but 12–18 months is not.

Matties: Time to market for the OEM is critical, and markets are moving at such a rapid pace such as LED lighting, which is an area that you focus on.

Goodwin: Yes. And now developing markets for thermal management in other areas are even more interesting like power electronics, which is going to be an even bigger and more technology-driven business. The electrical requirements put onto the material are far higher in that power electronic sector than in the LED lighting sector where the only consideration is thermal impedance.

Matties: Is UL sensitive to this?

Goodwin: UL is not so bad with insulated metal substrate (IMS) materials. The bigger issue with IMS materials is that there are no global standards. I think some of the ways IPC goes about things is a little old-fashioned, and before anybody says, "Then get involved," we are involved and trying to change it. We're not just criticizing from the sidelines—we're sharing our point of view—but there's no IPC or any other global standard for test methods to measure thermal conductivity or impedance for IMS materials. It's like the old days when everybody used to pick the right test method for Tg to give them the highest number. We can all play that game, but what's it doing for anyone? Nothing; it's not helpful.

Matties: You need real-world data.

Goodwin: And we need a standard for that. We really do need IMS standards. It's been five or six years since IPC has been working on it. We can't get a standard, but we need one.

Matties: What other challenges do you face in this business?

Automated presses.

Goodwin: Every day is a challenge in the PCB and electronics industry. There's always pressure on prices and for faster deliveries, but we're well set for that.

Matties: What impact have you seen in business so far regarding Brexit, tariffs, and the Chinese trading wars?

Goodwin: Practically none yet, but the U.K. market has definitely slowed down in Q3 and Q4 last year more than we've seen

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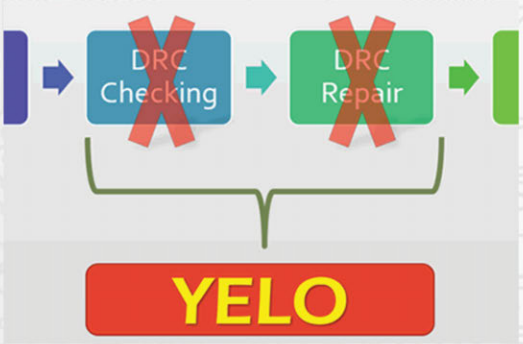

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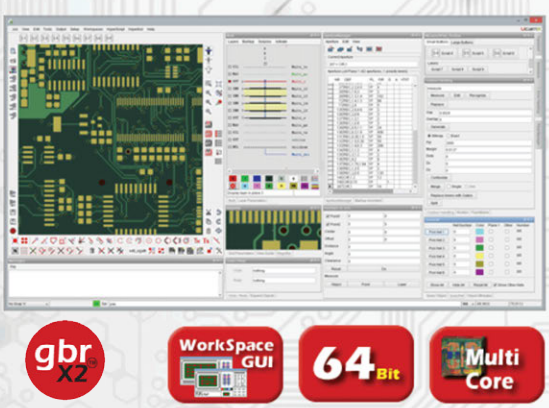

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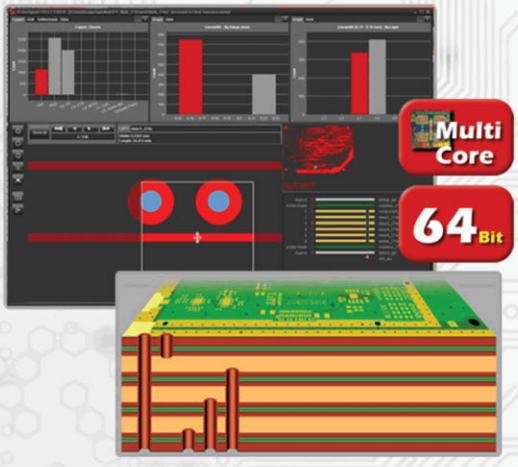

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in previous years. Is that part of a bigger cycle? Looking at some of Walt Custer's data, could argue it might be. Does it have to do with Brexit? You could argue that too, but I don't know. We're well-prepared if the U.K. crashes out. The big impact is going to be on logistics because everything from Europe that comes through seaports into the U.K. now clears in 45 seconds to two minutes. It's all automated customs clearance and very fast.

With Brexit, the risk is that all of the traffic has to go through normal customs clearance—goods have to be inspected—and those times go from a few minutes to hours or even days. None of our materials currently clear fast anyway as they come from outside Europe, but we could be in a much longer queue post-Brexit. So, we've increased the storage capacity in the U.K. within our facility, we put some more high bay racking, rearranged the factory to create more space, and put a bit more material in the supply chain. The U.K. business unit is also becoming an accredited Authorized Economic Operator (AEO), so we're regularly pre-audited by the customs authorities, which means our containers should clear customs quicker, as they know we have well-controlled and transparent import procedures.

Laminate visual inspection.

It's a bit of an investment, but we're doing everything we can to make sure that the logistical side of the business is as slick as possible, regardless of what happens with Brexit. We're not sitting on our hands doing nothing, saying, "What can we do? We don't know what's going to happen." We're doing everything we can sensibly do. My Brexit pitch to our customers is that I can't make any 100% guarantees, but I'm a good bet. We've thought about these things, we'll have material available, and I'm not intending to be the person that drops the ball because of a hard Brexit.

I'm a supply chain guy. I have a lot of very clever friends in Suzhou who are very technical, but my job is supply chains. We have really thought about this and developed a good strategy to keep our customer base in the U.K. supplied. And our customer base in the U.K. is military and aerospace, which is a very important market sector; we're not going to take risks with it.

Matties: You're also making a lot of investments throughout the factory. How do you prioritize your investments?

Goodwin: Technology and market. I'll talk more about the overseas business units because that's really where I influence the investment. Again, Brexit has been a big driver. We talked about inventory supply chain management in the U.K., but we have two service centers in Europe—one in Germany and one in the U.K. The two factories support one other to some degree, and we've been able to share inven-

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tories and processes; that's going to become tougher and maybe even impossible post-Brexit.

We recently invested in the German factory with more equipment because post-Brexit, it could become much harder to use the capability in the U.K. to support our mainland European customers. Of course, the capability is still there and we could use it, but we can't count on being able to move the product quickly enough across borders to use it in a meaningful way. We've just installed another cutting machine in the German factory. We have also improved the capability to support military and aerospace customers that have a higher quality standard out of the German service center where previously we've centered that business in the U.K. factory. Specifically, we've improved the prepreg cutting cleanrooms in Germany and left space to install additional prepreg cutting equipment as well, which we're thinking of for the middle of 2019 to give Germany the capability to grow and support the milaero sector without support from our U.K. operation.

People give me the argument, "You have all of this capacity. Why do you need it?" But it's not capacity; it's bandwidth and redundancy. We need to be able to deliver a lot of material in a standard working day. If I run the U.K. factory 24 hours, seven days a week, I could cut everything the U.K. requires and probably half of what Europe requires in the one factory, but I need to be able to cut significant quantities with a high mix of product types and sizes with a lot of machine setups within a working day, and I need separate cutting lines for polyimide and epoxy prepreg products.

I think the German market is heading the same way as the rest of Europe. They're going to keep the bigger factories there with some larger volumes geared towards automotive, but they're also going to have more and more high-mix requirements, meaning faster reaction and more flexibility from suppliers. We are set up to do that. There's no point in having flexible manufacturing capability in Suzhou, and then creating a bottleneck in flexibility in the supply chain in our overseas business units. The whole thing has to be constructed to deliver high mix and smaller to medium volumes quickly and reliably within a short space of time with redundancy built in to ensure supply chain security. Nobody wants to hear, "My one saw broke down. I can't cut anything for you." Thus, we have two. While one gives us more than enough capacity to do everything, we still have two to ensure continuity of supply.

Matties: You have to have that redundancy to be a good provider.

Goodwin: Absolutely.

Matties: It sounds like a good strategy and time to be in business, and you have made a lot of bright moves here.

Goodwin: I think so and hope so. We'll see.

Matties: Thank you so much, Mark.

Goodwin: No problem. Thanks for your visit. It was a pleasure showing you around. **PCB007**

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With the brain being the human equivalent of the "MicroProcessor", semiconductor companies such as IBM, Intel, MicroChip and MicroSemi have been well aware of potential for connectivity. Others have taken knowledge of neural interface to help humans manage their internal electrical systems, including Medtronic, Philips and Abbott, with a range of pacemakers, defibrillators and neural therapies.

Expanding the potential scope of linking the brain to computers and to the internet has attracted the likes of Amazon, Apple, Facebook, Google, MicroSoft, Neuralink and others, adding to the list that already includes J&J, G.E., T.I., Stryker, and Edwards. MicroProcessors and other ASIC Chips, coupled with MEMS and Sensors, are now seen as the "next-big-thing" over the next 5 years looking at the Internet-of-Things (IoT).

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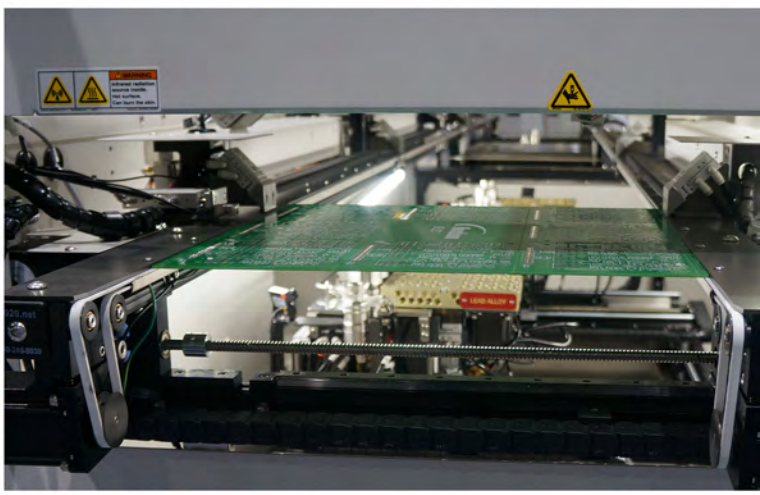

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Have You Heard About the New IPC Education Foundation?

One World, One Industry

by Dr. John Mitchell, IPC—ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

I'm excited about IPC's newest investment in electronics and training programs to address the skills gap in our industry. We've created the IPC Education Foundation—a 501c(3) organization to help students and the emerging workforce acquire the knowledge and skills necessary to succeed. The IPC Education Foundation focuses on strengthening and shaping the next generation of workers by engaging the emerging workforce, providing educational opportunities for students, awarding industry-recognized credentials, changing the perception of the industry, and offering scholarships to deserving students.

The IPC Education Foundation is one of many investments IPC is making in electronics and training programs to address the skills gap in manufacturing. Members of IPC employ millions of individuals worldwide and are highly dependent on workers with technical skills. The IPC Education Foundation will:

- Sponsor international STEM programs closely related to the industry
- Develop global electronics-focused curricula to engage high school and post-secondary students. The Foundation is currently developing curriculum and credentialing pilot programs oriented to high school students and career technical education (CTE) instructors for release later this year
- Work with industry leaders to establish and fund an internationally recognized academic scholarship program with scholarships going to students interested in careers in the electronics industry

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- Award professional development grants to teachers who support STEM education
- Create and expand a network of IPC Student Chapters at universities and community colleges. Foundation staff are engaged in talks with several schools and have already received commitments from the several to establish IPC Student Chapters, including Auburn, North Carolina State, Sacramento State, Central Carolina Community College, Gwinnett Technical College, and Michigan Technological University

IPC-member companies are also getting involved. Calumet Electronics is underwriting the student membership fees at Michigan Technological University, and Weller Apex Tool Group is supporting students at North Carolina State University and Central Carolina Community College.

These IPC Student Chapters create opportunities for IPC members to connect with prospective job candidates and get them interested in our industry. IPC members can share information with students on the latest processes and how they were developed. Member sites can host plant tours, offer internships, and give students an inside look at the industry. IPC Student Chapter members get the opportunity to connect their coursework with real-world applications, expand their professional network, and apply for scholarships and internships.

Our mission is to introduce students to careers in our industry and prepare them with skills that will give them an advantage as they enter the job market. We have begun our fundraising efforts and are actively seeking IPC members to take a lead role. We plan to award thousands of dollars in scholarships in 2019 and provide students with an understanding of the sophistication of today's smart manufacturing environments and opportunities available for an emerging workforce with the proper skills.

Please join us in supporting the workforce of the future. You can get involved by visiting the Foundation's website at ipcef.org or contact Colette Buscemi, senior director of the IPC Education Foundation at colettebuscemi@ipc.org. **PCB007**

Dr. John Mitchell is president and CEO of IPC—Association Connecting Electronics Industries. To read past columns or contact Mitchell, click here.

RTW IPC APEX EXPO 2019: Updates on Taiyo's Inkjet Solder Mask

Donald Monn, regional sales manager at Taiyo America, speaks with I-Connect007 Technical Editor Pete Starkey about the latest updates in their inkjet solder masks, and the many installations around the world that they are seeing for their product. He adds that the many tools supporting their latest product are giving much value to their customers because of the options they have. Watch here.

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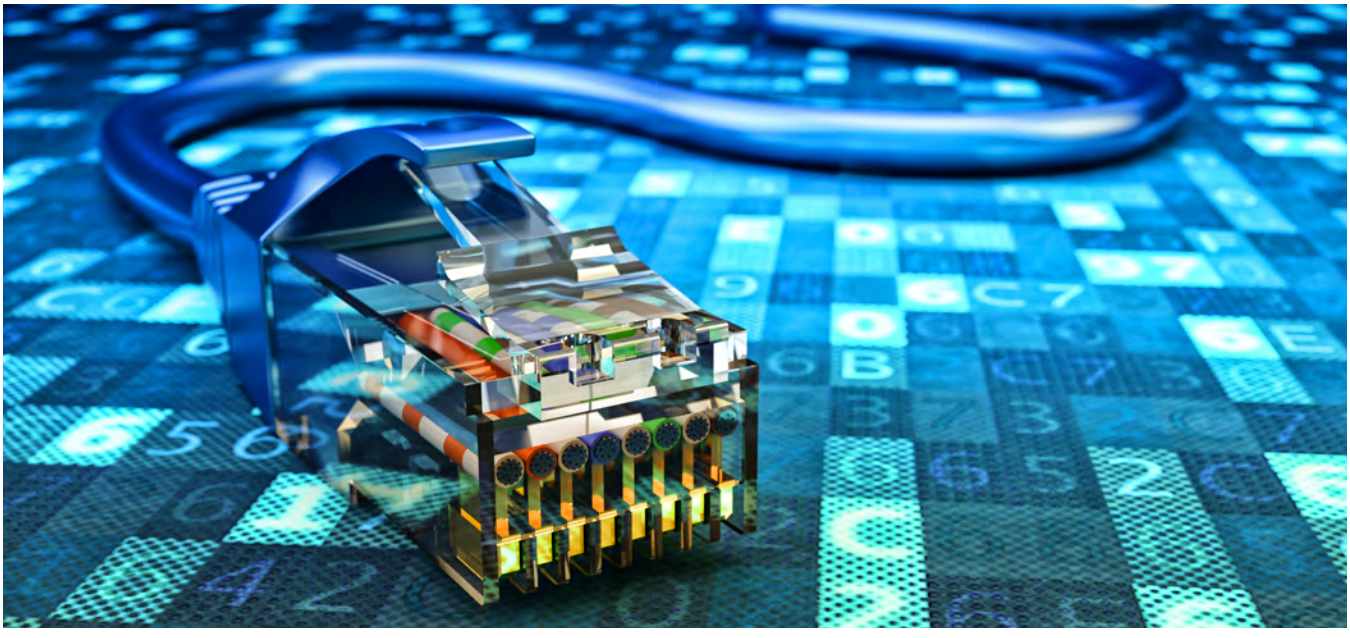

Hardware and Software in Smart Factories

Feature by Happy Holden
I-CONNECT007

As smart factories become a part of the present rather than a thing of the future, we will all need to become familiar with related concepts and components. This article is dedicated to various automation protocols, including some new ones just coming on the market. The messages and recipe data needed for production scheduling to machine connections has evolved over the years. I will cover hardware, including programmable logic controllers (PLCs) and machine interfaces, as well as software and network protocols, such as MAPS™, SECS/GEM, OML, CFX, IPC-2541, and custom software.

Hardware

Industry 4.0 Initiatives

Industry 4.0 originates from a project in the high-tech strategy of the German government that provides for the computerization of manufacturing. The first industrial revolution mobilized the mechanization of production using water and steam power. The second industrial revolution introduced mass production with the help of electrical power, followed by the digital revolution and the use of electronics and IT to further automate production. Also, the term "Industrie 4.0" was first used at the Hannover Fair. In October 2012, the working group on Industry 4.0 chaired by Siegfried Dais and Henning Kagermann presented a set of Industry 4.0 implementation recommendations to the German federal government. On April 8, 2013, the final report of the working group on Industry 4.0 was presented.

PLCs

Today, there are multiple lights-out factory and Industry 4.0 initiatives. Much of this progress is the result of the automotive industry's application of PLCs and robots to manufacturing. Figure 1 shows what the Germans foresaw for Industry 4.0 [1]. I was first introduced to PLCs by Allen-Bradley, as Hewlett-Packard (HP) had sold them its new CNC machines

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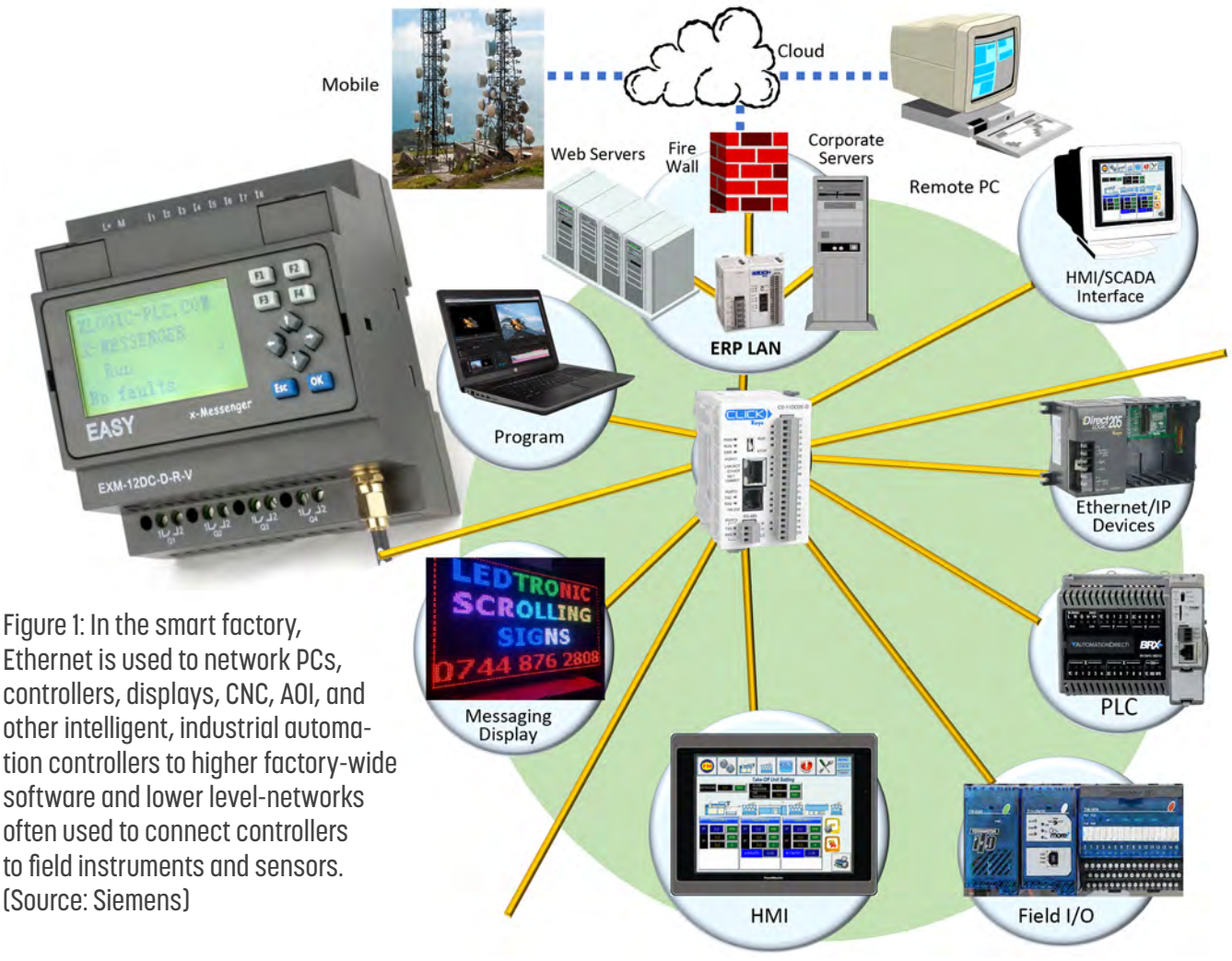

Figure 1: In the smart factory, Ethernet is used to network PCs, controllers, displays, CNC, AOI, and other intelligent, industrial automation controllers to higher factory-wide software and lower level-networks often used to connect controllers to field instruments and sensors. (Source: Siemens)

tool controller. PLCs became a major device in machine control (Figure 1).

