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The Legislative Outlook: Helping or Hurting?

This month, we take a look at the rules and laws governing the global business landscape, a reality that often makes business more difficult to conduct and profitability more challenging to achieve.

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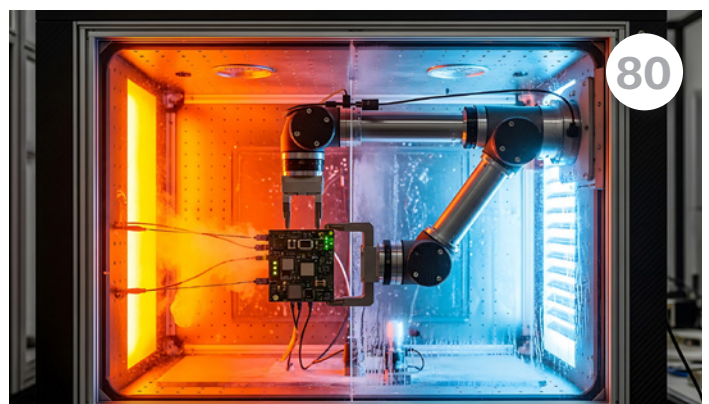
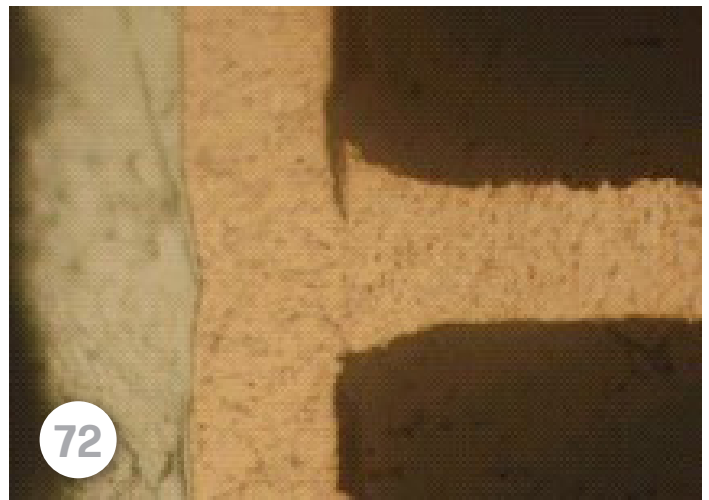
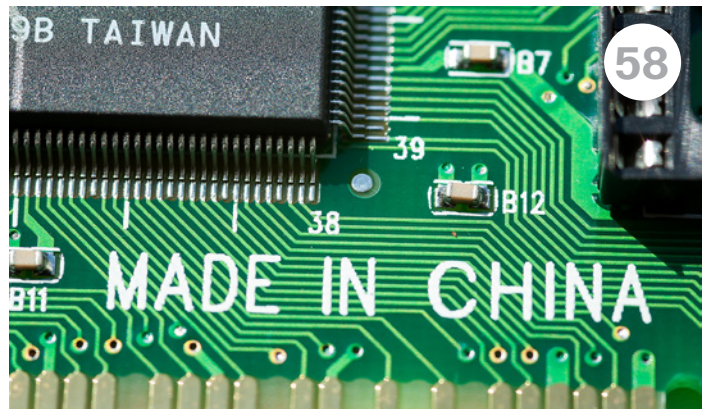
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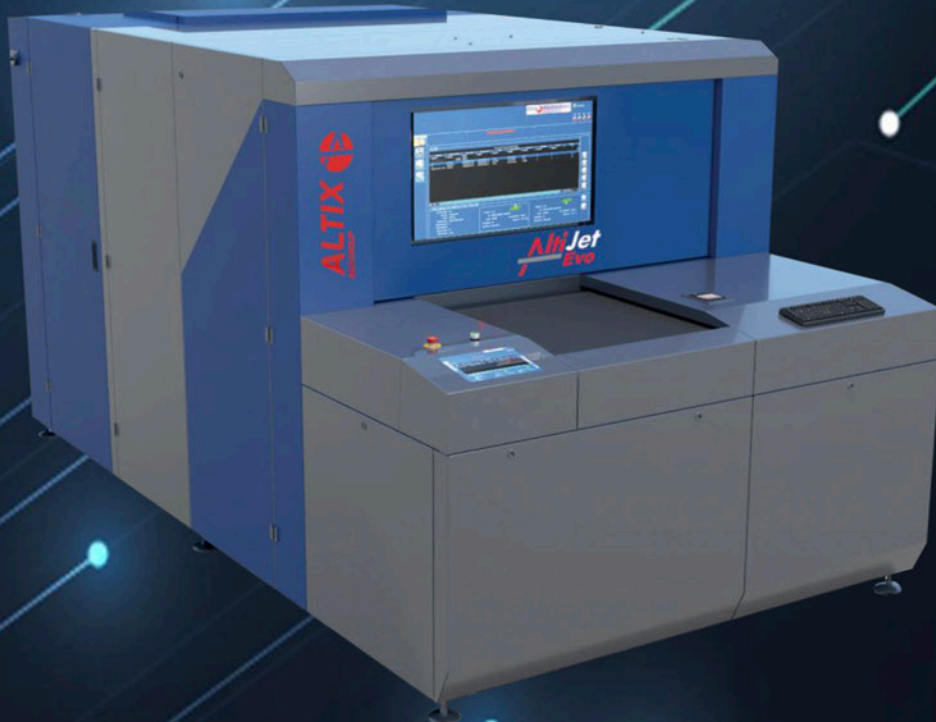
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The Legislative Outlook: Helping or Hurting?

by Marcy LaRont, I-Connect007



Just before we were ready to publish our October issue of *PCB007 Magazine*, some breaking news from the White House, unfortunately (but perfectly) parlayed into why the topic of this month's issue has been so important to cover in depth.

On Oct. 10, after U.S. trading markets were officially closed, President Trump announced a 100% tariff on Chinese goods, which will go into effect Nov. 1, unless trade negotiations yield favorable results for the U.S. In response, the Chinese swiftly shut down access to critical minerals, introducing new export controls that require a license for even a small amount of these minerals. Now, the upcoming trade-focused meeting between President Trump and Xi Jinping may never happen. Just as swiftly, the U.S. stock market took a dive, though experts still anticipate its continued strong performance, at least through the end of 2025.

Such moves are the latest in a litany of tumultu-

ous political moves and rhetoric affecting global markets, and thus, the continuous uncertainty and volatility under which businesses must now operate.

This month, *PCB007 Magazine* examines the rules and laws that shape the current global business landscape, and highlights some of the reasons they are complicating business operations and making profitability more challenging. Whether it is the additional cost being put on global electronics manufacturing companies due to U.S. tariffs, environmental regulations in the EU, or the near-total monopoly China is leveraging on critical minerals vital for defense, EV, and semiconductor manufacturing, there is a lot for businesses to digest to make their best strategy and risk mitigation decisions. This issue focuses on things you need to know to operate effectively and make informed business decisions.

An article by Chris Mitchell, VP of global government relations for the Global Electronics Association, sets the tone for this issue. His message outlines a significant paradigm shift in global trade relations. My interview with David Schild, executive director of PCBAA, provides a U.S. viewpoint on re-establishing and growing a robust U.S. PCB manufacturing industry. Alison James, leading the Association's European advocacy efforts, discusses a critical juncture for the EU, and we revisit a recent conversation about the state of EU security and defense and its unique challenges. Sydney Xiao, president of the Association in China, outlines China's need to adapt to a changing environment. The November issue of *SMT007 Magazine* will take a closer look at the increasing importance of Mexico in electronics manufacturing.

This issue also puts a spotlight on sustainability, where it's common knowledge that the EU far outpaces U.S. efforts, particularly the EU's progressive ESG policies and the enactment of formal legislation.

Nyron Rouse directs government grants for the Global Electronics Association and breaks down what's needed to obtain federal funding is available in the U.S. to support domestic business growth.

MacDermid Alpha Electronics Solutions leads an interesting discussion on surface finishes, specifi-

cally ENIPEG and the implications of the updated IPC-4556 specification for corrosion, as well as the utility of hybrid gold systems.

Our columnists always bring the goods. Kurt Palmer of Schmolz discusses depth routing in rigid-flex PCB fabrication, while Michael Carano explores Type 1 interconnect defects. Chemcut's Don Ball critically examines what it would take to bring circuit board production back to the U.S., Happy Holden recounts working in China, and Steve Williams completes the story of Electro-Tek, one of the industry's earliest PCB shop success stories. Finally, PCBAA Chair Shane Whiteside explains how "made in America" labeling may be deceiving.

It's October, so grab your favorite pumpkin-spice beverage and take some time to learn and read what industry watchdogs are saying about today's business and political climates. **PCB007**



Marcy LaRont is the managing editor of *PCB007 Magazine* and executive director of IPC Publishing Group. 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](#).

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A New Era for Global Trade and Electronics



The global trade system is undergoing an enormous, systemic paradigm shift. For decades, the World Trade Organization (WTO), with the support of the United States, its traditional European allies, and many other nations, stood at the center of efforts to create fairer, more predictable, and rules-based commerce. Today, however, that model is giving way to a more fragmented reality—so far U.S.-driven—in which individual nations and blocs are striking deals and imposing a variety of rules of their own liking.

President Trump launched this trend as far back as 2017 by questioning the value of multilateral institutions and placing greater emphasis on bilateral agreements. This was generally true during his first term, with the signature example in trade being the U.S.-Mexico-Canada Agreement that he proposed and secured.

The second Trump administration has pursued this approach with even greater zeal, ignoring the WTO and existing trade agreements and instead imposing new U.S. tariff regimes on a country-by-country, region-by-region, and sector-by-sector basis.

The result is that the WTO is no longer the anchor of global trade, and companies must navigate a complicated patchwork of overlapping rules, tariffs, and compliance requirements, and all of them are in flux.

For the electronics industry, which has the most globally integrated supply chains of any industry, this is a consequential development. A circuit board designed in California may involve laminates from Taiwan, copper from Chile, semiconductors from South Korea, and assembly operations in Mexico, before being shipped to a U.S. manufacturer that puts the boards and other components into final products and exports them to happy consumers worldwide.

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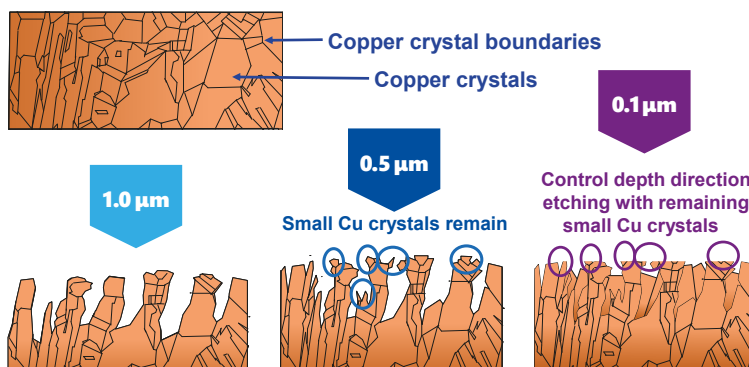
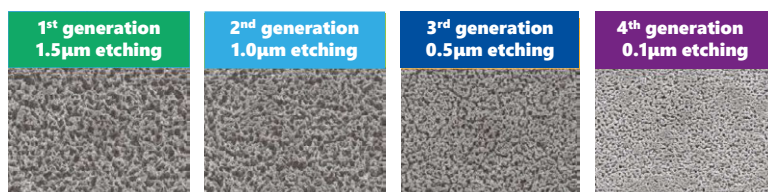
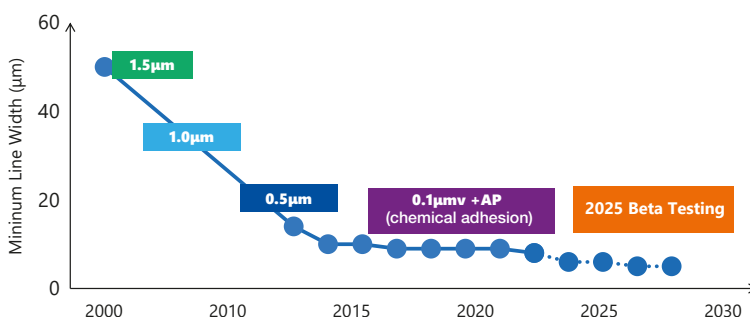
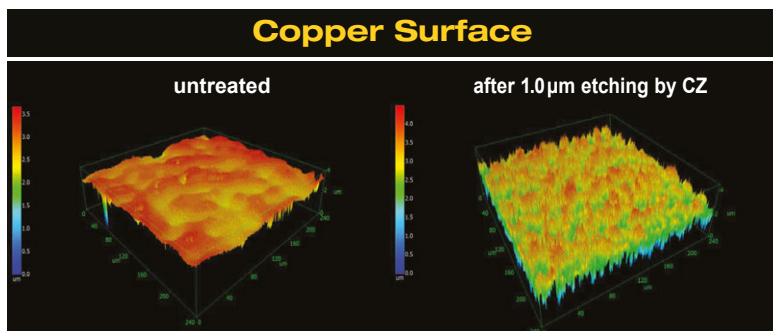
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Since the end of World War II, global trade rules have tended to converge. The costs of global manufacturing and shipping dropped, and supply chains accelerated. Now, each of those trends has been reversed, and a new framework is still being built.

There is a role for bilateral and regional agreements. They can be tailored to the unique needs of the participating economies and achieved faster than global negotiations. The USMCA, which took

about a year to negotiate and two more to ratify and enter into force, is one example. The various agreements reached this year between the United States, the UK, the European Union, China, and Japan are additional examples.

Still, the risks and impacts of fragmentation are real. A growing variety of rules and compliance requirements adds cost and complexity. Small and medium-sized manufacturers often lack the resources to manage multiple compliance regimes, leaving them vulnerable in global markets. There is no guarantee the United States will remain in the driver's seat.

From the Global Electronics Association's perspective, the priority is not to choose between multilateral and bilateral approaches, but to advocate for our industry in world capitals so that whichever approaches are taken, the new policies take our

industry's needs into account, because in today's world, our lives depend on electronics.

We still believe most people worldwide are best served by a global trade system that is fairer, more collaborative, and more predictable than it was in past decades. We support bilateral deals to address specific issues between nations. We counsel caution in deploying tariffs, which tend to raise the cost of manufacturing in an industry with extremely tight profit margins. We urge national governments to adopt multi-faceted policy strategies to build up their domestic industries.

It is impossible to imagine a future in which any one nation or region will source all its electronics needs domestically. To remain innovative and competitive, electronics manufacturers will continue to depend on stable, far-sighted policy frameworks at home and abroad.

To remain innovative and competitive, electronics manufacturers will continue to depend on stable, far-sighted policy frameworks at home and abroad.

As the paradigm shifts, our message to governments is simple: Trade policy should enable, not hinder, the flow of electronics that connect the world. **PCB007**

Chris Mitchell is vice president of global government relations for the Global Electronics Association, and an I-Connect007 columnist. To read past columns, [click here](#).



Chris Mitchell

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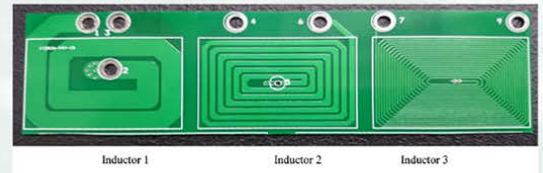
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China's Response to Global Trade Shifts: Adaptation, Not Retreat



As global trade enters a new phase of transformation amid rising geopolitical tensions, U.S. and European calls for supply-chain localization, and increasingly strict sustainability regulations, China's electronics industry faces not survival, but adaptation.

China's Enduring Role in Electronics

China remains the backbone of the global electronics supply chain. According to Prismark, the global PCB market grew 5.8% in 2024 to \$73.6 billion, driven by AI servers, networking, and a rebound in electronics. China remained the leading producer, supported by cost advantages, expansion, and technological progress despite price pressures¹.

This scale, built over decades, cannot be easily replicated. While Western markets discuss reshoring, China's supply-chain depth and expertise will remain indispensable for the foreseeable future.

Diversification, Not Departure

One trend is the expansion of Chinese manufacturers into Southeast Asia. Companies from Thailand to Malaysia are building what many describe as a second production line. This is not an exodus, but a pragmatic strategy to hedge against tariffs and regulatory risks while keeping core R&D and high-volume production in China. China and Southeast Asia are becoming complementary rather than competitive.



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Sustainability as a Competitive Edge

Sustainability has moved to the center of global trade. According to the World Economic Forum, over 800 large Chinese companies have pledged to achieve carbon neutrality by 2050². On Oct. 23, 2024, China's National Development and Reform Commission (NDRC) released a Work Plan on Carbon Emission Statistics and Accounting³, requiring national and provincial reporting systems by 2025.

For Global Electronics Association member companies in the region, these policies are more than compliance requirements; they are pathways to competitiveness. European carbon tariffs and U.S. supply-chain standards mean that green innovation is now as decisive as cost efficiency. Many Chinese firms are already adopting international certifications, improving energy efficiency, and investing in recycling and low-carbon production.



Sydney
Xiao

The Dual Market Advantage

Another key strength is China's domestic market demand. Electric vehicles, 5G networks, and AI hardware are fueling a large internal market that offers resilience against external shocks. This dual

circulation model—serving both domestic and international markets—ensures stability while reinforcing China's global role.

Conclusion

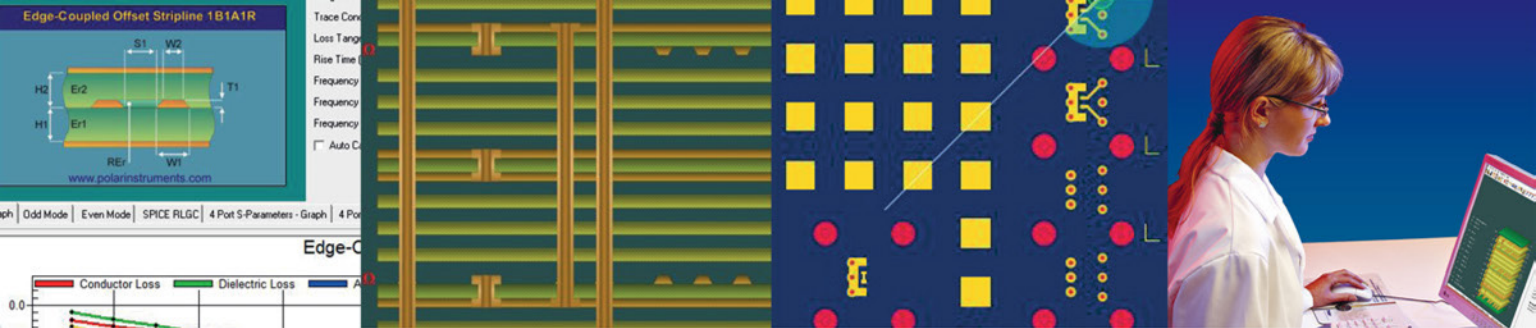
The Global Electronics Association is concerned with the health and well-being of our industry at large, working toward a place where all members of our interconnected industry can thrive. From our perspective, China's electronics sector is not retreating but repositioning. By diversifying geographically, embracing sustainability, and leveraging domestic demand, our industry is adapting to the realities of a more complex global trade environment.

It is erroneous to suggest that China is replaceable in the electronics supply chain. Collaboration will define the future under new terms: greener, more transparent, and more resilient supply chains. **PCB007**

References

1. Prismark posted these results on LinkedIn in July.
2. "How China is helping power the world's green transition," World Economic Forum, Jan. 17, 2025.
3. "Work Plan to Strengthen the Carbon Emissions Statistical Accounting System," Climate Cooperation China, Jan. 7, 2025.

Sydney Xiao is president of Global Electronics Association East Asia.



