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Points of View

We're three months into 2023 and wrapping up our first quarter. So, as a PCB fabricator, what's on your mind? Is it time to assess, and perhaps reassess, your expectations for the year and whether your reality is meeting your predictions? What are you hopeful about? What has you nervous? What are the opportunities and the obstacles to your business right now?

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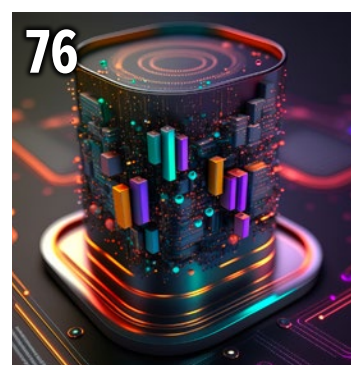
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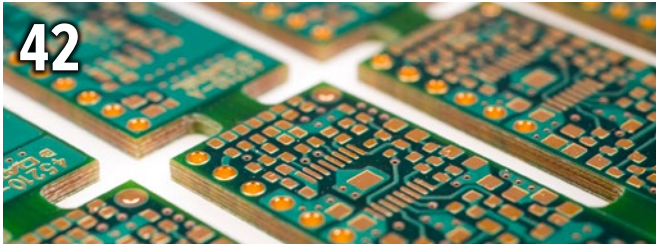
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The Fabricator's Mindset

Nolan's Notes

by Nolan Johnson, I-CONNECT007

If you've logged onto a popular social media account, the first thing you get asked is: What's on your mind? It's such a great question because it's so open-ended. There's no judgment, no general direction, no expectation. We just get to share what we're thinking about.

Well, we're three months into 2023, and wrapping up our first quarter. So, as a PCB fabricator, what's on your mind? Is it time to assess, and perhaps reassess, your expectations are for the year and whether your reality is meeting your predictions? What are you hopeful about? What has you nervous? What are the opportunities and obstacles to your business right now?

Several trends and challenges seem to be prevalent today: reshoring, high reliability, increased capacity, staffing, new capabilities, and the CHIPS Act. As you'll see in this issue, we touch on all those topics, as well as a few surprises.

It was clear at IPC APEX EXPO that you have plenty on your mind. A walk through the

Technical Conference uncovered that of the 28 technical tracks, 16 were related to printed circuit board fabrication; that's nearly 60% of the sessions devoted to fabrication issues. Interestingly, my impression of the show floor (based on booth presence) was that it was weighted

much more in favor of assembly services than fabrication.

Thus, as we strategized content for this issue, we encountered an interesting dynamic: Suggest a specific topic to a subject matter expert and they can usually deliver an essay, or produce a white paper already tucked away in their proverbial desk drawer. Sometimes they might refer to a technical paper presented at a recent conference or symposium which we can

publish. But this required a different approach. It was called, "Let's talk."

One of the best and most interesting aspects of being the editor of *PCB007 Magazine* is the opportunity to get inside someone's head. What do they know? How do they know it? How can their knowledge help you? Every-



LET'S TALK

body is different; everybody has their own story. It's these exact nuanced conversations that set this issue apart. We spent a lot of time talking to fabricators, and while each has a specific set of needs, you're going to find some common themes. It's definitely must-read content.

One side note: I want to discuss the rapidly-evolving CHIPS Act, legislation that passed last year. The U.S. Department of Commerce is now communicating the process it will use to allocate funds. The department has made several announcements about its intentions, each worded slightly differently, but with the same intentions. Five main priorities will guide the CHIPS for America program: catalyzing private investment, protecting taxpayer dollars, building a skilled and diverse workforce, engaging with U.S. partners, and driving economic opportunity and inclusive economic growth.¹

Hillsboro, Oregon (my hometown), is the base of operations for Intel's microprocessor development teams, and the CHIPS Act programs could have a significant impact on the local economy. Understandably, several local/state policy watchdog groups are reporting on the state's activities with the CHIPS Act. In citing the Commerce Department's announcement, the Oregon Center for Public Policy recently shared²:

"The Department encourages projects that include state and local incentive packages capable of creating spillover benefits that improve regional economic resilience and support a robust semiconductor ecosystem, beyond assisting a single company. Such incentives might include *investments in workforce, education, site preparation, or infrastructure* (including transit or utilities) that are not limited to the applicant, but designed to benefit both the applicant and the broader community. Likewise, the Department will *place less weight on incentives (such as direct tax abatements)* with less potential for spillover benefits." (Emphasis added.)

The center's reporting is consistent with the priorities that the CHIPS program has established. The Commerce Department seems to be saying that while state and local governments are required to offer applicants incentives, in order for those incentives to meet the program's priorities, they must be structured in such a way as to directly improve manufacturing infrastructure. Taking the easy route by providing a state/local tax abatement, for example, could be used by the recipient simply to improve the corporate bottom line, not build out infrastructure. Commerce is looking for infrastructure, site, or workforce improvements from these incentives—meaningful change, in other words. This sort of prioritization by the Commerce Department should be encouraging to smaller shops in working with local and state governments to effect some real change in their own businesses.

We found this issue to be quite interesting to compile. As you read the interviews, look for the larger themes that are suggested or implied in each conversation, which become clearer as you move from interview to interview. As always, we encourage you to contact us with your feedback. **PCB007**

References

1. "Biden-Harris Administration Launches First CHIPS For America Funding Opportunity," Feb. 28, 2023, U.S. Department of Commerce.
2. "Feds make it clear for Oregon lawmakers: no race to the bottom to compete for CHIPS Act dollars," by Daniel Hauser, March 1, 2023, Oregon Center for Public Policy.



Nolan Johnson is managing editor of *SMT007 Magazine* and co-managing editor of *PCB007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design

and manufacturing. To read other columns or to contact Johnson, [click here](#).



The Summit View of the Marketplace

Feature Interview by Nolan Johnson

I-CONNECT007

Investments, staffing, cybersecurity, and a peek into his crystal ball—John Vaughan, vice president of strategic markets at Summit Interconnect, sits down with Nolan Johnson to talk about it all. Business is good, by the way, thanks to Summit's portfolio of military contracts, and John has sound advice to offer for smaller shops in the United States, and their real ability to make a difference in PCB fabrication.

John, I'd like to address several topics with you: How are you approaching investments and facilities? Where does cybersecurity fit in? How are you handling staffing and training? How do you view the marketplace, and what are your regional concerns?

Although we're widely recognized for the breadth of military programs we support—

that's our core market—we're more diversified by virtue of acquisitions than you might realize. We touch heavily on test and measurement, industrial controls, EV automotive, and medical, among others. We have found growth prospects in all these markets but do note that the commercial sector is a little more challenging into 2023.

We continue to invest substantially across all eight Summit facilities to support our growth and the onboarding of many long-term defense programs.

The NDAA represents a plus-up of about 10% over last year's defense budget; we were anticipating closer to a 6% plus-up. That's good for us and others who are in that market. There are inflationary pressures across all inputs, including wage inflation, the cost of capital, raw materials, utilities, and transportation. Over-

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	Dk	Df
R-5795(U)	3.1 @ 14GHz	0.0012 @ 14GHz
R-5795(N)	3.1 @ 14GHz	0.0016 @ 14GHz

428°F
220°C
Tg

3.1
Dk

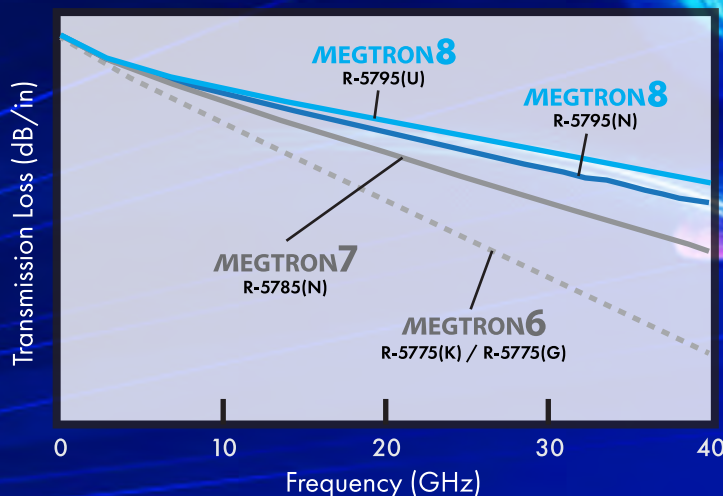
0.0012
Df

698°F
370°C
Td

*Test method used for Tg: DMA, Td: TGA, Dk and Df @ 14GHz

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PCB construction	3L PCB Strip line
Copper thickness	18 μm (1L)
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Prepreg	0.15 mm
Zo Impedance	50Ω
Inner treatment	No-surface treatment
Measurement method	2 port S-parameter
Frequency range	0.2 - 40GHz
De-embedded	Multiline TRL method

Evaluation Sample (cross section)



Summit Interconnect's facility in Orange, California.

all, the North American PCB industry itself is well positioned.

We pay close attention to the IPC book-to-bill ratios. The EMS numbers have been cruising up in the 1.50+ territory for a year. They're at 1.44 now, which means you're booking \$1.44 for every dollar you're getting out the door; I lay much of that strong book of business at the doorstep of the component supply chain challenges, yet they have been able to book business, so the demand side is certainly there. It's tougher to get to the revenue for our EMS customers when they don't have the parts, so that certainly influences the book-to-bill ratio.

We've also certainly observed order phasing by the EMS providers. The conversation goes something like, "John, if I can't get the chips for 38 weeks, why do I need to buy circuit boards that you deliver in four to six weeks?" So, they time phase those orders. We can see that trend, particularly with the EMS customers. On the PCB side, the overall PCB industry book-to-bill is running close to parity right now. It's a 0.94 book-to-bill ratio, so the industry overall is a little challenged to build back-

log. I think that as the component flows stabilize through the EMS providers, the board bookings will follow for most, so I think you will see an uptick in PCB orders with more component availability.

Over the past 40 years, my background has been equally split across EMS and PCB, and my first rule of EMS supply chain management is always: When you have new business that you booked with an OEM, you buy the fabricated parts first; you buy the metal and the printed circuit boards immediately. There will be all kinds of technical queries. It's a largely tradesmen and manual process—things will go wrong. Given the complexities, the opportunities to have to rebuild that product are certainly there. The quality requirements are very stringent, and the technology is challenging. You want to solve for that on the front end, not try and precisely time your PCB deliveries to your planned last component receipt date.

The EMS companies' order phasing also creates an artificial delivery pressure that doesn't really need to be there. If a component part is quoted at 30 weeks, some EMS companies are

phasing that PCB order to their component availability. If you miss that mark, it creates a ripple effect because the SMT lines can't process product and the EMS cannot recognize revenue. What began as an effort to control their payables and cash flow can end up having the opposite effect if they do not get to revenue.

How Summit Has Prepared for CMMC

Tell me about your preparation for CMMC, the government's cybersecurity certification.

Summit formed in 2016, and now we're the largest privately held printed circuit board fabricator in North America; we have a significant defense program portfolio. For CMMC, it's time-consuming and resource demanding, so it's important to have a top-down commitment, and we certainly have that from our CEO, Shane Whiteside. You need expertise, and certainly you spend capital along that path. It was part of Summit's charter to be an early adopter and be a market leader for CMMC compliance. The rulemaking process and final adoption processes are still ongoing across the DoD, but we are audit ready when they hit the Go button on the finalized version.

With your product mix and customer base, CMMC must be mission critical.

It is and it's the right thing to do. It's time for the highest possible security mindset to displace the lowest possible price mindset that many businesses in the U.S. have been operating under for a long time.

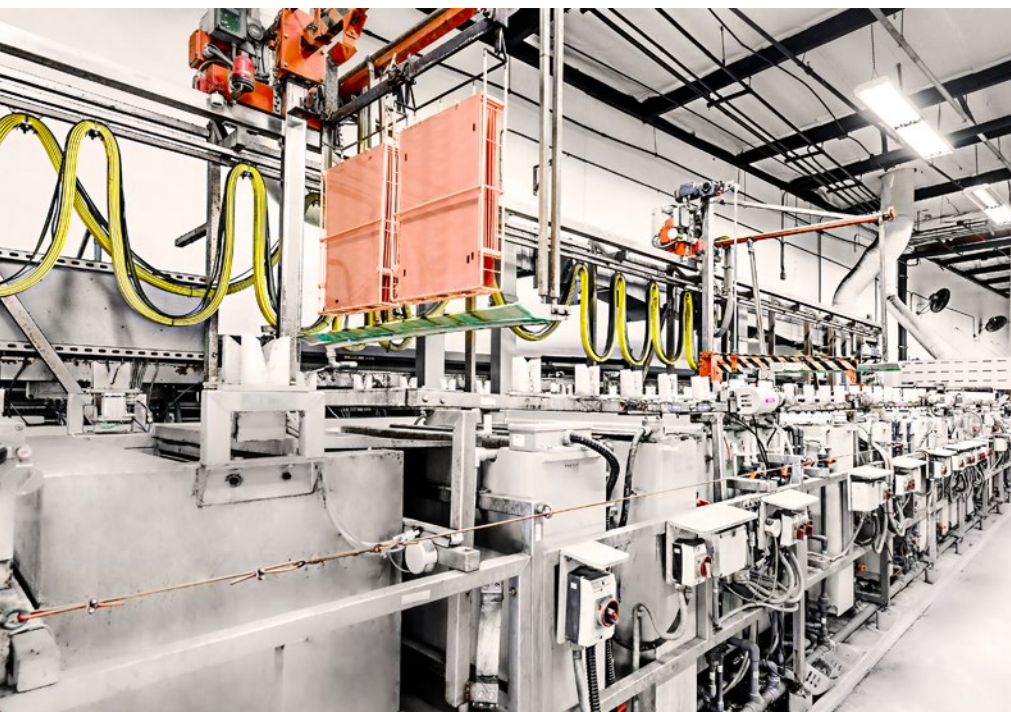
For example, there is a \$52 billion funding allocation with the CHIPS Act, as well as the PCBAA campaign that proclaims, "Chips Don't Float." It's an integrated

technology stack: You need the substrates, the printed circuit boards, and the chip; none will function without the other. To achieve the true goal—which is the restabilization and growth of the electronics industry—you need to broaden those markets. The markets we're servicing need to include transportation in the form of train platforms, planes, the electrical grid, the water system, and broadband, medical, and servers. Those types of products influence our day-to-day security as a nation, and, in my view, must be fabricated in the United States.

For the past 20 years, the PCB industry has been largely reliant on the defense sector for its business. It's estimated to have a value of about \$1.3 billion. If you look at the top five PCB fabricators and you add up their defense-related sales, at least 80% of the supply base for that DoD spend is concentrated in five PCB companies. What that means is there's only another \$300 million or so distributed amongst the remaining companies that are all largely sub-\$50 million; in most cases, truly sub-\$20 million organizations and most have a program or two that they build to support the defense industry. They may or may not be profitable,



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but they certainly are challenged to keep up on the CapEx side of things for technology. Now, burden them one more step with all the CMMC compliance, and it becomes difficult to see how that's a winning business proposition for them. Broadening the markets that should be viewed as trusted—for example, communications and electrical infrastructure, medical devices, transportation, etc.—would certainly go a long way in providing an opportunity for more PCB shops to grow, invest, and prosper. The net/net would be a stronger industry to support the DoD and our nation's security.

I know that you're very aware of the activity around advanced packaging. The boards we make today, especially in your sector, are much more complex than they used to be. Do we have the expertise in the U.S. to build out the industry in the way it ought to be?

Certainly not right now. I don't think it's feasible without some type of government/industry partnership and commitment. I think the answer lies in bringing together the thought leaders and the demonstrated high perform-

ers to solve the problem. It takes money and cooperative engagement to solve these big issues.

Data Security

You just made the point that the time for the highest security mindset is now, and that there is a move toward a more digital flow of data through the entire manufacturing chain. Those two trends dovetail together, don't they?

Yes. It's the operational technology, and for the inputs for the machine, that data is required for them to work

their magic. You either are digital and secure or you are not; there's no middle ground. Otherwise, it's the weakest link in the chain.

What's your perspective on the effectiveness and the role of the capital equipment manufacturers regarding CMMC?

It's been three years since the announcement, and CMMC is not yet live. It started as, "We have to protect the controlled unclassified information (CUI); these are the rules for how you operate in this framework." I think the more they have learned, the more they've had to adjust and broaden the participants to achieve that goal. It's more than just protection of the Gerber data and the drawings that are associated with building a printed circuit board; it's deeper than that. How do you accomplish that objective? Don't let perfect get in the way of good enough; you must start somewhere. There are multiple instances that have been reported where data has been transferred out of our country and is in use by adversary nations. If you start with the protection of data, then you must solve this in



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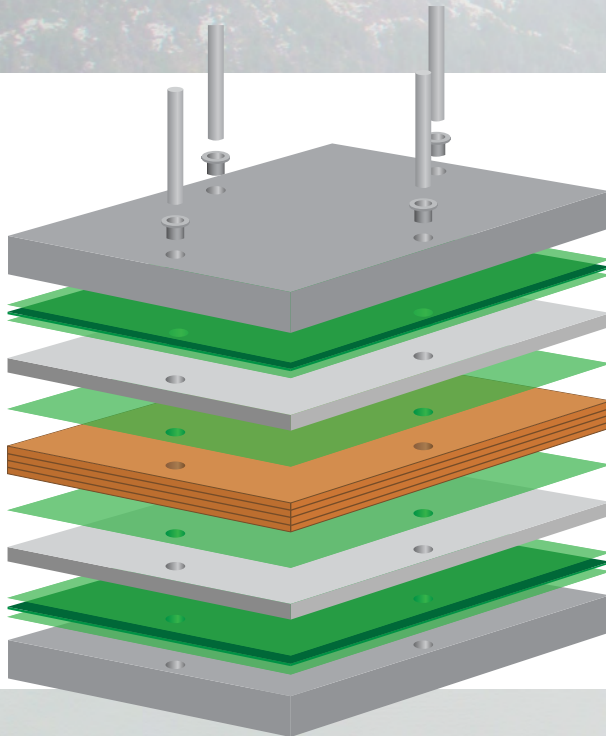


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That said, there seems to be a lot of inertia, but Summit is committed to the task. We're ready for CMMC Level 2 certification; all we need is an audit body and for those to be appointed through the DoD. All we can do is manage our piece of the infrastructure. If enough people across the supply chain take on that mentality, then we can get there a lot sooner.

The other challenge now is capital expenditures. The boards I've been doing over 40 years have changed dramatically—even more dramatically in the last five years, particularly with layer counts and the sequential lamination cycles you go through to accomplish the via structures and hybrid material builds. It might be one board with 24 layers in the customer's eyes, but we see maybe three or four sequential laminations required to manufacture it. That one board is multiple different boards when it moves through a factory prior to final lamination, so you need more press cycle capability, your drill sizes are smaller and performed by million-dollar laser machines, drill hit counts

are extraordinarily high, and there's the laser-driven fine line resolution that is required. It's not my dad's old circuit shop anymore. It's quite costly to stay on the leading edge.

For the military market, the deliverables are significant. When you look at the complexity of the coupons on the perimeter of the panels that we process, they're incorporating RF measurement features, controlled impedance, drill registration, image registration, and plating thicknesses. And that's just the coupons. There is the cross-sectioning that accompanies that, and all the engineering resources required to support a purchase order. It's significant in terms of manpower, so we

spend a lot of time building out world class labs to support cross-section and deliverable activities. I'm not sure our OEM customers are truly cognizant of the amount of effort—and there is a cost associated with all that activity. There are some challenges in all of that, and you must look at it like that's the ante to play in the space.

For smaller fabricators who have a couple of military program positions, pricing to achieve margin, however they're structured, becomes more challenging as the deliverables increase.

Moore's Law for PCBs: Staff and Automation

The support infrastructure for that is huge because it's thinking about those designs that will be manufactured; are we reaching a point where it's time to change how we fab to simplify that?

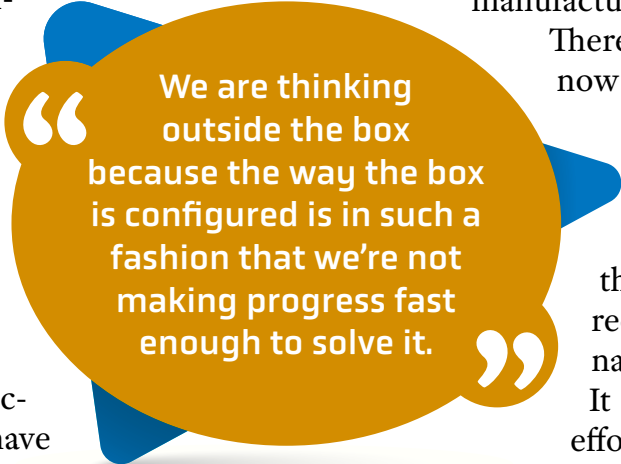
One would think we're at the bounds of physics, and we can't do any more. I've heard that my whole career, but somehow the innovators and the printed circuit board industry craft away and develop innovative solutions.

This is our version of Moore's Law?

Yes. Every time the new and exciting chip technology comes out, I look at it a bit cross-eyed because I know that means more pin-outs, more layers, more vias, more interconnects, smaller spaces and traces to accomplish whatever magic is embedded in that chip's capability.

Is finding qualified staff a difficult thing to do across North America and Europe? I have heard anecdotes about human resources departments for facilities in our industry cruising the supermarket, asking the retail staff if they'd like to make \$5 more an hour.

We have heard similar anecdotes. We are thinking outside the box because the way the box is configured is in such a fashion that we're not making progress fast enough to solve it. We've been doing this a long time—independently and collectively at Summit—and have both a long industry reach and a solid reputation in the industry, so filling the manager level roles is not as challenging for us as it might be for some. Filling the operator roles—which is the bread and butter of any manufacturing organization—has been a challenge because there's true wage inflation there and people are highly mobile in this society now.



We are thinking outside the box because the way the box is configured is in such a fashion that we're not making progress fast enough to solve it.

Educational Institutions

John, what's your current opinion on higher education? Those programs are never perfect, but are they adequate?

There are some programs directed specifically to the printed circuit board industry; the one in Michigan comes to mind. When I was

an owner of businesses that operated in the printed circuit board and EMS provider space, I was a huge advocate of the industrial-related schools and community colleges. The printed circuit board industry is not for the faint of heart; you must have a driven personality and a go-getter attitude. If you add in some intelligence, are motivated to show up, and have a willingness to learn, listen, and work hard, you can go a long way. High school graduates with some industrial arts training or an interest in computers, or someone in a community college or two-year school, are perfect candidates for our industry. The higher you go up the educational spectrum, interest seems to wane for the exciting world of printed circuit board manufacturing.

There's just so much exposure now in the world for our industry—our customers, country, national security, and economy are impacted daily by our industry and there is more widespread recognition of the critical nature of the work we do. It is encouraging to see the efforts by USPAE, PCBAA,

IPC, and others who are educating legislators on how vital our industry segment is to national defense. I've been part of that effort for 10 or 15 years through IPC, but I've never seen the coalescing of interest, activity, and thought leadership that I'm seeing now. I'm more encouraged now than ever that the guys on Capitol Hill are getting it. I'm hopeful that meaningful change is on the horizon.

What do you see ahead in the next five years?

I'm guardedly optimistic. A handful of fabricators support 80% of what the DoD spends on PCBs. Some other fabricators that are also participating may or may not be undercapitalized or be able to take the next step and continue

to exist. There are some potential government incentives that sound like they're on the horizon and it sounds like we have the right people's ears now that may bring fresh energy and resources into our industry.

