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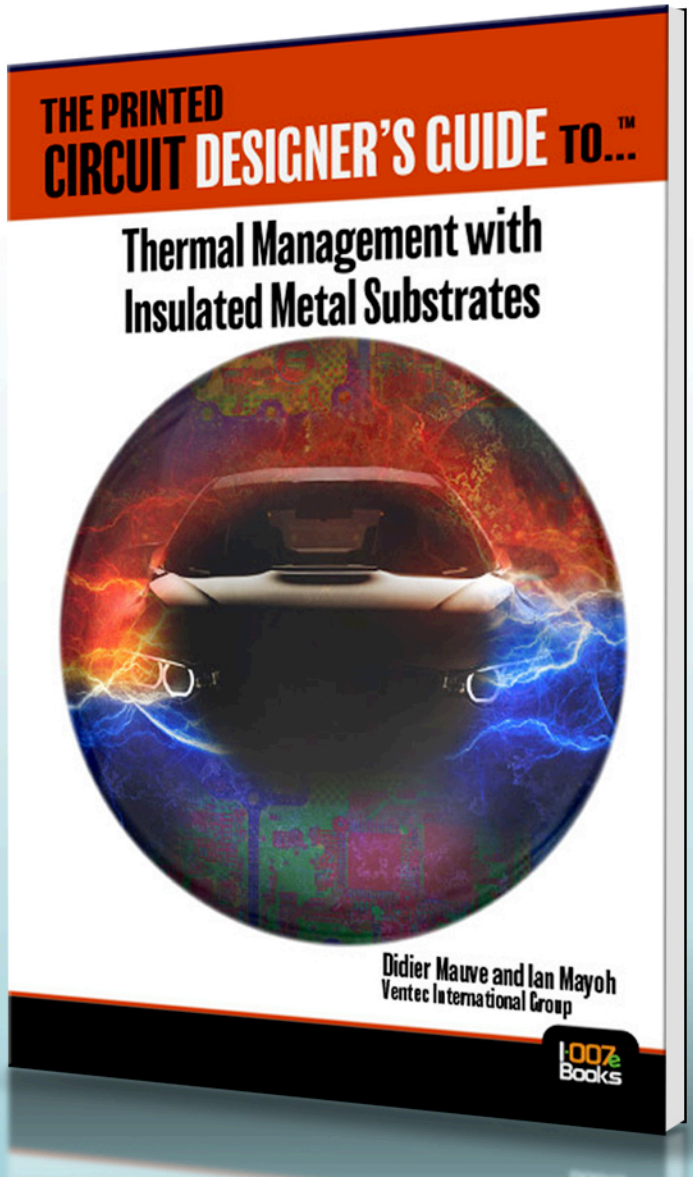

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Written by Didier Mauve and Ian Mayoh of Ventec International Group, this book highlights the need to dissipate heat from electronic devices.

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PCB007 MAGAZINE

New Technology

No doubt, new technology seems to be launching daily, from inspection systems to photoresist processes. How can we keep up? How can we even maintain? What's coming next and how can we best prepare, to stay in the game? This month, our experts give us a heads up on new technology: where we're at and where on Earth we are going.

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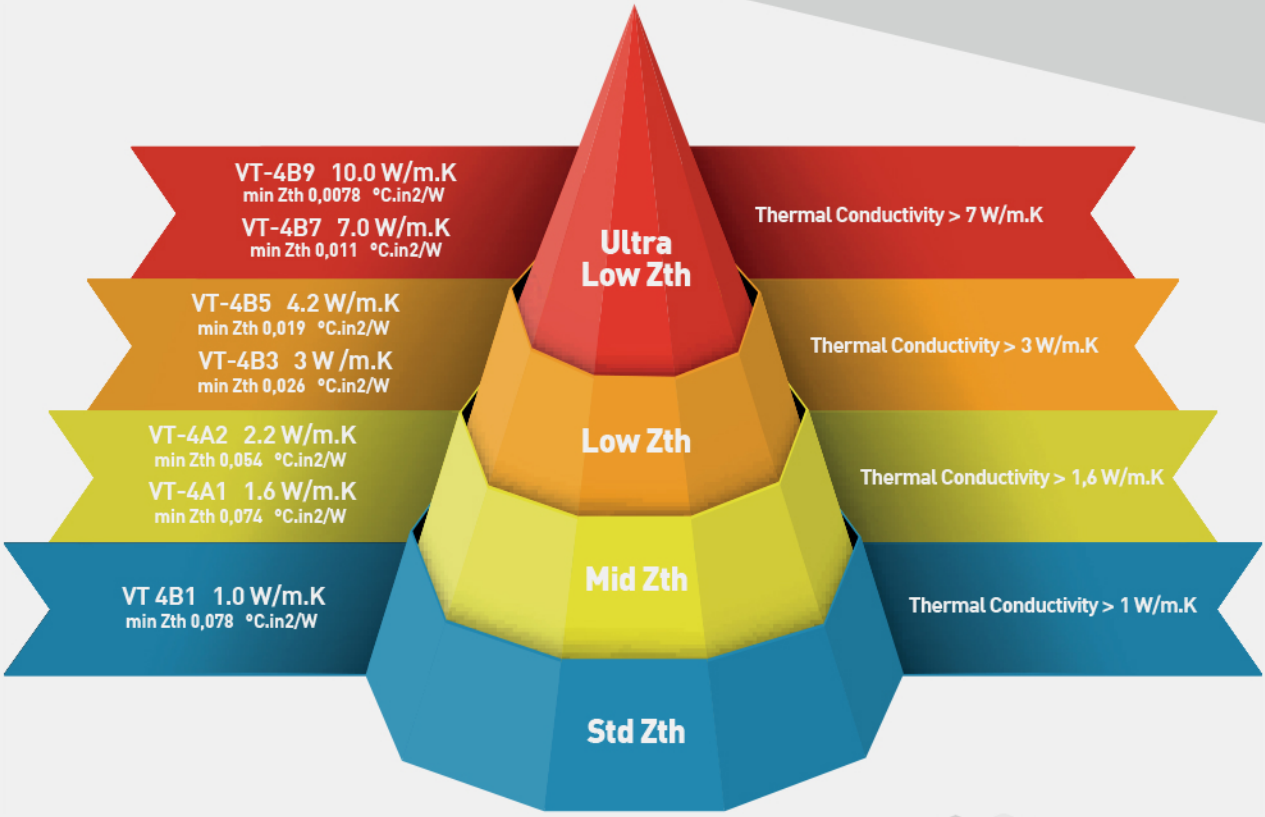

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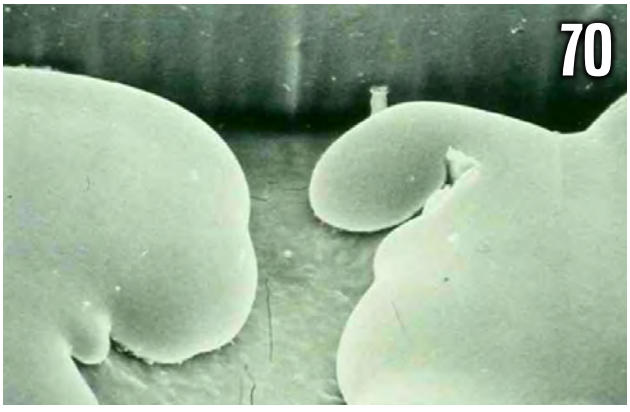

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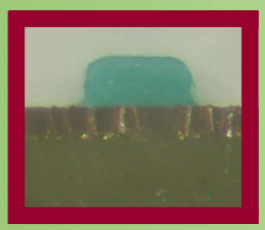

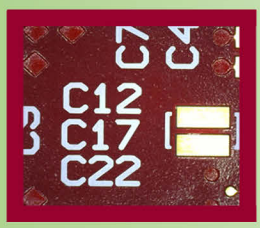

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The Direction of New Technology

Patty's Perspective
by Patty Goldman, I-CONNECT007

I don't have to tell you that things are changing fast in our industry. New tech seems to launch daily these days. How can we keep up? How can we even maintain? What's coming next and how can we best prepare, in order to stay in the game?

Fundamentally, what does all this gadgetry rely on at its core? Obviously, PCBs in one form or another. Faster, smaller, finer features for more memory, more capability, more, more, more—all of which affects us when making PCBs. Remember when 5 mil lines and spaces were the latest? When laser imaging was barely imaginable? Yeah, those memories are long gone. But that's what we all love and what keeps us going in this industry: the challenge to make it happen, to make that incredibly complicated board that two years ago you would have thought impossible.

We're talking new technology this month, to help you understand the ever-increasing, ever-more complicated requirements from your customers. Read about some of the latest here and remember: You can do it!

Our first article this month is by that guru of the latest in electronics tech, Dan Feinberg. You probably read his recent articles on the CES show, where his enthusiasm for all things techie comes shining through. This month, he focuses on disruptive technology—the latest, the greatest, and how quickly they are appearing.

If you have been paying attention and reading our magazines, you've heard of Alex Stepinski and Whelen Engineering. For nearly two years we've been keeping you updated on this fully-automated, green, captive PCB facility. Now it has been spun off, going commercial, and a vast upgrade to the latest in manufacturing technology is underway. In an interview, Alex discusses the latest innovations for GreenSource, with several people from one of his prime suppliers of both chemistry and equipment—Atotech.

While at productronica, I met with Elga Europe's CEO, Giorgio Favini, and learned about a new photoresist that does amazing things. Imagine developing 10-micron features on thick photoresist with a perfectly vertical sidewall. I've seen the SEMs and you can read about it right here.

Much of the new technology for our industry involves equipment—not just upgrades, but completely new ways for handling extremely thin materials and new ways to get process chemistry where you want it. In an interview with Schmid's Rüdiger Lange, he discusses some of the ways to solve these ever-more-important issues, focusing in part on solution cleanliness.

I can remember when automated optical inspection was first presented at an IPC meeting.

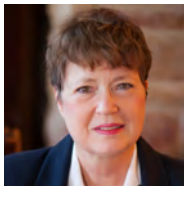
Many in the audience pooh-poohed it, saying a company was better off putting their money into their processes to make good boards rather than to try to "inspect in" their quality at the end with AOI. Well, we know where that went. And now columnist Todd Kolmodin, Gardien Services, makes a very strong case for AVI (visual), especially considering today's strict, but widely varying requirements of customers.

When is a technology truly new? How often does it build on previous generations of knowledge, be it chemistry or equipment? Viking's Marc Ladle discusses these points in his column using several examples. He is followed by Omni PCB's Tara Dunn; her column focuses on "new to you" flex and rigid-flex technology and she includes much good advice in the bargain.

And now for some in-the-trenches information as columnist Mike Carano, RBP Chemical, brings us Part 3 of his troubleshooting series on mouse bites and other resist-related problems. He includes a table listing developer variables and their effects on the process.

And bringing up the rear this month is Steve Williams, The Right Approach Consulting, with an interesting column on reshoring. He lists several OEMs that are moving or committing to move operations back to the U.S., citing a long list of drivers.

I am writing this column in San Diego at the start of IPC APEX EXPO. It promises to be a busy week, with the technical conference, committee meetings and of course the show. Already the level of enthusiasm is at a high. By the way, I-Connect007 is publishing a special issue on the show in mid-March (see sidebar), so make sure you are subscribed. Don't forget to check back in April, when we cover automotive electronics. Don't miss it! **PCB007**



Patricia Goldman is managing editor of *PCB007 Magazine*. To contact Goldman, click here.

Exclusive Coverage: IPC APEX EXPO 2018

This month, the I-Connect007 team attended the IPC APEX EXPO Conference and Exhibiton held at the San Diego Convention Center. It was a sold-out show with increased attendence and an overwhelming sense of excitement in the air, which generated valuable leads and relationships.

Real Time with... IPC APEX EXPO coverage resulted in more than 70 video interviews all shot in our booth on the show floor. I-Connect007 invited local student-photographers from the Art Institute of San Diego and San Diego City College to take part in a photo contest. Check out our videos and photos here.

Don't miss the premier issue of our special edition ***Show and Tell*** magazine that will be available to *my I-Connect007* registrants March 15th. Register/sign up to receive it here.

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Feature Article by Dan Feinberg
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There have always been disruptive technologies; thousands of years ago, fire totally disrupted the path of mankind. I have heard it said that truly disruptive technologies are like earthquakes on the seismographs of history. Some are so like old news to us living in the latter part of the first quarter of the 21st century, but think what the world would be like if there had been no iron smelting, truly disruptive back in 1200 BCE, or gunpowder discovered by accident by a Chinese alchemist back in the 8th century CE. How about something as simple as using latex to create rubber a few hundred years ago?

Figure 1: The Chinese invented gunpowder in the 9th century during the late Tang dynasty.

There can be no argument regarding the disruption caused by the development of the use of moving electrons to generate power with credit going to Benjamin Franklin, followed by Edison, Volta and one of my favorite tech heroes, Nikola Tesla. Did you know that in 1891, Nikola Tesla invented a device that could transmit electricity through the air? It could power lightbulbs and electric motors wirelessly, but only at a distance of a few feet. It may have been short range and inefficient, but it was 1891 after all.

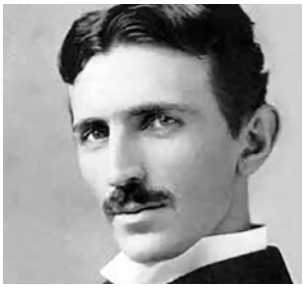

Figure 2: Nikola Tesla.

No one can dispute the disruption to civilization's path caused by the invention and development of heavier-than-air flight started by the Wright brothers' first 12-second manned flight over a century ago (Figure 3). And as time continued to march on, there were vacuum tubes and basic electronics (I = E/R) then nuclear fis-

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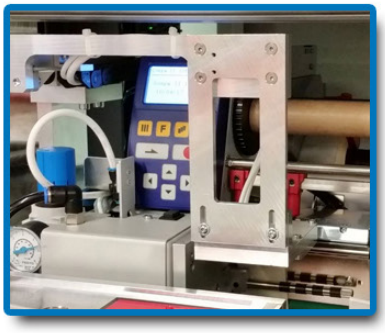

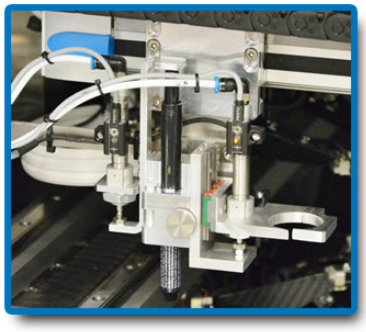

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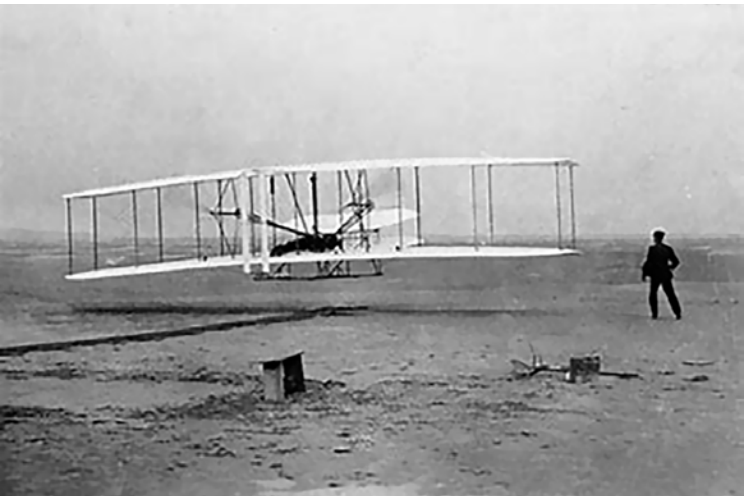

Figure 3: The Wright brothers' plane at Kitty Hawk, North Carolina.

sion, in the 1930s followed by the transistor and the microprocessor in the '50s and '60s. There can be little doubt that the rate and pace of disruptive technology has gone from an immeasurable crawl to a run and now to what is approaching supersonic speed.

Before we begin discussions on a few of the most disruptive technologies of the present day as well as what is right around the corner, for those of you who are as interested in disruptive tech and what it will do to change the look of civilization as we know it, let me recommend some light reading, you might like: Dan Brown's newest novel, Origin[1]. If you read it, let me know what you think.

OK, enough background, let's look at some of the most disruptive technology of the present and soon-to-be future. I have discussed virtual reality in recent articles, so except to state that it is clearly on the list, we are not going to cover it again here, but we will continue to watch and report. In addition, I feel that autonomous transportation is also in the top five, and I will be covering it in detail in the April issue, but one of the enablers for autonomous cars, trucks, etc., is another great disruptor, artificial intelligence. AI is kind of a catchall used to mean different things to different people. It basically means computer systems that can learn by themselves. There are different phrases to describe it such as deep learning, machine learning, deep influence and so forth, but all talk about how a computer can learn.

One of the leaders in AI technology and computer hardware, NVIDIA, defines machine learning as "the practice of using algorithms to parse data, learn from it, and then make a determination or prediction." For example, the NVIDIA computer controlling an autonomous vehicle (Figure 4) gathers data from its myriad sensors and then parses the data and decides the direction to steer and avoid the obstacles in its path. It allows the vehicle to safely arrive at its destination in spite of the thousands of other changes and moving vehicles along the way. An excellent video published by NVIDIA describes all the different things that AI actually is. You may wish to take a few minutes and watch it[2].

Let's talk economics. It is estimated that in just over a decade AI will contribute over $15 trillion to the global economy. It is expected to add 14% to the North American GDP by 2030. By 2027, just under 10 years from now, the AI-driven autonomous vehicle market is expected to be worth $127 billion. As stated earlier, much more on autonomous driving next month.

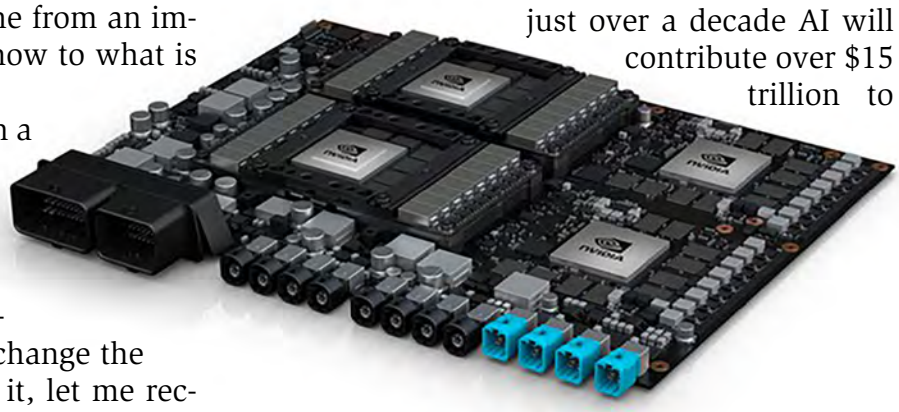

Figure 4: NVIDIA Drive PX Pegasus board.

Another major use of AI and one that is growing rapidly is the connected or smart home. The leader in this rapidly growing segment is Amazon's AI personal assistant, Alexa. Just last month I was asked to take part in a decision being made by a major retirement community here in Southern California regarding which smart home assistant they would incorporate into their assisted living units starting

Figure 5: NVIDIA's video on AI (see reference #2).

this year. They had already made a preliminary decision and when reviewing their reasoning with one of their committee members, I had to agree with their preliminary choice. They are going to install Amazon Alexa in their units. Amazon's Echo line, powered by Alexa, holds 70% of the smart speaker market right now in early 2018 and could add $10 billion the company's top line by 2020 (Figure 6). It is rumored that Alexa and Microsoft's Cortana AT assistant will partner making them a very strong, perhaps dominant, presence. Additionally, Alphabet is using its own AI, Google Assistant, to power its competing line, so the smart speaker rivalry is only going to grow.

There are concerns regarding AI, however. Elon Musk, co-founder and CEO of Tesla Inc. and founder of Space-X, has stated on multiple occasions that he is concerned that artificial intelligence could eventually be dangerous to people—and to humanity as a whole. In addition, Stephen Hawking has said he believes AI systems will eliminate many jobs, and not create enough to replace them. Specifically, he said (per International Business Times), "The automation of factories has already decimated jobs in traditional manufacturing, and the rise of artificial intelligence is likely to extend this job destruction deep into the middle classes, with only the most caring, creative or supervisory roles remaining."

In the short term, expect artificial intelligence to do…intelligent things, such as control driverless cars. Machine learning (ML) systems will do product recommendations. Logistics companies are already using AI and ML to identify the best routes, and it is easy to see a time when public taxis, buses and trains will rely on AI to adjust routes and schedules as necessary and to improve efficiency. Along with driverless cars, driverless buses and taxies are on the way, and drone package delivery, which is already being tested, may have public sector applications as well.

Some researchers expect artificial intelligence systems to be only fractionally as smart as a human for the next 10–15 years. But things may start to get a little awkward midcentury when AI could start performing nearly all the tasks humans do—and do them much better, faster, more error-free. Perhaps they may start to conclude that it (AI) is smarter than the directives and limitations set upon it by its human inventors/controllers.

For now, what does the average person do regarding AI? I suggest choosing your AI devices wisely. Is the smart home just "Big Brother" under a different name? From a financial perspective, you might also wish to do some due diligence and decide to invest in the companies who are leading in this arena; some of them may equate it to investing in IBM in the '50s, or Apple or Microsoft in the '90s.

