APRIL 2024

I-Connect007

# PCB007 MAGAZINE

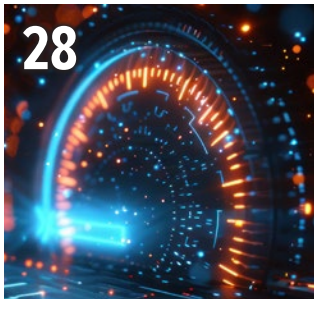
## The Growing Industry

PCB007 MAGAZINE

# The Growing Industry

The U.S., which seemed to have abdicated its title as the world leader in innovating high-technology cutting-edge manufacturing processes, is now in a race to regain what it lost and then some. But what does "growing" look like for the organizations that have received DoD funding, and for the rest of us? How can we sustain this growth?



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# The Growing Industry

## Marcy's Musings

by Marcy LaRont, I-CONNECT007

After more than two decades of steady decline in the U.S., the PCB industry is finally growing in the West thanks to the CHIPS and Science Act, DoD funding, and hopefully, the passing of HR 3249, the Printed Circuit Board and Substrates Act. The U.S. is now in a race to regain what was lost and then some.

But what does "growing" look like for the organizations that have received DoD funding, and for the rest of us? To get a picture of what's happening in the industry today, we start with M&A specialist Tom Kaster and IPC Chief Economist Shawn DuBravac, who kick off this issue by providing expert insights on the state (and sustainability) of industry growth in the U.S., especially as it relates to investment capital and as interest rates remain high. Also in this issue, Alex Stepinski of Smart Factory Design provides hope for continued growth with disruptive news that launching a PCB fab in the U.S.—one that is mil/aero capable—may be far less expensive than we think. (Stay tuned, as this will be discussed in detail in May *PCB007*.) The voices of our industry can be heard in an interview with Tom Edman of TTM, who discusses TTM's planned UHDI facility expansion in Syracuse, New York; a Q&A with Shane Whiteside of Summit Interconnect, who shares his thoughts on our growing industry; and an article by Lea Maurel of ICAPE, which provides a thorough overview of the PCB growth landscape.

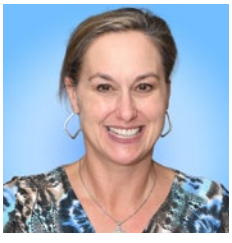
There are many aspects to growth. So, check out my interview with IPC's lead lobbyist Richard Cappetto, who talks about the increasing importance of advocacy in the U.S. economic environment for the printed circuit board supply chain, take a moment to read Travis Kelly's PCBAA column, "What About the Rest of the Technology Stack?" Learn

more about IPC Validations Services, which, after 11 years, has 140 companies able to verify they meet or exceed the written IPC standards. Finally, IPC's Joe O'Neil gives an important update on the U.S. Partnership for Assured Electronics (USPAE) research and development facility, the Printed Circuit Board Market Catalyst (PBMC)—what it is and what it will offer the PCB industry after it's built.

As usual, our columnists have shown up with force. Don Ball of Chemcut finishes his two-part series on reducing etch system water usage. Henry Crandall offers a compelling and personal column on the criticality of reliability in medical electronics as he takes us through the birth of his child and a malfunctioning sensor. Material scientist Preeya Kuray provides an excellent discussion on Dk, and Happy Holden uses his Tech Talk series to finish his coverage of power mesh architecture.

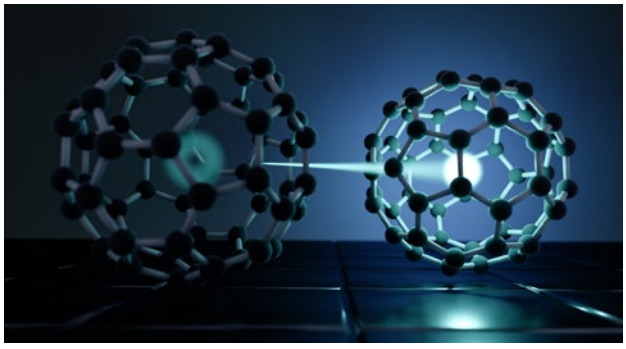
Last but not least, I know you'll find value in our new series of audio interviews entitled "Young Professionals," featuring the next-generation workforce in the varying areas of our industry who are crushing it. Workforce remains one of the biggest topics in our industry today, whether we are discussing workforce training, culture, or knowledge transfer. In this episode, you'll meet Jennifer Robinson of TTA.

Finally, many of us are just arriving home after a week in Anaheim at IPC APEX EXPO 2024. It was a full week and I-Connect007 was there. Make sure to visit our video and photo site, *realtimewith.com*, to see what you may have missed; and stay tuned for our 2024 *Show & Tell Magazine* in a few weeks. And when you find something in this issue that resonates, please share it with your friends and colleagues. **PCB007**



**Marcy LaRont** is the editor of *PCB007 Magazine*. Marcy started her career in PCBs in 1993 and brings a wide array of business experience and perspective to I-Connect007. To contact Marcy, click here.

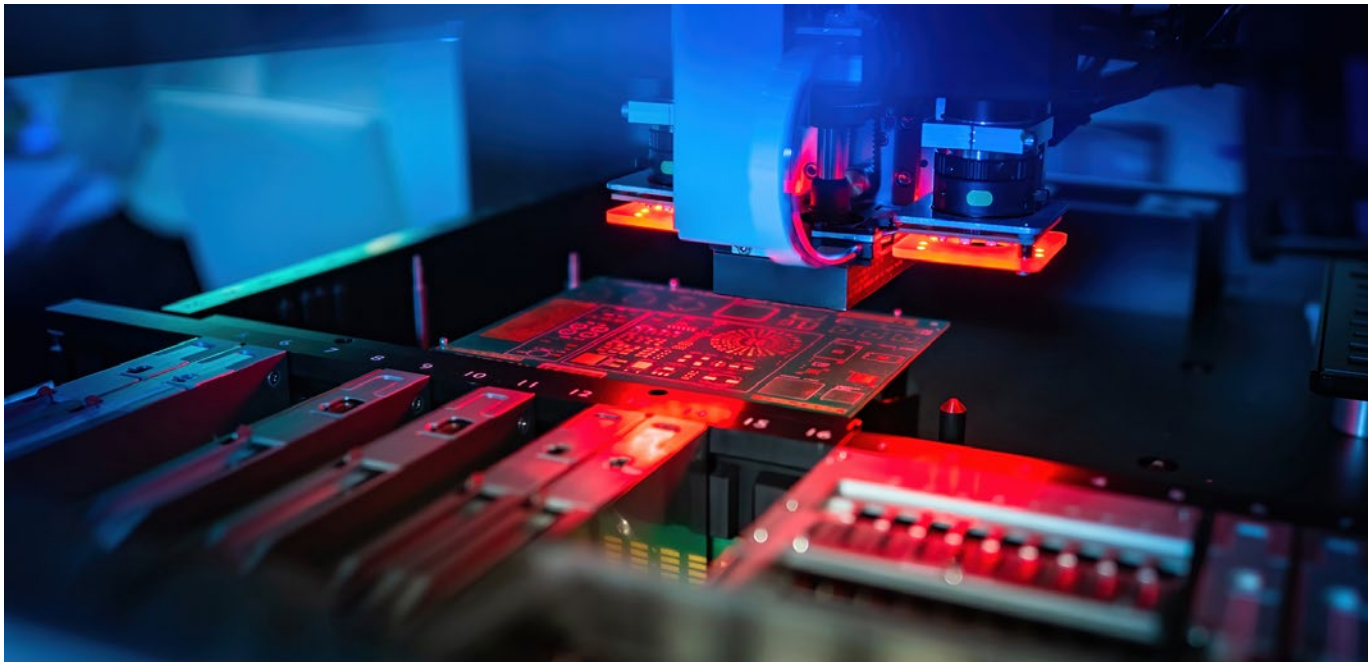
## Spectroscopy and Theory Shed Light on Excitons in Semiconductors



From solar panels on our roofs to the new OLED TV screens, many everyday electronic devices simply wouldn't work without the interaction between light and the materials that make up semiconductors. A new category of semiconductors is based on organic molecules, which largely consist of carbon, such as buckminsterfullerene. The way organic semiconductors work is largely determined by their behaviour in the first few moments after light excites electrons, forming "excitons" in the material. Researchers from the Universities of Göttingen, Graz, Kaiserslautern-Landau and Grenoble-Alpes have now, for the first time, made very fast and very precise images of these excitons—in fact, accurate to one quadrillionth of a second (0.000,000,000,000,001s) and one billionth of a metre (0.000,000,001m). This understanding is essential for developing more efficient materials with organic semiconductors. The results were published in *Nature Communications*.

When light hits a material, some electrons absorb the energy and this puts them into an excited state. In organic semiconductors, such as those used in OLEDs, the interaction between such excited electrons and left-over "holes" is very strong, and electrons and holes can no longer be described as individual particles. Instead, negatively charged electrons and positively charged holes combine to form pairs, known as excitons. Understanding the quantum mechanical properties of these excitons in organic semiconductors has long been considered a major challenge—both from a theoretical and an experimental point of view.

(Source: University of Gottingen )



# The New Industry: Will the Growth Continue?

**Feature Interview by the I-Connect007 Editorial Team**

How sustainable are the primary financial models in the United States regarding PCB fabrication shops? In this interview with IPC Chief Economist Shawn DuBravac and M&A expert Tom Kastner, we explore what's happening with U.S. printed circuit board shops in today's market, how consolidation affects the industry, and what can be done.

***Marcy LaRont: Shawn and Tom, thank you for joining us today. Tom, in another recent interview, you estimated there are 100 to 120 circuit board shops left in the U.S.***

*Tom Kastner:* Yes, and my number tends to be lower than IPC's, but I have a different definition of a printed circuit board "shop" because there are so many that are not making boards anymore. It's difficult to track anyone under $5 million.

Statistically, the number of board shops doesn't really matter because roughly 90% of production is done by something like the top 50 printed circuit board manufacturers. We see that the bigger shops are getting bigger, for example, the ones like APCT and Summit. There is some organic growth, but much of the growth is due to the acquisition of smaller shops. The bigger shops are more likely to have better equipment and technology to compete with Asia. Overall, that's good for the industry in the United States.

***Nolan Johnson: Tom, if some of those estimated 120 U.S. PCB shops aren't making boards anymore, what are they doing?***

*Kastner:* They are brokering, for example. Any business that has survived for 25 to 30 years under tough conditions can make much more

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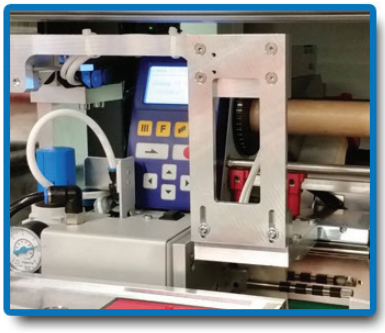

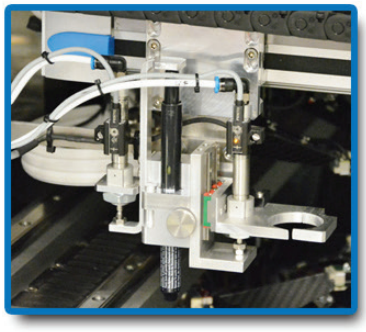

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money brokering because they don't have the headaches of CapEx or environmental regulations. They are brokering domestically as well as importing boards, and many of them have gotten into assemblies as well.

Tom Kastner

***LaRont: You've said there's more activity on the assembly side rather than PCB fabrication, but the profit margins can be very thin, so why is that attractive?***

*Kastner:* Several factors keep the number of EMS companies high. I don't know the exact number, but I think there are between 700 and 900 companies in North America. One key thing is that customers like their EMS shops to be local. Ninety percent of that business is within 100 or 200 miles of the customer for lower-volume manufacturing. Higher volume, especially more commodity products, are still made overseas and imported. Customers like to be able to see their products, especially if there is an issue in production.

Also, OEMs like the final touches to be done nearby in case there are any changes to the firmware, anything outside the box, whatever it might be. That is more easily done when it's nearby. There's also a much lower barrier to opening an EMS shop compared to a PCB fabrication shop. While it's still highly technical, you don't have the "black magic" of chemicals and the "dirtiness" factor with all the environmental regulations. That is a major factor. Finally, air freighting a box build final assembly is getting more expensive; it's almost prohibitive.

***LaRont: Why would someone buy or sell at this time? Why is this even an attractive investment opportunity? Are private equity owners looking to provide a return on investment for their investors?***

*Kastner:* The private equity guys see the trend toward reshoring, the government support in dollars, the nice military budgets, and a halfway decent economy for products. The market may not be growing quickly, but it remains robust. There is a lot of private equity money available overall, and they are investing in everything, not just electronics. That is providing a tremendous amount of liquidity for people in our industry.

*Shawn DuBravac:* The cost of cash is a lot higher than it was last year and is likely to stay higher. Investing in something like a lawn care business or consolidating dentists' offices into a group, for example—when your cost of cash is zero, and you think there are synergies in combining a number of them—doesn't translate as well today. The math doesn't work out. There will be a much higher threshold for investors to find higher returns on that cash. Previously, they could immediately make 5%, risk-free, or market yields of 7–8% if they were willing to take some risk. Now, with the cost of cash, to make the investment worthwhile you will need to have deals returning in the 15% range.

So, the consolidation we've seen from private equity from many industries will go away. There are modernizations that can take place with larger companies, but not enough to drive the level of return that private equity is looking for. In certain instances, electronics starts to look more attractive when you don't have cash going to law firms and lawn care businesses. Still, I believe we will see this situation affect electronics.

*Kastner:* It could be, but generally, the deals in electronics have not been very highly leveraged. Everyone recognizes that it is all project-based with no recurring revenue. It's not a software-as-a-service (SaaS) revenue model,

so most have been reasonably leveraged. The valuations could be down a bit, and more investment will be moved into alternative financing, like a seller note or rollover equity.

There are just not that many PCB shops to buy. Big companies must keep buying smaller shops or do something a little bit differently. On the EMS provider side, there are a lot of shops, and the demographics will likely support those deals, so I expect to see a similar number of deals this year. I'm not sure about the total value of those deals because the bigger deals certainly will be affected by higher interest rates.

Shawn DuBravac

***Johnson: With this change in the financial marketplace, does it change one's growth strategy? Does available funding encourage more internal investment rather than looking for a CapEx partner to sell the assets to?***

*Kastner:* Obviously, lower interest rates help with CapEx. To grow, the bigger companies must invest more. For example, I don't think there's anyone over $20–$25 million who doesn't have direct imaging. If they want to stay in the game, they must invest in CapEx. The smaller guys will either sell or have an exit strategy. But they've existed for 30 years, so there is a lot of ingenuity and intelligence there.

***Johnson: In this environment, can you build a PCB fabrication business without DoD?***

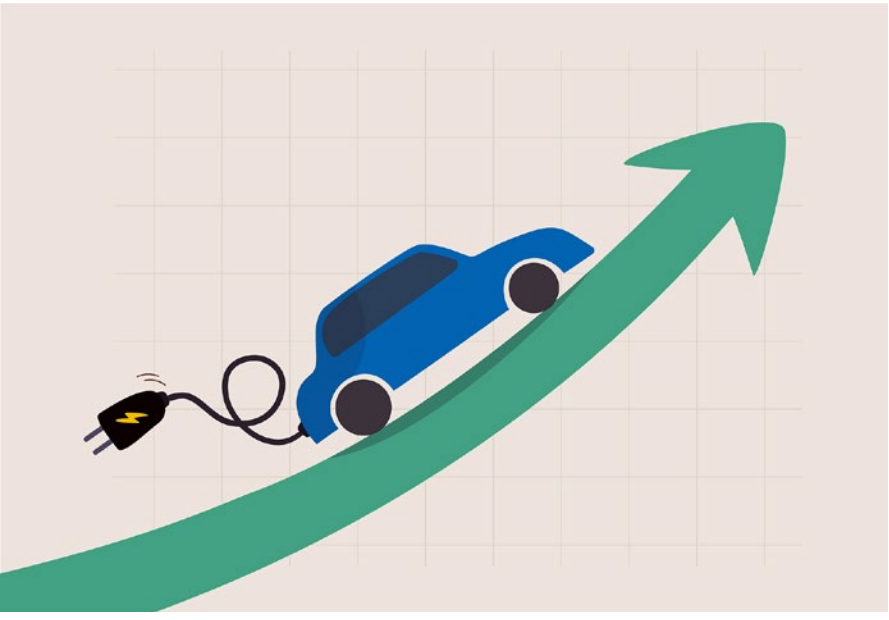
*Kastner:* I don't think so. Most new builds are captive, like GreenSource. Alpha Circuit in Schaumburg, Illinois, is building a new facility and bringing all their shops into one. If you don't have that business already, it would be incredibly tough. Without the DoD, I do not believe we would have a PCB fabrication industry in the United States.

***LaRont: Shawn, let's talk about broader market projections and the regional sustainability of this business. Some say the current U.S. situation is not sustainable. Where will we be in 10 years?***

*DuBravac:* This is the classic chicken-and-egg problem. If I build my business, will I continue to have enough business? Is it a sustainable investment? This is a big debate everywhere right now. You have government buyers and ITAR that have settled the market in a certain place. Can the market grow outside of where it has naturally settled? On the margin, I think it can.

The next question is, does that new growth get captured by already participating companies as they expand capacity, or does it expand from the existing base? The demographic change in the industry is interesting. You've got people who are ready to retire; the next generation doesn't want to take over the business. So, they're looking for a liquidity event, and they will take it any way they can. Some of the fuzziness in Tom's numbers is because some companies will just wind down. The owner will just decide one day, "We're done," then turn off the lights and walk away. That could be a long, slow process. It could even be a process that's ultimately invoked by the next generation when they decide it's time. So, yes, there is growth in North America happening on the margin, but it's still a big unknown about how big that grows and where.

Investment into EV infrastructure is a good example of this. There is production going into that. LG just announced a battery factory, and we will see more of those. There's a big EV investment in the Southeast U.S.—2022 was a record number for Georgia, North Carolina, South Carolina, and Tennessee for in-state investments. Those numbers may have even



been eclipsed in 2023. They saw record investments related to EV commitments, and even with the EV market slowing, it is still a growth area. On the margin, that helps.

To Tom's point, how much needs to be done locally vs. how much can be brought in? Clearly, Mexico is benefiting, and that will continue, if it remains stable and there are workers. There are several forces, though not all of them are moving as fast as they once were. Wages are definitely increasing in Mexico. Those things get added to the balance equation. If they were moving really fast, then you'd see people say the trajectory warrants the gamble of putting in a PCB shop. I don't know that we're growing fast enough to make that gamble.

***Johnson: Do you see any changes in the makeup of those employed in manufacturing as it grows? Is the need for workers being offset by meaningful investment in automation?***

*DuBravac:* There is definitely investment going into automation and robotics to augment the existing workforce and, in some cases, to fill a need where workers aren't available. Manufacturers still have a hard time finding people who are willing to work. It's hard to comprehend that people show up for a job, work for a couple of days, and then just leave without formally quitting. They leave by lunch and never come back. They don't even show up for their paycheck.

Manufacturers used to compete against other manufacturers for employees. Now, they compete against Starbucks. Manufacturing work has changed; the tastes and preferences of workers have changed. So, they are investing in automation and robotics, which is moving in a very measured way. My guess is that the LG battery factory being built in Texas will be more automated than a battery factory built five years ago. The nature of manufacturing will be more conducive to automation.

***LaRont: EV is a huge technology driver for markets in Asia and possibly Europe. What about HDI and UHDI? Has growth slowed?***

*DuBravac:* It's all relative. We went from a 99% growth rate in EV to around 50% in the U.S. We didn't double our growth again last year, and everybody is concerned, but we sold over a million units for the first time. There are still a lot of tailwinds in that category. The whole EV infrastructure must grow. Growth will be roughly 30% this year, which is still phenomenal.

As you get to a bigger base, your growth will slow; it's just arithmetic. The U.S. is still well below the rest of the world when it comes to EV, which suggests there's some room for growth. We are at about 9% of total EV sales. Europe is at about 18%. There are Nordic countries that have just massive EV penetration compared to what we see in the U.S., so we have a very long way to go. We were gripped by headlines from Ford saying it would delay its investment in battery technology and battery factories. We have had some delays, but not really cancellations. We don't always comprehend the meaning of a slower growth rate. The law of large numbers means the growth rate will slow, but we will see new entrants into the business. LG wasn't in EV chargers until they went into South Korea last year, and now in the U.S. this year.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How much is being produced in the U.S. vs. elsewhere? There is a movement toward nearshoring, but it's slow. What's the upper boundary? We know it's not 100%, so where is it? Is it another percentage point, or another 15? How long would it take to get to another 10 percentage points? As I noted in the December 2023 issue, if you just look at the data, Mexico has become a much bigger player. Imports are captured in two different ways in the U.S., which could mean that Mexico is an even larger player than we see with the current data.

***Johnson: What other investments are happening in PCB fabrication around the globe?***

*DuBravac:* That is a difficult question. Perhaps it is time to take another, deeper look at regional investment given all the geopolitical shifting. As far as the U.S., the DoD has always been very cognizant of what is being manufactured and the domestic capacity. During the pandemic and subsequent geopolitical tensions, it has become even more sensitive to what is available for domestic PCB production. Outside of DoD, the Commerce Department is now waking up to the greater concern for the U.S. economy and supply chain stability. That does result in movement, but it remains to be seen how much. There is definitely the sense in the U.S. and Europe that they are willing to invest in PCBs. Companies are asking, "Am I willing to put my dollar next to a government dollar and build a facility, and can I make it sustainable in the long term?"

***Johnson: What about the margins of new technology? Is now the time to consider growth by pivoting to something like substrates?***

*Kastner:* There is a lot of interest in advanced packaging and microelectronics, and those are sectors that either didn't exist 20 years ago or were completely blown out and moved to Asia in the late '90s and early 2000s. Now we are scrambling to recover some of those capabilities, but it doesn't really mean you should build a new plant. But there will be more investment in clean rooms, wire bonders, advanced 3D inspection equipment, and so on.

*DuBravac:* The history of manufacturing is the history of innovation. You must constantly reinvent yourself. That means moving into adjacent categories to where the market is. Pre-pandemic, a lot of the market in the U.S. was in rapid prototyping, short runs, and small batches. It shifted a bit during the pandemic. The people who have survived these past 30 years have always paid attention and listened to their customers. Like all good consultants or manufacturers, they respond, "Sure, we can do that. We'll figure out how to do that."