The printed circuit board industry is more elevated in the public consciousness than it ever has been. Twenty-five years ago, I could meet legislators who had no concept of what we did or how we fit into the overall picture, but more recently, there's heightened awareness about what we do and how important it is. I credit the organizations I mentioned for raising that consciousness in the collective. Our supply chain, our supplier base, and our customers, it is a big number when it comes to economic impact and importance to national security. I'm excited.

There are many opportunities to support our warfighters. To the extent that we recognize national security is dependent on more than just DoD platforms and systems, that there are risk levels across all our infrastructure, and we accept that it might cost a little more to build our strategic infrastructure domestically; our security level will certainly be much higher and that should be the goal in my view.

The Way Forward

Do you see a path forward for the 90% of the industry that is in the \$50 million and below portion of the market? Those for whom DoD work is not a specialty, but it's still in their portfolio? Will this market consolidate?

Yes, it is very likely in my view. To the extent that we get serious about broadening the trusted markets and creating more opportunities, however, the opportunity to not only exist, but to thrive, increases for the smaller operators. I think that a more robust Defense

Industrial Base is desirable to support our nation's security. We currently build only 4% of the global printed circuit board market in the U.S., which previously was up to 26%. When I came into the industry in 1979, I believe there were 2,300 fabricators. There are fewer than 150 today; that's a massive scale down. Kudos to all the survivors; it's been a long, tough road. But I think if the markets broaden and there are more opportunities, then the success stories will continue.

There are some well-operated and profitable small businesses where the ownership is at the point in their life where they're thinking about what's next. They're considering how they will exit and what that looks like. For the high performers, being acquired is certainly on their minds.

CMMC could be a decision point. The Summit organization is committed to CMMC; for three years we've invested in all technology, licensing, and the IT manpower resources to be prepared. It's not easy, but with this platform we have created, we can scale up new acquisitions and bring those under our NIST 800-171 and CMMC infrastructure. It's certainly simpler for us to leverage the investments that we've already made in all that infrastructure to scale those locations up to create an even more viable entity for the DoD. The DoD has learned a lot relative to what they thought the cost of CMMC compliance would be. Projections from the industry side gave DoD pause. We'll see how it all shakes out; I think we're close.



John Vaughan

John, thank you. This has been very informative.

Awesome. Thank you so much, Nolan. PCB007

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Preparing for a **New Normal** in Logistics

Feature Interview by Nolan Johnson

I-CONNECT007

While inflated prices and the supply chain's shift toward Asia have hit the commodities market the hardest, the wider industry is still feeling the squeeze. Flourishing in this "new normal" requires a diverse business approach and a keen awareness of the next big market shift—strengths that have fortified Ventec in the secure position it holds today. Alun Morgan, technology ambassador at Ventec, and Mark Goodwin, Ventec's COO, discuss the logistics landscape in a post-pandemic world.

Mark, you watch logistics very carefully at Ventec. What are you seeing?

Mark Goodwin: There are a lot of statements in the market that logistics have returned to pre-pandemic normal. My feeling is "yes and no"; they have and they haven't. There are prices

similar to pre-pandemic levels now available in the spot market, but these are all being subsidized by people who bought contract volumes in the contract market. As for contract, I don't know what prices they paid for contract containers, because, although we're a big exporter, we're not in the league of buying contract container traffic.

When we were paying \$15,000, \$16,000, even \$18,000 a container, they paid \$12,000. They're still paying \$12,000 today, but you can buy a general purpose (GP) container for \$1,000—a 20-foot GP container from Shanghai into Southampton—but that's not a real price. That price is only available because the ships are running 25% empty and they're just selling the spare capacity they have at marginal cost. It's anything to fill that space up, just taking any boxes they can get—and they're still not filling

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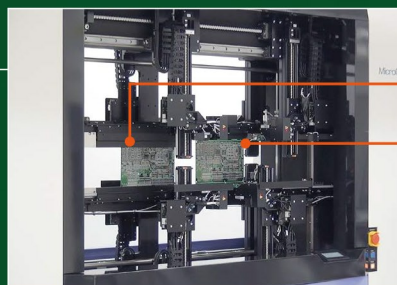
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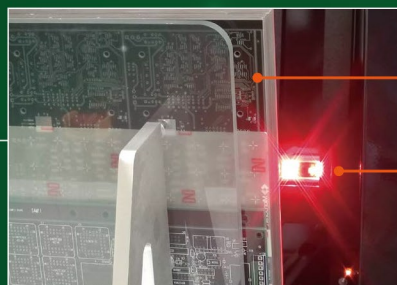


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the ships. Because of the Chinese lockdowns, demand was low, and this is still going on in the world.

My point is that we're a long way from normality. I don't think anybody knows when or where the "new normal" will set in, because these guys have gotten used to higher prices. Nobody will keep the prices up at \$16,000 or \$18,000 a container, but I don't think prices will be coming back to the levels we're currently seeing in the spot market either. I think it will be somewhere between the two. They're already blanking sailings; the next thing they'll do is take out services. They will manage the capacity to keep the price at a sustainable level. The rates we're seeing now are unsustainable.

Alun Morgan: Did you have some comments on the specialty containers? Like the reefers, for example?

Goodwin: It's true that when it comes to the 20-foot GP containers, we're seeing prices below pre-pandemic, but that's unsustainable and not real. In fact, if you read the Shipping Press, they're saying, "This is screwed up; this is an inverted market, and unsustainable." Reefer containers have not come down to pre-pandemic levels, so for shipping prepregs and specialty products that need temperature control, you are looking at prices that are still 50%, even 100% higher than pre-pandemic levels. Now, if you look at volumes in Europe and the U.S. that are sourced from Asia, often we need to ship containers of mixed laminate prepreg to make the supply chains work. We've still got to pay. We can't put prepreg in a GP container. We have to put prepreg in a refrigerated container, so we have to pay those prices.

Also, we got a bullwhip effect in inventory. After the pandemic, Ventec worked very hard to make sure that we kept our customers sup-



Mark Goodwin

plied. We ran out of very few things. The flip side of that coin was I had to charge people what I did because of the cost of logistics, and my argument was that the highest cost of all is having no flour to make bread. Without laminate, you can't make a circuit board, so you might not like my price, but you must like the fact that I've got it available.

Yeah, so we kept the availability. Now, of course, the market

has slowed down faster than we can reduce the flow in the supply pipeline, so we've got high inventory. With the market in Asia, the price for laminate has bottomed out and is now starting to increase again. We'll get on to that later in this conversation. What's happened is inventories are high in the West. The price has bottomed out in Asia, but we're still bringing high-priced inventories down in the West.

By the time we start topping those inventories up again, we won't be topping them up at the bottom of the market. We'll be back somewhere on the upswing on pricing. Now, you can argue that we should sell at a cheaper price. We can do whatever we decide to. We can liquidate stuff. We can do whatever, but the true cost—somebody somewhere has to absorb that. Yeah, some might call it inefficiency, but that's the built-in structural costs that are a part of any business—whether you're Ventec or any other laminate supplier—our supply chains start in Asia.

I ship finished goods from Asia. There are North American and European manufacturers who also ship prepreg from Asia because they don't have treaters in some of their markets. When you have a factory without treaters you have to ship prepreg along with copper foil, but these are all just different inventories at different parts of the manufacturing process. We've all got this bullwhip effect; we've all got inventories at various cost points and various logistics cost points.

Morgan: What's different now compared to 20–25 years ago, when we had the last sort of big downturn business-wise? Of course, back then, the supply chain was local, so we had glass fiber. We had copper foil. We had resins all local to Europe, so there was no need to ship that in. In the last 20 years, the supply chain has extended; now, the supply chain is in Asia for both European and American producers.

There's no sign of that changing, by the way, so that's an impact. What actually matters in the end is the container price—that's critical. What you put in your containers, and the value of that material, is what really makes the difference.

We talked with one of the other logistics guys, and he said, "They call this the barbecue effect." If you're selling a small number of Chinese-made barbecues, a container to ship them might cost \$1,000, but that won't fill the container. If you can fill the container, you can make money. Until you hit \$10,000, you can't ship those cheap barbecues, because you cannot make money on them. You cannot charge a price for them that offsets what you need to pay, and that's the issue. When you have a downturn like we're seeing now, the commodity business gets hit the hardest. The biggest impact is on the low end of the market.

Goodwin: Thinking about this in terms of laminate, a 20-foot GP container of rigid laminate is somewhere between 4,000 to 4,400 sheets, depending on copper weight. You hit weight before you hit bulk volume. Let's say it's 4,000 sheets. The impact of the price rise on the shipping containers for that amount is between 35–40 cents per square foot. That's more than the margin in rigid laminate has ever been in my working life.



Alun Morgan

Morgan: If you're selling a reefer or selling a 20-foot container of mixed, high-margin (or high-value) products like polyimide—low-loss material—it doesn't matter.

You don't get a uniform effect across an industry, but a very specific effect. Think about the business in Europe, in general. We still have a big dependence on the low-end materials, especially for automotive, in Europe.

Automotive is a relatively high material content business, and that's what's been affected the most. The other issue we're facing is, due to the logistics issues, people have started stocking more material. As Mark said, you build the stock level up by spending cash, but then you've got to borrow more cash to run the business. Inflation's running high, so instead of 2% interest, now it's anywhere from 5–12%, which makes getting cash expensive and, on top of that, the market has softened as well. Folks in the commodity business are feeling the squeeze the most because they're having to deal with high inventory costs, high cost of borrowing money, and now, reducing markets.

Goodwin: With the specialty business, I couldn't have afforded to make a rigid four-, six-, and eight-layer material available throughout the pandemic. I could only do that because I have an IMS business.

It's a high-margin business.

Morgan: We are a high-mix vendor. There are a lot of specialty requirements, and Ventec has a good slice of all of those.

Goodwin: That business subsidized our FR-4 business during the pandemic—not the other way around.

Morgan: Sometimes in business, it's nice to have a specialty, to focus on one thing and do it

well. Sometimes, diversity works. But Ventec has never been a big producer of any one item. I've used the word "niche," but it's not really the right word to use, because there are a range of niches, some of them quite big, and we have a place in many of them. Ventec's strength is in its range. Even during the height of the pandemic, there were certain products that didn't really suffer at all.

We have a war now on European shores. That has, of course, made defense spending increase. We're one of the major suppliers of polyimide in that sector, so that's sort of good for us. Over the last year, I expect you've seen a change in that, Mark; the market is slightly bigger, but there's no pressure there, as we're dealing with a different kind of product. As soon as you commoditize, you've got a problem. Luckily, Ventec is not a majority commodity business.

Goodwin: We have some commodity business, but it's not a strategic business for us. It allows us to balance our factories so that when we do sell commodities, we're able to position ourselves as the fast turnaround supplier in Asia. I'll say, regarding the fast-turn orders in Asia, 10,000–20,000 sheets, stock panels, our Asia team will turn those around in a few days for people. Again, it's a very service-oriented business at commodity-plus pricing, but if you want to buy your rigid FR-4, you're always going to find somewhere cheaper than Ventec. Ventec will provide it to you as part of a package of things; we'll provide it to you with service, with reliability of supply chain and quality, but we're never going to be the price leaders in this business. We're not big enough.

Morgan: It's not our game, either.

Raw materials

Goodwin: Look at things that have changed in the market recently. Heavy coppers are now in short supply in Asia. Why? It's simple: The Chinese manufacturers of copper foil have switched their production to batteries because the EV business in Asia is going crazy.

I was just asking Fabienne from Circuitfoil about battery foils because I know very little about them. Turns out, they're very easy to make. You don't have to put a treatment on the back; you don't have all these extra processes.

She said, "Actually, the plating is the easy part of the technology, relatively speaking, and you'll basically do a plating."

Morgan: It's just drum state basically. It comes off the drum.

Goodwin: This is a beautiful business. It's a large body of business, it's sustainable, it's everything. People don't want to make two-ounce, three-ounce, four-ounce foils, when battery foils are typically 5-micron, 9-micron, 12-micron.

Morgan: You get a lot off the drum.

Goodwin: A lot off the drum. Any foil goes a long way, or your raw copper goes a long way, unlike with the heavy foils. I was speaking to Jason Chung, our CEO in China, recently, and he said, "Yeah, it's gone crazy, the LMEs jumped by 10%." It's more than 10%. Yesterday, the LME was at \$10,500 a ton again already. Months ago, it was \$7,500, right? Two years ago, we had yet to break \$7,000. The price of copper is only going one way, and that's up. The Shanghai Metal Index is even more interesting; copper is \$1,000 higher per ton than the LME. Why? There's currently no scrap copper foil available in China because the infrastruc-

“ Ventec's strength is in its range. Even during the height of the pandemic, there were certain products that didn't really suffer at all. ”



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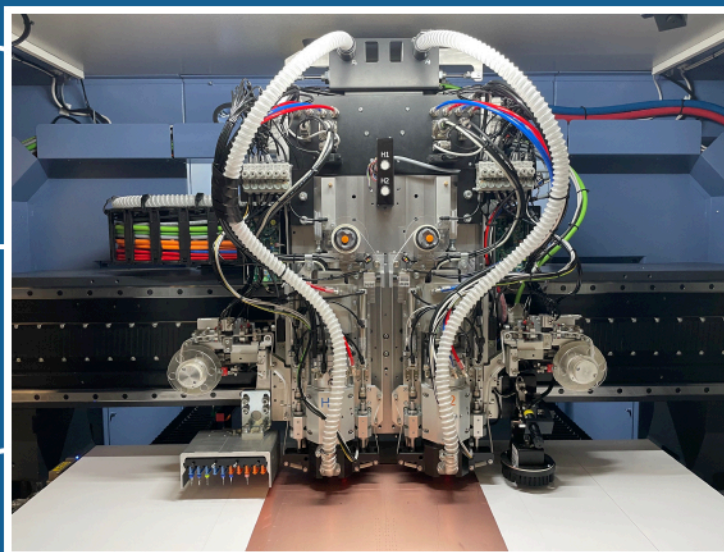
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ture projects have stopped as the economy has slowed down. There's more and more requirement on mining, not on secondary recycled copper.

Morgan: In the UK and Europe, a lot of copper was taken from old exchanges that were being ripped out. With the old copper, they burnt the insulation off. Not all producers did that, but those who did, that was their main feed style, with some that was recycled or used for cables. Of course, if you're not ripping it out, you've got to buy the new stuff.

Goodwin: Exactly.

Morgan: You've got to mine it and refine it, so that's another story. This is the same story we had with glass fabric producers. They made glass for the electronics industry, but they also made it to fulfill structural requirements for decorations for fabrics and wall coverings. In Europe, they've all stopped. There isn't anyone producing for our industry anymore, and that's because our industry has higher technical demands, as well as higher quality demands. Defects are not accepted. Second, we pay a low price, so they all moved away from the "hard" business. We were giving them less margins compared to an "easy" business that gave them greater margins. Isn't that the same as copper foil?

Goodwin: Jason and I first started looking at this with giga factories and the rising demand for gigawatts and batteries. Around November 2017, I made my first post on LinkedIn about copper foil shortages, and everybody told me I was mad. But the price trend is most definitely up, and I think we'll be over \$10,000 a ton again before we know it—maybe by 2024.

Morgan: All it takes is a strike, maybe by tool or mine workers, or a situation like the one in Ukraine. The situation in Ukraine has caused problems with nickel and hydrochloric acid, for example.

Goodwin: Well, I don't know if you know, but Warren Buffet recently made a huge investment in Taiwan Semiconductor.

Morgan: Oh, did he? Warren Buffett knows what he's doing, of course. It's a promising sign.

“The situation in Ukraine has caused problems with nickel and hydrochloric acid, for example.”

Goodwin: He thinks we're at the bottom of the market, so the next thing you'll see is speculators stepping in to get a piece of the market, and that'll drive the price up straight away.

You know what? I follow him. We did some work in this space earlier with an article or two on copper mining, where we discussed how this works with all the different demands coalescing in this space. It's not just batteries, but also moving copper into wiring and cabling, because if you want to build out an EV infrastructure, it's going to require a hell of a lot of copper.

Morgan: There are busbars, yes.

Goodwin: There's mining, too. The concept of copper ore will reduce as time goes on, so refining costs will increase. Refining costs energy, and energy will not go down in price. A great article by Goldman Sachs that came out about two years ago said, "Copper is the New Oil," and they are not wrong. Goldman Sachs has not changed their opinion that this is a medium-to-long-term bull market.

BENDING THE POSSIBILITIES



BY TAIYO

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Morgan: Copper is not the best conductor, but it's the most practical and cheapest overall. Silver is better, but silver's very expensive, so you can't really use silver. Copper is just a perfect mix. It's plated easily, you can protect it from corrosion, and it can carry high current as well. You want that in EVs, and we're talking high current as we are with power converters. Power electronics is big business now.

Goodwin: This is all two-ounce foils, three-ounce foils, and then sometimes the heat sink on the other side is a copper heat sink.

A lot of copper.

Goodwin: A lot of money, a lot of copper.

Morgan: But let's comment on the aluminum side as well. Yes, people do use copper for heat

sinks; they use it for all kinds of things. Copper will carry on increasing. Aluminum has a strong part to play there as well; it's much lighter, for one thing. For automotive, you've also got to watch the weight, so if you can use aluminum to distribute heat, it's much lighter than copper. I guess we have a whole niche with that as well, Mark, which fits into this story.

Goodwin: One of the things we've done there is the synergy part.

Morgan: Right. Usually, regarding the heat sink on the packages, we've got aluminum plate with the proprietary ER1 finish we've put on to improve the thermal emissivity.

Thank you both. I'm sure we'll chat again soon. PCB007

Feeling the 'Deal Energy'

by Tom Kastner

This may have been my favorite IPC APEX EXPO of all time. I've been coming since 1999, but I missed the last two years due to COVID and a busy schedule. It was great seeing some old, familiar faces and meeting some new ones, too.

Although M&A deals in the North American PCB and EMS sectors were down in 2022 compared to the past few years, there was a lot of "deal energy" at this year's show. One reason for that is the number of announced deals that are scheduled to close in early 2023: two PCB deals for Firan Technology Group and the pending APCT/Advanced Circuits deal. As of today, three EMS deals were announced in January: Artaflex's acquisition of Custom Rapid Solutions, both located in Canada; the Gladiator Group's acquisition of BEST, Inc., located near Chicago, Illinois; and Niche Electronics' acquisition of L-Tronics in Massachusetts.

Another reason for all the enthusiasm is that the industry's top companies are committed to growth and investment. Just about everyone I met was inter-

ested in acquisitions in 2023, not just in the PCB and EMS sectors, but also in equipment, materials, wire/cable, software, design services, and related industries. Most buyers are interested in acquiring profitable, growing companies. A few are also interested in distressed deals, but frankly, we have only seen a few of those lately.

Even with all this positive energy, sellers may be a bit hesitant due to the gathering economic storm clouds. But as long as backlog is strong and there are no major issues with the business, there are buyers out there. Some of the shine may have come off valuations in the second half of 2022, but the market still seems strong compared to pre-COVID levels. Owners dealt with material price increases,

parts and labor shortages, and other headwinds in 2022. Those issues may have calmed down somewhat, but now backlogs may be softening. U.S. buyers seem to be the most active.



Tom
Kastner

To read the rest of this article in *Real Time with... Show & Tell Magazine*, [click here](#).

Where Can We Improve?

Testing Todd

Feature Column by Todd Kolmodin, GARDIEN SERVICES USA

Suppliers and manufacturers alike are struggling to fill spots lost during COVID. Whether it was downsizing due to lower demand or loss due to the pandemic, we are all facing challenges on our return to full strength.

Looking at this from a high-altitude level, I wonder where we can improve. In process design and implementation, we look at the overall task, space, environment, ergonomics, facilities, and the like. We look to implement the process so that it is effective and provides the required deliverables. Right now, we are facing labor shortages that put a strain on processes that once were robust. What can we change?

One of the final stages of process development is automation. Can we automate any tasks or the process entirely? In many more challenging processes, this answer is no; human intervention is required. But even here, the shortages are being felt and throughput suffers. But we can make some changes that may be more efficient.

The word automation strikes fear in many as the first thought is loss of jobs to mechanization. This doesn't have to mean a loss of a job;

the "task" may be automated, and a human is no longer required, but that doesn't mean the human is replaced entirely. First, the key to automation is to remove the human from the tedious, repetitive tasks. The highest workplace injuries are attributed to lifting and twisting. Further, these types of tasks can introduce errors, as over time an operator can become fatigued and lose focus from a repetitive task. If there's a lift or twist injury, you might have lost time and insurance claims.

Our focus, rather, should be on automating these tasks. Lifting, twisting, and flipping can all be automated with today's handling equipment. Loading conveyers, flipping products, changing directions, and loading or unloading machines can all be accomplished by these intelligent machines. No more injuries, claims, or lost time.

Some periodic maintenance and they just keep on rockin'.

The human element can be moved to fill lost spots in other more important tasks that require critical thinking and activity. This can also help fill the voids where COVID took its

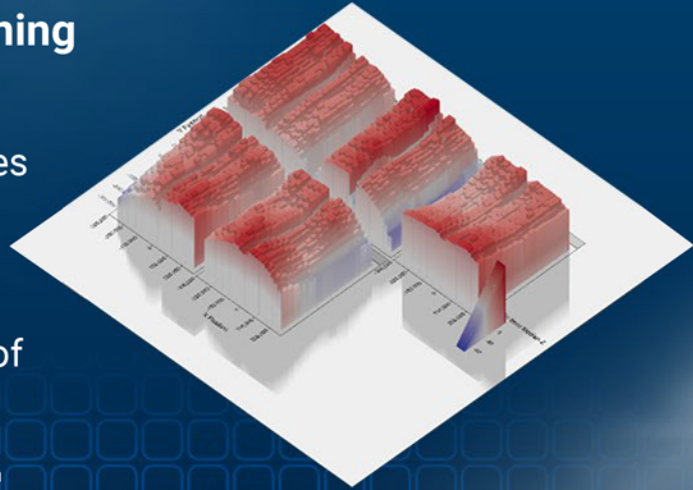


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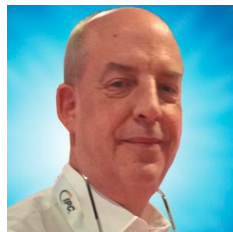


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toll. We can develop stronger employees with more interest and eagerness to learn something new; it's a win-win. So, as we look forward to changes in the upcoming months and years, let's use that higher perspective to see where we can automate tedious tasks and move those employees to more important tasks. We want them to develop meaningful skills and a greater understanding of the overall manufacturing picture in the environment in which they are placed.

Let's not look at it as employees who are losing jobs; automate the tedious and often harmful tasks, then transfer that available brain power to where it can best be utilized. **PCB007**



Todd Kolmodin is VP of quality for Gardien Services USA and an expert in electrical test and reliability issues. To read past columns, [click here](#).

Patrick Stockbruegger: Demystifying Laser Technology

Interview by Nolan Johnson

Nolan Johnson speaks with Patrick Stockbruegger of LPKF Laser & Electronics AG, whose paper, "Temperature Behavior of FR4 Substrates When Processing During Laser Depaneling," co-authored by Stephan Schmidt of LPKF Laser & Electronics Inc, won the Best Technical Paper award in the Next-Gen category at IPC APEX EXPO 2023. His paper demonstrated that the risks of heat damage to both FR-4 substrates and components during laser

depaneling may not be as high as once thought, a finding he believes could potentially make laser technology more accessible in a wider range of applications.

Patrick, you are the recipient of one of the awards for Best Technical Paper this year at IPC APEX EXPO 2023. Tell me about your paper. What was the research that you presented?

The topic of our paper was temperature behavior of FR-4 substrates during laser depaneling. We measured the temperature during processing at different distances to the cutting channel to see what kind of behavior the temperature has in the substrate; we integrated thermocouple elements into the substrate and then got a good measure of the temperature at each distance.