Another potentially disruptive technology is based on nanocrystal technology. A nanocrystal can be defined as a crystalline particle with at least one dimension measuring less than 1000 nanometers (nm). (1 nm is defined as 1 thousand-millionth of a meter [10^{-9} m].) Nanocrystals have a growing list of proven applications, with some already proven and in use such as in flexible solar panels. For example, they can be suspended in liquid and literally painted on to a wall or roof to create a solar-generating surface. They have also been used in the manufacture of filters that refine crude oil into diesel fuel. There are many possible uses such as flat panel

Figure 6: Amazon's Echo and Echo Dot.

displays, lighting, optical lasers, magneto optical memory for computers and more (Figure 7).

One area (of many possible) where nanocrystals may create a disruption is in a modern, significant advancement to Nikola Tesla's wireless transmission of electricity. Where Tesla could light an incandescent lamp wirelessly but inefficiently and expensively from up to a few dozen feet away, his dream has now been reborn. A company named NanoCrystal Electricity has started the build-out of a new wireless power delivery system. This is not putting your cellphone on a wireless charger, this is having your phone charge as soon as you are in range, which could be across your house, or across the mall or eventually anyplace.

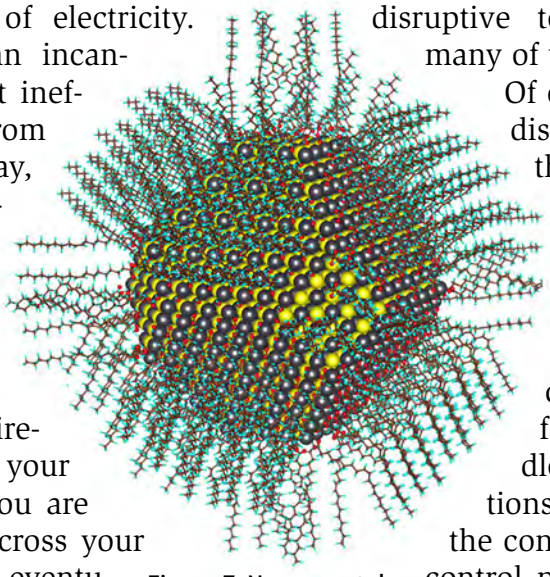

Figure 7: Nanocrystal.

Companies like Motorola, Canon, Toshiba, LG, Sony, and Samsung—among others—are working to fast-track what is called NanoCrystal Electricity tech. Think about no more wires and plugs, not for phones, not for lights, not for almost anything. The power transmission potential using this new technology is so powerful that most portable devices would not even need batteries; they would act as if they are plugged in but without a wire or plug. A page devoted to explaining this technology to the layperson, on the NanoCrystal website states, "Going on a camping trip? Imagine having a mini-refrigerator stocked up with hot dogs and beer right inside your tent… bring a toaster oven and heat up some bagels for breakfast. With NanoCrystal Electricity, everything will magically run everywhere—and anywhere—on its own. In fact, soon you won't even have to stop for gas because this new way to transmit power is going to put an end to the combustion engine and send electric car production through the roof."[3] While it is not as yet being promised it may be possible for a new generation of electric cars to run without batteries, or at least with minimal batteries, and no stop to charge up. The power will come to you just as the magic of radio communications did over 100 years ago.

The point is that we may be on the verge of a stunning breakthrough that powers up everything without plugs and cords. Talk about disruptive technology, and remember, many of you heard about it here first.

Of course, there are many other disruptive technologies, such as the Internet of Things (IoT); there is also the blockchain open ledger technology that can be used for far more powerful solutions than just tracking bitcoin or eliminating the need for a bank to serve as a middleman for money transactions. With blockchain, there is the concern that it lacks the central control preferred by governments as well as many of us average people.

From a consumer electronic standpoint, the new Samsung "The Wall" Micro LED TV will be a disrupter. This is a 146" modular unit; add more modules and make your amazingly bright, amazingly high-quality picture as large as you wish.

The point is that back in history truly disruptive technologies happened every few thousand years, then hundred years, and then every decade; now, almost every month we hear of something that can totally disrupt the world, or at least an industry. Perhaps the most disruptive thing of all is the accelerating rate of disruption. **PCB007**

References

1. *Origin*, by Dan Brown.
2. NVIDIA video on artificial intelligence.
3. NanoCrystal Electricity

Dan Feinberg is the owner and president of FeinLine Associates, Inc. and the technology editor for I-Connect007. To read past columns or to contact him, click here.

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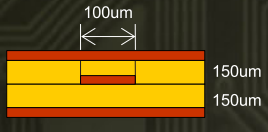
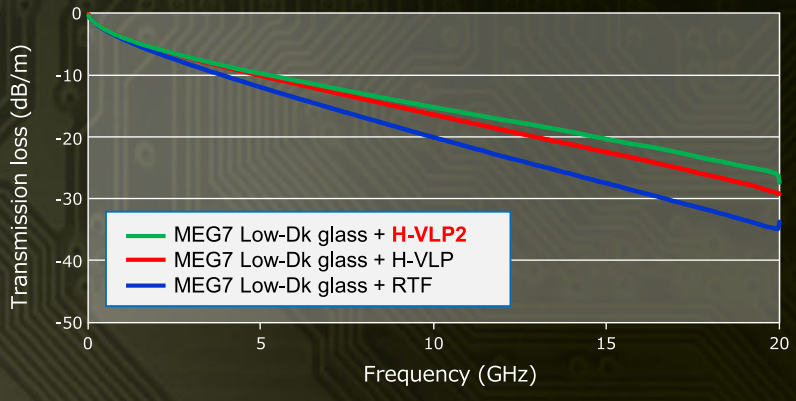


Line Length	1000 mm
Impedance	50 Ω
Copper Thickness	18 µm
Inner Cu Treatment	No-surface Treatment
Core Type	#1078 (RC67%) x 2ply
Prepreg Type	#1078 x 2ply



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Proudly introducing the inaugural issue of *Show & Tell*, the magazine dedicated to extensive coverage of IPC APEX EXPO.

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Figure 1: Pre-clean followed by electroplate copper which uses two separate electrolytes: THF (through-hole fill) or MVF (micro via fill).

GreenSource: Good for the Industry, Good for the World

Feature by the I-Connect007 Editorial Team

Whelen Engineering has recently spun off their new printed circuit manufacturing facility to service the merchant market as a new business entity, GreenSource Fabrication LLC. Because of this strategic move, their collaboration with Atotech regarding production automation and green PCB manufacturing is getting serious attention. Our I-Connect007 editorial team recently conducted a teleconference with Alex Stepinski, vice president and general manager of GreenSource, and Atotech's team, including North America Business Director Moody Dreiza; Gerhard Kruse, sales manager at the equipment plant in Feucht, Germany; and Daniel Schmidt, who oversees global marketing for Atotech's electronics business unit. We discussed the foundation of this partnership, the technical challenges of building green, fully automated fabrication facilities, and GreenSource's plans for the future.

Patty Goldman: Welcome, gentlemen. Gerhard and Daniel, let's begin with you. Can you tell me how you entered this project?

Gerhard Kruse: I was involved in this project during the sales process, so I was brought in at the very beginning, before I handed it over to our project management.

Daniel Schmidt: In Q3 2016, when we heard about Alex's plan to build a full-fledged automated and green PCB production facility in North America for GreenSource, which was Whelen at that time, we invited him to meet our chemistry and equipment expert group in Berlin and Feucht to talk about the available Atotech processes and equipment solutions, as well as possible challenges on his way to realizing the project. As part of the process, we opened our doors to our global technical centers in Berlin, Yokohama (Japan) and Jangan (S. Korea) and showcased our equipment in a production environment. Today, I am very happy to look at the status of the project and the amazing work by Alex and the Atotech team.

Goldman: Alex, why don't you give our readers an overview of what's going on with GreenSource.

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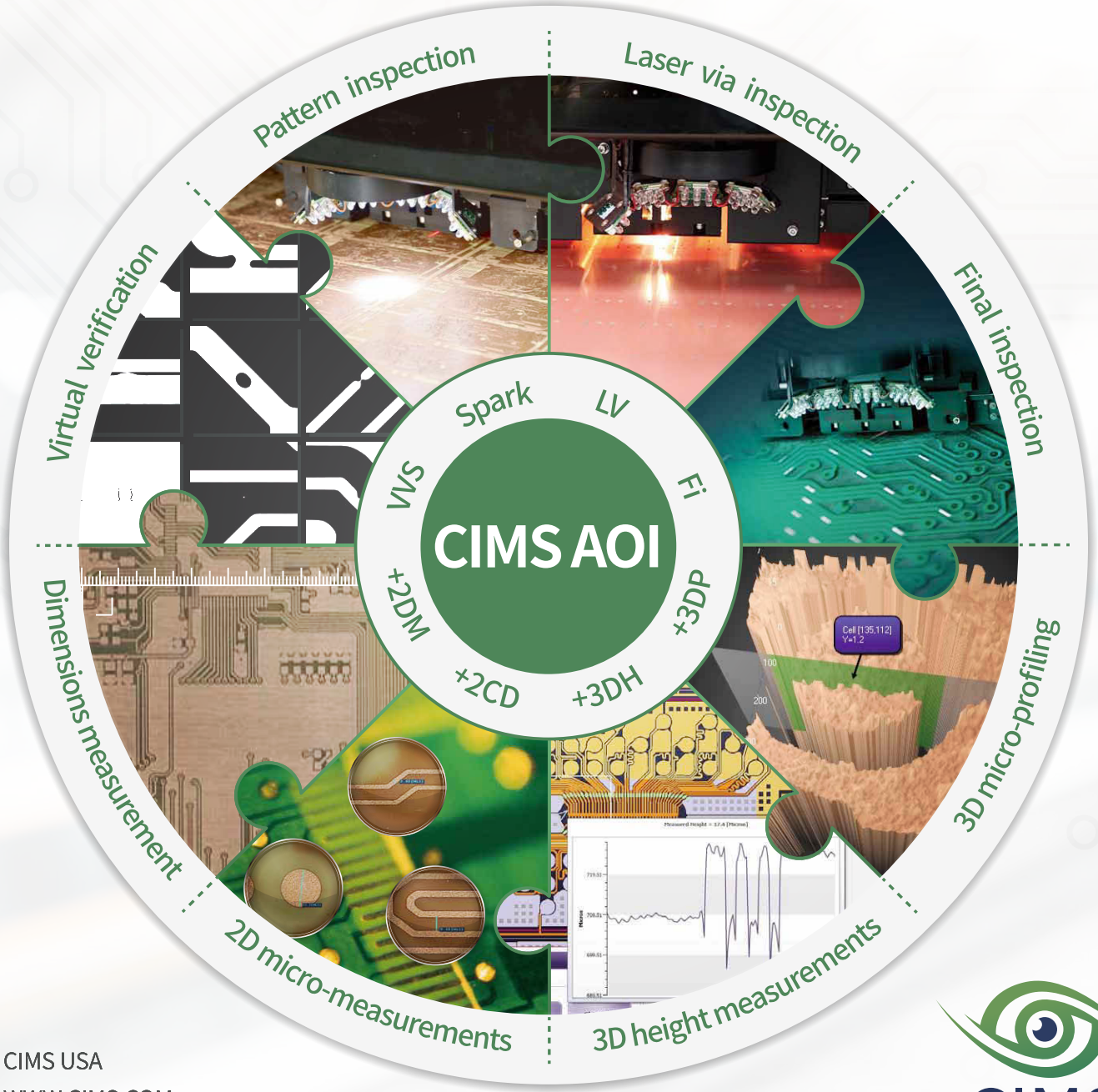

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"We have chosen CIMS AOI equipment for its excellent performance and configuration flexibility. Using CIMS metrology solutions, which are integrated with AOI systems, has become the essential part of Whelen Engineering's fully automated PCB production process."

Alex Stepinski

Vice President at Whelen Engineering/Greensource Fabrication

Alex Stepinski: Your magazine has highlighted some aspects of our project in recent articles. Our involvement with Atotech on this new phase dates to September 2016, when we first made contact to discuss possibilities, and they presented us with some very interesting technologies at the meeting in Berlin, and then another meeting at Feucht. We went to a couple of their tech centers to understand the technologies better. I'll preface this by saying that Atotech was a very successful supplier for us for our original project[1]. They provided an equipment set and overall process that was very, very reliable. We had a good experience with it, and this is the reason we came to them.

During discussions initiated in September, and then some follow-up face-to-face in late 2016, we arrived at an overall specification to create this high-mix process. We could fill buried vias, fill through-holes with copper, plated copper, on very thin substrates and on very thick product; we're able to do high-aspect ratios. These are all horizontal processes that we procure from them, and they are also engaging with us on the chemical side developing a unique vertical process.

All of this is done with a simple zero-discharge mentality. Controls have been integrated throughout the line so that we don't even have rinse water coming out of the lines now. It's a unique overall process where we can run a high mix of products through many different types of chemistries to achieve very challenging specifications, very fast, using equipment that's basically designed more for the Asian market in terms of high volume. But they re-engineered everything for us for a high-mix North American model. And they made it green as well. This is the summary of what we're doing to get there.

Figure 2: BondFilm LDD SR (splash reduction on laser-drilled holes followed by desmear processing.

Goldman: I understand that Atotech has built three platers for GreenSource. Are they providing equipment and chemistry?

Stepinski: Three platers, two electroless lines, two surface treatment lines, and a direct metallization line, so it's more than just three platers.

Barry Matties: In this development process, what was the greatest obstacle that you had to overcome to achieve these results?

Kruse: The main obstacle for this project was the highest degree of flexibility requested by Alex and his team. Atotech's core competence is manufacturing high-volume horizontal plating systems for the PCB industry, and this is typically a combined line starting from desmearing through the electroless copper and finally the plating process. Alex was looking for something totally different—a smaller capacity line. He wanted to have the utmost flexibility for through-hole and for blind microvia production, but also for through-hole filling as well as for processing thin and thick panels, so he challenged us. To deliver a systems set offering the highest degree of flexibility, while at the same time the best reliable solution available in the market, we decided on standalone plating equipment, as well as in-line processing consisting of PTH and plating lines with individual loaders in front and unloaders in between, to provide the solution Alex was looking for. And this is what is installed now.

Goldman: What was new in the equipment that has never been done before, that you're aware of?

Kruse: Regarding the equipment, we had a special request from GreenSource to install a new rinsing system to allow the high flow of a rinsing solution, which would then be used several times. Instead of fresh water for the rinsing system, we are operating with recycled water. For this prerequisite, we installed new devices to the system to avoid dirt due to algae generation in the rinses. Algae generation is an issue when using recirculating water!


Gerhard Kruse

The plating systems we have installed is our UniPlate advanced plater, which is considered leading-edge in Asia markets, and today we are looking at hundreds of installations worldwide. The installation at GreenSource is the first in the Americas. What else is new? GreenSource is the first customer to use different chemistries for one plater, meaning we have to fill the plater, use it for production, then we have to pump the solution back to the holding tank and come back with a new solution to make the same line suitable for another product and for another process. That is a unique setting in the market today, and it was for us a great achievement to engineer and provide a systems' set offering this high degree of process flexibility to one of our customers.

Goldman: Sounds very involved.

Schmidt: Yes, I can confirm we have been very involved and engaged in the project. Usually our clients purchase production equipment for specific applications and production demands. In the case of GreenSource, at that time, Alex entrusted Atotech to come up with a solution where all types of printed circuit boards can be produced using the same set of equipment, but applying different wet chemical processes to realize through-hole and blind microvia production, as well as the processing of thin and thick panels. The production of complex high-density interconnect PCBs is new to the North American market and today more common in Asia. We are as excited as Alex to bring this kind of production know-how to North America.

But let me also add to the subject of flexibility. Atotech systems solutions offer the highest degree of flexibility in the production of different PCB board types (e.g., from standard multilayer to higher complex multilayer, or flex and rigid-flex and high-density interconnect PCB designs), all can be realized with the different settings that our systems offer: different clamp design, oxamat and condenser, edge filter, automatic cleaning system (all for Uniplate P), transport systems, advanced fluid control system (Uniplate LB), reliable transport and uniform surface distribution (UniPlate Cu), etc.

In addition, all of our systems come with online controlling and analysis tools, supporting the systems integration to other machines and software, to comply with the highest degree of automation. Also important to mention is that our systems are designed to meet the highest safety standards and run at very low chemistry, water, and energy consumptions, while at the same time producing a minimum of waste (wastewater or drag-out chemistry), which, in the case of GreenSource, is exactly what Alex was looking for.

Also, the large amount and variety of different Atotech wet chemistry processes GreenSource has installed is remarkable and dates back to 2013, when Alex looked into conductive polymer-based direct metallization. Since then, and with the expansion, GreenSource is now using our high-throw electroless copper (Printoganth T1), the BMV filling process (Inpulse 2HF), the electrolyte for through-hole, BMV and conformal plating (Inpulse 2THF), electrolyte for conformal or flash plating (Inpulse 2HT), as well as laser direct drilling pretreatment (BondFilm LDD SR), higher copper loading bonding enhancement (BondFilm HC), and recently also our ENIG process (Aurotech DC). Alex, is that correct?

Stepinski: Yes, that is the product mix we are using at our GreenSource site and yes, we are also bringing in the nickel-gold process.

Figure 3: Atotech's alternative oxide BondFilm HC (high copper).

Moody Dreiza: The nickel-gold process obviously is a surface finish process, and we're also very excited to partner with Alex on that. Patty, you asked what is new that has not been done before. From my perspective, I would certainly say a lot of these activities have not been done before in the North American market. Key to many of the systems is our transportation systems, which are most likely the most advanced in North America.

Also, we did some customization, which is potentially one of a kind worldwide. The plumbing in the equipment was customized to conform to Alex's concept for minimal water use within the lines and the ability to handle multiple electrolytes.

The flexibility mentioned is only possible because of Atotech's unique status as both equipment fabricator and chemistry. Atotech provides the overall system solution of both equipment and chemistry, of which we are very proud.

We talked a little bit about some of the innovations on equipment and on the chemistry, like our Printoganth T1. This is the first installation of this process in North America. Printoganth T1 is really targeting those blind microvias, specifically reliability of blind microvias, which is something that is becoming increasingly important in the industry as the via sizes shrink. And automotive requirements that we want are introduced into the market. We see a very high focus on reliability of blind microvias and from that perspective; we believe that we have a very robust overall solution.

Matties: You mentioned your conveyor transport. Tell us what makes that so special now?

Dreiza: The ability to handle different thicknesses of material was something that we wanted to make sure was an option that was available to our customer. And I would probably turn to Gerhard, if you would like to give more detail on that. Gerhard, maybe you can dive into some of the aspects of our UTS access system.

Kruse: Yes, as Moody and Daniel just said, we have different lines at the facility. The different lines are equipped with different conveyor systems. One conveyor system is equipped to transport thick panels, and another one is equipped to transport very thin panels. And the UTS-xs concept is designed to process standard panels of 44 microns in thickness including 2 x 2 microns of copper clad, which I would consider is already very, very thin and flexible material.

Fluid management is key to enable reliable transport in UniPlate systems and we have implemented a lot of control devices to do this. For example, we control the solution level in the process area of the modules, and we control the pressure of the solution flow from the pumps through the fluid devices to the panels. We have built-in devices, which look different and which are more advanced compared to what we normally use to enable reliable transport. By these means we achieve the latest requirements for transport capabilities as required in the industry today. And we have also implemented fine filtration systems for all lines. This was required because GreenSource also wanted to process fine-line structures on these lines. To allow exactly that, we have a fine filtration concept for all modules, not only active modules, but also on rinses and on the plating modules.

Matties: From this experience of all this new technology, how is this going to come forward or help other fabricators or how is that impacting your offerings in the North American market? What should others learn from this?

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Dreiza: I would start by saying that I think the overall approach to one of a green manufacturing site, or a highly sustainable manufacturing site, that can handle some of the most advanced PCB materials and PCB projects, certainly is generating a good deal of interest from what we've heard in the North American market. It's a bold step, but it shows the possibilities of what is achievable. I'm seeing a high degree of interest in the market for comparable approaches. Maybe not necessarily to the whole way that Alex has put it together, because Alex has filled in a lot of the blanks and connected the dots between the different processes, which is already in its own right quite a good deal of work. But I think that certainly people are starting to sit up and take notice of what is possible with some of the more advanced systems, which is really the combination of equipment and chemistry.

Moody Dreiza

Matties: I would think that the zero-discharge requirement was a challenge and one that would be sought after as well.

Dreiza: Yes. So far as our horizontal systems, by design, are low-flow, low-water consumption. We have things, for example, like condensers on our exhaust, which capture a lot of the chemistry that is in the exhaust and brings it back into the tanks so that you're not just exhausting a lot of the chemistry and a lot of the water that you are bringing into the system. Our systems are, by default, already quite conservative in their use of water as Daniel also underlined. We are seeing that as a thing of very high interest in the market in all regions. I've seen it in the Northeast, and in the Southwest of the U.S., and in Canada. People are paying a lot more attention to it than I've ever seen before. What Alex has done of course is take that and multiply it across his entire factory, which is a great deal and achievement.

Goldman: It is. I guess a lot of people didn't think it was possible.

Schmidt: Yes, I agree. The results are remarkable and we are looking back at a great deal and achievement. Our systems have always run at a much lower chemical or water consumption rates compared to any of our competitors, and therefore also at a much lower process cost. In addition, we are looking at high productivity and yield rates at the GreenSource site. At GreenSource, our systems could be even further trimmed to perform at almost zero raw material consumptions, water and energy levels, as well as almost no liquid waste/discharge.