A couple of things are happening. Companies are always looking at how to move the value stack and increase the margin stack. It is the classic innovator's dilemma: finding new things to do that are of value to the customer and have higher margins.

***LaRont: This is the constant struggle for business: reinvention, relevancy, and translating value into profitability.***

***Johnson: We've recently spoken to well-known industry leaders working to shift PCB fab startup costs down dramatically to just barely eight figures. Is this a game changer in terms of potential investment into new PCB shops in the United States?***

*Kastner:* I think there's been a fair amount of talk, but you really haven't seen existing fabs do that. Instead, they have chosen to invest in their facilities. It sounds good, but I do not know whether that would translate to new facilities being built in the United States.

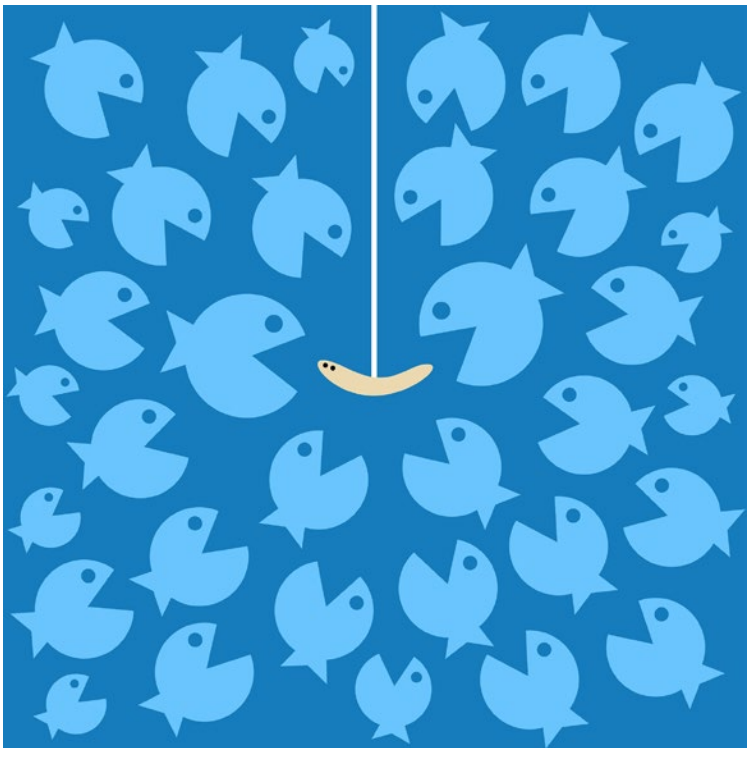
*DuBravac:* It goes back to the conversation we had in the beginning: the constraint is not about cost as much as it is demand. Not having clear demand is the bigger concern. As Tom mentioned, it seems that the companies that are investing typically are tied to a DoD contract or some other type of commitment.

***Johnson: It does seem like the growth for brand-new facilities in North America has been captive.***

*Kastner:* That's right, and believe me, I would love to see new plants go up here. That would be fantastic. In my view, the economics are just not there.

***LaRont: Shawn, do you foresee significant changes or shifts globally?***

*DuBravac:* Well, China has its own headwinds, and it's massive. It's not going away. China pre-announced its economic growth recently, and it was the lowest reported in decades. It's not really growing. Outside of China, there's growth in Malaysia and Vietnam, for example. There is opportunity here in the U.S., but it's not clear what that is. If the opportunities were clear, people would come. That's the beauty of America. If somebody sees an opportunity, they will 100% go after it. Tom and I agree that several things must line up for it all to make sense. But we will certainly keep an eye on it and look forward to reporting on what we see.



***Johnson: As always, it's interesting and educational talking with you both. Any parting thoughts?***

*DuBravac:* The main thing to walk away with is that everything hinges on demand. If demand is there, everything else gets in line. If demand is there, everybody comes out of the woodwork and says, "Yeah, I'll put money behind that." If demand is there, everything else will take care of itself.

*Kastner:* Investors are committed to growing, but for how long? These are smart investors. I don't foresee anybody going IPO on either side—boards or assemblies—but there is measured investor support out there. It's not crazy, over-the-top support, but it's there.

***LaRont: Tom and Shawn, thank you both for your time and insights.*** **PCB007**

*Tom Kastner is the president of GP Ventures, an investment banking firm focused on sell-side and buy-side transactions in the tech and electronics industries. GP Ventures has offices in Chicago and Tokyo, with five people in total.*

# Scalable ZLD and a Solution for PCB Start-ups

**Feature Interview by Barry Matties**
I-CONNECT007

Alex Stepinski talks about his business priorities for this year and what the market, particularly aerospace and defense, needs for orders to be filled.

***Barry Matties: What is your priority for 2024? What do you hope to accomplish this year?***

*Alex Stepinski:* ZLD (zero liquid discharge) systems have become a good ROI investment on a larger scale, but I have more work to do on a smaller scale. In 2024, I believe we will get all sizes of this system down to an ROI of one year or less. This year, my key objective is to develop a central recycling system with a good ROI so that every shop has a high desire to buy. Then I need to be able to deliver the system in an efficient and cost-effective way for everyone. I want to get that product going.

I have other interests beyond wastewater. While doing the due diligence for new factories in the U.S., I have found that many want to build circuit board shops but at a startup scale, and many want to build for aerospace and defense. Right now, the minimum viable bill of materials (BOM) to build a PCB shop is too high. If we make it all about defense-related products, the minimum viable BOM is traditionally tens of millions of dollars. I have a partner and we're bringing a solution to market this year that has a new bill of material for startups.

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Alex Stepinski

With this new approach, it's just under $10 million to do everything—laser drill, SAP, embedded products—but on a very small scale. Once you have your minimum viable product and are qualified, you can add more equipment. It's really the starting point that's missing.

There is a lot of concern in the market that there will be too much consolidation in the North American and European markets. Consolidation is not necessarily a good thing, because it's not an innovative ecosystem. We want and need the mid-sized, sub-$50 million turnover companies in the market. But they won't start out at $50 million, and you can't be begging everyone for tens of millions of dollars. We need to take this down to a much lower level to have more investments, which further de-risks things.

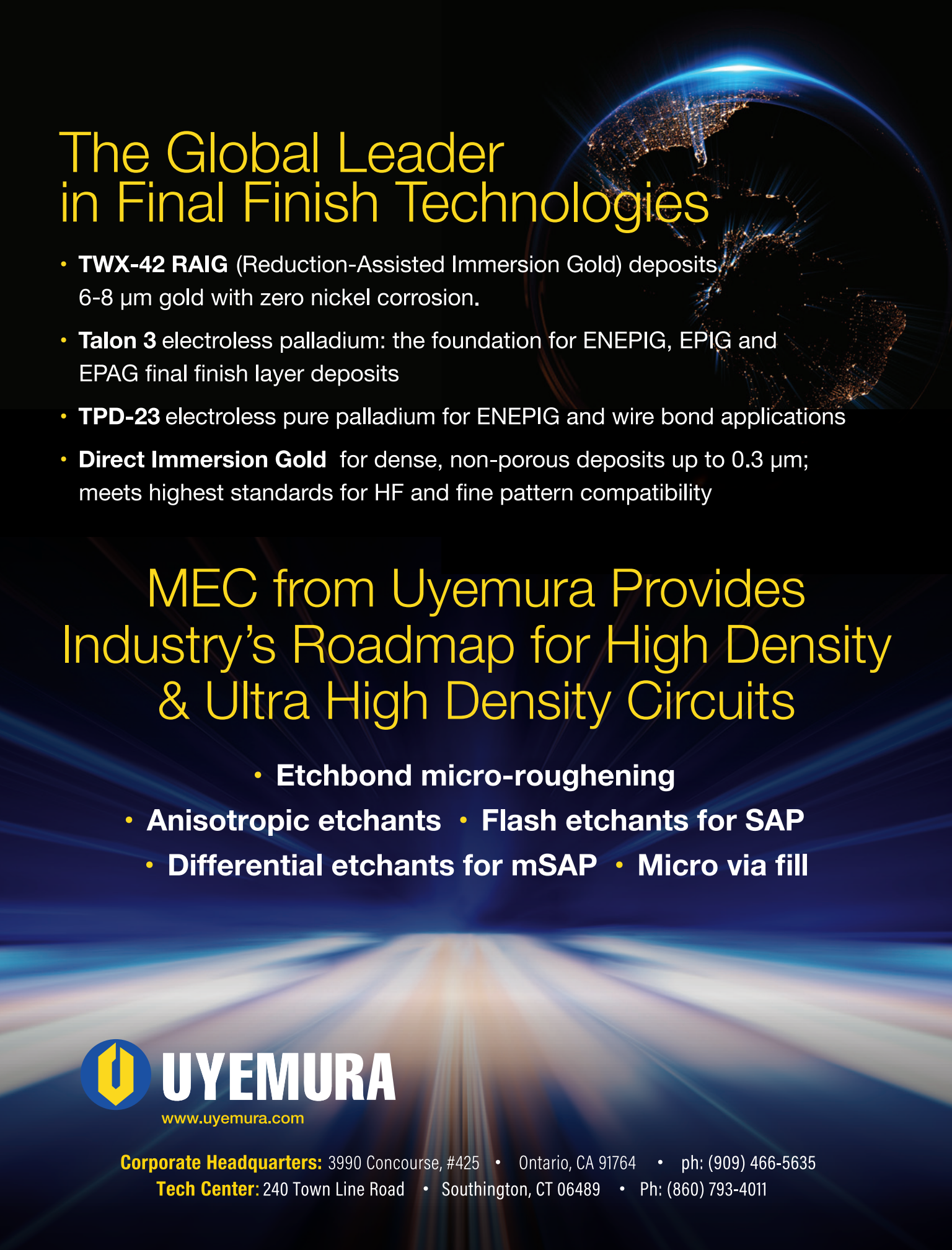
***Are these people more engineering-minded or more marketing- and business development-minded?***

They run the full gamut. We're trying to right-size a system with good operating costs that's green and automated and lets you get started. If you have such a BOM, you can make money very quickly in the defense and aerospace arena because the pricing is typically very high, and the market price is driven significantly by high labor operations. All the folks who are in this business have a lot of highly paid labor costs and a lot of equipment that all needs to be maintained. So, if you come in with a very nimble operation with fewer people, simple automation, low BOM cost, and low operating costs—because everything's on the small side—you can run circles around them. A little PT boat turns a lot faster than the aircraft carrier.

***I think the swarm approach with multiple smaller-sized satellites is much more productive than one giant one.***

Yes. Those are my two key focuses: the environmental/sustainability side, and distributed manufacturing. That ecosystem is the most sustainable, and it drives innovation. Many more companies are involved with more ideas. Having been in charge of both small and large operations, I did 100 times more invention and innovation at the smaller organizations than I did in the bigger operations where you're dealing with more bureaucracy.

***Those are exciting and worthwhile initiatives. We will definitely stay in touch and look forward to hearing more about them as you progress. Thank you, Alex, and good luck.*** **PCB007**



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# TTM's High Tech Expansion and Industry Innovation

**Feature Interview by Marcy LaRont**
I-CONNECT007

Tom Edman has been the CEO of TTM Technologies since 2014 and has an extensive background in electronics and manufacturing. TTM is a leading global manufacturer of technology solutions, including mission systems, RF component and RF microwave microelectronics assemblies, and quick turn and advanced technology printed circuit boards.

In this interview, Tom discusses the decision-making behind TTM's new ultra HDI PCB facility in Syracuse, New York, where the company already has a 160,000-square-foot RF microwave and microelectronics facility. He highlights TTM's commitment to innovation and meeting the dynamic demands of the industry, touches on the industry's need for supply chain resiliency and engagement with OEMs, and discusses what he finds most exciting about our industry right now.

***Marcy LaRont: On its face, it would seem like Syracuse naturally pops to the top of the list for your expansion. What criteria did you use in your selection?***

*Tom Edman:* We started with about 16 states as candidates, narrowed that down to 10 states for a more in-depth review, and then ended with two finalists. At the end of the day, it was

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much more than just a state incentive package. For us, it all starts with the quality of the people we can find in a particular area.

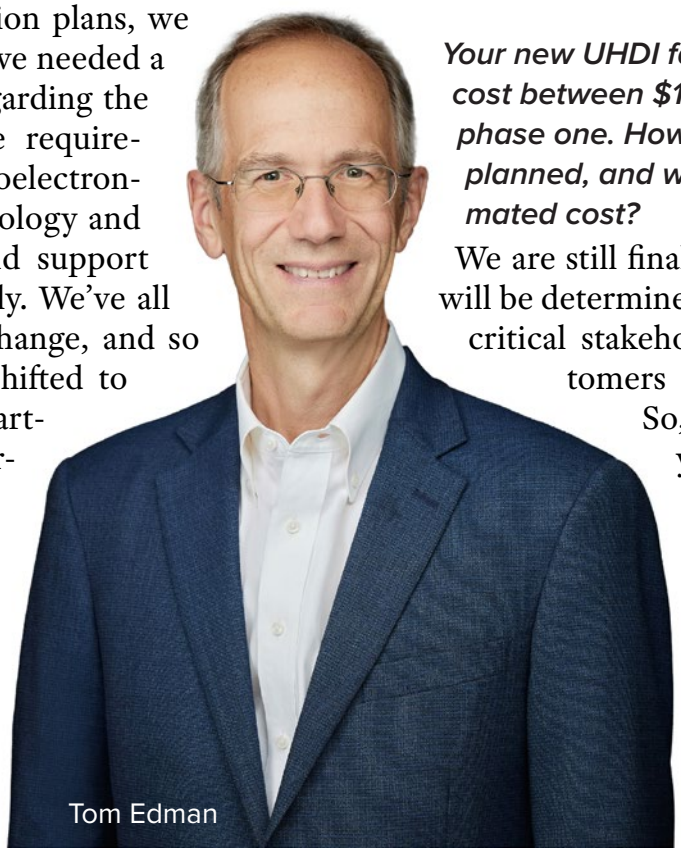
Both our RF microwave and microelectronics facility and our RF component facility are in the local area, which means we have the available infrastructure and a very strong engineering organization to help support the planning and the startup of this facility. The tipping point was the quality of the workforce and the infrastructure available, combined with very strong government support at the state and local levels. That convinced us Syracuse was the place for TTM to expand.

***As CEO, you are very plugged into advocacy efforts—Senate Majority Leader Chuck Schumer called you himself to persuade you to build in New York. How has this type of activity affected your approach to business?***

We really started our involvement in Washington, D.C., in 2018 because our critical customers in the commercial world were talking about the need for supply chain resiliency. As we surveyed our own footprint and future expansion plans, we quickly concluded that we needed a voice in Washington regarding the necessary infrastructure requirements to enhance microelectronics manufacturing technology and capacity in the U.S. and support our industry domestically. We've all watched as the world change, and so much of our business shifted to Asia. We realized that starting to reverse the offshoring trend and grow U.S microelectronics manufacturing would take incredible persistence, the support of our customers, and a set of incentives at the government level that reinforce the need for supply chain resiliency. The best way to create an environment for printed circuit board production in North America is to create a strong and resilient demand environment.

Recognizing this as an absolute need, we banded with our brethren in the PCB industry to form the Printed Circuit Board Association of America (PCBAA) as a way to supplement the incredible work IPC does for the broader electronics industry and to be a specific voice on PCBs in Washington, D.C. Partnering with IPC on initiatives here has worked out very well. In 2020, TTM hired our own representative in Washington, D.C., so that we have a permanent presence there, and he is doing a great job spreading the message for the company and the industry.

There was a need for industry voices in D.C., and I'm excited that the industry message is expanding and growing in Washington and that the government seems to be recognizing the needs for both defense infrastructure purposes and broader, critical commercial needs. I've been thrilled to personally participate and to have our organization be part of this effort.


Tom Edman

***Your new UHDI facility is estimated to cost between $100–$130 million for phase one. How many phases are planned, and what is the total estimated cost?***

We are still finalizing the scope, which will be determined with input from both critical stakeholders—our major customers and the government. So, we haven't decided yet what the sizing for phase one will look like.

***Will there be more than one phase?***

Yes. The intent will be to have at least a phase two portion of the project and


potentially a phase three. We're looking at a two-floor building that could accommodate more than printed circuit board production in the future, which only makes sense given that we have an adjacent facility focused on microelectronics and RF microwave. Eventually, you start running out of space, so we wanted to make sure that we had room for expansion for both PCB and non-PCB production.

For example, we have a phase one program in our Penang, Malaysia, PCB facility. We are completing the equipment investment, and the equipment is in place for this phase. We are starting to run production. We anticipate our phase two in Penang will add about 20–25% more capacity. The Syracuse expansion will be along those same lines: 15–25% of additional capacity per phase. This is just a rough sense of how we think about expansion, but again, we'll know more as we get closer to finalizing the scope and the timeline of phase one with our critical customers.

***You're a global company, so, what does the China Plus One strategy in terms of global footprint and expansion look l ike for TTM?***

Penang is an exciting new addition to our global TTM footprint, providing our customers with TTM's first PCB production solution in Southeast Asia. It's still early, but we have four anchor customers that have committed to that facility and signed long-term agreements with deposits. This positioned us to fund the facility early on and reinforced the partnerships we have with those customers. These agreements will account for approximately 70% of the planned capacity for Penang in phase one, and the base of business has allowed us to expand with confidence into Penang. There is a lot of interest there and the timing was right. We are drawing up phase two on Penang, so we will be ready to fill out that building when the time comes.

In the meantime, we have our current North American facilities meeting resiliency needs and the planned expansion in Syracuse which will bring advanced technology capability back into the U.S.

There are still some gaps. We would love to have a small European presence. Certainly, we're watching India. For now, we've not committed to anything; these are just areas we continue to watch. Malaysia and Syracuse are keeping us plenty busy right now.

***There seem to be frequent conversations about how manufacturers can better engage our OEM end customers. How can PCB manufacturers get more direct involvement with OEMs?***

As we're all engineering and building more complex products, the direct engineer-to-engineer OEM discussions have become much more important.

We are seeing a change in how the OEMs are viewing their supply chains as well. When

I first joined TTM 10 years ago, we were dealing predominantly with the supply chain organizations at our OEM accounts. Today, while we continue to support the supply chain organization needs, we have also developed critical engineering relationships because that early impact can influence the designs that enable innovation for our customers, and successful manufacturing at TTM.

Some things that have been hugely positive in pushing such engagement forward are webcasting and virtual meeting interactions at the engineering level. These efforts allow us to deal with 30 or 40 engineers in one sitting and provide education on design for manufacturing (DFM) requirements, especially for younger OEM engineers who are still learning. At TTM, we talk about that kind of engagement all the time. If our engagement is only with the supply chain, then there's really nothing that differentiates our capability. We are not adding value to the customer engagement so the customer will treat us like any other commodity supplier.

We have many touchpoints with our customers. If you take one of the major defense primes, they're probably engaging with 30 different touchpoints within TTM. The customer must hear and see a consistent set of values that focuses on performance and execution. That will define the experience. If we are consistently reflecting these values in our messaging and mission, and everybody knows exactly what their roles are, that's very reaffirming for the OEM. As a result, there is a higher likelihood of them becoming more involved with TTM.

***Tom, great things are happening in our industry. There's a lot of fun to be had. What are the most exciting things happening now or on the horizon?***

You're absolutely right. The change and dynamic nature of our business make it fun for everyone. When you wake up in the morning, you don't know what good things will occur on a given day. That makes it interesting and enjoyable, and it keeps engineers and technicians excited about their jobs.

That innovation cycle keeps getting shorter: We are being asked to do more, whether it's the features shrinking, the density of the circuits, the form factor we're building, or the material sets that we're using; it is all very dynamic. Apple and the initial smartphones certainly helped drive this 20 years ago, but that innovation cycle has spread across the electronics industry. This puts an expectation on our industry, whether it's printed circuit boards, RF, or microelectronics, to respond with agility. It's a big change, but that challenge makes our jobs even more enjoyable.