We did this for different circumstances. We tested different laser variants because results can vary depending on whether you're using UV or green wavelength, or different laser powers. The paper shows that what is also special about basic planning is that it is very versatile. You can cut very clean on the one hand, but on the other hand, you can also cut very fast. Also, we added a view of the clean cuts and the fast cuts on both sides because usually, we are only looking at the temperature behavior. If you are somewhere in between, you will also be somewhere in between those temperatures we measured, and that's a very interesting topic.

To read the rest of this interview in *Real Time with... Show & Tell Magazine*, [click here](#).





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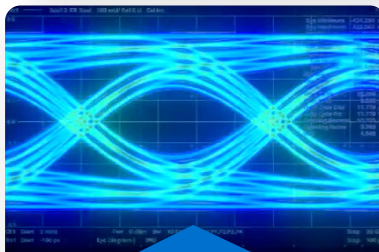
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PRACTICE
REALISTIC
OPTIMISM

A Goal of Higher Technology

Feature Interview by the I-Connect007 Editorial Team

Like many circuit board shops, Sunstone found itself climbing out of the deep well created by shutdowns during the pandemic. But 2022 was a good year, and Vice President Matt Stevenson greets 2023 with optimism. What's on his mind? He's looking closely at automation, price adjustments, a plating line, and the ongoing struggles with staffing.

Optimism

Andy Shaughnessy: *Matt, we're talking about mindset today. What's top of mind for you this year? What challenges and opportunities do you see in 2023?*

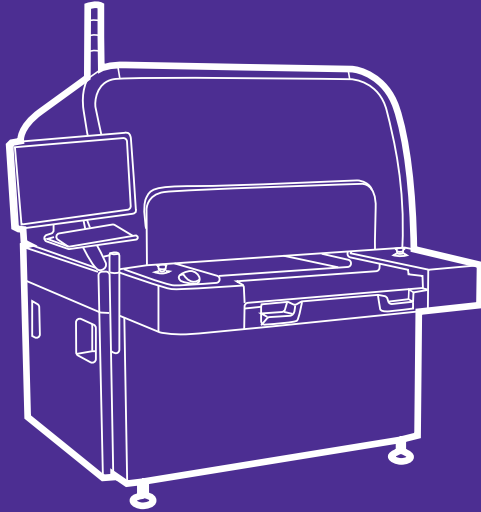
Overall, we're optimistic; last year was good and 2023 is looking even better. Some of the economic factors, customer interactions, and new customer trajectory that we experienced in Q3 and Q4 2022 left us feeling optimistic about 2023. We felt we were still climbing out of the COVID downturn last year, so it's been encouraging to see some good numbers.

We're working on attracting those new customers. People in this industry are always coming and going; there isn't a lot of switching costs, especially in the prototype industry. Tying them to Sunstone's business model, our customer support, quality, and on time delivery—this is how we retain and add more customers.

We've seen some shifts in pricing and marketing with our competitors over the past couple of years. They don't seem to be doing the same things they were before, such as spending money with publications and social media. A few have ramped up their presence, but for the most part, competitors are making changes and it may be cost-cutting or a strategy shift.

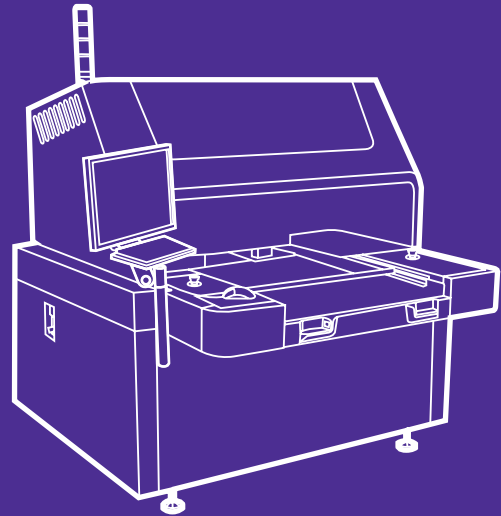
Nolan Johnson: *Matt, does that mean that you're seeing participants moving out of your space?*

That's what it looks like. They're still quoting, and trying to be competitive with their online pricing, but they're not spending the



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marketing dollars the same way that they were pre-COVID.

Johnson: Where do you think they're going?

It seems like the competitors are either trying to broker offshore or go into higher technology—something that's more direct, B2B type sales rather than the e-commerce type models. They're changing philosophies or cost-cutting a little bit to try and preserve some margin without having to increase prices.

Johnson: A few years ago, there seemed to be some new players coming into the e-commerce model for printed circuit board fabrication. Are they still in the mix with you?

Yes, but we don't see them nearly as much. Some seem to have really embraced that "brokering offshore" technology.

Johnson: What's the feedback from your customers? Are they trending toward a more traditional B2B model?

We are seeing more interaction with our customer support team, more hand holding of quotes and orders. But we still have a pretty strong e-commerce model as well, though it is shifting toward a chip-type model again, which I imagine OEMs would consider for one or two prototypes, and that's one of the areas that you focus on.

Johnson: Have you seen customers ordering less, or drift away because they've adopted 2D and 3D printed electronics?

I'm sure we've probably lost some customers to that type of model, and just not heard about it. Last I looked, the pricing is still not quite in line with classic manufacturing but could be an option when time is more important than money. The machine time just isn't quite there

yet for more than a few prototype boards but as they continue to develop the technology, and as the speed of the equipment and the material costs come down, it will be very important.

Technology, Capabilities, and Pricing

Barry Matties: What sort of equipment should be in your facility and what type of equipment do you feel should be developed for the industry?

We're looking at moving up the technology curve toward HDI; in fact, we're within a few weeks of adding controlled impedance to our online quoting. We're also looking at some of the HDI/via fill-type processes—our plating ability with higher aspect ratio plating. We're keeping our eyes on the additive manufacturing components right now; they don't appear to be a good fit for our business model, but we're open to it. We are looking for manufacturing partners who can help broaden our scope into flex, where we don't currently have the capabilities or the equipment. But we have customers who want that and reach out to us about it.



“We're looking at moving up the technology curve toward HDI.”

Matties: What's your typical work now?

Though we see a heavy mix in the two- and four-layer boards, the technology of most of the work continues to increase (tighter spaces, smaller holes, more layers etc.).

Matties: There's still a strong market in that space, though, isn't there?

There is, but it is becoming more price sensitive at the lower technology levels. Offshore pricing and even some of the domestic pricing on those simple two-layer boards are becoming more difficult to turn a profit on and we continue evolving where the technology is headed.

Matties: *How do your customers react to your pricing structures? Obviously, increases are resisted, but you have to do what's right; you can't exactly send a \$20 bill with every board you ship.*

Though some customers gripe about rising prices, they know it needs to happen. For too long in this industry, there wasn't a lot of pressure to make price increases; manufacturers were able to remain fairly flat. We weren't getting many price increases from our suppliers, so everything just rolled through. But over the last two years, pricing on everything—labor, insurance, raw materials, transportation, equipment, everything—has risen rapidly. I believe manufacturers are being forced to raise prices out of good business sense.

Johnson: *Matt, does that change how you approach your business model? Does adding different capabilities and regaining margin create an opportunity to pivot?*

We are actively looking for higher technology work that will give us better dollars per panel—similar sales dollars utilizing fewer panels. With some of the bread-and-butter stuff we've done over the past 20 years, the volumes are eroding and the pricing hasn't been able to keep up with the expenses. We are actively looking to enhance our offerings while keeping our customers happy on the lower end of technology.

Johnson: *What do you want the product mix at Sunstone to look like a year from now?*

Ideally, we would be implementing our technology roadmap and garnering a larger share of that higher complexity business. I would like to see a higher percentage of our revenue come from that type of work. It would be nice to keep the overall growth trajectory and the mix in our shop different from day to day.

Matties: *Matt, you had mentioned flex, additive, and so on. Where would you rank those in terms of priorities?*



Matt Stevenson

Those are not a priority in our shop today, but we don't have our head in the sand either. We are looking closer at additive technology as a complementary product within the scope of what we do well. Flex is another option we are exploring but it is different enough and would require a different level of attention and dedication to do well with high quality and we have not yet prioritized it in favor of some of the other initiatives. However, with a solid partnership on the flex side, we can service our customers' needs and continue utilizing Sunstone for their circuit boards.

Matties: *Where is the R&D being driven from in circuit board manufacturing?*

Overall problems with staffing and labor shortages in the U.S. are driving more automation and more additive processing where less labor will be needed. Classic circuit board manufacturing is a wasteful process, in general. From an environmental standpoint, it's probably being driven toward additive; it seems more logical as we progress in technology overall. Similar types of additive technologies, like 3D printing, are constantly getting better, and driving other technologies forward. As everything

moves in that direction, circuit board manufacturing will as well.

Johnson: *If you just had one piece of equipment that you could buy today, what would it be?*

There are so many that we would really love to have. Ultimately, we would probably look at an enhancement to our solder mask process (LDI or mask printer) or more of an automated copper plating process.

Matties: *You must choose just one, Matt.*

I'd choose the plating line; I would rather go in that direction first, but with the limitations in floor space in our shop, it would be a tough install.

Johnson: *Take the floor space out of this thought experiment. What one piece of equipment would be the greatest ROI to your current process?*

Probably the plating line. It would increase our capability and consistency with the higher aspect ratio plating holes, which is where our current roadmap is headed. Our current solder mask process probably has several years before it starts being pushed by technology. Overall, being able to metallize those higher aspect ratio holes consistently and effectively would be the single best piece of equipment we could purchase.

Managing Costs

Dan Feinberg: *What does your cost cutting look like? Is it by volume, where you can get better pricing on materials? Are you automating, so you can sidestep the increasing labor costs? What is the success behind that goal?*

We're attacking it from as many sides as we can, as we add equipment and capabilities. With every equipment upgrade we look at potentially adding some level of automation to minimize labor impacts. We're also looking at different chemistries and materials, as well as more efficiencies within our processes. We're looking to reduce some of the overbuild panels and boards that we have currently so that there's less to recycle and still meet customer needs. We've had fairly stable pricing in terms

of materials, but that is increasing. Our

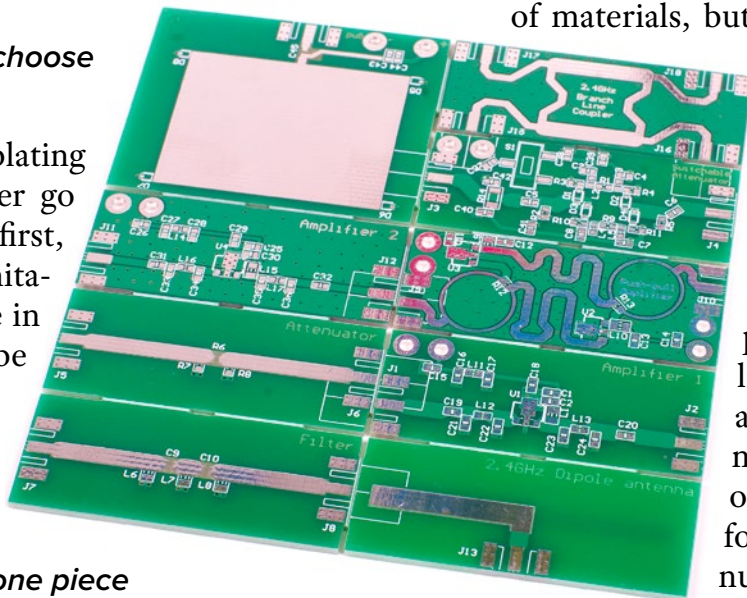
material vendors are fair with pricing. Volume isn't necessarily a very effective approach as a cost-cutting measure for us. As the volume goes up, the unit price decreases, the dollars per panel decrease, and labor becomes a much bigger percentage of those orders. The path forward is increasing the number of boards within a panel and improving the

capabilities aimed at higher dollar value per panel.

The Value of Marketing

Matties: *It sounds like, for you, the key factor is marketing to pick up a higher volume of more profitable part numbers.*

Yes, marketing has always been one of our key components. Unlike most circuit board shops, Sunstone has always had really effective and strong marketing. We continue to do so. Our challenge for this year and the next is to flip the perception that Sunstone is only a low tech, fast board shop. We want to be understood as being capable of higher production and higher capabilities—still fast, still high quality, and still reasonably priced.





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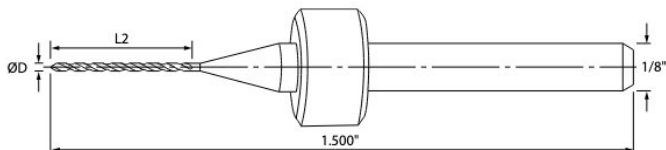


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4 Facet Point Geometry

REPOINTING will be a new service offered by Insulectro through Kyocera. The company has recently invested in automated, state-of-the-art equipment and all repointing will be done in Southern California.

CHIPs Act and Government Funding

Happy Holden: *Matt, when you say a higher dollar volume panel, what dimensions are there? Is that more layers, finer lines, smaller holes, and higher aspect ratios, or special things like cavities or plated edges that would provide higher dollars per panel?*

Yes, it would be more layers, different copper weights, thinner materials, controlled impedance, smaller holes, finer lines, filled vias, blind/buried vias, and more gold surface finishes on our core products. We will continue to advance with the microwave and RF products, those with the real fine and intricate two-layer products built on the Rogers materials. These have decent dollars per panel, especially due to the panel sizes being so small that even the dollars per square inch are relatively high.



“We’re still struggling to get employees when we need them.”

Staffing and Automation

Matties: *In our previous conversations you have mentioned employee turnover and training as an area of concern. How have you addressed those?*

We’re still struggling to get employees when we need them. It feels like we always have two or three openings that we need to fill. That level of unfilled positions is not too bad compared to some other local manufacturers, but it is definitely a change from a few years ago. It seems to take much longer to find a good fit—both for the work and for the culture of Sunstone.

Matties: *As you’re in a rural area, location might be a concern; it limits your pool to draw from.*

The good news is we’re centered among three good-sized communities, which makes the

local interest pretty good. The rural aspect does present several challenges; we’re not on a major bus route—the bus only runs eight to 10 hours a day—so it’s not a viable option for those on the off-shift who don’t have reliable transportation.

Matties: *What would be your labor savings if you had that automated plating line? Would the three job openings still exist?*

We could probably reduce labor by a person or maybe two if we had an automated plating line; we’re running about two plating operators per shift, so we might effectively be able to either repurpose or reduce headcount by a couple people with an automated plating line, but the real benefits are in the quality and consistency of the product.

Matties: *You would see quality improvement, of course, because every time you bring in new people it magnifies the potential for error.*

Yes, and it would improve our waste treatment processes by having a more automated solution. With all the bells and whistles on the rinses and everything else, it would make it more consistent.

Matties: *Right, and then if you automate the dosing, you eliminate all that handling of chemistry as well.*

You have the safety, extra handling, lifting, everything—you’re right.

Matties: *There you go; you do have some choices, though you mentioned the lack of U.S. suppliers. You have some hopeful choices who are committed to supporting the U.S. market as well.*

We appreciate our long-term partnerships.

When you start looking at all the higher-end technology, aside from reducing labor costs, obviously it would increase your capability and drive markets, and that would accelerate your ROI.

It would bring in additional work and an additional higher-profit margin.

Matties: *Yes, and it would increase the work.*

It would definitely accelerate the ROI beyond just the labor component—the quality component.

Matties: *What is the bottleneck right now in your facility?*

Plating is probably our next big bottleneck. It had been drill—and depending on product mix as it comes in, drill sometimes can be our bottleneck—but it's moving over toward the plating area. Again, another check for looking into that project.

Shaughnessy: *Matt, regarding labor, do you have relationships with colleges or tech schools nearby? How do you stay on top of that to keep a pipeline going?*

Yes, we have a good relationship with a local community college that has a manufacturing technician course of study. I'm on the board for that program, so we use that leverage to add

courses that will help our employees be more successful working at Sunstone—and have more appetite for it as well. That's probably our main source. We work with some local universities for designers. We could potentially bring people in for design help and get help through those programs as well.

Shaughnessy: *Are you hiring right now?*

We currently have four openings, all of them off-shift in the manufacturing department. They're all attrition at this point.

Shaughnessy: *Many of your staff members have been there for 20 to 25 years.*

Our average length of service is 12 to 13 years. Rocky Catt, one of our owners, has been here almost 50 years; we have a couple other 40-plus-year employees and several 10-plus-year employees. It's been a good place to spend a career.

Shaughnessy: *Well, you must be doing something right. That's good. Matt, thank you.*

You're very welcome. We're always willing to sit down and talk with you guys. We learn a lot, and hopefully you get something from it as well. PCB007

Download *The Printed Circuit Designer's Guide to... Designing for Reality* by Matt Stevenson.



Finishing the Job the **CHIPS Act** Started

American Made Advocacy

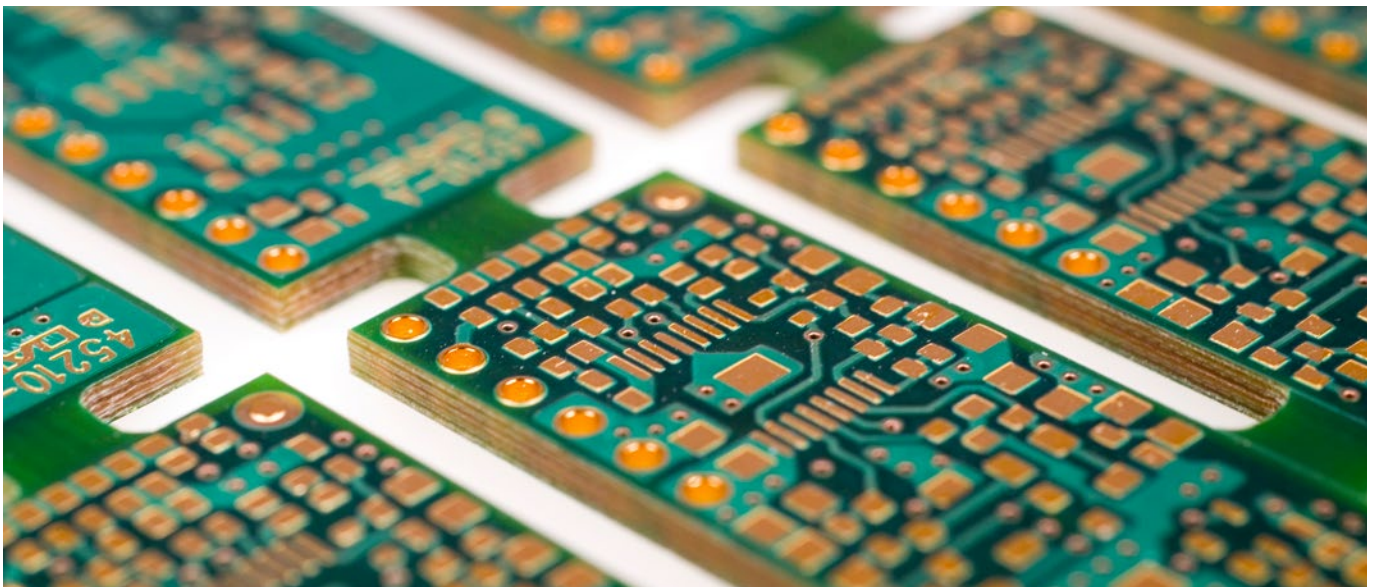
by Travis Kelly, PCBAA

I was pleased to see that President Biden mentioned the CHIPS Act during the State of the Union Address this year. That bill succeeded because lawmakers saw semiconductor manufacturing as a pressing national level issue. The CHIPS Act is a great first step in restoring one aspect of high-tech American manufacturing. What is missing from the dialogue in Washington is the rest of the micro-electronics ecosystem.

As printed circuit board suppliers and manufacturers know, our American PCB industry once claimed 2,200 companies and 30% of the world's supply. When the semiconductor industry's share of chip production fell to 13% of the world's supply, alarm bells went off inside the beltway; the result was the CHIPS Act.

Now that the U.S. can only claim 4% of the world's semiconductor supply, those same alarm bells should be sounding. Our challenge is to educate members of Congress and policymakers on the role PCBs play in electronics manufacturing. Few people outside the industry understand that semiconductors don't go straight into the electronics we all depend on. Every single chip—no matter how advanced—must be mated with a PCB before it's integrated into a telecommunications hub, electrical transformer, air traffic control system, or any other piece of critical infrastructure or consumer electronics.

PCBAA is educating members of Congress and their staffs on the critical stage we find ourselves in. We can't let them think that the CHIPS Act is a "one and done" effort that



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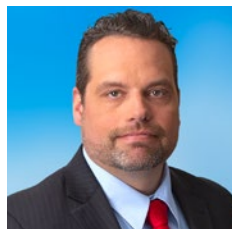
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needs no companion. In reality, the CHIPS Act doesn't solve supply chain problems because it doesn't adequately address the rest of the ecosystem. Few officials we speak to have any idea that we don't have the adjacent manufacturing capacity to create the entire technology stack. They don't know that we will be sending the chips made in the new fabs back to Asia for packaging.

In this session of Congress, we will see new legislation introduced that would revitalize American PCB manufacturing by funding R&D and workforce development, as well as creating incentives to buy American-made PCBs. Congress needs to act this year to set this recovery in motion and finish the job the CHIPS Act started. This is not an overnight fight. It took us decades to get to where we are

today, and it will take years to bring a meaningful amount of manufacturing back to the U.S.

To be successful we need your help. By joining PCBAA, you are expanding your influence over the future of the industry and giving us more power in Washington. Many voices matter. Join us, then contact your elected representatives and let them know how important this industry is to American high-tech manufacturing. **PCB007**



Travis Kelly is CEO of Isola Group and current chairman of the Printed Circuit Board Association of America. To read past columns, [click here](#).

Lothar Henneken, PhD: Shedding Light on Reliability Risks

Interview by Nolan Johnson

Nolan Johnson speaks with Lothar Henneken, PhD, of Robert Bosch GmbH, whose paper "Risk Prediction of Electrochemical Migration on Electronic Control Units—A Practical Approach," was one of three papers that won the prestigious Best Technical Paper award in the Best of Conference category at IPC APEX EXPO 2023. [Dr. Henneken's] paper, which was presented during Technical Conference Session S25: QRTI-Assembly Risk Prediction and Failure Analysis, on Wednesday, Jan. 25, sought to mathematically model the risk of electronic failures in relation to climate-related factors, such as local humidity, as well as a device's physical properties and the voltage applied.

Dr. Henneken, you received an award for one of the best technical papers at IPC APEX EXPO this year. Tell me about it. What was your topic?



My paper is about the reliability of electronics depending on the situation they are in. In a harsh or humid environment, the surface of electronic boards can get a little bit wet, which can cause undesirable parasitic currents or shorts; but determining the likelihood of such failures occurring is highly complex. It depends on the local humidity and the microclimate inside the device and the distances, so fine pitch components are more critical than larger components. It's also driven by the voltage that is applied. It's very important for the world because complexity is just going up and up, meaning that we have a higher risk of such failures.

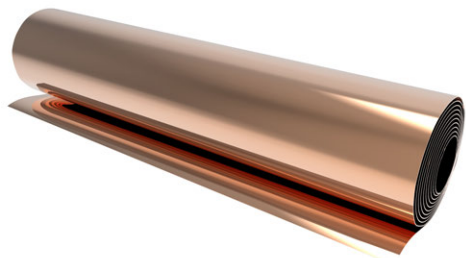
To read the rest of this interview in *Real Time with... Show & Tell Magazine*, [click here](#).