What Alex and his team have accomplished here is really a great deal. Extensive cleaning cycles in the desmear process, what is today considered standard could be almost completely eliminated. The electroless copper process saves a lot of water, as well as sodium hydroxide and formaldehyde, compared to a vertical system. In the electrolytic copper plating step, we can realize fast plating, excellent surface distribution and yield at lowest chemistry consumptions when compared to other insoluble anode systems using copper oxide or copper carbonate; several tons of plating solution can be saved per year. Last, but not least, a high copper loading bonding enhancement bath allows GreenSource to reduce the bleed amount and make-up frequencies, while keeping the same reliable performance of the high-end bonding solutions from Atotech.

Matties: It is remarkable, indeed. It's an achievement that doesn't go unnoticed here. You guys have mentioned the growing demand for HDI production in North America. What sort of inquiries are you getting specifically related to HDI from North America? Have you seen a large increase in that?

Dreiza: We are seeing a high interest in, for example, microvia reliability. That seems to be one of the hot topics that we've heard about in maybe the last six months. But in terms of people adapting new equipment, new processes, to address those, I think those are still com-

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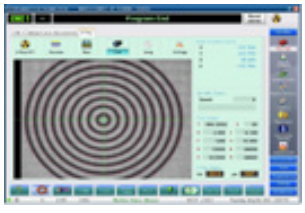

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ing from the industry. There are, of course, people who are looking at newer equipment, but I think maybe not something as advanced as what's been put together at GreenSource with all those dots connected. I can't underestimate the work around the equipment that we've provided, which is also very important. But we are seeing more interest in the industry, certainly.

Matties: And maybe one final question from me. Through this whole process, what has been the greatest surprise?

Kruse: That is a good question for our project manager to answer, who unfortunately cannot join us today. But what I saw, and what I experienced with these lines is that we have had no unexpected events. Everything was quite normal. Of course, as I said earlier, what Atotech normally provides to the industry are lines which possess a very high conveyor speed with a target to have a high output with a very high availability. And this is something that's different at GreenSource. They want to reduce the conveyor speed. They want to unload after one process and to load in front of the next process at whatever time they want. From my perspective, the high demand for flexibility was a challenge and maybe still is.

Goldman: Well, I think that most people who buy equipment simply come and say, "I need equipment to run this many parts per hour, etc." They don't make the kinds of demands that Alex has made on you. And you guys picked up the challenge, which was great. I take it that it was a challenge—you couldn't just say, "Oh, well, yes, we'll use this and we'll use that." I'm sure it took a lot of collaboration and I think that needs to be recognized and congratulated. Alex, maybe you have some thoughts on that, too?

Figure 4: T1 Electroless copper, with better throwing power than standard, followed by high throw electroplate copper HT.

Stepinski: I do. This is the result of a lot of collaboration. The real bottom line here is Atotech is an advanced HDI equipment and chemical supplier on the electronics side, amongst other things. They really are focused on the mass production Asian market, and to take those ideas and turn it into a high-flexibility, green, North American solution was a great challenge. It took a lot of face-to-face time and a lot of conference calls. It was a very good experience overall. We're happy with the state of things right now, and look forward to continuing to work together.

Goldman: Did you ever doubt that it would happen? That you would meet all these requirements?

Stepinski: Well, we didn't doubt it would happen. I think the challenge was all in how much time we had to put into it.

Matties: Is there anything we haven't talked about here that you feel we should have covered?

Stepinski: The only other open topic is that we are doing collaboration on vertical chemistry for a unique tool that we've had built here that's being installed in the next six weeks. Those chemistries are associated with semi-additive processing as well as ultra-high aspect ratios of 50:1. This is something rather new. Some chemistry is being built specifically for this application, or at least modified for this application. It's just getting started now. There's not much to talk about, but we are partnering with Atotech on this over the next

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Goldman: You barely got this other project running, and you're off onto the next one.

Daniel Schmidt

Stepinski: This was always part of the plan from the beginning. It was just that this was the next case.

Dreiza: Just as Alex said, this is still a very early stage in that process, but I might add something from my perspective. Atotech normally builds and typically provides a lot of attention to horizontal processing. Our equipment that we manufacture is really for horizontal processing, but when it comes to chemistry, even though we do provide those sorts of combined equipment and chemistry systems in horizontal, in vertical such as what Alex is describing now, we also are quite open to providing chemistry for vertical processes. We have an entire suite of chemistry for vertical processes, be they vertical conveyorized or vertical hoist-type plating systems.

Figure 5: Back side of the lines showing pumping system and dosing tanks.

What I think Alex is alluding to here is that we are also willing to partner and try to find a solution, maybe one that doesn't even exist today, that would be able to do some of these, I would say, futuristic or forward-looking challenges such as the 50:1 aspect ratio. It is early in the project, and we are partnering with Alex to check that we are driving towards that goal.

Schmidt: Let me add to this by saying that an aspect ratio of 50:1 is pretty high, not to say exceptionally so. But while exceptional and certainly challenging, it doesn't mean that plating reliably into such holes is impossible.

If you would ask me, this is how I would describe you, Alex. You have very interesting, visionary, and challenging ideas, and you always choose the best to cooperate with to reach your goal, which is impressive and makes you a great achiever. We are early in this project and we are working hard to push this forward together with Alex. We are ready for sampling of boards coming with this very high-aspect ratio criteria. Of course, it all requires a good quality PTH process prior to the plating step, which is the challenge here too.

Goldman: Gentlemen, thank you so much for your time.

Schmidt: Same here. Thank you for having us.

Dreiza: Absolutely.

Matties: And thanks to you, Alex, and to your team for being so open and sharing what you're doing at GreenSource. It's good for the industry and good for the world.

Stepinski: Thank you everyone. **PCB007**

References

1. Whelen Reduces Cycle Time by Building a New Automated PCB Factory, *The PCB Magazine*, October 2015.

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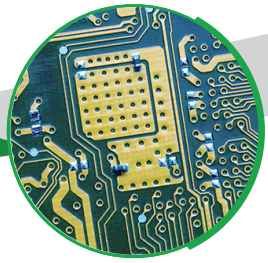

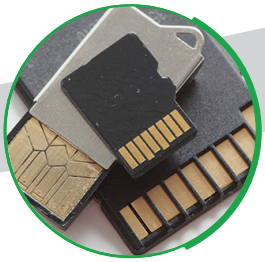

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Supply Line Highlights

I-Connect007 Launches Thermal Management with Insulated Metal Substrates eBook ▶

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Punching Out! Top 10 M&A Deal Killers ▶

I am often asked about some of the reasons why M&A deals die. Although this is a very painful subject, hopefully through sharing these reasons we can help some deals survive the M&A process. Here are my top 10 M&A deal killers (and a few solutions).

Orbotech's Strategic Decision for End-to-End Partnership Benefits Everyone ▶

Barry Matties met with Sharon Cohen, president of Orbotech West, at productronica 2017 to discuss what's new at Orbotech, specifically their shift to be more customer-centric and to provide regional coverage across the globe. Also discussed were the current trends in the marketplace and Industry 4.0.

Ventec International Group Now Trading on Taipei Stock Exchange ▶

Ventec International Group Co., Ltd. announces that its shares are now listed and trading on the Emerging Stock Market of the Taipei Stock Exchange since January 16, 2018, under the Stock Code 6672 and name, Ventec.

Aismalibar on Laminates, Following the Market, and More ▶

At productronica, I-Connect007's Barry Matties, Andy Shaughnessy, and Patty Goldman sat down for a chat with Eduardo Benmayor, director general with Aismalibar, a laminate supplier currently focusing on thermal management for the LED and automotive markets.

Staying Ahead of Market Trends through Education ▶

ESI equipment has been in high demand with the recent rise of flex and HDI. But when Barry Matties met with Patrick Riechel and John Williams at HKPCA, they explained that it is really ESI's future protection and flexibility in the process that keeps them ahead of the market and allows for ongoing success.

Whelen Engineering and AWP Explain Unique Collaboration ▶

If there was a buzz word in the PCB hall at productronica this year, it was probably Whelen, as in Whelen Engineering and Alex Stepinski, VP of Whelen's circuit board division.

Case Study: Pits and Mouse Bites, Part 2 ▶

In all troubleshooting situations, it is best to look at the problem with wide open eyes. Just because one is looking at an issue that is visible after copper plating, this should not mean that is the only place to look. And this case study illustrates that point quite clearly.

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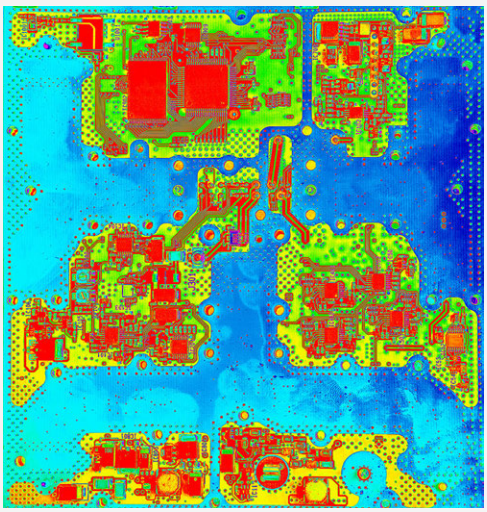

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Figure 1: Elga Europe facility in Milan, Italy.

Elga Europe Reality and Ultra-High-Resolution Photoresist

Feature Interview by Patty Goldman
I-CONNECT007

While walking around the PCB hall at productronica, I was approached by my good friend Gene Weiner. Gene emphatically directed me to the Elga booth to find out about their new extra-thick dry film that can image extremely fine features with a perfectly perpendicular sidewall. Elga Europe CEO Giorgio Favini filled me in on the details.

Patty Goldman: Giorgio, I understand you have a new photoresist that is pretty amazing, but why don't we start with a little bit about you and your company.

Giorgio Favini: Elga Europe was founded as Elga in 1973. At that time the company was very small with only one employee and a share capital value of €250. In 1979, an important joint venture with Lea Ronal began and the name changed to Elga Ronal. In 1989, the company started to import the dry film master rolls from Tokyo Ohka Kogyo, located in Japan, to supply the Italian market, with much success. Thanks to this success, in 1995 Elga Ronal made an important joint venture with TOK and built the actual dry film coating facility close to Milan. In 1999, Elga Ronal bought back the shares of Lea Ronal, changing the name to Elga Europe.

In 2003, for strategic reasons, Elga started its own independent R&D on dry film, and in 2010 my family decided to buy back the shares of TOK and then owned the company at 100%. In 2013, we began the first joint venture with Eternal, the largest worldwide dry film producer, based in Taiwan. This merger was completed in 2017 and Elga became part of the Eternal Chemical group.

This year I became CEO of Elga Europe and second shareholder of the company after Eternal. Today Elga is the market leader in Europe for dry film with a market share greater than 70%; we are also selling ultrapure chemicals

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At this moment Elga is following many different projects with European PCB producers and one of them we recently did was with one of our German customers, to develop the first radar boards in the automotive industry. We were very successful with them and for this reason, we are involved in practically all the European production of radar boards at this time.

Together we developed a new dry film dedicated to the mass production of radar boards.

Together we developed a new dry film dedicated to the mass production of radar boards. Elga also recently developed some other dry films which are dedicated to very high technological production. One of these is ultra-fine line dry film, which is the FP400 and FP700. It is a dry film with a very particular characteristic, which is that it allows the producer to use a dry film of double the thickness of the line width that you want to obtain, which is a 1:2 aspect ratio—and in some cases our customers have achieved 1:4. We developed a dry film with this characteristic because during PCB production, theoretically, the thickness of the dry film used is equal to the line size we want to produce—but with very thin dry films the dust presence in the cleanroom becomes critical with a consequent increase in scrap rate.

The lowest thickness we produce for these dry films lines is 15 microns, with a theoretical resolution of the lines below five microns. Another recent and important project of Elga's is developing a very thick dry film for some special production applications. We were successful with the production of 130-micron dry film and at this moment Elga Europe is the only company able to supply this dry film thickness to customers which is also for DDI/LDI exposure technology.

Goldman: Is the dry film that thick so they can plate thicker lines and features? Is that the idea?

Favini: Honestly speaking, I don't know, because the project just started with them, but I suppose it's dedicated for high copper thickness deposition.

Goldman: How are things in the European economy?

Favini: After 10 years of a difficult European ecomonic situation we are realizing an increase and improvement. This is very important for us, of course, because you know very well what happened in 2008–2009 when it was a complete disaster. But right now, all our customers are at capacity with their production. Some of them for the first time in their history are refusing orders and many are close to 1.8 as a book-to-bill ratio. So it is very, very positive. The problem is that everybody is a little bit afraid to invest again in Europe after what happened 10 years ago, but I think that if this situation goes on in this way for a medium/long period, new investment will be done in Europe with the opening of new PCB facilities.

Goldman: Along with the expansion of existing companies.

Favini: Yes. Some of our customers also started to use Elga dry film in their facilities located outside Europe, mainly in Asia, to be able to meet the high European order requests. This is very important for us because it's a big chance to export our dry films to Asia where we can produce locally thanks to the fact that Elga recently became part of Eternal Group.

Regarding the European market, right now we are leader with a market share of 71%, and the forecast for next year is 76%. We are also very strong in Russia with a market share of 62% thanks to excellent cooperation with our local distribution, Petrocommerz. Other very important markets for Elga are Israel and the U.K. where we practically have control of 100% of the market.

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Goldman: Gene told me that you can image extremely fine features. Can you tell me how that works?

Favini: Yes, the tendency of the market is to move to the production of fine or ultra-fine-line PCBs. For this reason, we developed the FP400 dry film series and recently a new version named FP700. With this new dry film, we can reach a line/space resolution below 10 microns.

The photoinitiators present in the resist, by UV light effects, trigger a radicalized action of monomers which join, causing their polymerization. During the exposure phase, the UV light impacts the dry film bottom-up, so there will be a difference of energy between the top of the dry film and its bottom, in touch with the substrate. That difference is proportional to the thickness of the resist, with an unavoidable difference of polymerization between the top of the dry film and the bottom of the dry film. To minimize that gap the different photo initiators must be balanced. There are photoinitiators in the formulation of the dry film which help the polymerization of the top and photoinitiators that help the deep polymerization of the track, i.e., on the base of the resist. Their balance is required to obtain the vertical profile of the dry film. This type of characteristic in the dry film formula has gradually become more important over time in the market with the increased use of laser exposure units. In fact, in these exposure units it is particularly crucial to have an optimal balance in the formula of the three principal photoinitiators to get very good verticality of the lines.

This type of characteristic of the verticality of the lines has become particularly critical with on-going growth of the dry film market for fine line and ultra-fine line applications. In the most recent project followed by Elga Europe regarding the design and use on industrial base of dry film FP400 and FP700 which Elga Europe, through its customers' exclusive cooperation, has been able to obtain very important technological results, producing by means of this dry film lines and spaces below 10 µm (Figure 2).

Goldman: Most dry films have a cover sheet, and when you image them, do you still have the cover sheet on there, or do you take the cover sheet off and image right against the dry film?

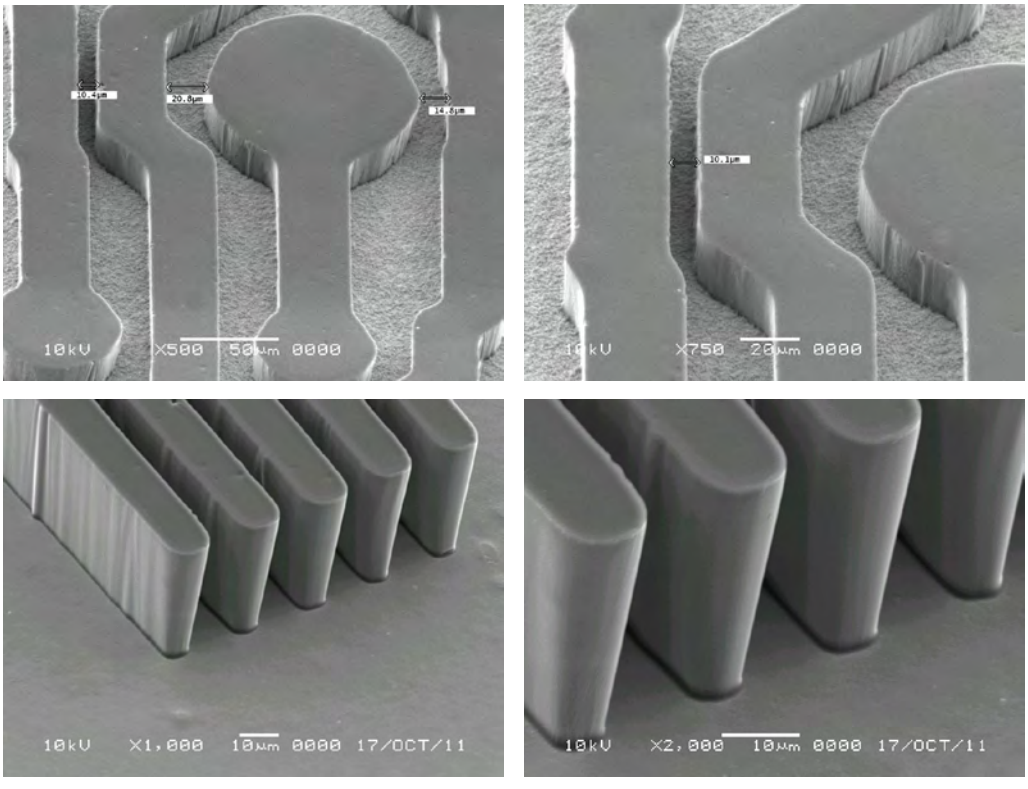

Figure 2: Examples of FP400 photoresist capabilities.

Favini: The dry film is made of three different layers. The first one is PET, which is used as a carrier during the coating of the resist, which is the liquid dry film (before drying in the oven) with 50% of solvent used to properly mix all the raw material. On average, 25 different raw materials are needed to produce a dry film and

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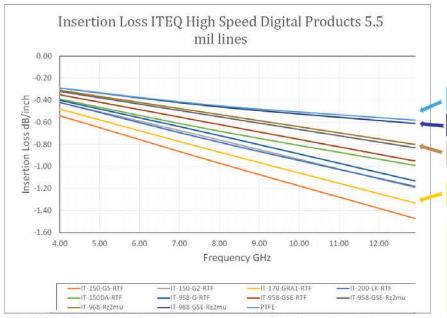

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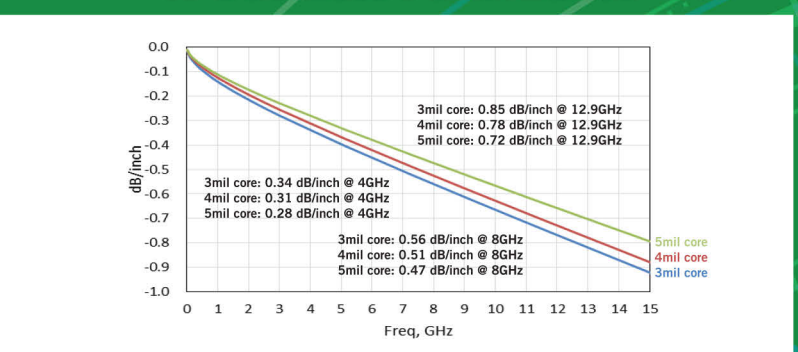
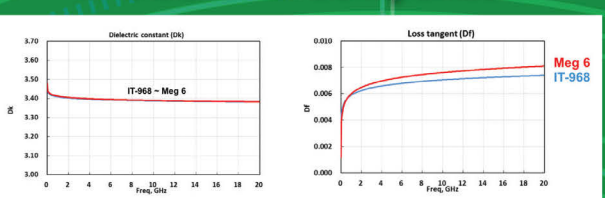


IT-968 SPP Comparison



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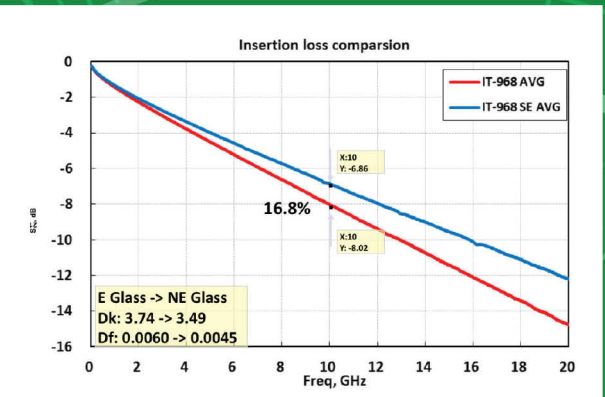
Td-5%(°C)	TGA 5% loss	390+	390+
CTE (%), 50-260°C	TMA	2.2	2.2
Peel strength (lb/inch)	1 oz	6	6
Water Absorption	D-24/23	< 0.1	< 0.1
Dk , 1 GHz 2-10 GHz	IPC TM-650 2.5.5.9 IPC TM-650 2.5.5.13	3.8 3.8-3.7	3.4 3.4-3.3
Df , 1 GHz 2-10 GHz	IPC TM-650 2.5.5.9 IPC TM-650 2.5.5.13	0.0032 0.0038-0.0050	0.0028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

E-Glass vs Low Dk Glass



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so it's very important that the mixing process is perfect. After coating, the resist, the second layer, goes into an oven 62 meters long and after the evaporation of the solvent we have what we call "dry film." To keep the different layers of the master roll from sticking together a third layer of polyethylene is applied before the winding of the dry film and which is what you call the cover sheet (Figure 3).