PLCs are the most abundant smart controllers on the factory floor today. They come in all sizes, capabilities, and price ranges; some start at $60 USD. Many are hardened for harsh environments or outdoor use. Further, the flexibility of PLCs comes from the variety of units that can be plugged into them, such as conveyors, robots, PID process controllers, inspection, and test. Figure 2a shows an Ethernet group controller, and Figure 2b demonstrates a typical PLC and display monitor.

Software and Network Protocols

For factory automation software, HP developed CAD tools for PCB design and mechanical engineering that had data acquisition, SCADA, and test systems. The business computer division developed MRP and ERP software. In 1982, HP acquired Genesis Corporation, including IC-10 and six others, such as PC-10 and software products for factory control. HP had a complete software solution for factory automation connectivity that they developed for General Motors and the MAPS™ implementation. As this new software group was made into a division, they expanded their product line to include quality, test, and inspection systems; a CNC system; materials handling software; and an industrial process control system licensed from Mount Isa Mines. HP's products were intended for typical factory automation networks typified by the four-level hierarchies seen in prior publications and by the ISA-95 standard. Application software can be much more complex, as shown with the seven-level ISO model. Figure 3 shows the data structures and data ownership that the application software needs to embrace to fulfill its command and control for levels 3–7.

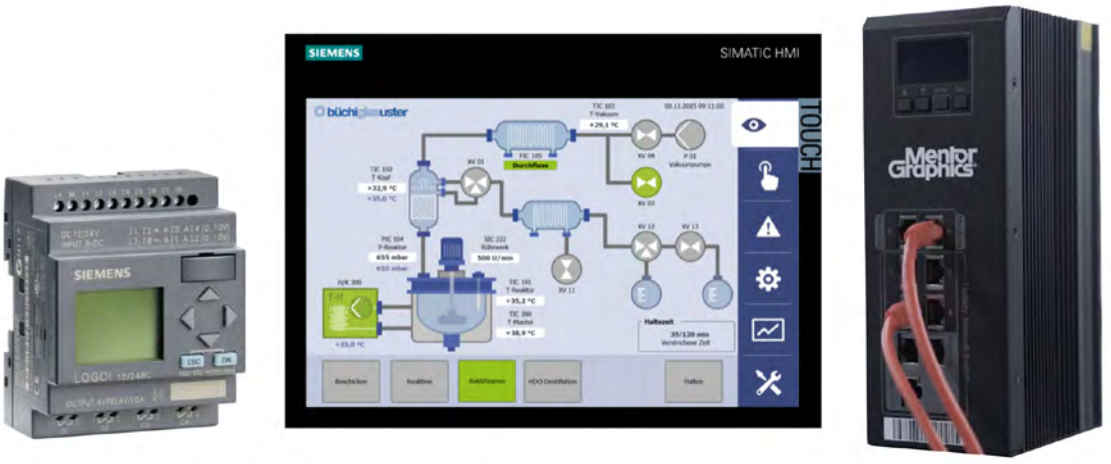

Figure 2: (a) The PLC is the most common factory-floor intelligent control, and (b) a typical factory-floor Ethernet concentrator and controller can connect islands of automation. (Source: Siemens and Mentor Graphics)

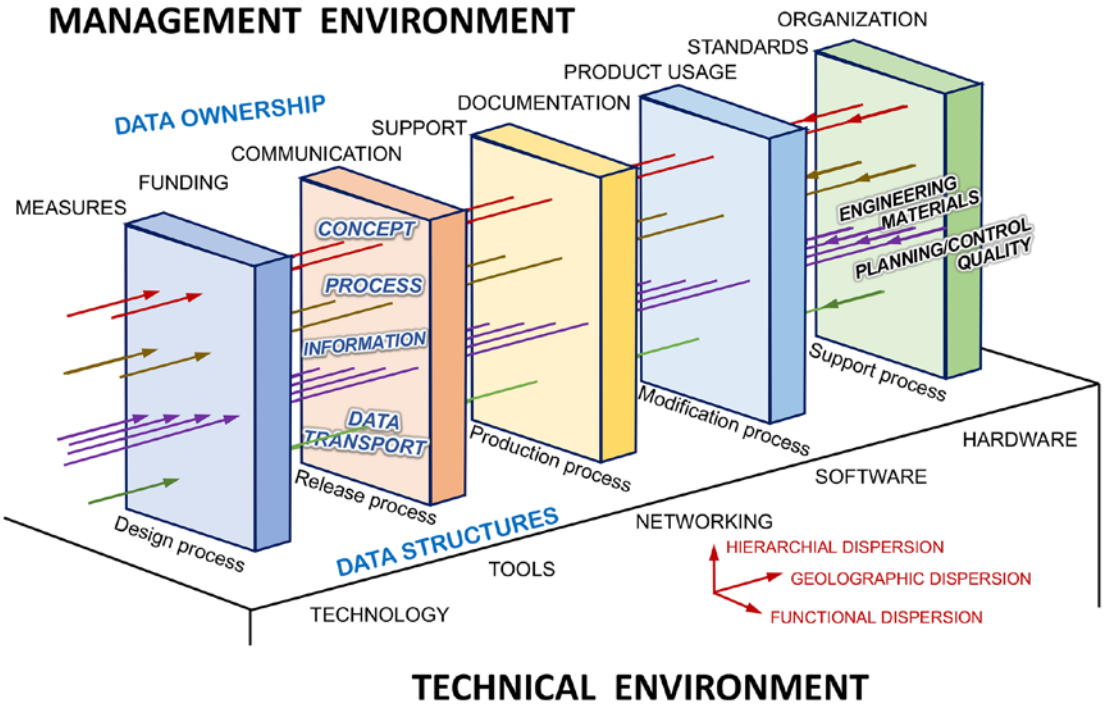

Figure 3: The management and technical environment for data structures and ownership.

Design Principles for Industry 4.0 Scenarios

One working paper [2] identified these six design principles that can support companies in identifying and implementing Industry 4.0 solutions:

1. Interoperability: The ability of cyber-physical systems (i.e., workpiece carriers, assembly stations, and products), humans, and smart factories to connect and communicate with each other via IoT and IoS

2. Virtualization: A virtual copy of smart factories created by linking sensor data from monitoring physical processes with virtual plant and simulation models

3. Decentralization: The ability of cyber-physical systems within smart factories to make decisions on their own

4. Real-time capability: The capability to collect and analyze data, and provide the derived insights immediately

5. Service orientation: Offering services of cyber-physical systems, humans, or smart factories via IoS

6. Modularity: Flexible adaptation of smart factories to changing requirements by replacing or expanding individual modules

Identified challenges include [3]:

- IT security issues, which are greatly aggravated by the inherent need to open up previously closed production shops
- Reliability and stability needed for critical machine-to-machine communication (M2M), including very short and stable latency times
- The need to maintain the integrity of production processes
- The need to avoid any IT snags that would cause expensive production outages
- The need to protect industrial knowhow also contained in the control files for the industrial automation gear
- The lack of adequate skill sets to expedite the march towards the fourth industrial revolution
- Threats of redundancy of the corporate IT department
- General reluctance to change by stakeholders

Current Automation Network Protocols

MAPS Protocol

MAPS stands for message automation and protocol simulation. As explained in an overview tutorial [4], MAPS specifies a set of standard communication services for factory automation and has been accepted as an international standard by the International Organization for Standardization (ISO). It is a protocol simulation and conformance test tool that supports a variety of protocols for factory-floor controllers such as PLCs, robots, and group and cluster controllers. MAPS is one of the oldest and most used of the factory floor automation protocols; it was pioneered by General Motors and adopted by General Electric for its factories.

MAPS is based on the reference model for the open systems interconnection (OSI) model of the ISO. It has three main components: file transfer, access, and management services; manufacturing message specification services; and X.500 services. Protocols include SIP, MEGACO, MGCP, SS7, ISDN, GSM, MAP, CAS, LTE, UMTS, SS7 SIGTRAN, ISDN SIGTRAN, SIP I, GSM AoIP, diameter, and others. This message automation tool covers solutions for both protocol simulation and analysis. The application includes various test plans and cases to support the testing of real-time entities. Along with automation capability, the application gives users the unlimited ability to edit messages and control scenarios and message sequences generated through scripts.

MAPS is designed to work on TDM interfaces as well as IP/Ethernet interfaces. Also, MAPS supports 3G and 4G mobile protocol standards for testing rapidly evolving mobile technologies and can simulate radio signaling protocols, such as LTE (S1, eGTP, X2) interfaces and UMTS (IuCS, IuPS, IuH), GPRG Gb, and GSM A over an IP transport layer. With the help of cellphones and other simulated wireless networks, a VoLTE Lab setup can be operated in real time for making VoLTE calls and interworking with PSTN and VoIP networks. MAPS is enhanced to a high-density version and a special-purpose 1U network appliance capable of handling a high call intensity (hundreds of calls per second) and a high volume of sustained calls (tens of thousands of simultaneous calls per 1U platform). A good description of MAPS and how it works is available in an HP Journal [5].

SECS I and SECS II/GEM Protocols

Semiconductor process equipment manufacturers identified the need for their equipment to communicate with a larger host computer system and developed the Semiconductor Equipment and Materials International (SEMI) equip-

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ment communications standard (SECS) [6]. SECS define parts of all seven ISO OSI communications layers. SECS/GEM standardizes two-way communication within a network or serial cable that connect equipment and is independent of any particular programming or computer operating system.

One HP Journal [7] explained SECS this way.

"SECS I incorporates the use of RS-232-C cabling and pin definitions and a relatively simple line protocol. SECS II defines messages to request and sends status information, transfers recipe data, reports alarm conditions, sends remote equipment control commands, and handles material transfer. SECS I uses a simple ENQ-ACK handshake across an RS232-C line with checksums at the end of each message. SECS I also defines timeout intervals between handshake responses, individual message characters, and message responses. Message headers are defined in SECS I to include equipment identifiers, message identifiers, message block numbers, and other system information.

SECS II define message types, format, content, and directions. SECS streams are groups of messages assigned to a general set of equipment functionality. Within each stream, the individual messages are assigned function numbers. For example, SECS stream 1 function 5 (abbreviated S1 F5) is a formatted equipment status request, and stream 1 function 6 is the reply with the status information. Similarly, stream 7 function 5 is used to request the transfer of a process recipe and stream 7 function 6 is used to transfer the recipe. SECS II also defines whether a reply is required or not, the message content and format (including data item definition headers), and whether a message may be used from equipment-to-host and/or host-to-equipment."

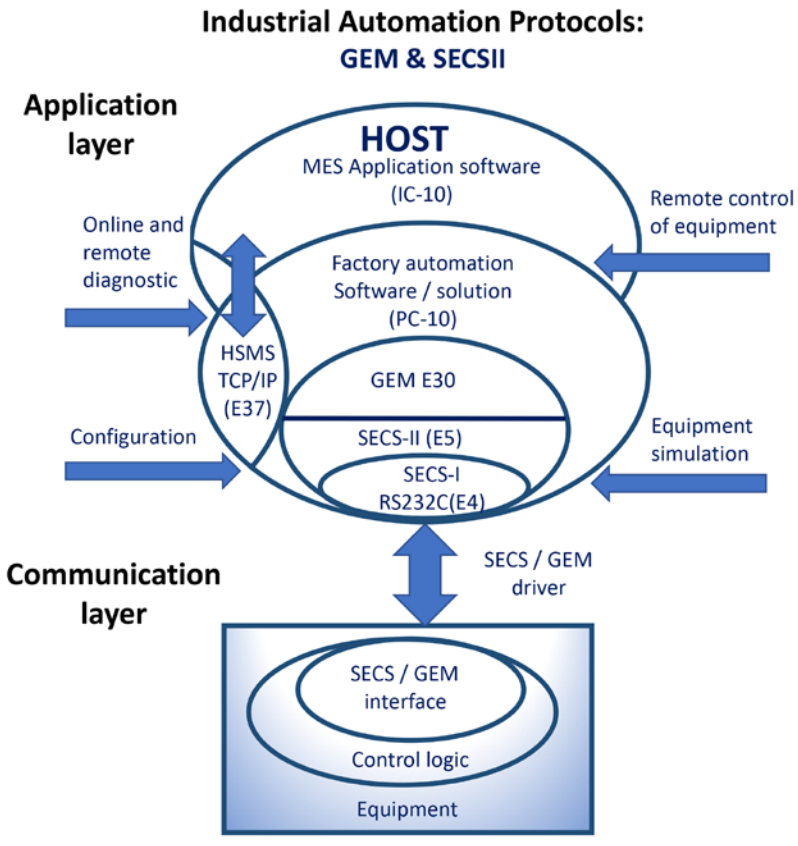

Figure 4: SEMI's SECSII/GEM communication standard documents machine connectivity and controls/recipes [7].

A major limitation of the SECS standard is that it defines messages and their content only; it does not define how the messages are used together to perform a function. Equipment manufacturers are left to decide what messages to use to perform functions that were performed manually before. This, of course, makes it difficult to develop translators for external systems to communicate with such equipment. Figure 4 shows more details of the SECS II/GEM standard built on the OSI seven-level communication model [5].

Open Manufacturing Language (OML)

OML provides an intelligent IoT connectivity platform for all PCB assembly production machines and processes, whether automated or manual while enabling support—such as planning, supply chain, and quality management—and corporate systems, such as MES, ERP, and PLM. The standard is the proprietary develop-

ment of Mentor Graphics/Valor and has hardware that can be purchased from them. The OML carries on the long-standing tradition of ODB++—the PCB design communication standard from Valor. No information has been presented if OML conforms to either MAP or SECS II standards.

The OML Community website [8] describes how, "OML features bi-directional data flows for shop-floor data creation as well as process control, all through a single, standard format, language, and protocol. Any creator or consumer of OML data will require the development and support of just one standard interface rather than the current need for many different interfaces."

One presentation [9] explains, "OML request/response messages provide OML applications with real-time control of equipment or processes at the shop-floor. These messages are bi-directional. Control can be initiated by the OML application toward an OML process on the shop floor (e.g., specific equipment or lines can be stopped). Control can also be initiated from the OML shop-floor process toward an OML application. For example, the shop-floor process can check if a specific PCB can enter specific equipment every time a PCB enters the process."

OML Data Formats

OML uses the JavaScript Object Notation (JSON) standard to represent each message. The use of JSON in the software industry has rapidly increased year on year with the format now widely used in most web-based technology and across the internet in general. For example, JSON can represent the same data while using significantly less space than XML, which means performance gains. However, like XML, JSON is still human-readable and can represent complex data. JSON is easily compressed to reduce size for further efficiency. JSON is a fully open standard with mature future support in most major programming languages and platforms. The complete OML users guide and standard can be found on the OML Community website [8]. Look for this standard to gain momentum in the industry as Mentor Graphics/Valor has been acquired by Siemens and is added to their large pool of MES, ERP, PLM, and automation products.

CFX

The IPC Connected Factory Exchange (CFX) initiative seeks to create an M2M protocol for SMT manufacturing. CFX is based on the old SMEMA 9852, but is now called the IPC-HERMES-9852. CFX uses the reliable TCP/IP communication protocol and XML tagged data messaging based on advanced message queuing protocol (AMQP). Over 43 companies have joined this working group. The Hermes standard uses TCP/IP to permit all stations on an SMT line (e.g., printers, conveyors, placement machines, AOI systems, reflow ovens, etc.) to talk to each other. Hermes employs expandable XML data structures to transmit information like board IDs, conveyor speeds, and circuit carrier dimensions. Each board must be identified only once by a Hermes-compatible machine at the start of the line. With its publication as an open standard, the Hermes standard will be available to all SMT equipment vendors at no cost. And since the protocol was designed to be expandable, users can pass additional information down the line. You can find the list of company supporters and more on the IPC-CFX website [10].

IPC-2541

IPC's 2-13 Shop Floor Communications Subcommittee brought together leading software developers, machine vendors, assembly equipment manufacturers, and their customers to work on the development of a new IPC standard to meet the current and future needs of the industry that will fill a gap identified by the group. This new standard will provide uniformity of data protocols that will allow ease of M2M communication.

Messaging as the Elements of a Network Protocol

Semiconductor fabricators like to avoid writing custom software to fit all the idiosyncrasies of individual processing systems. So, HP

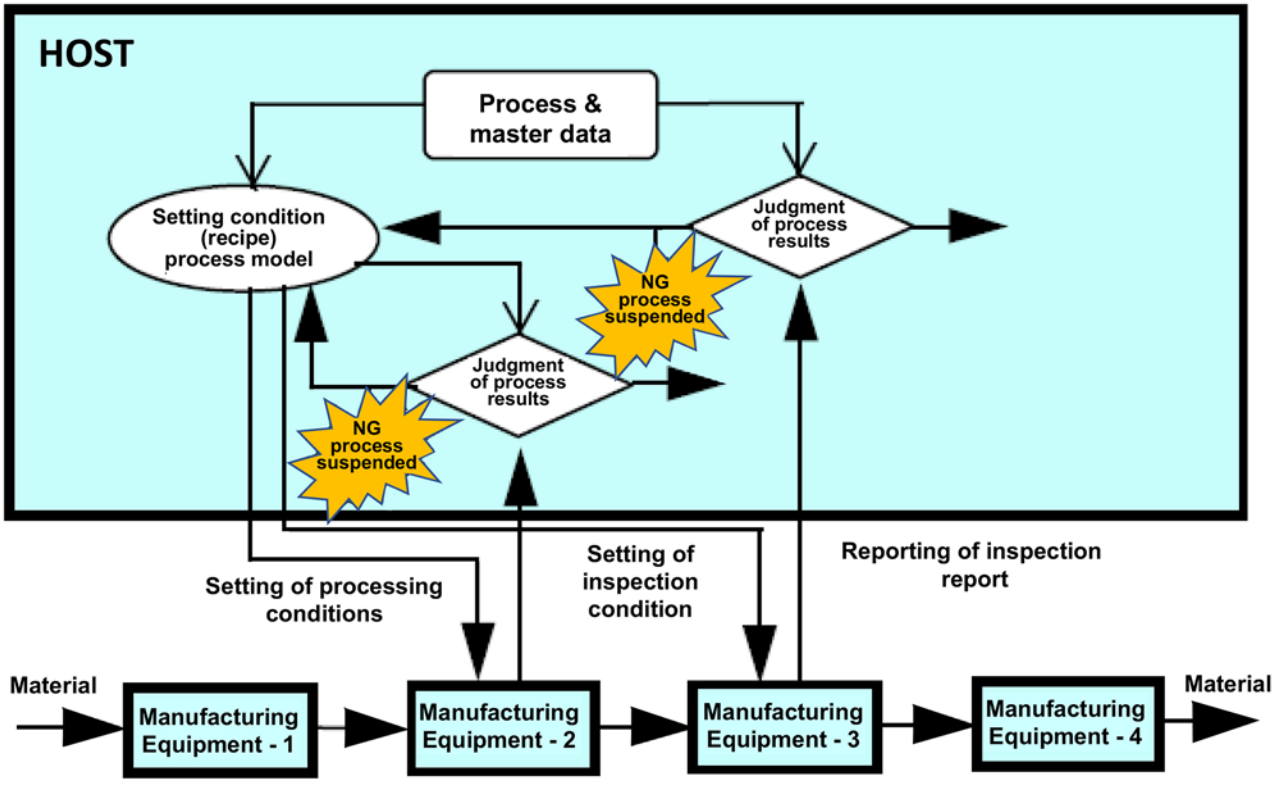

Figure 5: Real-time equipment status monitoring. (Source: Sematech Generic Equipment Model)

developed PC-10 to handle IC process equipment by separating it into general classes. SECS II was a mandatory prerequisite of the equipment before an interface to PC-10 could be developed (Figures 5 and 6).