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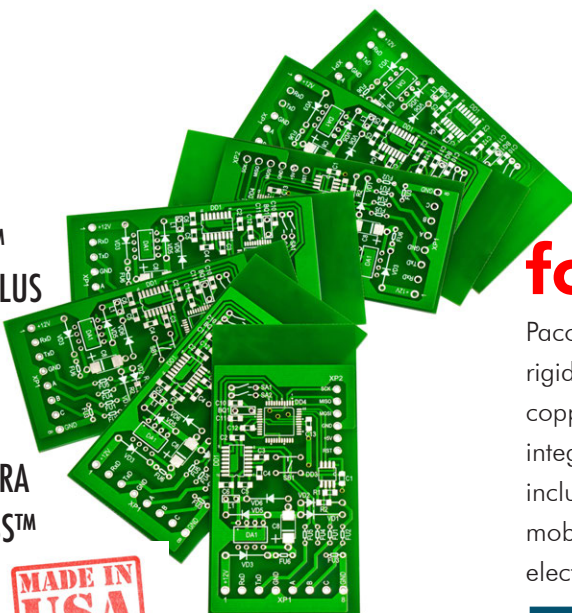


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MilAero007 Highlights



Printed Circuit Boards Have Champions on Capitol Hill ►

House Resolution 7677 from the 2021-22 Congressional session may have run out of time before the election cycle, but that hasn't ended the effort to help fund the printed circuit board industry alongside the semiconductor industry. IPC vice president of global government relations, Chris Mitchell, shared this letter, sent to DoD on Wednesday by Reps. Anna Eshoo (D-CA) and Blake Moore (R-UT), which insists DoD must "leverage all available resources, including the use of Title III of the Defense Production Act (DPA), to increase domestic production of PCBs and IC substrates."

A Conversation With 'The Space Gal' ►

With multiple advanced degrees in aerospace science, Emily Calandrelli could have had her pick of any project in earth and space science. Instead, she has chosen to use her skills in science policy and communication to break down complex science topics, advocate for women in STEM fields, and bolster enthusiasm for the next generation of scientists through her own Netflix show and an active slate of social media accounts. In this interview, Emily talks about her unconventional entry into science, what's ahead for space commerce, advice for industry leaders, and what she really thinks about going into space.

TTM Adopts Special Board Resolution with DCSA Replacing SSA ►

The replacement of the SSA with the SBR is a result of the significantly reduced foreign ownership of TTM. The effective date of the SBR is February 2, 2023.

Real Time with... IPC APEX EXPO 2023: PCBAA Legislative Update ►

PCBAA Chairman Travis Kelly and Editor Nolan Johnson discuss the association's activities, including legislation in the range of \$3 billion to \$5 billion that follows the CHIPS Act, and why Congress needs to support the PCB industry as they did the semiconductor segment.

FTG Announces Full Year, Q4 2022 Financial Results ►

Fourth quarter bookings of \$32.2M were up 15% over Q3 2022 and up 37% over Q4 2021. This was the eighth sequential quarter of bookings growth.

Flexible Thinking: A Once and Future Idea ►

Electronic assemblies are typically comprised of a mix of discrete resistors, capacitors, inductors, and the like, along with numerous integrated circuit chips, each chip having a certain function or range of different functions. In such assemblies, there are also several different connectors and/or sockets that allow for the assembly to be connected to other assemblies. Making interconnections between and among these many and various active and passive devices is the job of the circuit designer.

Nordson Corporation Appoints Sarah Siddiqui as Chief Human Resources Officer ►

Nordson Corporation announced that Sarah Siddiqui has been named executive vice president and chief human resources officer, effective February 20, 2023.


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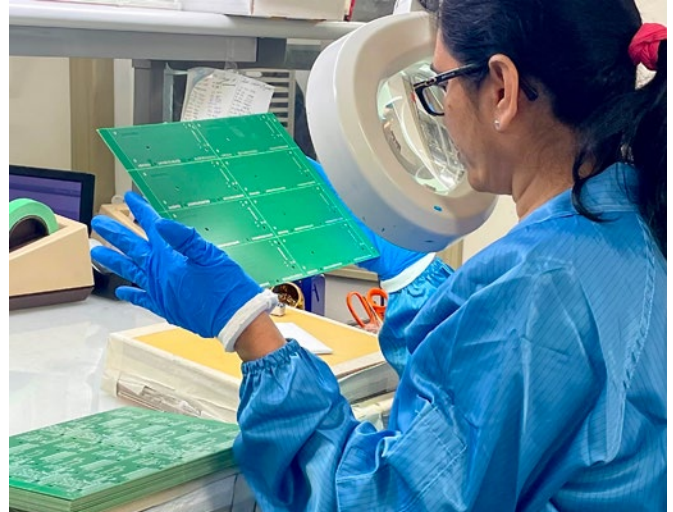
Feature Interview by Barry Matties

I-CONNECT007

The I-Connect007 team paid an onsite visit to American Standard Circuits in West Chicago, Illinois. While there, we talked at length with CEO Anaya Vardya about the issues on his mind as he pushes technology, expands his floor space, and considers the implications of the CHIPS Act, staffing issues, and what's happening in China.

Anaya, regarding new technology, is it usually customers who approach you and say, "Can you build this?" Or is your team saying, "Here's the next technology; we need to be prepared"?

In most cases we are listening to our customers and making our technology investments



or driving our technology direction based on that. Our customer base wasn't big into HDI for many years, but we've worked on putting in all the different processes for registration, plating, etc., as opposed to just buying a laser.

If you buy the laser, but you don't have everything else set up, it doesn't matter. We've chosen to subcontract the laser for a long time and we're ready now to do it ourselves. We found that for some things we've been doing, we've become noncompetitive, especially from a cycle time standpoint. If we have to go to a laser service three times to build a circuit board, that's three or four weeks you've missed.

When we decided to invest in manufacturing pre-bonded boards on aluminum, we knew that it was a very specialized process to plate those blind vias. We decided



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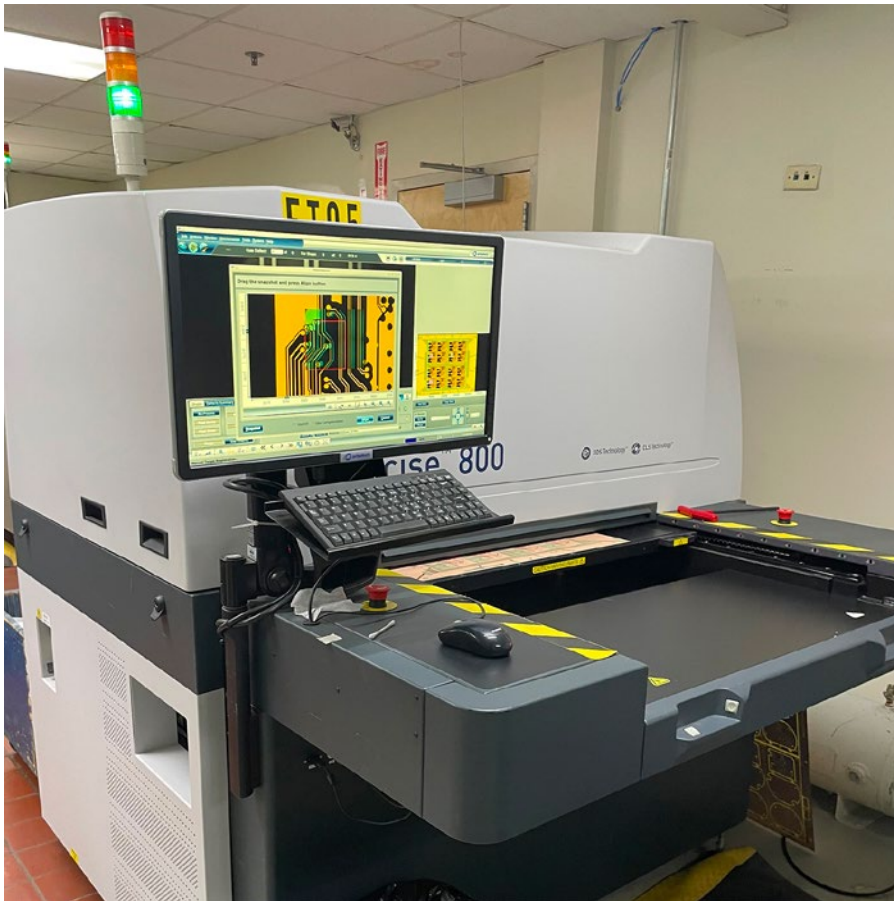
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started to utilize it also. Now you see more military designs that are acquiring HDI or complex and ultra-complex via structures.

Now, many people say producing HDI costs more money; Happy Holden, who wrote the book on HDI years ago, says it actually saves you money. Where are your thoughts on that?

You must look at it from a value standpoint. It's like a rigid-flex board. If you look at the flex piece and the rigid piece separately, it's easy to conclude that the rigid-flex board is obviously more expensive. But you could be saving your money in space and increased reliability because you're not assembling

to make that investment and purchase a sputtering unit. We did all that before we had a single customer for it. The Averatek process was the same thing. We made this investment because it makes sense; then we'll go find the customers.

I would say 80% of our investments from a technology standpoint are driving toward what customers are looking for, or because of quotes we have to no-bid right now.

Are the customers moving to HDI for functionality and/or cost reduction?

It's functionality for sure. But aerospace defense is always a late adopter. The world has been doing HDI for about 10 years, or even earlier for consumer products. From there, some of it ended up in networking boards, as BGA patterns got very dense. When you have thousand-IO BGAs, you must have a way to fan it out. Then it ended up in microvias. But about five or six years ago, the military

started to utilize it also. Now you see more military designs that are acquiring HDI or complex and ultra-complex via structures. One has to look at saving money from a total system perspective.

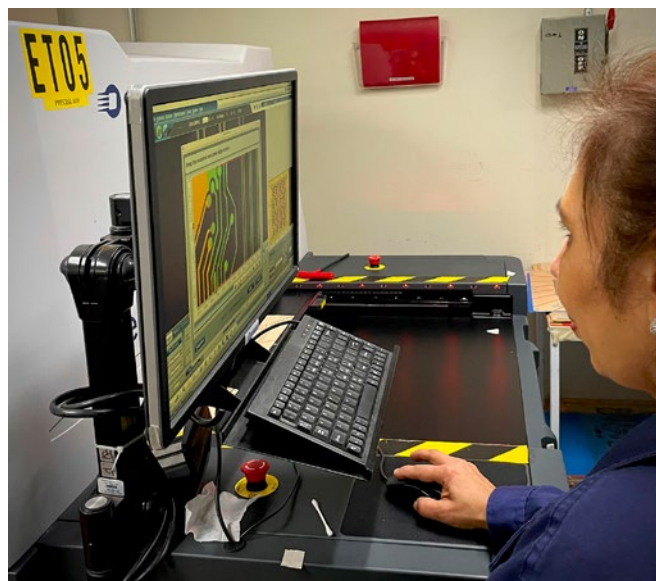


Now you have a regular six-layer panel with microvias. Well, guess what? That six-layer panel with microvias will cost you more money, there's just no doubt about it. Is it cheaper? It could be, compared to any alternative way to get to the same solution. That's really the point: HDI is expensive, but what is the cost of the real alternative solution, such as when you must put 40 layers in a board vs. eight? Suddenly, you are saving money. That's how you answer it. You look at it holistically.

Ultra HDI is getting attention right now from the marketplace.

It's just beginning. Part of it is designers being aware that it's available. Let's not kid ourselves, ultra HDI has been practiced in Taiwan for years. It's all about continuous education and customers now wanting domestic production of ultra HDI boards.

Do they look at it as a matter of practice, or is it typically a design cycle rev when they start looking at these things?



I think it's design revs. If you have a stable design, then nobody will cost-reduce it by putting microvias in. I don't think that ever happens. But in the electronics world we live in, technology is evolving so rapidly that eventually you change on some level. As you make those changes, you're incorporating the latest knowledge, newer components, and other things which require tighter fadeout patterns. Suddenly, you start doing these things.



Are you doing active embeddeds or anything like that?

We have an active R&D project we're working on for a customer where we will do an embedded chip that will be attached to a copper slug and then buried in the circuit board.

That's a whole different level of manufacturing because the cost of waste or scrap is quite expensive once that active is in there. Is this a new endeavor?

We do a lot of embedded passives, obviously, but embedded active is new.



Do you see a growing market for this?

Yes, it seems like there is a growing market for embedded actives also.

How important is quick turn right now?

The demand is starting to pick up for quick turn. People have gotten smarter. If they're going down a particular design path, they try to specify their components early. They try to at least source—in a lot of cases the very critical components—so that they don't end up having sourcing issues. That was a learning experience that everybody had to go through.

The Asian Market

Are you paying attention to the Asian market and the shifts happening there? Apple is moving out of China to some degree, reducing its footprint there, and we see a lot of money being invested elsewhere.

Ultimately, customers will drive the behavior. People say they want to get out of China, but the reality is that even with tariffs on circuit boards, they're just more expensive in any other country. We've explored facilities in India, but from a price standpoint, nothing beats China.





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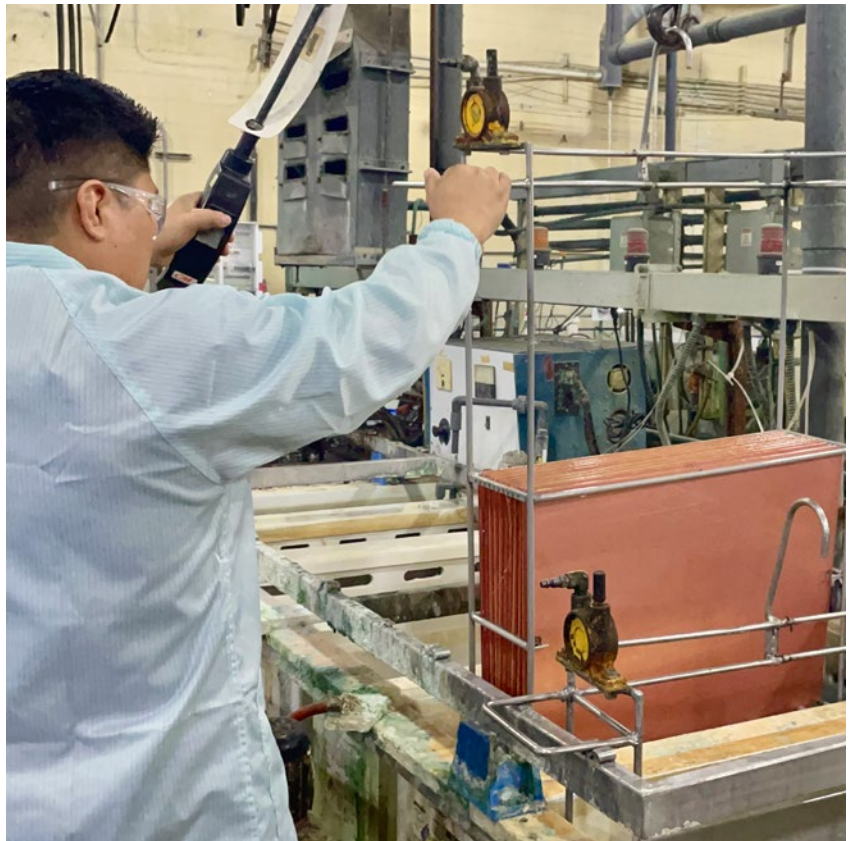
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Do you think India can make a play to be competitive?

It could be what happens. Unfortunately, they're getting all their raw materials from China, so that's one of the big issues. China has done a great job of setting up the entire infrastructure in the country, from laminate to the whole supply chain. That's why they can produce at such low cost; it's all right there.

We hear a lot about Connected Factory 4.0 on the assembly side. What's your take on the fab side?

We have ideas on that. With all the software we've put in, now we have a closed loop between the smart drill and our engineering system to be updating the scaling factors automatically. For example, we want to get to a point that you can actually do a virtual cross-section on the X-ray machine, so if you have a bad board, just throw it out at that step in the process. Don't even bother to put any more value on it at that point.



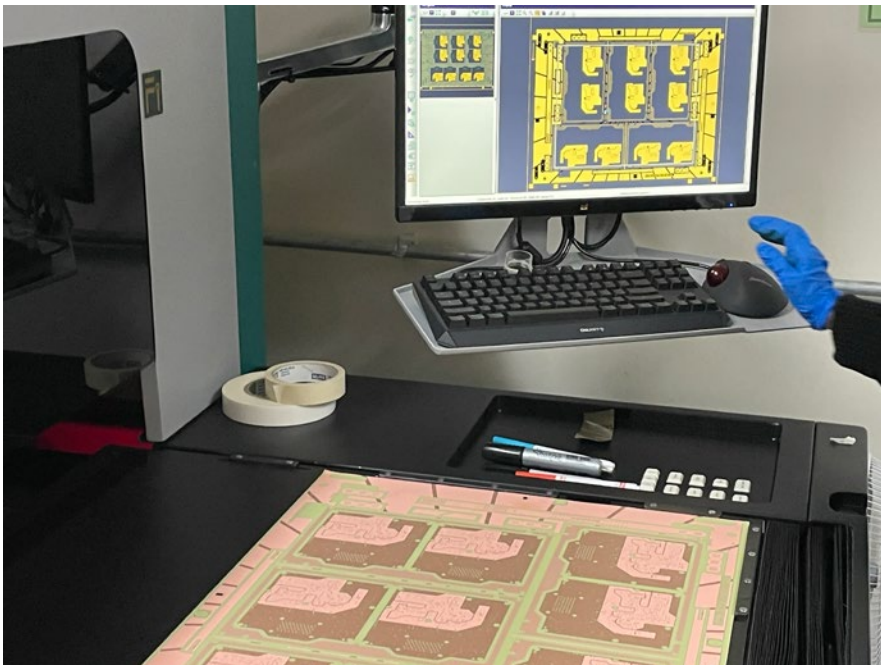
We are talking about serialization, of course—getting it to the point that we have complete traceability of every panel that's running through the factory. We had some interns work on an IoT project where you put sensors on your etch/strip processes to figure out

what's going on with the chemistry, temperature, and pressures, and recording that data. Our long-term strategy is to understand what has happened to every panel as it's processed through the factory.

Sensors: The Smarter/Smartish Factory (Industry 3.75)

In terms of all the data, what's the most important data to you?

I would say the data in understanding the customers who are growing and the custom-





ers who are not; that's a very important thing for me to understand. What can we do there? Our focus has been to keep growing, and if you do it all correctly, you hope the profit occurs. It's not always how it works, but that's how it should work.

So, having data about how your customers are performing is your best chance for success?

Yes. We're focused on growing the top line and trying to be at the leading edge of technology. Clearly, we've transitioned from leading to bleeding. Where a North American marketplace is concerned, of course, bleeding to some is not bleeding to others; it's a relative term. We try to have a mix of product in our facility, as we don't want 100% HDI product.

Is that because it's risky?

Yes, but it requires a lot more engineers than we currently have. We're always looking

to have a mix, and in business, that's a very good thing. I've always been a proponent of diversification and high standard deviation in terms of the mix. That's what we push for.

Anaya, we certainly appreciate all your time and hospitality.

I would like to thank you and the rest of the I-Connect007 team who visited us today and for taking time out of your schedule. **PCB007**



Processes to Support IC Substrates and **Advanced Packaging**, Part 2

Trouble in Your Tank

by Michael Carano, IPC CONSULTANT

Introduction

In last month's column, I framed the initial challenges for the PWB fabricator to be successful in producing IC substrates to support advanced packaging. In this month's feature, I'll explore two more areas of processing that fabricators need to master:

- Imaging/developing
- Etching

Fine-line Imaging/Developing

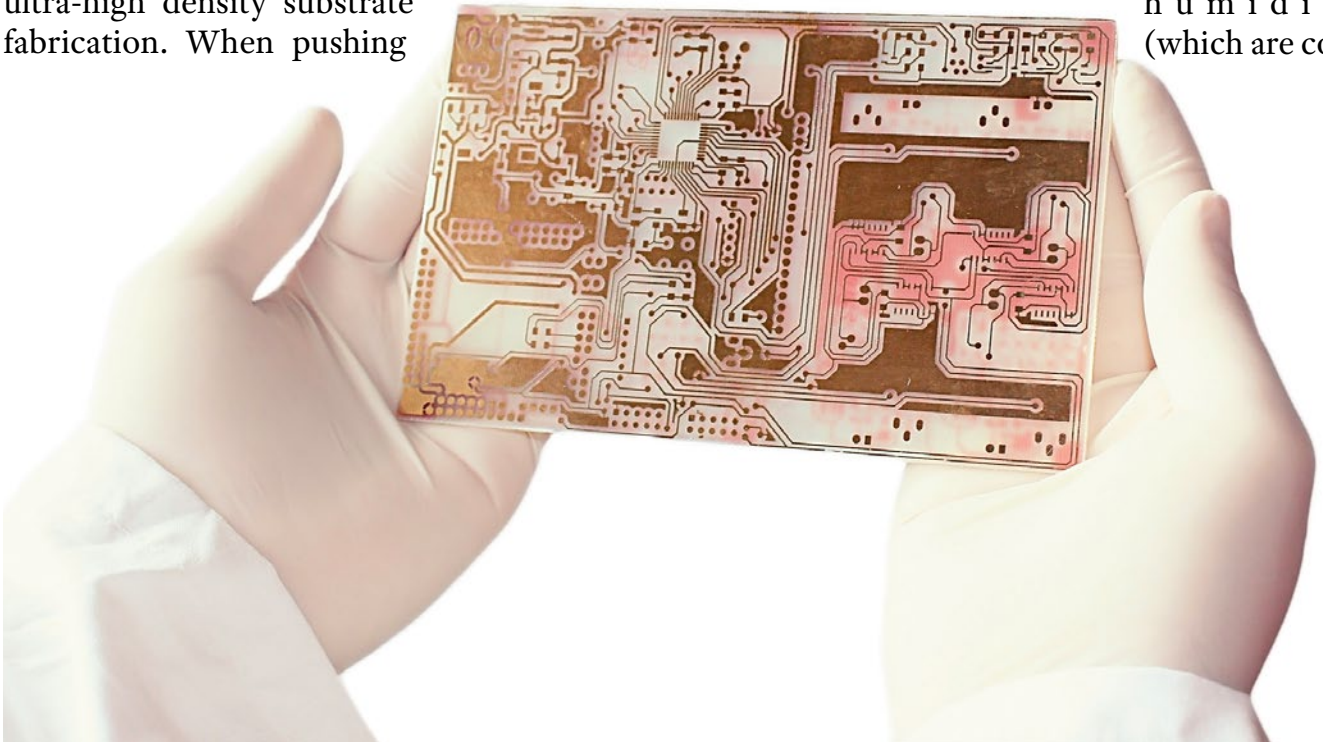
One must understand that photolithography is the cornerstone of advanced packaging and IC substrate production. Laser direct imaging is now a must for high density and ultra-high density substrate fabrication. When pushing

the limits of ultra-high density, conventional contact printing falls short. Usher in the development and implementation of laser direct imaging (LDI).

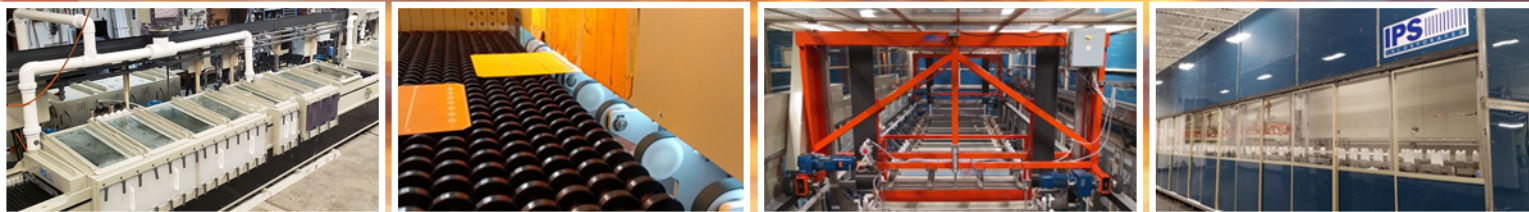
The capabilities of LDI systems provide several advantages over contact printing. Examples include the fabrication of boards with tight registration tolerances. In addition, the pattern is printed directly from the CAD system and does not require a phototool.