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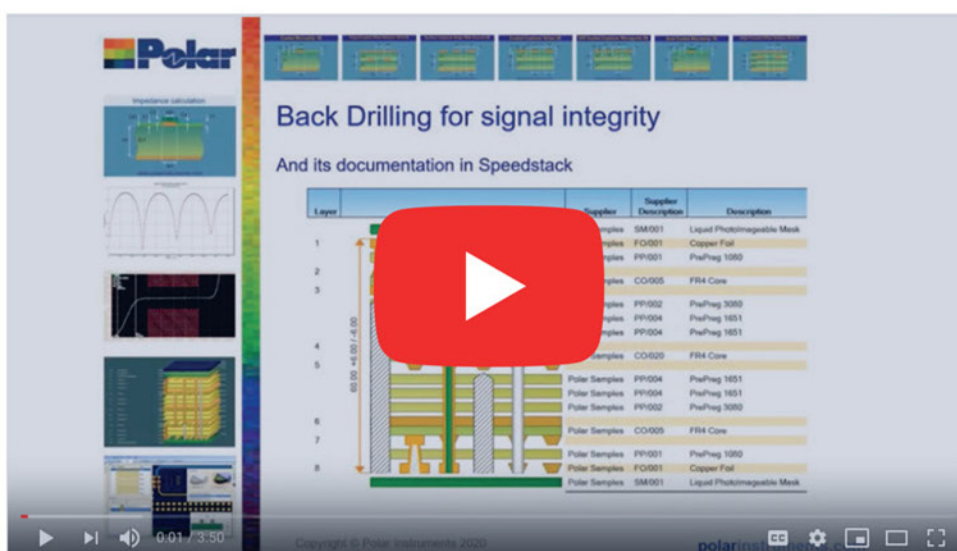
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Waging the Battle for American PCB Reshoring

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AUDIO INTERVIEW

David Schild
PCBAA

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Editor's note: The following is a transcript of the audio interview.

Legislation is shaping global trade, tariffs, and sustainability and environmental regulations. David Schild of PCBAA discusses exactly where the U.S. stands in its efforts to reshore printed circuit board manufacturing for critical industries. This conversation at PCB West occurred on the first day of the federal government's shutdown, so it seemed especially timely to hear David's thoughts and insights on how the current political climate is affecting efforts to achieve the U.S. industry's reshoring goals.

This is Marcy LaRont with I-Connect007, and I'm here at PCB West in Santa Clara with David Schild of the PCBAA. Hi, David, thanks for being here.

David Schild: Great to be here, Marcy. Always good to talk to you.

Today of all days, I'm especially happy to talk to you. We were all celebrating in March last year

based on what we thought were some spending appropriations that had been approved and some support in the government for the printed circuit board manufacturing sector in the U.S. part of the microelectronic stack and electronic stack. A lot has changed since then.

Thanks, Marcy. It's good to be here with you in Santa Clara at PCB West. This is a great trade show. There are so many of our members, and hopefully some prospective members in the room as well, but there is a real concentration of industry greats, and I'm thrilled to be a part of it.

You know, it's been a really interesting year. When we last talked, we were celebrating some wins in Washington. Of course, it was a big win just three years ago, when the president declared that printed circuit boards and IC substrates were a critical national security technology. That was a huge win.

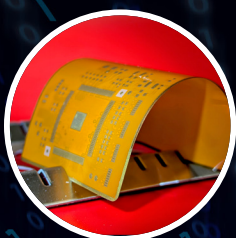
What followed was about \$118 million in funding through the Defense Production Act. That's the Pentagon giving out money, investing primarily in HDI and UHDI, and that money is at work right now



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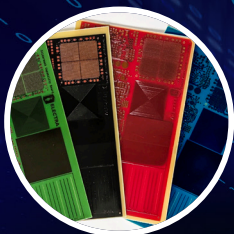
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Part of PCBAA's mission to educate, advocate and legislate mission in Washington, is to wring out real policy change and real funding. It's pushing the armed services committees, the appropriations committees, every year to tell the Pentagon, and fund the Pentagon to support our industry. That's one of our core objectives, and I think we've been pretty successful.

Unfortunately, coming into FY 2026, we saw that the microelectronics funding lines were zero. Now, part of that has to do with new philosophies, seats, and officials at the Pentagon—the Department of War, as we're now calling it. I think there are some reasons for optimism, even though that funding went away.

Is that something that would typically happen, that it would get zeroed out at the next budget?

You know, I was surprised, and I think all of us—our partners at GEA, everybody in the industry—were surprised that this was done, because the language from the authorizers says very specifically that the Secretary of Defense shall prioritize investments in printed circuit boards made in America. So, on one hand, you have Congress saying to the Pentagon, "Prioritize this." We also know that there is an

executive agent at the Pentagon. There is an Assistant Secretary of War for Industrial-based Policy, Mike Cadenazzi, who was just confirmed a couple of weeks ago. By staffing, by mandate from the Hill, the Pentagon is being told to prioritize American-made microelectronics, so it is surprising to see a zero in the funding line.

What I think may happen, where we have cautious optimism, is that there's money in other accounts, for example, the Industrial Base Analysis and Sustainment (IBAS). There's nearly \$2 billion there. That should be enough, not just for rare earths or rocket motors, but also for printed circuit boards made in America.

We will be working with Mr. Cadenazzi, Under Secretary Duffy, and the PCD executive agent based out of Indiana, to say, "Hey, we understand this particular line of the budget was zero. It's an unusual year, budget-wise. Where can we find other monies to make these investments? Because we all know that if you want to have a Golden Dome system, and triple your acquisition of high-end interceptors from companies like Raytheon, Northrop Grumman, Lockheed, Boeing, etc., you've got to have a microelectronics supply chain that is trusted, secure, and at capacity. We're being told America's OEMs are being told, "Triple your output." Well, that flows down into their suppliers, and if we're going to do that, and our aerospace and defense ecosystem is operating almost at capacity now, we're going to need some investment from the government."

Absolutely. I'll ask you later in this interview about demand signals, because that's obviously very important in the U.S. as opposed to a subsidized government, but it occurs to me, as today it was announced that the federal government is shut down, for now, that this is an incredibly difficult environment in which to advocate for anything just because of the craziness of the news cycle and where all the attention is going. How is PCBAA managing around this to continue to achieve its goals?

I think, like anybody in Washington, we are frustrated by the inability of legislators to come together and keep the government open. The shutdown is a loss, and I think anybody in our industry would say that. It makes it very difficult to access the right officials. Of course, programs are suspended, and I'm



hopeful that this will be a short shutdown and we'll get back to the business of governing.

On the optimism side, I would say that the issues that we're all concerned about—industrial policy, competition with China, restoring and reshoring American manufacturing capacity—are somewhat evergreen. We are in this golden age, "I want to see more things made in America. I want more of the electronics side to be trusted and secured, and domestically sourced. I want to compete on the global stage. I don't want all of our manufacturing capacity to go fallow." So, while this is a temporary problem, I think the attitude in Washington of, "Hey, we need to make more things. We need to build up on industrial capacity," is still there.

I agree. I guess that consistent thread is definitely helpful in continuing to carry the mantle. I would like to ask you about demand signal. We talk about the microelectronics supply chain. In addition to defense and security, what we've labeled national security-type items, we're really getting more into talking about critical infrastructure and that there's a lot more at stake than just what is very apparently defense-related.

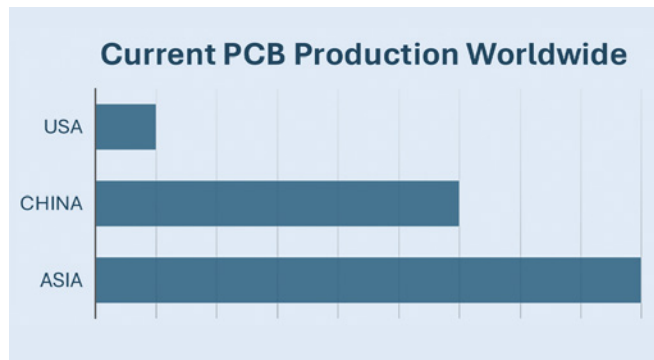
So, in that situation, how do you see—maybe a model or messaging in what you're starting to talk about—how the U.S. government will help to ensure that there is demand for these companies that are looking to make these huge investments, even if it is somewhat subsidized?

We saw with the CHIPS Act that the \$52 billion in government money was matched and exceeded largely by almost \$462 billion to date, in private money. We believe that when Uncle Sam backs an industry, Wall Street private equity takes that as a signal. How can we make a similar investment, a similar backing of the printed circuit board industry?

Well, there are a couple of things we can do. You talk about critical infrastructure. In the United States, most of the PCB work that remains is defense and aerospace-oriented. That's because ITAR restrictions mandate that the work be done domestically. I talk about ITAR like a tall fence around a small yard. It is marquee defense programs that we're all familiar with, but let's think more broadly about critical infrastructure. Do we want our water and power grid, banking servers, medical devices, and tele-

communications infrastructure populated with foreign microelectronics?

I asked that question on Capitol Hill and the answer, Marcy, is always, "No, I don't want that. I want that stuff made in America." Well, I've got bad news for you about where it's made today. The government absolutely can put up some guardrails. It can institute government purchasing rules, domestic sourcing requirements, and that would create a demand signal overnight.



If we said 5G telecommunications needed to be populated with American printed circuit boards, there would be a commercial demand signal overnight if we built out the next generation of air traffic control systems. With American-made printed circuit boards, there will be a need for huge commercial lines. So, there are actions the government can take.

We just need the executive branch and Congress to work together to come up with those rules. Of course, we need to work with the OEMs and the primes just to make sure the implementation schedule is realistic and that they can pivot out of their existing Asian supply chains.

I think many people want to diversify their manufacturing. They want to source all over the world, but right now, six out of 10 boards are from mainland China, nine out of 10 boards from Asia. The options simply aren't there. We need to make it work for your bottom line, and we need to create rules that slowly but surely, reshore production.

This is obviously a critical issue. You guys are doing amazing work. I know you're also working with the Global Electronics Association advocacy as well. What are the things that industry members should be doing, like talking to congressmen, signing letters, becoming PCBAA members? What are some



U.S. Congressman Blake Moore, primary sponsor of the STAR Act of 2025

calls to action that industry members should be aware of, and what should they be doing?

You're absolutely right. What we're going for helps many folks in the microelectronics space directly and indirectly. A rising tide will lift all boats. So, if you are in the test business, the critical minerals or refined materials business, the assembly business, the board business, the test business, any of these sectors—a robust and healthy American PCB industry is good for your bottom line.

You look at our membership from five to 75 members in four years, the reason for that and the diversity of our membership, the fact that we're putting a lot of dots on the map all over the country is because folks say, "Hey, if the American market is strong, my market is strong, if the American market is sustainable, my business in North America is sustainable."

Of course, we want people on our team, and joining is easy and beneficial. But we want them writing letters, coming to Washington, hosting members of Congress at their facility. As I'm here in Northern California this week visiting our members, I'm so impressed at the manufacturing operations, and the question I always ask is, "Has your mayor, the county commissioner, your senator, your governor walked through this facility and seen that we still do manufacturing in America? To see that you're supporting the F-35 program, the Columbia class

submarine, whatever it might be?" Too often, the answer is no. Part of my mandate and mission is to get those elected officials out to do those plant tours, and then they become our advocates at the State House and in Washington.

PCBAA will help facilitate that?

Absolutely. If you are scared about Washington, or intimidated about having a member of Congress walk through your facility, we will hold your hand and make that a beneficial visit for you.

Okay. I want to end on what I consider a positive note. Before you and I started chatting formally, we were chatting informally, and I want you to restate some of what you said to me. I know there's a tremendous amount of frustration, certainly from outside perception about the lack of Washington, and almost every sector, to be able to get anything done. Yet there is a reality of the people working on the Hill, and some of the people that you interface with regularly. So, can you just recount what you were saying?

Sure. If you're running a business, shipping product, or providing critical electronics solutions, and turn on the news, open the paper, or go online, your impression of Washington, of course, is negative because you see people with extreme positions screaming into the microphone. I want to reinforce that that's not who we are working with. There is a moderate, reasonable group of people on both sides of the aisle who want to see American manufacturing restored, want America competing on the global stage, and want us trusting our electronics.

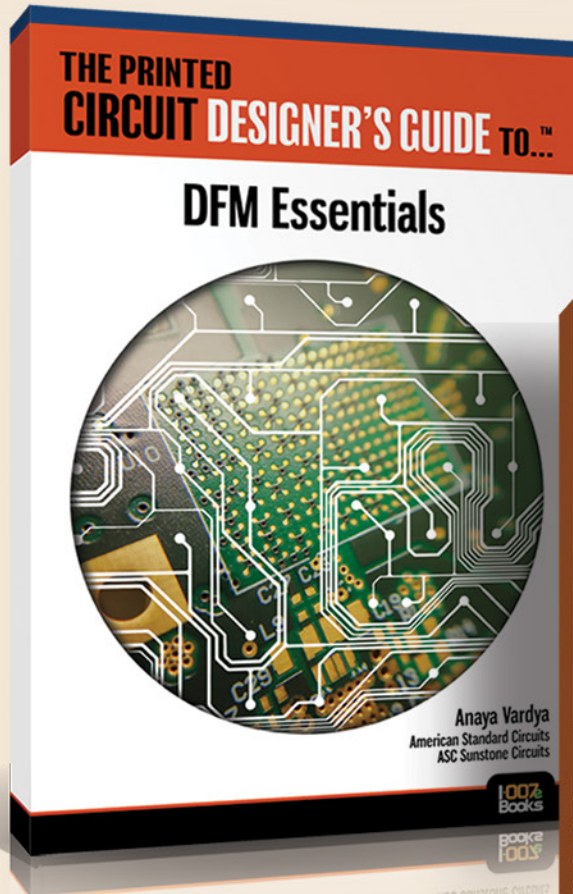
Those people, Republicans and Democrats, are working with PCBAA, Global Electronics Association, and anybody at the table to affect real change. That's how the CHIPS Act got done. It's how our bill, HR 3597, is going to move forward. It's how the Pentagon is going to invest.

I would just ask you to remain optimistic. Keep your head down, keep building great products, and we'll keep advocating for you in Washington.

That's a great place to end. David, always good to talk to you. David Schild of PCBAA here at PCB West in Santa Clara, California. Thank you for the work that you're doing and continuing to do. PCB007

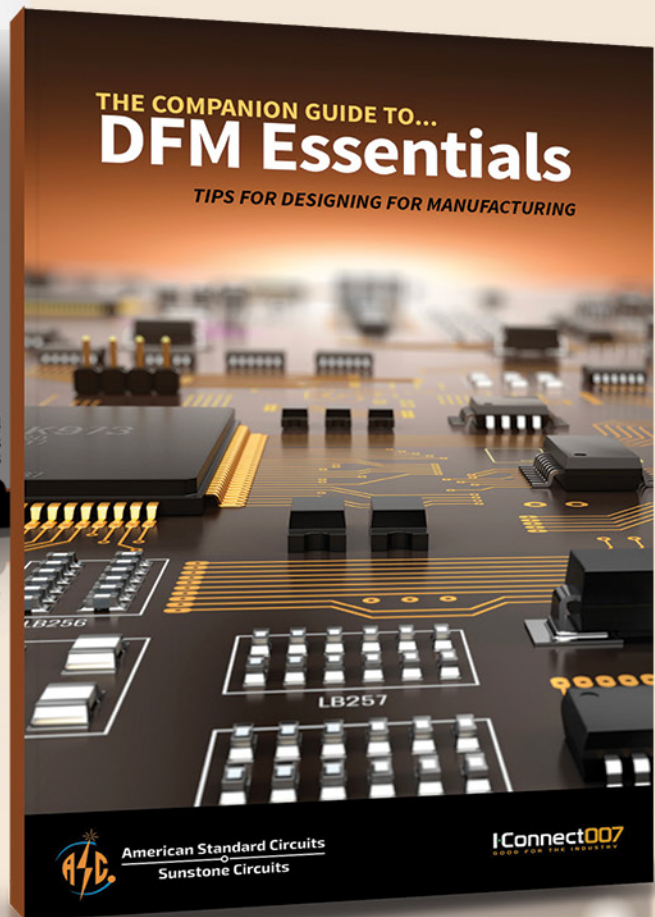
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An EU at the Crossroads



The European Union stands at a crossroads. Over the past several years, geopolitical shifts have been increasingly shaping regional approaches to industrial policy and supply chain resiliency. The European Union is no different in this respect; its policies continue to be shaped by geopolitical and geo-economic developments.

It can be no surprise that the EU-U.S. Trade Agreement has provided one more shock to the world order. In a recent report¹, the Global Electronics Association highlights that while the trade agreement restores a level of predictability between the two regions, providing a 15% baseline tariff for most European imports into the U.S., the new agreement does represent a paradigm shift in the world trading system.

As the new U.S. trade policy applies different rates to different countries (e.g., Vietnam, 20%, UK, 10%), this introduces an uneven playing field to the U.S. market. For global companies, this could lead to a review of their industrial strategy of where to produce what for the U.S. market.

Another important development in the EU is defence. While in the past, the larger part of EU Member States' procurement has gone to non-EU suppliers, the invasion of Ukraine has led to initiatives that prioritise European defence production and supply. NATO has announced an increase in defence spending to 5% of GDP, and the EU has also announced budget mechanisms to grow defence spending. As we highlighted in our report to EU leaders, electronics are an essential enabler for most defence equipment and for the capability gaps the EU is seeking to fill. These developments offer a growing market for the wider electronics industry.

Another recent Association report² highlights the urgent need to strengthen Europe's industrial base for critical electronics, including PCBs, as the region pursues greater defence autonomy. The report brings together key findings from several studies on vulnerabilities in the European supply chain.

There is a third major development. In the first half of 2026, [the European Commission is scheduled to revise the European Chips Act](#). A public



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consultation has been launched to seek industry input. The review process is heightened by the global race to secure high-end and AI chips. In Europe, we are calling for a “Chips Act Plus” that would address the needs of the broader electronics ecosystem. This is a continuing effort directed toward EU leaders to highlight the need for a system-based approach to strategic industries essential to Europe’s security, digital, and green transition, and critical infrastructure, and moreover, to reinforce the industrial base from chip to printed circuit board, from printed circuit board to final system assembly³.



The electronics industry is weathering quickly changing geopolitical and geoeconomic developments. This requires a resilient posture and an agile response. It offers challenges but also opportunities for our industries. **PCB007**

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1. “The New Transatlantic Trade Agreement,” Global Electronics Association.
2. “Securing the Electronics Value Chain: The Blind Spot in the European Union’s Defence Agenda?” Global Electronics Association.
3. “Securing the European Union’s Electronics Ecosystem,” Global Electronics Association.

Alison James is senior director of government relations for Global Electronics Association Europe.

1-007e

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The background of the entire advertisement is a high-contrast, artistic image of the Earth as seen from space. The curvature of the planet is visible, with a bright blue and white horizon line on the left side, suggesting a sunrise or sunset. The landmasses are shown in dark, muted colors, while the oceans are a deep, dark blue. Overlaid on this image is a complex network of thin, light blue lines that connect various points across the globe, resembling a global communication or data network. These lines are more densely packed in some areas and more sparse in others, creating a sense of interconnectedness and global reach.