***Tom, thank you for your time. Congratulations again on TTM's announcement and commitment to build a new UHDI facility in Syracuse, New York. Good luck with everything that comes next.***

Thank you, Marcy. PCB007

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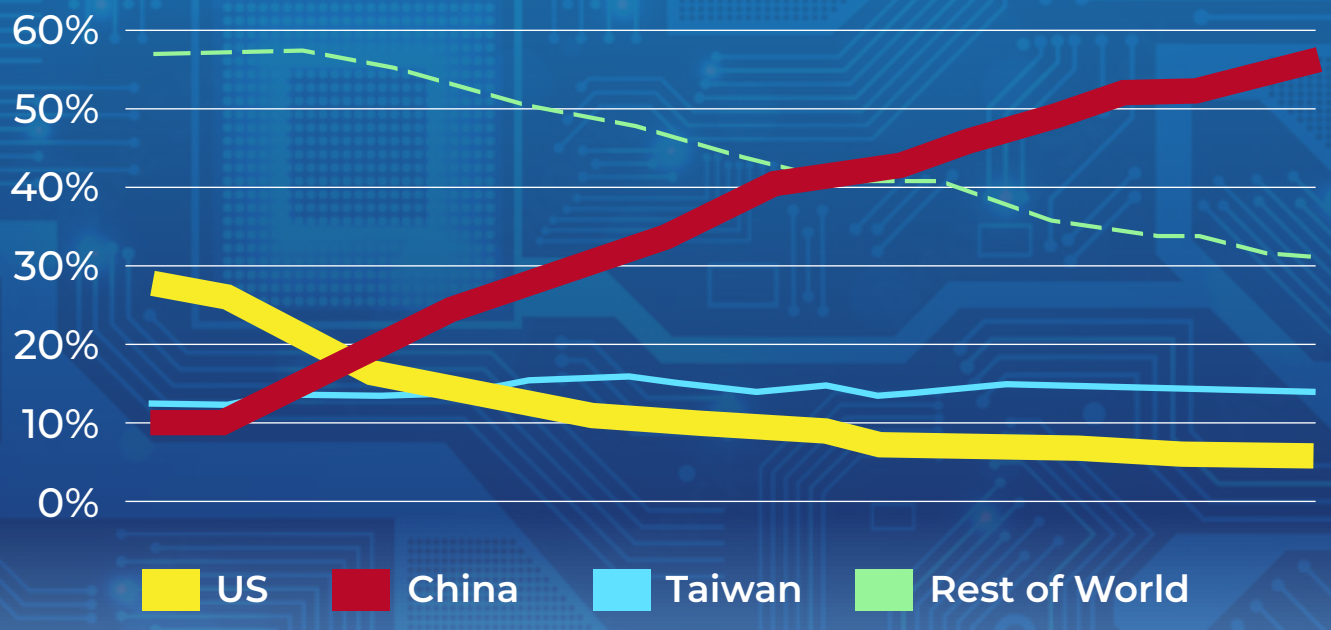
## Global Production of PCBs

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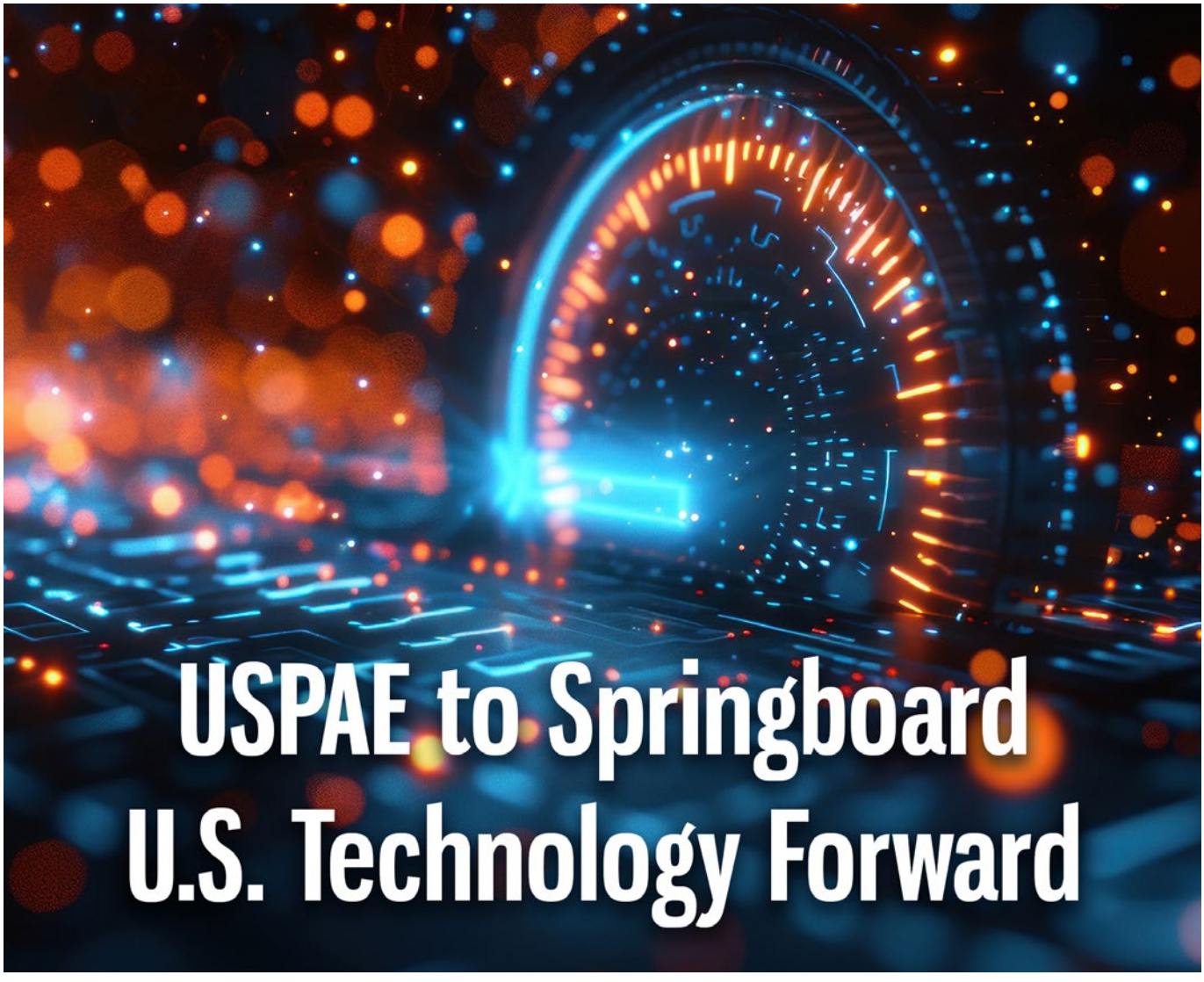

# USPAE to Springboard U.S. Technology Forward

**Feature Interview by Marcy LaRont**
I-CONNECT007

The U.S. Partnership for Assured Electronics (USPAE) was launched as a nonprofit subsidiary of IPC in 2020 specifically to manage the DoD relationship and access to funding and to develop a cooperative facility to develop ultra HDI capabilities in the U.S., not only for the defense sector but for the whole of the U.S. electronics industry.

Though a multifaceted initiative, its primary objective is to bring very high-tech manufacturing capability to the U.S. to lessen reliance on foreign sources for critical parts of our supply chain. It carries a great hope that we will never allow ourselves to fall behind technologically as we have over the past three decades and, moreover, that we will, once again, become global technology leaders in this space.

***Marcy LaRont: Joe, would you explain the Printed Circuit Board Market Catalyst (PCBMC)?***

*Joe O'Neil:* Formerly referred to as NewCo, the proposed Printed Circuit Board Market Catalyst is a unique public-private partnership (PPP) that will be designed to deliver five core benefits to the U.S. industry and government.

The first core benefit is to quickly bring ultra high density interconnect (UHDI) capabil-


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Joe O'Neil

ity to any U.S. PCB manufacturer as a subcontracted service. Second, PCBMC will catalyze commercial and government demand for domestic UHDI PCBs. Third, this PPP will transfer all the knowledge and expertise to operate a UHDI manufacturing facility to any U.S. PCB domestic manufacturer. The fourth core benefit provides education and workforce development. The PCBMC will be growing and upskilling the current workforce while attracting new workers into the industry. Finally, we will be delivering leapfrog technologies through R&D efforts to help U.S. PCB manufacturers become and stay more competitive globally.

***That is a big initiative with important goals. How did this project come about?***

This project has been developed by industry, for industry. USPAE began holding industry workshops with government input in late 2022 and early 2023 to better understand the challenges and start devising a solution. In the fall of 2023, the Department of Defense provided funding to USPAE to conduct qualitative and quantitative research documenting those needs and formally propose solutions for the PCBMC. We've got a great team.

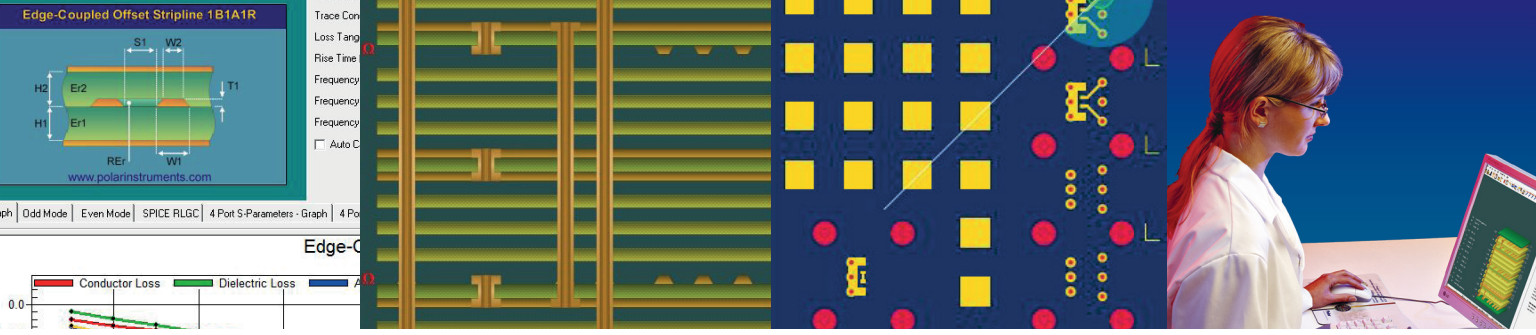
***Using the PPP business model, how will this facility bring UHDI capabilities to PCB manufacturers?***

With a mix of both government and private funding, our vision has been that the proposed manufacturing facility will be rapidly stood up utilizing modified semi-additive process (mSAP) technology. Once the facility is operational, the PCBMC will begin providing UHDI subcontracting services to the U.S. PCB fabrication base.

Our vision from the beginning has been that by utilizing a shared resource model, PCB fabricators would build a core using its existing capabilities and send that core to the PCBMC, which will be run through the mSAP process and shipped back to the PCB manufacturer. Obviously, there's a lot more detail in the data and product transfer that must be closely worked out with industry to determine the best approach to meet the needs of each of their unique business models. One of the keys is that the PCB manufacturers maintain their customer relationships. Now, they will be able to offer one additional level of up-capability.

***The PCBMC would be an outsourced process supplier, in essence, for very high technology work. Once you're operational, how much capacity will you offer to U.S. manufacturers?***

The exact capacity and how to measure it are difficult because we are not talking about just cores and panels anymore. We think of capacity in terms of the number of sequential build-up layers. At the same time, the PCBMC would certainly not be positioned to meet all production requirements. The logical outcome is that the PCBMC would obsolete itself through that knowledge transfer to industry and shift the focus toward continued education, workforce development, and R&D efforts. The facility could also provide additional capacity should there be a sudden demand surge.

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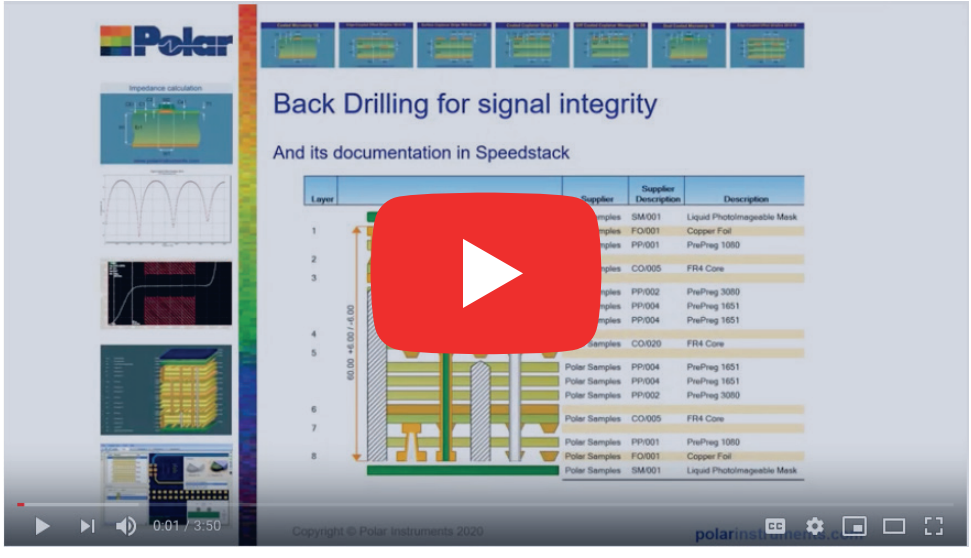


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***The lack of demand for domestic HDI PCBs has hindered private industry investments in this area. How will PCBMC catalyze commercial and domestic demand sufficiently so that companies can justify the investment?***

It will be a heavy lift. To catalyze domestic demand, we'll need to use several methods. First, we need to develop a variety of resources that make it easier for designers to integrate UHDI into their designs. That input will be based on developing IPC standards, working with EDA tool providers, and then integrating those design considerations, which include material selection and producibility. This must be supplemented with quality, reliability, data risk, and supply chain feedback. Getting that into the tool set architecture is critical.

Next, we must educate both the buyers and the sellers, allowing site visits to see the process capabilities firsthand and learn from that know-how. The most important thing to catalyze demand is working with government to require that all electronics supporting the national infrastructure have PCBs manufactured and assembled by trusted domestic sources, whether it's PCBs for banking infrastructure, medical devices, communications, transportation, energy, or defense. They must all require trusted domestic sources. This will help catalyze domestic demand for both commercial and defense projects.

***When you look at the transfer of capabilities industry-wide, is there a roadmap for that?***

The plan outlines steps to quickly elevate the capability and capacity of the entire U.S. PCB industry. Everything would be documented, from the bill of materials and equipment installation guides, to startup and operating knowledge. All those things would be captured, and that knowledge transferred along with assistance to implement the technology and processes whenever industry is ready to make that investment. Naturally, this would cannibalize business flowing to PCBMC, at which time the organization and facility would shift focus.

***Workforce is obviously a big challenge right now. In the past, there was the sentiment that by pushing the technology envelope, labor would just take care of itself. Do you worry you will experience the same issues with recruiting and retaining a workforce?***

Yes, there is some concern. Having a workforce is key to the industry's adoption of the technology. It goes well beyond training to the mSAP process. The project will need to be very focused on enabling technology in industrial automation: robotics, machine learning, artificial intelligence, and those building blocks upon which a highly efficient, highly automated, high-yielding, advanced manufacturing UHDI factory relies on. The proposed approach gives the manufacturer the education and the hands-on training to address all these core elements.

***Joe, why do you believe this endeavor is so important?***

We all saw the U.S. market miss out on the last big technical push within our industry. That move to UHDI was driven by demand for high-volume mobile devices exclusively outsourced from the U.S. for several reasons. Foundational changes in the industry abroad enabled products to be built to those high-level technical requirements. Those include industrial automation and robotics, data science, machine learning, and the like. This USPAE endeavor

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through the PCBMC, is, I believe, the fastest, most efficient way to ramp up production capacity, bring all those elements along with it, and then distribute that knowledge base to industry.

***Do you see this effort as informing or strengthening the relationship between government and business?***

A nonprofit PPP would be a great structure to accomplish what we are working to achieve. I've been very happy with the level of government support for this project, and equally surprised by the level of understanding of the challenges and even the technologies involved. This is a very different government landscape from 20 or 25 years ago when there was a general lack of understanding of electronics. That understanding is still a bit weighted on the silicon/chips side, but now there is a very strong level of awareness and understanding to address everything in that technology stack, from silicon to systems, and not just solve one or two elements within that stack.

***How will industry members learn more as this project builds and develops?***

Public information about this project will come from the Manufacturing Capability Expansion and Investment Prioritization Directorate within the Department of Defense. As soon as it is feasible, they will provide the industry with updates.

***Joe, we are excited to watch this initiative unfold. Do you have any closing thoughts?***

It won't be a matter of just a year or two for the U.S. to catch up with our colleagues overseas. As we move forward, we will begin to define what "catching up" looks like for us. But I believe we won't just catch up; we'll return to a leadership position in technology. The next-generation AI and other foundational elements will apply, whether mSAP, UHDI, or something else. We need to get the foundational data science and industrial automation elements proliferated throughout the industry, so we're positioned to make that next technological leap when it comes.

***That is a great sentiment to end on. Thank you, Joe, for all your work on behalf of the U.S. industry.***

Thank you, Marcy. We will stay in touch. **PCB007**

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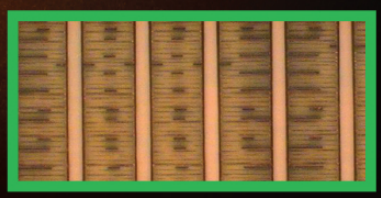

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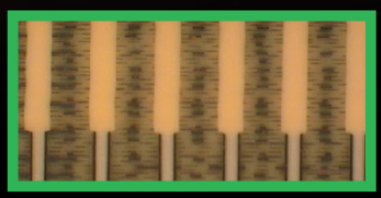

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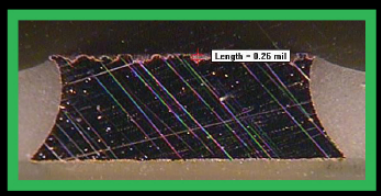

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# What About the Rest of the Technology Stack?

## American Made Advocacy

by Travis Kelly, PCBAA

Those of us who have been in the industry for any length of time know America manufactures very little of the world's supply of microelectronics. This happened over decades and was invisible or ignored by policymakers as companies shipped both their ideas and their production to Asia—and made a good profit in the process.

About five years ago, members of Congress on both sides of the aisle realized the pendulum had swung too far, and we were almost totally dependent on foreign nations for both the manufacturing and the workforce to produce semiconductors, integrated circuit substrates, and printed circuit boards: the essential elements of modern life.

After four years of deliberation and lobbying by some of the largest companies in the world, Congress passed the CHIPS Act, which injected a much-needed $52 billion investment into the semiconductor industry. Private investment of several hundred billion followed. Government officials' rationale for the legislation was that it was unacceptable that our share of the production of semiconductors had fallen to 12%. While that is an attention-grabbing statistic and was a key talking point for the legislative action, it addresses just one-third of the technology stack.

Here are two more alarming statistics that have mostly fallen off the radar: We make less than 1% of the IC substrates and a mere 4% of

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the PCBs. This means that semiconductor fabs have the attention of legislators and policymakers, but IC substrates and PCBs are an afterthought at best. The CHIPS Act was advertised as a way to create a secure, trusted, and resilient supply chain. What has actually happened is a disconnect between stated government goals and the reality of the CHIPS Act.

In fact, we don't solve the supply chain problem; we make it worse. As things stand now, we are all in to make semiconductors in the U.S. but have not given equal attention to the rest of the technology stack. So, when those new American-made chips roll out of the fabs, they will end up shipped to Asia to be mated with Asian-made IC substrates and PCBs and then shipped to final assembly with an end-use electronic device. The supply chain becomes more, rather than less, complicated when we address only one-third of the technology stack.

> **What needs to happen is clear: IC substrates and PCBs need their own version of the CHIPS Act.**

This disconnect is precisely why PCBAA was formed. Companies producing American-made IC substrates and PCBs need government investment to scale up to do two things. First, we should match the production of the semiconductor industry to avoid making long trips across the world. Second, we need to reduce our dependence on foreign nations for these critical microelectronics. Being reliant on other countries for most of these components is an economic and national security risk that is not being adequately addressed.

There have been hopeful signs at the Defense Department. In recent months, the Defense Production Act Investment Account has contributed millions of dollars to several companies that produce what is needed for defense applications. We are hopeful that Congress will fully fund this account and provide what our men and women in uniform need to do their jobs in a world where technology can mean the difference between victory and defeat.

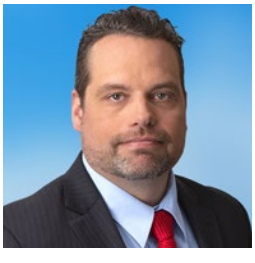
However, while defense applications are critical to national security, the volume represents only a small slice of the overall IC substrate and PCB markets. The need for trusted and secure microelectronics goes far beyond defense systems. Water systems, the power grid, air traffic control, banking, medical devices, and the rest of our critical infrastructure depend on components that come from far away countries that are sometimes global competitors.

What needs to happen is clear: IC substrates and PCBs need their own version of the CHIPS Act.

This is precisely why we are advocating for HR 3249, the Protecting Circuit Boards and Substrates (PCBS) Act. The PCBS Act calls for a 25% tax credit for companies buying American-made PCBs and substrates, along with a $3 billion investment in related research and development, physical plant, and workforce development efforts.

There are companies all over America that would benefit from the boost that the PCBS Act will provide.

PCBAA will remain vigilant in educating, advocating, and championing legislation and policies that will create more domestic manufacturing and create trusted, secure, and resilient supply chains. I invite you to join PCBAA today and add your voice to our effort to reinvigorate this essential industry. **PCB007**



**Travis Kelly** is CEO of Isola-Group and current chair of the Printed Circuit Board Association of America. To read past columns, click here.

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# Reducing Etch System Water Usage, Part 2

## The Chemical Connection

by Don Ball, CHEMCUT

In my last column, I reviewed some relatively simple ways to reduce water usage in existing etch systems: cutting down cooling coil water flow, adding chillers to replace plant water for cooling, lowering flow rate nozzles for rinses, etc. This month, I'll continue with more ways to control water usage in your etcher. Most of these are not easily retrofittable to existing equipment but should be given serious consideration when new equipment is contemplated. With the right combination of add-ons, it is possible to bring the amount of water used in an etch system to almost zero.

One of the best ways to reduce rinse water volume is the use of counter-current cascade rinses in place of single rinses to drain. This technology has been around for a long time and consists of several short stages, each with its own sump (usually nine to 10 gallons each), pump, and a single spray tube. Water is fed to the last stage, which then overflows into the preceding stage and so on down the line to the first stage immediately after the etcher. In this way, the water is used (n)times, with n being the number of stages in the rinse, instead of just once and down the drain. Also, most of the contaminants dragged into the rinse end up in the first stage of the rinse with each stage having fewer contaminants as the board passes through until the board sees fresh water in the final stage.

This concentration of contamination in the first stage also has waste treatment benefits. It is far more efficient and cost-effective to remove

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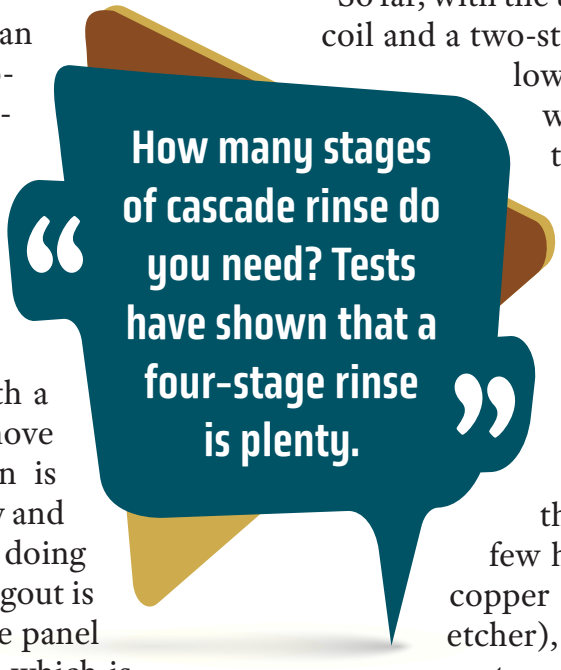
1,000 parts per million of copper from 10 gallons of water than it is to remove 10 parts per million of copper from 1,000 gallons of water. More water savings can be achieved by using some of the water from the contaminated first stage for specific gravity control of the etchant instead of sending it all to waste treatment.

How many stages of cascade rinse do you need? Tests have shown that a four-stage rinse is plenty. After four stages, you run into the law of diminishing returns where you spend a lot more effort for far fewer gains. For most, a three-stage rinse is more than adequate and doesn't take up much more space than a one-time rinse.