With respect to contact printing, registration errors occur due to dimensional changes in either the phototool or the panel. These dimensional changes happen because the materials used for the mask and panel (such as FR-4) vary in size as a function of temperature and

h u m i d i t y
(which are con-



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trolled in the typical fab environment to $\pm 2^{\circ}\text{C}$ and $\pm 5\%$ RH, respectively).

There are five steps to creating the circuitry:

- Surface prep
- Resist lamination
- Exposure
- Development
- Etching

Take a close look at the exposure process. With LED/LDI, one hears the term depth of focus (DOF). Setting up the correct DOF is critical to achieve optimum resolution. In turn, incorrect DOF will result in either line or space growth or off-contact and twisted rope defect. It is important then to insure the correct DOF.

Another “must” is to find stress points in the imaging process. One can accomplish this by using test patterns such as fine line spirals or fine lines and spaces. This should include graduated lines and spaces, including 100-, 75-, 50-, 25-micron lines and spaces. It is also important

to recognize that this type of evaluation will provide a deeper understanding of additional process parameters that influence the resolution of the image. As an example, higher exposure energies increase resist adhesion. Furthermore, copper foil type (ED, RTF, RA), surface preparation techniques, and development breakpoint influence the resolution of the image. Certainly, never underestimate breakpoint. An example of early breakpoint is shown in the schematic in Figure 1.

Even under ideal exposure energy and surface preparation, the risk of resist width reduction is highly likely. An actual SEM of the issue is shown in Figure 2. Early breakpoint leads to over-developing and undercut. And this causes a reduction of line widths on inner layers.

Etching

Developing and etching are connected at the hip, so to speak. As a cardinal rule of troubleshooting, everything is connected. It is neces-

sary to understand that etching, whether alkaline or acid, is isotropic. This means as copper is etched away in the Z-axis, there is also copper removed laterally.

With respect to etching, key process parameters must be tightly controlled. Alkaline ammoniacal etching is utilized for inner layer and outer layer etching. Regardless, the key parameter to control fine-line etching is the pH of the alkaline etching solution. Maintaining the pH of the alkaline etching solution between 8.0–8.2

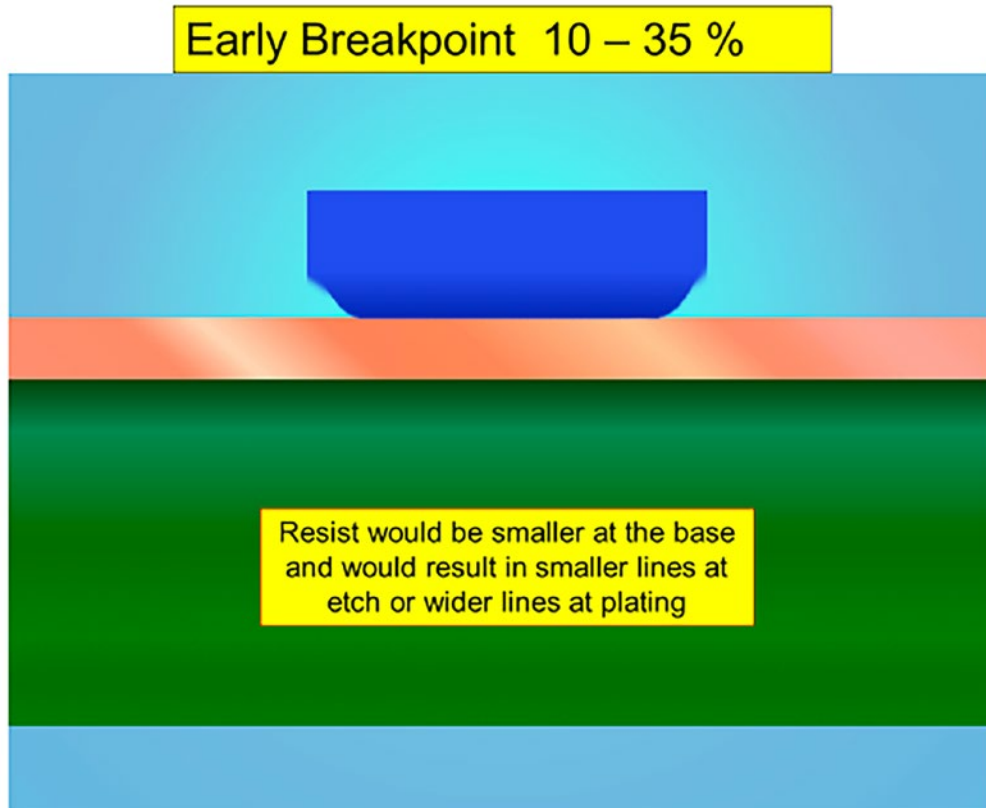


Figure 1: Early breakpoint in development.
(Source: Tim Blair, Tim Blair LLC)

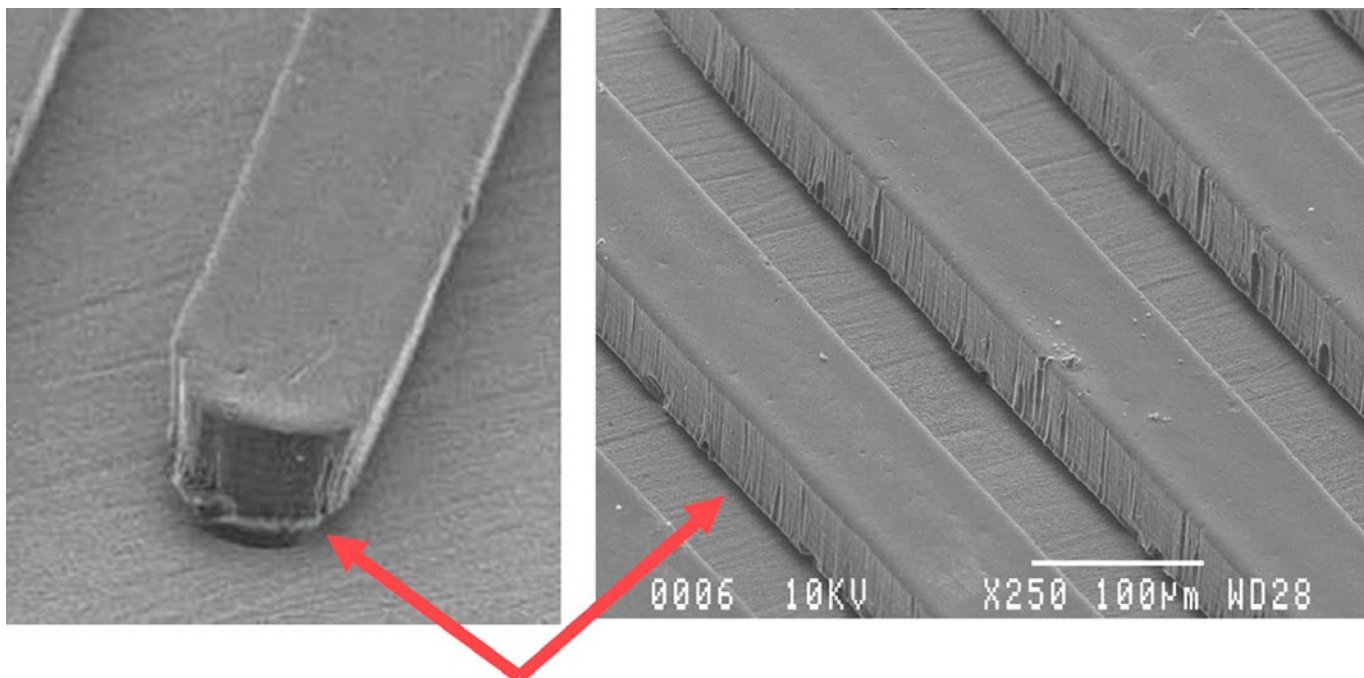


Figure 2: Over-developing due to early breakpoint. (Source: Tim Blair, Tim Blair LLC)

enhances the ability of the process to reduce lateral etch and undercut. Certainly, specific gravity of the solution is important as well. Maintaining the specific gravity within the upper range of the control limits reduces lateral etch.

On the other hand, acidic etchants, such as cupric chloride, are used only on inner layers. This etchant is incompatible with metallic etch resists. However, acid etching provides a more favorable etch factor and less undercut than alkaline etching. It has been reported that controlling acid etchants at very low free acid normality improves the etch factor¹.

There were additional studies that compared etch factors with different etchants as well as photoresist thickness. The earlier work of T. Yamamoto, et al,² shows the beneficial effect of wider etch channels and thinner resist. The above referenced work also lends credence to the benefits of cupric etchant in terms of undercut vs. alkaline etchants.

There are circuit density limitations related to subtractive etching. This is a well-known fact of life. The longer it takes for the etchant to remove the unwanted copper, the greater the

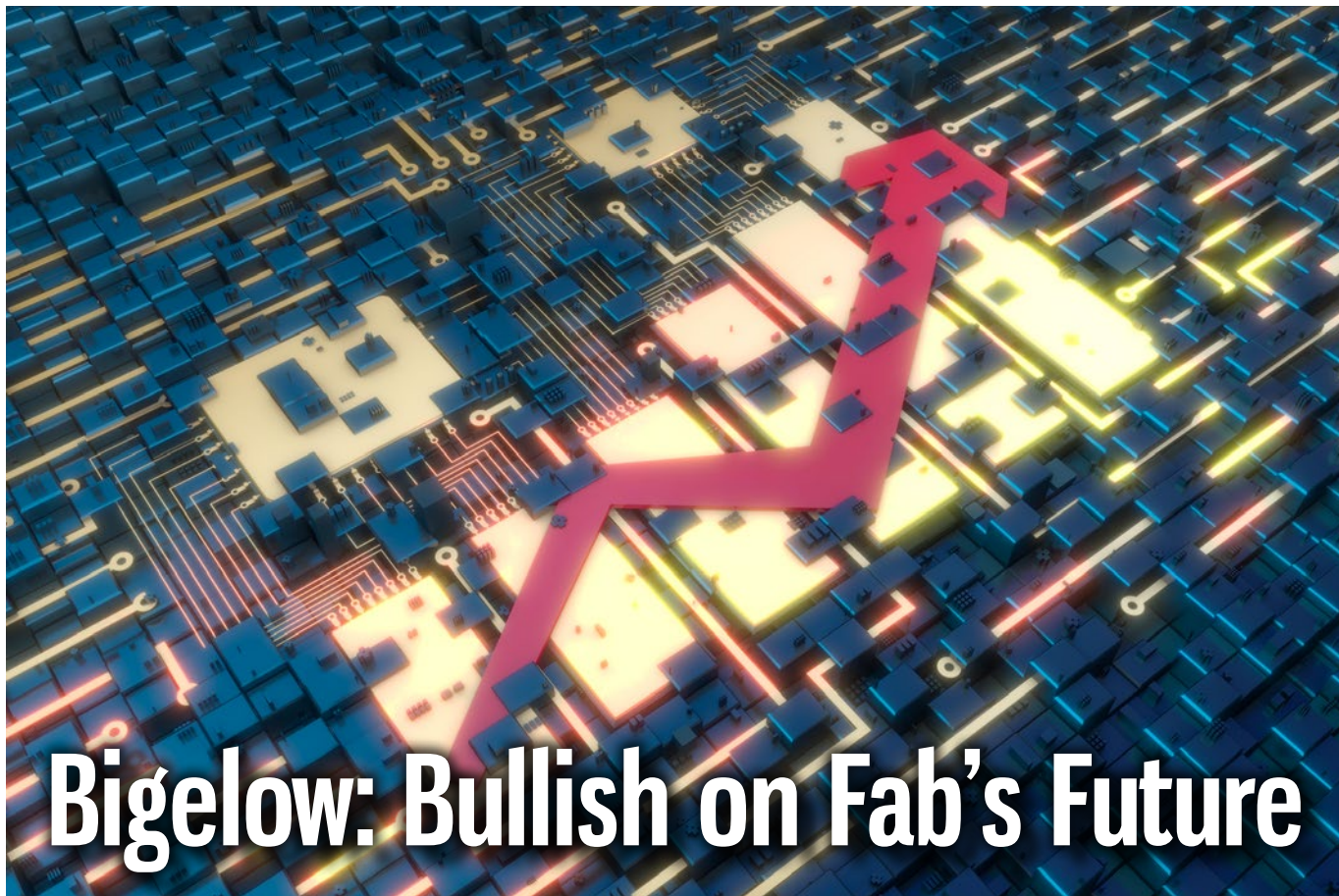
opportunity for undercut and reduced trace width. Moving to semi-additive processing and thinner copper foils or the use of dielectric films will improve the etch factor significantly. More on these processes in a future column. **PCB007**

Resources

1. "Fine Lines in High Yields, (Part CXXV): Fine Lines—Beyond the Limits of Semi-additive Processing?" by Karl H. Dietz, *CircuiTree Magazine*, February 2006.
2. "Allowable Copper Thickness for Fine-Pitch Patterns Formed by a Subtractive Method," by Takuya Yamamoto, Takashi Kataoka, and John Andresakis, *CircuiTree Magazine*, June 2000, Volume 13, No. 6, pg. 112 (see also Proceedings of the Technical Conference, S-07-3, IPC Printed Circuit Expo, San Diego, CA, April 4-6, 2000).



Michael Carano is an experienced executive in specialty chemicals, medical device, printed circuit boards, and semiconductor industries. To read past columns, [click here](#).



Bigelow: Bullish on Fab's Future

Feature Interview by Nolan Johnson

I-CONNECT007

Twenty-plus years is a long time to lead a business during a long decline in the industry, but IMI President and CEO Peter Bigelow remains quite confident about the future. The company is in a strong financial position, running well, and looking at new technologies. So, what's his biggest challenge? It's not much different than any other manufacturer you talk to, and while he may not have all the answers, he's clearly got insight to share.

Peter, as a PCB fabricator, what's happening in the industry? Talk about the changes you're seeing.

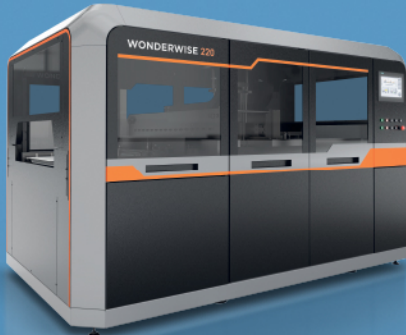
The past 18 or so years have been pretty miserable because the industry has been shrinking. We've had all kinds of turmoil in that regard. However, even with this rough period, I'm

quite optimistic and enthusiastic about where we are.

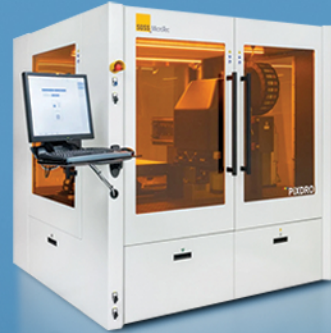
The trend is to bring manufacturing back to North America because there is a concern with cybersecurity issues, and companies want to buy from a viable, reputable source, rather than pulling it to the cheapest price. I think that's a positive.

The supply chain issues that took place during COVID were aberrations. First, tariffs meant things moved differently than they did before. Then you throw in a pandemic, and nobody can work. Ships at the ports were stuck because there wasn't anyone to unload them; they were overwhelmed. All these things happen, but I see them as aberrations to some degree. COVID is more manageable now than it was. We're used to the tariffs, so things are flowing more normally. We still have, how-

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ever, a very sophisticated supply chain that requires products moving around the world and we still want the lower-cost products, which means Asia will continue to be a very dominant partner.

Certainly, Washington has figured that out; it needs more suppliers from North America and that requires investment. Again, that's a positive thing. In many ways, we're in far better shape now than we were 10 years ago, and the trajectory is far better than it has been for a long time.

You said that the trajectory is getting better. Is it upward yet?

Yes, for certain markets. The military/defense area is upward. I can't speak for automotive, but I believe it's upward. If you're in regular industrial manufacturing or consumer products, you're probably not seeing it, but I'm guessing that most of that North American market is probably brokering a lot of stuff to be economical. We're more into the positive range than we have been for a long time.

My customers are all very bullish about the next few years and are making decent investments in their companies. On the manufacturing side, it's gone from, "Who's going out of business and what auction am I going to next?" to looking at, "How can I grow my business and invest properly? I'm in a better position because I'm actually making some money now and I can afford to do that."

There has to be some amount of pressure to grow, improve your capabilities, and meet new customer demands to maintain that momentum. What pressures are you feeling?

If you're a single-facility company, you can't do everything, so you find a niche where your



Peter Bigelow

customers can keep you going. Now you're looking to grow, but it must be more methodical.

If you're a larger company, you might be able to do a greenfield start-up and exponentially leapfrog the technology. In some cases, that would be a wise thing for some of the larger companies

to consider doing, especially for the capability lacking in North America. The good news is we're hearing from enough customers. We're seeing it in our sales that things are upward, and that's great. We're able to make some money and reinvest.

I wish I could say I'm going to a whole new area, but I really can't do that. You can't go from being "three yards in a cloud of dust" to being a race car. Instead, you have to say, "I will do what I can to accelerate into the right places so I can go in the right direction, but I can't do everything." Do you want to be cutting edge or do you want to have a proven reliable technology? When you've been through as much as these smaller North American companies, you will try to move as fast as you can, to make up for a lot; at least now we can see a roadmap to get there.

There's a well-used phrase in the industry: "It took 30 years to move all this business over to Asia. It won't come back in 30 months."

Right. It's not just money and equipment. You can buy equipment, borrow or raise capital. Finding people to work will be another big gate for our industry. If you're in a manufacturing environment, it's tough to get people who want to learn a trade or an industry. You simply can't walk in and be an expert 60 days later; we're doing fabrication. The assemblers are in a similar situation where employees must commit some time to it and be dedicated. I'm not seeing that level of long-term interest with the younger people coming through. It's more of a

gig mentality. When you're in manufacturing, you must commit to the process. That will be a real challenge for all manufacturing, especially electronics, where we're building someone's dream.

There are three main categories, then, responding to this market opportunity: money, equipment and facilities, and people. Customers are exerting pressure to bring business back. How do we meet their needs? The answer is to build more infrastructure. What is most urgent for you: money, equipment, facilities, or people?

People—and it's not just adding people, it's replacing those who are at retirement age. You should replace them before they leave so that you transfer as much of their knowledge as you can, but all too often that knowledge transfer happens too late and without enough time.

In fact, if anything, your employees need to be more skilled than ever before.

Absolutely.

Let's shift over to technology and capabilities. What direction are you moving in regarding the capabilities in your facility?

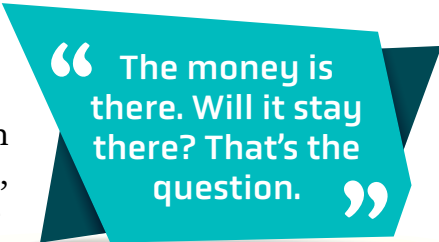
We're finessing some things. You know, we do substrates and most substrate fabs came out of metal-backed substrates and moved into doing PTFE-type work. We came out of FR-4, so sometimes you get to a point where you start asking why we can't do certain things; you come up with some basic areas to address. Maybe we have to re-address our waste treatment systems so we can treat different types of metals. It's not necessarily, "Can we make it?" It's more like, "Can we treat the stuff properly?" That opens us up to running new materials.

We meet with customers, and they might say, "If you can do this, then why can't you do

that?" That's when you suddenly realize that this was even a possibility, so you start doing research into what's next. Maybe we can run aluminum; maybe that's a direction we could go in addition to PTFE. Then you look at the adjacent capabilities: "We don't do that, but we should be able to."

So, that's what you look at. You need a customer with some kind of interest who is willing to work with you. We have some good customers like that; that's how you grow.

For example, we have a press that was state-of-the-art when it was new. Now it's 20 years old and if it just went 50 degrees hotter, we could do a lot more things. Now, if I'm going to spend money for 50 degrees, I'm not future proofing. However, let me get something of a much higher temperature, so that now I'm capable of a lot more materials that I currently can't process, then I am future proofing. That's how you grow, and that's how you build forward.



“The money is there. Will it stay there? That's the question.”

We've touched on facilities. What's your take on the landscape for capital? Can you acquire financing, or do you even need it?

One always needs financing. The last number of years have been great because interest rates have been low and there was still liquidity out there. We are privately owned, which means we have a bank relationship. We've got lines of credit and cash in the bank. We use most of the traditional types of funding. We have working capital and equipment lines of credit. While the money is there, it's getting more expensive, so you must be mindful about what you're walking away with. You pick what you do and borrow the money for something which is well worth it, then spend your cash on the replacement stuff. The money is there. Will it stay there? That's the question.

I'm not an economist, but we won't see inflation go away for a while. It may not get worse, but it won't reverse. There's always a chance

for a recession because it's been a lot of years and at some point, the economy has to readjust itself. When that happens, money may not be available. But if you're prudent, and you've been making some money for the last few years, you should have some money saved. You should have enough to invest in what you need to keep going and keep being viable, as well as to add onto some capabilities as well.

Are you finding customers who are willing to buy into you as a manufacturer? Somebody who's looking for some new technology you can roll out in partnership? How is that dynamic shifting?

We're in a niche area. Customers come in saying, "The last guy really screwed this up." You can't run everything in the same plant, and we will fire customers who don't fit. You realize there's nothing you can provide them because they're looking for different technology. I end up being the lead sales guy and I don't have the patience for that. I want to know: Do you even buy what I make? Do you have any interest in it? Are you a transactional customer or a relationship customer? If you buy what we make, I'll put the time in to develop a relationship.

As far as reshoring, we're heavily into defense, so most of what we make has not left our shores. We have some industrial customers who are coming back and it's a bit of sticker shock for them. I know it will be more expensive, so they're trying to work their way through. In some cases, I'll tell them, "You're probably not a good fit for us, but I can recommend a company that is a good fit because of your volumes, etc." So, yes, we've got customers that we work with very closely and we have good relationships with them. I can't think of a customer who doesn't like us, so I'll take that as a positive. But I'm always looking for new customers.

What's most pressing on your mind? What's keeping you up at night?

I don't think there's anything, really. We're in a better place now than we have been for a long time. I tell everybody I wish I were 20 years younger because there will be some exciting times ahead.


I worry about finding new people. How will I find employees who spend two years getting trained only to have them resign? And if they do resign, I don't want to find out they're leaving the industry for something totally different. How do you get people who you can build around, who will be the leaders of the future? Who will be the next generation in this company taking us forward? You ask yourself: What could I do differently? What have I learned from this? When you put out job postings and ads, you talk to colleagues, and they all say the same thing: I can't find people.

Not only do you need people who can, in our case, pass background checks because of NIST and CMMC, but you have to find people who can get to work and are willing to come to work every day. Some people are very honest and say, "I'm really looking for flexibility. I want to do

some work at home." I get that, but manufacturing doesn't work that way, unfortunately; you must be at the equipment. With workers in their 30s, I see differences in the way they work. The world's changing, and I absolutely get it. I'm looking for people who want to learn a trade and be here long-term. If they're really good, will a competitor offer them a better job? I may not like it, but I'll be happier knowing there's someone in the industry who's moving forward. It's better for everyone in that case.