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Mechanical and Optical Processes During Rigid-flex Production

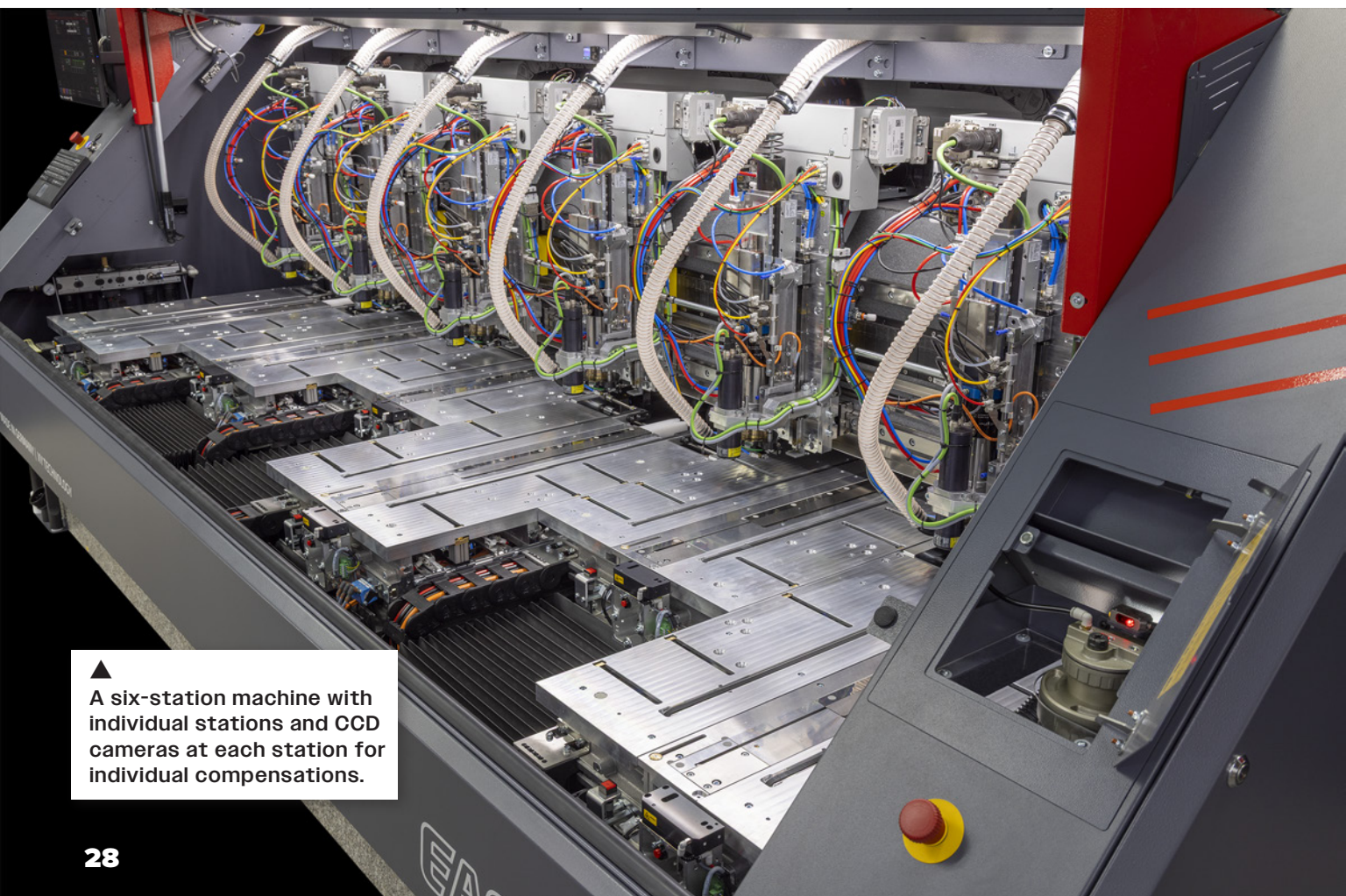
by Kurt Palmer, Schmoll America

Rigid-flex printed circuit boards are a highly effective solution for placing complex circuitry in tight, three-dimensional spaces. They are now indispensable across a range of industries, from medical devices and aerospace to advanced consumer electronics, helping designers make the most efficient use of available space. However, their unique construction—combining rigid and flexible materials—presents a fundamental challenge for PCB manufacturers. The mix of materials creates a host of complications for mechanical and optical pro-

cesses, requiring a unique blend of expertise and specialized machinery. This article explores how these material combinations influence critical manufacturing processes and the specific technologies that are helping process engineers successfully produce these advanced boards.

Alignment

The most critical topic in rigid-flex production is alignment. Getting the registration right is a two-step challenge that begins before lamination.



▲ A six-station machine with individual stations and CCD cameras at each station for individual compensations.

You should be in this picture.



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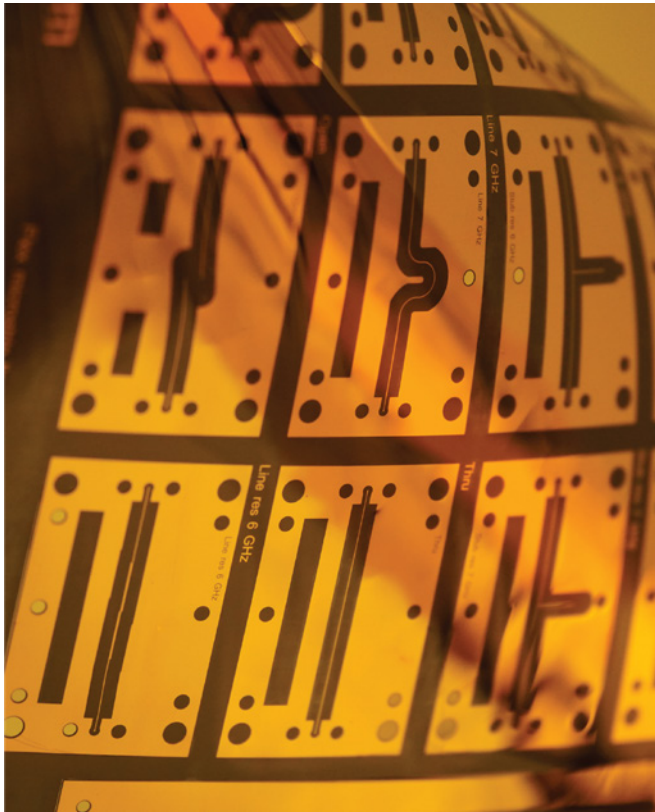
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▲ A flex board exposed by Schmolli MDI-Flex.

Alignment is especially complex because of the flexible portion of the board, which can bend and move easily. Alignment systems, such as post-etch punch machines, must be designed to work with these delicate materials.

It's also crucial to remember that flexible and rigid materials behave differently under thermal stress—

stretching and shrinking at different rates during lamination and prior processes. The first step in managing this is to gather statistical data about these deformations using X-ray systems. Production can then perform one of two compensation types, or preferably both for complex boards:

- **Compensate during direct imaging:** Each inner layer can be compensated individually during the direct imaging step by making adjustments for material type, copper density, layer position, and other factors.
- **Compensate during drilling:** Compensation can also be applied during the drilling operation, which is especially easy if the drilling machine is equipped with CCDs and individual tables.

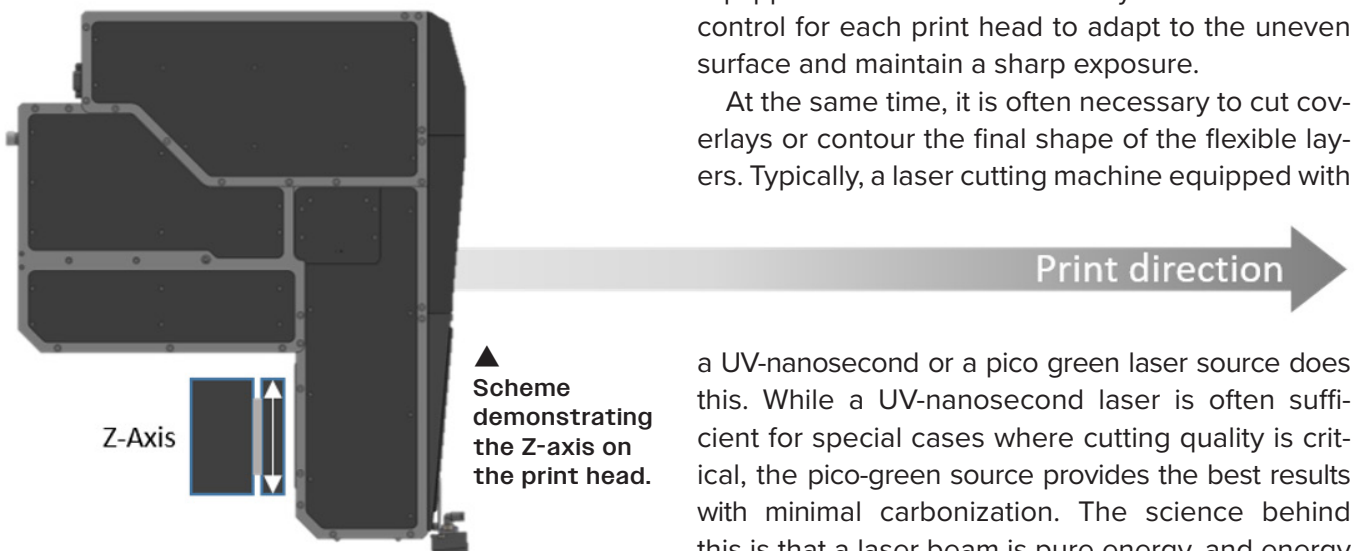
This standard approach, also vital for HDI boards, is sometimes more critical in rigid-flex production because of the very different behaviors of the rigid and flex layers.

Optical Operations

Engineers must carefully adapt optical processes, including direct imaging and laser cutting, for rigid-flex materials. For direct imaging, machines need to handle thin flex layers without causing damage. While manual loading is an option, automated machines require highly adaptable, adjustable grippers that can handle such delicate materials without stress.

After lamination, these mixed-material boards are never perfectly flat, so the machine must be equipped with an auto-focus system and Z-axis control for each print head to adapt to the uneven surface and maintain a sharp exposure.

At the same time, it is often necessary to cut overlays or contour the final shape of the flexible layers. Typically, a laser cutting machine equipped with

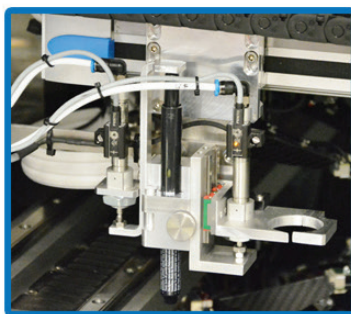


a UV-nanosecond or a pico green laser source does this. While a UV-nanosecond laser is often sufficient for special cases where cutting quality is critical, the pico-green source provides the best results with minimal carbonization. The science behind this is that a laser beam is pure energy, and energy

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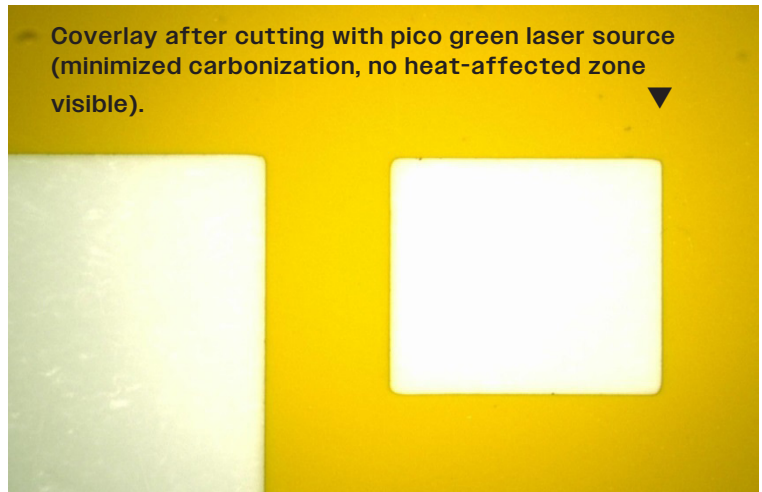
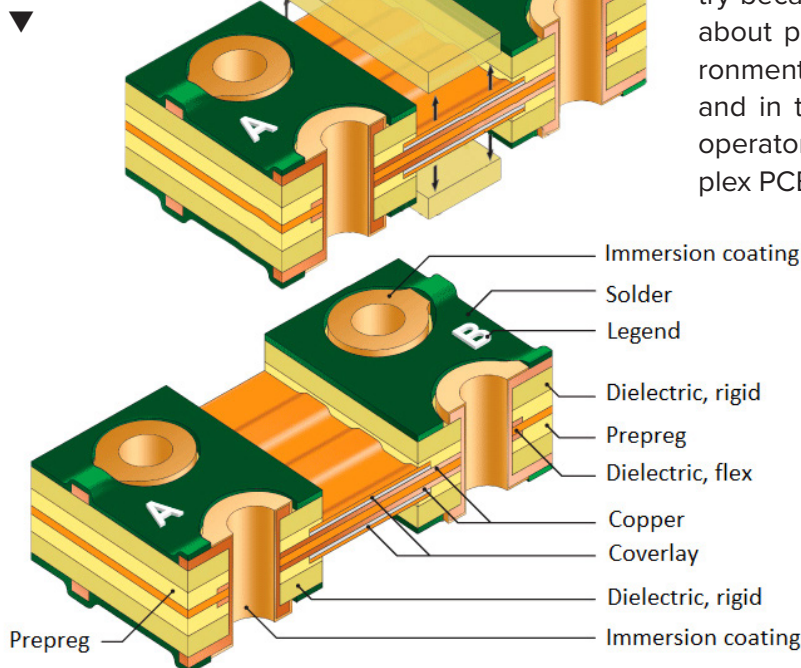
has two ways to dissipate: heat or ablation. The shorter the pulse, the more energy goes directly into ablation and the less into heat. Using a pico-green laser source, we see significantly less carbonization and a cleaner, more precise cut.

Mechanical Operations

Every material has a different recommended cutting speed, and this is a significant challenge when drilling a mixed-material PCB. The process engineer's goal is to find the "perfect recipe" by slightly varying the settings and performing micro-sections to identify the limits of the tools and set a proper hit count. Working with mixed materials, the need for different cutting speeds forces a compromise, making the process engineer's job even more critical. In such cases, simply following the material and tool manufacturers' recommendations may not be enough; dedicated time must be spent finding the ideal drilling parameters for that specific combination.

Depth routing for rigid-flex is a critical mechanical process. After lamination, the board is entirely rigid,

Demonstration of the last process steps during rigid-flex PCB production, involving depth routing.



but at the final stages, a precise depth-routing operation removes the unnecessary rigid parts to free the flex layer—a process often called “cup elimination.” If this depth routing is even slightly overdone, the flexible part would be damaged, and the entire PCB scrapped. To prevent this, it is critical to control the depth routing with a second measuring system (like a pressure foot). Process engineers must adjust the depth and choose the proper inserts for the pressure foot, making this a highly technical and precise operation.

Summary

I often tell people at PCB shows that I love this industry because it's not simply about the machines. It's about people, processes, materials, and the environment. Many factors influence the final result, and in the end, machines are simply tools in the operator's hands. Some people can produce complex PCBs with simple tools, but to achieve a stable and repeatable serial production, one needs good tools. At the same time, when working with specialized PCBs like rigid-flex, the influence and expertise of the process engineer is even more critical. **PCB007**



Kurt Palmer is president of Schmoll America. To read past columns, [click here](#).

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Caught in the ESG Crossfire: Transparency, Comparability, and Impact



In the evolving landscape of corporate responsibility, Environmental, Social, and Governance (ESG) reporting has become a cornerstone of stakeholder communication. Yet, as organizations strive to meet growing regulatory and investor demands, they find themselves caught between the need for robust ESG disclosure, the persistent lack of comparability across reports, and the elusive goal of translating ESG efforts into tangible business value.

The Reporting Imperative

Driven by frameworks like the EU's Corporate Sustainability Reporting Directive (CSRD), the U.S. SEC's climate disclosure rules (though currently not being enforced in the U.S.), and global standards by the International Sustainability Standards Board (ISSB) and the Global Reporting Initiative (GRI), ESG reporting is no longer optional. Companies must disclose not only their environmental footprint but also their social impact and governance

practices. This shift serves to foster transparency, accountability, and long-term thinking.

However, the proliferation of standards and metrics creates a fragmented reporting environment. While convergence efforts are underway, many organizations still must navigate overlapping frameworks, varying stakeholder expectations, and inconsistent definitions. Looking at the classification of Substances of Very High Concern (SVHC) from a Registration, Evaluation, Authorisation,

and Restriction of Chemicals (REACH) point-of-view and a European Sustainability Reporting Standards (ESRS) point of view demonstrates these difficulties.

- REACH is a comprehensive EU regulation that went into effect on June 1, 2007, and applies to all chemical substances, whether used in industrial processes or in everyday products such as paints, cleaning agents, clothing, furniture, and electronics.
- ESRS is mandatory reporting guideline developed under the CSRD, which aims to standardize how companies disclose their ESG impacts and risks across the EU.

Unlike REACH, which focuses on regulatory compliance, ESRS emphasizes sustainability impact and stakeholder relevance. This means companies may need to report on SVHCs even if they remain below the REACH thresholds, provided they are material. SVHCs represent a subgroup of Substances of Concern (SoC) with the most serious negative effects on the environment, health, and wildlife, as identified in Article 59(1) of Regulation (EC) 1907/2006 (REACH). Consequently, the definitions of SVHC and SoC are based on REACH, which also holds true for ESRS.

Before reporting under ESRS, AT&S followed the Global Harmonization System (GHS) and reported the GHS hazard classes (health-related, environmental, and physical) by applying these nine categories:

1. Explosive
2. Oxidizing
3. Highly flammable
4. Harmful to health
5. Toxic
6. Corrosive
7. Irritant
8. Dangerous to the environment
9. Other hazardous properties

The ESRS requirement primarily refers to health-related and environmental hazard classifications. Physical hazards remain relevant (e.g., for occupational health and safety and safety datasheets), but are not explicitly required under ESRS.

With ESRS, the hazard categories for SVHS and SoC are classified in Annex VI, Part 3 of Regulation (EC) 1272/2008 of the European Parliament and of the Council:

- Carcinogenicity, categories 1 and 2
- Germ cell mutagenicity, categories 1 and 2
- Reproductive toxicity, categories 1 and 2
- Endocrine disruption with effects on human health
- Endocrine disruption with effects on the environment
- Persistent, mobile, and toxic properties or very persistent, very mobile properties
- Persistent, bioaccumulative and toxic properties or very persistent and very bioaccumulative properties
- Respiratory sensitization, category 1
- Skin sensitization, category 1
- Chronic aquatic toxicity, categories 1 to 4
- Hazardous to the ozone layer
- Specific target organ toxicity (repeated exposure), categories 1 and 2
- Specific target organ toxicity (single exposure), categories 1 and 2

The conclusion is that even if the definition of a technical term is the same in reporting language, one cannot assume its classification remains the same across reporting systems.



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Green Technology: Enabling Productivity and Sustainability for IC Substrate Manufacturing

Green technologies often face challenges in striking a balance between environmental benefits and manufacturing efficiency and cost. However, some innovations can enhance productivity while reducing carbon footprints. This article examines the benefits of Acousto-Optical Device (AOD)-based CO₂ laser drilling systems for IC substrates, emphasizing their potential to reduce power consumption, lower CO₂ emissions, and enhance overall manufacturing efficiency.

Various factors, including regulatory requirements, corporate image, and the pursuit of sustainable energy solutions, drive the push for greener manufacturing processes. Despite the initial higher costs and potential productivity losses, adopting green technologies can lead to long-term benefits.

The Need for Reduced Power Consumption: In the PCB and IC substrate industries, high power consumption is a significant concern. Laser via drilling systems, essential for high-volume manufacturing, consume substantial electricity. Reducing power consumption not only lowers CO₂ emissions but also cuts costs, making it a critical focus for manufacturers.

AOD Technology and Productivity: AOD technology enhances laser drilling systems by adding a third degree of deflection, enabling faster and more accurate beam positioning. This non-moving, RF-actuated crystal modifies the laser beam's position, amplitude, and pulse duration, leading to higher productivity and lower power consumption.

Geode PCB Laser Drill: The Geode PCB Laser Drill is the only AOD-based laser drilling system in the industry. Its innovative design utilizes AOD technology to achieve exceptional power efficiency and cost-effectiveness. By incorporating AOD technology, the Geode system significantly lowers power consumption and operational costs, making it a prime choice for manufacturers looking to enhance sustainability and productivity.

A comparative study of the Geode™ AOD-based laser drilling system and conventional laser drilling systems showed a 3.5x improvement in throughput and a 65% reduction in power consumption for the AOD-based system. This increase in throughput results in fewer systems needed to meet the same demand, further decreasing overall power consumption and CO₂ emissions.