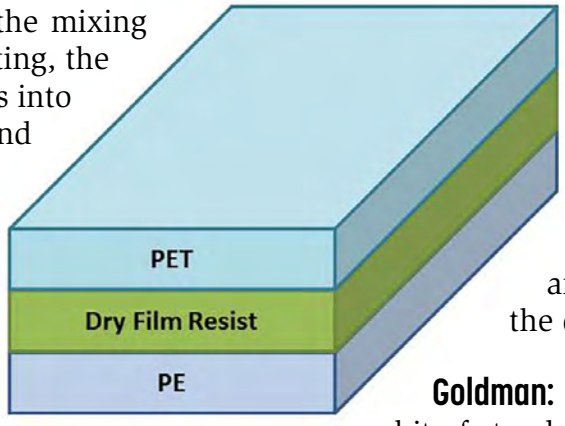

Figure 3: Schematic of dry film layers.

Goldman: Ah, that's what I was calling the cover sheet.

Favini: The polyethylene is removed just before the lamination of the dry film to the substrate. Then the dry film is exposed, and then also the PET is removed to proceed with the dry film developing process.

Goldman: The PET sheet stays on during exposure. How thick is that?

Favini: It depends, but about 18 microns.

Goldman: Does that somehow affect the image resolution?

Favini: No, the image resolution is affected by the transparency of the PET. A too-thin PET could break up during the removal process after dry film exposure. This is a characteristic of low quality dry film with the intention of the dry film producer to reduce the production costs but it creates problems for the PCB producers as mentioned. What is also very important is the thickness distribution of the dry film on the master roll during the coating process because this affects the resolution of the lines during PCB production. Elga Europe guarantees to the customer a maximum variation of ±1 micron on the master roll width, while some other dry film producers guarantee a maximum of ±4 microns. This worse distribution also creates wrinkles on the master roll during its aging and so an even higher thickness difference further worsening possible problems to the customers. It also creates an edge fusion problem on the dry film rolls.

Goldman: Because you've got a little bit of standoff from the resist, does that affect the shape of the line and the width?

Favini: Yes, it's very important to use a PET with high transparency to guarantee a very low refraction effect so that the light will not be diverted during the dry film exposure process. This can also be adjusted by regulating the exposure energy. Of course, with the increase of the PET quality, the purchasing cost will be higher, but these features are very important for production of high quality PCBs and mandatory for fine line and ultra-fine line work to guarantee a very good line definition. For this reason, to produce our ultra-fine line dry films we use a special and dedicated PET with even higher quality than the ones used for the other dry films. For example, Elga supplies a customer in the U.S. with the FP720 dry film of 20 microns thickness; with it they can produce five-micron lines and spaces. So it's clear how the quality of all the raw materials involved in the dry film production are important.

Goldman: That's very good. Was this done with direct imaging, perhaps laser?

Favini: In this case, it is a conventional one with a UV light. But this kind of dry film can also work with direct image with DDI, LDI, or laser diode sensor.

Goldman: Okay, thank you so much. This has been a very interesting discussion.

Favini: Thank you, Patty. **PCB007**

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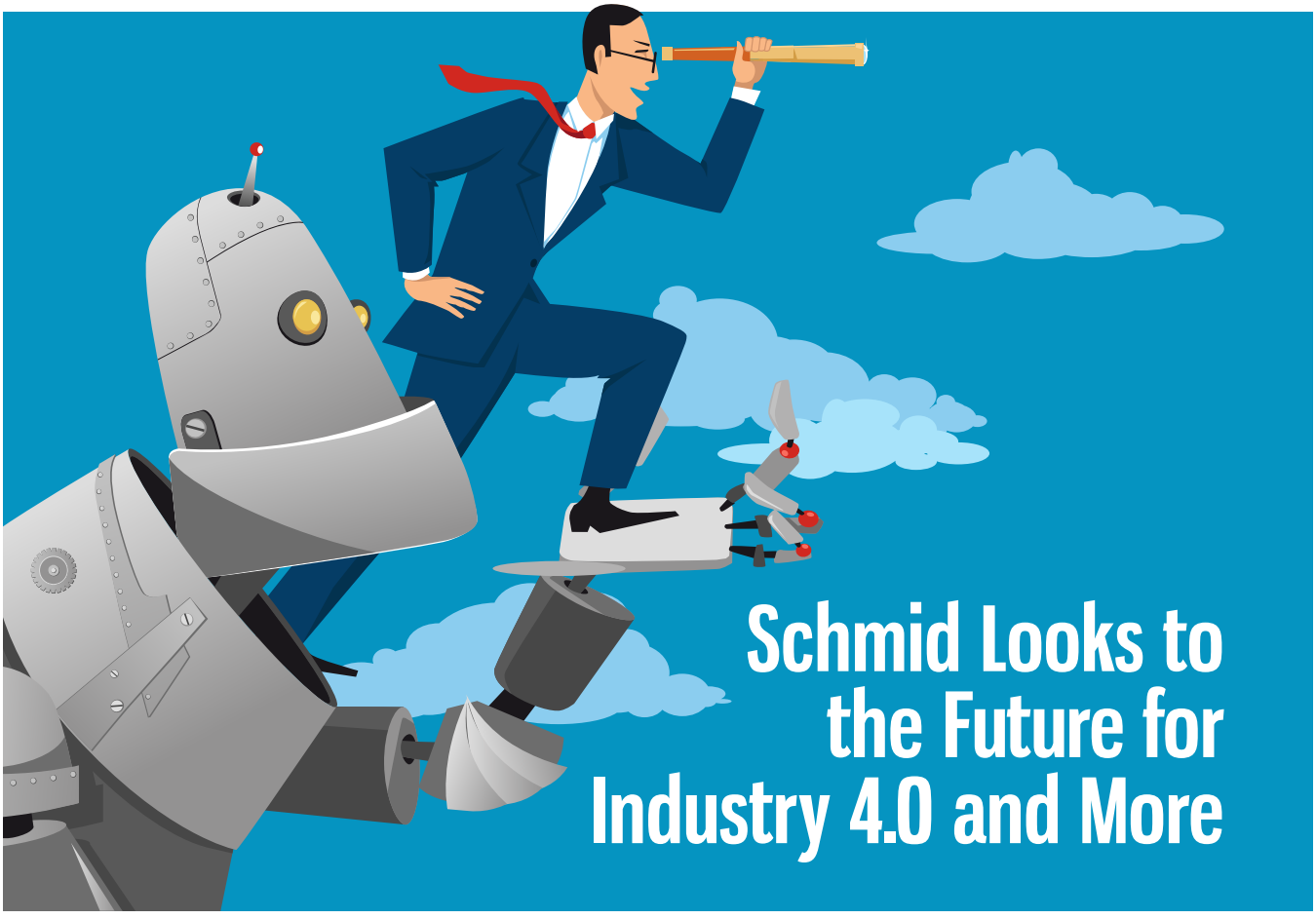

Schmid Looks to the Future for Industry 4.0 and More

Feature Interview by Patty Goldman
I-CONNECT007

I met with Rüdiger Lange, CSO at Schmid Group, in their spacious, comfortable booth at productronica. We discussed the current capital equipment market and Schmid's business direction for the future while watching some of their new technology in action.

Patty Goldman: Rüdiger, please begin by telling me something about yourself and Schmid Group.

Rüdiger Lange: I'm responsible for the sales and marketing at Schmid Group, which I joined about 18 months ago. I've been working in the high-tech equipment business for about 20 years, starting in the early days with Philips Electronics doing OLED displays, flat panel displays, and then moved into more semiconductor technology, SMT technology, process technology for plating and semi-conductor. Wet process equipment, Schmid's core business, is an area that is very familiar to me.

Rüdiger Lange

Schmid has been in the electronics business since the 1960s. The company is over 150 years old. In its early days it was building production equipment for iron foundries and wood mills. In the 1960s we started offering solutions for surface treatment of PCBs, consisting of washing, cleaning, brushing and then very quickly we moved into chemical processing of PCBs. That's still our main business today. We're experts in chemical technology, chemical surface treatment, developing, etching—any kind of surface treatment on a PCB or substrate—and we also use this expertise in other applications and markets. We also offer chemical process

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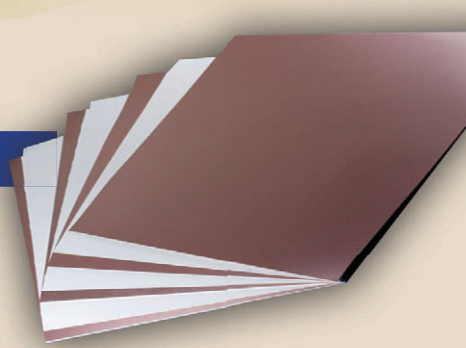

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systems in PV (photovoltaics), another core market for Schmid. Two more recent markets are batteries and automation. The latter has been a successful business for Schmid and is gaining momentum with new smart PCB fabs that rely on factory automation. Schmid Group makes 40% of its revenue in the electronics market. The productronica show is a very important event for us.

Goldman: OK, tell me what's new here at Schmid with your PCB equipment.

Lange: We've been in the electronics business for quite a few years and have seen many changes in the industry. By carefully reviewing the roadmaps together with our customers, we've followed the trend in the past years to higher-end PCBs, which means the feature sizes on the PCB can go below 10 microns. We've been working on processes for those boards in our R&D labs for a while. We see more requests coming in from customers that are working on the HDI plus, SAP (semi-additive process) and mSAP panels, so the focus in our R&D and engineering is on how to serve this market of the future.

We're convinced that this is where the electronics market is moving. It means higher integration and bringing embedded components into the PCB, and there's a couple of things that are playing a role here. Number one: as I mentioned, line and space is going down. That has consequences for the process technology. It brings in new requirements for the cleanliness of your processes and you get confronted with yield issues. Depending on the complexity, a traditional PCB panel might be anywhere between 100 to 400 USD per panel. If you integrate components you would have a multiple of that value. You can imagine that if we have a panel with integrated components worth, let's say 3,000 to 5,000 USD per panel, and we lose a panel in the production, it has significant impact on the production cost.

Goldman: Not only that, it's not likely to be repairable.

Lange: That is correct, and the integrated components are scrapped. How can we solve the problems that our customers are facing in the next few years? With our R&D staff we have been working on really new ideas. We've come up with a couple solutions, some are evolutionary, others are revolutionary, and we are showing a selection of that here at the booth. The feedback we are receiving is very positive. We have picked up a technology trend that I think will be first implemented in the high-end segment, which will then also continue to the lower-end consumer products.

Goldman: What is new in your conveyorized equipment?

Lange: What we show here is the second-generation vertical processing equipment, called InfinityLine V+ and we also show conveyor equipment for horizontal processing. We have improved the roller transport system, which is optimized for extremely thin substrates, meaning that we can handle products down to 25 microns in thickness. There is no slip, no friction, nothing that would slide or rub on the surface of the substrate and generate particles, which could potentially have a negative impact on the yield. Compared to the first-generation horizontal systems we have also

Figure 1: Schmid's vertical processing line, InfinityLine V+.

optimized the footprint and lowered the operational cost. However, cost is not the only parameter that a customer decides on. Customers are choosing the best technology, and it has to be at a reasonable price. Every customer is willing to pay a premium for a good machine, but it must be reasonable.

Goldman: It must have a payback or a decent ROI.

Lange: Cost of ownership and return on investment are one of our customers' most important criteria when they decide to purchase capital equipment. We're an innovative company, we're binging new technologies to the market and we are targeting the high-end segment of the market. In the horizontal process system that is shown here, we implemented the newest and best roller transport and spraying systems.

We have significantly improved the maintainability of the equipment by separating the operator and the maintenance side of the machine. In this new series all maintenance is done from the back of the machine. It's very accessible and the setup is completely modular. By choosing a new modular controls and software architecture we're preparing our machines for Industry 4.0. The only connections between the modules are network and power, no more than that. This is a big change from previous designs, in which network and power were distributed through the machine from a central cabinet. This truly modular approach is much easier to set up in the field, it enables faster maintenance for our customers, and that also defines the payback. Reducing downtime from 2% to 1% is a significant cost savings.

Goldman: That makes sense. You mentioned vertical equipment.

Lange: The first-generation vertical process equipment was designed six years ago. It was installed at a number of customers working in the high-end segment. Today, about 30 of those machines are in production, but there was a need for better process control and lower chemical consumption in these machines. At this year's productronica we're presenting the new-generation vertical process machine, the InfinityLine V + . The target of this new design was to enable smaller feature sizes on the panel and one of the most important topics was the reduction of particles in the machine. We have developed a new transport system, but we are staying with the proven clamping frame in which the panels are suspended. Instead of having a belt-driven transport—we know the belt creates friction and particles—we have an externally-driven roller system. There are no moving parts above the panel surface anymore, so the panel stays completely clean.

There are no moving parts above the panel surface anymore, so the panel stays completely clean.

As I said, our aim was to reduce the particle count in the machine. Optionally, this machine can be equipped for and placed in a cleanroom, which is where the high-end panel technology is moving. Line and space dimensions are going down, and if we're looking at the PCBs that are manufactured on the vertical process machines, we're talking ten microns today, going to five microns or below in the near future. If you visit hall B1 here at productronica, you will find semiconductor technology. They are typically working on features on the nanometer scale. Low-end semiconductor processes are going up to microns. This is where these two industries meet: Typical semiconductor processes are over-specified and too expensive and traditional lower cost PCB processes cannot reach the specification. What we're doing is extending the range to which tools from the PCB industry can be used into the area of the semi-conductor processing. We are addressing the market for boards with

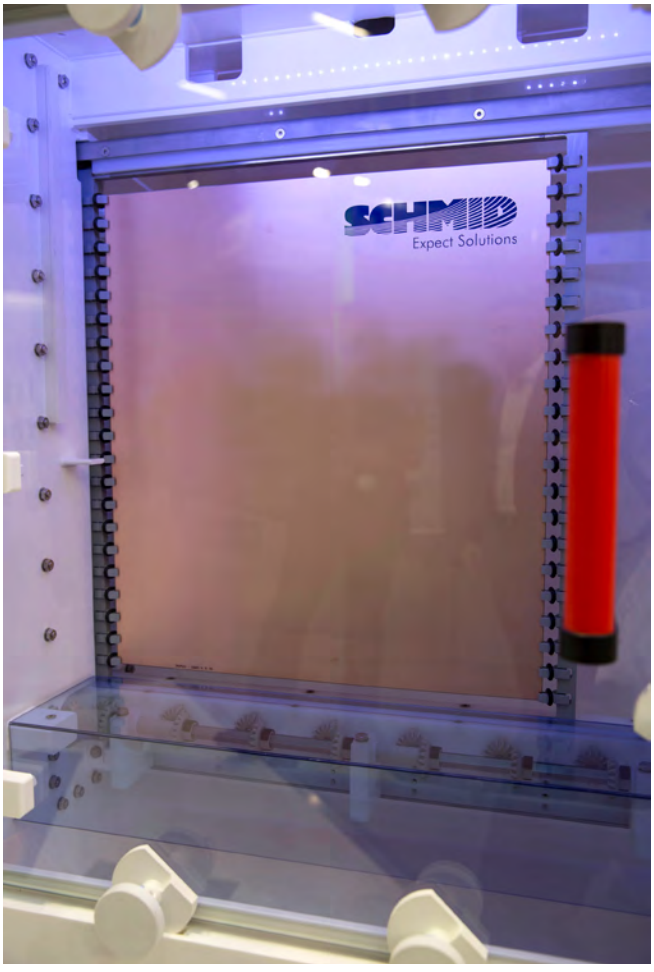

Figure 2: Using innovative clamping frames the InfinityLine V+ enables a contactless and safe vertical transport of PCBs and substrates.

integrated components that require lower pitches and higher accuracy.

That means that this machine must be fit to operate in a cleaner environment. It must be particle-free and that's also the concept you see here using the clamping frame. It's a new version of our clamping frame that doesn't have any moving components above the substrate surface. Any motion is below the substrate surface. Particles that are generated will drop to the bottom of the machine and get filtered out. Outside of our machine, we are transporting the new clamping frame in what is known in the semiconductor industry as a FOUP (front opening universal pod). It's a hermetically sealed transport container that will take up to 15 frames. The container is a clean particle-free environment, which increases the yield in the factory. We can store the substrates, we can transport them through the fab, even through different areas of the fab that might not be so clean, and then go to the next process.

Goldman: Where do particles come from?

Lange: Particles are generated basically by any moving part that you might have, but not the boards themselves. Of course, if you are developing, etching, and stripping photoresist, we take care of flakes and particles by filtering the chemicals in the machine.

Goldman: So the concern is wear and tear.

Lange: Wear and tear in the machine and in the automation. You'll see quite a bit of traditional automation here at the exhibition. Most of the systems are based on industrial robotic systems, having a variety of bearings and motors, which all generate particles. Traditional robotic systems grab a substrate from the top and there are many moving parts above the surface of the panel. With our universal loaders we have addressed and solved this issue.

Goldman: That is something we've never worried about before.

Lange: Until now it was not all that important and it's the value of the substrates and the size of the structures that's driving up the specification. We know from the semiconductor manufacturing that yield is a determining factor for the success of every factory and in that respect for every company. And that's really what we are doing here. The vertical line is only one part of the success story. We believe that the factory of the future will be a fully automated fab. The market is talking about Industry 4.0, which is not just robotics and automation, it's about the communication between the machines, it means creating a smart factory.

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tics for bringing material from the warehouse to the machines just-in-time for processing. The process recipes are controlled by the MES, the computer system of our customers, so you really have the optimized fab that will increase the availability of your machines. You have the material at the machine when you need it and it also enables you to handle smaller batch sizes efficiently.

There will be a change from today's manufacturing. Today we can stack the boards on top of each other, so we can easily have 150-200 PCBs in one stack. If you go to higher-end PCBs you cannot stack anymore; you need to singulate the PCBs, to handle them one piece at a time. You can transport them either in clamping frames where they're suspended and they are not touched again or you place them in single panel trays. It means that instead of transporting 150 substrates in a stack, you might be able to transport 30–50 substrates, and that means the transport and logistics in the factory will increase significantly. This can be solved by either putting in more people moving more carts with products, or by using intralogistics systems that takes care of this increased flow of goods in the factory.

Goldman: And you must be prepared for this change. What does that look like? This is all very interesting.

Figure 3: Detail of spray manifold in horizontal developing module.

Lange: It is, and we're ready to support this change. We have the machines that are ready for Industry 4.0 and we link them with an intralogistics material transport system. In our R&D labs we're looking at the next-generation processing tools, which we will introduce in one or two years.

We're giving a small insight in what it means to go from the subtractive process as we know it to semi-additive processing for PCBs. There's vacuum processing coming in, where we're using vacuum deposition and vacuum etching. You can imagine that for a PCB that has a fine line and space, the surface morphology will become very important. The roughness of the surface becomes important; we're going down to 50 nanometers or less and a wet process is just not enough anymore, so we're working on vacuum processing with those substrates.

Goldman: Thank you for this peek into the future. Any final thoughts?

Lange: I think this show confirms that the electronics industry is undergoing a major change in production from subtractive processing to semi-additive processing and we are offering solutions for these processes. We are developing new innovative processes that will come into the market in the next years. There are customers, the technology leaders, who will make this move in the next few months. We are having discussions about building an integrated automated fab. There's a lot of interest, and I think the direction is set for the electronics industry. I believe it will follow a similar development that the semiconductor industry has seen, improving factories for the highest yield and lowest cost.

Goldman: Rüdiger, thank you so much for your time and insights. Greatly appreciated.

Lange: Thank you for the opportunity, Patty. **PCB007**

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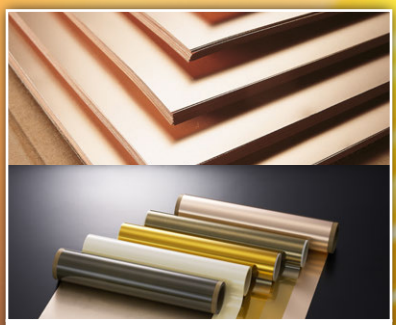

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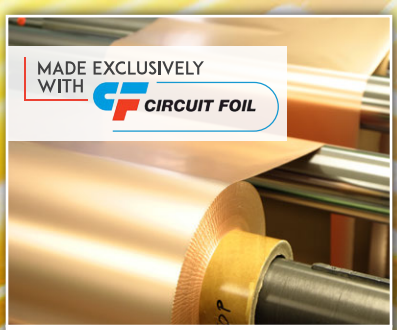

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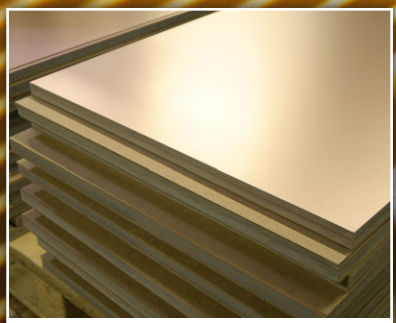

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Spending on Internet of Things in CEE to Exceed $11 Billion in 2018 ▶

Spending on the Internet of Things (IoT) in Central and Eastern Europe (CEE) is forecast to reach $11.2 billion in 2018, an increase of 15.5% over the $9.7 billion recorded in 2017.

New Tech Standard Could Shape Future of Electronics Design ▶

Researchers from Electronics and Computer Science at the University of Southampton have discovered a way of enhancing the capabilities of an emerging nanotechnology that could open the door to a new generation of electronics.

PC-Based Automation Market Worth $38.01 Billion by 2023 ▶

The market is expected to grow from $29.92 billion in 2018 to $38.01 billion by 2023, at a CAGR of 4.9% between 2018 and 2023. Some of the major factors driving the growth of the PC-based automation market are the evolution of IIoT and rising demand for smart automation solutions, increasing need for efficient monitoring in manufacturing plants, and growing emphasis on regulatory compliances.