That's a great answer. Thank you, Peter.

Thank you, Nolan. PCB007



I worry about finding new people.



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My Top 5 Skills for Manufacturing Engineers

The New Chapter

by Paige Fiet, TTM-LOGAN

I love speaking with high school and college students who are looking to join the electronics industry. Their enthusiasm always rejuvenates me. In our conversations, I have noticed several trends in their questions; the most popular is “What are you looking for in a new engineer?” Here is my list of the top five skills I believe any new manufacturing engineering graduate should have before they start their first job.

1. Communication skills

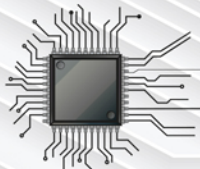
Having good communication skills is probably the most vital skill to have in any industry. It’s important to know how to boil down the information into the most critical parts for a management team and how to simplify directions for the operators. My dad’s favorite saying for this is, “Managers don’t want to know

how the clock is built, just what time it is.” On any given day, I may be tasked to explain the same issue in three different ways to my general manager, my engineering team, and my operators. The details in each explanation vary greatly.

Communication is also important when assistance is needed. It’s not likely that any engineer, let alone a new graduate, will know everything. Knowing when and who to reach out to, along with how to explain the dilemma, will make a difference in the performance of a department.

2. Problem solving

Just as communication skills are valuable across many industries, so is having a toolbox of problem-solving skills. However, manufacturing engineers in particular need to expe-

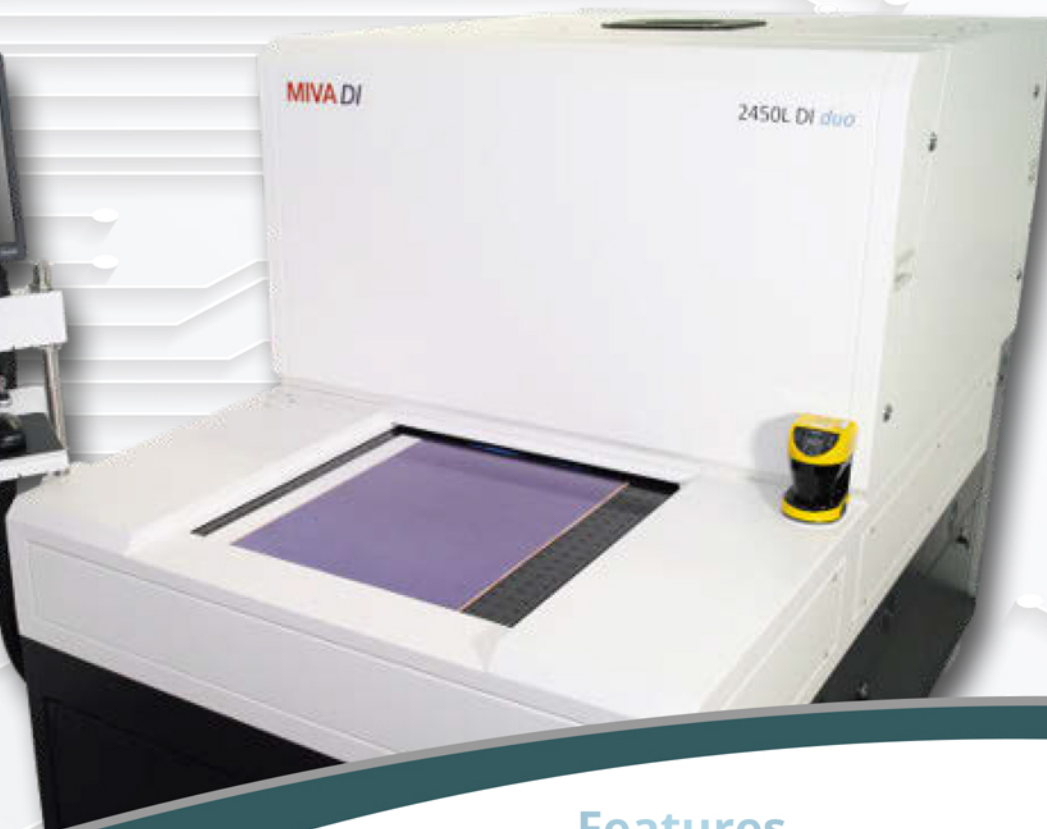


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dite the time it takes to solve a problem. Down time for machinery is one of the worst possible events for manufacturers. First, the engineers will be tasked with solving the root of the problem. This can be one of the greatest challenges, as the root cause may be complex. Next, they will need to find a solution quickly.

Nine times out of 10, there won't be time to solve all the math calculations taught in college. Instead, an engineer should have an estimation of what is required. For example, if I am reading a pH value on a developer after I have made a new bath, there won't be a "right" value that I am looking for. Rather, I know it should be between 10 and 11. If I have a reading of 2, then something is wrong.

**Nine times out of 10,
there won't be time
to solve all the math
calculations taught
in college.**

3. Statistics

Statistics wasn't my favorite class in college and I'm sure it's not a favorite for many others, but it is essential in understanding a process and causes of scrap. Every week, I make a Pareto chart for my operators to visualize our top defects so we can work together to reduce them. Statistics also come in handy when determining the source of intermittent defects. PCB manufacturing is very complex. It often comes in handy to know percentages of work that went through certain processing steps and when they did.

4. Intrinsic motivation

One of the starkest differences between college and industry lies in the motivation required. At the university level, grades are

assigned and due dates are given. That is not always the case in manufacturing. There is no hand holding to verify work is getting done in a timely manner. Within reason, it is left to the engineer to determine the tasks they will work on during the workday. The engineer must want to solve problems and engage in the work they are doing. My coworkers and I joke that if you are fully engaged with your department, you can't be bored in manufacturing.

5. Bouncing back after failure

I'm not sure any of us like to fail. It's surely not comfortable but it is necessary for growth. Learning not to take failure personally and move forward was one of the toughest skills to master as a new graduate. One of my favorite sayings comes from Mark Twain: "Good decisions come from experience. Experience comes from making bad decisions." I try to think of failure as an experience I don't need to have again. Sometimes, months down the road, I can even laugh about some of the mistakes I've made.

Of course, each hiring manager will be looking for different skills, but I believe most will agree with my top five. They are skills all of us can work on at any age or position in our careers. If you are a student looking into manufacturing of any kind, I encourage you to try it. Take opportunities to job shadow, intern, and co-op at companies that interest you. Find people in your life who are in positions you want to be in some day; ask them how they got there and what skills they find important. Hopefully, you will walk away from that conversation more informed and ready to take on a career of your choosing. **PCB007**



Paige Fiet is a process engineer at TTM-Logan, and in the IPC Emerging Engineer Program. To read past columns, [click here](#).

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Everything You Need to Know About Getting a PhD

The Doctor Is In

by Henry Crandall, UNIVERSITY OF UTAH/IPC STUDENT BOARD MEMBER

Editor's note: We welcome our new columnist, Henry Crandall, a doctoral student at the University of Utah and newest IPC Student Board Member. Henry plans to write about all things health engineering, graduate school, and wearable health monitors.

When it comes to advanced degrees, the PhD is often a misunderstood and undervalued option. In a world where MBA programs have strong name recognition, and master's degrees can seem relatively easy to obtain, the PhD is frequently overlooked. In fact, many people couldn't even tell you what the initials stand for. (Hint: It's Doctor of Philosophy.)

As someone who has embarked on this journey, I am eager to share the insights I've gained along the way. I'll cover the value of a PhD, the requirements for earning one, and some advice for successfully completing the program.

What Is the Value of Getting a PhD?

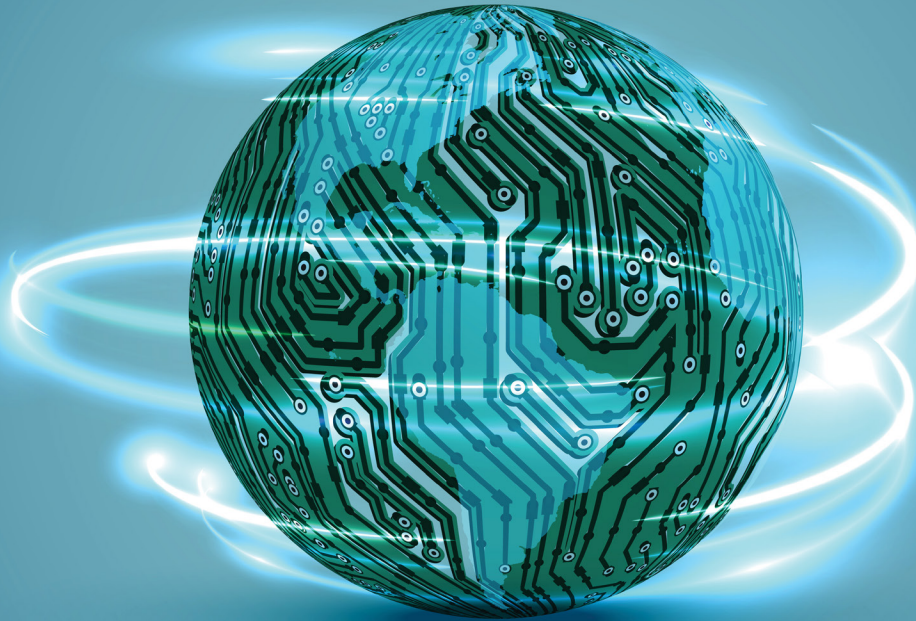
Getting a technical PhD can be an excellent choice if you're interested in pursuing a career in research, development, or academia. Here are some positive aspects of earning a technical PhD:

Expertise: A PhD provides an avenue to an unparalleled depth of knowledge and expertise in a particular technical field. You will be

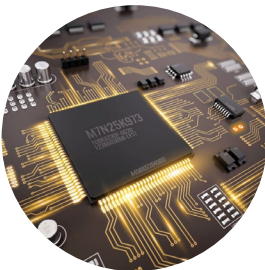




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Career opportunities: With a technical PhD, you will be eligible for a wide range of career opportunities, including research and development roles in industry, academic posts, and government positions. In many cases, a PhD is required for these types of jobs.

Recognition: A technical PhD is a significant achievement widely recognized as a mark of intellectual and academic excellence. This recognition can be valuable when seeking employment, funding, or promotions.

Personal growth: Pursuing a PhD can be a deeply rewarding personal and intellectual journey. It requires a high level of self-motivation, discipline, and creativity and can push you to your limits in terms of knowledge and problem-solving.

Collaboration: As a PhD student, you will have the opportunity to collaborate with other researchers within and outside your field. This can lead to new ideas and approaches and valuable connections that may benefit you throughout your career.

Impact: While earning your PhD, you will gain the skills and knowledge to significantly impact your field. By conducting original research, developing new technologies, and advancing the state of knowledge, you can make a real difference in the world.

Overall, a technical PhD can provide an excellent foundation for a successful and ful-

filling career in research, development, or academia. It will open many doors, provide personal and intellectual growth, and allow you to make a meaningful impact in your field.

What Are the Requirements for a PhD Program?

First things first: A PhD is not merely a glorified extension of your undergraduate studies. It's a whole new ballgame, requiring a level of independence, dedication, and time management that can feel overwhelming. But, as the saying goes, "Nothing worth having comes easy," and the same holds true for a PhD.

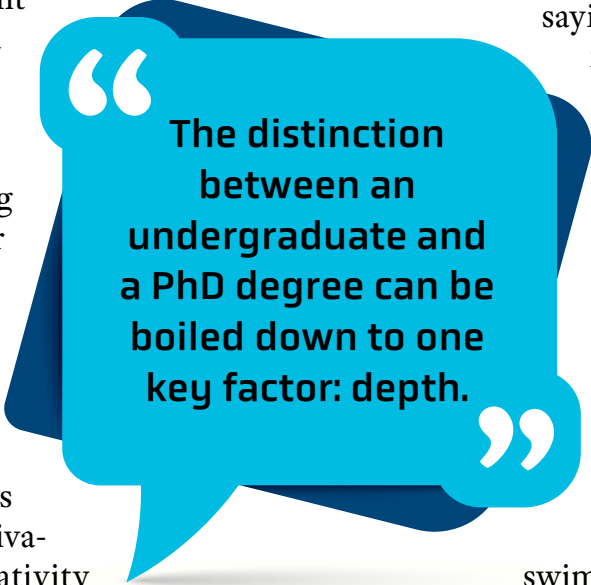
The distinction between an undergraduate and a PhD degree can be boiled down to one key factor: depth. Think of it as the difference between dipping your toes in the pool vs. diving into the deep end.

Undergraduate degrees offer a broad introduction to a field, akin to a leisurely swim on a sunny day. But if you're

seeking a real challenge, you'll want to take the plunge with a PhD program, which focuses on exploring uncharted waters through rigorous research and original contributions to your field. With PhD programs, you'll be expected to not only recite facts but to lead the conversation.

Undergraduate degrees typically require the completion of a set number of course credits, while PhD programs often have a greater emphasis on research, including conducting original experiments, analyzing data, and publishing findings in academic journals. The typical PhD program consists of four milestones:

1. Assemble a committee of five professors to guide your program of study.
2. Complete a written and oral technical exam on your field of research.



The distinction between an undergraduate and a PhD degree can be boiled down to one key factor: depth.

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3. Propose your thesis in a written and oral presentation.
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A PhD program is designed to provide students with the advanced knowledge and expertise necessary to contribute original research and ideas to their field. In contrast, an undergraduate degree program is designed to provide students with a foundational understanding of their field of study.

On a brighter note, PhD programs are among the few educational paths that don't leave you in the lurch. You may be surprised to learn that universities and research sponsors are willing to pay you to further your studies and conduct experiments. Graduate students often have all tuition expenses covered, receive subsidized insurance, and earn an average stipend of around \$30,000 per year. It's the only degree I know where, not only do you avoid piling up debt, but you actually get paid for your work.

And if that amount doesn't meet your needs, there are always opportunities to boost your stipend and benefits by pursuing one of the many research scholarships known as fellowships. In short, a PhD program can provide financial stability and the rare opportunity to invest in yourself without risking a mountain of student loan debt, all while qualifying you to earn a hefty six-figure salary.

Advice for a Successful PhD

Choosing the right advisor is one key aspect of PhD life. At the doctorate level, the institution's name on your diploma has far less influence than the name of your advisor and the colleagues in their network. This person will be your mentor, cheerleader, and occasional taskmaster. Ensure they align with your research interests and have a good track record

of mentoring students to successful completion. Remember, the relationship is a two-way street—be proactive in communicating your goals and needs, but also be willing to listen to their guidance and advice.

Next, don't underestimate the importance of networking. Attend conferences, join professional organizations, and get involved in collaborative research projects. Not only will these opportunities enhance your CV,

but they'll also provide a supportive community to lean on during the ups and downs of your PhD program. Remember, it's as much about your network as your knowledge.

Self-care is another crucial aspect of PhD life. Yes, your research is important, but

so are you. Make time for hobbies, exercise, and spending time with loved ones. It may seem counterintuitive, but taking breaks and recharging can actually lead to increased productivity in the long run.

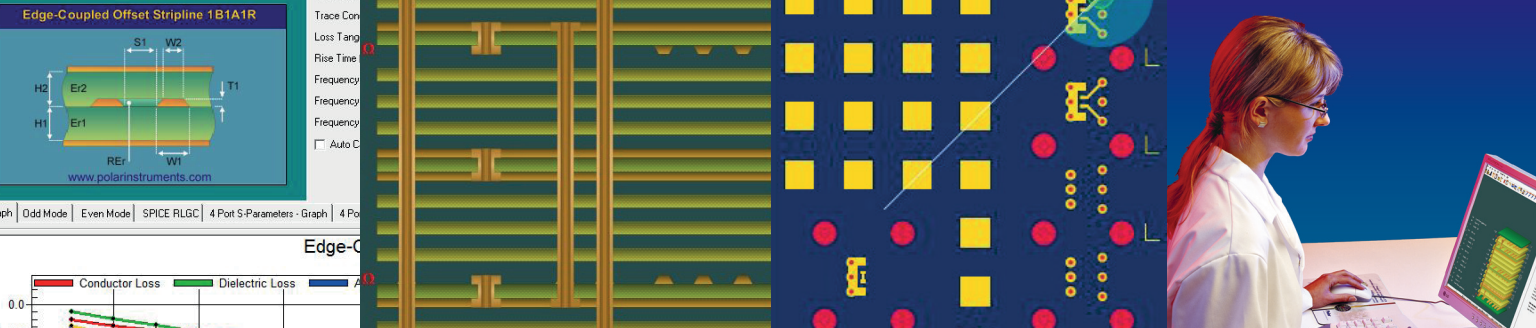
Finally, remember that the PhD journey is not a linear path. There will be setbacks, dead ends, and moments of self-doubt. But if you approach each challenge with determination and a growth mindset, you'll emerge on the other side as a more knowledgeable, resilient, and well-rounded individual.

The PhD journey is a marathon, not a sprint. Embrace the ups and downs, surround yourself with a supportive community, prioritize self-care, and, most importantly, never give up on your passion. **PCB007**

“ **Self-care is another crucial aspect of PhD life.** ”



Henry Crandall is the IPC Student Board Member. He is a graduate of University of Utah and currently pursuing a PhD in electrical engineering as the Advancing Research in College Scientists Graduate Fellow.

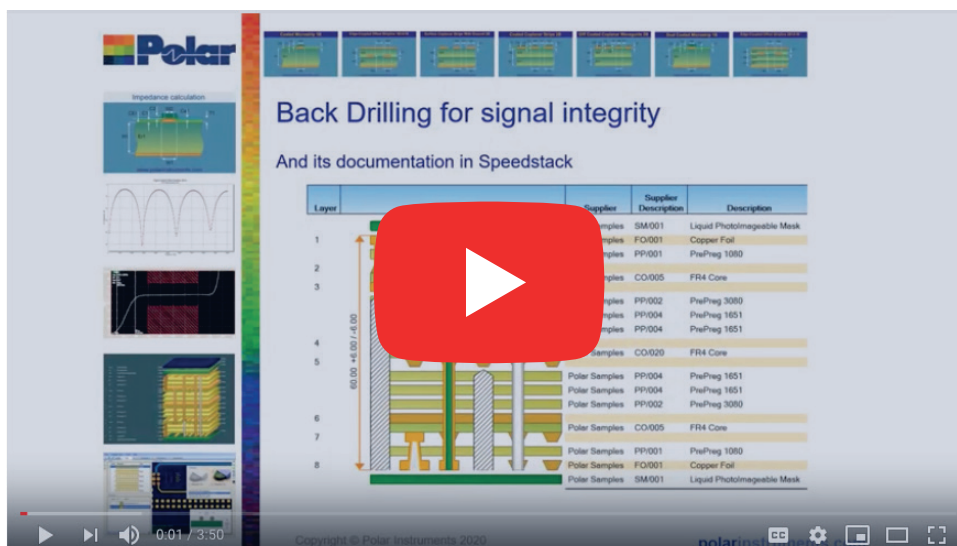


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Organizing Materials **Differently**

Feature Interview by Pete Starkey

I-CONNECT007

At a recent industry conference, technical editor Pete Starkey caught some time with Ventec's Mark Goodwin and Didier Mauve. In this conversation, Mark and Didier discuss Ventec's work to curate their product offerings into functional categories based on function and target application. The pair also share their thinking on markets which they see as driving material development work. When material performance becomes an integral part of the PCB's performance specifications, the traditional way of categorizing materials may not do the job.

Today, we will have a conversation about some of the technical aspects of materials

and some of the new materials that are available. Mark, could I ask you to give us a little bit of an introduction to Ventec?

Mark Goodwin: Yes, Ventec has been known as an FR-4, a polyimide supplier, a thermal management supplier, and we've had a few things in the high-speed digital area, tec-speed up to 7 now. We are really widening the scope and range of materials we supply and starting to shift the business toward supplying some of those higher technology materials.

Ventec is very well placed to do this because of the way our factories are built with many treaters, which means we can run many products. We also have a mixture of presses, every-

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Mark Goodwin

thing from our big 20-opening double format presses for FR-4, to smaller format presses with six or eight openings to allow us to make smaller quantities and very quick delivery.

The key is about supply chain and availability, and that's why I invited Didier Mauve, head of our global OEM and technology, to be part of the conversation; there's a lot of technology in these products. I'm a supply chain guy, far from technical, and the strength of what we're doing here is bringing both technology and supply chain together. We have the great manufacturing capability of Ventec, with product development skills led by Bill Wang, technical and quality director, but also with input from what we learn from the OEMs. Didier's team from around the globe is bringing that all together. The output from that is a series of products and product families which will be developed further, and which open a new direction for us. We'll keep doing the things we do but with an additional avenue of materials and technology that we've not been present in before.

We believe the world needs more suppliers in that field. When you think about things like supply chain security and all the instability in the world, now is the time to strengthen your

risk mitigation strategies. We've all learned a lot about these things over the past two or three years, and how important resiliency is as part of the mix. It's no good having technology at a price you can't afford, or with logistics that don't deliver it where and when you need it, at the right quality and price.

Finally, a key part of all this is curating our solutions into material sets that are relevant to market sectors and applications, because we don't want to create an extra load of work wading through our now extensive portfolio of materials to find what they're looking for. We're trying to make it easy.

We've had this conversation in the past, and it's the obvious thing to do, but nobody seems to have done it before, although I think you've probably set a trend now.

Goodwin: From what I've seen this week [at IPC APEX EXPO], we might have set a trend. Yes, several people seem to be picking up that it might be a good idea.

Didier, would you like to talk about anything specific? Any product families, product, or market sector that you're servicing?

Didier Mauve: Yes, as Mark said, we are slowly but surely shifting and expanding our product offering toward our mil-aero clients. This market, which was rather limited in volumes in the past, is rapidly and continuously growing. Now, the requirements and the volumes needed are increasing. We see demand from our customers, in both the West and Asia. One of the drivers for volumes was the automotive radars, the 77 GHz frequency products. It creates some scarcity of "specialty" products around the globe, therefore, we believe that's one reason customers are asking for better lead times—an alternative sourcing to a longtime existing supplier in this industry segment.

As a matter of fact, we've designed a complete RF lineup within the last five years,

including the two COVID years that were quite slow. We designed a complete product lineup in the higher frequency area for analog RF electronics. We have more than 25 different products now for our customers, starting from non-glass-reinforced PTFE laminates to pure dielectric, RCF with a carrier for the non-glass-reinforced materials, hydrocarbon-based laminates. We offer hydrocarbon combined with metal-based material for heat dissipation. Our knowledge in this thermal management segment helps us a lot. As Mark pointed out, we have multiple and numerous treaters in our factories, so we have fantastic flexibility and a very effective supply chain.

Goodwin: We're at the point now with some of these materials that we're holding inventory very much on spec, without order coverage, because we're starting to build a history of what our customers need. Other materials are more program-driven, but as we learn more about the programs and we do more programs, we'll take our usual view: our job is to manage the supply chain. We make product available in our warehouses in Europe and the U.S. We can't do that for everything, but when we can't, because of the flexibility we have in our manufacturing facilities, we can deliver these products quickly, and directly from manufacturing as well.

We're certainly not talking about months for delivery, which some suppliers are now. We are very much looking from point of order to point of delivery. In my mind, I want to build our capability around being able to supply directly from manufacturing within 14 or 15 days, including flying the material and clear-

ing customs. There are a few things that can go wrong, of course, outside of our control, but the shorter we can make our manufacturing cycle time in the manufacturing facilities, the more tolerance we have on the things we don't control. I'm trying to get to having it on the shelf in two weeks, maximum.

You've got flexible manufacturing capacity. Are you in anticipation of certain orders on certain technologies? Are you sort of keeping manufacturing capacity sitting there?