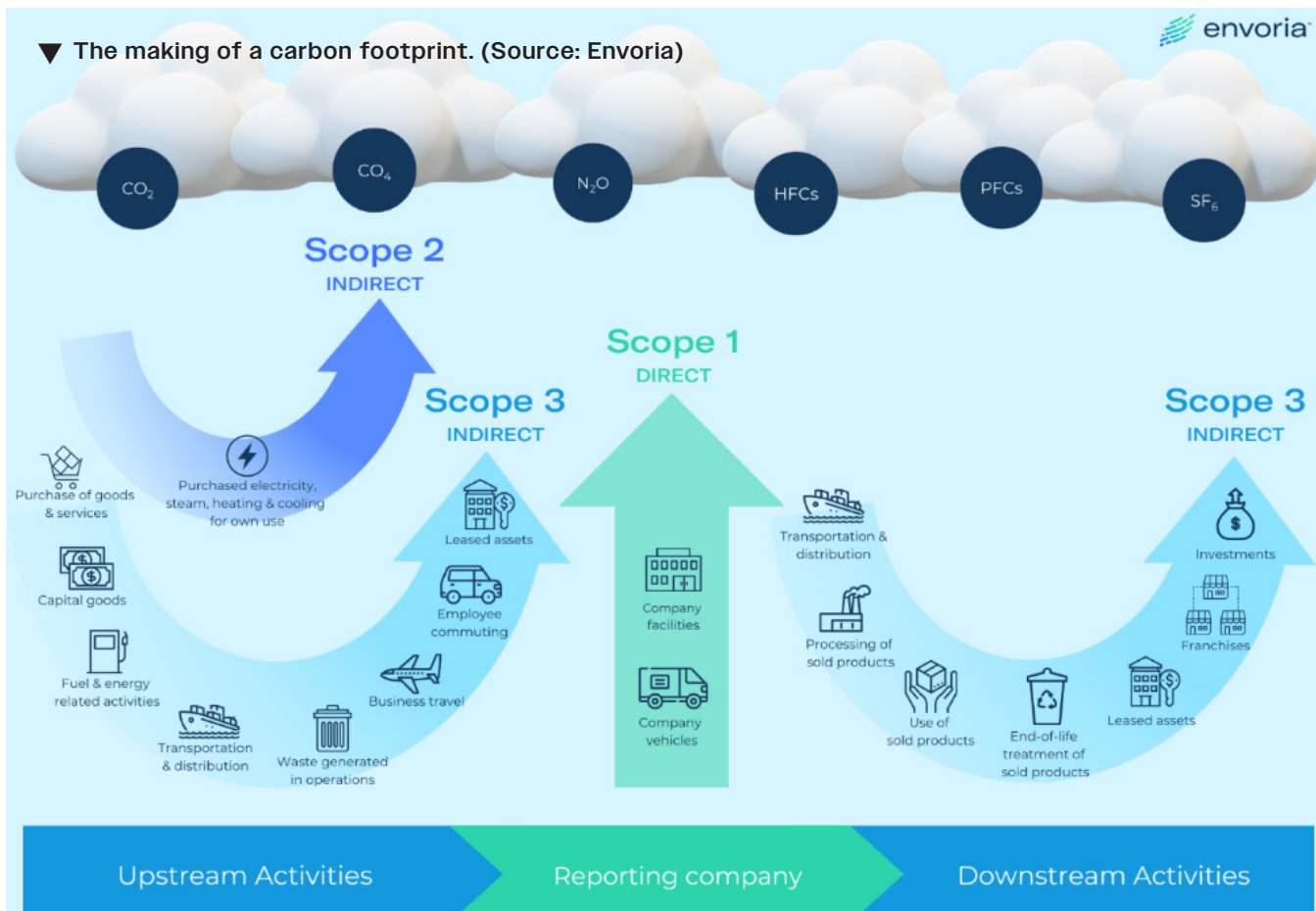
AOD-based CO₂ laser via drilling systems, such as the Geode PCB Laser Drill, offer a compelling solution for manufacturers seeking to enhance sustainability without sacrificing productivity. By reducing power consumption and operational costs, these systems support a greener manufacturing process, particularly in regions heavily reliant on fossil fuels.

Key Benefits of AOD-Based Systems:

- 1. Higher Productivity:** AOD technology allows for efficient beam positioning and raster-pattern via formation, enabling single-pass drilling of various via diameters.
- 2. Lower Power Consumption:** The reduced power consumption translates to lower operational costs, resulting in potentially significant savings over any given period.
- 3. Cost Reduction:** The reduced power consumption translates to lower operational costs, resulting in potentially significant savings over any given period.



Chris Ryder
*Senior Director of Business Development,
MKS Inc.*



The Comparability Conundrum

A pressing issue in ESG reporting is the lack of comparability. Two companies in the same industry may report on carbon emissions using different scopes, boundaries, or methodologies, making apple-to-apple comparisons nearly impossible. This undermines the very purpose of ESG disclosures: to enable informed decision-making by investors, regulators, and the public.

Taking the example of scope 3 emissions for category 1 as defined by the THG Protocol, scope 3 category 1 emissions, which cover purchased goods and services, are often the largest source of indirect emissions for companies, especially in sectors like electronics, manufacturing, retail, and consumer goods. These include all upstream (cradle-to-gate) greenhouse gas emissions from the production of goods and services that a company purchases during a reporting year. This includes raw materials, components, packaging, office supplies, and services such as IT support, consulting, and logistics. For electronics companies, this often includes emissions from semiconductor manufacturing, metal

extraction, and component assembly, which can account for 70% or more of their total emissions.

The GHG protocol outlines four principal methods, each with different levels of specificity and data requirements:

- 1. Supplier-specific method:** Uses emissions data from suppliers. It is the most accurate but requires strong supplier collaboration.
- 2. Hybrid method:** Combines supplier-specific data with secondary (industry average) data.
- 3. Average-data method:** Uses average emissions per unit of product or service.
- 4. Spend-based method:** Multiplies the monetary value of purchases by average emissions factors, which is useful for initial estimates or when detailed data is unavailable.

Depending on the method chosen, data output sets will be different.

The Global Electronics Association, in collaboration with the Responsible Business Alliance (RBA) and supported by Anthesis, has developed a guidance document to help the electronics manufactur-

ing sector account for scope 3 category 1 emissions. It is intended for companies across all tiers of the value chain and aims to foster consistency and alignment in category 1 emissions reporting. By addressing both general and industry-specific requirements, it serves as a practical tool to enable meaningful decarbonization through improved data quality and stronger engagement across the value chain.

Common databases, standardized metrics, comparable data sets, and a common language must exist to facilitate objective interpretations and clear comparisons between various reports.

Making ESG Make Business Sense

Beyond compliance and reputation, the true test of ESG lies in its integration into core business strategy, yet many organizations struggle to connect ESG initiatives with financial performance, operational efficiency, or innovation. This disconnect can lead to ESG fatigue, where efforts are seen as cost centers rather than value drivers. To overcome this, companies must shift from a reporting mindset to a strategic one. This means:

- 1. Embedding ESG into decision-making:** ESG factors should inform capital allocation, supply chain management, and product development, not just sustainability reports.
- 2. Quantifying impact:** Use data analytics to measure how ESG actions affect risk, revenue, and resilience.
- 3. Engaging stakeholders:** Collaborate with investors, employees, and communities to align ESG goals with shared value creation.

The Path Forward

The future of ESG lies in harmonization, digitization, and integration. Emerging technologies like AI

The future of ESG lies in harmonization, digitization, and integration.

and blockchain can enhance data quality and traceability. Unified standards will improve comparability. Most importantly, a focus on materiality—what truly matters to the business and its stakeholders—will ensure that ESG is not just a reporting exercise,

but a lever for sustainable growth. This will require an open and rigorous analysis of relevant materiality topics, which is sometimes subjective.

In recently published non-financial statements, there is a wide range of data points, the result of a list of materiality topics. If a company defines a long list of materiality topics, it must also report more data points, so there will always be a discrepancy with reports based on ESRS requirements. A review of the first 100 published CSRD reports performed by PricewaterhouseCoopers (PwC)¹ reveals that many companies are still navigating the complexities of the new reporting framework. Report lengths range from 30 to over 300 pages. While some companies disclose fewer than 15 sustainability-related impacts, risks, and opportunities (IROs), others report more than 80, highlighting the diverse approaches to materiality and disclosure.

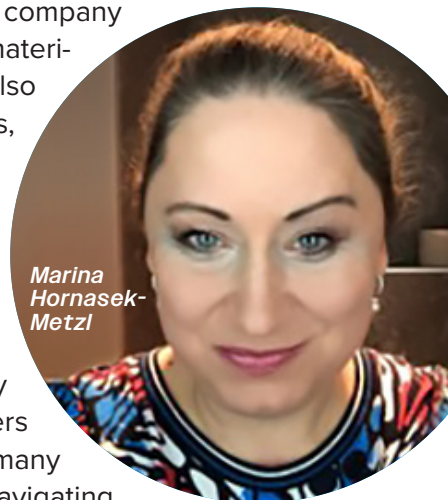
The EU Omnibus Package is a legislative initiative introduced by the European Commission in February 2025 to simplify and streamline sustainability-related regulations, including the CSRD and the ESRS. It aims to reduce mandatory data points by prioritizing quantitative over narrative disclosures as well as simplifying the double materiality assessment. The overall result will minimize complexity and provide greater clarity. The Stop-the-Clock Directive (EU 2025/794) has postponed this process for two years, ensuring at least one more difficult reporting season.

As we navigate this complex terrain, the question is no longer whether to report on ESG but how to report in a way that is credible, comparable, and commercially meaningful. **PCB007**

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Marina Hornasek-Metzl is VP Corporate ESG and Quality at AT&S AG.



The Impact of ENEPIG Specification IPC-4556A: Tighter Controls for ENEPIG Reliability



The demand for higher reliability, performance, and functionality in electronic devices has never been greater, especially in critical markets such as automotive, military and aerospace, and high-performance computing (HPC), where failure is not an option. To meet these rising demands, the 4-14F IPC Standards Committee has released a new revision of the IPC-4556 specification for electroless nickel/electroless palladium/immersion gold (ENEPIG) finishes.

ENEPIG remains a trusted surface finish for its wire bond compatibility, corrosion resistance, and durability through multiple assemblies, but under IPC-4556A, fabricators now face much tighter process

controls. These added requirements present both a challenge and an opportunity: the need to balance stricter compliance with the ability to deliver highly reliable, next-generation electronics.

Published in June 2025, revision A was developed in alignment with changes to the ENIG standard (IPC-4552B) to raise the quality bar for deposit uniformity, corrosion resistance, and measurement capability. For PCB fabricators, this poses a challenge in achieving and consistently delivering the required level of quality. This article will discuss the key changes to IPC-4556, helping fabricators understand and embrace the challenges posed by the new specification, enabling them to deliver higher-quality ENEPIG deposits.

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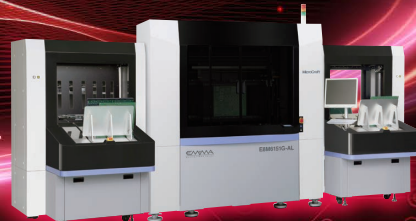


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Adoption of ENEPIG and Development of IPC-4556 for Improved Corrosion Performance

Surface finishes are protective coatings applied to PCBs, providing a solderable surface that withstands shipping, storage, and multiple reflow assembly operations. Numerous options are available for the final finishing of PCBs, including organic solderability preservatives (OSP), immersion tin, immersion silver, electroless nickel/immersion gold (ENIG), and electroless nickel/electroless palladium/immersion gold (ENEPIG). Selection is based on the lowest cost option that meets the end users' application criteria. Fabricators must consider the PCB's application, assembly complexity, frequency requirements, and environmental goals.

ENIG and ENEPIG surface finishes are renowned for their high corrosion resistance, long shelf life, and durability through multiple reflow assemblies, making them ideal for mission-critical applications that demand long-term reliability. Despite the increased costs associated with ENEPIG, the system has gained in popularity over the past decade. This is due to both an increasing need for wire bond capability (for example, in LED¹ manufacturing) as well as the perception that adding the electroless palladium layer will eliminate the corrosion defects typically associated with ENIG.

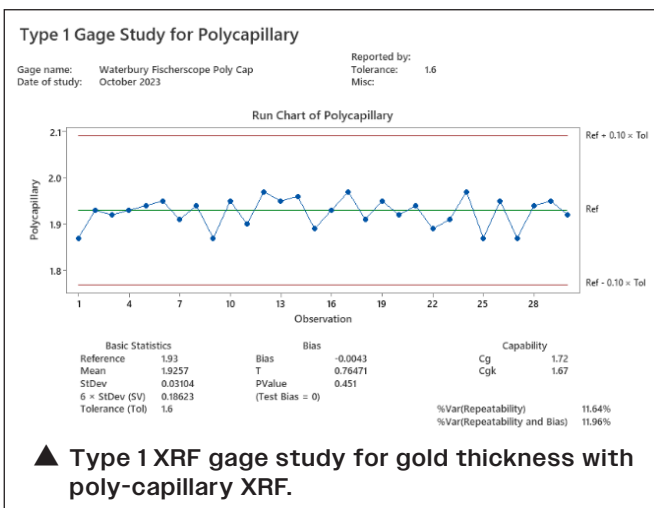
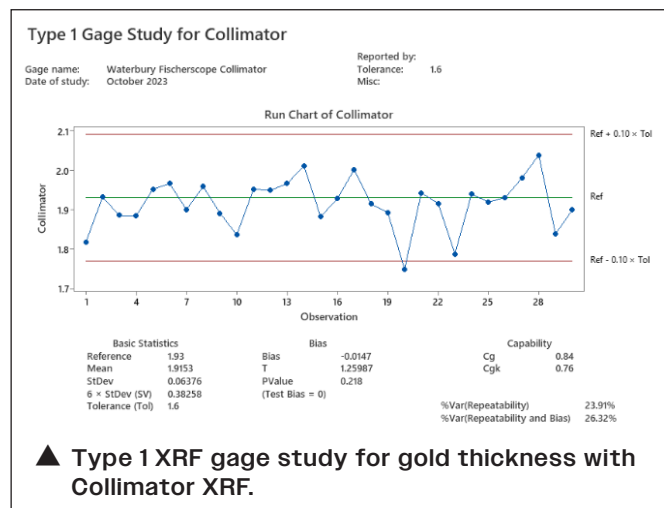
ENEPIG first gained traction in the mid-to-late 1990s as a solution to hyper-corrosion issues, such as black pad defects, commonly seen with ENIG. However, adding a palladium layer introduced new challenges, sometimes leading to more localized

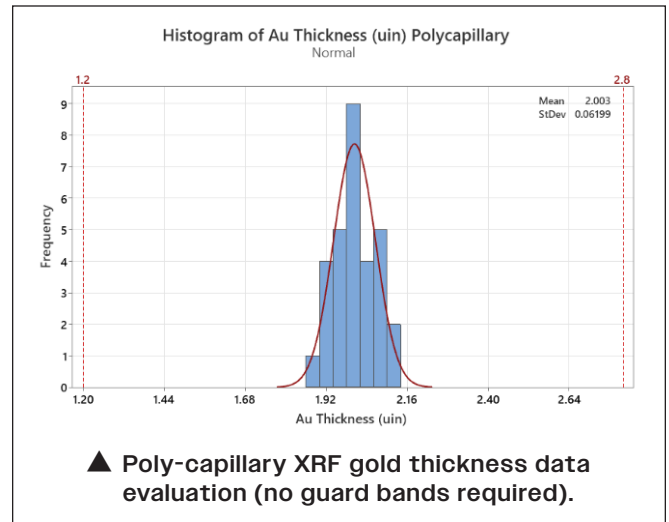
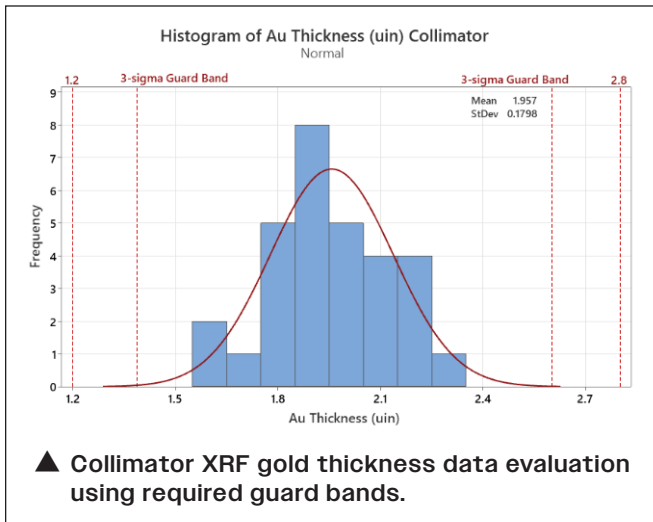
and aggressive corrosion events. The first edition of IPC-4556, released in January 2013, only specified a minimum gold thickness of 1.2 μm .

Many fabricators assumed that depositing thicker gold would improve wire bond performance. However, while longer immersion times drove higher gold thickness, this increased localized corrosion. To address this, Amendment 1 (March 2016) introduced a maximum gold thickness limit of 2.8 μm . With corrosion remaining a critical industry concern, chemical suppliers responded by developing alternative gold deposition technologies aimed at reducing these risks.

These reduction-assisted or hybrid gold systems utilize a chemical reducing agent to supply a portion of the electrons needed to facilitate gold deposition, thereby minimizing the amount of gold deposited by galvanic displacement and, as a result, the amount of nickel dissolution (or corrosion) required. Reduction-assisted gold systems were initially targeted for ENIG, but the development of traditional galvanic displacement immersion gold was sufficient to easily exceed the IPC-4552A and then B corrosion requirements. It is ENEPIG where real corrosion improvements are observed when using hybrid gold technology.

These developments, and a deeper understanding of what constitutes a reliable ENEPIG deposit, led to the 4556A update. IPC-4556A requires PCB manufacturers to show they can accurately measure and control the thickness of electroless nickel, palladium, and gold layers, as well as the phosphorus content in the nickel layer, and meet this new corrosion standard. IPC-4556A covers traditional ENEPIG





using immersion gold technology, as well as newer gold plating technologies such as reduction assisted gold. As a result, the fabricator must do more work to ensure an IPC 4556A-compliant ENEPIG deposit.

IPC-4556A: Tighter Control on ENEPIG Gold Thickness

IPC-4556A retains the same thickness specifications as previous versions for all three deposit layers:

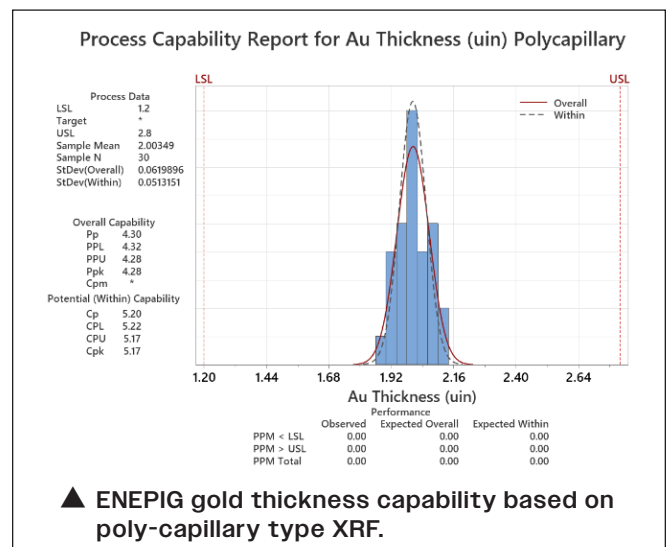
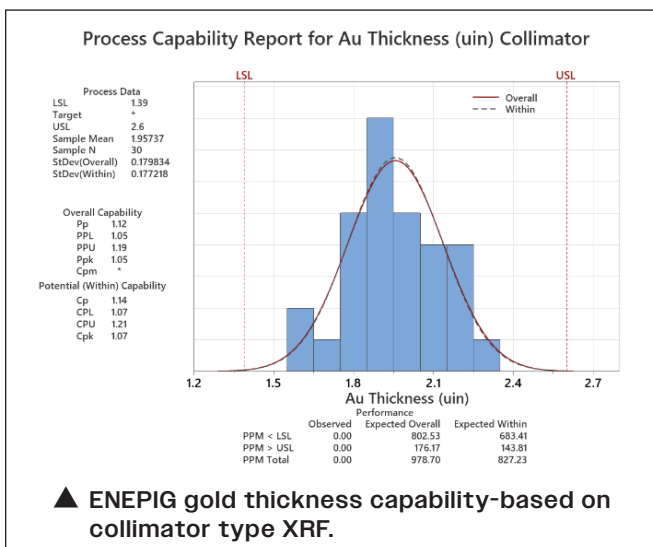
- **Electroless nickel:** 3 to 6 $\mu\text{m} \pm 3$ standard deviations from mean
- **Electroless palladium:** 0.05 to 0.3 $\mu\text{m} \pm 3$ standard deviations from mean
- **Gold:** 0.03 μm min ± 3 standard deviations from mean, 0.070 mm max

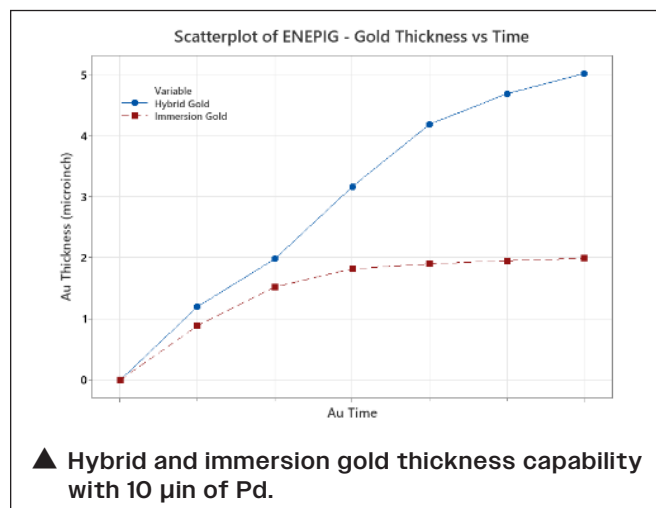
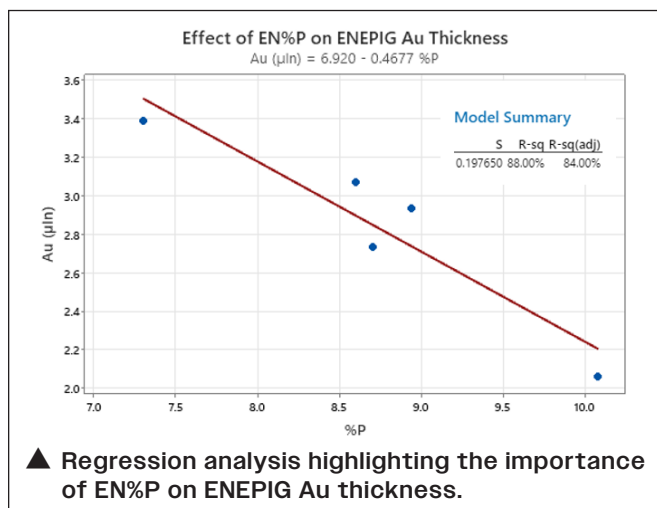
Nickel and palladium tolerances are easy to achieve. Gold, however, presents the greatest chal-

lenge, with the tightest specification range and more contributing variables than ENIG. The minimum gold thickness was based on round robin testing (IPC-4556, 2013) to ensure soldering and wire bonding performance. The maximum limit, defined in Amendment 1 (2016), prevents higher gold thickness deposition and corrosion risks using galvanic displacement/immersion gold systems.