Letting Molecular Robots Swarm Like Birds ▶

A team of researchers from Hokkaido University and Kansai University has developed DNA-assisted molecular robots that autonomously swarm in response to chemical and physical signals, paving the way for developing future nano-machines.

Breathable, Wearable Electronics on Skin for Long-term Health Monitoring ▶

A hypoallergenic electronic sensor can be worn on the skin continuously for a week without discomfort, and is so light and thin that users forget they even have it on, says a group of researchers at the University of Tokyo and their collaborators.

Sensors and Big Data Provide Farmers with Decision-Making Support ▶

Researchers in the field of e-agriculture like to repeat an anecdote according to which farmers used to tell their children they should study if they wanted to leave for the town but now tell them to study if they want to stay on the farm.

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AVI—Your Tireless Friend in Final Inspection

Testing Todd
Feature Column by Todd Kolmodin, GARDIEN SERVICES USA

After a brief hiatus, I'm back with a sharp pencil. With IPC APEX EXPO 2018 still fresh in our memory I'm sure you had time to see automated visual inspection (AVI) equipment at the show. Those who came by our booth saw one in action. This technology is gaining traction in our industry due to several factors.

The "automation vs. human" debate continues. There are experts with many years of experience performing final inspection with precise detail. This is not debated. However, in the course of human events, circumstances change with unpredictable results. This presents challenges to manufacturers striving to deliver product on-time and within specification guidelines. Let's face it: The specifications and requirements are more challenging day by day. Ever-changing IPC, ISO, AS9100, military, ITAR and required cybersecurity are all playing substantial roles in our daily life. Further complicating matters are the constraints of time-to-market demands vs. cost. The gap is shrinking between the market's willingness to pay vs. cost of manufacture, and with this comes the need to conjure whatever magic possible to stay afloat. Tough decisions to be sure whenever automation vs. human element is concerned.

The question comes up quickly: What can AVI do for me? It's another capital expenditure and what is the return? What is this thing going to provide?

Automated visual inspection is a straightforward term for exactly what this equipment does. Much akin to AOI, the PCB is scanned in its final form for defects previously done by an inspection technician. AVI algorithms allow for unwanted defects to be automatically identified and displayed clearly for review. These defects are preserved in a database for further review and can be used for statistical analysis of process capability.

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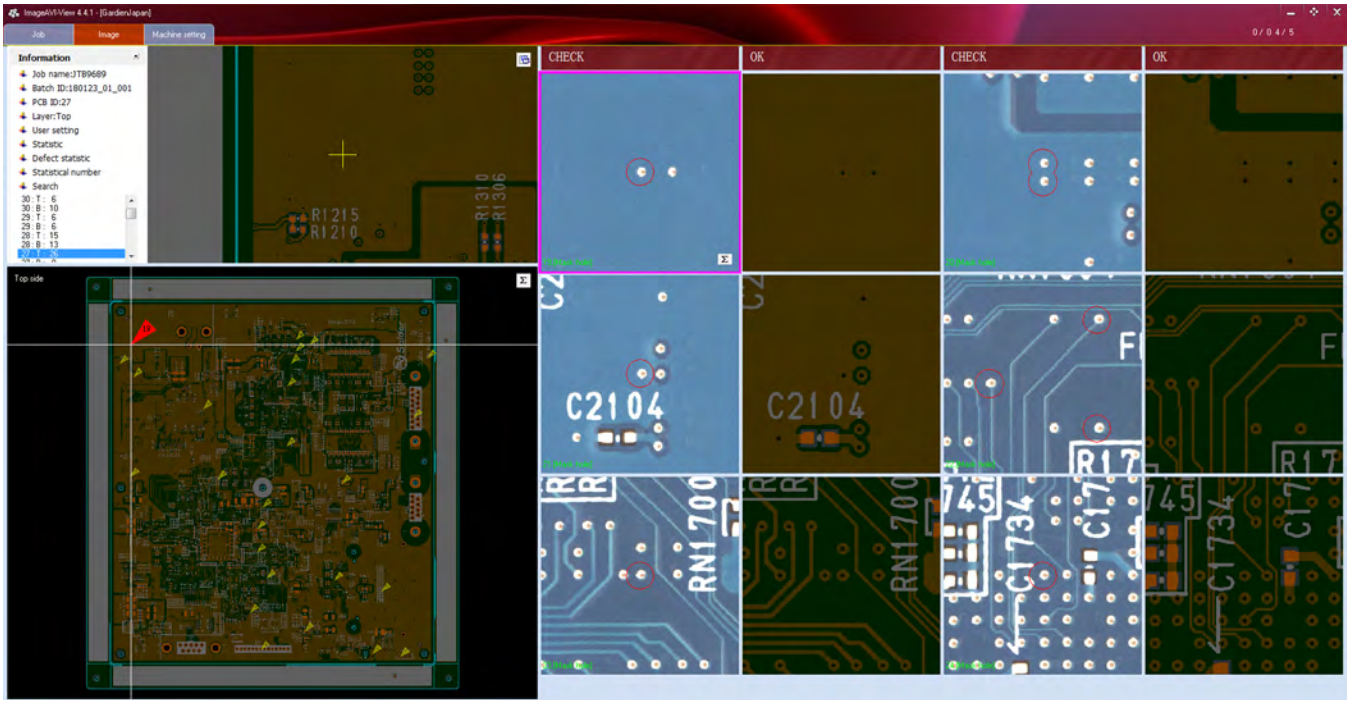

Figure 1: AVI display.

The difficulty with manual inspection is the operator's field of view, lighting, ambient distractions and memory retention of the tomes of information they need to review of any given PCB on demand. Not surprisingly, that demand can change mid-order, requiring the operator to immediately change focus to a whole new PCB, many times with absolutely different requirements! It can be overwhelming, to be sure.

The AVI uses sophisticated CCD multicolor cameras with detection resolution down to 5 microns. Coupled with LED multi-channel lighting, the capture effectiveness is impressive. Now with this technology we also achieve predictability and repeatability. AVI is driven by your CAD/CAM data so observance variance is removed. Of course, when the machine is set up for the specific PCB, fine-tuning can be accomplished to allow for manufacturing tolerances.

In Figures 1 and 2 we can see the display screen on an AVI machine. The CAM representation is shown vs. the actual board topography. From here on out, it is predictable and repeatable. One can calculate with favorable accuracy how many panels or square feet (depending on how you calculate throughput) will be produced. It is not uncommon to see throughput ~400 sf/hr.

Remember, the AVI is looking for multiple imperfection possibilities simultaneously. Exposed copper, land violations, annular ring, solder mask imperfections/violations, missing features, and even surface discoloration are all simultaneously screened. As noted previously, defects found are visually displayed to the inspection technician. Non-conforming product is segregated from conforming so that review can be performed on the non-conforming product. Remember, we are not making the decision as to whether the product is initially conforming or not. CAD/CAM is driving the inspection along with allowed manufacturing tolerance. Here is our predictability and repeatability coming back into play.

Suppose, due to manufacturing constraints, the job has to change immediately. If a repeat job, we just load the saved program and we are inspecting within minutes. Different restrictions on the new job? No problem. AVI already knows the requirements and moves right on with inspection. If a new job, it must be set up only once, saved and production moves on.

Now back to the automation vs. human argument. We are not replacing the human fac-

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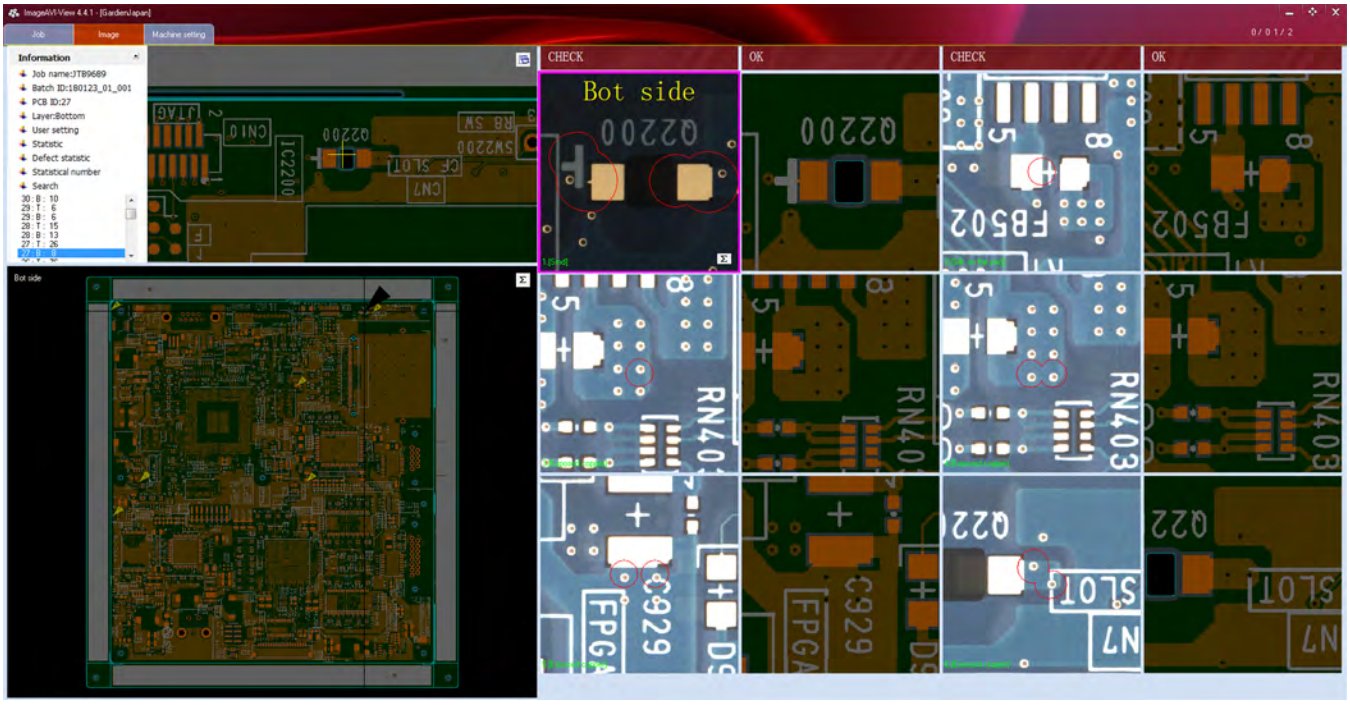

Figure 2: AVI display 2.

tor but shifting the focal point. AVI is not self-aware (yet), so we still need to tell the machines how to perform the task and review the outputs generated just like any automated process. It still must be monitored for accuracy, repeatability and stability. However, for the tedious task of squinting at a PCB for hours on end attempting to identify all possible surface defects, we can leave that to the AVI as it doesn't tire and its eyes don't strain! **PCB007**

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

Novel 3D Printing Method Embeds Sensing Capabilities within Robotic Actuators

Researchers at Harvard University have built soft robots inspired by nature that can crawl, swim, grasp delicate objects and even assist a beating heart, but none of these devices can sense and respond to the world around them. That's about to change.

Inspired by our bodies' sensory capabilities, researchers at the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) and the Wyss Institute for Biologically Inspired Engineering have developed a platform for creating soft robots with embedded sensors that can sense movement, pressure, touch, and even temperature.

"Our research represents a foundational advance in soft robotics," said Ryan Truby, first author of the paper and recent Ph.D. graduate at SEAS. "Our manufacturing platform enables complex sensing motifs to be easily integrated into soft robotic systems."

Integrating sensors within soft robots has been difficult in part because most sensors in traditional electronics are rigid. This technique–known as embedded 3D printing–seamlessly and quickly integrates multiple features and materials within a single soft body.

2018 Programs

February 24–March 1 — San Diego, CA, USA
IPC APEX EXPO 2018

March 1–2 — San Diego, CA, USA
The Pb-Free Electronics Risk Management (PERM) Council Meeting No. 35
IPC APEX EXPO

March 20 — Tempe (Phoenix), AZ, USA
IPC Day
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March 20–21 — Tempe (Phoenix), AZ, USA
IPC Technical Education
Day One: EMI Control-Grounding, Power Distribution, Board Stack-up and More
Day Two: Practices to Produce a More Manufacturable Board and The Complexities of Fine Pitch BGA Design

April 10 — Boston, MA, USA
IPC Day
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April 10–11 — Boston, MA, USA
IPC Technical Education
Day One: IPC Technical Education — PCB Fabrication Basics: Process and Specification
Day Two: IPC Technical Education — Advanced Troubleshooting

April 16–17 — Ingolstadt, Germany
IPC Europe Technical Education
in English

April 18–19 — Ingolstadt, Germany
IPC Europe Technical Education
in German

April 24 — San Jose, CA, USA
IPC Day
Complimentary event, network and learn more about IPC

April 24–25 — San Jose, CA, USA
IPC Technical Education
Day One: IPC Technical Education — SMT Design for Manufacturing: Principles and Practice, Problems and Promises in a Lead Free World
Day Two: IPC Technical Education — BGA & BTC Design and Manufacturing Challenges with Emphasis on Reflow Profiling, Backward Compatibility and Head on Pillow

May 2 — San Diego, CA, USA
IPC Technical Education — PCB Layout — Place and Route
In conjunction with Del Mar Electronics and Manufacturing Show

May 8 — Milwaukee, WI, USA
IPC Technical Education
Morning: Real World Challenges and how IPC-HDBK-630: (Guidelines for Design, Manufacture, Inspection and Testing of Electronic Enclosures) has Helped
Afternoon: IPC/WHMA-A-620 CABLE & HARNESS DOCUMENTS: The Evolution of IPC's Cable and Harness Documents – A Brief History
In conjunction with Electrical Wire Processing Technology Expo

May 15–17 — Linthicum (Baltimore), MD, USA
IPC High Reliability Forum

May 21–23 — Washington, DC, USA
IMPACT Washington, D.C.
An executive-level, members-only event

June 4–5 — Nuremberg, Germany
Automotive Electronics Reliability Forum

June 5–6 — Glasgo, UK
IPC PERM International Meeting No. 36

September 13 — Des Plaines, IL, USA
IPC E-Textiles 2018

October 13–19 — Rosemont, IL, USA
IPC Fall Standards Development Committee Meetings
co-located with SMTA International

November 13–15 — Schaumburg (Chicago), IL, USA
IPC/SMTA High-Reliability Cleaning and Conformal Coating Conference

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What's New?

Ladle on Manufacturing

Feature Column by Marc Ladle, VIKING TEST LTD.

When it comes to PCB processing, it is not often that you are able to come up with something completely new. There may be some notable exceptions, but often a new process is more honestly an adaptation of a similar process, perhaps from another industry segment or a different application.

Examples of this re-purposing are processes like drop-on-demand printing of ident and solder mask. The print heads that were most commonly used for early PCB machines originated from the packaging industry for marking their products. Print heads have now evolved quite a long way and current machines have versions that are much more appropriate to use with electronic manufacturing materials; however, the basic principle remains the same.

In many instances, process technology is not really new but it is new to the user. When a customer upgrades an etch line from a standard machine to an etch chamber that uses vacuum technology, the process is most definitely new technology for that user. In this respect, there is a large amount of new technology around currently in our industry. The vacuum etch process uses topside vacuum heads after each line of spray nozzles to remove the puddle from the top side of the printed circuit. The effect of this is that the top and bottom side etching is a lot more even. The effect can be useful if you are making products with fine line and space or if you are using heavy copper materials. Even for standard products there should be a notable improvement in performance. Right now, vacuum etch is a hot product.

Another process that is new to a lot of customers is vertical continuous plating (VCP). Instead of using a traditional gate-type transporter arrangement, VCP is laid out in a single line of process with the process panel being carried though the process in a linear direction, similar to an old-fashioned tab plater (remember what I said about there being very few truly original ideas). Conveyorised platers have been around for quite a while, but many of the horizontal versions have quite a few shortcomings when it comes to maintenance and care of process. VCP allows easy access to the spray bars and sumps and topping up soluble anodes is very simple. VCP works in a similar way to a horizontal process line but turned on its side.

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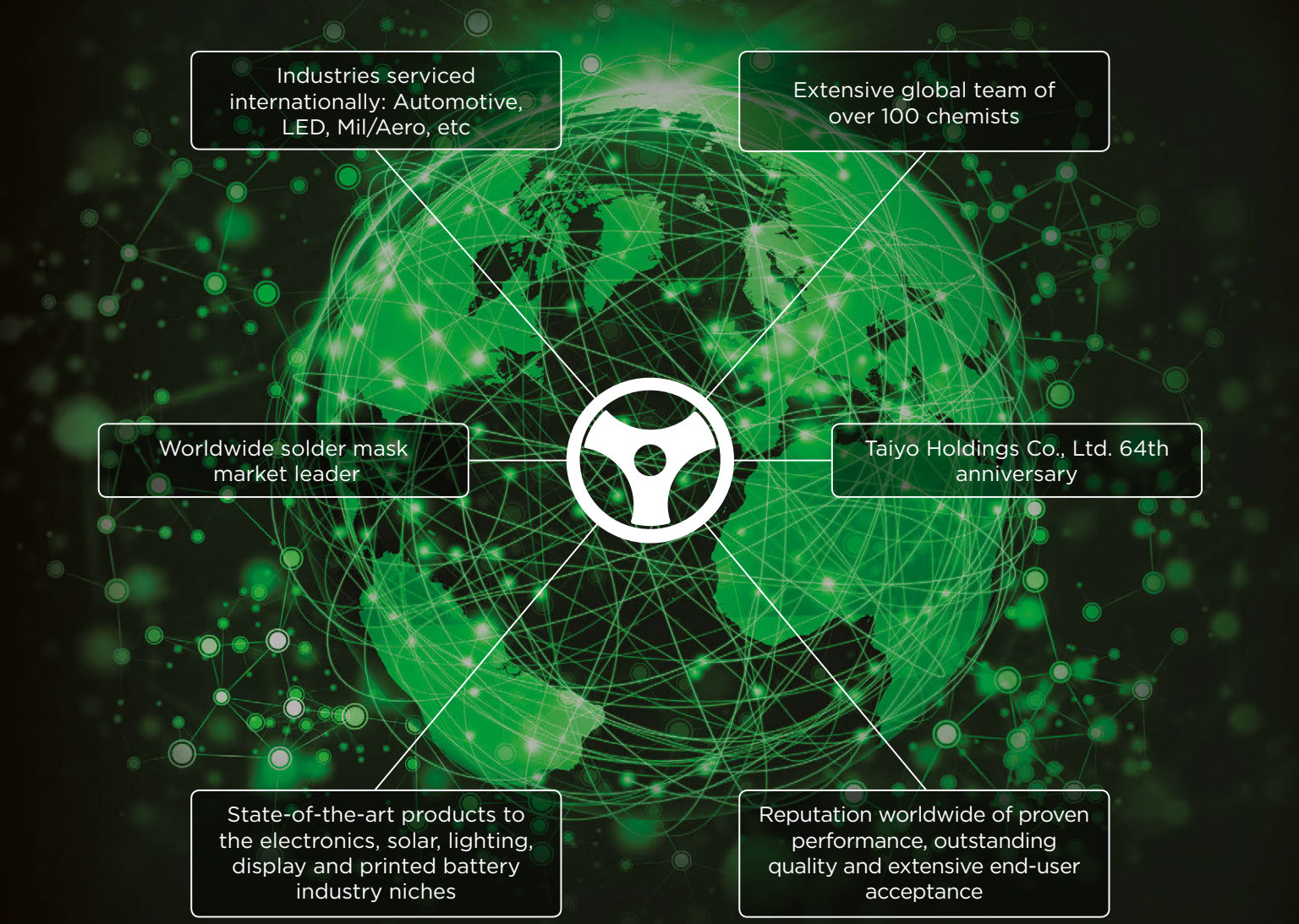

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This process has picked up steam already in Asia, but interest is now starting to gather in other parts of the world with some interesting applications being put forwards to benefit from the technology. Similarly to the vacuum etch mentioned above, VCP offers improvements in distribution—especially when combined with pulse rectification. I have seen trials of this combination that have been able to offer a better than 1:1 ratio of copper in the hole compared to the surface of the panel. This allows some products to be manufactured by a simple and relatively cheap panel-plate process that could only have been made by pattern plating before.

Sometimes it is the actual PCB manufacturing process which undergoes innovative changes.

Sometimes it is the actual PCB manufacturing process which undergoes innovative changes. Recent years have seen some interesting developments such as stretchable flexible circuits. These circuits have a base material and circuit pattern that allows them to stretch and flex in ways that a traditional flexible circuit would never be able to. Applications for this technology are only just starting to develop. The dynamic nature of these circuits allows them to be integrated into fabrics and clothing. Electronic medical equipment and sensors could quite literally be part of the clothing being worn by the patient with much more flexibility and comfort than more traditional electronics. Military clothing could be made to monitor the condition of the heart rate and blood pressure of the wearer and communicate back to mission control. In cold climates, emergency heating could be integrated within your underwear. Outfits for stage performers could quite literally be part of the light show and these high-tech clothes could be safe to pass through the washing machine.

Another recent development has been super-sized multilayer flexible circuits. A company called Trackwise in the UK is currently manufacturing multilayer flexible circuits more than 40 meters long. They have developed a manufacturing method allowing them to replace traditional wiring in a wide range of applications. They can even offer options such as impedance control over extended track lengths, which in turn is allowing their customers to develop their products in ways that were previously simply not possible.