Alkaline etchers have an advantage over cupric chloride and ferric chloride etchers in that they have a flood rinse with replenisher solution right after the etcher. The flood rinse is a low-pressure, recirculated rinse that floods the surface of the panel with a replenisher solution to remove contaminants. This solution is then used for specific gravity and pH control in the etcher. By doing this, most of the etchant dragout is washed off the surface of the panel and put back in the etcher, which is where it belongs.




There is no reason you can't use this principle for cupric and ferric etchers as well. A two-stage flood rinse using water instead of replenisher solution will wash most of the etchant dragout off the panel surface and put most of it back in the etcher by using this water for specific gravity control. An automatic water add to the second stage will replace the water used from the first stage for specific gravity control. Using this type of flood rinse will reduce the amount of etchant dragout going to your water rinse by about 90%. In turn, this allows even more water-saving options in that water rinse.

I have a three-stage cascade rinse following a two-stage flood rinse on my cupric etcher. Each stage of the cascade rinse has an upper and lower spray tube. Each spray tube has 11 nozzles, each with a flow rate of 0.5 gallons per minute (gpm) at 40 psi for a total flow of 5.5 gpm per spray tube or 11 gpm for the stage. By using the flood rinse to remove most of the dragged-out etchant from the panel surface before the cascade rinse, I can reduce the amount of freshwater flow into the third stage from 11 gpm to about 2 gpm and still keep the water in the sump clean enough to provide a good rinse.

So far, with the use of a chiller for the cooling coil and a two-stage cascaded flood rinse followed by a three-stage cascaded water rinse, we have been able to reduce the water usage in the etch system to about 2 to 3 gpm. With the flood rinse removing most of the drag-out and returning it to the etcher, and by using that water for specific gravity control, the contamination level in the first stage of the water rinse levels out at a few hundred parts-per-million of copper (or iron for a ferric chloride etcher), down from several thousand parts-per-million. This is very treatable and shouldn't overwhelm most treatment systems.

For those with cupric chloride etchers, even further water savings are possible. The flow and copper levels in the first stage are low enough that a small ion exchange column can be added to the rinse. Water from the first stage goes through the ion exchange to remove the copper and is returned to the last stage of the cascade rinse. In this way, the water usage of the etcher is reduced to practically zero (you'll need a few gallons per hour of new water due to drag-out and evaporation) and the load on waste treatment systems is greatly reduced. A

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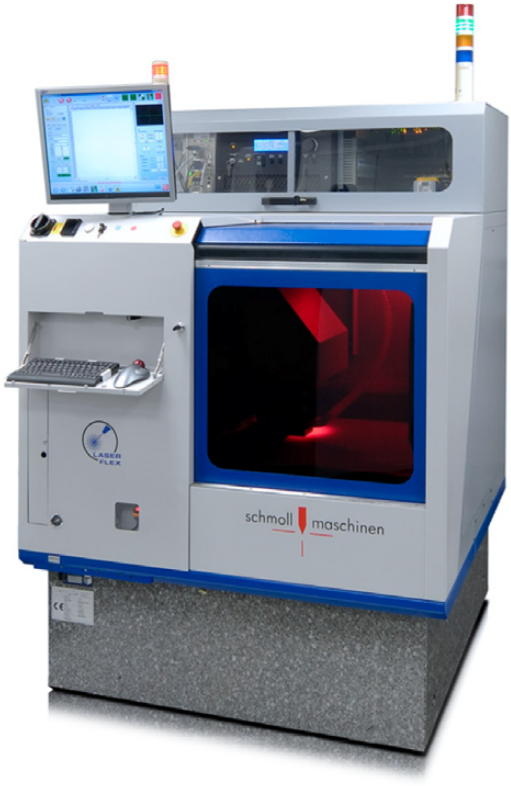


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look at your costs for water and waste treatment should allow you to quickly determine whether the extra expenditure involved for this type of system is justified.

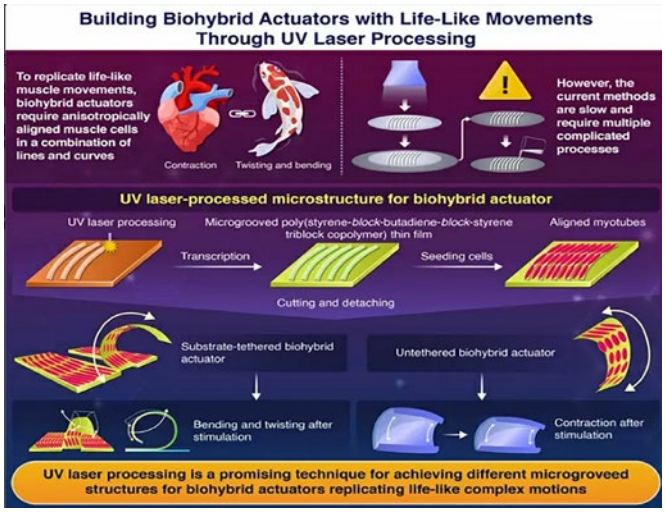
**Note:** A further environmental benefit can come from using an ion exchange column. It will periodically need to be regenerated as the copper levels inside build up. This is usually done by backwashing with a sulfuric acid solution, resulting in a concentrated copper sulfate solution. This solution can be transferred to an electrolytic cell, and the copper can be recovered, so virtually no copper goes into the waste treatment flow. When we showed this to our local waste treatment authority inspector, he was so ecstatic about it that he forgot to do the rest of the inspection. As everybody knows, a well-disposed and friendly environmental inspector is a good thing. **PCB007**

**Don Ball** is a process engineer at Chemcut. To read past columns or contact Ball, click here.

# A Novel Method for Easy and Quick Fabrication of Biomimetic Robots with Lifelike Movement

Ultraviolet-laser processing is a promising technique for developing intricate microstructures, enabling complex alignment of muscle cells, required for building life-like biohybrid actuators, as shown by Tokyo Tech researchers. Compared to traditional complex methods, this innovative technique enables easy and quick fabrication of microstructures with intricate patterns for achieving different muscle cell arrangements, paving the way for biohybrid actuators capable of complex, flexible movements.

A team of researchers from Tokyo Institute of Technology (Tokyo Tech) in Japan, led by Associate Professor Toshinori Fujie from the School of Life Science and Technology, has developed an ultraviolet (UV) laser-processing technique for fabricating complex microstructures. "Based on our previous prototypes, we hypothesized that biohybrid actuators using an SBS (hard rubber) thin film with arbitrary anisotropic MGs fabricated by a UV laser process can control cellular alignment in an arbitrarily anisotropic direction to reproduce more lifelike flexible movements," explains Dr. Fujie. Their study has been published in the journal *Biofabrication*.




The novel technique includes forming curved MGs on a polyimide through UV-laser processing, which are then transcribed onto a thin film made of SBS. Next, skeletal muscle cells called myotubes, found in living organisms, are aligned using the MGs to achieve an anisotropic curved muscle pattern. The researchers used this method to develop two different biohybrid actuators: one tethered to the glass substrate and the other untethered. Upon electrical stimulation, both actuators deformed through a twisting-like motion. Interestingly, the biohybrid actuator when untethered transformed into a 3D free-standing structure, due to the curved alignment of myotubes like a native sphincter.

"These results signify that compared to traditional methods, using a UV-laser is a quicker and easier method for the fabrication of tunable MG patterns. This method raises intriguing opportunities for achieving more life-like biohybrid actuators through guided alignment of myotubes," remarks Dr. Fujie, emphasizing the potential of this innovative technique.

(Source: Tokyo Institute of Technology)

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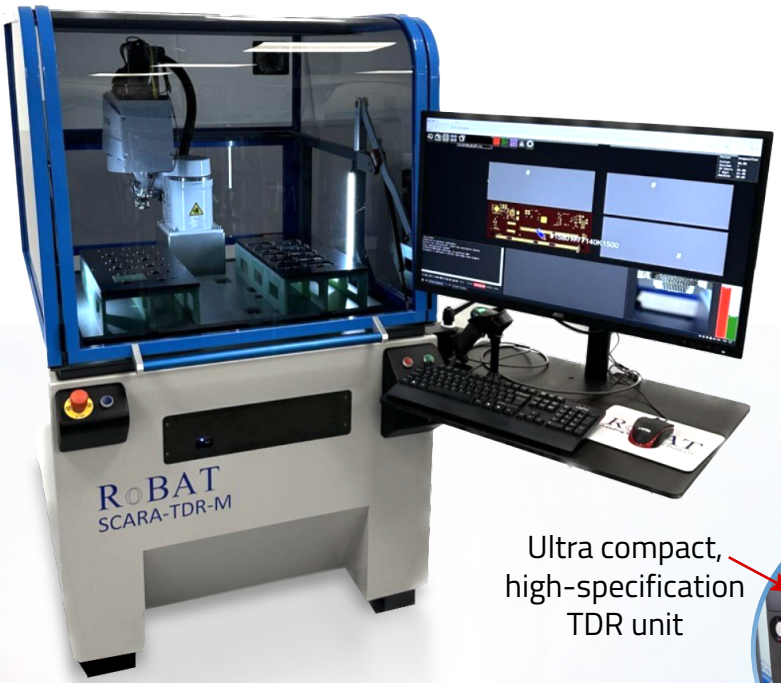


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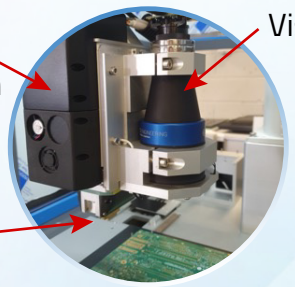


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# The Ever-expanding Horizons of PCB Manufacturing: Global Trends and Local Impacts

**Article by Léa Maurel**
ICAPE GROUP

The global printed circuit board industry is in an unprecedented transformation, driven by a confluence of technological advancements, shifting market dynamics, and geopolitical factors. As the demand for advanced electronics continues to soar, investment in the PCB sector is witnessing a remarkable uptick, with notable developments reshaping the landscape. Concurrently, the emergence of new local PCB shops, defense contracts bolstering supply chain resilience, growth projections across different regions in 2024, and the inflation outlook collectively delineate the evolving panorama of PCB manufacturing.

## Rise of China Plus One Strategy and Local PCB Shops

The China Plus One (China+N) strategy has emerged as a response to the imperative of diversifying supply chains and mitigating risks

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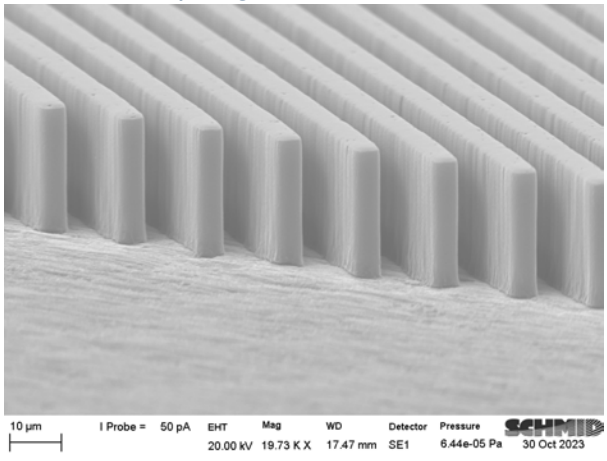


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associated with over-reliance on a single manufacturing hub. Southeast Asia, particularly Vietnam and Thailand, are primary beneficiaries of this movement. Notably, projections suggest that by 2025, more than a quarter of the top 100 PCB suppliers could have operations in these countries, underscoring their growing significance in the global supply chain. There has been a resurgence of local PCB shops across various regions catering to niche markets with agility, customization, and proximity to customers. This trend toward decentralization and diversification within the PCB industry reflects stakeholders' quest to enhance flexibility and resilience in supply chains, juxtaposed against the backdrop of globalization.

## AI-driven Demand for Complex PCBs

The proliferation of artificial intelligence (AI) technologies is driving demand for complex PCBs capable of supporting advanced functionalities. Flexible substrates, AI accelerators, and 3D printing are revolutionizing PCB design, enabling the development of highly sophisticated systems capable of handling high-frequency transmissions and mixed-signal processing. As AI applications continue to proliferate across various sectors, from data centers to autonomous vehicles, the need for specialized PCBs is expected to soar, further fueling investment in advanced manufacturing capabilities. In 2024, forecasts predict +8.5% in ML PCBs driven by AI servers and high-speed networking, as well as +5.9% mostly driven by AI edge devices.

## Recyclable PCBs and Sustainable Practices

In line with growing environmental consciousness, the PCB industry is witnessing a shift toward recyclable materials and sustainable practices. Innovations in materials science and manufacturing processes are enabling the

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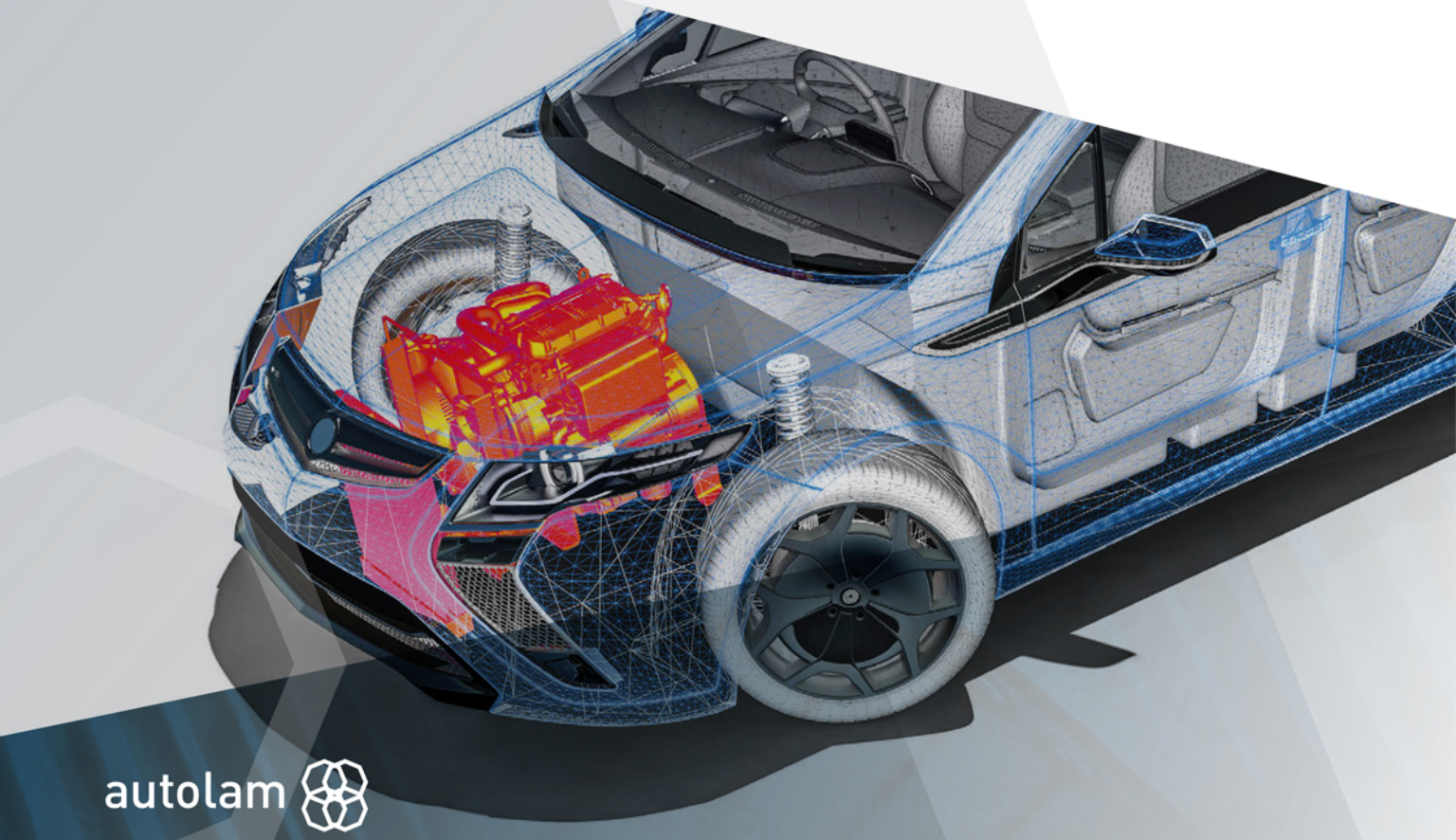

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development of eco-friendly PCBs that minimize environmental impact while maintaining performance and reliability. The emergence of recyclable PCBs reflects a broader industry trend toward sustainability, driven by regulatory pressures and consumer demand for environmentally responsible products.

## Advancements in 3D IC Technology

The advent of 3D integrated circuit (IC) technology is poised to revolutionize PCB manufacturing, enabling the stacking of multiple layers of silicon to achieve unprecedented levels of integration and performance. By vertically integrating semiconductor components, 3D ICs offer significant advantages in space efficiency, power consumption, and signal integrity, making them ideal for a wide range of applications, including high-performance computing, telecommunications, and IoT devices. As 3D IC technology matures, it is expected to drive further investment in advanced packaging and assembly techniques, ushering in a new era of innovation in PCB design and manufacturing.

## Solar and EVs Powering the Future

The rapid growth of solar energy and electric vehicles (EVs) is driving demand for specialized PCBs capable of handling high power requirements and voltage levels. With solar panels typically operating at 24V or 48V and EVs requiring even higher voltages, there is a growing need for robust, high-power PCBs capable of delivering efficient energy conversion and distribution. This trend presents significant opportunities for manufacturers specializing in high-voltage PCBs as they play a crucial role in enabling the transition toward renewable energy and electric mobility.

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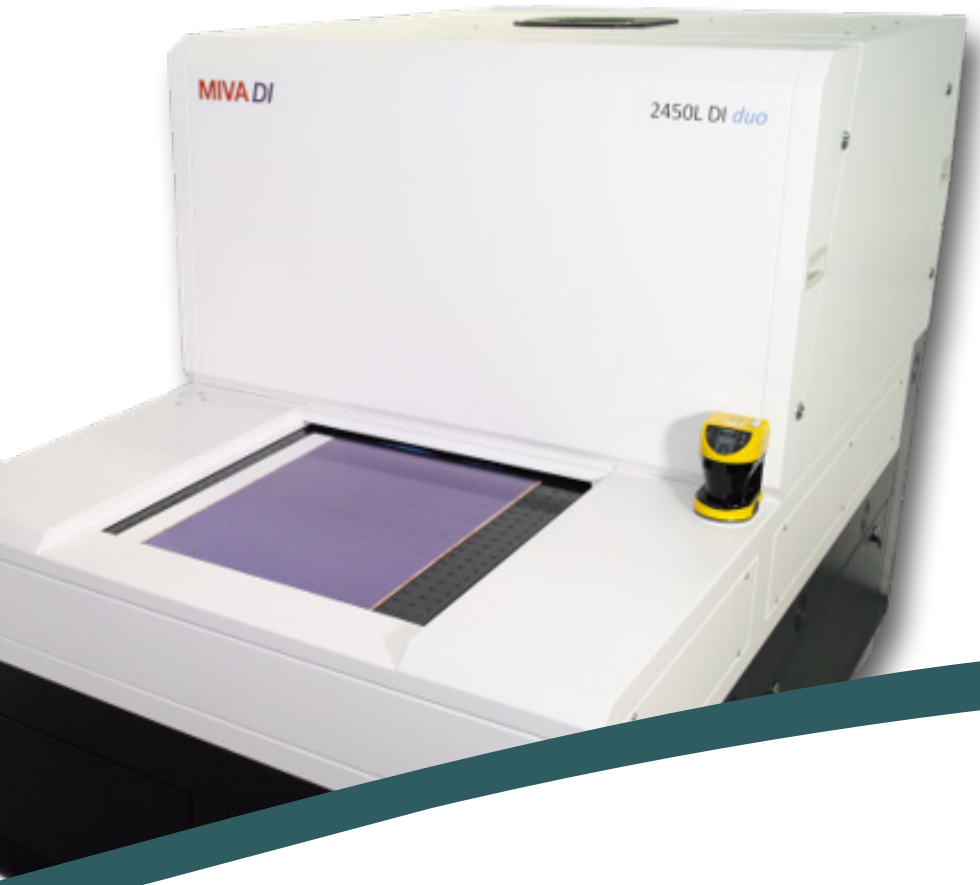


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## Defense Contracts and Supply Chain Resilience

The U.S. Department of Defense (DoD) has embarked on a strategic endeavor to fortify domestic supply chains for printed circuit boards amidst escalating geopolitical tensions and concerns over supply chain vulnerabilities. Noteworthy allocations of $39 million in November 2023 and an additional $115 million in March 2024, specifically targeting the production of PCBs for hypersonic weapons, underscore the criticality of the PCB industry in bolstering national security and defense preparedness. These investments not only enhance domestic manufacturing capabilities but also emphasize the imperative of collaboration between government agencies, defense contractors, and private sector stakeholders in fortifying the resilience and reliability of the U.S. supply chain for critical technologies.

## Growth Projections and Inflation Outlook

Amidst the evolving geopolitical and economic landscape, growth projections vary across different regions for 2024. The Euro Area is anticipated to witness modest growth of 1.2%, reflecting ongoing challenges and uncertainties. Conversely, the Middle East and Central Asia are poised for robust growth of 3.4%, propelled by investments in infrastructure, energy, and technology. Similarly, Latin America and the Caribbean, Sub-Saharan Africa, and emerging and developing Asia are projected to experience varying degrees of growth, underpinned by favorable demographics, infrastructure development, and expanding consumer markets. The inflation outlook anticipates a gradual easing across OECD countries, with annual headline inflation forecasted to decline from 7.0% in 2023 to 5.2% in 2024 and 3.8%

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in 2025. This moderation in inflation reflects a confluence of factors, including improved supply chain dynamics, normalization of commodity prices, and central bank policies aimed at price stability.

## Our Strategic Initiatives to Navigate These Changes

The PCB industry is witnessing a paradigm shift with the rise of the C+1 strategy, emphasizing diversification and resilience in supply chains. To address this demand, we have bolstered our capabilities with a strengthened field application engineering (FAE) team boasting an average of 20 years of experience. This seasoned team is equipped to provide invaluable support in design optimization, value-engineering changes, and customer-centric solutions.