Maintaining ENEPIG gold thickness involves more contributing variables than ENIG, meaning more statistical process control (SPC) requirements are needed to maintain the tighter 4556 ENEPIG thickness tolerance. IPC-4556A's gold range for ENEPIG is just 1.6 μm , compared to 2.36 μm for ENIG in IPC-4552B. Maintaining this tighter range requires robust SPC and careful management of measurement system error (MSE).

Following IPC-4552B, repeatability of XRF mea-





surement systems are evaluated using a type 1 gage study. Low-capability systems ($Cg \leq 1.33$) must either increase measurement counts, which is often impractical for production, or apply guard bands that further narrow the tolerance window. In practice, non-conforming XRF systems can reduce allowable gold tolerance by up to 20%, increasing non-conformances and forcing tighter process control.

For fabricators, especially those with older XRF equipment, the combination of a tighter specification, increased SPC demand, and production cadence makes ENEPIG compliance under IPC-4556A a significant manufacturing challenge.

Deposit Thickness Measurement Capability in IPC-4556A

IPC-4556A maintains the requirement for a type 1 gage study to confirm XRF measurement repeatability when monitoring ENEPIG deposit thickness. Repeatability ($Cg/Cgk \geq 1.33$) ensures the same reading can be consistently obtained on the same part under identical conditions, leaving more of the specification window available for true process variation.

As mentioned previously, older collimator-based XRF systems often fall short of this threshold, requiring guard bands that further tighten the tolerance window. Newer technologies, such as poly-capillary optic XRF, significantly improve repeatability, reducing the need for guard bands and allowing full use of IPC 4556A's gold thickness range.

In a comparative study, both systems measured a 1.93 µin ENEPIG gold standard over 30 identical

readings. The collimator XRF produced Cg/Cgk values of 0.84/0.76, triggering guard bands and cutting the usable tolerance to 76% of the standard. The poly-capillary system achieved 1.72/1.67, requiring no guard bands.

Process capability analysis of production samples showed both systems met IPC-4556A thickness limits, but the lower capability XRF reduced Cpk from 5.17 to 1.07. The results underline the importance of high-repeatability XRF systems to avoid unnecessary guard band penalties and maintain stable ENEPIG gold thickness control.

Electroless Nickel Phosphorous Content in ENEPIG

The phosphorous content of electroless nickel (EN) directly affects corrosion resistance and, in turn, gold deposition. In ENEPIG, as in ENIG, immersion gold relies on a galvanic displacement reaction, making gold thickness sensitive to variations in the EN percentage of phosphorus. Fluctuations in the (phosphorous) content can cause gold thickness variation, challenging compliance with IPC-4556A's tight tolerances.

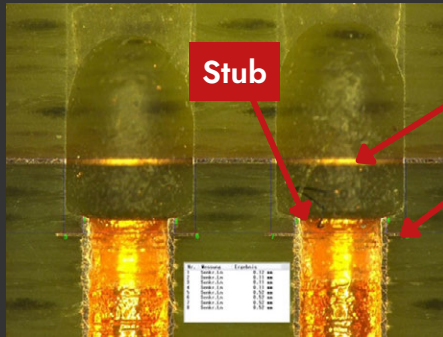
Using an EN chemistry with minimal percentage phosphorus variation helps maintain consistent gold thickness. Hybrid or reduction-assisted gold systems can lessen, but not eliminate, the impact of EN percentage of phosphorus variation, as gold initiation still depends on galvanic displacement.

Electroless Palladium Challenges

While adding a palladium layer between EN and

EAGLE EXY

HIGH-END EQUIPMENT FOR **BACKDRILLING**
AND **DEPTH DRILLING** APPLICATIONS

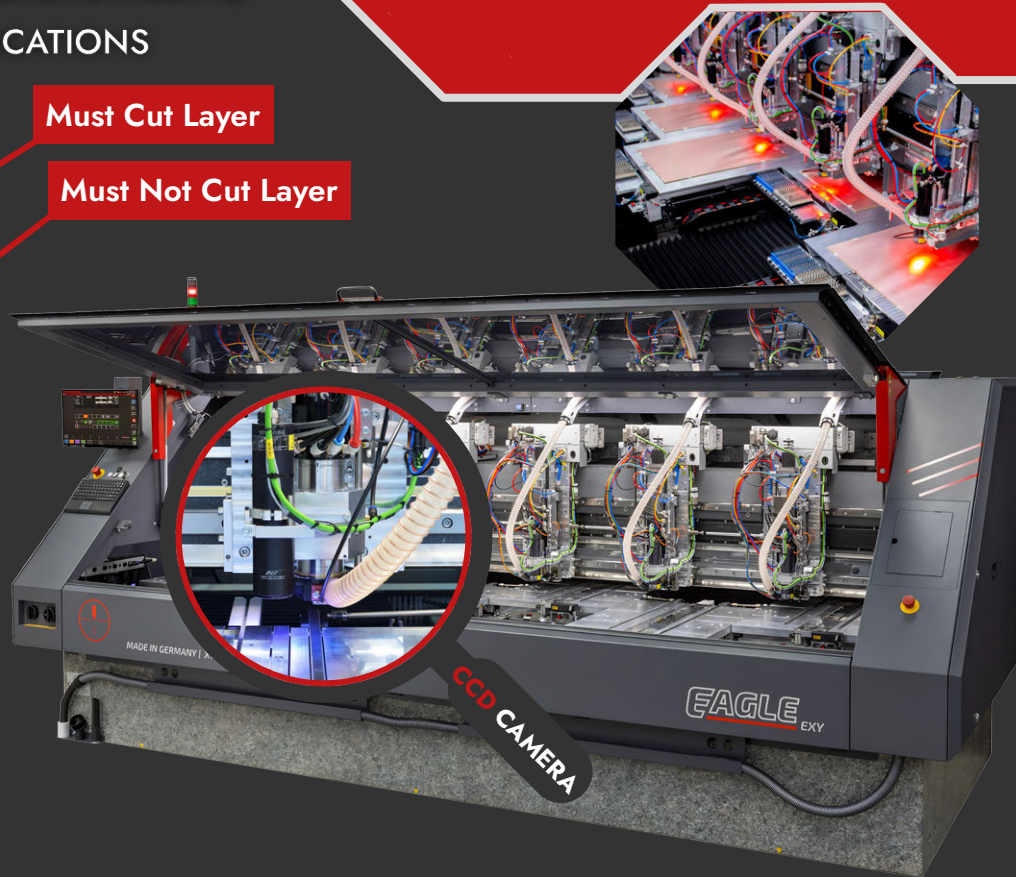


Back Drilling: stop of depth drilled hole before must-not cut layer within stub length tolerance

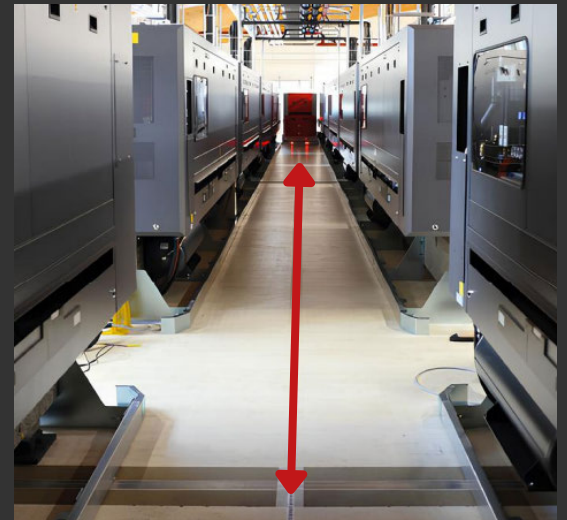


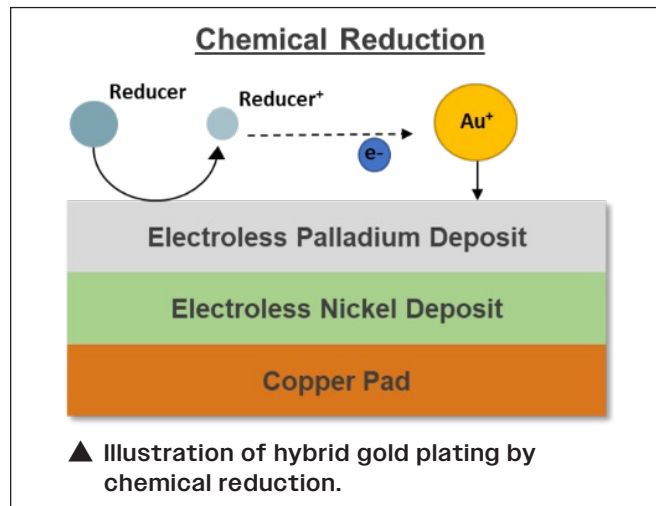
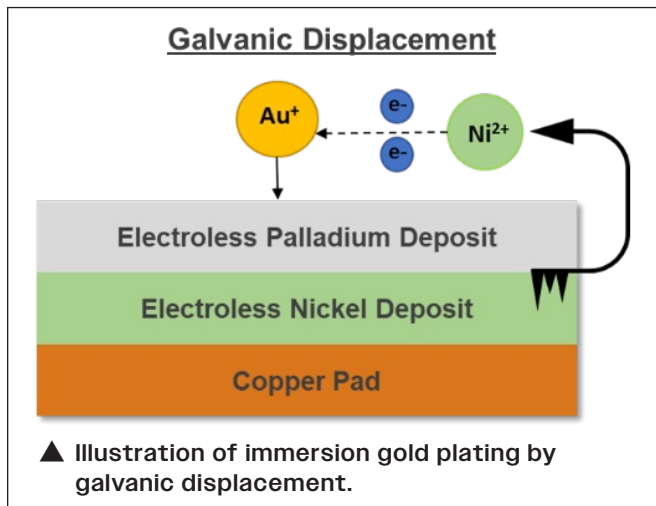
Depth Drilling: precise and reliable drilling to defined inner layers, enabling high-quality blind vias.

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**AUTO LINE SHUTTLE (ALS)
AUTOMATION**





gold is essential for ENEPIG, it increases gold thickness control complexity:

- Palladium thickness variation increases within-panel gold variation
- Excessive palladium thickness restricts gold build-up
- Palladium defects can expose nickel, concentrating galvanic displacement and causing localised corrosion

Hybrid gold technologies reduce reliance on nickel ions, enabling gold build independent of palladium thickness and with significantly less corrosion risk, making them an attractive option for ENEPIG fabricators seeking tighter process control.

Introduction to Hybrid Gold Systems

Hybrid gold plating technology has been on the market for several years, but with the inclusion of corrosion evaluation and compliance in IPC-4556A, hybrid gold systems are now becoming increasingly attractive to fabricators to reduce the number of ENEPIG production challenges.

Frank Xu

Traditional immersion gold relies heavily on the galvanic displacement reaction, meaning fabricators must tightly control multiple factors, such as EN percentage of phosphorus and palladium thick-

ness, to meet gold thickness specifications and prevent corrosion.

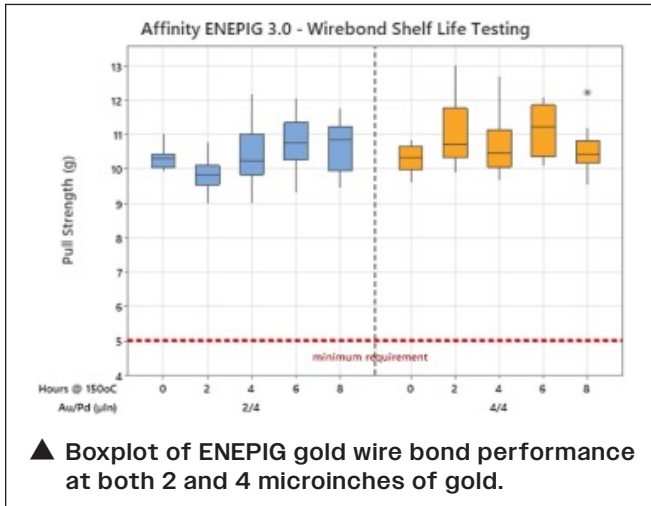
Hybrid gold systems work differently. By incorporating a chemical reduction step, they reduce reliance on nickel ions for deposition. This makes gold thickness less sensitive to EN percentage of phosphorus variation and palladium uniformity, giving fabricators more process flexibility and simplifying production while still meeting specification requirements. IPC-4556A is the first specification to formally recognize hybrid gold, validating its role as a viable alternative for ENEPIG fabrication.

Corrosion Evaluation in IPC-4556A

For the first time, ENEPIG will be evaluated using the same guidance as ENIG's corrosion grading system. In IPC-4552B for ENIG, the corrosion specifications widened to four levels—0, 1, 2, and 3—allowing for a product rating of 0 and defect-free ENIG with zero evidence of corrosion. In this revision, IPC-4556 has used the same guidelines from ENIG in IPC-4552B to create the first specification for corrosion on ENEPIG finishes.

Under IPC-4556 section 3.6, ENEPIG corrosion acceptability and reliability follow similar points as ENIG:

- **Single occurrences of hyper corrosion:** Not rejectable. (It is expected that if enough samples are taken from a PCB, some occurrences may be observed.)
- **Hypercorrosion present, but does not interfere with solder joint formation (intermetallic compound (IMC) formation):** Not rejectable.



- **Hypercorrosion that negatively impacts solderability:** Rejectable condition.
- **Inspection of corrosion (including hyper corrosion):** Must be performed using optical microscopy, maximum 1000x magnification.

If soldering is found to be non-wetting, hyper corrosion should not be assumed to be the first reason, as there are many possibilities for this defect that do not include the final finish of the PCB. Consistent and low-level nickel corrosion is the best course of action to prevent any solderability failure being diagnosed as hyper corrosion and a rejected product.²

This change gives fabricators clearer guidance and aligns ENEPIG with ENIG's proven assessment framework.

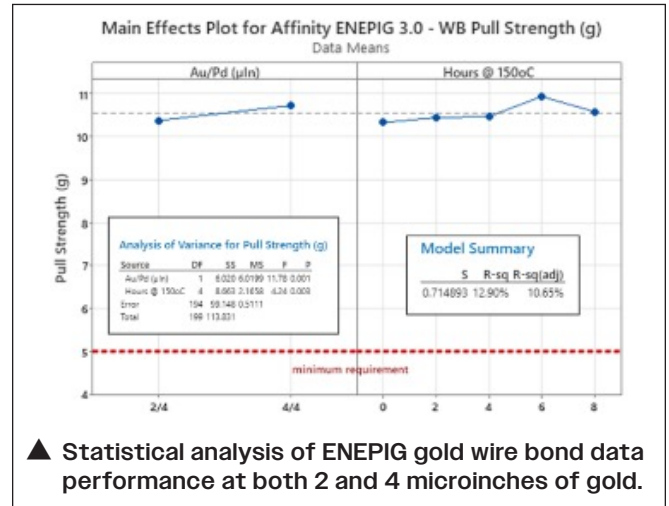
A Need for Higher Gold Thickness?

The updated standard allows gold thicknesses above 2.8 µin, but only for hybrid gold processes. While this can ease compliance and wire bonding concerns, committee discussions and testing show no measurable wire bond strength benefit between 2 and 4 µin deposits, even after aging. For most fabricators, more gold means more cost without proven performance gains.

Conclusion

IPC-4556A raises the bar for ENEPIG reliability, demanding tighter controls, better measurement capability, and more disciplined SPC. Fabricators can adapt by:

- Upgrading measurement capability to meet gold tolerance without guard bands



- Enforce SPC across nickel, palladium, and gold baths
- Selecting stable EN chemistry to minimise percentage of phosphorous variation
- Considering hybrid gold to reduce corrosion risk and process control challenges

The path forward may be more demanding, but those who embrace these requirements will be well positioned to deliver the most consistent, reliable

The path forward may be more demanding, but those who embrace these requirements will be well positioned to deliver the most consistent, reliable ENEPIG finishes to their customers for next-generation, high-performance electronics.

ENEPIG finishes to their customers for next-generation, high-performance electronics.

To speak with our experts or learn more, click here or visit our website. **PCB007**

References

1. "Nitride Semiconductor Light-Emitting Diodes (LEDs) (Second Edition)," by Xiaobing Luo and Run Hu, Woodhead Publishing, 2018.
2. "Achieving a Successful ENIG Finished PCB Under Revision A of IPC-4552," by Bunce, Clark, and Swanson, SMTAI 2017.

Dr. Frank Xu is the global product director for final finishes at MacDermid Alpha Electronics Solutions.

Better Sustainability Policies for Electronics



I joined the Global Electronics Association in August 2025 as the director of sustainability policy. Since then, much has happened in terms of geopolitics and in the development and re-envisioning of sustainability policies in the industry. While the European Commission has released several legislative packages to simplify sustainability requirements (“omnibus”), these developments haven’t yet settled and are not in effect.

Given the many recent and ongoing public consultations, with often conflicting input from a broad range of stakeholders, final negotiations remain rather polarized among policymakers.

At the same time, we are seeing many changes in the U.S. The entire Environmental Protection Agency (EPA) Toxic Substances Control Act (TSCA) framework is being legally challenged and this creates business uncertainty. In other countries and regions, Asia and Latin America included, we notice a visible focus on emerging due diligence, corporate sustainability, and REACH-like regulations.

In this article, I’ll discuss this year’s EU highlights and 2026 developments and reflect on how the electronics industry can take practical steps to inform smarter policies.