HP's approach to interfacing was to survey a representative number of processing systems within a class to develop a generic model. A class is a group of equipment systems that operate similarly and perform the same general functions so that the communications requirements look the same to PC-10. The assumption is that each piece of equipment in a class supports a subset of the SECS II data streams and functions that PC-10 supports for that class. HP also assumed that the order of the messages, which is not

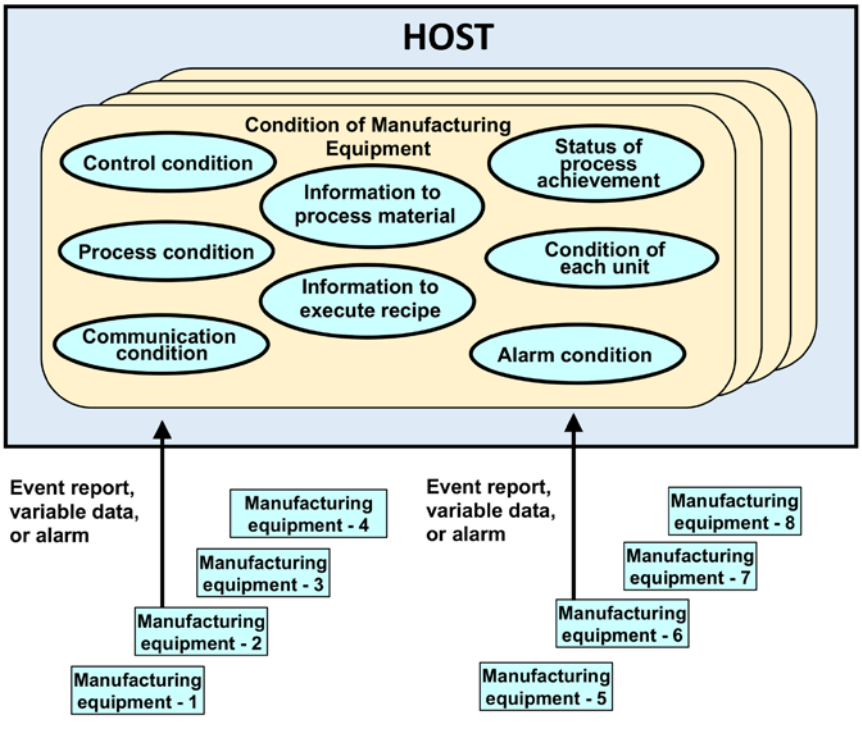

Figure 6: In real-time monitoring of equipment, messages/requests are sent to the host, and replies contain recipes and instructions. (Source: Sematech Generic Equipment Model)

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defined by SECS II, is generally the same for all equipment in that class.

In one HP journal article [7], the author reported the following.

"To date, they have encountered batch, metrology, serial, and material handling equipment…batch processing systems, such as diffusion furnaces, process wafers in large quantities (batches). The primary characteristic is that once a batch has started processing, no more wafers can be added until the process sequence has run to completion. PC-10 will download only one recipe to the batch station when the batch is tracked in, and no other batches will be allowed in until the first batch is done.

Metrology systems are classified separately because they provide certain measurement data to PC-10. PC-10 supports SECS II stream 6 messages, which handle the transfer of measurement data to the host system for this class of equipment. Examples are line width, film thickness, and defect measuring devices. Wafers passing through these stations are not processed but merely measured to determine the effectiveness or accuracy of previous process steps.

Serial processing handles wafers one at a time. Wafers from one lot may enter the equipment for processing before the preceding lot has been completed. Photolithography wafer track systems are a prime example of serial equipment. To ensure that the proper recipe is executed for each lot, PC-10 must check to see if the recipe already executing is the proper recipe for the next lot. If not, it must download the new correct recipe at the proper time for beginning processing of the new lot.

Material handling requires an entirely different set of messages since material handling

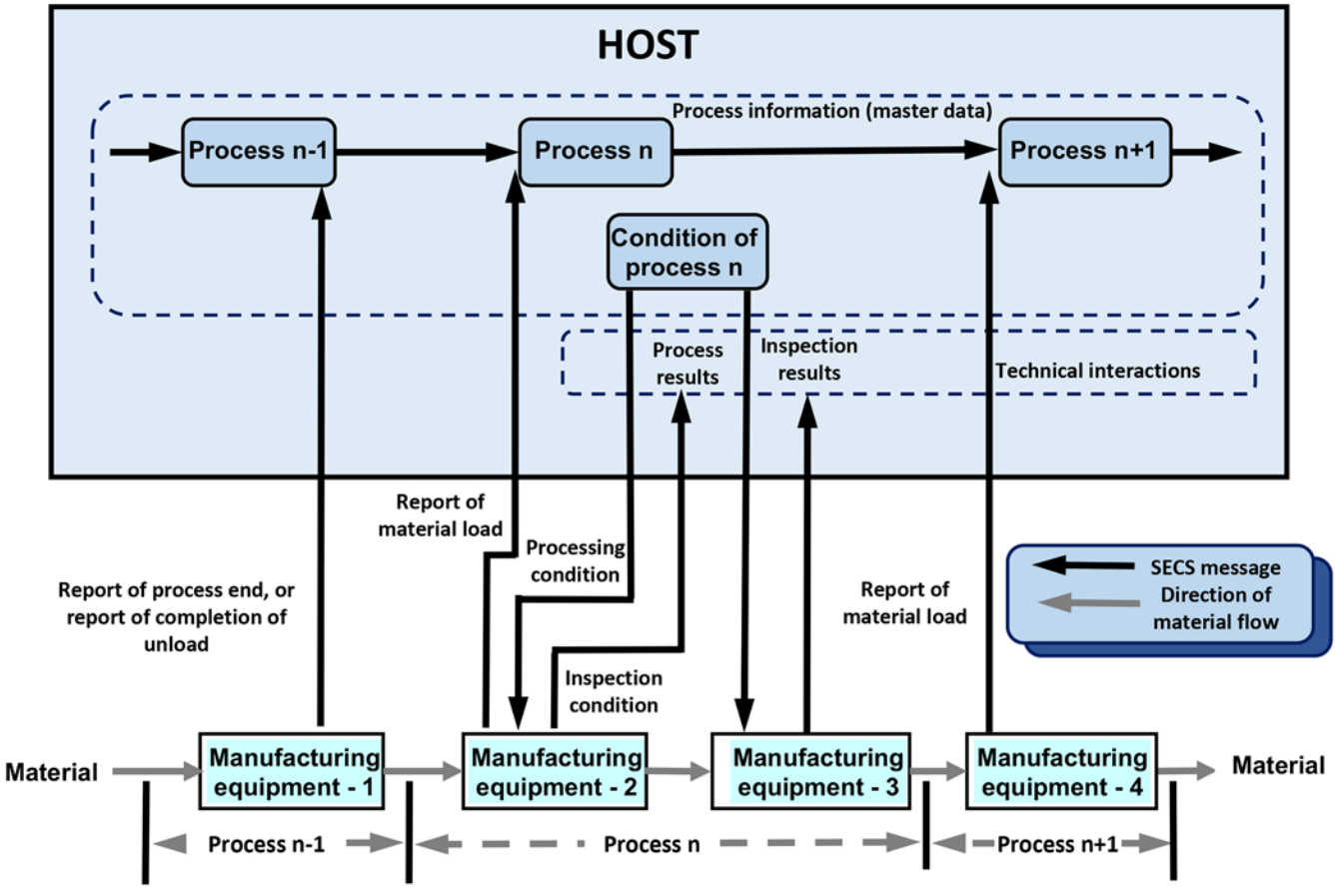


Figure 7: PC-10 process control and supervision, including recipe downloading. (Source: Sematech Generic Equipment Model)

systems are responsible only for transporting the wafers from one station to another. PC-10 instructs the material handling system to take a lot or a group of lots to a piece of equipment. Examples of material handling systems include robots or tracks used to move the wafers through the fabrication area. The challenge we face when we address a new class of equipment to develop our models is to perform an adequate survey of equipment on the market and develop an accurate yet general model of how these pieces of equipment operate."

Figures 7 and 8 are simple schematics of the CIM hierarchy in wafer fabrication using PC-10 as the equipment controller.

Custom Software

Custom software for smart factories can be challenging, but with proper planning, the task can be executed quickly. Custom software planning phases and deliverables might include (Figure 9):

- Investigation: Investigation report and data sheet(s)
- Design: External/internal specifications and design outline
- Construction: Code, test, and document
- System testing: Ensure code meets requirements
- Release: Transfer to manufacturing and quality review
- Support: Enhancement and updates

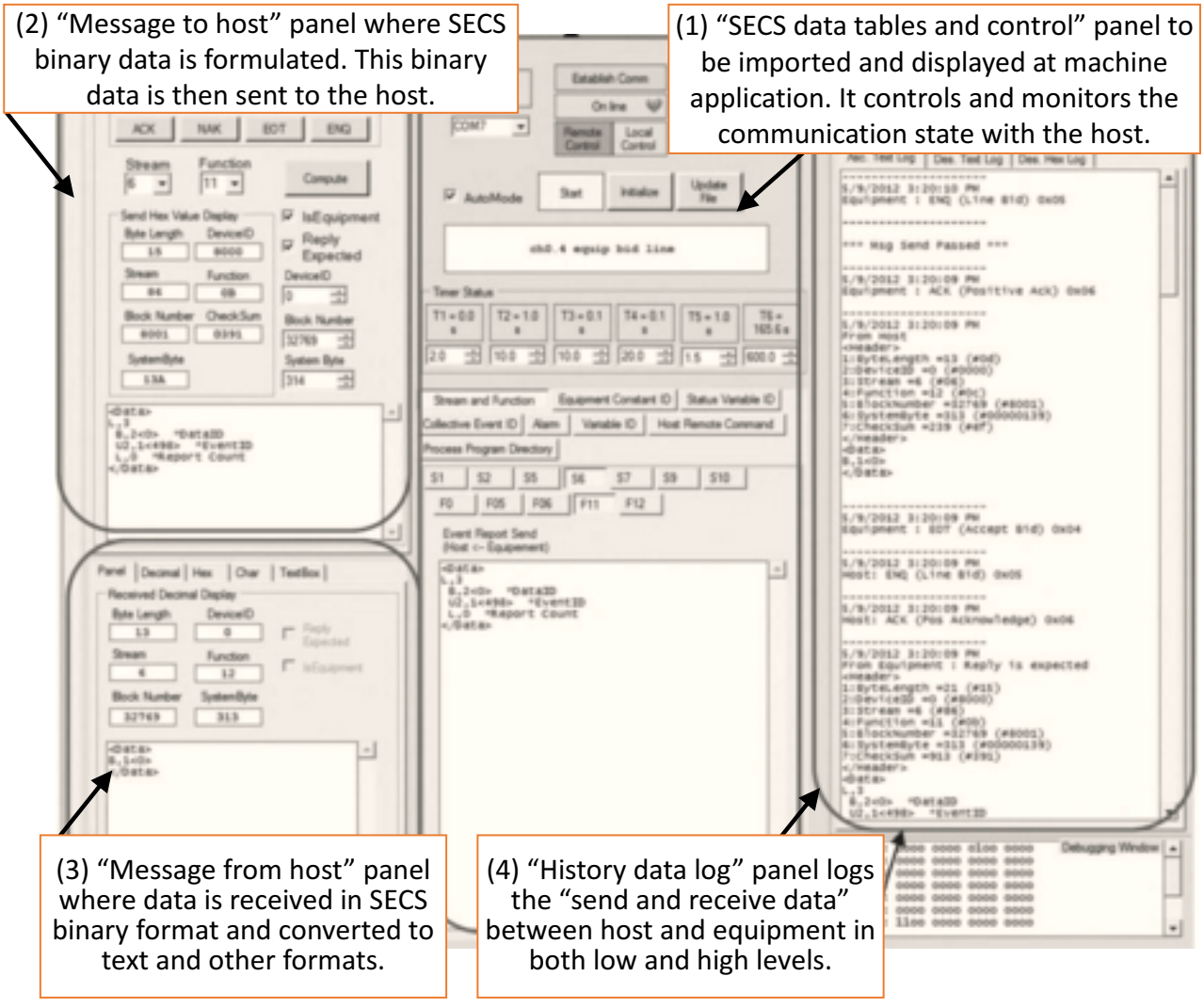
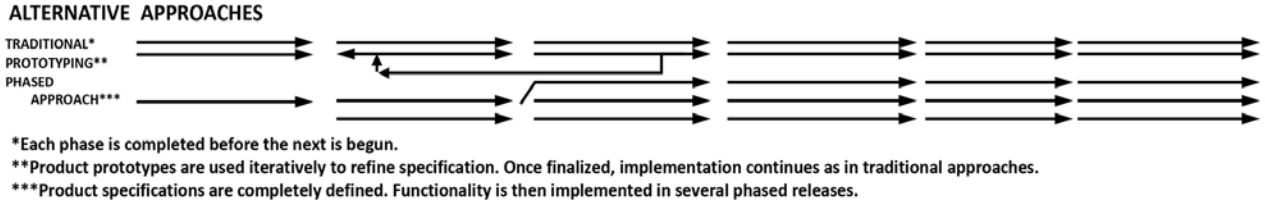


Figure 8: Process recipe on PC-10 to be downloaded by SECS II and GEM [7].

	INVESTIGATION	DESIGN	CONSTRUCTION	SYSTEM/USER TESTING	RELEASE	SUPPORT
OBJECTIVES	• Determine requirements to be successful in the market • Functionality overview • Feasibility/viability • Product objective • Quality objective • Establish product team • Internal objective (Localization, support, etc.)	• Define external features & internal structure • Specifications • Design • Project plans	• Code, test, & document Product components • Code • Integration • Test package • User documentation & training	• Ensure product meets user objectives • System testing • Alpha testing • Beta testing • Supportability • Evaluation	• Package & transfer to manufacturing & field • Pricing • Introduction • Quality review • Transfer to manufacturing	• Ongoing enhancement & product fixes • New system requirements • New functionality • Problem correction • Regression testing
DELIVERABLES PHASE	• Investigation report • Preliminary data sheet	• External specifications • Design outline • Internal specifications • Quality plan • Documentation plan • Support plan • Product plan	• Code • Internal maintenance Specifications • Automated test package • Performance test plan • Field training plan • Manufacturing plan • User documentation • User training • Field training	• Production version of code • Alpha site signoff • Beta site signoff • Testing	• Released product • Quality Report	• Update software • Update documentation • Updated test package
FOCUS ISSUES	• Problem/ alternatives analysis	• Design • Planning	• Code • Test	• Support • Maintenance	• Packaging • Transfer to manufacturing • activity	• Maintenance • Support
ORGANIZATIONAL	• Requirements/objectives • R&D/marketing	• R&D	• Documentation/ manuals • R&D/marketing	• R&D/marketing	• Manufacturing marketing	• R&D/marketing • Manufacturing marketing
VALIDATION	• Reviews • Product team users • Management	• Reviews • Product plan • Technical review team • Related project/OEM • Inspection • Walkthroughs	• Review • Product team • Technical review team • Related projects/OEM • Inspection • Walkthroughs • Module/unit testing • Functional testing • Integration testing	• System testing • Performance testing • Installation testing • Alpha site testing • Beta site testing • Support classes • Automated test package	• Reviews • Product test • User site results	• System certification • Regression testing • Alpha sites • Beta sites



*Each phase is completed before the next is begun.
**Product prototypes are used iteratively to refine specification. Once finalized, implementation continues as in traditional approaches.
***Product specifications are completely defined. Functionality is then implemented in several phased releases.

Figure 9: Custom software development cycle.

Figure 10 details the planning tools for the design of the following software: vertical table of contents (VTOC) and hierarchical inputs programmed output (HIPO). VTOC and HIPO documents are important methods of creating the internal and external specifications for custom software. Coding is the easiest and fastest part of the process once all of the planning has been completed.

VTOC

The VTOC can be used as a framework in developing programs, and contains these elements and steps (Figure 11):

- Group various tasks into modules
- Identify relationships between the various modules
- Optimize modules

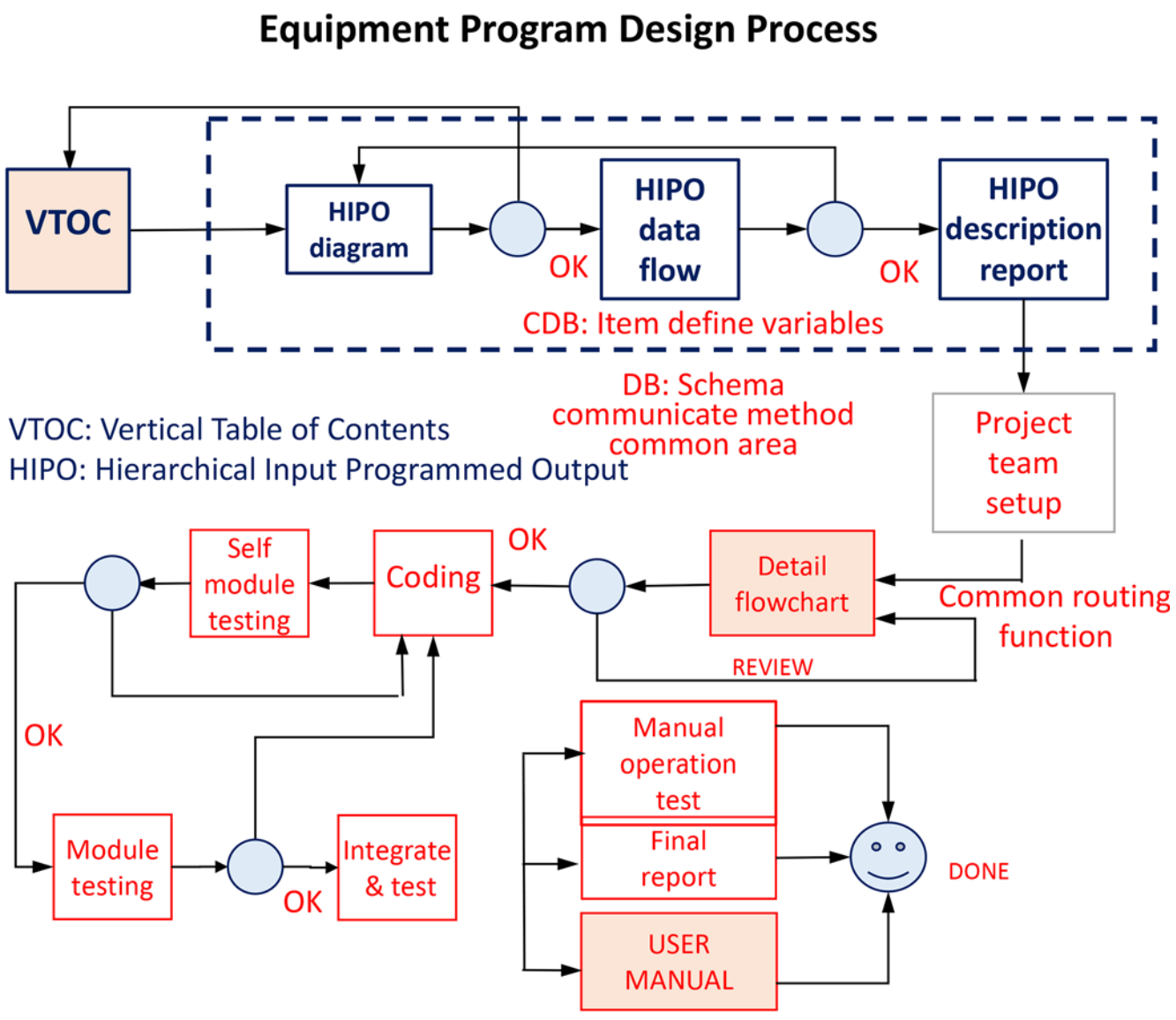


Figure 10: Flow diagram of the process of custom software creation, including VTOC and HIPO documents.

- Define a VTOC number for each module
- Define a short name describing each module
- Attach a description for each module
- Put identical modules with same VTOC number and name with a shaded area in the upper right-hand corner

HIPO Documents

HIPO documents include a set of diagrams that show the functional breakdown of a program system in hierarchy charts, and separate diagrams on a hierarchy chart into a set of three boxes showing inputs, processes, and outputs (Figure 12).