In response to the complex PCB demand and the imperative for environmentally friendly options, we have strategically acquired three local factories. These include two PCB factories—one in Sweden and another in South Africa—and a keyboard factory in France. These acquisitions cater to the C+1 demand and offer a more sustainable option with closer proximity to our clients, minimizing environmental impact and enhancing operational efficiency.

Furthermore, we have forged partnerships with factories across Europe, the Americas, Africa, and Asia, including Portugal, Slovenia, Macedonia, the U.S., Mexico, Taiwan, Thailand, Vietnam, and South Korea. This network of partner factories enables us to leverage local expertise, optimize supply chains, and meet diverse customer requirements effectively.

In alignment with our strategic vision, we have embarked on an ambitious expansion trajectory, with the opening and acquisitions of seven entities in 2023. Primarily focused on the U.S. and Europe, these initiatives reinforce our commitment to enhancing local presence, fostering innovation, and delivering exceptional value to our customers.

Léa Maurel

## Conclusion

The PCB industry stands at the precipice of unparalleled growth and transformation, underpinned by technological innovation, market dynamics, and sustainability imperatives. As investment surges into new manufacturing facilities, advanced technologies, and sustainable practices, the industry is poised for continued expansion and evolution. Stakeholders must adeptly navigate the complexities of the evolving landscape, leveraging agility, resilience, and innovation to seize opportunities for growth and differentiation in this dynamic and rapidly evolving sector. **PCB007**

**Léa Maurel** is the Americas marketing manager at ICAPE Group.

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

# Reliability in the Delivery Room

## The Doctor's In

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

Six months ago, my life changed forever when I held my first child, a healthy, blue-eyed, brown-haired baby boy. The calm beauty surrounding this tender moment was a happy applause for the long and intricate performance of his delivery. While his delivery was safe and complication-free, I witnessed a real-world demonstration of the critical importance of reliable electronics.

### Fetal Vital Sign Monitoring

Nurses routinely monitor two vital signs during most deliveries: fetal heart rate and uterine contractions. Fetal heart rate monitors and contraction pressure sensors are some of their most essential tools for monitoring the progression of labor and the well-being of both the mother and baby during childbirth.

Fetal heart rate sensors typically utilize Doppler ultrasound technology to detect and measure the fetal heart rate. These sensors emit high-frequency sound waves into the mother's abdomen, which bounce off the pumping fetal heart and return to the sensor, allowing them to calculate the heart rate.

On the other hand, contraction pressure sensors function by measuring the intensity and frequency of contractions experienced by the mother during labor using a method known as Tocodynamometry. These sensors typically consist of strain transducers placed externally on the mother's abdomen. As contractions occur, the pressure on these sensors changes, allowing

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them to detect and record their strength and duration.

Tocodynamometry is a method that explicitly measures uterine contractions using pressure sensors placed on the mother's abdomen. These sensors detect changes in the shape and firmness of the uterus during contractions, providing additional information about the timing and intensity of labor. Together, these sensors provide valuable real-time data to healthcare professionals, enabling them to monitor the progress of labor and intervene when necessary to ensure a safe delivery.

## The Delivery Room

The need for these instruments to maintain high-reliability standards cannot be overstated. In such a high-stakes environment, where decisions are heavily influenced by their readouts, these sensors often dictate the course of delivery. Such was the case with the birth of my son.

Like most deliveries, my wife had an inflection point where the activity in the room accelerated from intermittent check-ins to constant monitoring. The relatively calm, nervous energy that permeated the room was replaced by the focus and determination required for the final stage of delivery: pushing. It was go-time. By then, it was a crisp 4 a.m., and our OB-GYN was peacefully sleeping in his home. Not knowing how short the pushing stage would be, our nurses' language quickly progressed from, "We will page your doctor" to "We've paged your doctor" to "Your doctor may not make it in time." Sure enough, our doctor walked into the sound of faint crying just seconds after our son was born.

Adding another layer of unpredictability to our delivery, a heart rate sensor malfunctioned. The nurses had placed an electrode on our son's scalp to monitor his heart rate during the final push. At a critical moment, when the on-call doctor entered the room, he had a brief period of panic when our baby's heart rate seemed to have some concerning fluctuations. To our relief, he quickly diagnosed the heart rate monitor as faulty and ordered the nurses to switch back to the original external abdominal monitors. At that moment, I was simultaneously glad that the doctor had the experience to discover the fault and frustrated by the lack of reliability in the monitor.

My firsthand experience of the faulty heart rate monitor will stick with me for years. It is clear to me that reliability is not just a technical specification; it's a fundamental aspect of ensuring the safety and well-being of individuals in critical situations. From a newborn entering the world to a patient undergoing surgery, the reliability of medical instruments (and electronics in general) can make all the difference. **PCB007**

**Henry Crandall** is the 2023 IPC Student Board Member. He is a graduate of the University of Utah and is currently pursuing a Ph.D. in electrical engineering as the Advancing Research in College Scientists Graduate Fellow.

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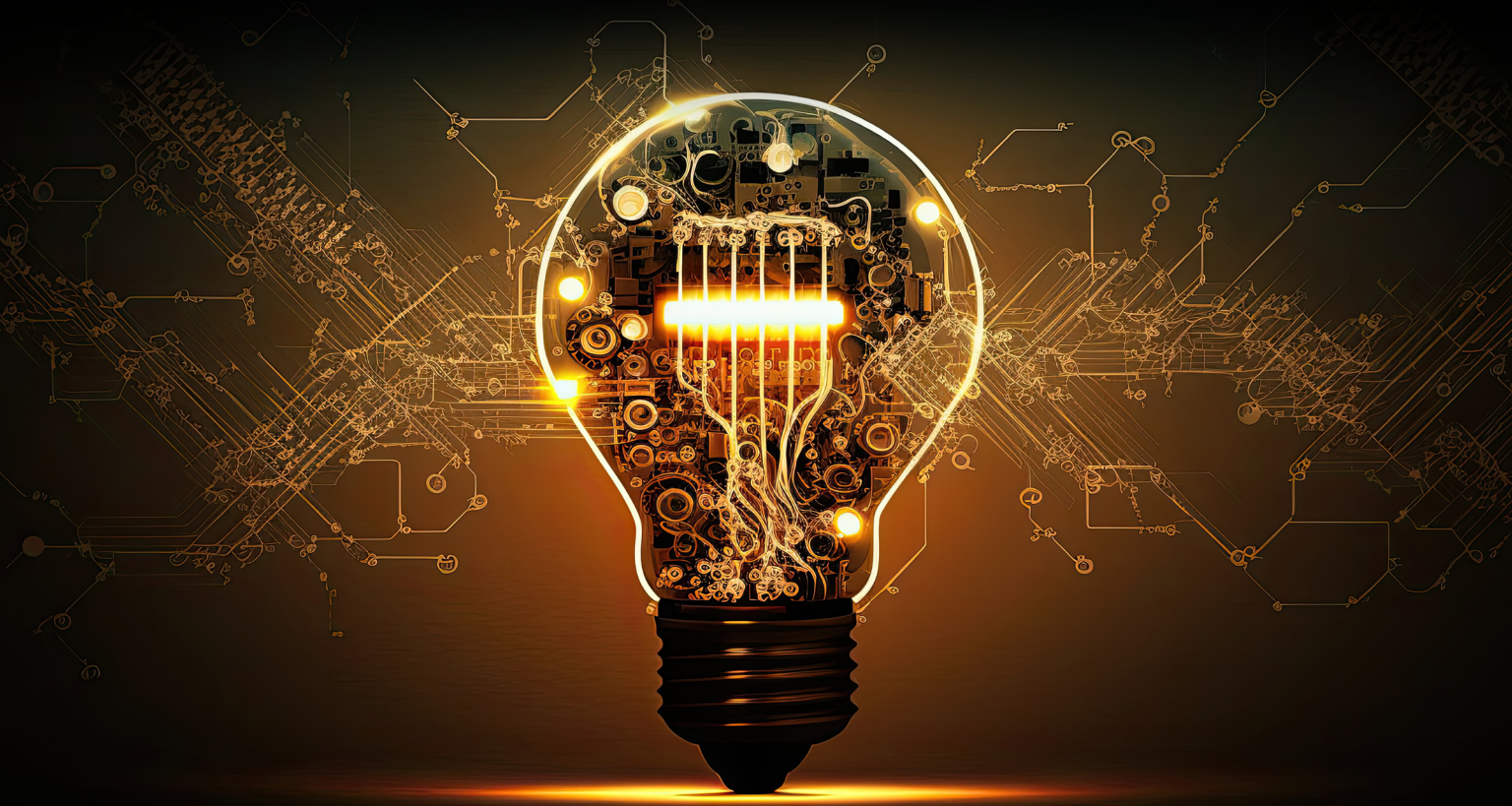

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# Shane Whiteside Discussing PCB Landscape

**Feature Q&A With Shane Whiteside**
SUMMIT INTERCONNECT

Summit Interconnect began as a printed circuit board manufacturing company just eight years ago and has seen impressive growth organically and through acquisition. Summit President and CEO Shane Whiteside takes a few moments to share his thoughts on the growing PCB industry in the United States.

***How do you feel about the current landscape in the United States for manufacturing and electronics?***

*Shane Whiteside:* I see improvement in the North American electronics sector resulting from an increase in awareness by OEMs and political leaders toward supply chain risk. Geopolitical trends and COVID have shifted mindsets toward addressing this risk. Our manufacturing base continues to be challenged with engaging the new workforce, but I think a lot of progress is being made in acquiring and training talent and re-fortifying our industry.

***Some reports indicate that there is a record amount of growth through new and expanded PCB shops in North America. Given Summit's growth trajectory over the past several years, does this feel true to you?***

Our industry has grown from its low point more than eight years ago, but cycles continue, and growth can be difficult to attain at

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Shane Whiteside

times. IPC's data shows two consecutive years of declining demand, which I believe is a run-out of the COVID-era tech refresh and component shortages. Still, it's great to see the industry investing for expansion, and I believe all this new capacity will be utilized in the coming years.

***Do you see the PCB growth in the United States as something we can sustain?***

I continue to be very optimistic about long-term growth in the North American PCB industry. But truly healthy and sustainable growth must come from multiple market sectors, not just defense. It's good to see growth in the commercial space and medical sectors; this will help provide balanced growth in our domestic industry.

***Can the U.S. regain its role as a technology leader?***

I believe we will regain more relevance in technology leadership over time. At the board-technology level, we continue to be challenged by not having newer and purpose-built factories like those in Asia. Much of the equipment supply chain has focused on Asia over the past two decades, but as our market continues to grow and draw more investment capital, I think the situation will continue to improve. However, I believe North America continues to maintain a leadership position in building for smaller volume, highly complex applications with high-reliability compliance requirements.

***What is the most exciting thing happening in our industry? What are the biggest challenges ahead of us?***

I've already mentioned some of the sectors where we expect growth and the exciting prospects that will come. Something we focus on is partnering more closely with our customers to provide engineering and solutions development given our critical role in their supply chain. Our biggest challenge is workforce development from engineering to the manufacturing environment, but we are constantly getting better at addressing these challenges through internal efforts and involvement with IPC's training and Emerging Engineers program.

***What's next for Summit?***

Our company was formed only eight years ago, and we have an amazing group of facilities and capabilities that provide an incredible value proposition to our customers. Over the past two years, we have focused on optimizing our business and building differentiated and sustainable platforms within our company that will help us serve our customers even better into the future. We have also expanded our capabilities to provide customers with a broad portfolio of PCB services. Design engineers now come to Summit for nearly all their requirements, from early-stage prototypes to mid-volume production and even quick-turn assembly. Our aspiration is to be our customers' best manufacturing partner; it's been an incredible journey, and there is still a lot of work ahead of us. **PCB007**

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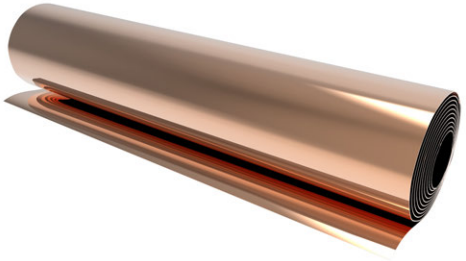

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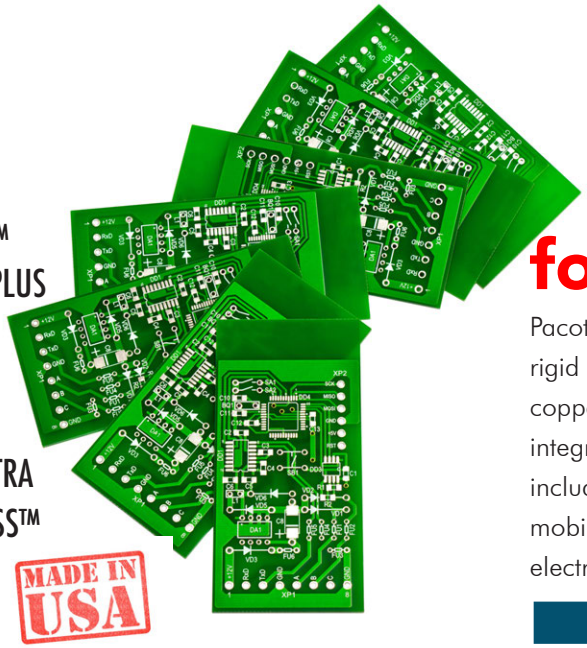

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# Advocacy: There's No Time to Waste

**Interview by Marcy LaRont**
I-CONNECT007

In the late 1990s, I worked for a PCB company ardently working to build manufacturing presences in Malaysia, Taiwan, and eventually China's mainland. For some of us who had the resources, we followed our OEM customers offshore as they began demanding increasingly greater price concessions from their stateside suppliers. The government was not coming to the rescue of the PCB manufacturer, so we rode the changing economic tide as it turned unwaveringly toward globalism and cheaper labor.

In my youth and naiveté, I figured that capitalism would dictate the survival of the market's fittest, both in the United States and across the globe, especially given the reality that our greatest international critics were so clearly driving their economies via the capitalism they had spent much energy decrying. But the playing field would never be level.

Most U.S. PCB manufacturers still in business then were running tight processes, building high yields, and making decent money. Still, the U.S. PCB supply chain continued to shrink. As we each pushed toward ITAR to get a piece of the then-limited mil/aero pie, the first wave of PCB (and EMS) mergers and acquisitions commenced.

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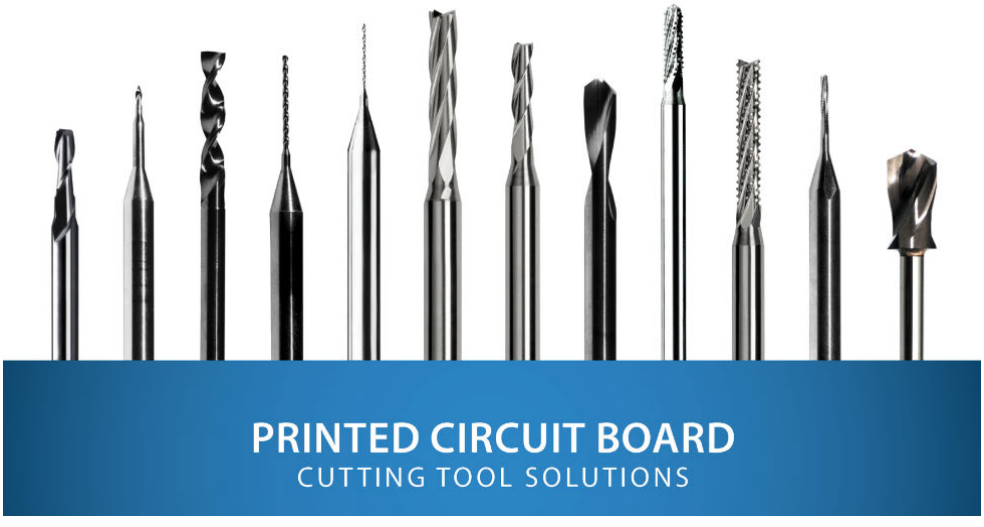
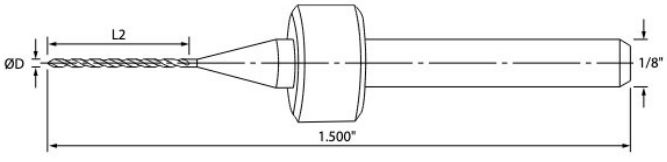



Kyocera designs and manufactures tight tolerance precision carbide cutting tools for PCB applications. Products include drills, routers, end mills, and specialized cutting tools ranging from: 0.05mm to 6.70mm diameters (0.0020" - 0.2638").

## Drills, End Mills, Routers, Specialty Tools

Kyocera's renowned array of drills, routers, end mills, and specialty tools offer many benefits and advantages to customers for all their drilling and routing needs. Kyocera's tool reliability and design flexibility are key strengths of their products, along with a complete R&D facility in the US, new tool manufacturing capability, and local technical resources, all available to support customer needs.




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.

The "new world order," as I had hoped for in my youthful American idealism, did not come to fruition. But it certainly highlights the importance and role of advocacy for our businesses today. In 2024, the stakes are as high as they have ever been. So, I was thrilled to speak with Richard Cappetto and Kate Koger, members of the IPC advocacy team in Washington, D.C. They explained exactly what IPC advocacy is doing for the electronics value chain, why now is an important time for electronics, and how you can help.

***Marcy LaRont: Rich and Kate, please introduce yourselves.***

*Richard Cappetto:* I'm the IPC senior director for North American government relations. I am the lead lobbyist for IPC, advocating for the electronics manufacturing industry in the United States. Most of my time is spent meeting with policymakers and staff on Capitol Hill and within the administration, letting them know what electronics manufacturing is, its role in the economy and national security, how public policy can strengthen or weaken the industry, and making a case for the U.S. government to back policies that promote a strong electronics manufacturing industry in North America.

*Kate Koger:* I'm the public affairs coordinator for IPC. I provide project management support and content when needed across all sectors of the team. I work on sustainability with Dr. Kelly Scanlon, and with Rich in government relations. I also assist Michelle Mermelstein, senior director of media relations for IPC, and I work with IPC's marketing team to coordinate efforts between government relations and IPC headquarters.

***Rich, tell me about the rest of IPC's advocacy team. It has grown quite a bit.***

*Cappetto:* Kate and I joined IPC last summer, along with two other colleagues. The four of us came aboard within a few weeks of each other.

Kate Koger

Michelle works to bring more attention to the industry by working with national, business, and tech media. She works across IPC—standards, education, advocacy, and solutions—and with the marketing team to bring stories about our industry into the national press. We're quickly learning about IPC and its members. There is a lot of energy and new ideas in the office. Everyone is eager to make an impact for the industry.

Another exciting new team member who joined last summer is Nyron Rouse. Like Michelle, Nyron is establishing a new role at IPC as the director of government grants and strategic funding. He is building a grants program for IPC so that we can identify and secure funding both for our member companies and for IPC to enable us to deliver solutions faster and at a greater scale for the industry.

Chris Mitchell is our VP of global government relations. He leads the IPC advocacy division (North America, Europe, and Asia), sustainability, and industry intelligence. Since IPC is a global organization, he keeps the pedal to the metal in Asia and Europe as well.

Alison James is the senior director in Europe. She is engaged in work similar to mine in Europe: building relationships and advocat-

Richard Cappetto

ing through the European Commission for policies aimed at building a strong electronics manufacturing industry through things like working on their Chips Act.

Kelly Scanlon is IPC's lead sustainability strategist. As one of IPC's strategic priorities, Kelly is leading efforts to build sustainability across all our operations, including standards, design, and of course, advocacy and solutions. She leads IPC's Sustainability for Electronics program.

***Kate, you've written an article for IPC Community about your advocacy team. Can you give us a preview of what's in that piece?***

*Koger:* The focus is how IPC reacts as our industry becomes more politicized. There is so much going on in the world politically speaking, and it is affecting every part of electronics and manufacturing. In response to this reality, we have strengthened the advocacy team and built a robust system that provides the best reaction to all that is happening. There are things that the industry needs to be doing in this environment, and IPC can help them do it. We want to share all that we are doing in this arena and, honestly, put out a call to action for industry members to become more involved and engaged so that, through these programs, their voices will be heard.

***The issue of sustainability is a big and important topic. Is Capitol Hill now actively discussing this?***

*Cappetto:* My number one job is to educate policymakers about this part of the electronics industry: We exist and are critical to the economy. I am delivering the message that the cars you drive every day, the devices you use, the military equipment that keeps us safe—these all rely on a stable, secure supply chain, and if you are or become over-reliant on one global region to do all that work, those products and the economy are at risk. As your readers know, the U.S. printed circuit board industry went from providing 20% of the global supply in 2002 to now just 4%. Over-reliance on imported sources and the lack of capability and capacity to produce needed components domestically represent significant risks to the way of life that people are used to.

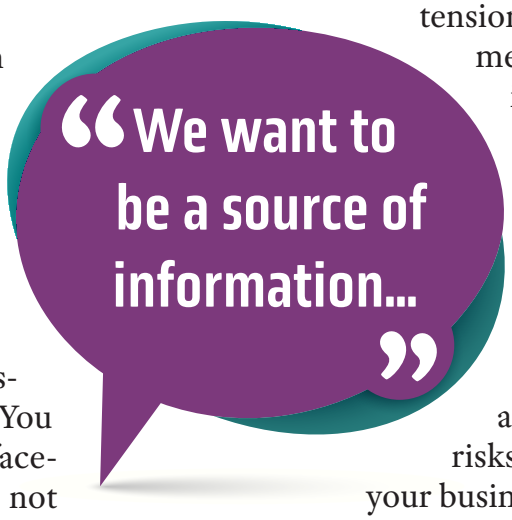
***On Capitol Hill, is the issue of supply chain sustainability primarily seen as an issue of security?***

*Cappetto:* Yes, but it is an economic risk as well as a security risk and a risk to innovation. If you are not building the things that you design, and not doing the manufacturing, or doing it at scale, then you have a hard time innovating and being at the cutting edge. Advanced packaging is a good example of that. It is becoming the future of computing because chips can't get any smaller, so the advanced manufacturing processes to package the electronics inside the device, putting multiple chip sets together, becomes the critical capability, or in the case of the U.S., a critical vulnerability. Our priority is educating policymakers on the industry and why it is so important to invest in and support the growth of the domestic industry.

***You both are relatively new to the advocacy team, but hasn't IPC been involved in this effort for years?***

*Cappetto:* Yes, Chris Mitchell has been involved in this advocacy work for years. This work requires constant effort. I believe the average member of Congress is about six years younger than has traditionally been the case and has only been in office for two or three terms. This means that since 2010, there has been about a 70% turnover in Congress. Many people we were talking to only a few years ago aren't there anymore. This requires constant communication.