Electronics and Sustainability

Advancing a profitable business and sustainable solutions at the same time is challenging. Sustainability for electronics companies requires a concerted effort, but it is within reach. This is due to:

- Inherently complex supply chains and reliance on rare materials
- Limited lifespans and planned obsolescence
- Recycling is technically challenging and economically unattractive
- Consumer behavior and infrastructure gaps
- Regulatory reporting burden
- Lack of coherence in regulatory definitions around the globe; a lack of mature circularity policies to date

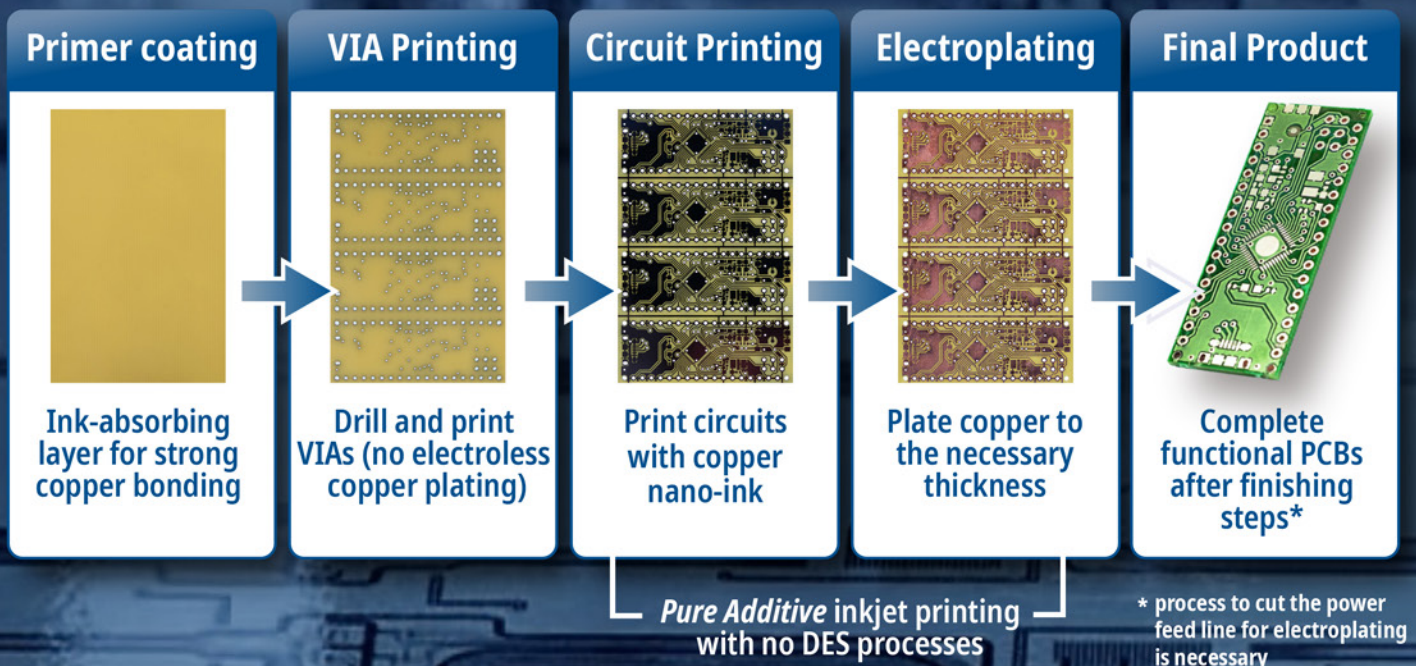


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Stronger, data-informed sustainability policies are essential for business, not only to improve compliance with climate targets, for example, and to reduce the use of toxic chemicals, but also to address the structural barriers that the electronics industry faces in becoming more sustainable. Such policies must be shaped by insights from within the industry itself, through real-life business cases and consolidated data. As an industry, we need to proactively provide sufficient technical information to policymakers up front.

In a global sentiment survey earlier this year¹, it was noted that 59% of the surveyed companies across the electronics sector expected to see an increase in their sustainability efforts in 2025. Yet, such efforts are largely driven by regulatory compliance needs (for 66% of companies). Managing regulatory complexity in an ever-changing regulatory landscape is no walk in the park. Just when we think, as an industry, that we have figured something out, another piece of legislation hits that needs to be unpacked and put into practice, on top of everything else we are doing to run a business.

Omnibus Package on Sustainability Reporting and Due Diligence

Omnibus is the new buzzword in the current mandate of the European Commission. In terms of sustainability policies alone, we have seen three major omnibus packages: Sustainability Reporting and Due Diligence, the Chemicals omnibus, and the Environmental omnibus proposal, where we contributed with a joint industry request to better align the concept of “substances of concern” across different chemical policies. The first omni-

Omnibus Legislative Timeline, EU Legislative Process: Where Are We Now?	
Date	Legislative Milestone
October 13, 2025	Final JURI Committee Vote: Critical vote by Legal Affairs Committee
October–December 2025	Three-way (trialogue) negotiations: EU Parliament, Council, and Commission
November 30, 2025	EFRAG Revised European Sustainability Reporting Standards submitted
December 30, 2025	Final vote and adoption target: Final vote in EU Parliament and Council
Contingency timeline	Contingency timeline: Possible spillover if adoption is delayed

bus proposal, released by the European Commission in late February 2025, aims to reduce complexity across the Corporate Sustainability Reporting Directive (CSRD), the Corporate Sustainability Due Diligence Directive (CS3D), EU Taxonomy, and the Carbon Border Adjustment Mechanism (CBAM), but it hasn’t taken effect yet.

In a June webinar, co-hosted with the Anthesis Group and Incap Corp, we informed the electronics industry of changes ahead and consolidated membership input. In September, we released a position statement² on this topic, including voting recommendations on the JURI (the Legal Affairs Committee in the European Parliament) legal amendments released in July, as well as general recommendations to a broader range of European policy makers, ahead of upcoming triilogue negotiations. Based on members’ input, we advocate for a Tier-1 due diligence approach, the adoption of sector-specific standards (which are key for our industry) by 2030, and more regulatory coherence between different sustainability reporting policies.

What Can the Electronics Industry Do?	
Area	Recommendations
Engagement and advocacy	Join our omnibus working group and continue to share sector-specific feedback to help shape final omnibus provisions and promote a workable framework
Regulatory scope	Continue to check developments and applicability of CSRD/CSDDD given ongoing negotiations on employee thresholds and direct supplier focus
Materiality and risk	See our double materiality assessment (DMA) whitepaper and upcoming DMA toolkit

The Ecodesign for Sustainable Products Regulation (ESPR) and Digital Product Passports (DPPs)

The first official Ecodesign Forum under the new Ecodesign for Sustainable Products Regulation (ESPR) in Brussels this past February brought together approximately 130 stakeholders—from Member States, industry representatives, NGOs, and academia—to help guide the ESPR implementation and energy labelling strategies. Of note, ESPR is an “empty legal framework,” meant to enable the development of delegated acts by product groups.

In April, the European Commission published its 2025–2030 Working Plan under the ESPR, which prioritizes product categories such as textiles, furniture, steel and aluminum, tires, and mattresses, plus horizontal measures covering reparability, recyclability, and recycled content for electrical and electronic equipment. Final EU rules for electronics DPPs are expected in late 2026, with the DPP becoming mandatory for all electronics starting in 2027.

Since January, the Association has been actively engaging with industry representatives in the CEN-CELENEC workshop series, which led to the guidance document “Enabling Circular Economy Practices: Repair and Recycling of PCBAs.” This document relies on IPC sustainability standards and should be finalized shortly. Moreover, we have recently applied to join the Ecodesign Forum.

What Can the Electronics Industry Do?

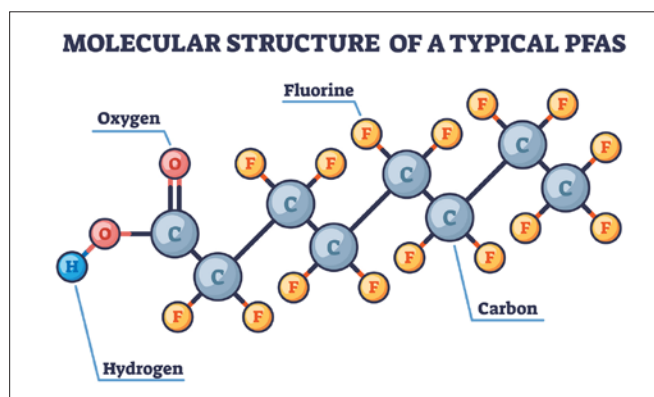
- Apply for the Ecodesign Forum and consolidate industry input through us. This will inform Forum meeting conduct and ensure that we advocate for fit-for-purpose ESPR delegated acts for electronics.
- Proactively prepare for the new DPP era through design rethinking, supply chain modification, and involvement in stakeholder consultations.

Chemical Policies and PFAS Advocacy

A lot is happening in the chemical policies area, and it can be quite overwhelming for the industry: never-ending renewal applications for exemptions related to the restriction of hazardous substances (RoHS), the upcoming REACH revision, a potential universal PFAS ban, a chemicals omnibus package, and the list can go on.

PFAS: A Bad Reputation for a Too Broad Substance Group at Risk of Incoherent Regulation

There are many practical challenges in terms of how PFAS is (or soon will be) regulated around the globe, including regulatory incoherence around PFAS definitions in different regions, blanket restrictions that do not consider the fluoropolymer subgroup that continues to be essential to electronics, and the lack of viable alternatives. The properties that make PFAS so necessary in, for example, defense and aerospace, are precisely what make it persist in the environment. The regulatory momentum is asking us to step up and share real learnings and challenges in this area. We continue to engage with this topic.



What Can the Electronics Industry Do?

- Get ready for the two-month consultation on the European Chemicals Agency (ECHA) Socio-Economic Committee (SEAC), expected in March 2026, by proactively collecting information on the following:
- Potential impacts of restricting PFAS across sectors, like repercussions of non-use scenarios such as no impact, closure of operations, relocation, or substitution of PFAS
- Availability and feasibility of alternatives
- Information on missed uses and derogations, where relevant to socio-economic aspects
- Tell us up front: How should better PFAS definitions look?
- Support your arguments with scientific data and real-life business situations
- Support us in informing position papers and other advocacy work on this topic
- Tell us: What might be suitable alternatives that your organization is looking into?



Looking Ahead: The Circular Economy Act

The Global Electronics Association's position is that emerging regional circularity policies can help promote circularity for electronics. In addition, we observe that circularity and digitalization are becoming increasingly linked in the current policy sustainability landscape.



Diana Radovan

The European Circular Economy Act, expected at the end of 2026, will be a transformative piece of legislation, establishing foundational rules for sustainable product design, recycling, and material sovereignty.

The Act aims to transform the classic economic model from “take-make-dispose” to a true circular economy while promising to align sustainability with competitiveness and strategic resilience. It targets the issues of electronic waste (e-waste), trade barriers due to the persistent, yet unresolved challenge of the EU single market, and secondary raw materials recovery. The first consultation is open until Nov. 6. We will be consolidating and submitting feedback by late October on behalf of our Association members.

What Can the Electronics Industry Do?

- Engage early on with policymakers, through GEA as the consolidated voice of the global electronics industry, to shape this upcoming act into a workable policy
- Pilot circular business models and share lessons learned with GEA and policymakers
- Identify roadblocks to material recovery and reuse, beyond associated costs
- Support the development of global quality standards for recyclates derived from waste from electrical and electronic equipment (WEEE).

The Road Ahead, the Map, and the Territory

We believe that sustainability policies must be ambitious, pragmatic, and aligned with business realities. This belief, together with your data, is what informs advocacy. Our best advocacy work is driven by data, in dialogue with the industry we serve.

What Can the Electronics Industry Do?

You can support the development of better sustainability policies for electronics by:

- Sharing-life business cases (e.g., when regulations prevent innovation)
- Sharing your challenges in trying to implement more sustainable alternatives
- Joining our working groups, webinars, surveys, and consolidated public consultations
- Proactively getting in touch with us with advocacy ideas, long before issues occur

Let's build sustainability policies that are smarter, clearer, and more impactful together. **PCB007**

References and Resources

1. [“Wired for Change: Electronics Industry Sentiment on Sustainability,”](#) authored by the Global Electronics Association.
 2. [“Why Double Materiality Assessments Matter: Compliance and Competitive Advantage,”](#) authored by the Global Electronics Association.
- [Circular Economy Act](#)
 - [Get Ready for the ECHA SEAC Consultation](#)
 - [Joint Industry Request to EU on Omnibus Package](#)
 - [Recent Global Electronics Association Position Statement](#)

Diana Radovan is director of sustainability policy at the Global Electronics Association.

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Onshoring PCB Production: Daunting but Certainly Possible

by Don Ball, Chemcut

In the past year, several potential customers, concerned about the impending application of U.S. tariffs on incoming goods, have asked us what it would take to bring their circuit board production back to the U.S. While they also had other considerations, the threat of new tariffs was the tipping point that started them thinking about the economic advantages of bringing their manufacturing back onshore. It might be interesting to relate our experiences with two of those inquiries.

Was This Venture All a ‘Waste?’

The first company has never produced its own circuit boards, depending instead on outside suppliers, mostly from China, for several thousand square feet of boards per month. The pending tariffs would cut their profit levels significantly, and this, along with some problems incurred when using offshore providers, led them to think about starting their own PCB facility in the U.S. Inventory control has always been a problem—not knowing what was in China, in

transit, or on hand. Quality control was also a problem. With the supplier several thousand miles away, yields were hard to control. Communication problems also made it hard to get anything done quickly. Does any of this sound familiar?

Starting from scratch for a circuit board facility of this size is daunting, but after initial meetings and discussions, the project looked doable, at least from my point of view. We supplied them with satisfactory budgetary quotes for the wet processing equipment based on their requirements and put them in touch with other suppliers for equipment (etch resists, laminators, exposure units, etc.) and chemistries we couldn't provide. These fell into line with the company's expectations, and we got into the details of chemical usage, process controls, and waste stream management. This is where the project stalled.

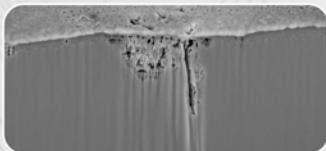
The state and local environmental regulations were stringent, and in the end, the cost of an onsite treatment plant to meet those regulations exceeded the cost of the entire facility combined. The com-



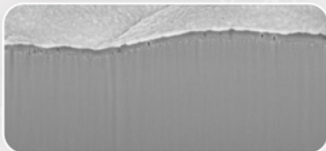
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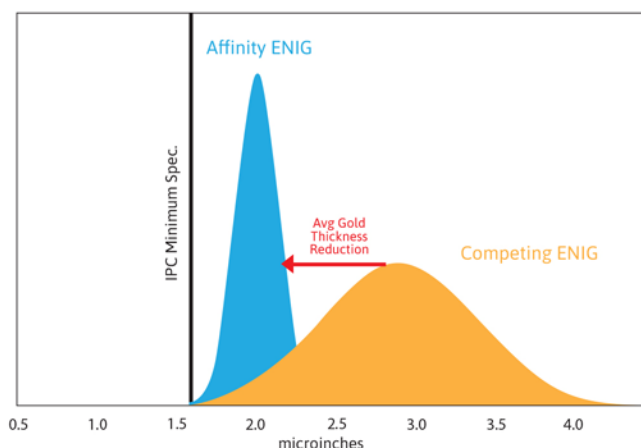
Electroless Nickel Immersion Gold



Traditional ENIG systems can show variation in electroless nickel deposition, resulting in unwanted, localized, aggressive corrosion which may exceed the IPC-4552B specification.



Affinity ENIG 2.0 delivers consistent and uniform deposition over the working life, delivering an IPC compliant solution and eliminating corrosion and reliability concerns.



Stable and consistent nickel-gold plating allows **Affinity ENIG 2.0** to meet the highest requirements of the updated IPC-4552B specification.



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pany decided that this made the project economically unfeasible, and it would be better off continuing to purchase their circuit boards rather than onshore production. This was, of course, a bitter disappointment for us, but, given the circumstances, probably a wise decision for them for the immediate future. Hopefully, the proposed tariffs will raise the price of offshore-manufactured boards to where they look at U.S. suppliers for their boards. That would be good for them and, in the long run, for us.

This may have been a case of too much, too soon. Perhaps a better approach would have been to bring a percentage of the offshore product in-house and then, as experience and expertise are gained, gradually expand to the production needed. The other lesson is to make sure you understand the local environmental regulations before seriously considering bringing your board production in-house. Fortunately, the second example illustrated here shows that it is possible to go from zero to full in-house production.

The Devil's in the Details

The second example is about a company that makes precision measuring equipment and prototypes. This company requires far fewer circuit boards than my first example, but their circuit boards have very tight tolerances, and they've had trouble getting what they need from their outside suppliers. (I'm not sure whether their suppliers were on- or offshore). This company asked: Would bringing our board production onshore to allow for better quality control be economically feasible? We went through the same procedures as above. We provided quotes for the equipment we could supply and pointed them to other suppliers for their other equipment and chemistry needs. After all that, the company determined it would be feasible to make their own boards and bought equipment and supplies to set up a shop. Our contribution was a two-stage cleaning system for surface preparation and a cupric chloride DES system.

However, we could tell by the questions they asked about our equipment that they had no experience in actually running a circuit board shop and no idea how to keep it running efficiently. This was a situation we generally don't run into as an equip-

ment supplier since most of our customers are already familiar with circuit board manufacturing. We had to think about what non-capital equipment a shop needs to keep the place running efficiently—those little things that you don't think of until you need them. We provided them with a list of useful things to have around that make running a shop easier and more efficient, including things that any small- to medium-sized shop should have.

I convinced them they needed a small chemical analysis lab tucked into a corner somewhere to back up the automatic chemistry controls, especially for the free acid in the cupric chloride, just enough to do simple acid/base titrations. These are relatively uncomplicated and don't require a trained chemist, but are invaluable in confirming that the automatic chemistry controls are functioning as designed. We supplied a list of the necessary glassware and chemicals, and they set up a small chemistry lab near the etch area.

Another list of frequently overlooked items in the initial planning included handheld pH and ORP meters (keeping in mind that a person with one pH meter will always know what the pH is, while the person with two pH meters is never certain). Also included were a scale with at least a 200-pound max for making up their process chemistries, an electric drum pump for moving large amounts of chemistry, hand-operated siphon pumps for moving small amounts of chemistry, a shop vac, and a mop and bucket. A mop and bucket may seem somewhat mundane, but you'll find them to be the most-used in the shop. Due to column length requirements, this isn't a comprehensive list of all we supplied, and many of you can likely think of several other items that were overlooked.

So far (knock on wood), everything seems to be running smoothly, but the next several months will tell.

Starting a circuit board manufacturing facility from scratch is not something to be considered lightly, but it is possible with careful planning and foresight. **PCB007**



Don Ball is a process engineer at Chemcut. To read past columns or contact Ball, [click here](#).

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Smart Policies Can Ensure AI Data Centers Are Secure

by Shane Whiteside, PCBAA

Megatrends in the economy always capture the interest of the media, politicians, investors, and industry titans. The latest megatrend is artificial intelligence (AI), which has created a mad rush to increase American capabilities and has manifested itself in the proliferation of massive data centers.

When you go beyond the headlines, there are very real supply chain and security challenges. Each data center can house tens of thousands of computer servers containing millions of semiconductors and printed circuit boards.

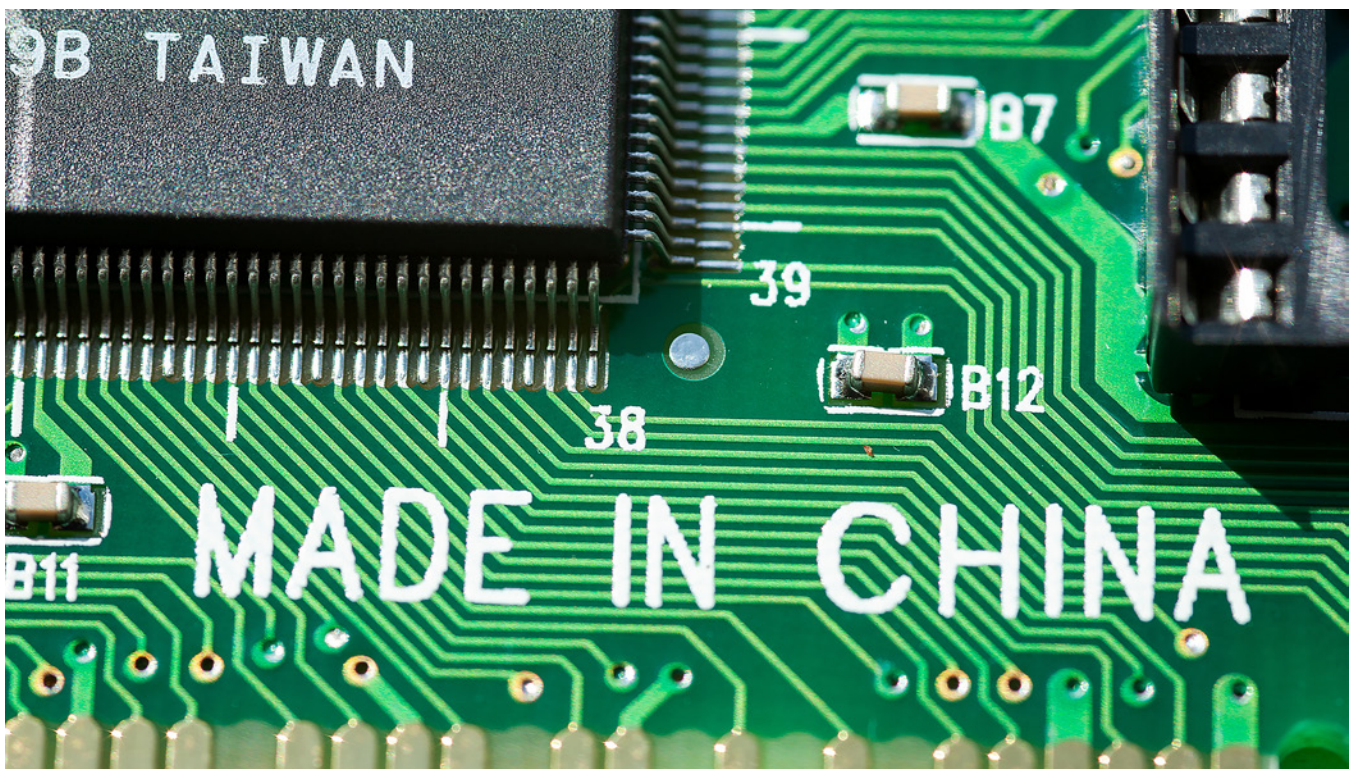
Who is making the printed circuit boards for those servers? One thing is for sure: Much of the content originates in other countries.