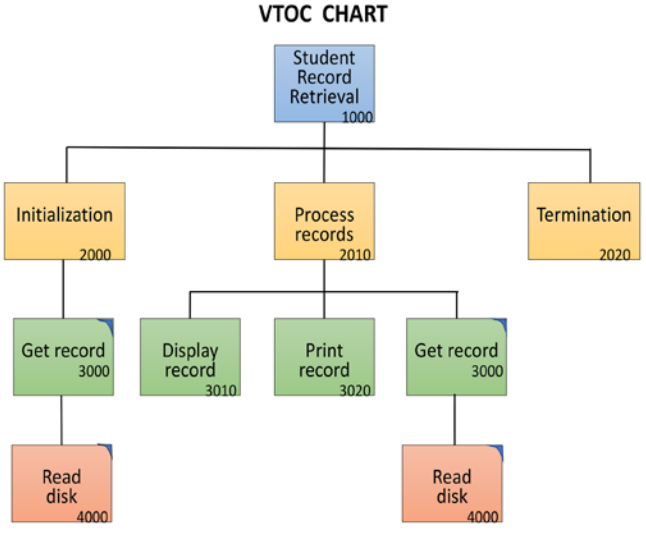


Figure 11: VTOC chart.

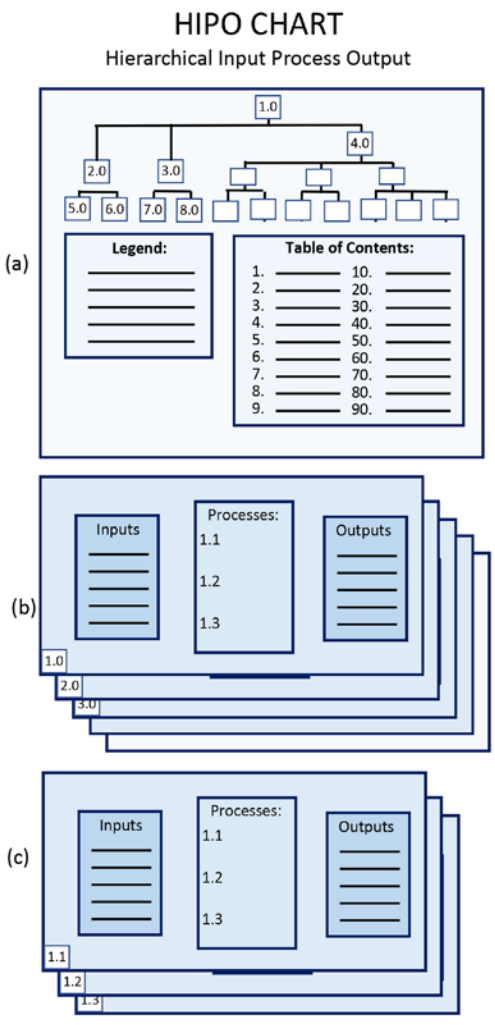


Figure 12: HIPO documents.

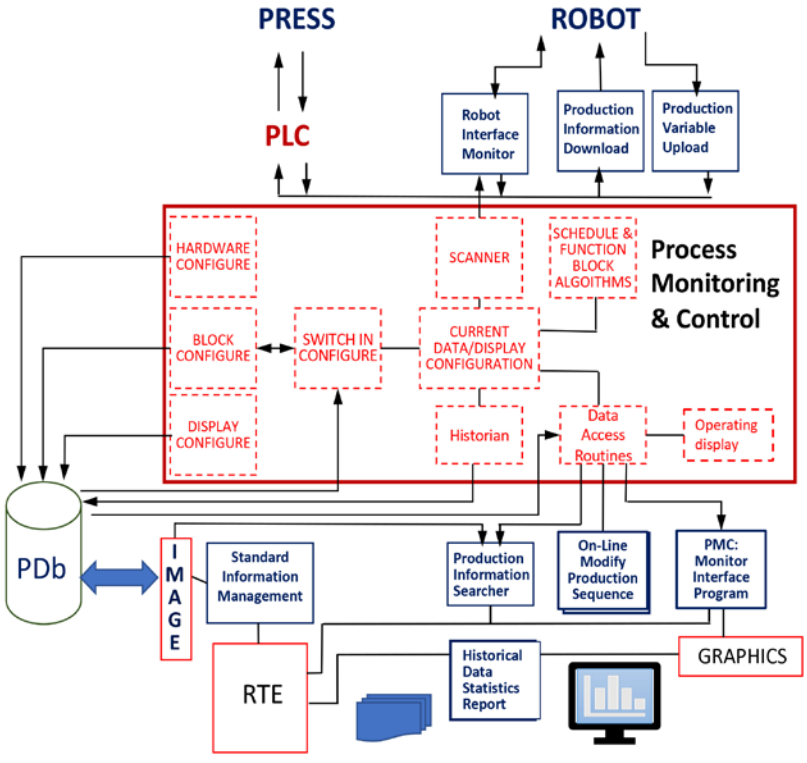


Figure 13: Software blog diagram of custom software for recipe-driven control of robotic lamination and material handling.

This custom software example was for the custom software that connected many vacuum multilayer hot and cold presses to the articulating robot that loaded and moved the heavy caul-plate sandwiches from press-to-press and to and from automatic conveyors; all of these actions were controlled by the part-number recipe. While also controlling the pressures, platen temperatures, and vacuum, the robots would disassemble the finished multilayers and send the caul plates off to be cleaned (Figure 13). The software took three new programmers approximately eights months to plan, code, test, install, train, and document.

Variations on this custom coding process are many, but the outcome is still the same—a working software program that executes the user's intentions. As time goes by, more software for smart factories will emerge. **PCB007**

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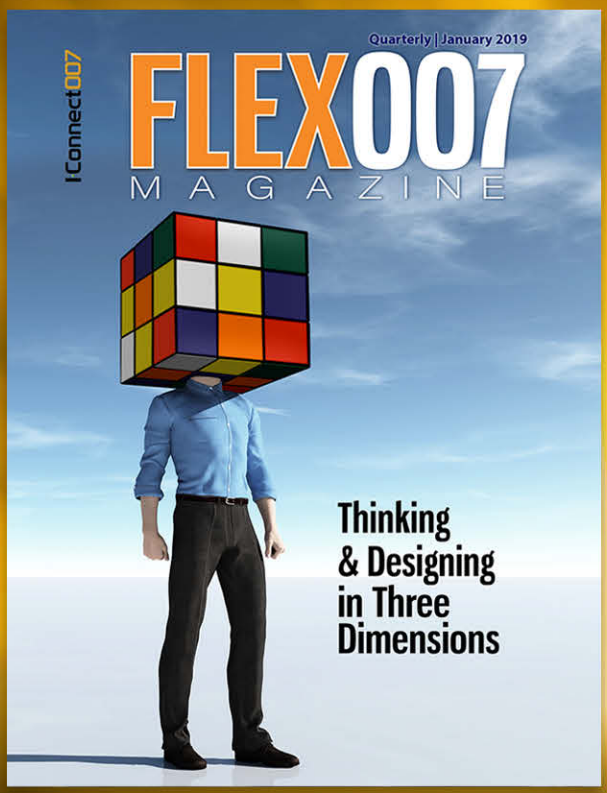

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GOOD FOR THE INDUSTRY

Victory Giant Technology

by Barry Matties
I-CONNECT007

Recently, I-Connect007 toured Victory Giant Technology (VGT) Co. Ltd. in Huizhou, China–one of China's largest PCB producers. Currently, VGT generates about $500 million USD in annual sales, and have plans to reach $1.5 billion in the next few years. VGT's facility covers an area of 236,000 square meters with a staff of around 4,000. Its monthly production capacity achieved is currently 600,000 square meters per month and increasing.

Mr. Chen Tao founded VGT in Danshui Subdistrict, Huiyang District, Huizhou. VGT started construction in 2006 and became operational in 2008. Today, VGT have three manufacturing facilities with more under construction. Mr. Chen continues to lead his team through an impressive expansion plan.

Our tour included engineering and factories one, two, and three. The fourth factory–a dedicated HDI facility–is under construction. Though some resources are shared between the factories, core operations are set up as individual factories. Factory one is basically a traditional PCB shop staffed with operators running each process, but it is being upgraded to support higher mix, lower volume, and higher-tech products.

Factory two is a good example of what automation can do to reduce manpower. Built in 2007, and realizing a 30% reduction in labor, VGT determined that costs could be reduced even further with a smart factory. Which brought us to factory three–the smartest factory of all.

Read about the tour and our interviews with VGT leadership in the March issue of *SMT007 Magazine*.

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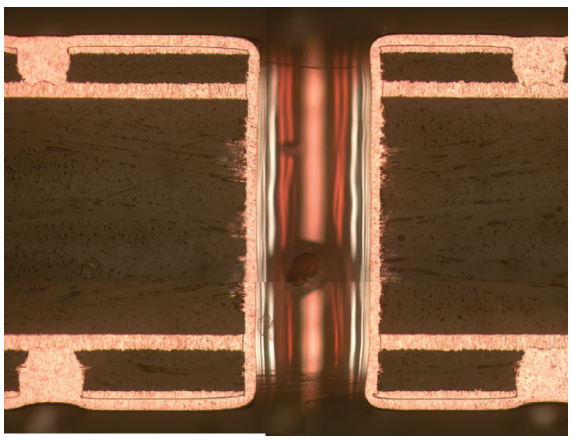
2	276	22.42	306	75
3	265	19.67	274	81
4	270	18.67	296	76
5	272	21.72	307	74
6	257	21.91	287	75
7	259	20.14	286	75
8	279	18.94	303	77
9	271	18.83	288	78
10	252	20.73	268	78
Mean	268	20.28	291	77

VF-TH 200 passes IPC 6012D, DS, DA and 6013D. More than 276 MPa [40,000 PSI], and greater than 18% elongation.



MacuSpec VF-TH 200 can fill 3x3 mil to 5x3 mil vias in less than 60 minutes with optimal physical properties and structural attributes.

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A PCB Broker's Guide Through the Galaxy of Automation

Feature Column by The PCB Norsemen

Automated factories, or so-called smart factories, where machines handle it all just like in the movies from the 80s are no longer utopian. Smart, automated fully digitalized factories are a reality, but it's not all new.

Defining "Smart Factories"

In 1913, Ford Motor Company introduced a car production assembly line considered to be one of the pioneer types of automation in the manufacturing industry. Previously, the job was done by skilled and unskilled workers. Production automation improved Ford's production rates and increased profits. The assembly line and mass car production were the first of their kind globally. It reduced the car assembly time from 12 hours per car to about one and a half hours per car [1].

However, being able to produce cars faster and better was good enough back in 1913, but it's not today. Automation and connected smart factories are the most recent manufacturing trends. Most processes in a PCB factory can be automated and monitored through implementing Industry 4.0 and IoT trends into PCB manufacturing. An increasingly digital production line will increase the efficiency, rule out mistakes and misinterpretation, and allow the focus to be on quality and innovation, which will create new value for the customers.

So, we hear a lot about smart factories lately, but what are they really? A smart factory is defined by its ability to harness manufacturing data flowing throughout the enterprise and then convert that data into intelligent information that can be used to create improvements

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in productivity, efficiency, savings, yields, automation, enabled traceability, compliance, and reduced risk of errors and rework. All of these items are crucial factors when manufacturing printed circuits.

In a recent publication on smart factories, Deloitte University Press [2] stated the following:

"The smart factory represents a leap forward from more traditional automation to a fully connected and flexible system—one that can use a constant stream of data from connected operations and production systems to learn and adapt to new demands. A true smart factory can integrate data from system-wide physical, operational, and human assets to drive manufacturing, maintenance, inventory tracking, digitization of operations through the digital twin, and other types of activities across the entire manufacturing network. The result can be a more efficient and agile system, less production downtime, and a greater ability to predict and adjust to changes in the facility or broader network, possibly leading to better positioning in the competitive marketplace."

Not Necessarily Smart

A factory itself cannot be smart; it needs smart technology to support. For a smart factory to act, it needs data. For this, we need smart technologies that make the appropriate data available so that the machines can do their job. No data input or output. IoT, API, AI, and Industry 4.0 allow large amounts of manufacturing data to be collected, transferred, read, and interpreted through multiple sources and cloud-based, secure storage without any human involvement. However, machines tend to be bad interpreters.

For machines to interpret and make use of data and enable computer-talking-to-computer, they all need to speak the same language. The supply chain has evolved from some points of contact to a complex chain of designers, OEMs, assemblers, brokers, distributors,

John Steiner

factories, and subcontractors all sending data back and forward, doing manual labor trying to interpret the data. If we cannot interpret the data correctly, how can we expect the machines to do it?

Still, Rome was not built in a day, and progress is happening as we speak. We saw the need for this common language for specifying printed circuit fabrication data, which is why we initiated CircuitData.

In Need of Robots

Again, smart factories are characterized by adaptability, resource efficiency, and ergonomics as well as the integration of customers and partners in business and value processes. The goal of a smart factory is to optimize the concept generation and transform the production and the production transaction into a more efficient process. It is a subset that employs computer control and high levels of adaptability. When visiting smart factories, the one thing that instantly strikes you is how little human involvement there is at the plant [3].

But smart factories do not operate by themselves; they still need the workforce, which is where robots enter the picture. However, this is not a new asset to be added to the manufacturing floor. Robots and humans have been working side by side for many years. What's new about the robots of today is they are smarter, more independent, and can perform several tasks without stopping the workflow and the need for reprogramming. Again, AI is the key.

Connecting the Dots With Data

We all know that the future is all about data. Imagine how things are today—a supply chain built partly on paper and digitally. The tracking and controlling process are time-demanding, and it's difficult to have full control and a broad overview. In PCB manufacturing plants, large amounts of design and production data are held in many places and different formats.

By connecting the dots, we simply mean that when the supply chain becomes digital with the data input in a common language—and data is accessible, analyzed, modified within the same language—we can use APIs for interpretations and robots can take decisions and actions in real time at the manufacturer. Continued innovation is accelerating the Industry 4.0 transformation of the PCB factory, but we need to solve the question about data language. Otherwise, we will end up with machines doing the job digitally and humans interpreting the mistakes manually. As some say, "Shit in is still shit out."


Andreas Lydersen

Some forecasts expect the smart factory market to exhibit significant growth potential at a CAGR of 9.3% between 2017 and 2022 and get up to $205.42 billion (USD) by 2022. The key driving factors for the growth of the smart factory market are the increase in adoption of industrial robots, the evolution of IoT, growth in demand for smart automation solutions, and the increase in emphasis on regulatory compliances. However, factors such as huge capital investments and the risks associated with security of cyber-physical systems are the major factors restraining the growth of this market [4].

Every year, we visit and audit several PCB factories. Lately, a growing trend spotted is for even more traditional factories to have connected equipment, such as online and real-time monitoring of processes, remote production, and maintenance alarms. China is now making a significant amount of investments in AI and smart automation for PCB manufacturing and other related applications, meaning not just taking over the role of human to load and unload production panels in the production processes. Asia Pacific (APAC) is expected to be the fastest-growing region in the AI in manufacturing and the largest market for industrial robots.

Robots and Humans Working Side By Side


Didrick Bech

Smart automation identifies which machine is going to be ready, and robots move the panels to the identified machine, unload the completed panels, and load up new panels. Completed panels are then moved to a holding position to be transferred to the next processes. We have seen this in a Chinese factory where panels are checked, stacked, pinned by a machine, and moved by the robot to the respective drilling machine unload and load. The machines are all interconnected where the process cycle time is calculated and planned in real-time.

Another plant in Singapore had the production processes manned by the Smart ERP system not only with robots moving panels from processes in the best sequence but also the system informed the engineers when there are problems detected and require a human decision. Each production lot is tagged with an RFID; thus, the system locates the lot for the engineer. Both examples show an improvement in automation where data is constantly being used to plan and make a decision in real time by the system, which improves efficiency and allows humans to focus on more critical work.

Advantages

Overall, here are four advantages of smart factories from a PCB perspective:

1. Increased Productivity and Efficiency

People are great (we love people), but people also make mistakes and sometimes make decisions based on the wrong parameters. Automation with the use of an application programming interface (API) and AI will give us the ability to produce at a faster speed with even higher accuracy and no need to worry about human errors during repetitive work. It is a win-win situation for all involved in the purchasing process. It's no secret that automation

is the key to the future. The implementation of AI also permits more customization, minimizing the downtime for retooling, the need to restart or re-program the machines for new operations, which results in continuous operation and enhanced flexibility.

2. Improved Quality and Change of Focus

Production needs to be monitored thoroughly and take an equal amount of time, resources, and production capacity. With automation, the basic manufacturing processes can be performed quicker and more precisely, freeing up time, resources, and production capacity to focus on the complexities. Then human knowledge can be spent more wisely on innovation, improved quality, and developing new technologies.

3. Increased Possibilities for Optimization

As technology develops and the possibilities for more tailoring the customer's demands increases, the need for more optimization and flexibility in production arises. Automation allows manufacturers to be more flexible in production, and mart robots make the assembly line more efficient, which opens the possibility for tailored mass production due to customer specifications.

4. Product Innovation

The goal of smart factories and automation is not only improved productivity and lower costs during production but also a smarter and more flexible production. The focus is on better products, improved quality, and a supply chain that is agile and can handle the complexity that the products of the future will demand.

What can we say about the future? Predicting the future is not easy, but we can definitely say it will be an exciting ride! **PCB007**

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To read past columns or contact The PCB Norsemen, click here.

Isola Executive Vice Chairman and Acting CEO Travis Kelly on the Upcoming Year

In an interview with I-Connect007, Isola Executive Vice Chairman and Acting CEO Travis Kelly discusses the recent milestones for the company, including the leadership transition. Kelly outlines his agenda for the upcoming year, gives an update on Isola's new facility in Chandler, Arizona, as well as the culture in the company and how to carry it forward

Kelly also talks about the Asian market, their strategies in the region, and the opportunities and trends he is seeing this year.

To read the full interview, click here.

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The New Frontier of Manufacturing

The Right Approach
Feature Column by Steve Williams, THE RIGHT APPROACH CONSULTING

Even my good friend James Tiberius Kirk, who has spurred major technological advancements in the medical field, could have predicted the quantum shift in today's manufacturing technologies. What just a short time ago would have been fodder for a Jetson's episode is now manufacturing reality in today's smart factory realm.

It's All About Connectivity

In the rise of this fourth industrial revolution (Industry 4.0), connectivity is king. Buzzwords like the internet of things (IoT), and machine-to-machine (M2M) and human-to-machine (H2M) communication appear to be involved in every conversation as the industry shifts from more traditional automation to a fully connected and flexible system—one that can use a constant stream of data from connected equipment and manufacturing systems to learn and adapt to ever-changing customer needs (Figure 1).

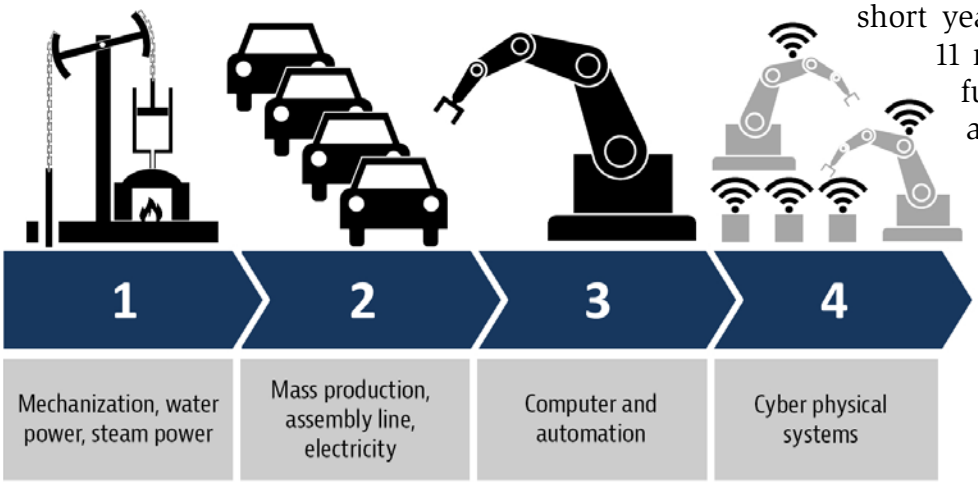

Figure 1: Smart factory development. (Source: Christoph Roser, AllAboutLean.com)

At IPC APEX EXPO 2019, I interviewed Norihiro Koike, president and CEO of Saki. Nori described the technology behind Saki's industry-leading automated optical inspection (AOI) and 3D equipment. Imagine if a 3D AOI or solder paste inspection (SPI) system could be self-programming, require only a few clicks, and take less than 10 minutes to program. There's no need to imagine because Saki offers this technology today! Focusing on smart contract manufacturing factories, automated SMT lines require cutting-edge innovation to keep up. These systems feed back real-time process data that allows the SMT equipment to make on-the-fly process adjustments based on the incoming data. Amazing!