When I first got involved in politics and received campaign training, my first lesson was that if there was any chance something could happen at a political meeting—city council, water board, etc.—you had to be there. So, being physically present is a big piece of the job. You must be on the Hill, having face-to-face interactions. If you're not at the table, your interests are not represented. That is a baseline.




In D.C., we are talking to Congress members, making sure they hear from us when they're developing ideas for hearings and creating legislation, and we're talking to the executive branch as they implement things like the CHIPS Act. We want to be a source of information for them as well, to help them make good decisions. That is starting to happen. For example, the CHIPS Act office reached out to IPC seeking input on how to implement the R&D section of the bill. When the advanced packaging program strategy was released in November, the only outside report they cited was our IPC advanced packaging report. It was exciting to see.

***That's tremendous. Congratulations to your team.***

*Cappetto:* The IPC advanced packaging report was primarily the work of Matt Kelly, IPC chief technology officer and vice president of technology solutions. It is a tremendous accomplishment resulting from the IPC's collective work in this area.

***Has the changing demographic in Congress affected how IPC and this messaging are being received?***

*Cappetto:* Generally, attitudes have changed over the last four or five years, especially since the pandemic. There is a lot of geopolitical tension in multiple regions, as Kate mentioned, and people realize that things are not as stable as they once thought. There is a risk that if something goes unpredictably wrong somewhere in the world, you could be caught up and unable to supply what is needed. Now, there is a heightened awareness of the risks associated with outsourcing your business completely.

***Kate, how does the general divisiveness and polarity in Washington impact the work you're trying to accomplish?***

*Koger:* Obviously, we are trying to get bills through Congress, and you need to work with both sides. Most bills we are interested in should be bipartisan. Unfortunately, that can be quite difficult, even if they agree in principle. You must work hard to find policy ideas that appeal to policymakers on both sides of the aisle and have a realistic chance of support. The appetite for different policies is something that can change with the political environment. That's the essence of representative government. At any given time, certain levers of government policy—taxes, grants, controls, requirements, bans—fall in or out of favor. It is not the case that simply "X is good for our economy" and we will all get behind American

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jobs in our states. There are different visions of how that should look in America.

***How do you define advocacy, and why is it so important for our industry? How do you engage more of our industry in those efforts, especially when they think their voice is inconsequential?***

*Koger:* To me, an advocate is the voice for someone who needs a bigger voice. That's what we're doing for the industry. Obviously, there are many big organizations or corporations whose names everyone knows. They bring a lot of weight to advocacy, but there needs to be a voice for the whole industry. That's important as well.

*Cappetto:* We're a voice for the whole electronics industry, but we're also a voice specifically for electronics manufacturing. Our members are involved in other associations, which makes sense for their business. However, IPC's strength is that, as an organization and by virtue of its broad membership, we understand and represent the specific pressures and challenges in value chain manufacturing because we talk to members of electronics manufacturing directly. We are dedicated to our members. Where they want us to speak, we are their advocates.

> "We're a voice for the whole electronics industry..."

***This effort represents all industry members, regardless of where you might find yourself on the size spectrum, not just the big guys.***

*Cappetto:* Absolutely. Kate and I were at a meeting on the Hill last September with a Congressman from Michigan, and we showed him a list of relevant companies in his state. His biggest reaction was to a small company in his district. He was very interested in many of those small- and medium-sized companies. Of course, the big names are well-known brand names, have a lot of resources, and tend not to have a problem getting attention. But especially on Capitol Hill, people like to hear from the businesses that employ people within their state and their district, no matter the size of the company. In another example, DoD released its national industrial strategy in early January, and the Assistant Secretary of Defense said the ideas in the strategy came directly from talking with members of industry. That input is imperative to the policymaking process. The point is that all these businesses matter. All voices are important and valid.

***How important is advocacy now, and how do industry members become involved?***

*Cappetto:* We are at a moment where policymakers are aware that something needs to be done, and their attention is turned in our direction. Now is the time to have a seat at the table. When people are discussing what needs to be done, you want your voice in the mix. Over the past 20 years, this is the most interest I've seen from Capitol Hill on what's typically considered niche business issues.

*Koger:* The best way to get involved is to send an executive from your company to the Hill and talk to Congress members with us. You are welcome here, and we will help facilitate that visit.

*Cappetto:* In the past, IPC organized an annual "IMPACT Day," where we had multiple industry members come to D.C. and meet with members of Congress. We may continue to do that, but we want to be nimble. If there's an opportunity for you to step in and talk to just one or two members on the Hill, we will facilitate that. We want to have a constant presence, even if it's small. Members of Congress are happy to hear from you. It is a lot of fun.

You don't even have to visit Washington to do this. Members of Congress are always welcome to host you in their local state office and probably would be more excited to meet you there. We can help facilitate that as well. You can invite a member of Congress to visit your facility. They love seeing what's in their district. It's a great way to get press attention and use the opportunity to share with them the issues that are important to you.

*Koger:* A simple and noninvasive way to support advocacy efforts is through your signature on the letters of support we draft and submit to Congress. At a bare minimum, we ask companies in our industry to engage with us to share their pain points and how the government is helping or hurting their businesses. You do not need to be an IPC member to contact us. We represent the whole industry. Our agenda comes directly from what IPC members and the industry tell us is most important.

***Thank you both for this conversation. Clearly, advocacy is an important topic, and I hope we continue to talk about it.***

*Cappetto:* Thank you, Marcy. **PCB007**

## YOUNG PROFESSIONALS SERIES:

# Meet Jennifer Robinson, TTA Technologies

As part of our new Young Professionals series, meet Jennifer Robinson with TTA. She is a graduate of Texas A&M University and holds the position of Sales Engineer at Test Technology Associates. She says she is in a small minority of individuals who are working professionally in exactly what they studied at University: test engineering. She loves what she is doing and offers advice to other young professionals.

# MilAero007 Highlights

## Lockheed Martin Conducts Historic LRASM Flight Test ▸

The U.S. Navy in partnership with Lockheed Martin [NYSE: LMT] successfully conducted a historic Long-Range Anti-Ship Missile (LRASM) flight test with four missiles simultaneously in flight. During the 12th Integrated Test Event (ITE-12), the U.S. Navy was able to demonstrate the weapon's inherent high-end lethality from mission planning through kill chain integration and its effects on the target. All mission objectives were met, reinforcing high confidence in the weapon's capabilities and superior firepower.

## Boeing Awarded Contract to Continue Extreme Environmental Testing for Critical Defense Platforms ▸

The U.S. Air Force has awarded Boeing a contract worth up to $559 million over five years to operate, maintain and perform testing at the Little Mountain Test Facility at Hill Air Force Base, Utah. The state-of-the-art site is designed to test functionality of the nation's current and future intercontinental ballistic missile force, nuclear modernization programs and other critical defense and deterrence capabilities in the most extreme environments.

## Saab Announces Plans for New Munitions Facility in U.S. ▸

Saab announced plans to build a new munitions facility in the U.S., continuing the company's strong investment and growth domestically. The innovative new site will support the engineering and production of missile weapon systems for the U.S. military, such as components for the Ground-Launched Small Diameter Bomb (GLSDB) system, and close combat weapons. Final site selection and groundbreaking is planned for 2024, with production underway by 2026.

## Northrop Grumman, EpiSci to Collaborate on Advanced Autonomy Capabilities ▸

Northrop Grumman Corporation is collaborating with EpiSci to further develop advanced, trusted autonomous tactical solutions for the United States and its allies. EpiSci's TacticalAI software will integrate into Northrop Grumman's aeronautics system architecture to accelerate the delivery of advanced autonomous solutions. "Northrop Grumman collaborates with innovative small businesses, like EpiSci, to help meet the needs of our customers," said Tom Pieronek, chief technology officer and vice president, research and technology, Aeronautics Systems, Northrop Grumman.

## US Navy's Need for New X-Band Radar Underscored by Service's Red Sea Fight ▸

The Navy's search for a next-generation X-band radar is becoming more relevant by the day as U.S. warships fight in the first significant naval conflict since World War II. Since late last year, U.S. and coalition naval forces have fought off regular attacks on commercial shipping in the Red Sea. Houthi rebels have launched sophisticated anti-ship ballistic missiles and swarms of long-range drones to slip through radar detection and destroy unarmed civilian vessels. The Navy has not had to repel such wide-scale attacks since WWII, Admiral Brad Cooper, Commander, FIFTH Fleet and Combined Maritime Forces in the Middle East told CBS News for its Feb. 18 story.

# DESIGN TIPS #124:

## ETCH COMPENSATION

What is minimum space and trace? The answer depends on the starting copper weight.

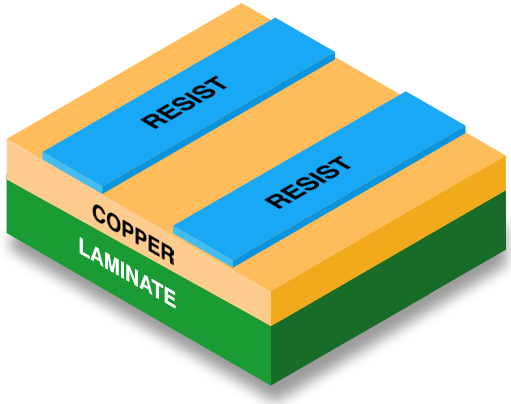
This is because we must do an etch comp on the traces in CAM to compensate for known etch loss. The space between traces after compensation will play a role in whether a board can be manufactured.

The lower the spacing width, the higher the cost. Designers don't always account for the proper starting copper weight after edge compensation.

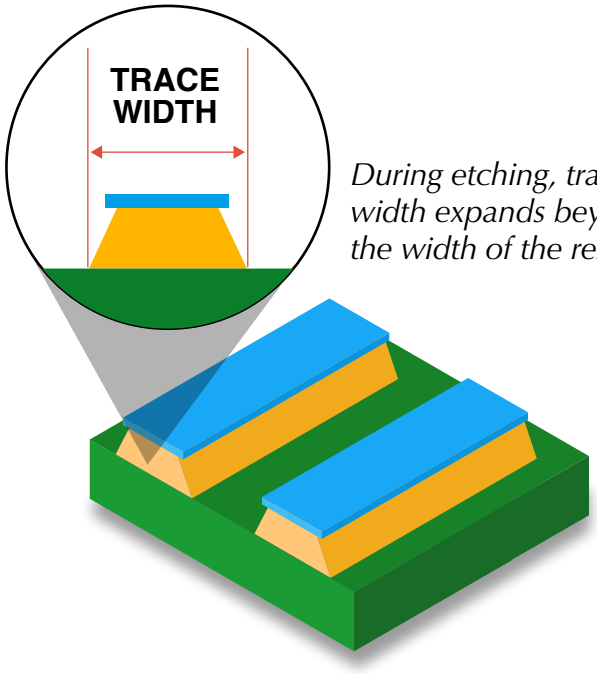
### Design tips:

- For accurate starting copper weight, **add a half mil (.0005″) to all copper features**.
- **Start with 3/8 or 1/4 oz. foil**, reducing etch comp and less likely to cause a spacing issue.
- **Boards that call for full body electrolytic gold are not comped** to avoid gold slivers occurring during the etching process.

**Before etching**




**After etching**




*During etching, trace width expands beyond the width of the resist.*

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# Solving Problems and Validating Excellence

**Interview by Marcy LaRont**
I-CONNECT007

"IPC's slogan is Build Electronics Better, which is 100% what Validation Services is," says Randy Cherry, who directs the program, now in its 11th year. Having created the program from the ground up and weathered the COVID drought just when the program was gaining momentum, IPC Validations Services has 165 customers and an impressive 98% retention rate.

Why is this program important? That was the question no doubt more than a few IPC members were asking themselves when David Bergman, VP of Standards and Technology, first thought of the idea for a value-added service that would provide analyses, auditing, and qualification to global manufacturers built around specific IPC standards. This would be the first audit of its kind and would take place on the factory floor.

Starting any new system is a tremendous amount of work, but defining, creating, and implementing such a complete system of oversight and qualification took time. As VS took off, it yielded a continuous stream of direct industry feedback about what companies most needed and would find most helpful. Out of this, the program grew.

In 2016, the Standards Gap Analysis (SGA) program came into being, allowing for a completely confidential pre-audit process for companies considering a full VS audit, but wanting to identify areas for process improvement beforehand. Out of the audit and SGA programs, Technology Solutions became a service offering in 2018, providing technical expertise to help manufacturers solve problems on the factory floor. In 2019, the IPC-1791 Trusted Supplier and Cybersecurity List came to frui-

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tion, a clear sign to OEMs and customers that the listed PCB and EMS manufacturers are "safe" suppliers who will consistently guard their IP and where no counterfeit parts will ever be used.

Though the word "audit" continues to instill fear and trepidation in business owners, "The difference between Validation Services and something like an ISO audit is that a VS audit is completely confidential, and you are simply given what you need to improve so that you can complete your audit successfully," says Mike Milostan, IPC director of marketing. "Once a company is ready, we come back in, do the full-scale audit, and issue a qualification that is valid for three years. Both internally, from a process improvement and quality control standpoint, to externally, from a customer perception perspective and passing that first hurdle of vendor qualification, Validation Services is a tremendous value for the companies that participate."

Here is everything you need to know about Validation Services and whether it is something you should consider.

Randy Cherry

***Marcy LaRont: Why should a company pursue Validation Services from IPC? What does it mean and what are the benefits?***

*Randy Cherry:* The goal for Validation Services (besides "Build Electronics Better") has always been to create a series of qualification programs that focus on manufacturing processes. Quality is considered by reviewing a company's existing Quality Management Systems (QMS). Qualifying to an IPC standard is a clear sign to OEMs and customers that this company has completed the steps to verify that it manufactures and makes products that either meet or exceed the written IPC standards.

***What's the difference between a Qualified Product List (QPL) and a Qualified Manufacturer List (QML)?***

The QPL program focus is on the products and equipment used in the electronics industry. The QML program's focus is on the manufacturing and assembly processes. Between QPL and QML, we have over 140 company certifications.

***Why is there a need for both?***

IPC facilitates the development of industry-written standards in many areas. IPC Validation Services takes these standards and develops vigorous qualification programs that take a deeper dive into the products and the processes that are required for best in class.

***Take us on a typical QPL/QML journey.***

We begin with our team educating the customer on the value and how to use the IPC standards properly. There is often a lack of clarity around this for the customer. Next, our team determines which program is the best solution for that customer. We provide a quote and create the contract and the actual assessment/audit checklist for the internal customer self-assessment. Once the self-assessment is completed, reviewed, and discussed with the customer, an audit date is scheduled. Onsite audits can take anywhere from one to four days, depending on the program. Once that's complete and all open corrective actions are closed, a three-year qualification certificate is provided. Annual assessments are conducted on the anniversary date of the completed onsite audit. After three years, the process starts over.

IPC Validation Services has an incredible retention rate of 98%. This clearly shows that customers who sign up for any VS program stick with it because they have seen the value of participating.


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***Which IPC standards are the most "qualified" through the VS process?***

The IPC J-STD-001/IPC-A-610 (soldering and inspection) QML program is the most popular, but the IPC-1791 Trusted Supplier program continues to gain traction.

***Could you provide some general guidance on how a company can prepare itself for an audit?***

If you are not one already, you must become an IPC member, which allows you to acquire the IPC standards you need and begin to determine the amount of training and education that will be required for your manufacturing employees to maximize their potential. The final step is to begin the VS audit qualification process, but the VS team can assist you at every step of this process.

***Why would someone do a Standards Gap Analysis (SGA) and not simply do an audit?***

SGA is a program designed to help a customer become more familiar with using an IPC standard. It may be surprising, but it is very common that manufacturers require education and clarification around the standards they are using. There is a lot there. An SGA provides a high-level overview of the manufacturing processes. The team visits a customer and conducts a yes/no type of interview using the IPC standard(s) as a guide. We provide a completely confidential internal report showing all gap findings and containing recommendations for improvement. Some customers feel an SGA is a good prerequisite to a full QPL or QML audit and qualification. Some customers will use SGA if they are considering a merger or acquisition. But SGAs have proven to be valuable tools for our customers, no matter the primary reason for participating.

***Tell me about the Technology Solutions program, something that perhaps a PCB fabricator would be more inclined to use than some of the other VS programs.***

Technology Solutions was created to provide troubleshooting and problem-solving for a particular manufacturing problem. In essence, we go in and help solve a problem. For example, an EMS provider's conformal coating process experiences bubbles after curing. The team troubleshoots the problem and determines a root cause. A confidential report is provided showing the findings and recommendations to correct the problem. The team then follows up with the customer to verify the problem has been successfully resolved and has not re-occurred. This has proven a tremendous value to our customers, whether they ever participate in a formal audit process. PCB fabricators are more likely to engage in the Technology Solutions than others in the Validation Services program. It can be applied to pretty much any part of the value chain for root cause analysis and problem-solving.

***If someone is interested in learning more about VS, participating in a gap analysis, or getting assistance solving a problem through the Technology Solutions program, who should they contact?***

Please contact me at RandyCherry@ipc.org. I've been in various parts of manufacturing for over 40 years, and I love to go to a customer's site and help solve a problem, whether through the SGA, audit process or by providing technology solutions on the ground.

***Thank you, Randy. This has been an interesting discussion. As we work to develop more standards and standardize more technologies across the value chain worldwide, Validation Services will become of even greater value to industry members.***

***Congratulations on 11 years.*** **PCB007**

Read "The Journey to IPC-1791 Validation," in *IPC Community*. In his interview, John Vaughn of Summit Interconnect details the process of working with IPC and what it means to be certified to this standard.

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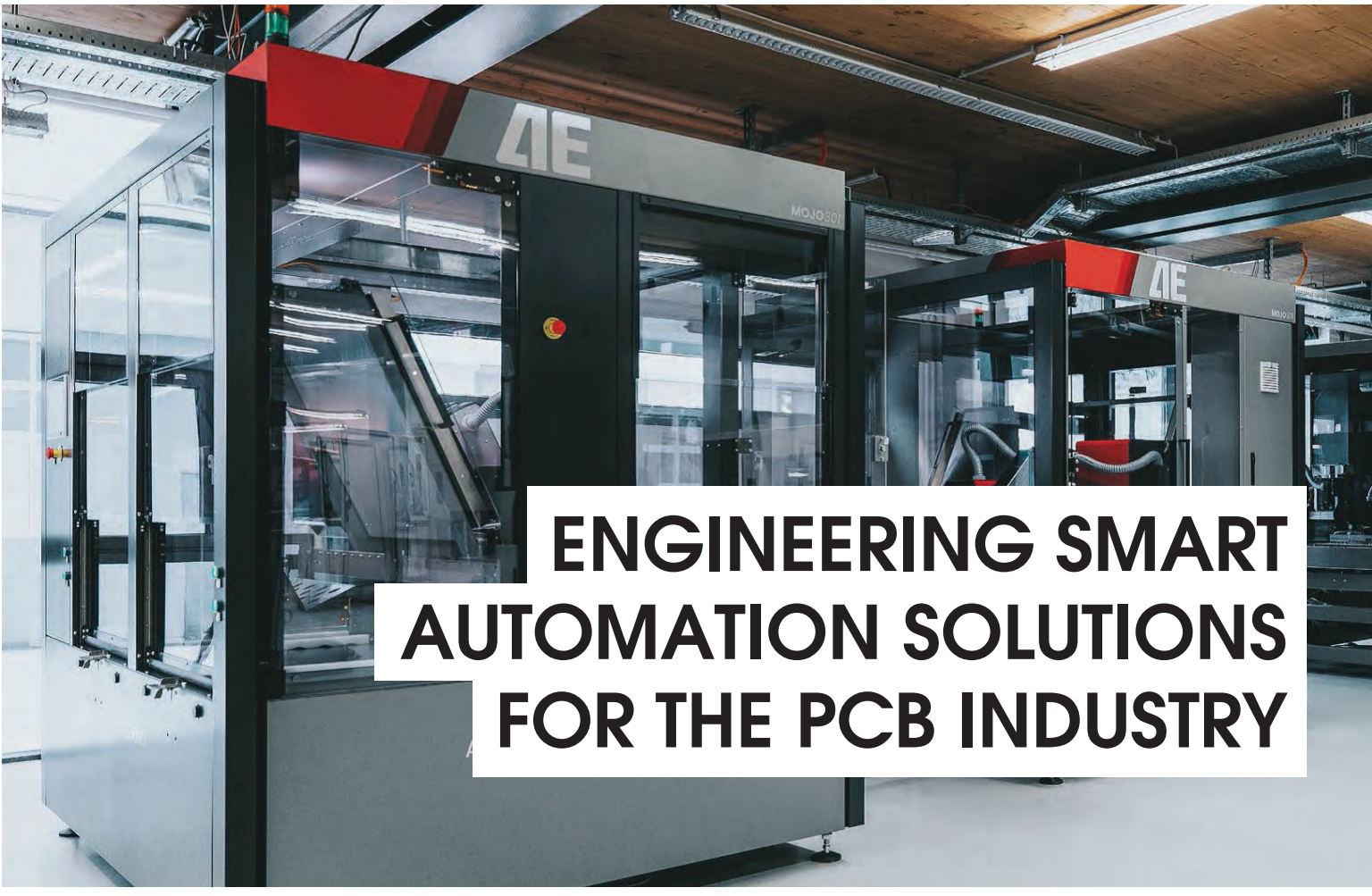

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# The Dielectric Constant of PCB Materials

## Material Insight

by Preeya Kuray, Ph.D.