It is wonderful how the PCB industry continues to develop and evolve. Good ideas and innovation will continue to open new opportunities and markets. For those of us who work in the supply of equipment, we are constantly having to push our designs to better serve the new ideas of our customers. If somebody wants to electroplate a circuit that is more than 40 meters long it takes some fresh thinking to come up with a cost-effective method. The long-term success of machinery suppliers is very much tied to that of our customers so we too need to play our part in the development chain and make sure we can meet everchanging demands.

There can be a downside to some of these new manufacturing ideas. If you want a one-off special machine to enable you to produce your new and innovative product, there is usually a cost premium to be paid. There must be a reasonable market for your new products to make commercial sense of the time and effort and expense of making changes to manufacturing processes.

Change can be difficult for all kinds of reasons and costs of improvement can be hard to control. The alternative, however, is not really an option. If nothing changes it certainly will not get any better. If you use your new technology wisely then you can get a step in front of your competition.

My advice this month: innovate and prosper!

PCB007

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

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Something New for Everyone

Flex Talk

Feature Column by Tara Dunn, OMNI PCB

Just the other day, I was recording a podcast with Altium discussing flexible circuit cost drivers. During that discussion, I was asked a question about what I see as a trend in the market. My first thought was that I am seeing an increase in frequency of questions coming from people that are just new to flex and rigid-flex design. There are enough idiosyncrasies with flex that people are a little unsure and are reaching out with questions. Around this same time, I had been contemplating what would be a good topic to write about for the "New Technology" theme of this month's magazine. The light bulb went off; there is such a range of experiences one can have with flex and rigid-flex that even more experienced users can feel like they are working with it for the first time, when in fact they're not. Imagine what it's like for people who are totally unfamiliar with it! So at the end of the day, brand new to flex and flex-rigid or not, most people who use it feel like they are working with new technology.

Single- and Double-Sided Flex

Single-layer flex, flex with one layer of copper, is a place many new to flexible circuits start. This is used when all conductors can be routed on one layer of copper. This may be replacing wire, solving a packaging problem or even be used for aesthetic reasons in a package that will be visible to the end user. When circuitry can't be routed on a single layer, or shielding is needed, the progression is to move to double-sided (two copper layers) flex, or even multilayer flex.

If single- and double-sided flexible circuits are a new technology for you, material selection can be daunting. There are many material options to consider, but the predominant material is rolled annealed copper/polyimide laminate. Within this material type, there are two different options. Adhesive-based material, with either acrylic adhesive or flame-retardant adhesive, or adhesiveless material. Many single- and double-sided designs will use the adhesive-based materials. These materials are often less expensive than the adhesiveless version. Laminates are typically provided with ½ oz. to 2 oz. copper and ½ mil to 6 mil polyimide.

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The most commonly spec'd materials tend to be ½ and 1 oz. copper with 1 mil or 2 mil polyimide and, because they are the most common materials, pricing tends be lower and fabricators will often have this material in stock. Adhesiveless materials are most often recommended for higher layer count flex designs and rigid-flex construction.

Rigid-Flex

Rigid-flex construction consists of a flexible section and rigid section on the same board. What differentiates this construction from flex with a stiffener is that plated through-holes extend through both the rigid and flexible sections. This construction is most often used when the design requires dense surface mount pads on both sides of the circuit.

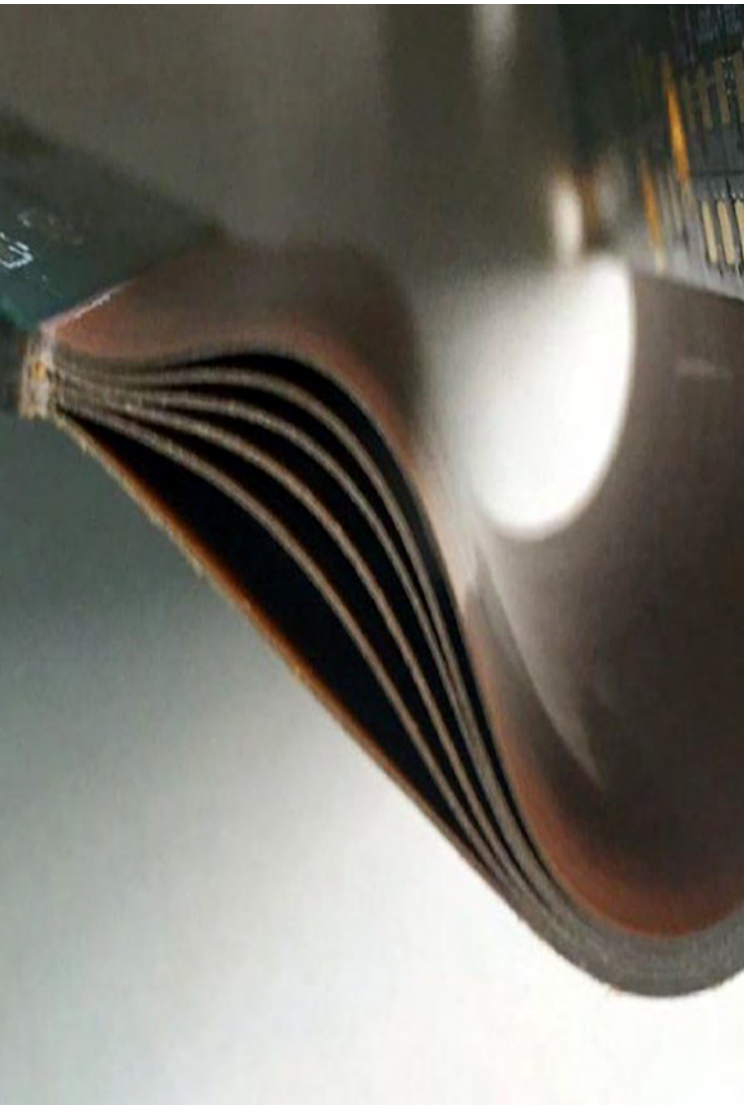

Figure 1: Unbonded layers improve flexibility. (Source: The Printed Circuit Designer's Guide to… Flex and Rigid-Flex Fundamentals)

If rigid-flex is a new technology for you, there are a few key things to keep in mind. The term "bikini cut" is important. It is recommended to keep the adhesive within 0.050" of the edge of the rigid portion of the design. Adhesiveless flex materials should be used and coverlay should not extend into the plated through areas. There is a Z-axis mismatch between the rigid materials and the adhesive that can impact the reliability of the design.

The simplest version of a rigid-flex construction is to keep all plated through-holes in the rigid area of the designs. It is certainly possible to create a rigid-flex with plated through-holes in the flex regions as well, but this type of design requires additional processing, adding cost to the design.

The flex layers can also be bonded or unbonded. If there are several flex layers or flexibility is a concern, one common solution is to eliminate the adhesive between selected flex layers, providing more flexibility to the overall design (Figure 1). Often, this is confused with bookbinder rigid-flex construction.

Bookbinder Rigid-Flex

Bookbinder construction has been around for decades but seems to be regaining popularity in the market. A bookbinder rigid-flex is similar to a hard-covered book. The flex layers are staggered, each flex layer gaining length as it is stacked on the bend so that when the flex area is bent, it does not buckle and create stress on the flex layers. Bookbinder construction is both labor and engineering intensive and there are only a handful of fabricators that specialize in this construction.

If bookbinder rigid-flex is new to you, attention should be given to the variables that need to be considered to allow the proper fit. It is advisable to add extra length if air circulation is required to keep the flex cool in a high current application rather than tightly nest the layers. It is also important to plan for the mechanical space this bulge will require in final assembly. Moving along the technology scale would

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be dual bend bookbinder rigid-flex, which includes multiple bookbinding areas that do not all bend it the same direction causing a hump on both sides of the board.

Additive Process, Sub-1-mil Lines and Spaces

Using an additive process, rather than a subtractive etch process to form the circuitry, opens up significant advantages in the HDI and fine line market. The process I am most familiar with uses a special catalytic precursor "ink" that can be imaged to create the patterns or areas where conducting metal is to be deposited. The ink controls the horizontal dimensions of the line width and spacing and the vertical dimension is controlled using an additive plating process that deposits metal only on the patterns defined by the ink.

If this additive process is new technology for you, this is your chance to use your imagination and think outside of the box. Vias can be drilled prior to the metallization process and are then plated at the same time that the surface conductors are formed, eliminating several process steps. This process can deliver fine lines down to 5 microns in width. There is a significant advantage to RF designs with this process. Because the traces are formed with an additive process, the trapezoidal effect from the subtractive etch process is removed. This process also offers the option of using metals other than copper, which is critical for applications with biocompatibility concerns.

Whether you are new to single- and double-sided flex, moving into rigid-flex construction, thinking of using bookbinder technology, or investigating an additive process, working with new technology can be both exciting and challenging. My best advice when working with flex and rigid-flex is to involve your fabricators as early in the design process as possible. They work with this technology every day, have an enormous wealth of knowledge, and are happy to share and guide designers as they learn and adjust to new technology. **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 to contact Dunn, click here.

European Investments in Technologies Enabling Smart City Initiatives to Reach $19 Billion in 2018

European spending on smart city initiative related technologies is expected to reach $19 billion in 2018, according to International Data Corporation (IDC). In the first release of the Worldwide Semiannual Smart Cities Spending Guide, IDC provides a look at the technology investments associated with a range of smart city priorities and use cases.

"European cities face significant forces for change–urbanization, collaboration, and the democratization of public services, to name a few. In response, cities are becoming increasingly smart; they are adopting innovative technology solutions and redesigning business and service delivery models to take a more user-centric approach, while allowing users to have greater input into how their city works," said Chris Pennell, research director in IDC 's Government Insights Europe group. "In turn this is helping to drive expenditure across a range of use cases.

In IDC's view, a smart city begins to be developed when multiple smart initiatives are coordinated to leverage technology investments across an entire city, use common platforms to decrease service time/maintenance costs, share data across systems, and tie IT investments clearly to smart missions. Smart city programs are enabled by 3rd Platform technologies, and emerging technologies are accelerated in the city ecosystem to deliver innovative solutions in very specific areas.

UCE WET PROCESS LINE

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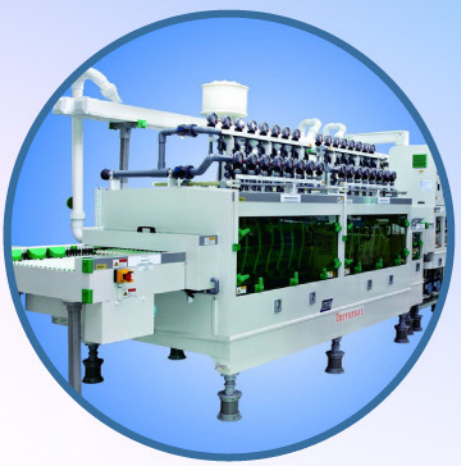

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MilAero Highlights

Beyond Design: Signal Flight Time Variance in Multilayer PCBs ▶

A transmission line does not carry the digital signal itself but rather guides electromagnetic energy from one point to another. Signals travel at the same speed, given the same medium. However, the microstrip (outer layer) traces are embedded in a mélange of dielectric material, solder mask, and air.

Merlin Flex Achieves AS9100 Rev D ▶

Merlin Flex Ltd, Hartlepool UK, has successfully made the transition from AS9100 Rev C to the latest Rev D. In January 2018, Merlin Flex also maintained their SC21 Bronze award for the 6th year running and is working with Thales UK, the companies SC21 sponsor, in achieving Silver by June 2018.

Flights Show Promising Technologies from Industry and Academic Partnerships ▶

The technologies ranged from proposed new space suits to cryogenic propellant research, with implications for future NASA space missions as well as other research efforts.

Improving Military Communications with Digital Phased-Arrays at Millimeter Wave ▶

There is increasing interest in making broader use of the millimeter wave frequency band for communications on small mobile platforms where narrow antenna beams from small radiating apertures provide enhanced communication security.

Pioneer Circuits' Solutions Used in NASA's PUFFER Collapsible Bot ▶

The PUFFER collapsible micro-rover is a part of NASA's "Game Changing Development Program." It is a compact rover that rides on board with future space vehicles to land on space bodies such as planets and asteroids for photographs and microanalysis.

Army-led Effort Demos New Atomic Effect for Potential Isotopic Battery ▶

A multinational research team, led by Army scientists, successfully induced a controlled release of stored isotopic energy using a physical effect involving atomic electrons. The process was proposed more than 40 years ago but never before demonstrated experimentally.

FTG Releases Full Year and Q4 2017 Financial Results ▶

"2017 was a year of transitioning work from the acquired facilities in 2016 to FTG facilities. There were many challenges in the transitions and it took longer than expected but by year end the transitions were complete," stated FTG President and CEO Brad Bourne.

Designing Electronics for Harsh Conditions ▶

We expect a lot from our products, especially our electronic products. Think about it: cellphones, wearables, medical devices—for some reason we think they should still work after being immersed in liquid, left outdoors in freezing temperatures or dropped on concrete from a standing position.

Pits and Mouse Bites, Part 3

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

In the first two columns in this series, the author presented two critical areas of the PCB fabrication process thought to contribute to the mouse bite and pitting defects seen in production at a fabrication facility. In those first two parts, photoresist lamination and exposure parameters were investigated as to the possible root cause of the defects.

Since the original assessment determined correctly that the mouse bites and pits had different origins, the troubleshooting effort focused on the potential for air or gas bubbles in the acid copper plating tanks (Part 2). While corrections (with positive results) were made in the acid copper plating tank filtration, the issue of pitting down to the laminate or electroless copper was not completely eliminated. As stated previously, the developing operation was scrutinized as a possible contributing factor.

Developing of Negative-Acting Resist

Unexposed resist is selectively removed through the chemical and mechanical actions of a sprayed carbonate solution (a.k.a., the developing solution). The addition of a foam control agent may be required. "Time to clean" and "break point" (i.e., the percentage of useful development chamber length traveled by the board to achieve the visible removal of unexposed resist) are characteristic data that is generated in the development process.

A water rinse removes residual unexposed, partially polymerized resist and developer solution. The remaining exposed resist is "fixed" by stopping the development action through rapid removal of the developer solution in the water rinse. This is a critical and often overlooked step. Any residual developer solution that remains and is not adequately rinsed away will potentially lead to sidewall damage as well as contaminate the copper surface. This in turn will lead to pitting and other plating anomalies.

One idea worth exploring (to ensure development is stopped) is to rinse after develop with hard or acidified water. This action turns the binder molecules within the resist to insoluble entities. A final drying step removes residual moisture to harden the exposed resist for better survival in etching or plating solutions.

An example of what can happen when resist residue is not effectively removed is shown in Figure 1.

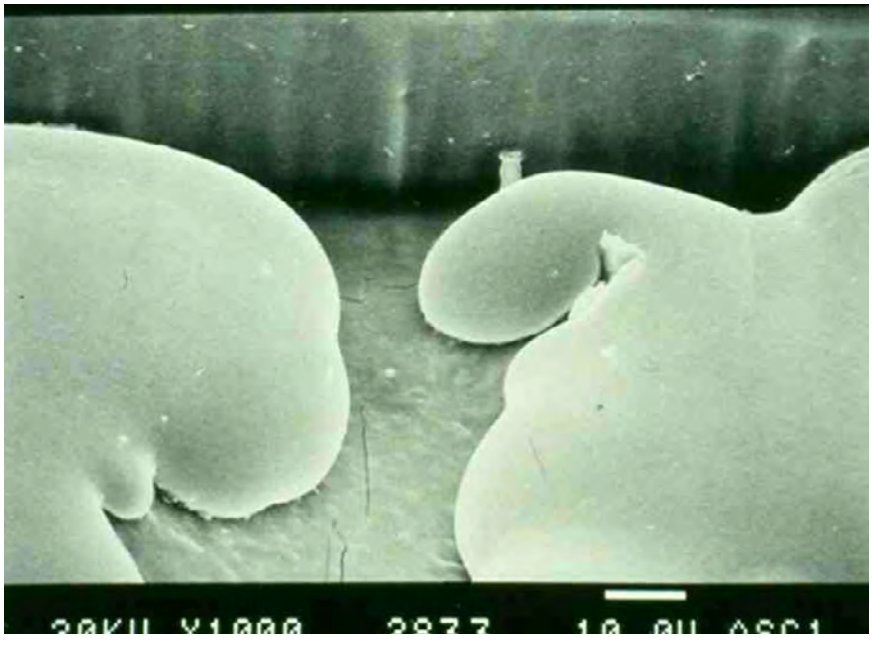

Figure 1: Note pitting of plated copper down to base. Residue is evident on the base copper inhibiting complete electroplating of the copper, resulting in a pit.

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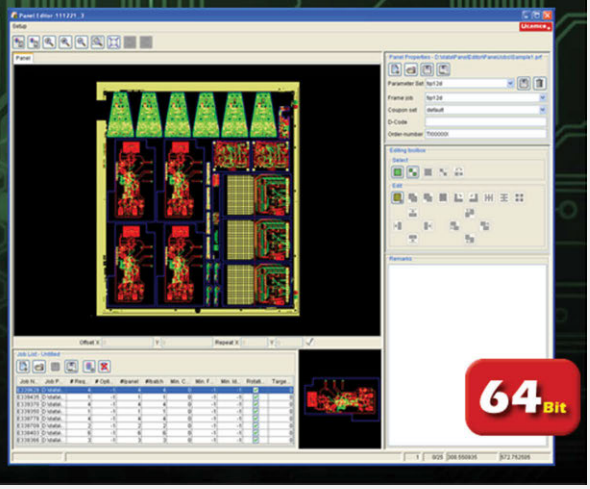

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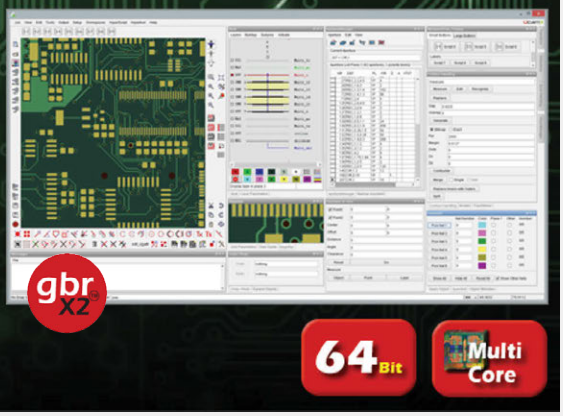

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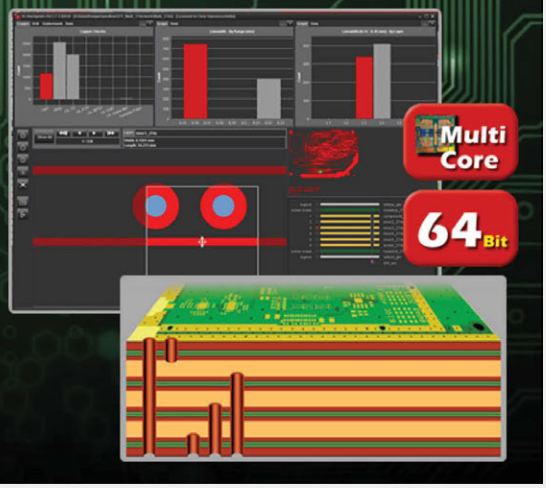

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Variable or Feature	Range/ Spec.	Process Effect
Concentration of active ingredient, typically K_2CO_3 or Na_2CO_3 (NaOH may be used with positive working resist, not addressed here).	0.6-1.1 wt.% (most common: 0.8-1.0 wt.%) Spec: resist specific	Development speed (removal/solubilization of unexposed resist) **Too high:** May attack exposed resist. **Too low:** Slow or incomplete development.
Water hardness (developer solution; rinse)	150-350 PPM $CaCO_3$ equivalent (8-20° German Hardness Units)	"Fixes" developed resist, renders it less soluble. Higher hardness may lead to scale build-up and nozzle plugging.
Developer temperature	26-32°C (75-90°F)	Development speed **Too high:** Attack on exposed resist.
Developer spray pressure	1.4-2.1 bar (20-30 PSI) Note: Top sprays are usually set 2-5 PSI higher than bottom sprays)	Mechanical impact and mass transport assists the chemical development process. **Too High:** Attack on exposed resist. **Too Low:** Incomplete development, resist residues, scum.
Break point (and break point uniformity, side to side, top to bottom)	50-75% (per resist process data sheet)	Proper break point balances the time needed to develop off the bulk of the unexposed resist (time up to break point) vs. the time allowed to clean off unexposed resist traces and semi-polymerized resist, without damaging the exposed resist.
Developer time (total time in developer)	30-60 seconds (resist & resist thickness specific)	Correct development time allows sufficient time for clean development but avoids attack on exposed resist. (overdevelopment)
Resist loading	Batch: 0.05-0.3 mil-m^2/l (2-12 mil-sqf/gal) Feed/bleed: 0.15-0.20 mil-m^2/l (6-8 mil-sqf/gal)	Proper loading balances chemical consumption cost v. resist overloading which could lead to "scumming," incomplete rinsing.
Post-development rinse water hardness	See above	
Rinse water pH	pH 7.0-9.5	High pH, due to excessive developer drag-out or insufficient rinse water flow, may cause continued development.
Rinse temperature	20-30°C (about 70-85°F)	Rinse efficiency goes down at lower temperatures.
Rinse nozzle type, array	High-impact fan type preferred	Rinse impact, efficiency.
Rinse pressure	1.5-2.5 bar (about 25-35 PSI)	Rinse impact, efficiency.
Drying	Dry by visual appearance and to touch.	
Post-development hold time	0-14 days (short hold times preferred, especially for tent/etch)	To accommodate process flow requirements. Short times normally preferred to avoid mechanical damage, contamination; resist tents may weaken with time due to embrittlement.