Goodwin: Absolutely, but we've always done that because our game is always to be fast and flexible so we never run out.

If I order a special material, it won't go in a queue, it goes straight to the customer?



“We're certainly not talking about months for delivery, which some suppliers are now. We are very much looking from point of order to point of delivery.”

Goodwin: Yes. I mean there's always a queue, but the queue isn't very long. I think we'll also be in the position where we can deliver pre-production for a lot of products. Not all the products we're talking about yet, but it will come. For our tec-speed 3 and tec-speed 6, which are more in the high-speed digital realm than the RF realm, we're already at the point where we can deliver pre-production small and medium volumes from inventory in Europe. We're rolling that out in the U.S. in the next month or two. We'll do that with more materials, so we can get people started in production with those and fill in with product arriving a couple of weeks later directly from manufacturing, either to replenish what we've sold, or to supply bigger volumes directly to the fabricators.

Which of your markets are growing most quickly?



Didier Mauve

The drone is a pretty small sort of assembly, but probably with a big range of technologies and material requirements.

Goodwin: Yes, absolutely.

Mauve: The high-res camera is a perfect example. On one side you have a lot of information to process and transmit. So, it's an amazing development of technology in such areas. Recent armed conflicts tell us a lot about the battlefields of the 21st century and, especially, the importance of UAVs and their tactical and strategic use.

The use of drones, including consumer equipment on the battlefield, makes all military strategists think about how they anticipate and will have to manage future conflicts, as well as the types of professional and military grade equipment they will need.

Goodwin: I've got a new iPhone 14 and when the signal drops it now puts a little picture of a satellite on the top, because it is connecting with these low orbit satellites, looking for a signal. It's only for emergency calls, but it's already starting to happen.

Mauve: This is where we see the market. As a laminator, we want to offer reliability, availability of material, no compromise with quality, and always at the best price. That's what it's all about.

The performance is a given, price is negotiable, but the availability is something valuable.

Goodwin: It's a key driver now. We want to be part of that mix. We have a good reputation for managing supply chains and doing things in a slightly different and more creative way.

Mauve: We're far away from being convinced that the difficult times are behind us. To the contrary, we believe more challenging times are yet ahead of us. Down the road we will expe-

Goodwin: In terms of geography, there's a lot of stuff going on here in the U.S., especially with low orbit satellite networks. That's also coming in Europe and in Asia. There are really three networks, aren't there?

Which of your product ranges, your technologies, is this market sector calling for?

Mauve: The primary market sector is definitely military, which for the reason we know, has had tailwind for some months; in addition to that, it's the radar industry with commercial radars, antennas, etc. These are all our primary targeted markets, and where we see our product meet our customer demands.

Goodwin: You've got drones as well with the other big example being high resolution cameras.

Mauve: Exactly.

Goodwin: So, you have high-speed data processing going on there, but you've then got to transmit that information back. These are the kinds of applications.

rience more challenges. Just think about copper, the raw material, and energy as a whole. We have to figure this out because in the near future there can be some surprises, and I don't mean good ones.

Goodwin: Surprises are never good in business.

The focus of the supply chain management from our point of view has been on maintaining the supply of materials from manufacturer to the user. But you have another supply chain to control as well—the supply of your raw materials to your manufacturing.

Goodwin: Absolutely. Didier touched on copper, and heavy copper is an interesting conversation now. Let's start with the price. You have the LME price of raw copper, which interestingly is up by more than 10-12% in the last month, and I think it's heading for the highs of the last 18 months. We'll see it over \$10,000 a ton again.

So, this is number one: raw copper. We have the energy crisis in the world, and electrodeposited foil is all energy and copper. This creates two problems. We have huge demand. Even though the markets are somewhat quiet at the moment, there's still a huge, fundamental, underlying demand for copper foil, not just for electronics, but also for batteries. Now battery foils are thin foils. Didier, what was the typical thickness of batteries?

Mauve: 10 micron and below.

Goodwin: Yeah, 9-, 10-, 5-, 6-micron, things like this. The volume for us is 18 microns.

We're already twice what the battery guys are. The output per square meter is significant.

Mauve: And the treatment on batteries is easier.

Goodwin: Yes, treatment on the batteries, treatment on ours. Then you get to heavy coppers. A lot of the applications now require heavy copper because there are a lot of amps and thermals to manage. Third, you have to find somebody who's prepared to make copper heavier than one ounce these days. One ounce is now a heavy copper.

But with some of these applications—like thermal management—have four-ounce, five-ounce, six-ounce copper. So, you have copper and energy, and the premium to get someone to make six-ounce for you instead of 18 micron, a half-ounce copper foil or thinner.

In the end, that comes down to relationships. That was useful to us in Munich because we ended up actually buying copper at the electronica show. It wasn't a huge quantity, but it was 15 tons of six-ounce copper foil from people that we know very well. Because we behave in the management of our own supply chains in a good way, they were willing to help us.

You get back what you put in when it comes to relationships.

Goodwin: My point is that it isn't all about money now; it's way more than that.

Well again, you've stressed it's about relationships all the way down the line. plus management capability and intelligence.



Goodwin: It's about market intelligence as well, knowing what's going on. The bit of the business that I run is really a distribution business, but we are linked very closely to a manufacturing business, and we're one company. Our market intelligence and what's going on in supply chains is way better than some of our third-party distribution competitors. Some of my predictions and things I've said have turned out to be right. That's because the people commenting find out what's happening when they place their order for the next container of laminate. I find out because the guy making the laminate is my boss, and we talk every day. That has strengthened our ability to manage supply chains, and it's valuable to our customers.

Mauve: What Mark mentioned is especially true when you have the very high-mix, low-

volume technology like RF/analog. The mil-aero segment is basically, by definition, a low-volume, high-mix electronics segment. This is one of the market segments we have been supplying for ages, and we have been successful with our polyimide VT-901 material, our no-flow/low-flow prepregs.

Goodwin: We brought a new polyimide to market, and how did we take the market? Well, we took the market because it's a great product; we took the market because it's an interesting price, but we kept the market because we've got robust supply chains.

Gentlemen, it's always a pleasure sitting down with you. PCB007

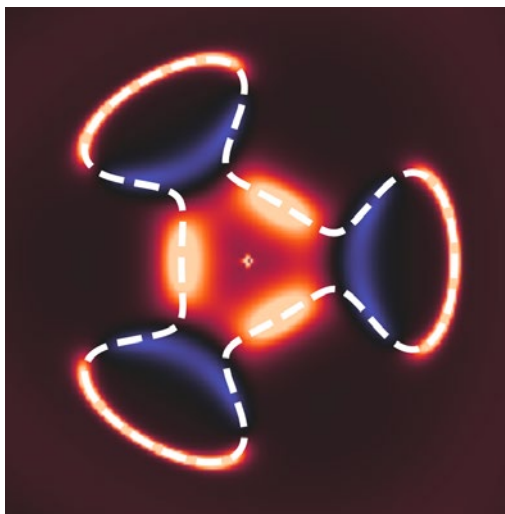
Reaching Superconductivity Layer by Layer

Graphene is a strange material. Understanding its properties is both a fundamental question of science and a promising avenue for new technologies. A team of researchers from the Institute of Science and Technology Austria (ISTA) and the Weizmann Institute of Science has studied what happens when they layer four sheets of it on top of each other and how this can lead to new forms of exotic superconductivity.

Postdoc Areg Ghazaryan and Professor Maksym Serbyn from ISTA, together with colleagues Dr. Tobias Holder and Professor Erez Berg from the Weizmann Institute of Science in Israel, have been studying graphene for years and have now published their newest findings on its superconducting properties in a research paper in the journal *Physical Review B*.

"Multilayered graphene has many promising qualities, ranging from widely tunable band structure and special optical properties to new forms of superconductivity—meaning

being able to conduct electrical current without resistance," Ghazaryan explains. "In our theoretical model, we are continuing our work on multilayer graphene and are looking at various possible arrangements of different graphene sheets on top of each other. There, we found new possibilities for creating so-called topological superconductivity." In their study, the researchers simulated on a computer what happens when you stack a few layers of graphene sheets on top of each other in certain ways.

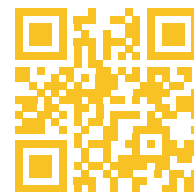


"It is like a big beauty contest among the different configurations of stacked sheets of graphene to find the best one," Serbyn adds. "In it, we are looking at how the electrons that move in the multilayer graphene behave."

This kind of theoretical research lays the foundations for future experiments that will create the simulated graphene systems in a laboratory to see if they really behave as predicted. (Source: ISTA)



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Chemical Control for Wet Processes

The Chemical Connection

by Christopher Bonsell, CHEMCUT

As I've mentioned in previous columns, etching can be the most complex process in the wet processing stages because there are many factors that contribute to your etch rate. Without keeping these contributing factors steady, your etch rate will vary and, therefore, so will your product quality. If you are looking to implement an automated approach to maintaining your etch chemistry, here are the basic concepts you will need to understand.

The Structure of Control

Most, if not all, process control systems rely on a simple feedback loop. Through this loop, we get a clear approach to process control. In Figure 1, you can see that we initially go through a monitoring stage. At this stage, we look to see if all the desired parameters

meet specifications. If they do, then the process can continue normally. However, if something does not meet specifications, it will initiate a process to make the necessary changes. With this change being identified, it goes into an "adjusting" process. After adjustments, the parameter is monitored again to ensure that it meets requirements. This process will repeat until the desired outcome is obtained. This is only a rudimentary version of the feedback loop, meaning that this can become more complex given a certain process. What the process will look like may differ, but conceptually, the processes should remain similar.

Implementing Control

Now that we have the base structure of process control, how can we apply it to our etch-

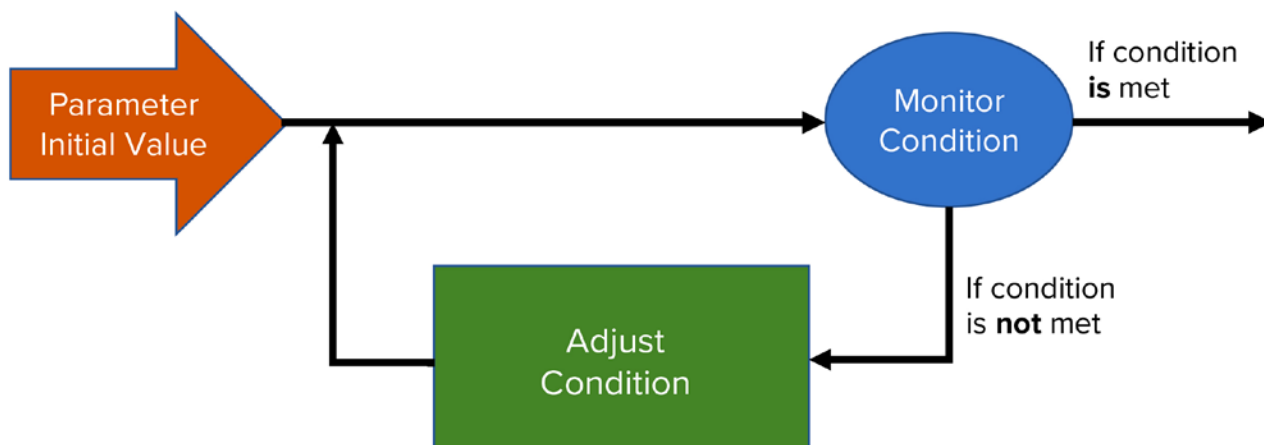


Figure 1: Simple process control feedback loop.

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ing process? In etch chemistry control, there will be multiple feedback loops involved. This is because each parameter of the etchant has its own method of control. Every etchant available has its own set of parameters. Before you get started with an approach to process control, you will need to first evaluate all the parameters that contribute to etch quality. The most common parameters you will see in an etchant are shown in Table 1, along with their monitoring methods and ways to control them. It should be noted that temperature and spray pressure are major contributing factors to etch quality, but these parameters are automatically controlled in all etching equipment; therefore, they will not be covered.

From the table, you will notice most of the parameters in etching have a specific measurement tool that makes the monitoring stage simple. Since each factor monitored describes a contributing chemical in your etchant, most cases just require adjustments through adding the lacking chemical. This makes it simple because, with a proper monitoring system, you can link it to a pump that will trigger when it is out of range. This will provide a sim-

ple system to restore the chemical contents of your etchant. There are some exceptions to this because, in some cases, the link between monitoring and adjusting is not so direct. With factors such as chloride and free HCl content, it is harder to simply monitor them; therefore, the

Before you get started with an approach to process control, you will need to first evaluate all the parameters that contribute to etch quality.

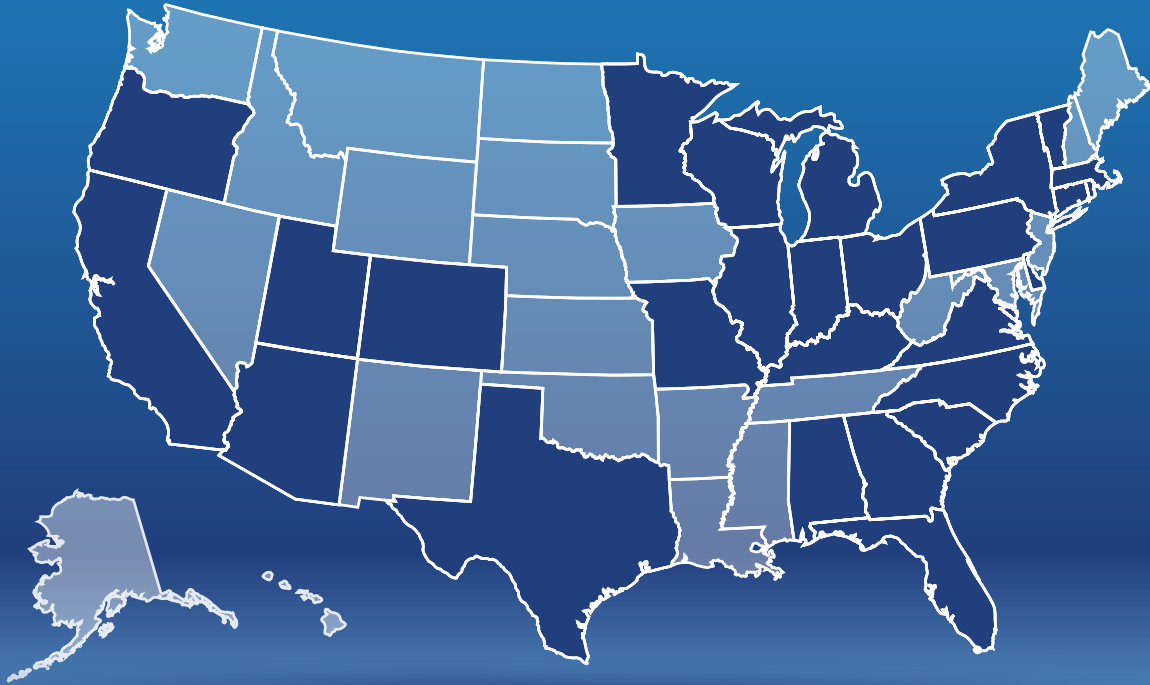
adjusting of those factors will have to be done differently. If one of these factors were found to be out of range after performing a titration, you would likely have to manually add the chlorides or HCl into the machine.

Along with that, if your process technicians do not perform the titrations regularly, then

Table 1: Common etchant chemical parameters and their respective monitoring and adjusting methods. Associated etchants only show cupric chloride, alkaline cupric chloride (alkaline), and ferric chloride. Other etchants that are not mentioned may have similar or the same contributing parameters

Etchant Chemical Parameter	Monitor Method	Adjusting Method	Associated Etchant(s)
Specific gravity	Hydrometer	Add water to reduce	Cupric chloride, Alkaline, Ferric chloride
Oxidation reduction potential (ORP)	ORP probe	Perform regeneration reaction or “feed and bleed” to increase	Cupric chloride, Ferric chloride
Free HCl content	Titration	Add concentrated HCl to increase	Cupric chloride, Ferric chloride
Chloride content	Titration	Add dissolved ammonia chloride to increase	Alkaline
pH	pH probe	Increase ventilation to decrease; add ammonia to increase	Alkaline

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you can be out of range without knowing it. To avoid this, there is another option where instead of queuing chemical additions manually after titrations, you could simply add a certain amount of those reagents after a specific number of panels are run. This would need some fine-tuning for your process and thus require some testing and trial-and-error. Once you have nailed it, that factor of the process becomes much easier to control. Despite the fine-tuning, you will need to continue monitoring the contents to account for any variations that can occur during the etch process.

To Regenerate or Not to Regenerate

The next major contributing factor is ORP. As discussed before, ORP is the measurement of your ready-to-etch etchant and your spent etchant. As the spent etchant dilutes your etchant bath, etching becomes less efficient. Therefore, it is important to keep a steady

If you are utilizing an uncommon PCB etchant, such as ferric chloride, you will not be able to effectively regenerate your etchant.

ORP factor for a consistent etch process. To do this, you will have to consider whether you are able to regenerate your etchant. The PCB etching process primarily consists of cupric chloride or alkaline cupric chloride; you have the option to regenerate your etchant and therefore have an easier time keeping your ORP consistent. If you are utilizing an uncommon PCB etchant, such as ferric chloride, you will not be able to effectively regenerate your etchant. This is because of an unwritten

rule that is in etching chemistry. The rule is that it is ideal to use etchants that are more “alike” to the metal you are trying to etch. This means the metals you etch should have the same metals in the etchant, if that is possible. This is because the larger the number of different components dissolved in the etchant, the more difficult it becomes to monitor the etchant effectively and to perform regeneration.

For example, if you etch copper with cupric chloride, the copper can be directly used to make more cupric chloride. However, if you etch with ferric chloride instead, the iron content of the etchant would become less concentrated because you are adding copper into the solution—this gets in the way of regeneration and develops complications. If you are using an etchant that is not copper based, you will likely have to settle for what is referred to as the “feed and bleed” process to control your ORP. This is simply a method where after so many panels are etched, some of the used etchant will be pumped out of the machine as fresh etchant is pumped in. Once fine-tuned, this process allows you to maintain a steady state for your process to remain consistent.

Conclusion

From this brief introduction to etchant chemical control, you should have a fair understanding of how you would implement controls in your etching process. With tools such as normal monitoring methods, control based on panel count, and “feed and bleed,” you should be capable of mapping out a chemical control method that works for nearly any etch process. **PCB007**



Christopher Bonsell is a chemical process engineer at Chemcut. To contact Bonsell, [click here](#).

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Leadership 101: The Law of Legacy

The Right Approach

by Steve Williams, THE RIGHT APPROACH CONSULTING

Introduction

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

“A leader’s lasting value is measured by succession.” —John Maxwell

You Control Your Legacy

Legacy is what you leave behind; how you will be remembered. This is 100% in your control, and everyone can write the ending to their own life story. What kind of legacy do you want to leave behind once you’ve moved on from your leadership position? For most people, legacy is all about what they have personally achieved: their successes, awards, and

accomplishments; in other words, the things they leave behind. For leaders, these things are certainly part of their legacy, but their lasting value as a leader is in the people they leave behind.

Sustainability

Throughout this series, I have talked about the difference between a manager and a leader:

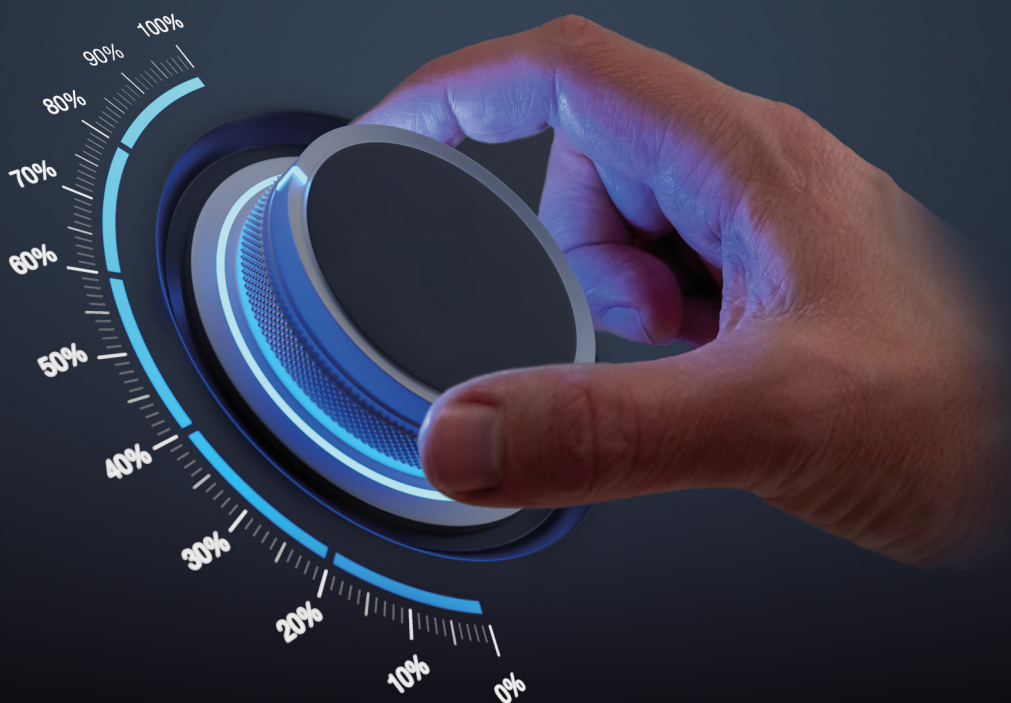
“A manager does things right; a leader does the right thing.” —John Maxwell

How many people do you know who take a bit of pride in the fact that their team cannot function at the same level of performance when they are not around? You hear things from them like, “I am going to have a lot of cleanup to do next week when I get back from vacation,” or “My team just doesn’t know what to do without my constant direction.” This is the mentality of an insecure manager. They need to hold onto their control and knowledge to make them indispensable. Guess what? Anyone is replaceable.

Contrast that to the person who takes pride in the knowledge that their team can perform autonomously with no drop in effectiveness. This type of person is a leader; one that is intentional in developing others to fully realize their potential, and in some cases to be in a position to take the reins. A leader under-



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Neoganth® E Activator – Reduced costs with no loss in performance

On-going market pressure is increasing the need for cost-efficient yet high performance processes for PCB production. With Neoganth® E Activator, MKS' Atotech has developed a cost-sensitive, low palladium solution for the horizontal production of PCBs, including those requiring automotive approvals. Operating at a concentration of 80 ppm Pd, the unique formulation of Neoganth® E Activator significantly reduces Pd precipitation which maximizes bath life, while maintaining the excellent Pd adsorption required for use with a wide range of dielectric materials. Compatible with existing MKS' Atotech horizontal electroless copper processes and equipment, this is a simple drop-in solution that lets you take control of your process costs.

To find out more about Neoganth® E Activator, scan the QR-code to the right.





stands that the best way to create value is in helping others improve their skills and knowledge.

Pass the Baton

Any track coach will tell you that the race is won or lost with the passing of the baton and not the running of the race. This handoff of responsibility is the only part of the race that is a team effort; the rest is all about the individual. The passing of the baton is analogous to succession in business—the handoff of responsibility from one person to another. Just as in the race, if the handoff is not smooth, the outcome will not be successful. In a business sense, if the succession transition has not been well planned and the “new blood” expertly groomed to ascend, it will also be unsuccessful. Because leaders work with people, including other leaders, they have the potential to influence beyond their own career (and lifetime). Therefore, all leaders should be concerned with succession and legacy.

Developing Your Legacy

How do you accomplish this? The following guide outlines the steps to develop your legacy, but they require intentional, ongoing effort.