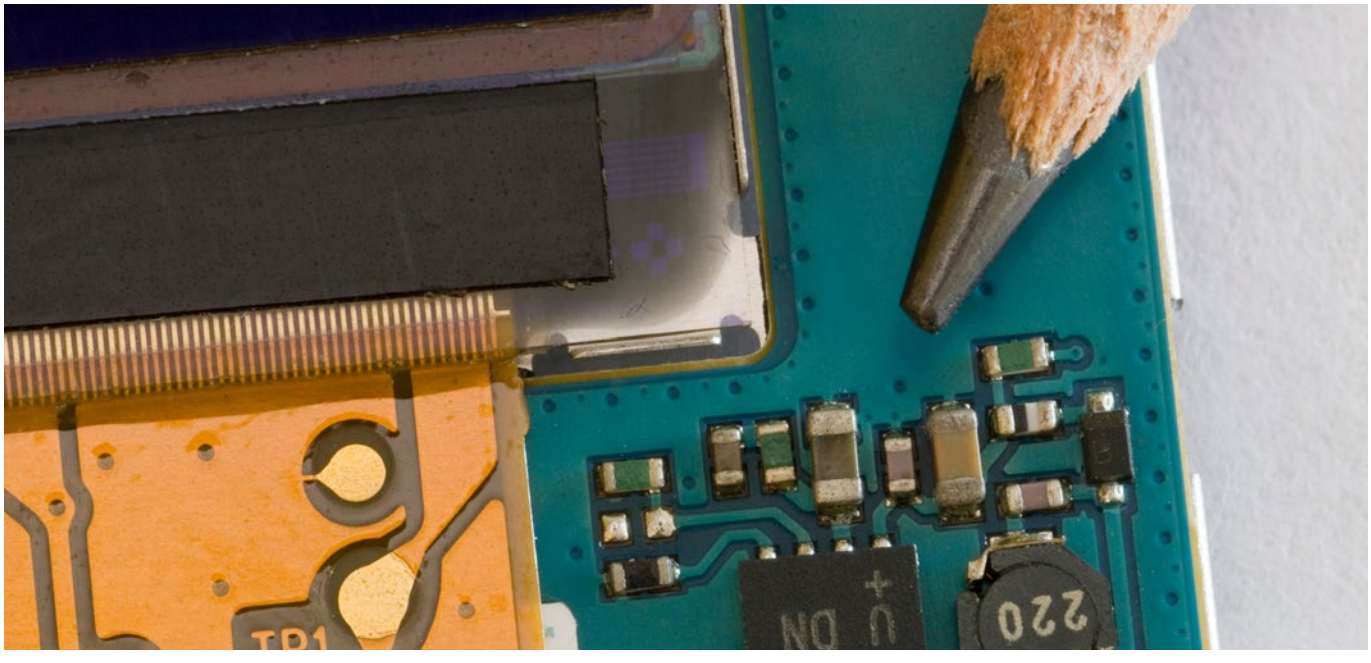
In the world of PCB design, miniaturization can be achieved by using low dielectric constant (Dk) materials. Low Dk materials can allow for a reduction in thickness while maintaining a given trace width, leading to lower transmission loss and higher density circuitry:

$$Z_0 = \frac{60}{\sqrt{\varepsilon_r}} \cdot \log_{10}\left(\frac{w}{h} + \sqrt{\left(\frac{w}{h}\right)^2 - 1}\right)$$

In this equation, $Z_0$ is the characteristic impedance, $\varepsilon_r$ is the dielectric constant, w is the trace width, and h is the distance from the trace to the ground plane. When the characteristic impedance of a transmission line matches the impedance of connected devices (source and load), there is minimal reflection of the signal, and energy is efficiently transferred. Utilizing a material with the appropriate dielectric constant to achieve impedance matching is imperative to ensure signal integrity and proper circuit operation.

But from a materials science perspective, what is the dielectric constant? Why do some classes of materials inherently have lower or higher dielectric constants?

Scientifically, the dielectric constant of a material represents its ability to store electrical energy when exposed to an applied electric field. It also represents how well a material's dipoles (i.e., internal charge distribution) align with that applied field. Just like how a magnet has a north and south pole, all materials have an internal charge distribution, contingent upon the atoms that make up that material and



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how they are bonded together. When an electric field is applied to a dielectric material, its internal dipoles align with the field, resulting in polarization of the material. This polarization allows the material to store electric charge by creating an electric field opposing the applied field. The higher the dielectric constant, the more the material can polarize and the more charge it can store. In contrast, materials with lower dielectric constants exhibit weaker interactions with the applied field (storing less charge), allowing for electrical signals to propagate faster throughout the material.

Another way to contextualize the dielectric constant is to imagine a highway where cars are moving. Think of the PCB as that highway but with tiny signals instead of cars. The dielectric constant can be thought of as analogous to the road surface: some roads are smooth, allowing cars to move faster, while others are bumpy, slowing them down. In a somewhat similar sense, the dielectric constant is a measure of how easily the signals on a PCB can move. A material with a low dielectric constant indicates that signals can move smoothly throughout the substrate. This next equation equates signal propagation speed to dielectric constant, where v is the propagation speed of a signal throughout the material, c represents the speed of light, and $\varepsilon_r$ is the dielectric constant of the substrate material:

$$v = \frac{c}{\sqrt{\varepsilon_r}}$$

It is the job of the formulation scientist to create new kinds of PCB materials that will achieve the target dielectric constant of the desired application. This is achieved by combining different materials with different dielectric constants. Ceramic fillers and polymer resins are two important classes of materials used in creating PCB bondply that will contribute to the overall dielectric constant of the final product. It is imperative to consider the dielectric constant of every material used to successfully achieve the target properties of the final product. **PCB007**

**Preeya Kuray, PhD,** is a materials scientist. To read previous columns, click here.

CONNECT THE DOTS

# Designing for Reality: Prioritizing Manufacturability

**By Matt Stevenson**

Realistic PCB designs should prioritize manufacturability and reliability of the PCB as well as meet the other design requirements. To do so, one must account for the production variables associated with individual manufacturing partners.

Understanding and creating robust PCB designs, especially in terms of board manufacturing, requires a lot of attention to detail. When more detail is included in the design, the manufacturing process goes more smoothly, and process yields are higher.

Product development professionals with limited PCB design experience get tasked with designs. Not immersed in the PCB design discipline, they don't know all the unwritten rules, best practices, techniques, and design requirements.

I recently sat down with Nolan Johnson for the first in a series of discussions about designing PCBs for the reality of manufacturing. By sharing lessons learned over a long career in the PCB industry, we hope to shorten learning curves and help designers produce better boards with less hassle and rework.

**PCB Manufacturing 101**

PCB manufacturing is the physical manifestation of a digital design, and to design manufacturable boards, it's important to understand how they are produced. At a high level, these are the steps associated with PCB manufacturing.

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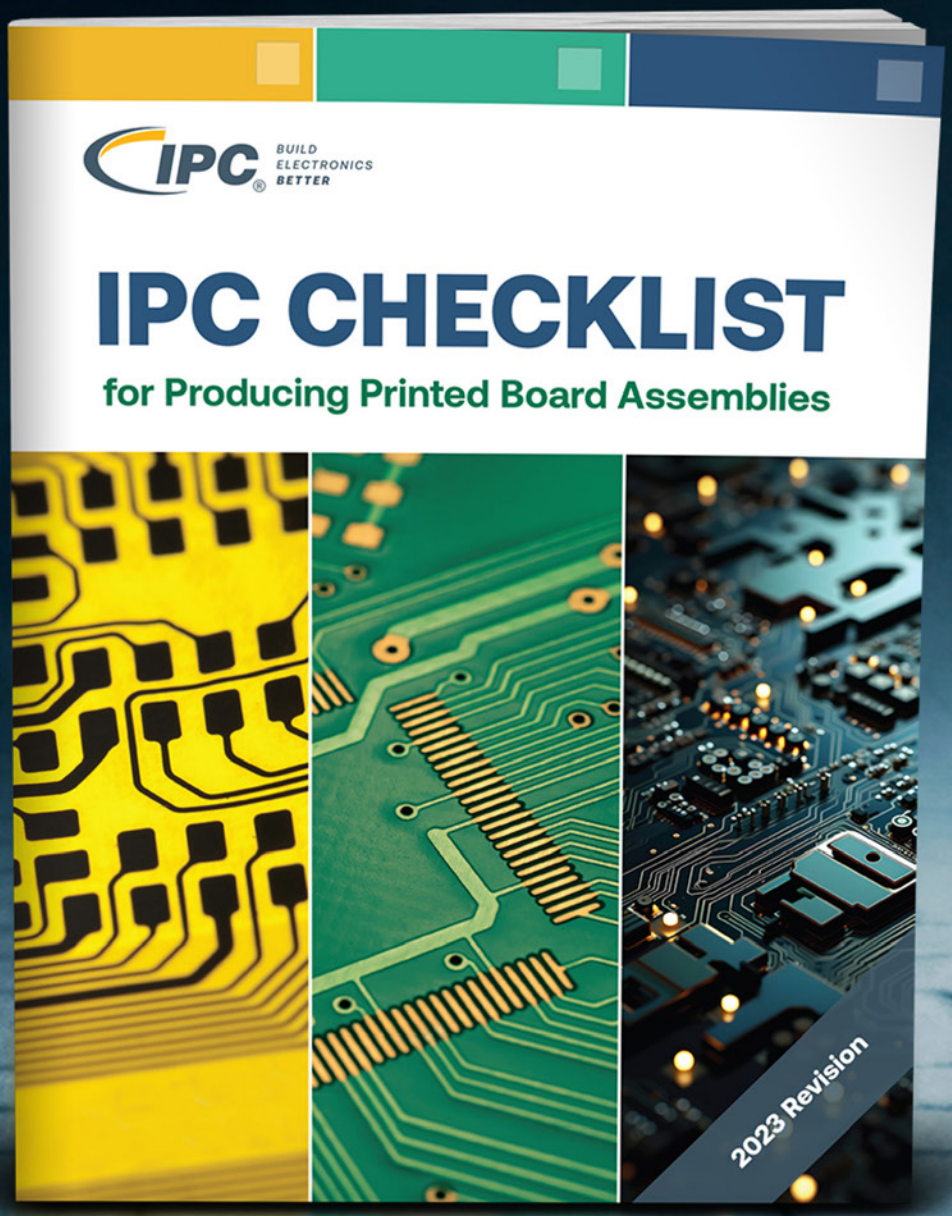


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# The Power Mesh Architecture for PCBs

## Happy's Tech Talk #28

by Happy Holden, I-CONNECT007

A significant decrease in HDI substrate production cost can be achieved by reducing the number of substrate layers from conventional through-hole multilayers and microvia multilayers of eight, 10, 12 (and more), down to four. Besides reducing direct processing steps, yield will increase as defect producing operations are eliminated.

This Tech Talk describes the power mesh architecture (PMA), an innovative interconnection topology that leverages the production technologies of microvias, via-in-pads, and fine-line lithography to allow planar power distribution and dense signal interconnection on only four metal layers.

The PMA was derived from the Interconnected Mesh Power System (IMPS), developed and patented by the High-Density Electronics Center (HiDEC) of the University of Arkansas, Fayettville, Arkansas. The IMPS topology was created to reduce the cost and metal layers on thin-film and ceramic mul-

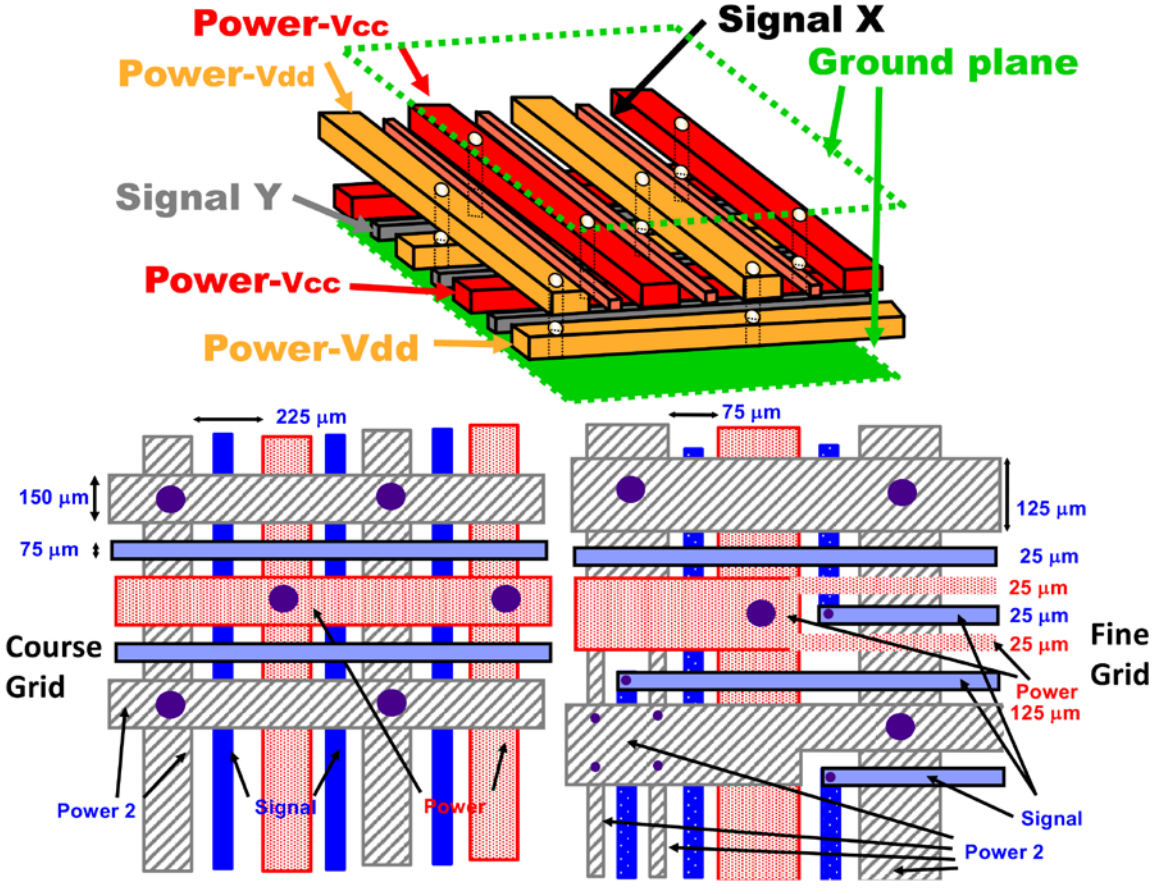


Figure 1: Power mesh was adapted from the IMPS architecture but does not route GND bussing.

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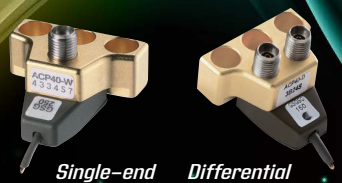

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tichip modules. Power distribution characteristics of IMPS are presented as measured from various test vehicles[1].

In this column, the PMA for PCBs and impedance tables are presented. The initial application of PMA is shown, as well as an application that helps develop the wiring density model for PMA. Finally, the eight-step design process is outlined to create a PMA board.

## An Introduction to the Benefits

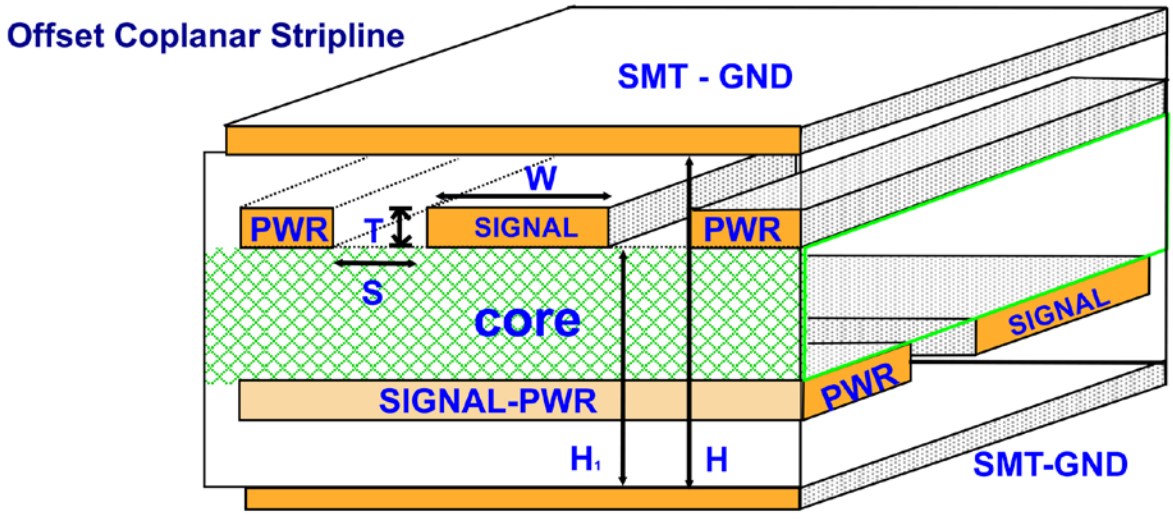
In the mid-1990s, thin film multichip modules (MCM-D) were supposed to be the salvation of the interconnect industry. The fine-line lithography would allow miniaturization with ease. Unfortunately, the four or five metal layers to which integrated circuits were wire bonded proved to be too expensive when compared to printed circuit multilayers and the emerging silicon integration on ball grid arrays.

The test vehicle was built on 2-mil Sheldahl material, an adhesiveless polyimide film called ViaThin. The basic design rules are 50 µm lines and spaces and 150 m via target lands over 25 m laser-drilled vias. The IMPS mesh consisted of 200 µm lines and 50 µm spaces, with the lines offset from the via row or column centers. Wire-bond pads consisted of 200 µm x 350 µm rectangles on both metal layers, tied together with two vias.

The test vehicle showed conclusively that the IMPS topology could be applied to MCM-Ls and BGA substrates without the use of multilayering.

## Power Mesh Architecture

In 1993, a large electronics OEM had the problem of having to redesign the control board of its largest 3.5" hard disk drive. The boards were a standard 3.87" x 5.45", but the problem was that they wanted to cut a 2.8"-diameter hole in the board so that another platter could be added to the drive. This would enable the drive to have a capacity of 16 GB, quite a capac-




| Overall thickness (H) | Dist to far reference (H2) | Dist to far reference (H1) | Trace Width (W) | Mesh Spacing (S) | Impedance (diff. imp) |
|---|---|---|---|---|---|
| 11.4 (15.6) | 1.0 | 10.0 | 1.0/2.0 | 3.0 | 50.0 (100-105) |
| 42.4 (45.6) | 2.0 | 17.2 | 2.0/3.0 | 3.0 | 50.0 (100-105) |
| 20.4 (23.6) | 4.0 | 16.2 | 3.5 | 4.0 | 50.6 (99 - 107)* |
| 22.4 (25.6) | 6.0 | 16.2 | 5.0 | 5.0 | 50.0 (100-105)* |
| 36.4 (39.6) | 6.0 | 30.2 | 5.0 | 5.0 | 49.6 (98-105)* |
| 56.4 (59.6) | 6.0 | 50.2 | 5.0 | 5.0 | 49.8 (98-105)* |

All thicknesses in mils, copper is 0.5 oz., * depending on Mesh width

Figure 2: The impedance and crosstalk model for power mesh is an offset coplanar stripline. The table presents single-ended and differential impedances for various traces and thicknesses.

ity for 1993. The solution to the loss of nearly 5.8 square inches out of 17.5 square inches was to employ microvias and microvia-in-pads. The new microvia board (called Lynx) was designed with a reduced surface area and as a six-layer design (1+4+1), two fewer layers than the original.

Reading about the IMPS topology from HiDEC in 1994, the Lynx board was again redesigned to a four-layer construction. To minimize the microvias, the outer two layers (1 and 4) were flooded with ground, and only power and signals were placed on the inner layers. Figure 1 shows the new power-signal routing architecture, which was called power mesh to differentiate it from IMPS.

## Electrical Model

The original Lynx board was not a controlled impedance, but additional PCB designs were that used power mesh. The consensus is that power mesh is an offset coplanar stripline. Figure 2 shows this cross-section of the offset coplanar stripline. The table shows the values for 50-ohm single-ended and 100-ohm differential impedances for different trace widths, spacings, core thicknesses, and overall thicknesses.

The crosstalk model indicates that the PMA creates a naturally low crosstalk condition. Each signal trace of X width is approximately 3X or 4X distance from the next signal, depending on the power trace width. This creates horizontal crosstalk of less than 2%. The vertical crosstalk is extremely low. From 15 mV/V for thin cores (0.012") to 2.6 mV/V for a thick core (0.051").

## PMA Application

The first PMA was completed in 1994. The Lynx multilayer is shown in Figure 3. The inner layer FR-4 core (Figure 3a) was 12 mils thick (0.012"). The initial design used epoxy-resin coated copper foil of about 2-mils thick as the microvia layers 1 and 4. The microvias were 7 mils in diameter with 14-mil pads. Traces and spaces were 5 mils.

Figure 3b shows the finished power mesh multilayer. Without any traces on the surface—as all components had via-in-pads—the unbroken ground plane serves as the effective ground return and impedance reference. It was also highly effective as an RFI/EMI shield. Switching noise was reduced because the ground connections were micro-resistance and had no inductive or capacitive elements in series to the ground connection. Similarly, noise budgets were improved because the connection to power had the minimum inductance and capacitance, nearly 1/10 that of a through-hole and trace connecting the component land.

## Designing With PMA

The one discouraging characteristic of the PMA is that EDA tools do not recognize nor automatically design with the PMA. That does

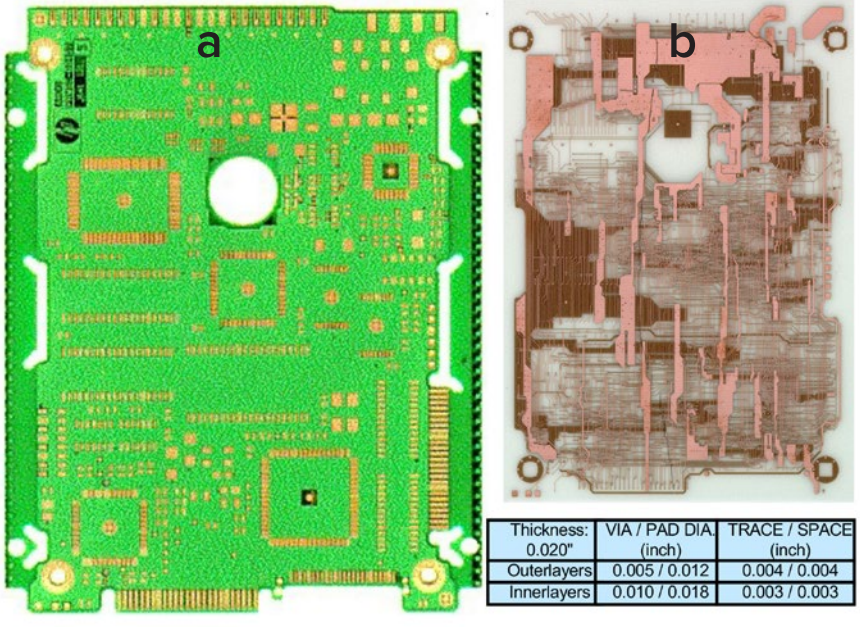



Figure 3: Example of a power mesh design: a) Inner layer (L2 & L3) with buried vias; b) Finished four-layer power mesh multilayer with microvia-in-pad and unbroken ground plane.

not mean you cannot design with PMA; it just means you must do it by hand. The process for designing a printed circuit with power mesh can be simplified to eight steps:

## PMA Design

1. Build a special library for all fine and extra fine pitch geometries that include locations for blind via-in-pads.
2. Create the board stackup in the EDA tool for a four-layer or six-layer PMA.
3. Place all parts at a closer proximity. The critical factor in placing parts is to place the power pins and connections on a grid approximately equal to the power mesh traces' center-to-center distance.
4. Break through all signal and power nets using blind vias-in-SMT pads.
5. Protect all breakthrough vias so that they are not moveable.
6. Route the power traces to all power pins and connections and protect them. Route critical timing and clock lines and protect them, then route the remaining signal nets on one inner layer and only orthogonal routings on the other inner layer. Buried vias are used to transition from one layer to the other.
7. Complete the power mesh traces to fill in missing legs and balance the power mesh over the entire board's surface. Blind vias need to be placed at each intersection of the same power levels (Vcc or Vdd) so that a power mesh results on the two layers that provide current distribution uniformly across the board. Clean up the board to minimize vias and trace length. Diagonal routing is okay now that routing is complete.
8. Expand all power traces (the mesh) until they meet a signal trace or another voltage level trace. This will create the maximum surface area for the power mesh traces and increase the distributed capacitance between power and ground. Fill the outer layers with ground plane and then stitch the ground planes together where possible (Figure 4).