Source: IPC 5001 Handbook and author's personal experience.

Table 1: Developer variables and corresponding process effects.

Solving the Problem

At this point the troubleshooting team moved to the developing area in order to ascertain what was required to solve the residue problem shown in Figure 1. The team looked at several plausible areas including:

- Developer concentration
- Break point
- Rinsing time and rinsing effectiveness
- Spray pressure in developer

In Table 1, an extensive list of developer variables is shown along with the respective process effects. However, the four areas listed above showed the most promise as to the root cause of the pitting defect.

One of the first areas studied was the actual spray pressure within the developer chamber. It was recommended by the resist supplier that the minimum spray pressure be 25-35 psi. During the routine check, the spray pressure was reading less than 20 psi. Upon further examination by the engineering team, it was discovered that some of the spray nozzles were plugged with resist residues and others were badly worn from extended use. These two conditions reduced the effective spray pressure.

A second area that needed attention was the seemingly poor ability to rinse away the solubilized unexposed resist during development. It was also discovered that while the fabricator was using city water for post-development rinsing, that incoming water was too soft to ensure effective removal of resist binder salts. A word to the wise: Use of soft

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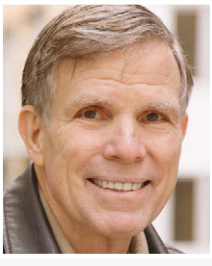

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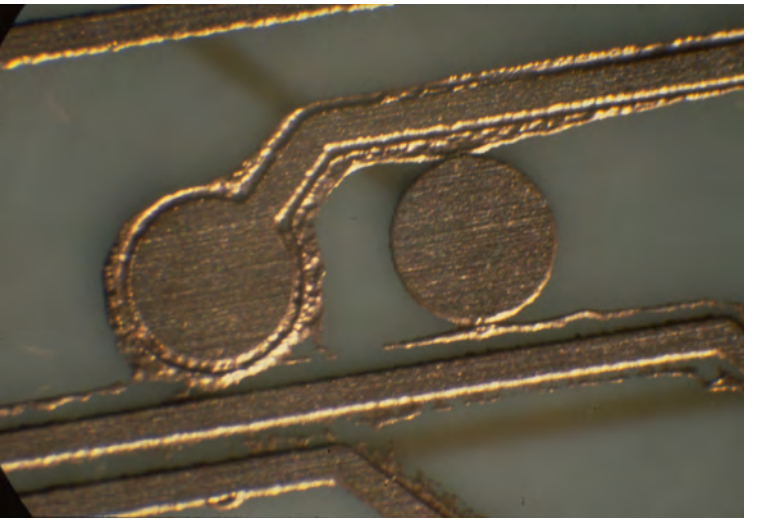

Figure 2: Copper remaining after etching; resist residues prevented the complete etching of the copper.

water for rinsing after developing is not as effective as hard water. It was decided that to improve the efficiency of post-developer rinsing, the engineers added 200 ppm of calcium carbonate to the rinsing solution. This made a marked difference in the quality of the rinsing and the subsequent plating quality.

In Figure 2, one can see the remaining copper that was not etched away. This illustrates that resist residue remained in the areas that should no longer have resist. The remaining residues—most likely from incomplete development—acted to prevent complete removal of the copper during the develop, etch, and strip (DES) process.

Summary

Based on the changes discussed above, the fabricator solved the mouse bite and pitting issues. However, one can see from this case study that there were several factors that contributed to the defects. From this study it is quite clear that most defects are not caused by just one process issue. It is usually a combination of factors that must be vetted properly. From there, the experienced troubleshooter can make corrections to the processes and eliminate loss of yield. **PCB007**

References

"Pits and Mouse Bite Issues, Part 2," *PCB007 Magazine*, January 2018, p.90.

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

Scientists Pave the Way for Resilient Robot Swarms

Researchers from Electronics and Computer Science (ECS) at the University of Southampton will use bio-inspired algorithms and machine learning to develop fault-tolerant robotic swarms in a new scheme funded by the Engineering and Physical Sciences Research Council (EPSRC).

Assistant Professor Dr. Danesh Tarapore from ECS's Agents, Interaction and Complexity research group will lead the New Investigator Award project that will create groups that can rapidly detect faults and adapt to environmental changes, paving the way for real-world applications such as the monitoring of pollutants in large bodies of water. The research will lead to the next generation of robot swarms, capable of sustained operation for extended periods of time without human intervention.

"Robots are increasingly becoming an important part of our day-to-day lives, automating tasks like keeping our homes clean and packing parcels at large warehouses," Danesh explains. "Our aging population and the need to substitute human workers in dangerous and repetitive tasks mean that new tasks are emerging on the horizon, such as automation in agriculture and environmental monitoring. This will require robots to do more and work in large-numbers as part of a swarm, acting over vast areas and efficiently performing their mission.

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The Rebirth of Made in America

The Right Approach

by Steve Williams, THE RIGHT APPROACH CONSULTING LLC

The topic for this discussion came to me, as most of my best ideas do, during a casual conversation about life over a cold beer. Having finished day one of a nine-day motorcycle trip, my friend Mike and I had just settled in at a friendly watering hole to soothe away the aches and pains of spending all day on 1,000 pounds of Milwaukee iron. We have had some very interesting discussions over the years on a variety of topics, but mostly our conversations tend to center around Harleys, sports, or politics.

This particular evening, Mike turned to me and asked "Steve, I want your opinion on something. Is American manufacturing back?" Now this is not quite the radical departure from our normal topics as you may think. You see, Mike is not only a good friend and fellow Harley enthusiast; he is also a fellow small business owner whose sales have been significantly impacted by Asian competition. Like Mike, I had grown up in this business "making stuff," and before I had time to even think about an answer, I blurted out a resounding "Hell yeah, it's back," as my American pride and loyalty involuntarily kicked in. But after thinking more about it in the following days, I thought it would be worthy of some research to support my well-intended gut reaction.

The Lost Millennium

The year was 2000; the most popular song was "Breathe," by Faith Hill, the St. Louis Rams won the Super Bowl, gas was $1.26 a gallon, Y2K turned out to be a non-issue, and American manufacturing was in the tank. Using the metric of 'Services as a Percent of Gross Domestic Product (GDP),' in the year 2000 the United States led all industrialized countries at 80% (CIA World Factbook)[1]. Simply put, 80% of our revenue as a country came from service-related industries, and only 20% from manufacturing. The data provided by the *Handbook of U.S. Labor Statistics*[2] for the percent of the U.S. labor force in each sector was equally disturbing.

Using 1950 as a baseline, 60% of U.S. employees worked in manufacturing and 40% in service industries. By the year 2000 this mix

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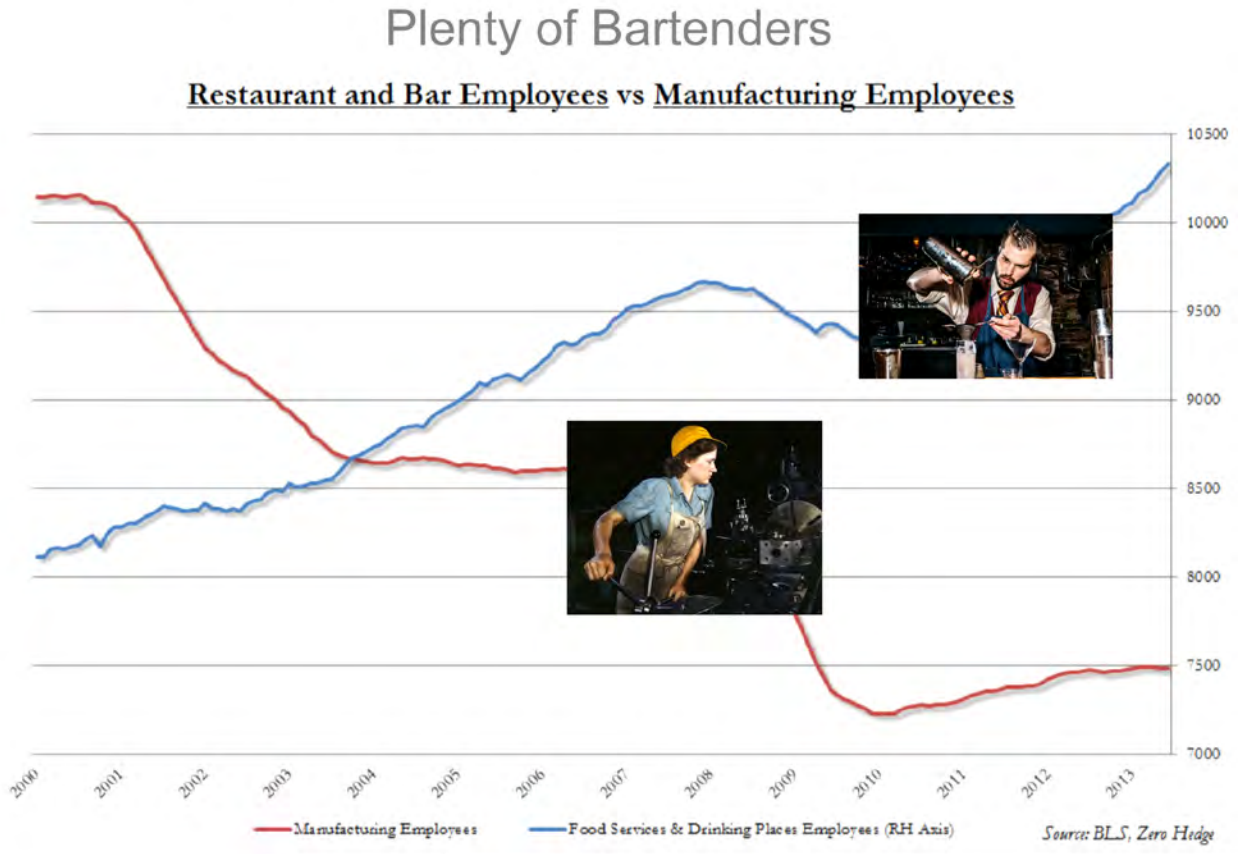

Figure 1: Bartenders vs. manufacturing employees, 2000–2013.

had changed to only 20% in manufacturing and 80% in service. While these statistics are great news if you are selling insurance, they are catastrophic for the once mighty American manufacturing sector. The sad state of affairs was that the United States was no longer a manufacturing nation. This is painfully obvious when looking at Figure 1, which shows that beginning around 2004, bartending jobs began to outpace manufacturing jobs.

Reshoring

This interesting buzz word surfaced around 2010 and refers to the return of work to America that had been previously lost to offshore competition. This reversal was being driven by a number of factors as the economic conditions were forcing customers to change their focus from unit cost to total cost of ownership. Perhaps the grass isn't always greener on the other side *(of the world)!* The bulk of reshored jobs—about 60% from 2010 through 2016—came from China, according to a recent report by the Reshoring Initiative[3]. Labor has become more expensive in China than in the past, with Chinese wages going up 12 – 15% a year for the past 15 years. Figure 2 presents a breakdown by country of where all the reshoring jobs are coming back from.

Reshoring Drivers:

- Higher transportation and fuel costs
- Increasing foreign wages
- IP/counterfeiting concerns
- Reduction of pipeline inventory for JIT
- Localizing manufacturing near R&D facilities
- Regulatory compliance risk
- Design and delivery flexibility
- Political and infrastructure stability
- Improved U.S. competitiveness through Lean
- Higher reject rates/quality
- Product liability

The Rebirth of 2017

There is no question that manufacturing in the U.S. is increasing, with companies not only

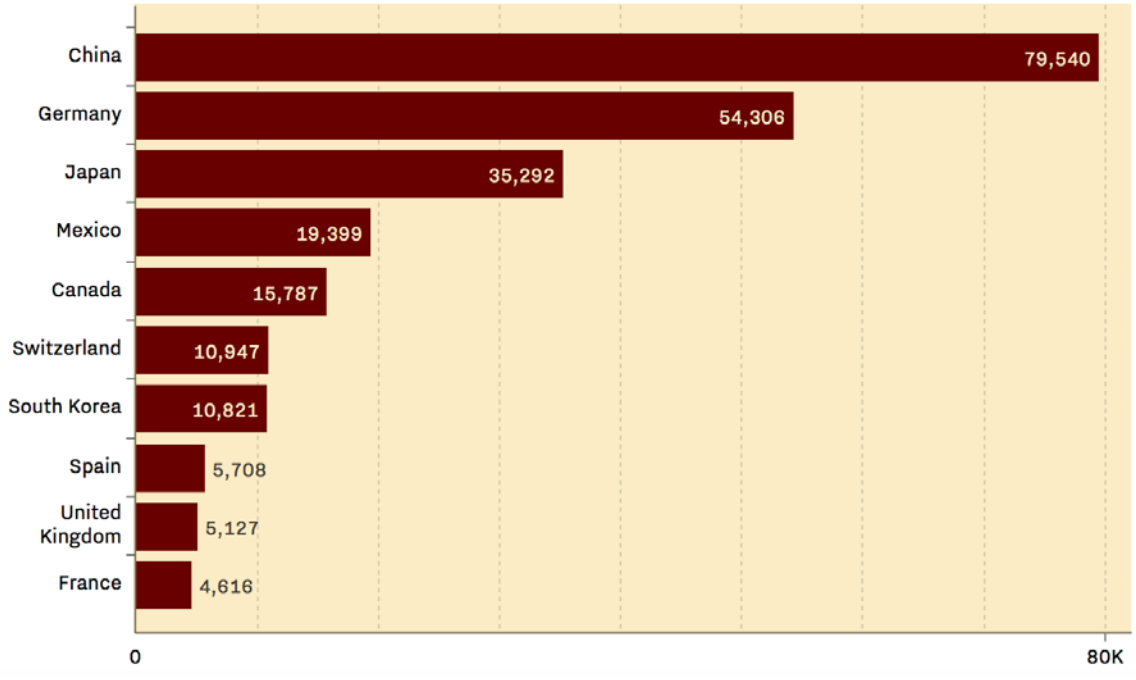

Figure 2: Where reshored U.S. jobs are coming from, 2010-2016.

staying here, but bringing business back. Designers are spinning new designs, OEMs are reinvesting in R&D, and manufacturing companies across the nation are hiring again. And hiring full-time, high-paying skilled jobs. A recent CEO survey by Deloitte Touche Tohmatsu ranked America second in the world for global manufacturing competitiveness in 2016, with a projection to pass China for the No. 1 spot by 2020 (Figure 3).

The following list is just a snapshot of just how massive this "Made in America" rebirth is.

Foxconn

The contract manufacturing goliath will be spending $10 billion to build a 13,000-employee flat-screen manufacturing campus in my home state of Wisconsin, with a second Wisconsin campus currently being negotiated.

Ford

On Jan. 3, 2017, Ford announced plans to cancel a new $1.6 billion plant planned in San Luis Potosi, Mexico. The move saved approximately 3,500 U.S. jobs, according to a Ford press release. Instead, 700 additional new jobs will be created from a $700 million expansion of a Michigan plant focused on building high-tech electric and autonomous vehicles along with the Lincoln Continental and Mustang.

Dow Chemical

Dow Chemical's Chairman and CEO Andrew Liveris announced a new state-of-the-art facility in Michigan that will add several hundred jobs to the 7,000 Dow employees already in the community.

Trans-Lux

The LED Jumbotron digital display manufacturer is moving its China operations to Hazelwood, Missouri, creating jobs and investing in the new facility.

Sprint

The telecommunications giant will create 50,000 new American jobs and invest $50 billion in the U.S. economy, which started in 2017.

General Motors Company

The company recently issued a press release affirming its commitment to support the U.S. manufacturing industry with $1 billion of ad-

2016 (Current)		
Rank	Country	Index score (100=High) (10 = Low)
1	China	100.0
2	United States	99.5
3	Germany	93.9
4	Japan	80.4
5	South Korea	76.7
6	United Kingdom	75.8
7	Taiwan	72.9
8	Mexico	69.5
9	Canada	68.7
10	Singapore	68.4
11	India	67.2
12	Switzerland	63.6
13	Sweden	62.1
14	Thailand	60.4
15	Poland	59.1
16	Turkey	59.0
17	Malaysia	59.0
18	Vietnam	56.5
19	Indonesia	55.8
20	Netherlands	55.7

2020 (Projected)			
Rank	2016 vs. 2020	Country	Index score (100=High) (10=Low)
1	(▲ +1)	United States	100.0
2	(▼ -1)	China	93.5
3	(⟷)	Germany	90.8
4	(⟷)	Japan	78.0
5	(▲ +6)	India	77.5
6	(▼ -1)	South Korea	77.0
7	(▲ +1)	Mexico	75.9
8	(▼ -2)	United Kingdom	73.8
9	(▼ -2)	Taiwan	72.1
10	(▼ -1)	Canada	68.1
11	(▼ -1)	Singapore	67.6
12	(▲ +6)	Vietnam	65.5
13	(▲ +4)	Malaysia	62.1
14	(⟷)	Thailand	62.0
15	(▲ +4)	Indonesia	61.9
16	(▼ -1)	Poland	61.9
17	(▼ -1)	Turkey	60.8
18	(▼ -5)	Sweden	59.7
19	(▼ -7)	Switzerland	59.1
20	(▲ +3)	Czech Republic	57.4

Source: Deloitte Touche Tohmatsu Limited and US Council on Competitiveness, 2016 Global Manufacturing Competitiveness Index

Figure 3: 2016 Global Manufacturing Competitiveness Index (Top 20).

ditional investment in U.S. manufacturing operations and the creation of 25,000 new American jobs.

Carrier

The HVAC manufacturing giant announced the cancellation of a planned move of 1,400 jobs from its Indianapolis factory to Mexico.

Apple

The technology company will bring hundreds of billions of overseas dollars back to the U.S. and invest tens of billions on domestic jobs, manufacturing and data centers in the coming years. The iPhone maker plans capital expenditures of $30 billion in the U.S. over five years and will create 20,000 new jobs at existing sites and a new campus.

These are only some of the high-profile companies putting their money behind Made in America. You can see the optimism at all levels of business; from the mom & pop local pharmacy to the big box retailer, business is better than it's been in a long time.

In Conclusion

I have been on the record for the past 10 years saying that jobs we lost overseas may move out of China to a new low-cost country, but they were never coming back. I have never been happier to be wrong! I talk to a lot of CEOs, and the first question I ask is, "How's business?" The answers are overwhelmingly positive, and it is clear that their optimism is at a level not seen for over a decade.

America as a low-cost country. Think about that. **PCB007**

References

1. CIA's The World Factbook
2. Bureau of Labor Statistics
3. Reshoring Initiative

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

“ This concise, yet very thorough eBook is destined to become every RF and microwave engineer's PCB fabrication bible. ”

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Recent Highlights from PCB007

1 Failure Analysis: A Critical Component to Process Engineering ▶

My definition of process engineering: attempting to put together the perfect manufacturing stages to produce the desired product. Printed circuit production includes many diverse production stages requiring a wide range of skills and knowledge to manufacture the perfect product.

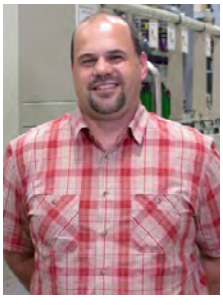
2 I-Connect007 Launches Fundamentals of RF/Microwave PCBs Micro eBook ▶

I-Connect007 is excited to announce the release of the latest title in our micro eBook design series: The Printed Circuit Designer's Guide to…Fundamentals of RF/Microwave PCBs.

3 All About Flex: Polyimide vs. Silicone for Flexible Heaters ▶

Flexible heaters are sub-divided into two primary technology platforms: etched-foil and wire-based technology. Wire-based (wire strands woven together or single strand wire) is the more common technology, with multiple customers offering a wide range of products.

4 Equipment/Process Selection: Case Study of a DMADV Approach to PCB FAB Process Design ▶



This article outlines the approach we took to designing this new phase of our commercial existence, which has now been spun off as a separate business unit known as GreenSource Fabrication. This new business unit is expected to go live in 2018.

5 EIPC's 2018 Winter Conference in Lyon, Review of Day 1 ▶

Venue for the 2018 EIPC Winter Conference was the splendid new Alstom Transport Information Solutions facility in Villeurbanne, in the Lyon metropolitan area of the Auvergne-Rhône-Alpes region in Eastern France. An extremely popular event—117 delegates represented a total of 20 countries, unprecedented in recent years.

6 The Best It's Ever Been, Every Year: The Goal for IPC, Part 1 ▶

The end of 2017 caps an exciting time for IPC and IPC China as membership has grown substantially, in part because of new offerings from the organization to its Asian members. Meeting with Barry Matties at HKPCA, John Mitchell and Phil Carmichael discuss the areas of focus for IPC in the upcoming year, first and foremost being education and welcoming a new generation into the industry.

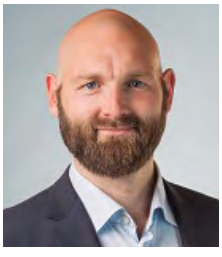
7 Solder Limits: Updates for the Age of Surface Mount ▶

Solder limits are one of the fundamental parameters used when evaluating the PCB, solder resists, and metal-clad base materials for safety under the UL Recognition programme.

8 All About Flex: Copper Thickness Requirements for Flex Circuits ▶

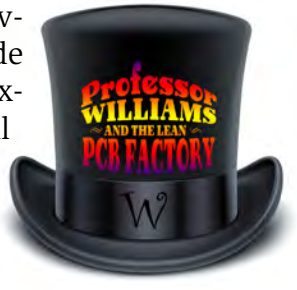
An end user will specify the copper thickness of a printed circuit for different reasons. The most obvious reason would be for current-carrying capacity, but copper thickness also directly impacts thermal performance and impedance. All these are vital properties impacting the functionality and reliability of a flexible circuit.