1. Decide early what your legacy will be.

Consider your sense of purpose, strengths, opportunities, and whom you might be able to impact. Some people accept, rather than drive, their lives; instead, choose how you will live your life.

- For example, it still amazes me how little time many leaders spend thinking about their legacy—what they will leave behind for the organization and the people they serve. Building a legacy is an intentional, continuous activity that must be done throughout a career. Make a list of the things that drive you and your legacy will quickly become clear.

2. Start living your legacy while you're still in your leadership position.

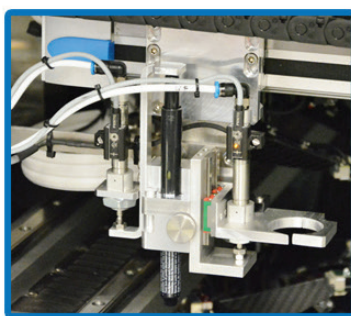
Follow Laws #6 (leaders are trustworthy and have good character) and #13 (leaders lead by example). Be what you want to inspire in others.

- For example, when you always make decisions based on truth and with integrity, you inspire others around you. People always respond favorably to those who live by their highest ideals. Character is what is left after charisma is gone. Keep aligning all your actions with the legacy you want.

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Highlights:

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3. Pick successors.

Legacy is about people, not things. An inanimate building named after you won't be able to influence people.

- For example, people can judge how good a person you are by your grandchildren. You've raised your kids using your values and how well they raise your grandchildren is a measure of how well you did with them.

4. Create a succession plan.

If you're a good leader, and your successor is a good leader, that's a good start, but there needs to be a handoff. Succession does not happen by chance, it must be diligently planned and executed.

- For example, the owner of a small business, Nancy, is training her daughter, Morgan, to take over the company. Morgan has gradually taken over many of Nancy's responsibilities while she is still the leader. This allows Morgan to observe, learn, and practice under Nancy's mentorship.

Leadership Wrap-up

Someone once asked John Maxwell why he wrote *The 21 Irrefutable Laws of Leadership*. I laughed out loud when he responded, "Because there are 21 Irrefutable Laws of Leadership, not 19 and not 22. If there had been 22, I would have written *The 22 Irrefutable Laws of Leadership*." I would fully concur; John has effectively outlined the true keys to becoming a great leader into these 21 laws. As we went through this leadership journey together in this series, I hope you have learned a few lessons you can apply immediately to improve your leadership skill set.

If you follow the guidelines in *The 21 Irrefutable Laws of Leadership*, you will truly be surprised at the results. By intentionally focusing on enhancing your leadership skills, I promise the results will be epic. Good luck! **PCB007**



Steve Williams is president of The Right Approach Consulting. He is also an independent certified coach, trainer, and speaker with the John Maxwell team. To read past columns, [click here](#).

Careers in Electronics: What Does a Process Engineer Do?

Process engineers often function as the point persons for or during the continuous processes commonly found in the chemical, petrochemical,

agricultural, and mineral processing sectors. They also work in this capacity with advanced materials found within the electrical and biotechnology industries.



They create set specifications for the raw materials, and develop, implement, and monitor the equipment in use and the process of the materials and the manufacturing systems. They can also work in sales or design, and they sometimes work for the optimization of the sales and software processes.

Process engineering is similar to industrial engineering; many job duties overlap with each other. However, industrial engineering focuses more on how to make general production processes more efficient.

To learn more, visit [CareersinElectronics.com](https://careersinelectronics.com).



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One World, One Industry: Advanced Packaging Year in Review

Over the past year, IPC has stepped up its efforts to educate policymakers and other key audiences on the importance of investing in the entire semiconductor supply chain to achieve the goals of the CHIPS and Science Act, including in advanced packaging and printed circuit boards. Our message to policymakers is that building a more robust, domestic ecosystem for advanced electronics will require four key policy decisions.

EIPC Winter Conference 2023: Day 1 Review



The EIPC Winter Conference returned to the Metropolis of Lyon in eastern France

this month. In 2018, the venue was Villeurbanne in the Auvergne-Rhône-Alpes region. Five years later the setting was the Groupama Stadium in Décines-Charpieu, and leaders of the European printed circuit community gathered in expectation of a spectacular programme of 16 presentations, a visit to a nuclear power station, and an invaluable networking opportunity. They weren't disappointed.

Testing Todd: Turning Into the Wind



The last three years have been a challenge, from the pandemic to the circus of shenanigans in Washington, neither of which have been pleasant. So, it's not hard to

figure out why we are all in this current situation. We're not quite in a recession but rather a stagnation. The winds of change have come, but many are still Wilson looking over "Tool Time" Tim's fence to see what he is going to do. It's time to go back to our sheds and sharpen the saw.

The Chemical Connection: The Subtractive Vision

The November issue of *PCB007 Magazine* included a fair amount of discussion on the growing need for ultra-high density interconnects (UHDI). UHDI is an area replete with manufacturing challenges due not only to the feature sizes this technology requires (< 50 micron or < 2 mils), but also the lack of familiarity U.S. manufacturers have with this technology. In an interview with Calumet's Todd Brassard and Meredith LaBeau, they stated that the U.S. is roughly 30 years behind the curve in manufacturing UHDI, which is likely the result of companies offshoring UHDI manufacturing for many years. How can we catch back up?



Real Time with... IPC APEX EXPO 2023: Challenges of New Product Development

John Ekis, market segment director, Aerospace and Defense, Rogers Corporation, discusses with Pete Starkey the importance of close applications engineering relationships in understanding and responding to the requirements and challenges of specialist new product development.

TTM Technologies Announces Consolidation of Manufacturing Footprint

TTM Technologies, Inc., a leading global manufacturer of technology solutions, including engineered systems, radio frequency (RF) components and RF microwave/micro-electronic assemblies and printed circuit boards (PCBs), announced that it plans to close three manufacturing facilities in order to improve total plant utilization, operational performance, customer focus and profitability.

Why Gold Layer Thickness in ENIG Matters for Soldering



Dr. Britta Schafstetter

The main task of the final finish is to protect the copper pad from tarnishing or oxidation while simultaneously keeping the surface active for the assembly. Electroless nickel/immersion gold (ENIG) is a widely accepted finish in the market that provides a good solderability and capability for Al-wire bonding. A main function of the gold layer is to prevent the oxidation of the nickel layer.

Coreen Blaylock: Opening Doors for New Professionals



Coreen Blaylock, recipient of the IPC Excellence in Education Award, is in project management and ping operations at Lockheed Martin. She shares her unconventional introduction to the industry and how her work in STEM education and building industry partnerships has been instrumental in reinvigorating the manufacturing workforce.

Time to 'Finish the Job' on PCB Funding

In his State of the Union address in early February, President Biden departed from his usual topics about education and the economy to mention the new CHIPS Act, as well as supply chain and infrastructure issues. For perspective on those remarks, Nolan Johnson chats with David Schild, executive director of the Printed Circuit Board Association of America (PCBAA).

APCT Completes the Acquisition and Merger with Advanced Circuits

APCT, a designer and custom manufacturer of advanced technology printed circuit boards, has completed the previously announced acquisition and merger with Advanced Circuits, Inc., and its affiliated entities and subsidiaries.

For the latest news and information, visit [PCB007.com](https://www.pcb007.com)

Career Opportunities



Find industry-experienced candidates at jobConnect007.

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

In addition, your ad will:

- be featured in at least one of our newsletters
- appear on our jobConnect007.com board, which is promoted in every newsletter
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Career Opportunities



Production Manager

Sunstone Circuits, a leading provider and manufacturer of custom printed circuit boards (PCBs) located in Mulino, Oregon (20 miles south of Portland), is searching for an experienced and talented manager to lead our Production team.

Responsibilities

Directing and coordinating activities of the manufacturing department in processing materials and products by performing the duties personally or through subordinate supervisors.

Sunstone is a fast-paced, custom electronics manufacturing environment that requires a “hands on” approach, extreme customer focus, and sense of urgency to ensure all products manufactured are built to quality standards and on-time product delivery. Successful candidate will perform these duties in conjunction with department leads, partners and suppliers.

Qualifications

Bachelor's degree (B.A.) from four-year college or university; or five to six years related manufacturing management experience and/or training; or equivalent combination of education and experience.

Competitive salary, bonus program, benefits, and robust wellness package. Offer of employment will be contingent upon passing drug screen, background check, and reference check.

Email resume to jobs@sunstone.com

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THERMAL SYSTEMS

Sales Engineer SMT North Mexico

Rehm Thermal Systems, a leading German manufacturer of reflow soldering systems with convection or condensation and drying and coating systems, has produced energy-efficient manufacturing equipment for the electronics and photovoltaics industry since 1990. We also offer tailor-made applications related to the soldering, coating and hardening of modules.

Responsibilities:

- This position is responsible for expanding our customer network and maintaining existing customer relationships in the Northeast Mexico region. The Sales Engineer would work closely with the German headquarters and the General Manager Rehm Mexico to implement the sales strategy.
- A candidate's proximity to Monterrey, Mexico, is a plus.

Qualifications:

- An Engineering degree or comparable qualification with a strong technical background is required.
- Sales-oriented attitude, good communication skills and willingness to travel frequently within Mexico is essential.

We offer innovative products, a great dynamic work environment and exciting training opportunities in our German headquarters.

To learn more about Rehm Group please visit our website at www.rehm-group.com.

Please send resumes to: Mr. Luis Garcia at luis.garcia@rehm-group.com.

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Career Opportunities



Sr. Test Engineer (STE-MD)

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

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

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

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

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Europe Technical Sales Engineer

Taiyo is the world leader in solder mask products and inkjet technology, offering specialty dielectric inks and via filling inks for use with microvia and build-up technologies, as well as thermal-cure and UV-cure solder masks and inkjet and packaging inks.

PRIMARY FUNCTION:

1. To promote, demonstrate, sell, and service Taiyo's products
2. Assist colleagues with quotes for new customers from a technical perspective
3. Serve as primary technical point of contact to customers providing both pre- and post-sales advice
4. Interact regularly with other Taiyo team members, such as: Product design, development, production, purchasing, quality, and senior company managers from Taiyo group of companies

ESSENTIAL DUTIES:

1. Maintain existing business and pursue new business to meet the sales goals
2. Build strong relationships with existing and new customers
3. Troubleshoot customer problems
4. Provide consultative sales solutions to customers technical issues
5. Write monthly reports
6. Conduct technical audits
7. Conduct product evaluations

QUALIFICATIONS / SKILLS:

1. College degree preferred, with solid knowledge of chemistry
2. Five years' technical sales experience, preferably in the PCB industry
3. Computer knowledge
4. Sales skills
5. Good interpersonal relationship skills
6. Bilingual (German/English) preferred

To apply, email: BobW@Taiyo-america.com with a subject line of "Application for Technical Sales Engineer".

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Career Opportunities



IPC Instructor Longmont, CO

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

IPC instructors will primarily conduct training at our public training center in Longmont, Colo., or will travel directly to the customer's facility. It is highly preferred that the candidate be willing to travel 25–50% of the time. Several IPC certification courses can be taught remotely and require no travel or in-person training.

Required: A minimum of 5 years' experience in electronics manufacturing and familiarity with IPC standards. Candidate with current IPC CIS or CIT Trainer Specialist certifications are highly preferred.

Salary: Starting at \$30 per hour depending on experience

Benefits:

- 401k and 401k matching
- Dental and Vision Insurance
- Employee Assistance Program
- Flexible Spending Account
- Health Insurance
- Health Savings Account
- Life Insurance
- Paid Time Off

Schedule: Monday thru Friday, 8–5

Experience: Electronics Manufacturing:
5+ years (Required)

License/Certification: IPC Certification—
Preferred, Not Required

Willingness to travel: 25% (Required)

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Technical Sales Manager

Objectives

Provide sales leadership and management for a regional sales territory. Responsible for retaining current customers as well as developing and attracting new customers and markets. Responsible for selling current and new products, keeping abreast of new technologies, market trends, and customer product needs.

Essential Functions and Responsibilities

- Develop and service assigned geographic region
- Actively and consistently seek new customers
- Visit customers and potential customers to develop relationships, deliver sales presentations, follow up on leads, and close sales
- Provide technical support and product recommendations in person, by email, and phone
- Manage major accounts; establish long-term, ongoing relationships with key individuals
- Provide feedback to Chemcut as well as sales peers regarding competition, pricing, and marketing opportunities

Qualifications

- Bachelor's degree in mechanical, electrical, chemical engineering or related fields
- 3-5 years of field sales experience with technology driven industrial products
- Well-developed sales and customer relations skills
- Ability to make decisions and evaluations to determine customer needs
- Ability to travel up to 50% of the time
- Excellent oral and written communication skills
- Knowledge of target market industries

To apply, please submit a cover letter and resume to hr@chemcut.net.

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Career Opportunities



Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB manufacturer located in Tucson, AZ, is looking for sales representatives for the Southeastern U.S. territory. With 35+ years of experience, our PCB manufacturing capabilities reach far beyond that of your typical fabricator.

Reasons you should work with Prototron:

- Solid reputation for on-time delivery (98+% on-time)
- Capacity for growth
- Excellent quality
- Production quality quick-turn services in as little as 24 hours
- 5-day standard lead time
- RF/microwave and special materials
- AS9100D
- MIL-PRF- 31032
- ITAR
- Global sourcing option (Taiwan)
- Engineering consultation, impedance modeling
- Completely customer focused team

Interested? Please contact
Russ Adams at (206) 351-0281
or russa@prototron.com.

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Test Engineer, Electronics Engineer

Keytronic is a dynamic, team-based contract manufacturer with facilities worldwide. Innovation defines us. Come join us in Spokane, Washington! We invite you to bring your engineering expertise and passion for excellence. In turn, we provide meaningful opportunities for you to implement these attributes to their fullest while working together to bring our customers high-tech automotive, aerospace, medical and commercial products to full production.

We encourage you to apply to one of our open positions below if you enjoy being challenged, working in a dynamic work setting and being a part of a team creating products to improve our world.

- **Test Engineer**—You will assist in conducting electrical test engineering support involving automation, assembly, maintenance, and data collection.
- **Electronics Engineer**—You will work on a team creating electronic circuitry, writing firmware for microprocessors and interfacing with customer development teams producing a wide array of products.

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Career Opportunities



Regional Manager Midwest Region

General Summary: Manages sales of the company's products and services, Electronics and Industrial, within the Carolinas and Mid-Atlantic Region. Reports directly to Americas Manager. Collaborates with the Americas Manager to ensure consistent, profitable growth in sales revenues through positive planning, deployment and management of sales reps. Identifies objectives, strategies and action plans to improve short- and long-term sales and earnings for all product lines.

DETAILS OF FUNCTION:

- Develops and maintains strategic partner relationships
- Manages and develops sales reps:
 - Reviews progress of sales performance
 - Provides quarterly results assessments of sales reps' performance
 - Works with sales reps to identify and contact decision-makers
 - Setting growth targets for sales reps
 - Educates sales reps by conducting programs/seminars in the needed areas of knowledge
- Collects customer feedback and market research (products and competitors)
- Coordinates with other company departments to provide superior customer service

QUALIFICATIONS:

- 5-7+ years of related experience in the manufacturing sector or equivalent combination of formal education and experience
- Excellent oral and written communication skills
- Business-to-business sales experience a plus
- Good working knowledge of Microsoft Office Suite and common smart phone apps
- Valid driver's license
- 75-80% regional travel required

To apply, please submit a COVER LETTER and RESUME to: Fernando Rueda, Americas Manager

fernando_rueda@kyzen.com

apply now



Application Engineer

Flexible Circuit Technologies (FCT) is a global supplier providing design, prototyping and production of flexible circuits, rigid flex circuits, flexible heaters and full assembly services.

Responsibilities

- Gain understanding for customer/specific project requirements
- Review customer files, analyze - application, design, stack up, materials, mechanical requirements; develop cost-effective design to meet requirements
- Quote and follow-up to secure business
- Work with CAD: finalize files, attain customer approval prior to build
- Track timeline/provide customers with updates
- Follow up on prototype, assist with design changes (if needed), and push forward to production
- Work as the lead technician/program manager or as part of FCT team working with an assigned application engineer
- Help customer understand FCT's assembly, testing, and box build services
- Understand manufacturing and build process for flexible and rigid-flex circuits

Qualifications

- Demonstrated experience: flex circuit/rigid-flex design, including design rules, IPC; flex heater design +
- Ability to work in fast-paced environment, broad range of projects, maintain sense of urgency
- Ability to work as a team player
- Excellent written and verbal communication skills
- Willing to travel for sales support and customer support activities if needed

Competitive salary, bonus program, and benefits package. Preferred location Minneapolis, MN area.

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Career Opportunities



Technical Marketing Engineer

EMA Design Automation, a leader in product development solutions, is in search of a detail-oriented individual who can apply their knowledge of electrical design and CAD software to assist marketing in the creation of videos, training materials, blog posts, and more. This Technical Marketing Engineer role is ideal for analytical problem-solvers who enjoy educating and teaching others.

Requirements:

- Bachelor's degree in electrical engineering or related field with a basic understanding of engineering theories and terminology required
- Basic knowledge of schematic design, PCB design, and simulation with experience in OrCAD or Allegro preferred
- Candidates must possess excellent writing skills with an understanding of sentence structure and grammar
- Basic knowledge of video editing and experience using Camtasia or Adobe Premiere Pro is preferred but not required
- Must be able to collaborate well with others and have excellent written and verbal communication skills for this remote position

EMA Design Automation is a small, family-owned company that fosters a flexible, collaborative environment and promotes professional growth.

Send Resumes to: resumes@ema-eda.com

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MACHINES FOR PRINTED CIRCUIT BOARDS

Field Service Engineer

Location: West Coast, Midwest

Pluritec North America, Ltd., an innovative leader in drilling, routing, and automated inspection in the printed circuit board industry, is seeking a full-time field service engineer.

This individual will support service for North America in printed circuit board drill/routing and X-ray inspection equipment.

Duties included: Installation, training, maintenance, and repair. Must be able to troubleshoot electrical and mechanical issues in the field as well as calibrate products, perform modifications and retrofits. Diagnose effectively with customer via telephone support. Assist in optimization of machine operations.

A technical degree is preferred, along with strong verbal and written communication skills. Read and interpret schematics, collect data, write technical reports.

Valid driver's license is required, as well as a passport, and major credit card for travel.

Must be able to travel extensively.

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Career Opportunities



ventec
INTERNATIONAL GROUP
騰輝電子

European Product Manager Taiyo Inks, Germany

We are looking for a European product manager to serve as the primary point of contact for product technical sales activities specifically for Taiyo Inks in Europe.

Duties include:

- Business development & sales growth in Europe
- Subject matter expert for Taiyo ink solutions
- Frequent travel to targeted strategic customers/OEMs in Europe
- Technical support to customers to solve application issues
- Liaising with operational and supply chain teams to support customer service

Skills and abilities required:

- Extensive sales, product management, product application experience
- European citizenship (or authorization to work in Europe/Germany)
- Fluency in English language (spoken & written)
- Good written & verbal communications skills
- Printed circuit board industry experience an advantage
- Ability to work well both independently and as part of a team
- Good user knowledge of common Microsoft Office programs
- Full driving license essential

What's on offer:

- Salary & sales commission--competitive and commensurate with experience
- Pension and health insurance following satisfactory probation
- Company car or car allowance

This is a fantastic opportunity to become part of a successful brand and leading team with excellent benefits. Please forward your resume to jobs@ventec-europe.com.

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KOH
YOUNG
AMERICA

Technical Service & Applications Engineer Full-Time — Midwest (WI, IL, MI)

Koh Young Technology, founded in 2002 in Seoul, South Korea, is the world leader in 3D measurement-based inspection technology for electronics manufacturing. Located in Duluth, GA, Koh Young America has been serving its partners since 2010 and is expanding the team with an Applications Engineer to provide helpdesk support by delivering guidance on operation, maintenance, and programming remotely or on-site.

Responsibilities

- Provide support, preventive and corrective maintenance, process audits, and related services
- Train users on proper operation, maintenance, programming, and best practices
- Recommend and oversee operational, process, or other performance improvements
- Effectively troubleshoot and resolve machine, system, and process issues

Skills and Qualifications

- Bachelor's in a technical discipline, relevant Associate's, or equivalent vocational or military training
- Knowledge of electronics manufacturing, robotics, PCB assembly, and/or AI; 2-4 years of experience
- SPI/AOI programming, operation, and maintenance experience preferred
- 75% domestic and international travel (valid U.S. or Canadian passport, required)
- Able to work effectively and independently with minimal supervision
- Able to readily understand and interpret detailed documents, drawings, and specifications

Benefits

- Health/Dental/Vision/Life Insurance with no employee premium (including dependent coverage)
- 401K retirement plan
- Generous PTO and paid holidays

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Career Opportunities



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

- Engineering
- Quality
- Various Manufacturing

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

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

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

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

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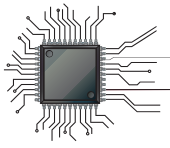
Are You Our Next Superstar?!

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

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

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Career Opportunities



MivaTek

Global

Field Service Technician

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

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

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

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

More About Us

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

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eptac

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

Qualifications and skills

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

Benefits

- Ability to operate from home. No required in-office schedule
- Flexible schedule. Control your own schedule
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- Training and certifications provided and maintained by EPTAC

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Career Opportunities



American Standard Circuits

Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

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

ESSENTIAL DUTIES AND RESPONSIBILITIES

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

ORGANIZATIONAL RELATIONSHIP

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

QUALIFICATIONS

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

PHYSICAL DEMANDS

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

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U.S. CIRCUIT

Plating Supervisor

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

Competitive benefits package.

Pay will be commensurate with experience.

Email to:
mfariba@uscircuit.com

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Career Opportunities



APCT, Printed Circuit Board Solutions: Opportunities Await

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

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

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

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

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GOOD FOR THE INDUSTRY

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

Designing for Reality by Matt Stevenson, Sunstone Circuits

Based on the wisdom of 50 years of PCB manufacturing at Sunstone Circuits, this book is a must-have reference for designers seeking to understand the PCB manufacturing process as it relates to their design. Designing for manufacturability requires understanding the production process fundamentals and factors within the process that often lead to variations in manufacturability, reliability, and cost of the board. Speaking of making better decisions, [read it now!](#)



Thermal Management with Insulated Metal Substrates, Vol. 2

by Didier Mauve and Robert Art, Ventec International Group

This book covers the latest developments in the field of thermal management, particularly in insulated metal substrates, using state-of-the-art products as examples and focusing on specific solutions and enhanced properties of IMS. [Add this essential book to your library.](#)



High Performance Materials

by Michael Gay, Isola

This book provides the reader with a clearer picture of what to know when selecting which material is most desirable for their upcoming products and a solid base for making material selection decisions. [Get your copy now!](#)



Stackups: The Design within the Design

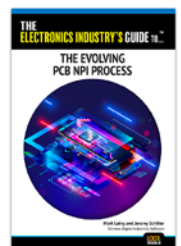
by Bill Hargin, Z-zero

Finally, a book about stackups! From material selection and understanding laminate data-sheets, to impedance planning, glass weave skew and rigid-flex materials, topic expert Bill Hargin has written a unique book on PCB stackups. [Get yours now!](#)

THE ELECTRONICS INDUSTRY'S GUIDE TO... The Evolving PCB NPI Process

by Mark Laing and Jeremy Schitter, Siemens Digital Industries Software

The authors of this book take a look at how market changes in the past 15 years, coupled with the current slowdown of production and delivery of materials and components, has affected the process for new product introduction (NPI) in the global marketplace. As a result, companies may need to adapt and take a new direction to navigate and thrive in an uncertain and rapidly evolving future. Learn how to streamline the NPI process and better manage the supply chain. [Get it Now!](#)



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