A History Lesson

It is hard to believe that iPhones have only been around since 2007. The smartphone was such a step-function advancement in mobile technology that it led to the concept of IoT a short year later. Apple sold about 11 million iPhones in the first full year after their launch—a number that has skyrocketed every year since to a level of 217 million last year [1]. In addition, there were less than five billion connected devices in the world in 2008, but by the end of this year, it is predicted that this number will explode to over 50 billion [2].

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What Makes a Factory Smart?

Automation? Duh! However, it is not enough to employ automation whenever possible; smart factories require intelligent automation. In other words, equipment must talk to each other and adjust the process based on the data being collected. Challenges that many operations face are the fact that we have a lot of equipment and/or processes that do not lend themselves to connectivity, either as mechanical processes or the capability of the equipment. This is where mobile solutions can play a major role. Such solutions collect data from stranded assets that are not digitally integrated and can be sent digitally to decision makers through tablets or apps. The overall productivity and efficiency of the workplace improves using actionable insights derived from the data using mobile access.

Quality Has a Role

AOI has been around a long time in our industry, but new technologies make use of incredibly high-resolution cameras that can detect defects and concerns far more reliably (and infinitely faster) than the human eye. When integrated with a cloud-based data collection system, defects are instantly flagged and actions are automatically coordinated.

Artificial Intelligence

There have been a number of science-fiction movies over the years about well-meaning machines built with AI that learn too much and became autonomous and malicious. Most of these movies deal with a single machine that rebels against its inventor. I could make a convincing argument that the absolutely horrid 1986 movie "Maximum Overdrive" was actually the first introduction of IoT and M2M in the movies, which is astounding since the World Wide Web was not even created until 1990 (I really don't recommend renting the DVD to prove my point).

In the context of IoT and M2M, machine learning is a reality and equipment really can learn from performing a task over and over or collecting repetitive process data. One such application is the concept of predictive maintenance, which is your typical PM program on steroids. Smart factories are employing machine learning cloud-based software to detect and predict defects in their machinery *before* issues arise through data collection. This allows for predictive maintenance that can cut down on unexpected delays, which can cost time, money, and customers.

Machine-to-business

While M2M and H2M connectivity are the primary focus of Industry 4.0, the true underlying benefit of Industry 4.0 comes in the form of machine-to-business (M2B) connectivity or the "machine-as-a-service" concept. This is changing the way we purchase equipment. Today, some companies look past the traditional efficiency equipment and focus instead on how it can drive revenue. For example, contract manufacturers no longer purchase manufacturing equipment in a one-and-done payment. Instead, they negotiate the key performance indicators (KPIs) of the equipment in advance, and then partially finance or lease the equipment based on the machine's output. This ensures that their equipment set is always the latest and greatest and that their technology remains fresh and current. PCB manufacturers could take a lesson from their upstream brethren here.

I have been a life-long believer in the old adage "Work smarter, not harder." I preach this to all of my clients. It is both interesting and exciting to watch our factories begin to follow suit. **PCB007**

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Steve Williams is the president of The Right Approach Consulting. To read past columns or contact Williams, click here.

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Supplier Highlights

Isola Executive Vice Chairman and Acting CEO Travis Kelly on the Upcoming Year ▶

Isola Executive Vice Chairman and Acting CEO Travis Kelly discusses the recent milestones for the company, including the leadership transition. Travis also outlines his agenda for the upcoming year and gives an update on Isola's new facility in Chandler, Arizona.

EPTE Newsletter: Predicted Sales Decrease for the Taiwanese Electronics Industry ▶

In a recent report on the printed circuit industry in Taiwan, some voiced concerns about the industry's declining revenues and a potential domino effect for the rest of the electronics market. Unfortunately, this may become a reality.

AltiumLive Munich: Day Two Keynotes ▶

Having enjoyed the conference dinner and robot battles of the previous evening, a good night's sleep, and a hearty breakfast, Altium's family of over 220 electronics engineers and designers eagerly returned to the conference room. Many jostled to secure the best seats for the second day of the European AltiumLive design summit in Munich, keen to make the most of the "learn, connect, and get inspired" opportunity it offered.

RTW IPC APEX EXPO 2019: Taiyo Discusses New Solder Masks and Photoimageables ▶

Donald Monn, Midwest regional sales manager for Taiyo America, turns the tables on I-Connect007 Technical Editor Pete Starkey and quizzes him about his knowledge of Taiyo's new crack-resistant white solder mask for automotive, and the company's standard photoimageables re-formulated for laser direct imaging (LDI) that avoid the need for UL requalification.

Laser Focus on Flex and Rigid-flex ▶

ESI's Chris Ryder, director of product management, and Shane Noel, flex systems product manager, discuss laser vias for flex users and the increasing necessity for companies to collaborate early on and become more and more involved, whether that be in the product design or with the process or base material manufacturers.

RTW IPC APEX EXPO 2019: Ventec's Goodwin on Global Technology Directions ▶

Mark Goodwin, Ventec International Group CEO EMEA and USA, comments on technology directions globally and in the North American market. He also explains how Ventec's quality accreditations, technical expertise, and flexible manufacturing capacity continue to strengthen their leading position.

Selective Solder Mask Deposition by Inkjet ▶

At IPC APEX EXPO 2019, I-Connect007 Technical Editor Pete Starkey spoke with Joost Valeton, product manager for PiXDRO inkjet printing equipment with Meyer Burger, about their newly configured inkjet printer for PCB applications, bringing awareness to opportunities using selective solder mask deposition.

RTW IPC APEX EXPO: Rogers' Anthony Mattingly Discusses the Advanced Laminate Market ▶

Rogers Corporation's Senior Product Manager Anthony Mattingly and I-Connect007 Technical Editor Pete Starkey discuss the ever-evolving market for advanced laminates for technologies such as 5G. Mattingly explains how Rogers has invested heavily in infrastructure for adding about 40% more capacity in the next few years.

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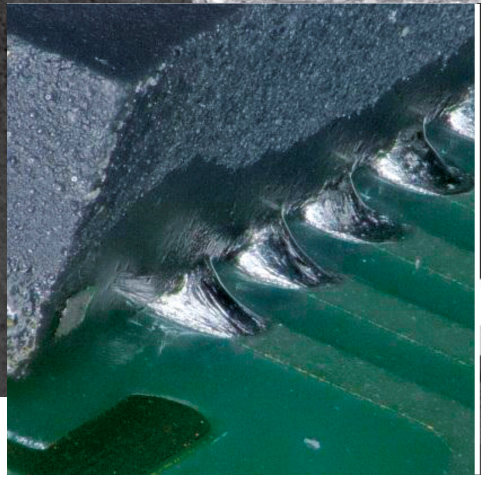

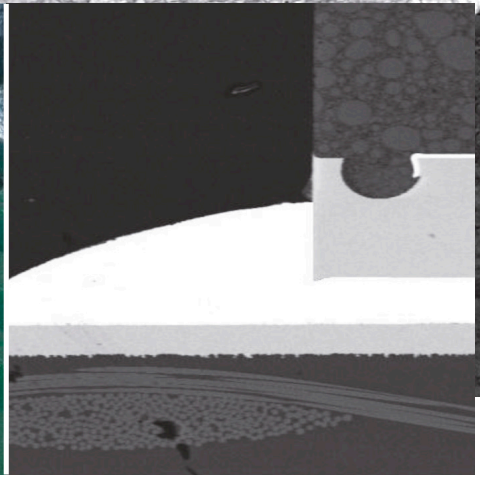

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Two Full CFX Demo Lines at IPC APEX EXPO 2019

by Dan Feinberg
I-CONNECT007

On January 22, 2019, IPC announced the approval of IPC-2591—the Connected Factory Exchange (CFX)—by the 2-17 Connected Factory Initiative Subcommittee, delivering an industry standard for the implementation of Industry 4.0 in electronics manufacturing. David Bergman—IPC VP of standards and technology—spoke with Dan Feinberg at IPC APEX EXPO 2019 about CFX in general, IPC's CFX software, and machine-to-machine communication.

CFX intends to facilitate machine-to-machine and machine-to-manufacturing execution systems communication. CFX is intended to become the common language between these systems, serving as the foundation of Industry 4.0.

Because CFX is an industry standard, it creates a level playing field for any manufacturer to prepare for Industry 4.0 or to simply benefit from the machine-to-business data communication. The standard also was developed with simplicity and ease of implementation in mind. To illustrate this point, IPC set up two full demonstration lines at IPC APEX EXPO 2019, integrating multiple vendors in the lines. In addition, 80+ companies are now supporting CFX.

This interview was originally published in the *Real Time with... IPC APEX EXPO 2019 Show & Tell Magazine*. Read the interview here.

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Old-fashioned Networking

Flex Talk
by Tara Dunn, OMNI PCB

I attended IPC APEX EXPO this year determined to find an answer to a question that I had been asked and couldn't answer, even after some fairly extensive internet searching. So where did I go for answers when the internet wasn't helpful? With thousands of people in attendance, I couldn't imagine a better place to search for PCB information. Knowing that I had three days to find the information I was looking for, I started with the shotgun approach. I walked up and down the aisles, kept an eye out for related items, and asked questions when something caught my eye.

After realizing this probably wasn't the most efficient way to look for the information, I turned to the IPC APEX EXPO 2019 app on my smartphone and the hard copy of the show guide. This helped narrow my search, and I went off to investigate. While I did learn a few new things in this investigation, I didn't find the answer to my initial question while walking the expo aisles. Thankfully, as I stopped to talk to a long-time industry friend and mentioned this search, he referred me to someone who had the answer I needed.

We live in a connected world. Our smartphones connect to our cars, music speakers, household lighting, and appliances, and there is a full issue of this magazine dedicated to connected factories. Information is collected at an astonishing rate, and people are working diligently to put this information to good use. It is new, fun, and exciting. So many industries are exploding with applications, such as home appliances, medical applications, agriculture, energy management, retail, and the list goes on.

I sometimes wonder what is going to happen to the good, "old-fashioned" networking. You know, not networked devices, but the act of going out and meeting people in our industry, learning about their story and expertise, and sharing yours—mutually beneficial sharing of information and resources. Seeing a long-time industry friend at IPC APEX EXPO 2019 certainly helped me answer the question I was looking for.

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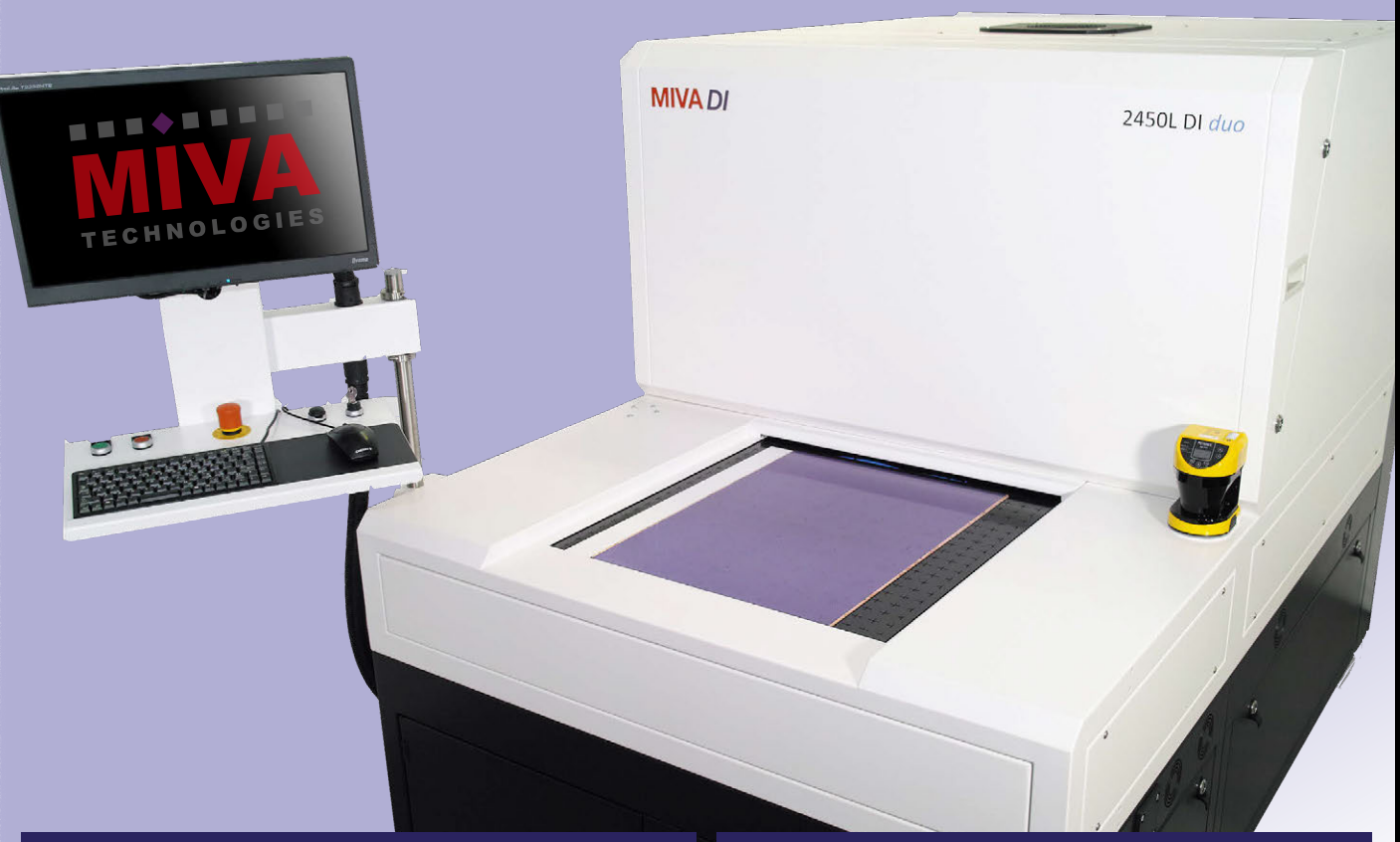

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For many people, when they hear the word networking, it causes a little panic and brings to mind images of walking into a room of strangers, trying to find someone to talk to, and feeling awkward and out of place. Truthfully, even I find it a little intimidating, and I host networking events! I also find that once I get to an event, it is almost always interesting and enjoyable.

In this column, I want to challenge you to attend some of the industry events that are available and be intentional about meeting at least one new person. And I want to challenge the industry associations to find creative ways to make the act of attending these events less intimidating. Where do you start? Here are a few places to review when looking for events nearby.

Design Tool User Groups

Altium, Cadence, Mentor, and others regularly host user groups. These events provide a great opportunity to learn more about how to better utilize your design tool of choice and meet other users at the same time. Not only are the tool experts available to answer questions, but attendees can meet with experts and other users to make connections that may help answer a question the next time they are struggling to solve a challenge.

These events provide a great opportunity to learn more about how to better utilize your design tool of choice and meet other users at the same time.

Geek-a-Palooza

Geek-a-Palooza was founded specifically to bring all aspects of the local electronics community together for an evening of food, fun, and face-to-face interaction. The annual event has been held in Minneapolis, Boston, and Orange County with plans to continue expanding to other locations. Geek-a-Palooza is unique in the fact that the event serves all aspects of the electronics community: raw materials, designers, fabricators, EMS, component manufacturers, component distributors, manufacturers reps, and industry associations. This is an excellent opportunity to meet new people and expand your resources and network. To learn more, visit geek-a-palooza.com.

IEEE

Another organization supporting the advancement of technology is the IEEE. An excerpt from their website explains, "IEEE local geographic organizational units (sections, chapters, affinity groups, and student branches) provide unique opportunities for members to attend technical presentations, create strong peer-to-peer connections, and participate in leadership opportunities that can make a positive distinction in IEEE members' jobs and careers." To learn more, visit ieee.org.

IPC

IPC serves designers, board manufacturers, assembly companies, suppliers, and OEMs. An excerpt from their brochure states "By being the hub of knowledge in the electronics industry, IPC provides standards, training and certification, market research, education, and public policy advocacy to help member-companies achieve their goals. We are here to help our members create better-quality products, enhance the skills and knowledge of their employees, reduce costs and waste, comply with regulations, and be ready to capitalize on what is next." IPC hosts many conferences and events worldwide, such as IPC APEX EXPO, and provides excellent opportunities to meet new people with similar interests. To learn more, visit ipc.org.

IPC Designers Council

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ing. According to their website, an active IPC Designers Council chapter consists of a minimum of 12 designers and meets at least four times per year. Structure of the meetings will vary, but most chapters focus on technical education and networking activities. Also, most chapters host roundtable discussions, facility tours, and presentations on hot topics in the PCB design world, including DFM, EMI, RFI, high-speed design, ultra-fine pitch design, etc. Some chapters have formed designer certification study groups to help prepare their members for the PCB designer certification exam. To find information on local chapters, click here.

SMTA

SMTA is a global organization working at the local level. An excerpt from their website states, "For electronics engineering and manufacturing professionals seeking to improve processes through best practices and real-world solutions, SMTA offers exclusive access to local and global communities of experts as well as accumulated research and training materials from thousands of companies dedicated to advancing the electronics industry." SMTA hosts several large expos and events and is also very active with smaller, local programs. Local chapters host smaller expos with technical information and opportunities to interact with the supply base. Throughout the year, local chapters host chapter meetings geared to toward technical training and facility tours. These are excellent opportunities to meet new people with similar interests. To learn more, visit smta.org.

Summary

Overall, while the world of connected devices is fun, new, exciting, and without a doubt is going to change the way we do business, I hope this column serves as a reminder that building personal connections with each other is something that will never be obsolete or outdated. I regularly reach out to people I know when I need help answering a question, usually after I have tried an internet search first; in turn, I am regularly asked for advice. Knowing people with expertise in other areas has been invaluable. I issued a challenge above for those of us in the electronics industry to get out to events that facilitate meeting new people and a challenge for industry associations to make that even easier for us to do. Do you accept the challenge? If so, I would love to hear your comments and experiences. **PCB007**

Tara Dunn is the president of Omni PCB, a manufacturer's rep firm specializing in the printed circuit board industry. To read past columns or contact Dunn, click here.

RTW IPC APEX EXPO 2019:
Atotech Discusses Developments in Metallization Chemistries

Roger Massey, technical marketing manager at Atotech, and Technical Editor Pete Starkey discuss the challenges technologists face as circuit lines and spaces get smaller and smaller, and the latest developments in metallization chemistries to help customers address these issues.

Click image to watch the interview.


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MilAero007 Highlights

Defense Speak Interpreted: DARPA ERI ▶

DARPA ERI stands for the Defense Advanced Research Projects Agency and the Electronics Resurgence Initiative. This tongue-twisting acronym is the latest Department of Defense (DoD) effort to catch up and surpass world semiconductor technology for the secure IC chips needed by advanced defense electronics systems.

TTM Reports Fiscal Fourth Quarter and Fiscal 2018 Results ▶

Net sales for the fourth quarter of 2018 were $711.0 million compared to $739.3 million in the fourth quarter of 2017 and $755.8 million in the third quarter of 2018.

Siemens Launches Camstar Electronics Suite Software ▶

Siemens launched the Camstar Electronics Suite software, an innovative manufacturing execution system (MES) for electronics.

Printed Circuits Installs Zünd High-speed CNC Cutter/Routing Machine ▶

Flex and rigid-flex circuit board manufacturer Printed Circuits has purchased and installed a Zünd high-speed CNC controlled cutter and router.

Storz GmbH Praises Gardien's Universal Tester ▶

Schaltungsdruck Storz GmbH achieved a significant increase in productivity with the installation of Gardien's KAIMA GUDAA.

FTG Reports Record Sales in 2018 ▶

For FTG, overall sales increased by $14.7 million or 15.5% from $94.7 million in 2017 to $109.4 million in 2018. Both the circuits and aerospace segments contributed to the growth.

American Standard Circuits Acquires Lenz Router ▶

PCB fabricator American Standard Circuits (ASC) recently acquired an RLG 550-2 routing machine from Lenz.

Insulectro Supplier Oak Mitsui Names Michael Coll Technical Director ▶

One of Insulectro's best-in-class suppliers, Oak Mitsui Inc., has hired industry veteran Michael Coll as technical director. Coll has over 20 years of experience in the PCB industry.

AT&S Reports Increase in Revenue in Q1-Q3 2018/19 ▶

AT&S has reported revenue of €790.1 million, which is up by 3.2% compared with the same period in the previous year. Sales increases for IC substrates and in the medical and healthcare segment partially offset the decline in demand recorded in the mobile device, automotive, and industrial segments in the third quarter.