9 CircuitData: Creating an Open Source Language for PCB Data Exchange ▶



I recently had the opportunity to speak with Elmatica CTO Andreas Lydersen on a subject of great interest to him and his supply chain, namely CircuitData. This open source language promises to greatly improve communication of details that can often be misinterpreted due to the differences in terminology used throughout the supply chain.

10 Willy Wonka: The Lean Case Study ▶



No matter where my travels take me, I hear a wide and limitless supply of excuses for why Lean will not work in "my" organization. One of my favorite ways of illustrating that Lean will indeed work anywhere is to take a Lean look at a very unlikely organization, Willy Wonka's Chocolate Factory.

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- Account management: work with local and international team to provide customer support
- Phone and email communications with prospects
- Occasional travel

Qualifications

Successful candidates should possess a university degree or equivalent, experience with managing and cultivating leads, projecting, tracking and reporting revenue. We are looking for positive, high-energy candidates who work well in a self-managed, team-based, virtual environment.

Compensation

This is a base salary-plus-commission position. Compensation commensurate with experience.

Requirements

- Must be located in China Mainland, South China area preferred
- Good command of Chinese language, proficient with English speaking and writing
- Able to follow established systems and learn quickly
- Able to maintain professional external and internal relationships reflecting the company's core values
- 2-5 years' sales experience
- Experience with Microsoft Office products
- Must be highly motivated and target-driven with a proven track record for meeting quotas
- Good prioritizing, time management and organizational skills
- Create and deliver proposals tailored to each prospect's needs
- Experience in the electronics industry desirable

QUALIFIED CANDIDATES: CLICK HERE TO APPLY

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WWW.ICONNECT007CHINA.COM

Career Opportunities

MacDermid Enthone
ELECTRONICS SOLUTIONS

Account Manager, North East

Do you have what it takes? MacDermid Enthone Electronics Solutions is a leading supplier of specialty chemicals, providing application-specific solutions and unsurpassed technical support.

The position of Account Manager will be responsible for selling MacDermid Enthone's chemical products. The position requires a proactive self-starter who can work closely and independently with customers and sales management to ensure that customer expectations and company interests are served while helping to promote MacDermid Enthone's exclusive line of products.

- Develop a business plan and sales strategy that ensures attainment of company sales and profit goals
- Prepare action plans for sales leads and prospects
- Initiate and coordinate action plans to penetrate new customers and markets
- Create and conduct proposal presentations and RFQ responses
- Possess the ability to calm a situation with customers, initiate a step-by-step plan, and involve other technical help quickly to find resolution

Hiring Profile

- Bachelor's Degree or 5–7 years' job-related experience
- Strong understanding of chemistry and chemical interaction within PCB manufacturing
- Verifiable sales success in large complex sales situations
- Desire to work in a performance driven environment
- Excellent oral and written communication skills
- Decision making skills and the ability to multitask

apply now

KYZEN
Where Science and Care Converge.

KYZEN Regional Manager – Midwest Region

General Summary: KYZEN is seeking a Regional Manager to join our sales team in the Midwest. This position is ideally suited for an individual that is self-motivated, hard-working and has a "whatever it takes," positive attitude, especially with customers. Being mechanically inclined is a plus. KYZEN will provide on-going, in-the-field training to help you succeed.

CORE FUNCTIONS:

- Collaborates with the Americas Manager in establishing and recommending the realistic sales goals for territory
- Manages the assigned geographic sales area to maximize sales revenues and meet corporate objectives
- Develops sales strategies to improve market share in all product lines (Electronics and Industrial)
- Ensures consistent, profitable growth in sales revenues through planning, deployment and management of distributors and sales reps as well as continued direct support for customers and prospects processes

REPORTING:

- Reports directly to Americas Manager

QUALIFICATIONS:

- A minimum of seven years related experience or training in the manufacturing sector or the equivalent combination of formal education and experience
- Excellent oral and written communication skills
- Working knowledge of Microsoft Office Suite
- Mechanically inclined a plus
- Valid driver's license
- Travel within the region up to 75% of the time with occasional travel outside the region

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, tradeshow, 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

apply now

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

Front-End CAM Operators

Chicago-based PCB fabricator, American Standard Circuits, is currently seeking front-end CAM operators to join their team. Desired applicant will have three years of CAM experience.

The candidate should also possess:

- Expertise in Valor/Genesis CAD/CAM software and PCB process
- Ability to process DRC/DFMs
- Excellent customer/people skills
- Ability to be a self-starter
- Ability to read prints and specifications

American Standard Circuits is one of the most diverse independent printed circuit board fabricators in the country today, building PCBs of all technologies, including epoxy MLBs, flex and rigid-flex, RF and metal backed.

To learn more about this position, please send your information to American Standard Circuits.

apply now

Career Opportunities

MacDermid Enthone
ELECTRONICS SOLUTIONS

Technical Service Rep, North East

Do you have what it takes? MacDermid Enthone Electronics Solutions is a leading supplier of specialty chemicals, providing application-specific solutions and unsurpassed technical support.

The position of the Technical Service Rep will be responsible for day-to-day support for fabricators using MacDermid Enthone's chemical products. The position requires a proactive self-starter who can work closely and independently with customers, sales group members and management to ensure that customer expectations and company interests are served.

- Thoroughly understand the overall PCB business, and specifics in wet processing areas
- Prepare action plans for identification of root cause of customer process issues
- Provide feedback to management regarding performance
- Create and conduct customer technical presentations
- 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

Hiring Profile

- Bachelor's Degree or 5–7 years' job-related experience
- Strong understanding of chemistry and chemical interaction within PCB manufacturing
- Excellent written and oral communication skills
- Strong track record of navigating technically through complex organizations
- Extensive experience in all aspects of customer relationship management
- Willingness to travel

apply now

orbotech

Electronics Expert Engineer

Orbotech is looking for an Electronics Expert Engineer to handle various hardware activities, including communication, data path processing, device interfaces and motion, as well as system supporting functions in a multidisciplinary environment.

What Will Your Job Look Like?

- Providing cutting edge hardware solutions for challenging product line needs
- Developing board design and Logic in VHDL
- Defining and managing interfaces (software, algorithm, mechanics and electricity)
- Successfully integrating hardware with other product disciplines
- Supporting the product needs during and following release

What Do You Need to Succeed?

- BSc in electronics engineering
- At least 5 years of R&D experience in complex board design, mainly FPGA (communication interfaces, DDR controller, algorithm implementation)
- Experience in an Altera/Xilinx development environment
- Experience in ECAD design tools (DxDsigner, ModelSim) is an advantage
- Knowledge in laser interfaces, RF and analog is an advantage

Who We Are

Virtually every electronic device in the world is produced using Orbotech systems. For over 30 years, Orbotech has been a market leader in developing cutting edge inspection, test, repair, and production solutions for the manufacture of the world's most sophisticated consumer and industrial electronics.

apply now

Career Opportunities

Printed Circuits

THE FUTURE OF RIGID FLEX CIRCUITRY

Sales Administrator

Purpose:
To assist the Sales Department in entering and tracking customer orders, supporting sales and marketing functions, and growing Printed Circuits customer base and sales.

Nature of Duties/Responsibilities:
- Provide point of contact for customers' quotes and orders
- Enter purchase orders
- Check orders for accuracy and completion
- Resolve order errors and inaccuracies
- Handle customer emails and phone calls
- Track and expedite customer requests and inquiries
- Work with customers to resolve outstanding questions and/or issues
- Report on open orders
- Keep customer contact database current
- Work with Engineering and Quality Assurance to meet customer expectations
- Complete other sales and/or marketing tasks as required

Education and Experience:
- At least 2 years of previous customer service center experience
- Ability to work with Microsoft (MS) Office, with focus on demonstrated working knowledge of MS Excel and Word
- Ability to work well in time-sensitive situations where customer satisfaction is the goal
- Ability to apply creative problem-solving techniques to situations using sound business judgment
- Excellent verbal and written communication skills
- Ability to multi-task in an effective, timely and professional manner
- Proven ability to apply attention to detail, role-related accuracy and task follow-through
- Willingness to learn new software products such as ACT!
- Bachelor's degree a plus

apply now

saki

The Future in Focus

Field Application Engineer

Saki America Inc., headquartered in Fremont, CA, a leader in automated inspection equipment, seeks two full-time Field Application Engineers (FAE), one in the Fremont headquarters and the other for the Eastern and Southern United States.

The FAE will support the VP of Sales and Service for North America in equipment installation, training, maintenance, and other services at field locations. The FAE will provide technical/customer support and maintain positive relationships with existing and future customers.

Strong analytic abilities and problem-solving skills are a must in order to understand customer applications and troubleshoot issues. The FAE will perform demos and presentations for customers and agents as well as assisting in trade show activities. Candidate must have a minimum of a two-year technical degree, experience in AOI, SPI, and X-ray inspection, and strong verbal and written communication skills. The position requires the ability to travel about three weeks per month. Must be a US citizen and be able to lift up to 40 lbs.

apply now

Career Opportunities

Altium

Business Development Representative at Altium

New Logo Business Development representatives are highly motivated and hardworking with an upbeat can-do attitude. They work with our New Logo Sales Team to displace our competition in accounts by offering Altium's unified PCB development tools within a defined region.

The New Logo Developer's (NLD) main responsibilities will be qualifying leads and prospecting into competitive lists, searching the web, and utilizing internal sales tools (Inside View, LinkedIn, Marketo, SalesForce) to uncover and work with opportunities for the New Logo Closer to close. They are expected to meet or exceed monthly, quarterly & annual quota.

Responsibilities:

- Develop lead opportunities by collecting information that includes business pains/needs, timelines, authority and project teams, budget, competitive information, etc.
- Aggressively drive daily prospecting calls to build pipeline of prospective clients and occasionally closing smaller deals
- Develop relationships with key partners in their territory to identify new business opportunities
- Plan and prioritize personal sales activities in conjunction with the New Logo Closer, with the goal of achieving sales targets
- Work alongside inside sales teams on specialized projects such as call-out campaigns, promo drives and webinar fulfillment
- Once trained, maintain an in-depth knowledge of Altium products and technologies, competitive products, and industry trends.

apply now

CHEMCUT

BOUNDLESS INNOVATION | UNBEATABLE PRECISION

Field Service Technician

Chemcut, a leading manufacturer of wet-processing equipment for the manufacture of printed circuit boards for more than 60 years, is seeking a high-quality field service technician. This position will require extensive travel, including overseas.

Job responsibilities include:

- Installing and testing Chemcut equipment at the customer's location
- Training customers for proper operation and maintenance
- Providing technical support for problems by diagnosing and repairing mechanical and electrical malfunctions
- Filling out and submitting service call paperwork completely, accurately and in a timely fashion
- Preparing quotes to modify, rebuild, and/or repair Chemcut equipment

Requirements:

- Associates degree or trade school degree, or four years equivalent HVAC/industrial equipment technical experience
- Strong mechanical aptitude and electrical knowledge, along with the ability to troubleshoot PLC control
- Experience with single and three-phase power, low-voltage control circuits and knowledge of AC and DC drives are desirable extra skills

To apply for this position, please apply to Mike Burke, or call 814-272-2800.

apply now

Career Opportunities

orbotech

Electronics Team Leader

Orbotech is seeking an Electronics Team Leader to join our electronics team, which develops multi-disciplinary systems, including vision/laser, image processing, and control and automation missions.

What Will Your Job Look Like?

- Lead a team of electronics engineers in a multi-disciplinary environment
- Lead electronic activities from requirement phase to development, integration and transfer, to production
- Be the focal point for other disciplines and projects managers
- Maintain and improve existing electronics platforms

What Do You Need to Succeed?

- BSc/MSc in electronic engineering/ computer science from a well-recognized university
- 5+ years' experience in digital board design, high-speed links, computing embedded systems, and HW/SW integration
- 2–3 years' experience in leading a team of engineers
- Solid skills in complex FPGA design with multi-modules
- Solid skills in high-speed board design, DDR3/4, PCIE, USB, IO, and optic links
- Ability to design and execute end-to-end solutions

Who We Are

Virtually every electronic device in the world is produced using Orbotech systems. For over 30 years, Orbotech has been a market leader in developing cutting-edge inspection, test, repair, and production solutions for the manufacture of the world's most sophisticated consumer and industrial electronics.

apply now

ventec
INTERNATIONAL GROUP
騰輝電子

Ventec Seeking U.S. Product Manager for tec-speed

Want to work for a globally successful and growing company and help drive that success? As a U.S.-based member of the product and sales team, your focus will be on Ventec's signal integrity materials, tec-speed, one of the most comprehensive range of products in high-speed/low-loss PCB material technology for high reliability and high-speed computing and storage applications. Combining your strong technical PCB manufacturing and design knowledge with commercial acumen, you will offer North American customers (OEMs, buyers, designers, reliability engineers and the people that liaise directly with the PCB manufacturers) advice and solutions for optimum performance, quality and cost.

Skills and abilities required:

- Technical background in PCB manufacturing/ design
- Solid understanding of signal integrity solutions
- Direct sales knowledge and skills
- Excellent oral and written communication skills in English
- Experience in making compelling presentations to small and large audiences
- Proven relationship building skills with partners and virtual teams

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

Please forward your resume to
jpattie@ventec-usa.com and mention
"U.S. Sales Manager—tec-speed"
in the subject line.

apply now

Career Opportunities

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.

apply now

ventec
INTERNATIONAL GROUP
騰輝電子

Technical Sales Engineer

Positions available in the Chicago area and California

Do you want to advance your career by joining a globally successful and growing world class CCL manufacturer and help drive that success? As a California-based member of the technical sales team, your focus will be on Ventec's core market segments: mil/aero, automotive and medical, offering a full range of high-reliability materials including polyimide, IMS and thermal management products.

Skills and abilities required:

- Drive & Tenacity!
- 7 to 10 years of experience in the PCB industry in engineering and/or manufacturing
- Detail-oriented approach to tasks
- Ability to manage tasks and set goals independently and as part of a team
- Knowledge of MS office products

Full product training will be provided. This is a fantastic opportunity to become part of a successful brand and a leading team with excellent benefits.

Please forward your resume to:

jpattie@ventec-usa.com and mention "Technical Sales Engineer - California Based or Chicago area" in the subject line.

apply now

Career Opportunities

Application Engineer

The application engineer is the first contact for our customers who have technical questions or issues with our product. We value our customers and wish to provide them with highest quality of technical support.

Key Responsibilities:

- Support customer base through a variety of mediums
- Log, troubleshoot, and provide overall escalation management and technical solutions
- Create various types of topic based content, such as online help, online user guides, video tutorials, knowledge base articles, quick start guides and more
- Distill complex technical information into actionable knowledge that users can understand and apply
- Continually develop and maintain product knowledge

Requirements:

- Understanding of EDA electronic design software, schematic capture and PCB layout software
- Bachelor's degree in electronics engineering or equivalent experience
- Sales engineering and/or support engineering experience
- Circuit simulation and/or signal integrity experience
- Understanding of ECAD/ MCAD market segments
- Understanding of micro controllers, SoC architecture and embedded systems market
- Database experience preferred (i.e., MySQL, PostgreSQL, Microsoft Access, SQL, Server, FileMaker, Oracle, Sybase, dBASE, Clipper, FoxPro) etc.
- Experience with PLM/PDM/MRP/ERP software (Program Lifecycle Management) preferred
- Salesforce experience a plus

Salary based upon experience. Comprehensive benefits package and 401k plan. Openings in USA, UK, and Germany.

For more information, contact Altium.

apply now

PCB Process Planner

Accurate Circuit Engineering (ACE) is an ISO 9001:2000 certified manufacturer of high-quality PCB prototypes and low-volume production for companies who demand the highest quality in the shortest time possible. ACE is seeking a skilled individual to join our team as a PCB process planner.

Responsibilities will include:

- Planning job travelers based on job release, customer purchasing order, drawings and data files and file upon completion
- Contacting customer for any discrepancies found in data during planning and CAM stage
- Consulting with director of engineering regarding technical difficulties raised by particular jobs
- Informing production manager of special material requirements and quick-turn scheduling
- Generating job material requirement slip and verify with shear clerk materials availability
- Maintaining and updating customer revisions of specifications, drawings, etc.
- Acting as point of contact for customer technical inquiries

Candidate should have knowledge of PCB specifications and fabrication techniques. They should also possess good communication and interpersonal skills for interfacing with customers. Math and technical skills are a must as well as the ability to use office equipment including computers, printers, scanners, etc.

This position requires 3 years of experience in PCB planning and a high school level or higher education.

apply now

Career Opportunities

IPS INTEGRATED PROCESS SYSTEMS INCORPORATED

PCB Equipment Sales

World-class manufacturer of wet process equipment for the PCB and plating industries, Integrated Process Systems Inc. (IPS) is seeking qualified candidates to fill a position in equipment sales. Potential candidates should have:

- Process engineering knowledge in PCB manufacturing
- Outside sales background
- Residency on the West Coast to manage West Coast sales
- Knowledge of wet process equipment
- Sales experience with capital equipment (preferred)

Compensation will include a base salary plus commission, dependent upon experience.

more details

ACE ACCURATE CIRCUIT ENGINEERING

PCB Assembly Supervisor—full time
Accurate Circuit Engineering—Santa Ana, CA

Position Summary: Responsible for all assembly processes to ensure continued growth as directed by management.

Essential Job Functions:

- Create, implement, and supervise in-house manufacturing facility
- Recruit, hire, train, and supervise assembly floor personnel
- Extensive hands on experience with all aspects of PCB assembly
- Understanding of IPC-A-610 standards
- Research and acquire additional assembly resources
- Gather data on product shortages, lead times, price changes, etc.
- Coordinate the assembly activities with sales to ensure 100% on-time delivery
- Create, implement, and supervise daily quality processes to ensure 100% accuracy
- Document, monitor and review progress of the business unit
- Respond to internal and external customers in a timely manner
- Coordinate walk-through, site audits, etc.

Qualifications:

- Minimum 3 years as operations supervisor of electronics assembly house
- 5+ years' experience in the electronics industry
- Previous experience as a quality or operations supervisor preferred
- Ability to solve practical problems using pre-established guidelines
- Strong facility in Microsoft Office applications
- Excellent verbal and written communication skills
- Ability to work with people of diverse backgrounds
- Highly organized/excellent time management skills
- Ability to perform at the highest level in a fast-paced environment
- Valid California driver's license.

apply now

Career Opportunities

FPGA Design Expert

Orbotech is seeking a FPGA Design Expert to join our electronics team, which develops multi-disciplinary systems including vision/laser, image processing and electro-optics.

What Will Your Job Look Like?

- Lead image acquisition and processing activities in the team
- Engage in all aspects of FPGA design activity: requirement phase, coding, synthesizing, verification support and LAB bring up
- Participate in system definitions for current and next generation products
- Collaborate with other teams: SW, algorithm and QA

What Do You Need to Succeed?

- BSc/MSc in Electrical Engineering from a well-recognized university
- Extensive knowledge of VHDL
- 5+ years of FPGA development experience (requirement, architecture, RTL coding, simulation, synthesis, timing analysis, P&R, board level integration and verification)
- Experience in designing and implementing low-latency, high-throughput FPGA designs utilizing PCIe Gen2/3, Gigabit Ethernet, SERDES, DDR3/4
- Experience in complex FPGA such as Altera Stratix-II and Arria 5&10 devices
- Authoring documentation experience such as FPGA specifications and FPGA verification plans

Who We Are

Virtually every electronic device in the world is produced using Orbotech systems. For over 30 years, Orbotech has been a market leader in developing cutting-edge inspection, test, repair, and production solutions for the manufacture of the world's most sophisticated consumer and industrial electronics.

apply now

Arlon EMD, located in Rancho Cucamonga, California is currently interviewing candidates for **manufacturing** and **management positions.** All interested candidates should contact Arlon's HR department at 909-987-9533 or fax resumes to 866-812-5847.

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

Our facility employs state of the art production equipment engineered to provide cost-effective and flexible manufacturing capacity allowing us to respond quickly to customer requirements while meeting the most stringent quality and tolerance demands. Our manufacturing site is ISO 9001: 2008 registered, and through rigorous quality control practices and commitment to continual improvement, we are dedicated to meeting and exceeding our customer's requirements.

more details

Events Calendar

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

2018FLEX Japan ▶
April 19–20, 2018
Tokyo, Japan

KPCA Show 2018 ▶
April 24–26, 2018
Kintex, South Korea

Thailand PCB Expo 2018 ▶
May 10–12, 2018
Bangkok, Thailand

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

IMPACT Washington, D.C. 2018 ▶
May 21–23, 2018
Washington, D.C., USA

2018 EIPC's 50 Years Anniversary Conference ▶
May 31–June 1, 2018
Bonn, Germany

JPCA show 2018 ▶
June 6–8, 2018
Tokyo, Japan

electronica India productronica India ▶
September 26–28, 2018
Bengaluru, India

electronicAsia 2018 ▶
October 13–16, 2018
Hong Kong

SMTA International ▶
October 16–17, 2018
Rosemont, Illinois, USA

TPCA Show 2018 ▶
October 24–26, 2018
Taipei, Taiwan

Additional Event Calendars

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APRIL: **AUTOMOTIVE ELECTRONICS**
What's driving the automotive electronics industry?

MAY: **5G**
What is it and how will it affect your business?

JUNE: **WET PROCESSING**
The latest on wet processes for PCB manufacturing.

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