Even if the server has an American flag on the outside, there is a high probability that the printed circuit boards originated in China or other Asian

countries. China is particularly problematic given the adversarial relationship with the U.S.

Chinese firms like Huawei, Tencent, and Alibaba are major players in the data center and cloud computing space. Taking a global look at the countries of origin for Chinese technology in cloud data storage¹, you can see that even if it says Mexico, Turkey, Saudi Arabia, Singapore, or Indonesia on the outside, it's likely you will have Chinese technology inside. "China Inside" is a red flag for those focused on the security of our national defense and critical infrastructure systems like data centers.

August saw a few high-profile factory investment announcements² signaling possible long-term confidence. But further examination of those reports reveals that U.S. manufacturing is a mixed bag. While it is true that pharmaceuticals and some other



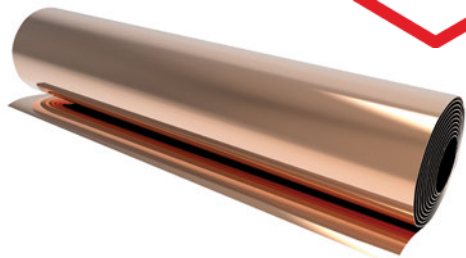
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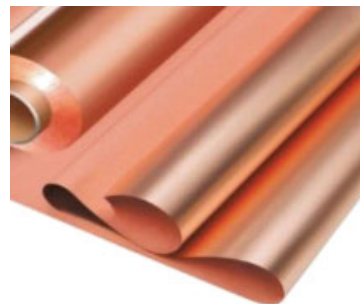


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industries showed an uptick, PCB manufacturing remains steady at about 4% of the world's supply. PCBs for AI applications require advanced manufacturing capabilities and scale that is lacking in the U.S., and despite recent planned investments, will continue to fall short of what is required for secure AI infrastructure.

The need to restore domestic capacity and build an AI infrastructure we can trust presents a unique public policy and private investment opportunity.

Members on both sides of the aisle in Congress are signing on to sponsor H.R. 3597, the Protecting Circuit Boards and Substrates Act. That bill would provide government grants and game-changing tax credits certain to spur private investments, similar to the CHIPS Act. PCBAA and the Global Electronics Association are pushing hard to pass legislation that would end up on the president's desk to bolster his Made in America campaign.

The AI revolution and the data centers that power

it are being built today. Smart policies now can ensure American leadership for years to come.

The nation's security and prosperity depends on a vibrant and innovative microelectronics industry.

Join PCBAA today and add your voice to our outreach in Washington, D.C. **PCB007**

References

1. "Where Chinese or American Tech Is Used in Cloud Data Storage," by Katharina Buchholz, Statista, May 5, 2025.
2. "Aust 2025 Manufacturing Insights," US Manufacturing Report, Sept. 15, 2025.



Shane Whiteside is president and CEO of Summit Interconnect and current chair of the Printed Circuit Board Association of America. To read past columns, [click here](#).

Mirror-like Graphite Films Break Records in Strength and Conductivity

Graphite has attracted global interest due to its unique anisotropic properties, including excellent electrical and thermal conductivity. Widely used as a battery anode material and in applications such as electromagnetic shielding, catalysis, and nuclear technology, graphite remains a critical material in both industrial and research fields.

For decades, researchers have sought to produce high-quality artificial graphite with large grains and smooth, layered structures. Conventional methods typically involve high-temperature treatment of polymer films under mechanical stress. However, the resulting materials often suffer from limited grain size, lower density, and surface irregularities, with their bulk mechanical properties seldom evaluated. Another well-known synthetic form, highly oriented pyrolytic graphite (HOPG), offers improved crystallinity, but still exhibits relatively small domain sizes. Moreover, such materials tend to develop wrinkles and distortions during cooling, and their properties are typically studied at the microscale—using exfoliated flakes rather than intact graphite films.

Led by Director Rodney S. Ruoff at the Institute for Basic Science (IBS), researchers have developed a groundbreaking method to produce mirror-like graphite films with millimeter-sized grains—approximately 10,000 times larger than those found in conventional synthetic graphite. Central to this achievement is a clever "porous substrate" strategy: by selectively evaporating nickel from a molten Ni-Mo alloy after graphite growth, the team created a sponge-like substrate that dramatically weakens the interaction between the graphite and the metal surface. This effectively eliminates interfacial stress during cooling, preventing the formation of wrinkles or kinks in the film.

The potential applications are wide-ranging. Defect-free, high-purity graphite films could transform thermal management in high-power electronics, such as AI chips, serve as ultra-strong and conductive components in MEMS and sensors, and enable frictionless coatings or advanced battery anodes. Looking ahead, the team is working to scale up production toward meter-sized films.

(Source: Institute for Basic Science)



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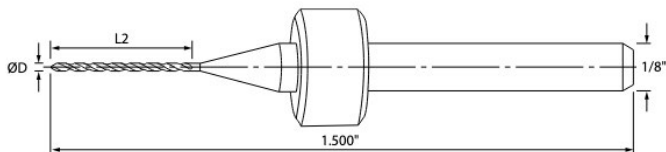


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Kyocera's renowned array of drills, routers, end mills, and specialty tools offer many benefits and advantages to customers for all their drilling and routing needs. Kyocera's tool reliability and design flexibility are key strengths of their products, 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.

Draganfly Enlisted by U.S. Army to Deliver Drones on Heels of Developing Drones for Border Security ▶

Draganfly Inc., an industry-leading developer of drone solutions and systems, announced its selection by the U.S. Army to provide Flex FPV drone systems. Under the initial order, Draganfly will deliver Flex FPV drones designed for high-performance operations as well as help establish on-site manufacturing of the Flex FPV (First Person View) within overseas U.S. Forces facilities to accelerate deployment and reduce supply-chain timelines.

HANZA Completes Acquisition and Expands Capacity for the Defense Industry ▶

HANZA AB has completed the acquisition of Mil-ectria, a leading contract manufacturer of electrical systems for the defense industry. The acquisition is an important step in HANZA's LYNX program and strengthens the Group's capacity, customer base, and geographical presence.

UK Space Agency Goes Global with 23 New Projects ▶

A new batch of 23 projects will strengthen international space partnerships, develop national capabilities and boost economic growth, the UK Space Agency announced. This is the second round of projects from the successful International Bilateral Fund (IBF), representing a £6.5 million boost for UK companies and universities collaborating internationally on space innovation with partners in Australia, Canada, France, Germany, India, Japan, Lithuania, and the U.S.

Boeing Delivers Second ViaSat-3 Satellite to Viasat ▶

Boeing has delivered ViaSat-3 F2, the second spacecraft in Viasat's next generation, ultrahigh capacity constellation. The Boeing 702MP+ platform, optimized for high power and allelectric propulsion, was integrated with Viasat's payload at Boeing's satellite factory in California and is proceeding toward launch in the second half of October aboard a United Launch Alliance Atlas rocket.

Safran, Rheinmetall Sign Framework Agreement for Advanced Defense Solutions ▶

Safran Electronics & Defense and Rheinmetall Electronics have signed a new framework agreement at DSEI London, strengthening their long-term collaboration in the defense sector. The contract streamlines procurement processes and supports future joint projects.

Honeywell Successfully Demonstrates Counter Swarm Drone Technology to Military Operators ▶

Honeywell announced it has successfully showcased its Stationary and Mobile UAS Reveal and Intercept system and its ability to counter swarm drones in two recent demonstrations to local military operators in the United States. The system was utilized in a format in which it can be operated directly from a ground vehicle.

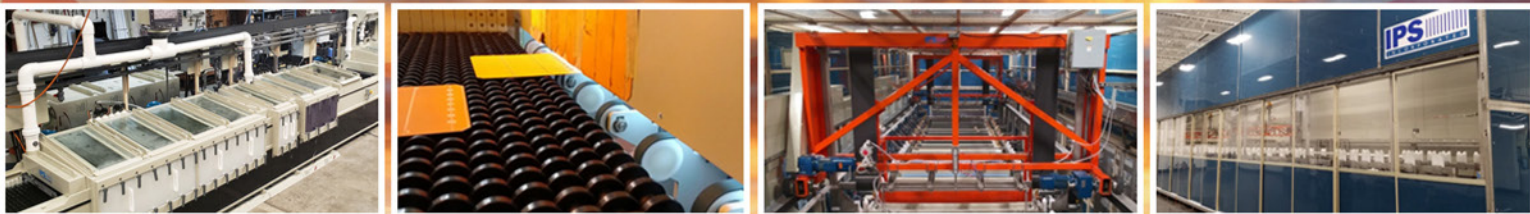
Wojskowe Zakłady Elektroniczne Spółka Akcyjna, Lockheed Martin Conduct Production Line Validation Milestones ▶

WZE S.A. and Lockheed Martin recently performed a production line validation of two major Patriot Advanced Capability—3 Missile Segment Enhancement (PAC-3 MSE) activities through the WISLA offset program to certify that the WZE S.A. Attitude Control Section (ACS) and Attitude Control Motor (ACM) components meet quality, safety, and compliance standards.

BAE Systems-built Carruthers Geocorona Observatory and SWFO-L1 Spacecraft Successfully Launch ▶

BAE Systems is celebrating the successful launch of two spacecraft from Kennedy Space Center in Florida, supporting vital NASA and National Oceanic and Atmospheric Administration (NOAA) space weather missions. NASA's Carruthers Geocorona Observatory and NOAA's Space Weather Follow On – L1 (SWFO-L1) launched together on a SpaceX Falcon 9 rocket on their way to Lagrange point 1, an orbit approximately 1 million miles from Earth toward the Sun.

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Becoming Grant-ready in the Private Sector

Companies in the electronics industry are expected to innovate faster, modernize operations, deliver resilient supply chains, and compete on a global stage. It's a high bar to meet for manufacturers facing tightening margins, talent shortages, and evolving economic and policy conditions, but opportunities remain for those prepared to take action.

That is why external funding, once considered the domain of universities, nonprofits, and government contractors, is now firmly on the table for the private sector. While the grant landscape is shifting, investment in manufacturing, training, and innovation is still flowing. What is new is the degree to which our industry is being invited to participate. The exciting reality is that companies and programs that once thought of grants as out of reach now have real opportunities to pursue.

Some leaders still worry that the process is too complicated, the odds too low, or the paperwork too burdensome. These concerns are understandable, but they no longer reflect the full picture. If

your company or program is growing, hiring, developing technology, or expanding capabilities, you are already doing the things external funding was designed to support. Being grant-ready is about preparation. It means knowing your goals, being able to describe the broader benefit of your work, and positioning yourself to act when the right opportunity aligns with your direction.

At its core, grant readiness is not about becoming an expert in grants. It's about mindset, and seeing external funding not as a distraction but as a catalyst that helps you achieve more, faster. Organizations that are grant-ready treat funding as a tool. They clarify their capital and talent needs. They gather basic materials such as capability statements and project ideas. They learn how their priorities connect to national, philanthropic, or industry goals. Most importantly, they position themselves so that when the right opportunity arrives, they can move forward with confidence.

Opportunities are arriving. Across the country, new investments are being made in workforce pipelines, advanced manufacturing, and supply chain resilience. These programs are not abstract. They are paying for new equipment, funding apprenticeships, and supporting collaboration between companies, schools, and communities. Increasingly, they are designed with applicants like you in mind.

Knowing that funding exists is only one part of the story. The other part is knowing how to access it. This is where many organizations hesitate. They may not know who should lead the effort internally. They may feel unsure about the requirements or intimidated by the process. But these challenges are starting points, not roadblocks, and help is available.

At the Global Electronics Association, we are working to make funding more accessible. We provide workshops and briefings to make the process clear. We create templates that make it easier to share your story in ways that resonate with





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funders. We develop tools to help you demonstrate the impact of your work, such as how it creates jobs, drives innovation, supports regional economies, and strengthens competitiveness. When needed, we help connect you with strong partners to increase your chances of success. In other words, we are here to walk alongside you, not just point you in the right direction.

But this is not a one-way effort. Your organization or program area must take the first steps. Identify a point person who can keep an eye on opportunities and engage with us. Clarify two or three areas where outside funding would make a meaningful difference. Refresh a short company or program narrative. Most importantly, ask yourself: What would we pursue if funding were not a barrier? That



single question can spark new ideas and reveal possibilities that may once have seemed out of reach.

To help you reflect on where you stand, here's a quick and confidential pulse check that will help you measure your readiness while showing us where you may benefit from added support. Whether you are completely new to grants or already experienced, your input shapes the resources we continue to build for you.

Funding is not a magic solution. Yet for the electronics industry, it remains a powerful resource that can expand what is possible. The time to begin is not when the next RFP is released. The time is now. Be ready, believe in what you can achieve, and let us help you make the most of the opportunities ahead. **PCB007**

Nyron Rouse is director of government grants and strategic funding at the Global Electronics Association.

Are You Grant Ready?

This quick self-assessment is designed to help your organization or program area assess readiness for pursuing funding opportunities. Answer honestly, as this is for your internal reflection and preparation. The answers must be: **Yes, No or In Progress.**

- 1. Strategic Alignment:** Do you have a clear and updated strategic plan that connects your projects to potential funding opportunities?
- 2. Budget Preparedness:** Do you maintain an organizational or program area budget that is realistic, detailed, and tied to your goals?
- 3. Policies and Procedures:** Do you have documented organizational or program area policies (procurement, HR, compliance, etc.) that are accessible?
- 4. Financial Documentation:** Do you have audited financial statements or other reliable financial records ready for funders?
- 5. Leadership and Staffing:** Is there a designated point of contact or team responsible for grants and funding pursuits?
- 6. Compliance Tracking:** Do you use a system for tracking deadlines, reporting requirements, and compliance obligations after receiving funding?
- 7. Staff Qualifications:** Do you keep resumés, bios, and staff qualifications updated and accessible for proposals?
- 8. Partnerships and Support:** Do you maintain a record of letters of support, MOUs, or partnership agreements to strengthen proposals?
- 9. Performance and Outcomes:** Do you track and maintain performance metrics and outcomes data from past projects that demonstrate impact?
- 10. Risk and Eligibility Review:** Do you have a process to review eligibility, matching requirements, and risk factors before pursuing an opportunity?

Scoring (optional): Count your "Yes" answers.

8–10 = Strongly Grant Ready, **5–7** = On the Path, Needs Strengthening, **0–4** = Early Stage, Significant Preparation Needed



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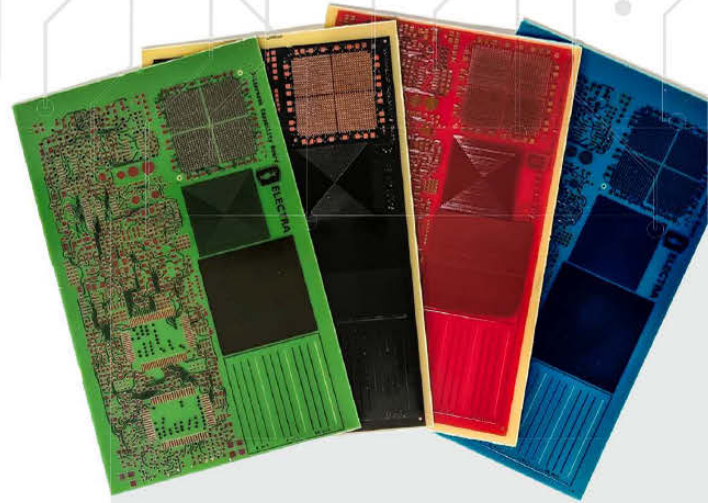
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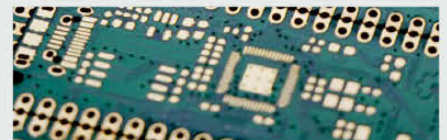
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Memories of the 'Mystery Systems of the East'

by Happy Holden, I-Connect007

For some time now, I've wanted to share my observations about living and working with the Chinese. If you plan to stay in the electronics profession, specifically printed circuits, China will have a profound effect on you, and I hope some of my experiences will help you.

My Historic Connection to China

It is ironic that I would end up working with the Chinese. My father was a farm boy from Wisconsin who fought alongside the Chinese to defeat the Japanese on the China-Burma border during WWII. My father took many photos and had stories that he later shared with us kids. I remember the story he told of

shooting an Indochinese leopard he saw lurking in a tree, its eyes glowing. It looked ready to pounce and to kill. Fearing for his life, my father took the shot, and the leopard landed right in the back of his jeep.

As a boy, my father used to trap, skin, and trade muskrat pelts to the local Native Americans, so it was no issue for him to take the leopard back to the local village and trade the meat to the village leader in return for tanning the pelt. He carried that pelt with him throughout the war, brought it home, and I grew up with it on the living room floor. That experience had such a profound effect on my father, and even 60 years later, he still remembered many words in Mandarin.



▲ Happy's father carrying the leopard through camp during WWII.

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My personal connection to China began with three days of R&R on the beach in Kaohsiung, Taiwan, in 1969, on my way back from Vietnam. Many years later, you can appreciate the irony of my having dinner with the engineers of Boashung Steel in Shanghai and them declaring me a “comrade” as they also fought the Vietnamese, and their fathers fought the Japanese.

Mystery Systems

When I became involved with the Chinese nearly 45 years ago, I read an article about the “mystery systems of the East” that contrasted Eastern vs. Western cultures in history, religion, philosophy, language, government, law, education, and geography. These fundamental observations were very helpful to me as I began working with Chinese companies. As U.S. companies have moved their operations overseas to China and Southeast Asia during the past few decades, we have all become more familiar with the Eastern perspective and way of looking at life and business. Will these perspectives begin to dominate the world’s production of PWBs, and will it be to our benefit?

Working for the World’s Largest PCB Manufacturer

Until 2008, my work experience was mostly limited to Taiwan, where I had lived for many years, working for Hewlett-Packard. I also lived in Hong Kong before its return to China in 1997. In 2008, my HP boss from Taiwan, who had been promoted as the executive vice president of Hon Hai Precision

Industry (Foxconn), asked me to become the CTO of Foxconn’s components division, which made all the connectors, cables, flex, and PCB multilayers. He even sent me a 150-slide PowerPoint presentation about the division.

To say I was flabbergasted is an understatement. Foxconn PCB had five sites in China, all built after 2006, with 17 facilities of 1 million square feet each. Of those four plants, Huai’an alone produced over 18 million square feet of an average eight-layer multilayer board every month. The entire captive manufacturing was eight times the size of the known largest PCB manufacturer in the world (a Japanese giant). Foxconn’s largest site, 300 km north of Beijing (where the Great Wall begins), had six enormous plants and 30 more planned, making it the largest in the world.

I was tasked with improving efficiency, yields, and profits over the next three years so Foxconn could launch an IPO for the PCB unit.

Fundamental PWB Infrastructure Advantages

In my experience, the Chinese have many infrastructure advantages over the Western world, including:

1. Long-term business planning and vision to drive strategic focus.
2. Access to low-cost, vast technical resources and manpower in engineering.
3. Belief in organic growth through added capacity, not by acquisitions, including verticalization of the supply chain.
4. Connections to financial backing (banking and investors) that also shares the same vision of growth and market share over profits—overseas Chinese banking, not China’s banking system.
5. Cooperation of government research laboratories to develop and promote new materials, processes, and technologies.
6. Innovative use of the world’s best ideas, equipment, and processes.