Transport Canada Grants TSO for FTG's Cursor Control Device Avionic Equipment ▶

Firan Technology Group Corporation (FTG) received a Canadian Technical Standard Order (CAN-TSO) certification from Transport Canada for its cursor control device (CCD).

U.S. Army 2020 Budget Begins Dramatic Shift ▶

A U.S. Army budget drill that identified $30 billion in savings was partly about finding money for future modernization and to "do better with every dollar we have," said Undersecretary of the U.S. Army Ryan D. McCarthy.

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Optimizing the OSP Process for High Performance, Part 1

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

Engineers must understand the limitations of organic solderability preservatives (OSPs) and how best to optimize the performance of the finish. Paying close attention to equipment systems, pH control, and pre-OSP process steps will help to ensure optimum OSP performance.

Introduction

Never underestimate the importance of the equipment set-up and the operating parameters for any chemical process, and OSPs are no exception. Complex PCB assembly presents significant challenges concerning the solderable finish selected. While there are many choices available to assembly engineers and OEMs, some finishes—such as OSPs and ENIG—occupy a significant market share. Even with the significant market acceptance of OSPs, there are many questions related to the finish. These include the performance of the coating under multiple lead-free reflows, solder flow-up, and creep corrosion, among others. In addition, as with all finishes, there are limitations.

In this month's column, those limitations will be presented along with a thorough discussion of key equipment and chemical process parameters that influence the performance of the OSP. No one finish will meet all criteria that an end user and assembly company may desire. However, it is critical that the final finish selected meet several criteria depending on the environment and functionality of the final assembled product.

Since electronic products are often grouped according to the end-use environment or application, it makes sense to gain a thorough understanding of the key attributes that will determine how well that particular finish functions. The engineer must consider a number of attributes that will determine which finish is the best fit within the following well-known market segments:

- Medical
- Aerospace/defense
- Computer/office
- Consumer/handheld
- Telecommunications

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Attributes and related questions include [1]:

- What is the cost sensitivity of the product (how important is the surface finish cost)?
- What are the product volume requirements (high, medium, or low)?
- Is it an SnPb- or Pb-free process?
- If Pb-free, is shock/drop a concern for your product?
- Is fine pitch assembly required (how fine)?
- What is the user environment (is corrosion a concern)?
- Is wave solder required, and if so, how thick are the boards?
- Is high yield in-circuit testing required?
- Is wire bonding required?

As you review the list of final finish desired attributes, there is concern that no one finish will meet all product segment requirements. So, where does OSP fit?

OSPs

As of this writing, over 45% of the PCB surface area produced annually is finished with OSPs. This is significantly more than any other final finish can claim [2]. However, certain conditions and end-use environments may negatively impact the use and implementation of OSPs. As an example, many EMS providers desire to perform in-circuit test (ICT) to measure electrical continuity of the assembled circuit before shipping to the end customer. This can be a challenge because the coating is often difficult to probe through. OSP coatings are nonconductive. One procedure is to print solder paste on test points. However, flux residues can coat the probes and impact ICT. There is also a concern that multiple IR reflows will harden the OSP, further impacting ICT.

As of this writing, over 45% of the PCB surface area produced annually is finished with OSPs. This is significantly more than any other final finish can claim.

Another potential drawback with OSPs is its compatibility with lead-free assembly. With the introduction of lead-free alloys, the higher temperatures and dwell times of assembly impact the solderability of any final finish. Oxidation is the enemy of good solderability. So, how does OSP fare under these conditions? What if moisture removal bakes are implemented?

Other perceived downsides include solder flow-up through vias and solder paste spreadability. Will OSP processes meet the minimum criteria for solder joint strength and overall reliability? In the past, there was documented evidence that solder flow-up is not successful with OSPs under extreme temperature conditions. Of course, this must be addressed.

Finally, there are additional concerns with corrosion of final finishes. How do OSPs compare under harsh environments to other finishes including ENIG, immersion silver, and hot air leveling? These and the other aforementioned questions will be answered in a future column.

Equipment Considerations

Let's discuss equipment as the equipment design relates to effective OSP process performance. While OSPs can be effectively applied to the PCB by immersion or conveyorized processing, the latter provides a more controllable and higher through-put option. As stated earlier, the proper processing sequence is:

- Acidic cleaning
- Rinse
- Microetch
- Rinse
- Pre-dip (optional)
- OSP process
- Rinse
- Dry

If persulphate microetches are used, it is highly recommended to utilize an acidic pre-

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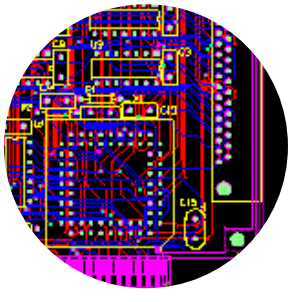

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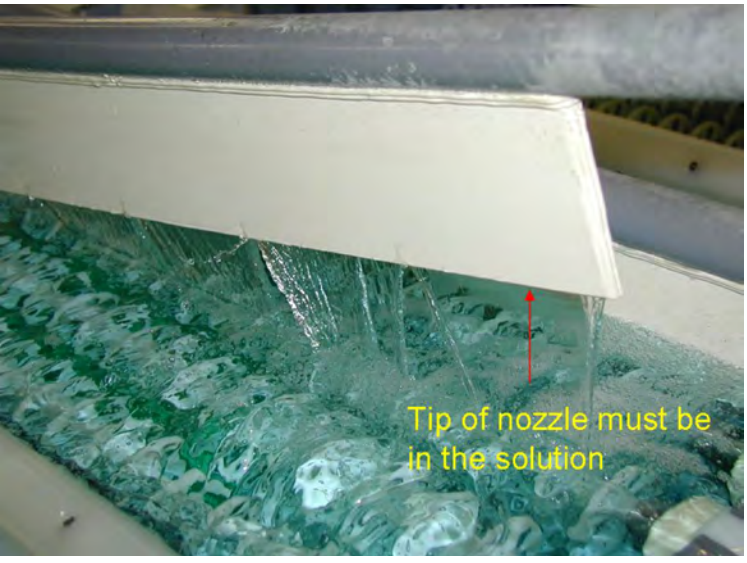

Figure 1: OSP spray chamber configuration.

Figure 2: Top view of the OSP chamber (yellow arrows point to the PVA sponge rollers).

dip before the OSP process to remove any residues remaining. This step is not necessary if hydrogen peroxide-sulphuric acid is used. Also, it is important to note that this process does not require a pre-coat step. The OSP (if a conveyorized system is used) can be applied by spray or flood, but spray is preferred. The ideal configuration provides spray nozzles just immersed in the OSP solution (Figure 1).

A second critical design feature for OSP equipment is to ensure minimal drag-out of the OSP chemistry. To minimize drag-out, PVA sponge rollers should be installed at the exit of the OSP chamber. These super-absorbent rollers squeegee the excess liquid from the panels, and it remains in the OSP chamber. The PVA roller covers are tubes of the sponge material with an inner diameter sized to fit the core and an outer diameter sized slightly larger than the current solid rollers. This slightly larger outer diameter ensures good contact with the boards and compression of the sponge to create the squeegee action.

Compression of the rollers is aided by either the weight of the top roller core or a screw compression device that pushes down on the upper roller shaft. The compression also wrings out the rollers between panels to return the excess to the chamber (Figure 2). These rollers should also be present at the entry of the OSP chamber to prevent the potential of rinse water drag-in to the OSP. Drag in of water (potentially acidified from the microetch) will dilute the effective concentration of the azole compound and reduce the operating pH. Both situations will reduce the thickness of the OSP coating on the copper. Deleterious effects on solderability can be expected.

Summary

The performance of chemical processes used in the fabrication of PCBs depends on equipment function and design, not just chemistry. Keep that in mind when designing equipment for future purchase. **PCB007**

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2. Prismark Partners LLC. 2013. "Final Finish Survey."

Michael Carano is VP of technology and business development for RBP Chemical Technology. To read past columns or contact Carano, click here.

2019 Programs

NORTH AMERICA

IPC TECH ED

April 2
King of Prussia, PA
Process and Acceptability Requirements: Utilizing J-STD-001 and IPC-A-610 Together

May 7
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The Evolution of IPC's Cable & Harness Documents — IPC-D-620, IPC/WHMA-A-620 and IPC–HDBK–620

September 10
Huntsville, AL
Process and Acceptability Requirements: Utilizing J-STD-001 and IPC-A-610 Together

November 12
Raleigh, NC (in conjunction with PCB Carolina)
Topic Coming Soon

December 3
Anaheim, CA
Process and Acceptability Requirements: Utilizing J-STD-001 and IPC-A-610 Together

MEETINGS

March 5–7
Raytheon in Huntsville, Alabama
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May 21
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IPC IMPACT Washington, D.C.

June 15–20
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Electronics Industry News and Market Highlights

Additive Manufacturing Leaps From Prototype to Production ▶

According to a new report by ABI Research, additive manufacturing will produce more than $360 billion worth of parts and end products each year and nearly $2 trillion in sum by the end of the next decade.

Digital Transformation to Advance Global Airlines' Growth Prospects ▶

Frost & Sullivan's latest analysis reveals that digital transformation will continue to be a major focus for airlines. New digital tools have helped airlines grow direct and indirect revenues, optimize costs, improve the passenger experience, and advance growth prospects.

Canalys Expects Fewer Than Two Million Foldable Smartphones Will Ship in 2019 ▶

Foldable phones have arrived in the shape of the Samsung Galaxy Fold and Huawei Mate X. More vendors will soon follow with their own takes on foldable displays, but 2019 will not be the year that foldable phones go mainstream.

Remote Patient Monitoring Revenues to Reach €46.1 Billion in 2023 ▶

Revenues for remote patient monitoring (RPM) solutions reached €17.5 billion in 2018, and are expected to reach €46.1 billion at the end of the forecast period, according to a new market report from Berg Insight.

Cognitive Computing Market to Expand due to Growing Adoption of the Connected Devices ▶

According to TMR, the global cognitive computing market achieved the revenue of the $29.67 billion in 2016 and is expected to expand with the CAGR of the 49.9% for attaining a value of $1.0 trillion by the end of the year 2025.

Digitization Remains a Key Focus for Most Industries in 2019, but Challenges Remain ▶

More and more enterprises are looking toward new technologies such as machine learning and artificial intelligence, edge computing, and software-defined in their push toward digital transformation.

China's Smartphone Market Falls 14% in 2018 ▶

China's smartphone market falls 14% in 2018 with just under 400 million units shipped. In 2018, smartphone shipments in China fell to their lowest level since 2013 at 396 million units.

The U.S. Secures 5G Superiority, at Least in Short Term ▶

The race for the leading role in 5G connectivity has already started, and while the U.S., China, South Korea, and Japan are the four countries in the lead, it is the United States who will win the 5G race in the short term, according to ABI Research.

Semiconductor R&D Spending Will Step Up After Slowing ▶

IC Insights claims 3D die-stacking technologies, manufacturing barriers, and growing complexities in end-use systems are among the technical challenges expected to lift R&D growth rates through 2023.

Global Semiconductor Sales Up Nearly 14% to $468.8B in 2018 ▶

The Semiconductor Industry Association (SIA)—representing U.S. leadership in semiconductor manufacturing, design, and research—announced the global semiconductor industry posted sales of $468.8 billion in 2018, which is the industry's highest-ever annual total with an increase of 13.7% compared to the 2017 total.

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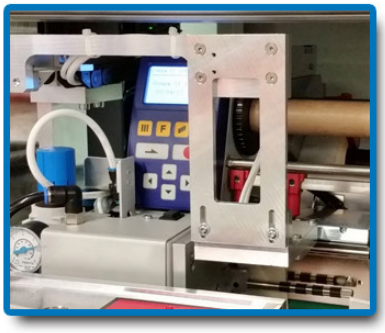

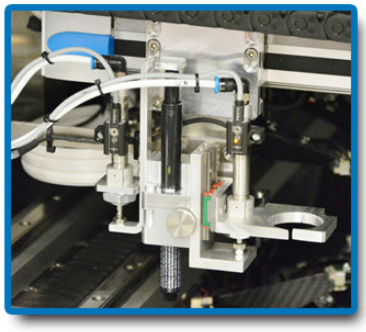

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Confidence in Inspection

Testing Todd

by Todd Kolmodin, GARDIEN SERVICES USA

In the world of planning, manufacturing, and consumerism, we rely on the fact that what we design or purchase meets the requirements set forth. For a consumer, it really is a leap of faith that what we buy does what the label or manufacturer says it will do. For consumable goods, that is basically it; if it doesn't work or do what it should, we don't care—just return it.

However, in the second tier of this scenario are durable goods. For housing, construction, and other trades that have safety and health concerns, we rely on independent inspection to make sure things are being done correctly and to the standards for which the work must conform. An example could be home electrical or plumbing. The work is performed by licensed tradespeople but requires an inspection by a third party. This guarantees what was done is compliant with health and safety standards. If something is found to be incorrect, the third-party inspector will not pass the work performed until corrections are made. This stops the possibility of unsafe or incorrect work being hidden. Of course, in this case, the consumer cannot pick the third-party inspector or have a say in how the work is performed other than the plan or scope.

Now, in our third scenario, we have total control of the product. We design it and decide who manufactures it. We give the design and performance requirements and the final criteria. However, this is where the control falters. When we receive our product from the manufacturer, we have to assume that it was manufactured to our specifications. Sure, it may work, but will it work for the long term? It was inspected by the manufacturer and even has their stamp of approval, but that doesn't tell us much.

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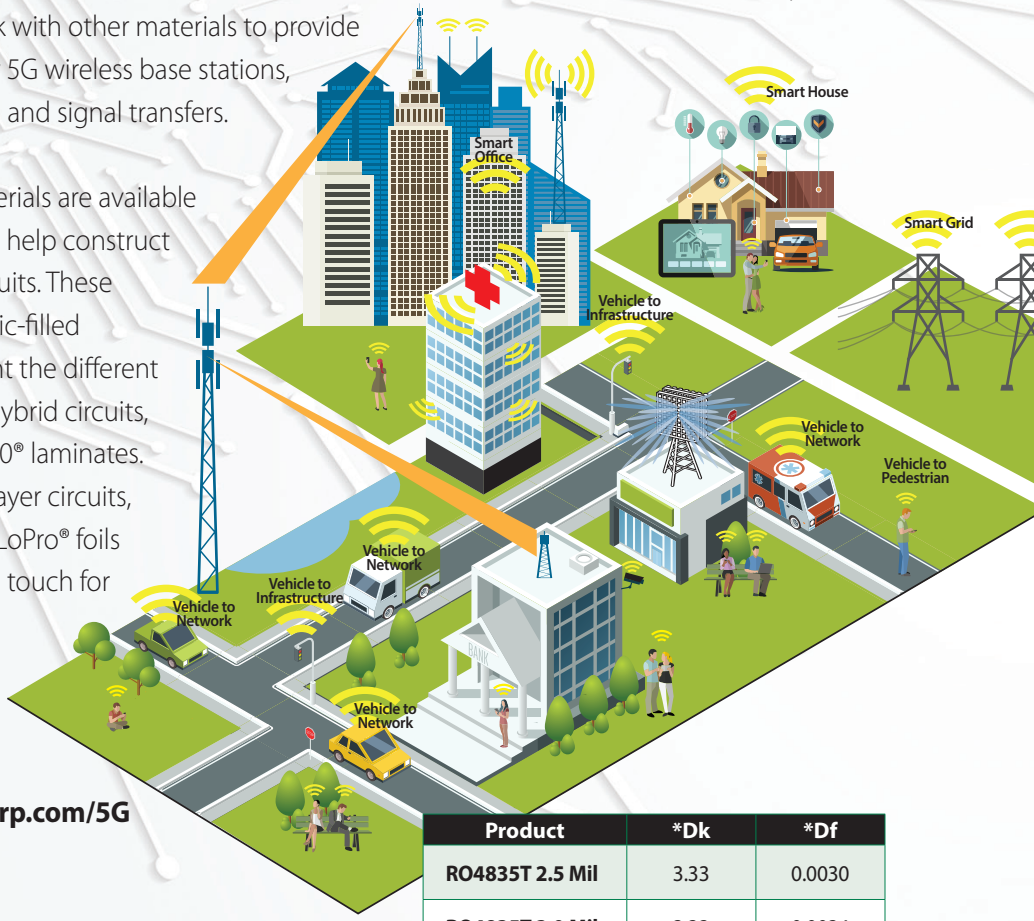

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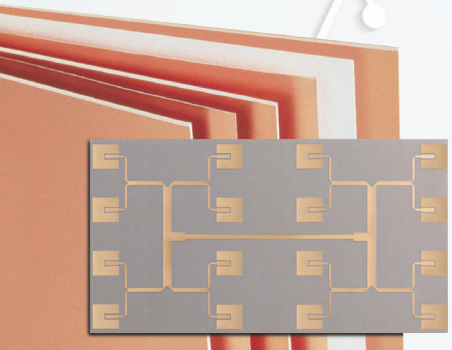

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Many quality accreditations state that an auditor cannot audit their own work. Remember, within a manufacturing facility, all employees work for the same company, the same monthly revenue goals, and the same deadlines. Here is where the game gets a little fuzzy. Imagine that the shipping deadline is 4:00 p.m., the delivery is already late, the customer is demanding their product, and the identification ink on the product is blurred. Now, someone in that manufacturing facility is going to make a call on whether they ship it anyway since it's only ink and it's close enough, or scrap it and make it right. Oh, did I mention it was the end of the month too? They are short on their revenue target.

How confident are you now?

This is where third-party inspection provides you the missing confidence. Many end-user companies require in-process or out-of-the-box inspections. These are cases where an end user dispatches one of their own inspectors to physically go to the manufacturing plant and inspect their product in one of the two aforementioned ways. This inspection process puts the burden on the end-use customer because they must incur the cost of their inspector traveling to the manufacturing plant. However, this does satisfy the customer since they do inspect their own product to audit it is manufactured properly. Again, this is not the ultimate solution.

Independent, third-party inspection is where all the pieces fall into place. The third party must remain neutral to either side. The job of third-party inspection is to provide a non-biased review of the customer requirements versus the final product manufactured. This inspection can include both physical and functional criteria. In the instance of PCBs, this can be cosmetic, dimensional, electrical, and in some cases, functional. In this neutral playing field, the customer provides the requirements and/or inspection criteria to the third-party inspection entity as well as the procurement order to the manufacturer, which also includes the deliverables.

When the product has completed its manufacturing cycle, it is sent to the third-party inspection entity. This entity may be local to the manufacturer or located elsewhere. When the product arrives at the third-party inspection entity, it is given an unbiased review based on the requirements of the end-use customer as previously described. When the inspection is complete, the product is either certified to meet the customer requirements or is found to be non-conforming. The strong point here is that the review is unbiased, and the results are binary—either conforming or non-conforming based on the requirements set forth as deliverables.

The customer is then briefed on the results and provided objective evidence regarding any non-conformances. If all product is conforming, it is then shipped to the customer or duly designated receiver. Non-conformance issues require resolution, and after review, the customer either accepts the product under an authorized deviation or the product is returned to the manufacturer for resolution and/or disposition. There is no grey area with third-party inspection. Ultimately, the product is shipped conforming to the end-use customer, or it is returned non-conforming to the manufacturer. Another key point is that some referee testing can be accomplished. These may be specific to plating (latent voiding), TDR, and other tests that may not be possible at the manufacturing facility.

Conclusion

With our earlier example regarding third-party inspection in the construction industry, which is required, we see the growing acceptance and requirement of third-party inspection in many theatres of the manufacturing industry. This is becoming more prevalent with military, aerospace, and medical. When high reliability is an absolute necessity, the requirement of independent inspection also becomes the necessity. **PCB007**

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

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The Travelling Engineer, Instalment 1

Ladle on Manufacturing

by Marc Ladle, VIKING TEST LTD.

If you have ever wondered what it is like to work as a travelling engineer for a machine supplier, then perhaps I can give you a small insight into how the reality matches up to the job description. After 15 years of working for Viking Test Ltd. and having the opportunity to visit a variety of interesting locations around the world, any illusions I previously held have been shattered. The details that follow may not be 100% accurate, but they are how I honestly remember the experiences.

Before I started working for Viking, I had a series of jobs based in different factories. These factory roles were each based on a single site with a regular commute to work and reasonably regular working hours. Some travel was involved from time to time. I made visits to various machine suppliers to look at new and updated equipment, and at the time, I felt that I was reasonably experienced at negotiating airports and finding my way to foreign locations. Little did I know that I had hardly started to scratch the surface!