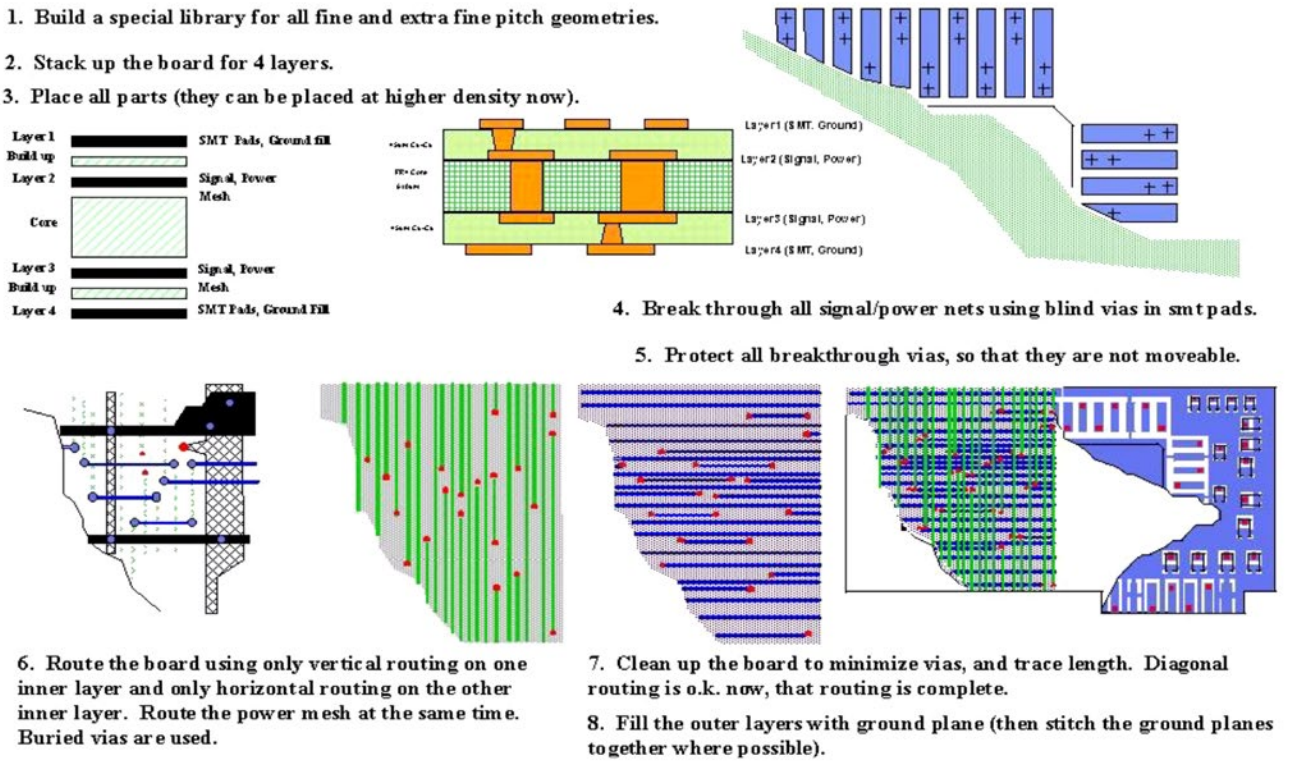



Figure 4: Eight-step PCB design process for power mesh boards.

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## Wiring Model

In 1994, StorageTek, an OEM in Colorado, conducted performance benchmarking with microvia designs and fabrication[2]. The successes of that program contributed to its continued use of microvias. In 1998, it became apparent that they required some wiring model to indicate that a microvia structure was required. In performing that model development, a power mesh benchmark was designed for one of the microvia boards[3]. Figure 5 shows the two inner layers of the four-layer power mesh structure and two of the six inner layers from the original eight-layer through-hole design. The wiring density model for the PMA is:

### Power Mesh = 17 to 40 signal inches per square inch per layer (dependent on trace width and spacings)

- Calculate the Statistical Wiring density using Coors, Anderson & Seward[4]
- Calculate the Manhattan Wiring Density using Wd=0.0068(X)^2 – 0.1644(X) + 35.1, where X is the Coors Statistical Wiring Density
- Calculate the Routability Index for Power Mesh[3]
- Calculate the Layout Efficiency using: L.E.(%)= 4.0642(RI)^-1.189, where RI is the Routability Index

## Summary

The microvia topologies of power mesh have demonstrated the application to simplifying complex multilayer, PBGAs, and MCMs. IMPS can reduce the structure to a two-metal interconnect, while power mesh uses a four-layer reinforced laminate structure. These results show that these topologies have the capacity of positively impacting how electronic products are packaged and Interconnected. **PCB007**

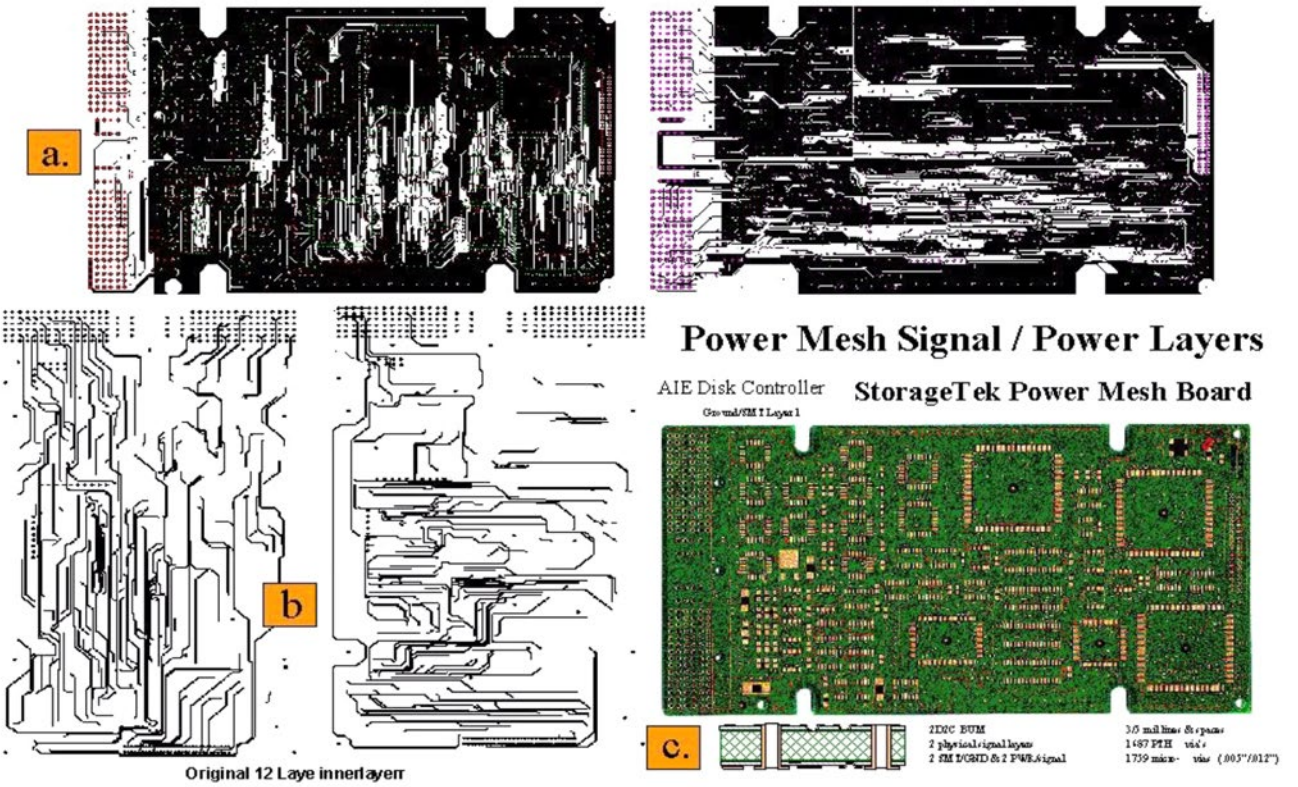


Figure 5: Power mesh example at StorageTek provided coefficients for density models: a) The two PMA inner layers compared to b) two of the six inner layers of the original eight-layer TH design; c) circuit side view and cross-section view of the finished power mesh board.

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1. Happy's Tech Talk #27: Integrated Mesh Power System (IMPS) for PCBs, by Happy Holden, *PCB007 Magazine,* March 2024.
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4. "A Statistical Approach to Wiring Requirements," by G. Coors, P. Anderson, and L. Seward. Proceedings of the IEPS, 1990, pp. 774-783.

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

# Pushing Material Boundaries for Better Electronics

A recently tenured faculty member in MIT's departments of Mechanical Engineering and Materials Science and Engineering, Kim has made numerous discoveries about the nanostructure of materials and is funneling them directly into the advancement of next-generation electronics.

His research aims to push electronics past the inherent limits of silicon—a material that has reliably powered transistors and most other electronic elements but is reaching a performance limit as more computing power is packed into ever smaller devices.

Today, Kim and his students at MIT are exploring materials, devices, and systems that could take over where silicon leaves off. Kim is applying his insights to design next-generation devices, including low-power, high-performance transistors and memory devices, artificial intelligence chips, ultra-high-definition micro-LED displays, and flexible electronic "skin." Ultimately, he envisions such beyond-silicon devices could be built into supercomputers small enough to fit in your pocket.

The innovations that have come out of his research are recorded in more than 200 issued U.S. patents and 70 research papers—an extensive list that he and his students continue to grow.

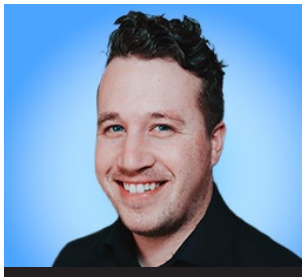
Kim credits many of his breakthroughs to the fundamentals he learned in his university days. In fact, he has carried his college textbooks and notes with him with every move. Today, he keeps the undergraduate notes—written in a light and meticulous graphite and ink—on a shelf nearest to his MIT desk, close at hand. He references them in his own class lectures and presentations, and when brainstorming research solutions.

"These textbooks are all in my brain now," Kim says. "I've learned that if you completely understand the fundamentals, you can solve any problem."

(Source: MIT)

# TOP TEN

EDITOR'S PICKS


Cameron Burke

## Catching Up with Jove PCB's Cameron Burke

As we are working to highlight young professionals in the industry, Dan Beaulieu's interview with Jove PCB's Cameron Burke is a solid example of our industry's next generation in action. A Shenzhen based PCB manufacturer with five fabrication facilities, Jove PCB has reached nearly $250 million in sales since their founding in 2004. Cameron is their North American sales manager.

## IMAPS Wrap-up: AI, Chiplets, and 3D Cube Architecture

The market and technological perspective that I was subject to attending the last day of the IMAPS Device Packaging conference was quite something. If you did not get a chance to read this, I recommend you take a moment. As our part of the supply chain begins to truly grapple with advanced packaging challenges, it is good to understand where we are really going. Being led through a chiplet journey by both AMD and Intel, highlighting the future of 3D packaging architecture and sub 1-micron features.

## The Many Complexities of PFAS


There are probably few acronyms that strike more fear in the heart of manufacturers than PFAS. IPC's Kelly Scanlon, lead sustainability strategist breaks down the complicated issue of PFAS for electronics manufacturing. With so many regulatory agencies, both locally and worldwide, and often conflicting or incomplete definitions of PFAS, my Q&A with Kelly is enlightening. I recommend adding this quick read to your list, if you missed it the firt time around.

## The Delicate Balance of Sustainable Business and Going Green

Resident PCB expert and inventor Alex Stepinski is a self-proclaimed "activist" of sorts. Having developed ZLD technology, and working to make it more accessible and cost effective for all industry members, Alex hopes it will go viral over the next 10 years. Our March interview with Alex discusses what sustainability looks like for our companies, both environmentally and financially. He also talks about what process technology he may be tackling next to further our environmental sustainability.

## The New Chapter: Attracting 'Generation Green'

TTM's Paige Fiet starts out her March column with the question, "Why should companies care about Gen Z's love for the environment?" and proceeds to answer with compelling data and commentary. She cites that 64% of Gen Z'ers have noted the importance of their employers acting on environmental issues.

## The Impact of U.S. Defense Production Act on PCB Industry

March marked two years from President Biden's original Chips and Science Act, and one year from the original Presidential Directive on printed circuit boards, advanced packaging and IC substrates. David Schild of PCBAA discusses the recently approved FY2024 funding for the DFA and proposed legislation to include the protection of PCBs in this interview.

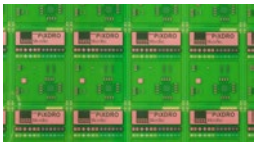
## Digitalisation and ESG

AT&S's Marina Hornasek-Metzl provides a high-level view of electronics waste and implementing sustainability goals and does an excellent job of presenting the paradox between digitalization as a waste producer, while also being a primary means for creating sustainability solutions.

## Water Management in a Large Printed Circuit Board Manufacturer

TTM's Charles Nehrig takes readers for a glimpse of what it looks like to approach water use reduction at a large TTM. Grounded in their Environmental Statement and Sustainability Policy, Charles and his team work on all fronts to reduce water consumption and their water footprint at every TTM facility. Breaking things down, he discusses waste water treatment upgrades, wastewater segregation, water use reduction, and stormwater management. No matter what size PCB manufacturer you are, this article is must-read.

## Inkjet Solder Mask Has 'Arrived'



The incomparable Pete Starkey attended an interactive webinar hosted by SUSS Microtek entitled, "Solder Mask Coating Made Easy with Additive Manufacturing." Pete recounts his webinar experience, taking us through the highlights, including a presentation by Marianna Van Dam.

## Punching Out: Acquiring a PCB/EMS Shop: Brownfield vs. Greenfield

Tom Kastner of GP Ventures tackles one of the biggest growth questions manufacturers are grappling with when it comes time to expand - greenfield of brownfield. Does it make more sense to develop a new company or buy an existing one? Breaking it down, Tom adeptly takes the reader through a list of variables for each solution to help guide the business owner or entrepreneur who is looking at expansion.

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## Field Service Engineer (or) Field Service Technologist

SCHMID Group is currently in search of a Field Service Engineer or Field Service Technologist for its USA subsidiary SCHMID Systems, Inc. (SSI). This position acts as an advocate for the company providing worldwide customer service on-site or remotely.

General scope of duties includes machine installation, commissioning, maintenance, and repair of PLC and PC-controlled systems primarily in the company's proprietary industrial machines within the wet chemical processing industry as well as automation technology.

This is a full-time exempt position with limited supervision. SSI provides full-time employees different options for benefits including medical, dental, vision, flex, 401K, and more.

Contact Bob Ferguson:
Ferguson.ro@schmid-group.com

apply now

# Career Opportunities

GARMIN

## Senior Printed Circuit Board (PCB) Designer

Garmin is seeking a full-time Senior Printed Circuit Board (PCB) Designer in our Olathe, KS, Cary, NC or Salem, OR location. Relocation allowance provided.

### Essential Functions

- Partners with Product Design Engineers and Mechanical Engineers to produce loosely defined complex PCB Designs that are timely, robust, and economical
- Key technical contributor and ECAD/MCAD interface expert in the design of new or challenging PCB designs or projects bearing directly on organizational objectives
- Leverages thorough knowledge of Garmin processes and procedures through leadership of major research or product development projects consisting of multiple modules or sub-projects that align the team with Garmin and departmental mission and vision
- Leads the advancement of team capabilities through identification and testing of new PCB design technologies for ECAD software
- Connects engineering teams, communicating effectively with all project stakeholders (ex. Electrical, Process and Mechanical Engineering)
- Serves as an expert in PCB Design and Engineering processes including mentoring one or more PCB Designers

### Basic Qualifications

- Associate's Degree in Electronics Technology or related field AND a minimum of 10 years relevant experience performing similar consumer electronics industry duties OR an equivalent combination of education and experience
- Demonstrates expert proficiency using Garmin's ECAD tools (Cadence Allegro)

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GARMIN

## Lead eCAD Librarian

Garmin is seeking a full-time Lead eCAD Librarian in our Olathe, KS or Cary, NC location. Relocation allowance provided.

### Essential Functions

- Ability to define library solutions with a cross functional understanding of the overarching library impact
- Manages/delivers a global library database solution within established Garmin standards
- Develops reliable solutions for exceedingly complex eCad Library parts which require the regular use of individual thought and creativity
- Verifies/validates schematic symbols and physical footprints for parts created by other librarians for accuracy
- Leads advancement of team capabilities through identification and definition of eCAD Library technical strategy
- Expert in evaluation of new eCAD features and capabilities as they relate to the eCAD Library
- Ability to define eCAD Library process for new technologies and capabilities
- Ability to mentor one or more eCAD Librarians

### Basic Qualifications

- Possess a minimum of 15 years experience in an eCAD librarian position OR an equivalent combination of education and relevant experience
- Demonstrates expert proficiency of eCAD Library best practices and design standards for all PCB technologies used in current Garmin designs
- Demonstrates a working knowledge of all types of electronic components
- Demonstrates proficiency to interpret Manufacturer Data Sheets
- Demonstrates proficiency of PCB manufacturing processes

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# Career Opportunities

pluritec®

MACHINES FOR PRINTED CIRCUIT BOARDS

## Sales Manager, Remote

**Location:** North America

**Experience:** Minimum of 4 years in the PCB industry

**Job Description:** We are looking for a highly motivated and experienced sales manager to join our team. The ideal candidate will have a minimum of 4 years of experience in the PCB industry and a proven track record of success in sales. The successful candidate will be responsible for developing new business and sales network, maintaining existing accounts, and achieving sales targets. The candidate must be able to work independently, have excellent communication and interpersonal skills, and be willing to travel.

**Qualifications:**

- Minimum of 4 years of experience in the PCB industry
- Proven track record of success in sales
- Excellent communication and interpersonal skills
- Strong technical process background
- Ability to work independently.
- Willingness to travel

**Education:** Technical or related field preferred

**Compensation:** Competitive salary and benefits package

Pluritec develops high end equipment for the printed circuit board (PCB & PCBA) manufacturing industry. We offer a wide range of equipment including drilling and routing, wet processing, spray coating and more. We are a global supplier with more than 3,000 systems installed worldwide.

**Contact Nicola Doria**
**nicola.doria@pluritec.org to apply.**

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TTC The Test Connection, Inc.

## Rewarding Careers

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

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

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

## Associate Electronics Technician/ Engineer (ATE-MD)

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

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

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# Career Opportunities

TAIYO AMERICA

## 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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BLACKFOX
Premier Training & Certification

## 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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# Career Opportunities

Prototron Circuits

## 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.

apply now

EMA Design Automation

## 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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# Career Opportunities

ARLON ELECTRONIC MATERIALS

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

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

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

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

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

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

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INSULECTRO

## Are You Our Next Superstar?!

Insulectro, the largest national distributor of printed circuit board materials, is looking to add superstars to our dynamic technical and sales teams. We are always looking for good talent to enhance our service level to our customers and drive our purpose to enable our customers 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

TRAIN. WORK SMARTER. SUCCEED.

## Become a Certified IPC Master Instructor

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

### Qualifications and skills

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

### Benefits

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

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# Career Opportunities

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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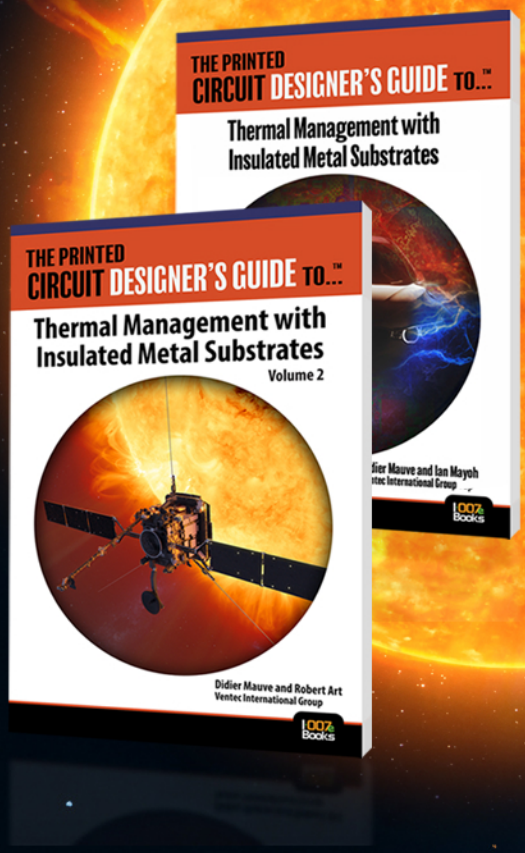
# Companionship at its Best


This must-read sequel to Ventec's book series on Thermal Management describes the applications, IMS products and support services to help you understand and overcome thermal management challenges.

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