I knew Jake Kelly who runs Viking long before I was offered a job with the company. I had been involved in the purchase of flying probe testers supplied by Viking for a backplane factory where I worked for seven years. The testers worked really well for the unusual requirements required by the products we made. Based on that experience, I felt comfortable taking up a position working with that and other equipment that Viking supplied.

Day one with Viking was straightforward. They handed me the required tools for the job, which included a laptop computer and a cellphone along with a company credit card. At this stage, I could only see the positives, and it never even crossed my mind that along with the cellphone came the possibility that people may call it at any time regardless of whether I was working or not.

My first substantial assignment was to look after the supply and installation of a special flying probe tester for a customer in Holland. The machine was pretty technical and could make a test based on Latent technology as well as being able to make very accurate resistance measurements. The machine was manufactured in Japan, and I was asked to attend the sign off of the machine to help the customer through the sign off process. I was excited about making my first long-haul trip. It was made even better as Jake suggested that my wife, Linda, should accompany me, so we could share the experience in Japan.

We flew to Osaka via Paris, and everything was exciting and new to me. Japanese Airlines (JAL) were and still are the most polite

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and attentive company I have ever flown within the economy cabin. We landed, collected our luggage, and headed for the railway station to catch the bullet train to Osaka city. Reality hit me at this point; this was the first time I had been to a country that did not use a standard alphabet, which meant it was difficult to read the signs directing us to the ticket office.

The situation became even more difficult when I reached the front of the ticket queue and asked for two tickets to Osaka City in my best English. To say the guy at the other side of the desk looked a little blank was probably an understatement; he almost looked upset. I realise now that this is how importantly most people in Japan view their jobs, and the fact that he was not able to help me was probably a low point in his day. It is also typical of the excellent Japanese railway system that within a short time, they had managed to find an English-speaking member of staff to help me.

Lessons one and two were pretty swift—don't assume it is going to be easy to read the signs, and don't expect to be able to speak to the locals when you travel long haul. For a short while, I stood and considered the painted lines on the station platform. There were loads of coloured letters and numbers. After a minute, when orderly lines started to form, the penny dropped; the markings were to show you where to stand to get on the train through the most convenient door for your assigned seat. Super-efficient! The train stopped, inched towards the perfect for position, and pulled away at the correct time almost to the second. If you have ever travelled on British Rail, you understand what a revelation this was for me.

We made it to the hotel and headed for our room where I promptly lay down on the bed and fell asleep (we had been travelling for 24 hours since leaving home, and I had been awake for the whole time so far). Linda nudged me and suggested this was not the best plan, as it was only 4:00 p.m. and I should really try to get in line with the local clock. I napped for a while, managed to raise myself, and headed for the hotel restaurant located on the 20th floor overlooking the neon lights of the city of Osaka. The meal experience is a special memory for me. The waiters would quite literally run to the table to pour your glass of wine before you were able to touch the bottle yourself. The view was superb with trains far below coming from different directions on multiple levels. It felt like we were on the set of a Hollywood film. It was definitely an experience above my paygrade!

The following day, Linda and I headed for Okayama where the test machines were being manufactured. We were met at the station by Hiromi—one of the women from the factory—and taken to the factory apartment where we would be staying. My wife rested, and I headed to work. Hiromi asked what my wife would be doing for the week while I was in Okayama. I realised that perhaps I should have thought about this before issuing the invitation. The working days at the factory could be quite long, and it did not seem like much fun being left in a business apartment on your own. I should not have been too concerned because the women from the factory had it covered. Each day when they picked me up, they brought a set of instructions for a day out and handed my wife a Japanese cellphone to use in case of problems.

Linda had some adventures! I take my hat off to her; she definitely entered into the Japanese experience wholeheartedly and had a great time. Even nearly missing her stop on the train, which would have taken her non-stop to Hiroshima, didn't phase her. The recurring problem with not being able to read the local language was recognising station names and trying to use automated ticket machines.

I signed off the machine with two guys from Holland from a great company who were very skilled engineers. The work progressed and was regularly punctuated with breaks for meals. It is impossible to talk about trips to Asia without mentioning the food. We sat down to lunch one time to a perfectly presented meal of sushi presented in a stacked box. When you laid the meal out in front of you, there were perhaps 20 beautiful individual pieces. Even though neither the Dutch guys or I could use the provided chopsticks very well, we tucked in as best we could. Amongst the pieces was a small green item that looked like a perfectly formed inverted thimble. One of the guys with me picked it up and put it in his mouth before our host could stop him. He instantly went white, and I could see his eyes scanning the table for all cold liquids he could put in his mouth; a mouth full of Wasabi will do that to you. He survived without lasting damage, although I expect he remembers the experience even more vividly than me.

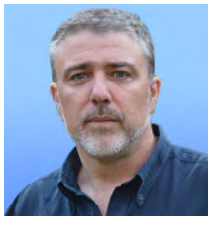
Just before it was time to leave to return to the U.K., we were lucky to experience the Cherry Blossom festival. Linda and I walked around the local park along with literally thousands of local people. At one point, we were separated by a few meters due to the density of people meant I just had to go with it. It was easy enough to see Linda anyway due to being quite tall compared to the local population, and her blonde hair was unique as far as the eye could see. I remember small children reaching out to touch her hair to see if it was real.

The main event for this trip was the test machine, and it was a great piece of kit. It was manufactured to be able to test a 1.2 m back panel up to 12 mm thick. It had very enhanced test capability compared to other machines of this generation, and the high-accuracy resistance test with resolution to a single milliohm worked extremely well so much so that it was successfully used to detect plating defects in individual holes. The test method for this was simple enough; each hole barrel had to be individually resistance tested, and the results were recorded and mapped. The normal resistance of a perfect hole was proven to be consistent across the whole panel for each hole size. The resistances in question were small—just a few milliohms—but if there was a defect in the plating, the resistance might be a couple of milliohms higher than all of the good holes.

When you consider that you may be searching for a defect rate less than one in two million holes, then you understand that there was a lot of testing to find only a few faults. In this case, the value of the circuit boards justified the effort involved, and every panel had to undergo this enhanced test. When a failure occurred, the hole in question was microsectioned and the nature of the defect identified. If these defects had made it into the final assembled product and installed in the field, there would have been a high risk of premature failure. In this case, the potential cost of failure in the field drove the whole project, justified the price of the tester, and the added manufacturing time required for the special test.

When you consider that you may be searching for a defect rate less than one in two million holes, then you understand that there was a lot of testing to find only a few faults.

Japan has some happy memories for me, and it is a country I would recommend to anybody travelling for pleasure. The super polite and friendly nature of the Japanese people almost guarantees you a great experience. Bowing at every opportunity is quite infectious, and I could not help myself from continuing for weeks after I returned home. **PCB007**



Marc Ladle is a director at Viking Test Ltd. To read past columns or contact Ladle, click here.

An Overview of the PCB Industry: 2018 HKPCA & IPC Show

Article by Hu Yang
ZHONGTAI SECURITIES

Editor's Note: The PCB007 China Team invited Mr. Hu Yang from Zhongtai Securities to interpret the 2018 HKPCA & IPC Show from the perspective of a security professional, and to analyze the current industry situation and prospects. PCB007 is proud to reprint this article for our global readership.

As one of the largest PCB and electronic assembly exhibitions in the world, the HKPCA & IPC Show covers the PCB and electronic assembly supply chain in all categories and provides one-stop services in exhibiting the equipment and technology needed in the industrial chain.

As an industry observer, I visited the exhibition during the three days and conducted a complete study tour. On the first and second days, I heard many senior experts from various industries share their opinions on the market, technologies, and trends regarding PCBs. At the same time, over 500 exhibitors at home and abroad shared their thoughts over the three days. The topics covered the complete ecology of raw materials; manufacturing, processing, and assembling; finished products testing; and environmental protection treatment.

From those beneficial opinions, you can get a glimpse of the current full-swing development trend of the industry. In recent years, the efficiency of PCB production lines has continuously improved, and the most important input-output ratio (annual income/equipment input) of investment has increased, which greatly benefits from the improvement of equipment performance and production technology. My review includes six questions and answers about the industry based on my time at the HKPCA & IPC Show.

1. What is the market size and what are the features of each of the sectors of the PCB industry in 2018?

The global PCB industry maintained a strong momentum of growth in 2018, benefiting from the demand for mining machines, data centers, 5G, IoT, and new consumer electronics products. At the exhibition, Prismark and other organizations forecasted that global PCB output would reach $63.8 billion in 2018, which is an increase of 8% compared with 2017. This is a

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very good number, especially given that in the second half of the year, the demand for mining machinery declined.

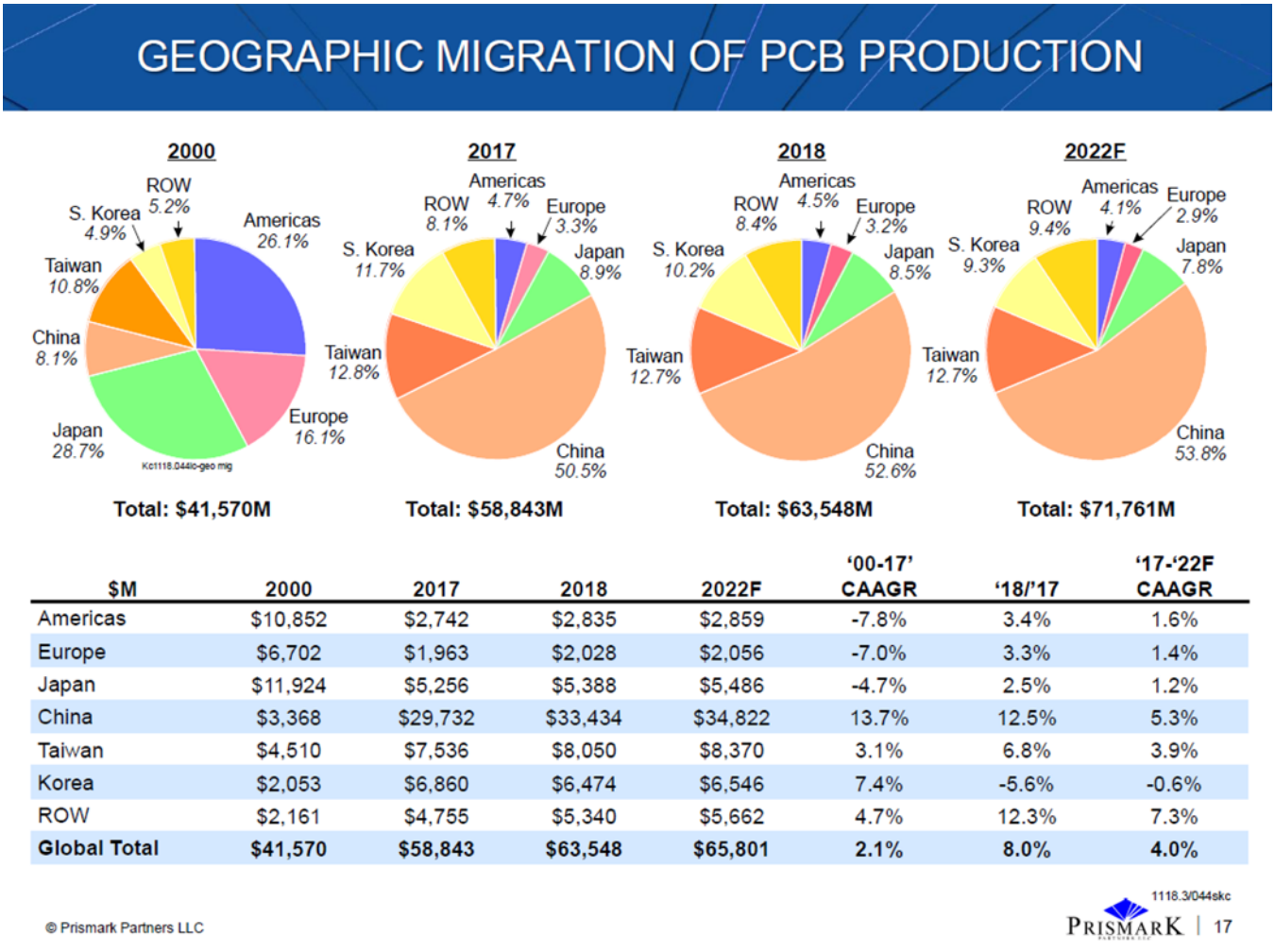
Other fast facts include:

- The cellphone market is still maintaining an average annual growth rate of 2–4%
- Although only occupying a small share currently, the wearable electronics market is expected to grow by 12–14%
- Television shipments maintain an average annual growth rate of 2–3%
- Automobile PCBs grow by 6–7% each year
- Starting from 2019, the demand for PCBs for 5G communication will be increased by large quantities, and this situation will last for several years
- In other areas—such as medical, industrial, military, etc.—the annual PCB demand will steadily increase

2. How will the global share of Mainland China change?

After leading for more than a decade, the industry growth rate in Mainland China is expected to be 12.5% in 2018. This is a surprising number. In the shadow of the trade war, the PCB industry in Mainland China has achieved excellent results of over 10% growth against the trend. This also means that the global share of Mainland China will reach 52.6% in 2018 and continue to grow by 2.1% from 50.5% in 2017.

Dr. Hayao Nakahara, president of N.T. Information Ltd., was even more optimistic. He pointed out that despite the long-term uncertainty of the Sino-U.S. trade war, with the trend of China's investment in PCB industry, China's PCB output would probably account for more than 70% of the global PCB output in the next five to six years. The process of industrial transfer from the rest of the world to



$M	2000	2017	2018	2022F	'00-'17' CAAGR	'18/'17	'17-'22F CAAGR
Americas	$10,852	$2,742	$2,835	$2,859	-7.8%	3.4%	1.6%
Europe	$6,702	$1,963	$2,028	$2,056	-7.0%	3.3%	1.4%
Japan	$11,924	$5,256	$5,388	$5,486	-4.7%	2.5%	1.2%
China	$3,368	$29,732	$33,434	$34,822	13.7%	12.5%	5.3%
Taiwan	$4,510	$7,536	$8,050	$8,370	3.1%	6.8%	3.9%
Korea	$2,053	$6,860	$6,474	$6,546	7.4%	-5.6%	-0.6%
ROW	$2,161	$4,755	$5,340	$5,662	4.7%	12.3%	7.3%
Global Total	**$41,570**	**$58,843**	**$63,548**	**$65,801**	**2.1%**	**8.0%**	**4.0%**

Figure 1: Geographic migration of PCB production.

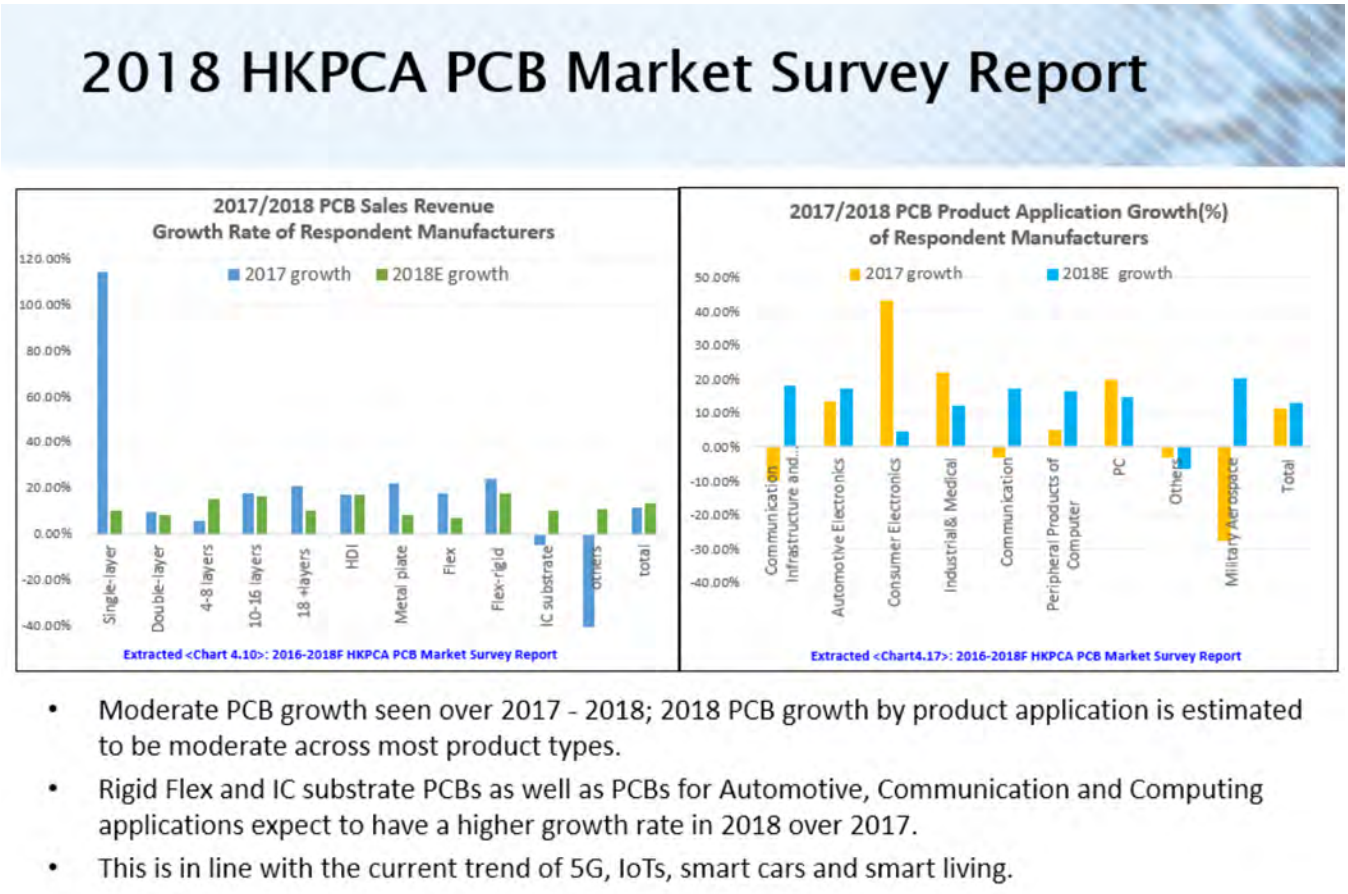


Figure 2: 2018 HKPCA PCB market survey report.

Mainland China was still underway, and Mainland China would play a more important role in the global PCB industry.

3. Which are the best race tracks in the industry?

The industry believes that 5G and automotive will be the main drivers of PCB growth in the future. New energy vehicles will continue to boost the demand for PCB for automobiles, and demands for PCBs will be driven by 5G communication infrastructure, which is expected to rise soon.

4. How will technology evolve?

Information strongly suggests that the communications and automotive sectors will use more HDI, and HDI in cellphones and wearable electronics will become more complicated represented by SLP. In addition, the trends toward double-sided blind holes, BGA blind hole filling, multilayer blind holes, HDI high-order and soft-hard bonding boards are becoming more and more obvious. The line width requirement will be 35 µm or even 25 µm. The demand from new energy vehicles for large-sized circuit boards is also rising, and it needs a variety of high-frequency, high-speed, and environmental protection materials together to make it work. If material development cannot keep up with the development of technical designs, enterprises will need to invest more time in R&D and innovation.

5. What is the current status on the materials side?

Domestic manufacturers already have considerable capacity and technological strength in the fields of copper-clad laminate, copper foil, PCB chemicals, etc. The situation of material monopoly dominated by the United States and Japan is constantly improving, but in the field of high-end raw materials, both countries still have significant advantages. Due to the rising prices and environmental restric-

tions on production and other factors, copper foil, fiberglass cloth, and resin as the three major raw materials will also be accelerated to transfer to China with the rising demand from downstream applications. With the requirement of 5G for high-speed and high-frequency development, domestic manufacturers have made great progress in high-frequency PTFE.

Mr. Wu Yunlong, technical services manager of Rogers Corporation Asia, pointed out the direction of R&D. Due to the increasing demand of customers for 5G and HDI, materials began to develop toward thinner types. The influence of high-frequency bands on the material is increasing. It is necessary to ensure the bonding force and compression degree of copper foil to achieve low loss and small Dk power difference to enhance stability. In the matching of the core board and semi-curing sheet, to ensure the reliability of small aperture through holes, the thinnest materials cannot be used.

National environmental penalties from 2015 to 2017. (Data by Secretariat of HKPCA)

No.	Category	2015	2016	2017
1	Environmental fines (billions CNY)	4.25	6.63	11.56
2	Number of sequestration and seizure cases	4,192	9,976	18,332
3	Number of production stoppage cases	3,100	5,673	8,756
4	Number of consecutive daily penalties	716	1,017	1,165
5	Number of cases sent to public security unit	4,426	6,064	11,340

Figure 3: National environmental penalties are increasing as China aggressively enforces regulations.

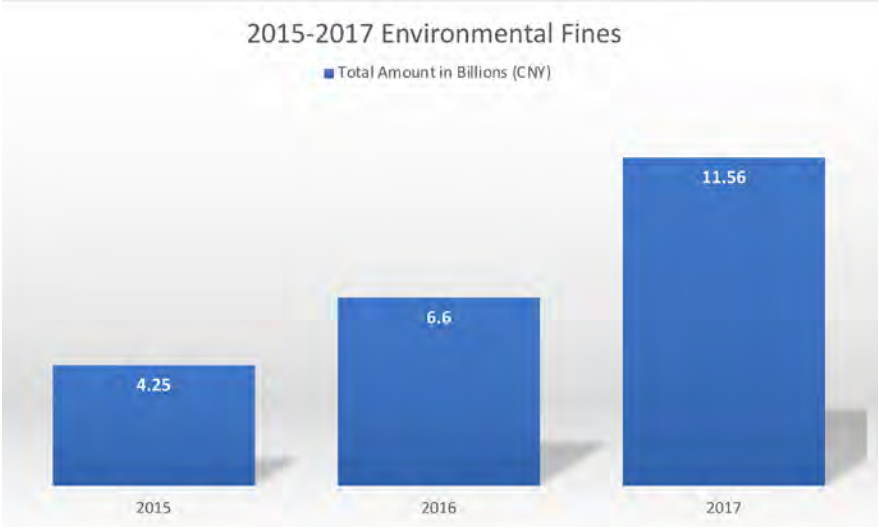
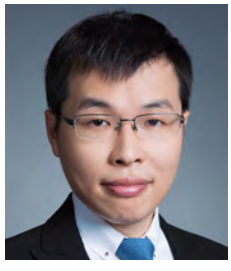


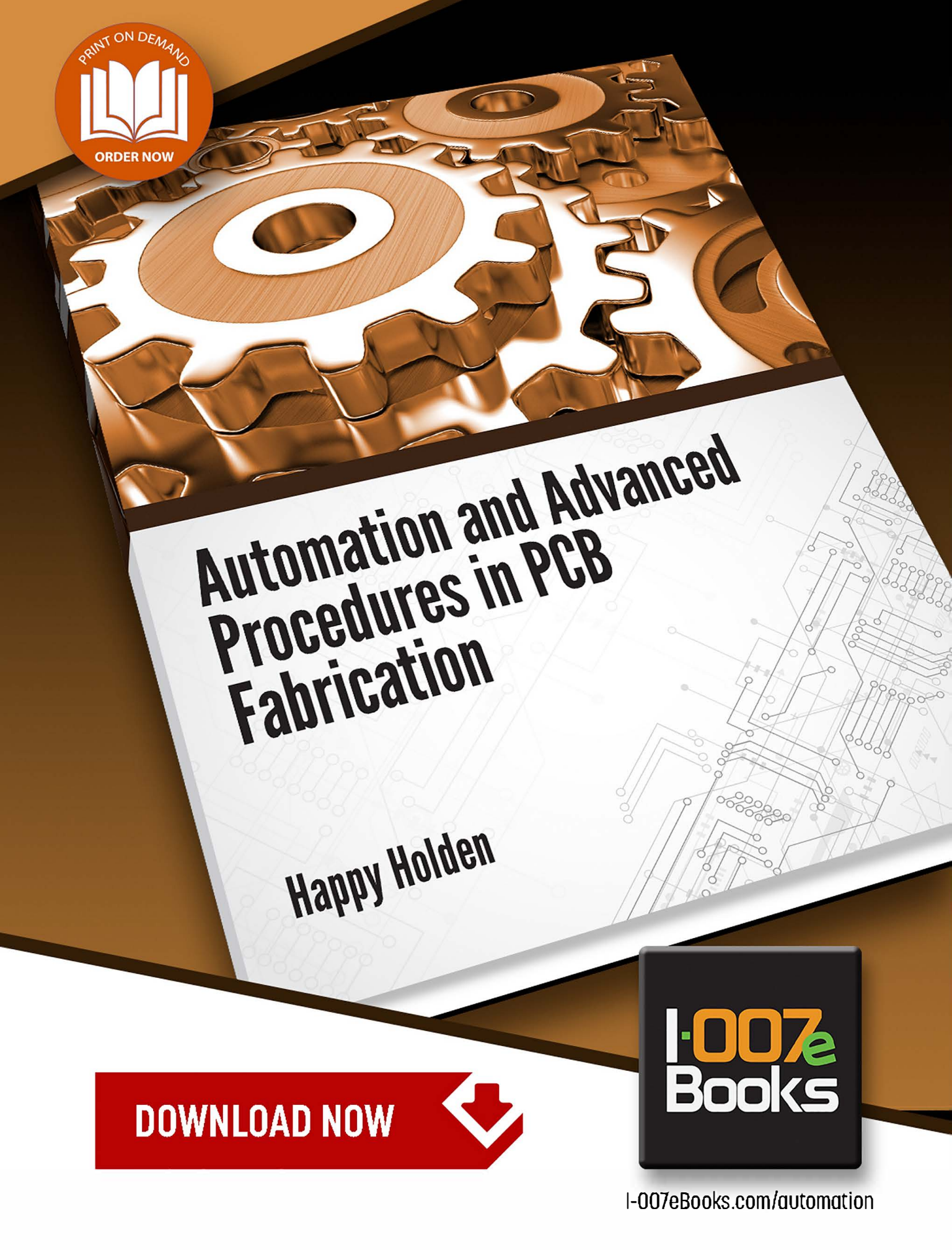
Figure 4: Environmental fines are also increasing.

6. What will be the impact of environmental protection and intellectualization?

The speed of the factory population growth is much lower than the speed of output expansion. Domestic manufacturers in China may need to set up factories in the United Kingdom and the United States to avoid tariffs. Mr. Wang Dele, BP and secretary general of the Hong Kong Circuit Board Association, pointed out in his report "Interpretation of Hot Points Regarding 2018 China's Environmental Protection Policy" that environmental protection supervision in China tends to be severe. Environmental protection has been promoted to be a basic national policy, and further efforts are being gradually made to increase criminal punishment or environmental violations. For example, in 2017, 233,000 written decisions of the environmental administrative penalty were issued nationwide. The total amount of fines was 11.56 billion yuan, which rose 86.5% year-on-year. Follow-up environmental protection pressure on enterprises will be enormous. **PCB007**



Mr. Hu Yang is an electronic analyst for Zhongtai Securities with a master's degree in microelectronics from Peking University. His research focuses on PCBs, LEDs, semiconductors, etc.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Editor Picks from PCB007

1 It's Only Common Sense: Eight Great Tips to Teach a New Salesperson—Listen! ▶


Dan Beaulieu

Today, all of us are working diligently on getting more young people involved in our industry, and many of those people are going to be involved in sales. To help you with developing that training, here are eight great tips to teach a new salesperson.

2 Punching Out! Beware of Cultural Issues in M&E Deals ▶

Company culture is hard to define and manage, but it is a critical factor in making an M&A deal successful. It is also often ignored or misunderstood during and after due diligence because culture is a "soft" science instead of a "hard" subject like finances, legal contracts, IP, or accounts receivable, among other things, which makes culture a difficult factor to deal with.

3 Standard of Excellence: Seven Things Your PCB Vendor Can Teach You ▶


Anaya Vardya

One of the great things about having a good PCB vendor is that they can teach you and keep you informed about when it comes to their technologies, products, and business. Just as you and your company are experts in your technology, they are experts in theirs.

4 North American PCB Sales Ends 2018 With 8.7% Growth ▶

Total North American PCB shipments in December 2018 were up 7.7% compared to the same month last year. Shipment growth ended the year at 8.7%. Compared to the preceding month, December shipments increased by 17.1%.

5 Unimicron Raises Capex Budget for 2019 ▸

PCB and IC substrate supplier Unimicron Technology decided to increase its capex budget this year by NT$2.32 billion ($75.5 million) to total NT$8.3 billion, according to a resolution passed by the company's board of directors, Digitimes reports.

6 RTW IPC APEX EXPO 2019: Super PCB Discusses High-end PCB Procurement Services ▸


Jessica Zhang

Kelly Dack speaks with Jessica Zhang, program manager for Super PCB, who focuses on serving customers with a small-business-type relationship. Based in Plano, Texas, Super PCB matches customer design requirements to a myriad of supplier capabilities through time-saving, direct communication with the supplier and best pricing.

7 IPC Validation Services Introduces New QML Program ▸


Randy Cherry

IPC Validation Services introduced a new qualified manufacturers listing (QML) program—the IPC-1791, trusted electronic designer, fabricator, and assembler requirements QML—to address gaps in current electronics industry trusted supplier accreditation programs.

8 NCAB Expanding in Malaysia ▸

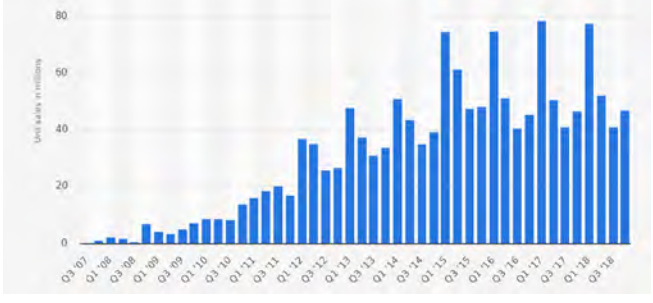
NCAB Group starts the first quarter of 2019 by establishing operations in Malaysia.

9 IPC Report: How PCB Manufacturers Meet Technology Demands ▸

"PCB Technology Trends 2018," a new global study published by IPC, is now available. The survey-based study shows how PCB manufacturers are meeting today's technology demands and looks at the changes expected by 2023 that will affect the whole industry.

10 Flexible PCB Makers Plagued by Lackluster iPhone Sales ▸

Among supply chain partners for iPhones, Taiwan's PCB makers have suffered significantly from the devices' latest wave of lackluster sales with flexible board suppliers Zhen Ding Tech, Flexium Interconnect, and Career Technology bracing for more negative impacts in 2019 as their revenues have already seen notable downturns since November 2018.



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- Provide and report to the marketing team all valuable feedback, market intelligence, and statistics obtained during your outreach activities
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Essential Duties and Responsibilities (Other Duties as Assigned)

- Displays excellent communication skills including presentation, persuasion, and negotiation skills often required in working with customers and colleagues, including the ability to communicate effectively and remain calm and courteous under pressure
- Directly support the marketing department by focusing on outreach activities to create, build, maintain, and rebuild customer relationships
- Provide and report to the marketing team all valuable feedback, market intelligence, and statistics obtained by you from our customers
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- Salary: $16.00 to $24.00 /hour
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- Develop technical strategy for customers.
- Possess the ability to calm difficult situations with customers, initiate a step-by-step plan, and involve other technical help quickly to find resolution.

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ventec INTERNATIONAL GROUP 騰輝電子

Technical Support Engineer, Germany

We are looking for a technical support engineer to join our team at our German facility in Kirchheimbolanden. The successful candidate will assist potential and current customers in appreciating the benefits of using and optimizing the use of Ventec materials in their PCB manufacturing processes, enhance customer loyalty and satisfaction, spread the use of Ventec materials, and grow sales. The technical support engineer will provide a two-way channel of technical communication between Ventec's production facilities and U.K./European customers.

Skills and abilities required for the role:

- Scientific and technical educational background
- Experience in the PCB industry in engineering and/or manufacturing
- Strong communications skills (German and English) with the ability to write full technical reports for group or customer distribution
- Ability to work in an organized, proactive, and enthusiastic way
- Ability to work well both in a team as well as an individual
- Good user knowledge of common Microsoft Office programs
- A full driving license is essential
- Willingness to travel regularly throughout Europe and occasionally to Asia

We offer:

- Excellent salary and benefits commensurate with experience

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

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

apply now

ventec INTERNATIONAL GROUP 騰輝電子

Technical Sales Engineer, Germany

Want to advance your career by joining our globally successful and growing world-class CCL manufacturing company and help drive that success? Tasked with driving sales in the German-speaking markets, you will be a key member of the technical sales team. Your focus will be on Ventec's core market segments: military/aerospace, automotive, and medical offering a full range of high-reliability materials including polyimide, IMS, and thermal management products.

Skills and abilities required for the role:

- Seven to 10 years of experience in the PCB industry in engineering and/or manufacturing
- Strong communications skills (German and English)
- Project management experience
- Detail-oriented approach to tasks
- Ability to manage tasks and set goals independently as well as part of a team
- Knowledge of Microsoft Office products
- A full driving license is essential.
- Willingness to travel regularly throughout Europe and occasionally to Asia

We offer:

- Excellent salary and benefits commensurate with experience

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

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

apply now

Career Opportunities

Field Service Engineer West Coast

Pluritec North America, ltd., An innovative leader in drilling, routing and Automated Inspection in the Printed Circuit Board industry, is seeking a full-time Field Service Engineer, located on the West Coast.

This individual will support service for North America in Equipment installation, training, maintenance and repair. Candidate must be able to handle trouble shooting electronic and mechanical issue's as well customer applications in the field. A technical degree is preferred, along with strong verbal and written communication skills. The position requires the ability to travel 2-3 weeks per month.

Please send your resume to:
Carolina.zeppieri@pluritec.org

apply now

Sales Personnel, Japan

The Gardien Group is looking to expand the sales team in Tokyo, Japan, and seeking highly motivated team players with a positive attitude. Prior experience in the PCB industry is an advantage but not necessary for the right candidate.

The role involves working closely with the customer to identify their needs and deliver the right solution. The candidate should be able to offer a high level of customer satisfaction to ensure ongoing sales.

Training will be provided along with a competitive benefits package, excellent growth opportunities, and periodic bonuses.

Interested candidates, please contact us at careers.jp@gardien.com with your resume.

Kindly note only shortlisted candidates will be notified.

apply now

Career Opportunities

U.S. CIRCUIT

Sales Representatives (Specific Territories)

Escondido-based printed circuit fabricator U.S. Circuit is looking to hire sales representatives in the following territories:

- Florida
- Denver
- Washington
- Los Angeles

Experience:

- Candidates must have previous PCB sales experience.

Compensation:

- 7% commission

Contact Mike Fariba for more information.

mfariba@uscircuit.com

apply now

MivaTek Global

Multiple Positions Available

Want to work for a fast-growing company? MivaTek Global may be the place for your next career move. 2018 has brought significant growth, increasing sales and revenue. And, we are just getting started! To support the current customer base and fuel further expansion, we are looking for bright and talented people who are energized by hard work in a supportive and flexible environment.

Open Positions:

- Technical Service Technicians
- Regional Sales Representatives
- Regional Leader for Asia Sales and Support

Proven experience in either PCB or Microelectronics and willingness to travel required for all positions.

More About Us

MivaTek Global is a distributor of manufacturing equipment with an emphasis of Miva Technologies' Direct Imager, Mask Writer, Flatbed Photoplotter imaging systems and Mach3 Labs X-Ray Drills. We currently have 45 installations in the Americas. Expansion into Asia during 2018 has led to machine installations in China, Singapore, Korea, and India.

To be part of our team, send your resume to n.hogan@kupertek.com for consideration of current and future opportunities.

apply now

Career Opportunities

ELECTROLUBE
THE SOLUTIONS PEOPLE

We Are Recruiting!

A fantastic opportunity has arisen within Electrolube, a progressive global electrochemicals manufacturer. This prestigious new role is for a sales development manager with a strong technical sales background (electro-chemicals industry desirable) and great commercial awareness. The key focus of this role is to increase profitable sales of the Electrolube brand within the Midwest area of the United States; this is to be achieved via a strategic program of major account development and progression of new accounts/projects. Monitoring of competitor activity and recognition of new opportunities are also integral to this challenging role. Full product training to be provided.

The successful candidate will benefit from a generous package and report directly to the U.S. general manager.

Applicants should apply with their CV to
melanie.latham@hkw.co.uk
(agencies welcome)

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ZENTECH

Zentech Manufacturing: Hiring Multiple Positions

Are you looking to excel in your career and grow professionally in a thriving business? Zentech, established in Baltimore, Maryland, in 1998, has proven to be one of the premier electronics contract manufacturers in the U.S.

Zentech is rapidly growing and seeking to add Manufacturing Engineers, Program Managers, and Sr. Test Technicians. Offering an excellent benefit package including health/dental insurance and an employer-matched 401k program, Zentech holds the ultimate set of certifications relating to the manufacture of mission-critical printed circuit card assemblies, including: ISO:9001, AS9100, DD2345, and ISO 13485.

Zentech is an IPC Trusted Source QML and ITAR registered. U.S. citizens only need apply.

Please email resume below.

apply now

Career Opportunities

Mentor®
A Siemens Business

PCB Manufacturing, Marketing Engineer

Use your knowledge of PCB assembly and process engineering to promote Mentor's Valor digital manufacturing solutions via industry articles, industry events, blogs, and relevant social networking sites. The Valor division is seeking a seasoned professional who has operated within the PCB manufacturing industry to be a leading voice in advocating our solutions through a variety of marketing platforms including digital, media, trade show, conferences, and forums.

The successful candidate is expected to have solid experience within the PCB assembly industry and the ability to represent the Valor solutions with authority and credibility. A solid background in PCB Process Engineering or Quality management to leverage in day-to-day activities is preferred. The candidate should be a good "storyteller" who can develop relatable content in an interesting and compelling manner, and who is comfortable in presenting in public as well as engaging in on-line forums; should have solid experience with professional social platforms such as LinkedIn.

Success will be measured quantitatively in terms of number of interactions, increase in digital engagements, measurement of sentiment, article placements, presentations delivered. Qualitatively, success will be measured by feedback from colleagues and relevant industry players.

This is an excellent opportunity for an industry professional who has a passion for marketing and public presentation.

Location flexible: Israel, UK or US

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BLACKFOX
Premier Training & Certification

IPC Master Instructor

This position is responsible for IPC and skill-based instruction and certification at the training center as well as training events as assigned by company's sales/operations VP. This position may be part-time, full-time, and/or an independent contractor, depending upon the demand and the individual's situation. Must have the ability to work with little or no supervision and make appropriate and professional decisions. Candidate must have the ability to collaborate with the client managers to continually enhance the training program. Position is responsible for validating the program value and its overall success. Candidate will be trained/certified and recognized by IPC as a Master Instructor. Position requires the input and management of the training records. Will require some travel to client's facilities and other training centers.

For more information, click below.

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Identity Branding

What do you stand for?

I don't know who you are

I don't know your values

I don't know what you stand for

I don't know your reputation

Now, what is it you want to sell me?

This may seem extreme, but don't assume your prospects already know or remember this about you...

In fact, they may know something quite the contrary if you leave it up to your competitor to educate them about you.

At I-Connect007 we can help you build and strengthen your brand.

Learn how we can help you!

I·Connect007

GOOD FOR THE INDUSTRY

Events Calendar

China International PCB & Assembly Show (CPCA Show 2019) ▶
March 19–21, 2019
Shanghai, China

Electronica China ▶
March 20–22, 2019
Shanghai, China

Semicon China ▶
March 20–22, 2019
Shanghai, China

Hannover Fair ▶
April 1–5, 2019
Hannover, Germany

MicroTech 2019 ▶
April 4, 2019
Cambridge, U.K.

Del Mar Electronics & Manufacturing Show ▶
May 1–2, 2019
San Diego, California, U.S.

Medical Electronics Symposium 2019 ▶
May 21–22, 2019
Elyria, Ohio, U.S.

Industry 4.0—Smart Factory ▶
May 29, 2019
Tel Aviv-Yafo, Israel

PCB Pavilion @ LCD EXPO Thailand ▶
June 27–29, 2019
Bangkok, Thailand

Additional Event Calendars

Coming Soon to *PCB007 Magazine:*

APRIL: Emerging Technologies and Youth in the Industry
Young professionals will accompany the new wave of Industry 4.0 equipment and processes. How will this change business as usual?

MAY: New Materials
Evolving designs and applications require advanced levels of performance from materials. We look at new materials across the industry.

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