Challenges for the Chinese

Despite this, I’ve observed that China does have its own set of difficulties to work through. I’ll list a few that come to mind.



Starting from Scratch

Their practice of training to copy until perfection and not sticking out means that their first action is to look for an answer from others. The top-down rule means they will do whatever the boss says, even if it is a waste of time. The idea of brainstorming a problem breaks too many cultural-hierarchical protocols to be effective, but with training and coaching, they can learn to be self-starters.

Higher Education

University attendance is not open to everyone. Herculean entrance exams make getting into a state university all-consuming. If you do get in, you are required to continue at a hectic pace. Where I attended college, our engineering program let just about everyone in. Only the strong would survive, meaning each year about a quarter of the students could not make the grade. Another advantage of the U.S. education system is that age is not a factor for entrance. Many motivated older family men or military veterans were my classmates.

Regard and Understanding of Intellectual Property

The Chinese have a hard time understanding that you can own an idea and that you can buy and sell it. To them, objects have intrinsic value based on their materials and the labor to construct them. Since they were taught to copy the masters until they had perfected their techniques, imitation was a sign of respect and honor. At one time, 90% of industrial software in China was pirated. When I lived there, I could buy a Microsoft XP or Windows 2000 for \$1.20 a disk, or a CAM350 v8.6 field solver for \$4. It has taken many years for IP to be respected.

Technical Management (Middle Management)

The concepts of delegating and coaching still need to be established. Chinese hierarchical protocol is still the rule, with the people at the top making the decisions and issuing the orders. It's a battle to climb the ranks against so many, and it's difficult to share your knowledge and experience with your subordinates.

Engineering Statistics

Japan realized that quality comes from engineering on the factory floor and in product refinement, and



made it a national priority. China and Taiwan have a poor record of using statistics and DOE. I taught Chinese engineers about it, so I know some of them are using it. However, most process optimization comes from one-change-at-a-time experimentation. Beware of “chàbuduō,” “about right,” or “good enough.”

Conclusion

Learning about other countries and living and working with them has been one of my life's greatest experiences. You learn that there are so many ways to approach the same problem, and that solving them together contributes to the greater good of the industry—and the individual.

An excellent set of articles I read early in my career was authored by Mia Doucet, an international marketing consultant who wrote *China In Motion: 17 Secrets to Slashing the Time to Production, to Market, and to Profits in China, Taiwan, Japan, and South Korea*. This helped me enormously to understand the differences in culture and doing business in Asia. Maybe I will write another column listing some of the most useful advice and how it worked for me. **PCB007**



Happy Holden has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa Westwood, Merix, Foxconn, and Gentex. He is 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](#).

Understanding Interconnect Defects, Part 1

by Michael Carano, Consultant, Global Electronics Association

This month, I'll address interconnect defects (ICDs). While this defect continues to rear its ugly head, don't despair. There are solutions, most of which center on process control and understanding the relationship of the chemistry, materials, and equipment. First, though, let's discuss ICDs.

Interconnect Defects

As circuit boards become more complex with multiple layers, finer lines and spaces, and vias with smaller diameters and greater aspect ratios, the possibility of an interconnect defect looms large. If small hole voiding issues are not enough to keep everyone hopping, interconnect or interplane separation surely will. Unlike voids, where, if detected in time, the panels can be reprocessed, it is impossible to rework the ICD defect.

ICDs are not always detected by Quality Control, mainly because ICDs are rarely catastrophic failures. Rather, constant thermal cycling or the high temperatures of assembly operations cause a weakened interconnect to separate. Many engineers expect that performing one or two solder floats on plated coupons removed from panels will provide a sufficient QC check. Unfortunately, this often allows the problem to go undetected until it is far too late. An example of an ICD is shown in Figure 1.

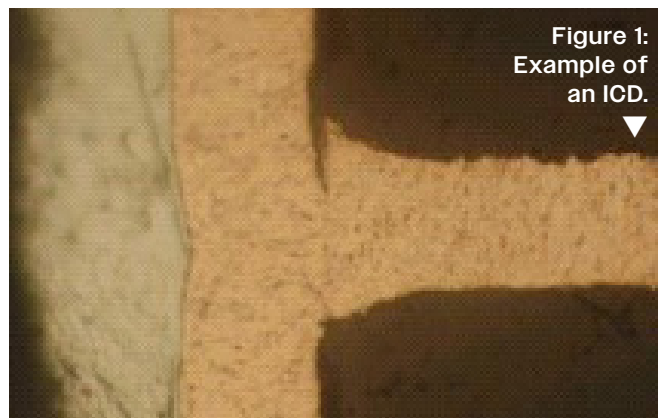


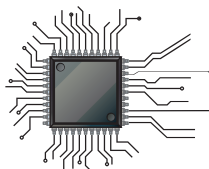
Figure 1:
Example of
an ICD.

A slight separation becomes detectable after the coupon undergoes two solder floats at 550°C for 10 seconds. If not seen by cross-section, the panel will easily pass electrical test. However, because of the weakness in the interconnect, continued thermal stresses and vibrations of the PWB will most likely lead to an open circuit. If you're unsure whether the defect is present, regrind and polish the potted coupon, then inspect the ICD. Do not etch the specimen, otherwise, a line of demarcation can be visible with electroless copper deposits, which can lead you to conclude that it is a true ICD. It is imperative that un-etched coupons be used to detect the presence or absence of the defect.

An ICD is not confined to just the interplane. Blind vias can also exhibit a separation of the plated copper from the capture pad. Interconnect defects (IP separation) generally exhibit these underlying characteristics:

1. Occurs during the stress of thermal shocks such as soldering. This creates expansion in the Z-axis and places strain on the copper in the hole wall.
2. Most often seen on the first inner layer from either side of the board. (i.e., on a 12-layer board, the defect can be seen on layers 2 and 11).
3. The weakest bond breaks first.
4. Under-cured boards are most susceptible.
5. Affected by board construction, PWBs with more resin, less copper, and lower Tg materials show more expansion in the Z-axis.
6. ICDs are often accompanied by a hole-wall pullaway, but not always.

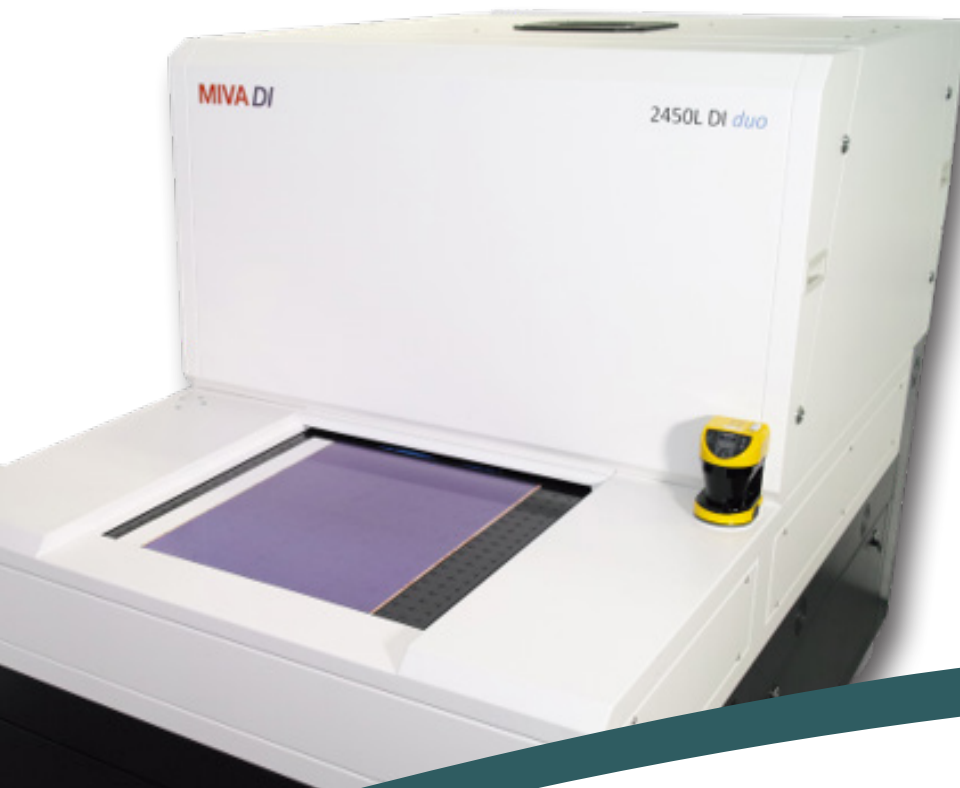
There are several causes of interplane separation, making this defect so difficult to pinpoint and eliminate. To confuse the issue further, one must first determine which of the three types of IP it is. The three types of IP separation are:



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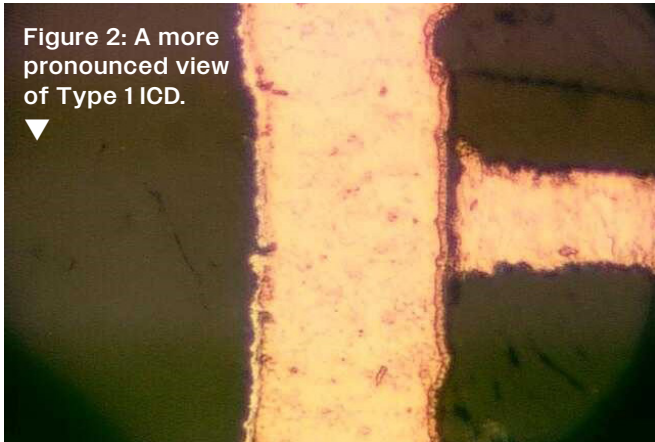


- High power, Quad-wave, data streaming light engine for high resolution imaging.
- Multiple resolutions including 4, 6, 15, 30 μm features for conventional processes.
- External Rasterization provides 10x precision for fine feature adjustment on the fly.

- Type 1: Separation of the electroless copper deposit from the interconnect
- Type 2: Separation of the electrolytic copper deposit from the electroless copper deposit, but the electroless remains on the post
- Type 3: Cohesive failure of the electroless whereby the electroless copper deposit separates from itself

The three types of IP failure have their own inherent causes. We will discuss Type 1 in this column and Types 2 and 3 next month. Figure 2 shows a more pronounced view of Type 1 ICD. One can see the electroless copper deposit adhering to the electro-deposited copper, not to the interconnect.

Figure 2: A more pronounced view of Type 1 ICD.



Why is Type 1 the most common and often the most difficult to mitigate? Generally, it's because there is significant internal stress in the electroless copper deposit, causing it to pull away or separate from the interconnect post.

So, ensure there is no drill smear remaining on the post. This will show as a separation. However, don't confuse smear with Type 1 ICD. Type 1, in its true fashion, is caused by several factors that may be interacting in such a way as to exacerbate the defect. Remember that the weakest bond breaks first.

Generally, Type 1 ICDs can be attributed to the following:

- "Invisible" drill smear not removed by the desmear process. Check parameters if using alkaline permanganate or plasma. Is the drilling process creating more smear than normal because of dull drill bits, faster in-feed rates, poor quality entry and back-up material, or

because drill bits are remaining in the hole for an excessive amount of time?

- The micro-etch in the electroless copper pre-plate line does not sufficiently roughen the copper surface to provide adequate anchoring sites for the copper deposit.
- Excessive dwell time in the catalyst or inadequate tin removal in the acceleration step leaves a barrier on the copper interconnect. Anything that weakens the bond between the copper deposit and the interconnect can cause separation.
- Drag-in of cleaners into the various process tanks or poor rinsing due to insufficient dwell time. Rinse water quantity and/or quality can cause Type 1 ICDs.
- Electroless copper deposit exhibits inherent stress. An excessively high deposition rate typically causes this. The primary cause of the stress is the amount of copper micro-inches deposited per minute. Operate the process within its designed parameters. Any change in the process that results in the electroless being deposited at a higher-than-normal rate can cause the Type 1 ICD.

A good rule is that if the electroless copper process is designed to deposit 40–50 microinches in 30 minutes and the deposit is somewhere in the 70–100-microinch range, then there is a problem with the copper being deposited much too fast. This will cause the copper grains to "re-orient," leading to stress in the deposit. The stress can only be relieved by the deposit pulling away from the interconnect.

Think about process control and understand all variables, both mechanical and chemical, that can cause the process to drift out of control. Next month, I'll discuss Type 2 and 3 ICDs. **PCB007**

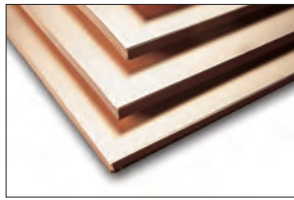


Michael Carano brings over 40 years of electronics industry experience with special expertise in manufacturing, performance chemicals, metals, semiconductors, medical devices, and advanced packaging.

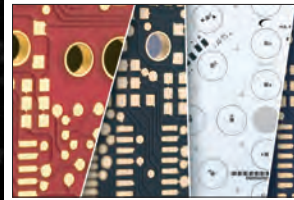
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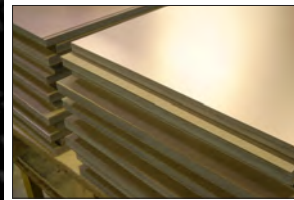
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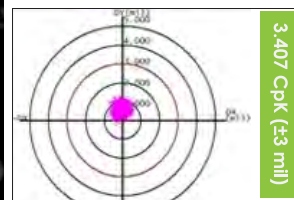
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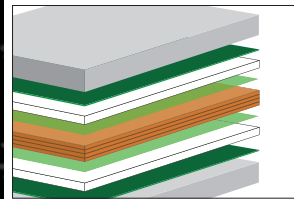
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China Plus One: Vietnam and Thailand Manufacturing Solutions



U.S. electronics manufacturing companies are weighing the “China Plus One” solution as they strategize how best to mitigate the ever-increasing pressures and costs of manufacturing in China. Several global markets, particularly Thailand and Vietnam, are seeing significant growth in their sectors. One has infrastructure and a more established history of success in manufacturing, while the other has a much larger number of eager, young workers. This article breaks down the pros and cons of each market, including a look at U.S. tariffs and how each country is addressing a significant skilled labor gap to support their electronics manufacturing goals.

How Do They Stack Up?

Vietnam has emerged as a top-tier electronics hub in Asia, powered by foreign-invested enterprises

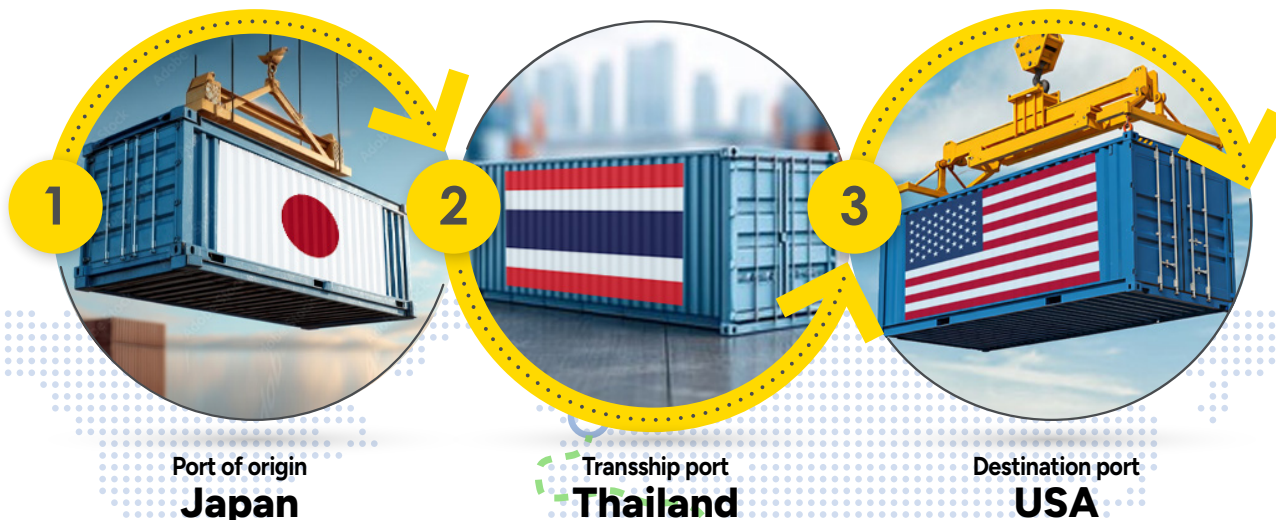
(FIEs) clustered around Hanoi and Ho Chi Minh City. Electronics now account for over 30% of Vietnam’s exports, and FIEs contribute more than 90% of the sector’s shipments—evidence of deep integration into global supply chains. Global majors like Samsung, LG, Foxconn, Intel, Pegatron, and Canon anchor industrial zones in Bac Ninh, Bac Giang, and the HCMC–Binh Duong–Dong Nai corridor. This footprint brings scale, supplier ecosystems, and export infrastructure.

Thailand offers a different value proposition. Its electronics and engineering (E&E) base is broad and mature, with manufacturing concentrated in central/eastern provinces (Chonburi, Rayong, Chachoengsao, Samut Prakan) and embedded across both industrial estates (~4,500 factories) and outside zones (~65,000 factories). The sector ranks among Thailand’s top exports; official investment promotion

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data show electronics and engineering (E&E) repeatedly topping new project applications, signaling a sustained pipeline and supportive policies.

Pros include established estates, utilities, logistics, and a dense network of local suppliers and services. Policy tools are concrete: a 250% tax deduction for employer-provided training and sizable Board of Investment (BOI) grants (up to THB 5 million or 50% of training costs). The government's Ignite Thailand plan targets 280,000 workers across semiconductors (80k), EV (150k), and AI (50k) in five years, which is helpful for firms planning higher-tech ramps.

What About the Workforce?

Vietnam gains major points here with a clear “pro” in its demographics. Vietnam's 100.8 million population is relatively young, with a large 15–34 cohort, providing a broad pipeline for factory and technician roles. World Bank data confirm a sizable working-age population base. The cons are mainly talent depth and skills alignment. Despite ~84,000 annual ICT (information communication technology) graduates, only about 35% are industry-ready without retraining, and a 150,000–200,000 engineer shortfall is projected for 2023–2025. That skills gap raises onboarding and training costs, especially for

higher-value processes (advanced SMT, test, failure analysis, NPI).

Though not as generous as those in Thailand, Vietnam is responding with ambitious vocational strategies, such as a national VET (vocational education training) plan, a semiconductor human-resources initiative, and an Investment Support Fund (ISF) that would reimburse up to 50% of training costs for hi-tech firms. Policy momentum is a pro; execution time and institutional capacity are the things to watch.

By contrast, workforce structure and demographics are Thailand's chief “cons.” Thailand has nowhere near the potential workforce numbers that Vietnam can boast, citing an acute skilled labor shortage and an aging workforce population. E&E employment is stable (~750,000), but the skills mix is skewed: ~82% low-skilled, ~16.5% medium-skilled, and only ~1.5% high-skilled. Training is greatly needed to address gaps in digital/advanced manufacturing skills, pressuring wages and hiring cycles, and prompting increased reliance on imported labor.

However, unlike Vietnam, which is still working to create advantageous incentives for foreign companies to invest in its workforce, Thailand offers strong incentives for investment in training and upskilling, with up to a 250% tax deduction. While Thailand's

policy incentives are robust, companies may need to budget for longer upskilling lead times and targeted recruitment strategies to secure engineers, quality specialists, and operations leaders.

Tariff Exposure and Risk Mitigation

Another evolving risk is tariff exposure in the U.S. market. Recent U.S. measures have increased duty risk and scrutiny of rules of origin, with early trade data showing some near-term impact on Vietnam's U.S.-bound exports. Currently, a 40% duty rate is in place for goods identified as being transshipped through Vietnam, in lieu of the 46% reciprocal tariff that is also in place in certain circumstances.

By contrast, Thailand has (at the moment) worked out a proposed 19% U.S. tariff on Thai goods and guaranteed the elimination of its own tariffs on over 10,000 imports from the U.S. also It has committed to streamlining its





arduous customs process and creating investment incentives for certain industry segments, such as clean energy and semiconductors. With a healthy ecosystem of mature electronics manufacturing in place, the incentive for Thailand is there to figure this out sooner rather than later.

Compare and Contrast

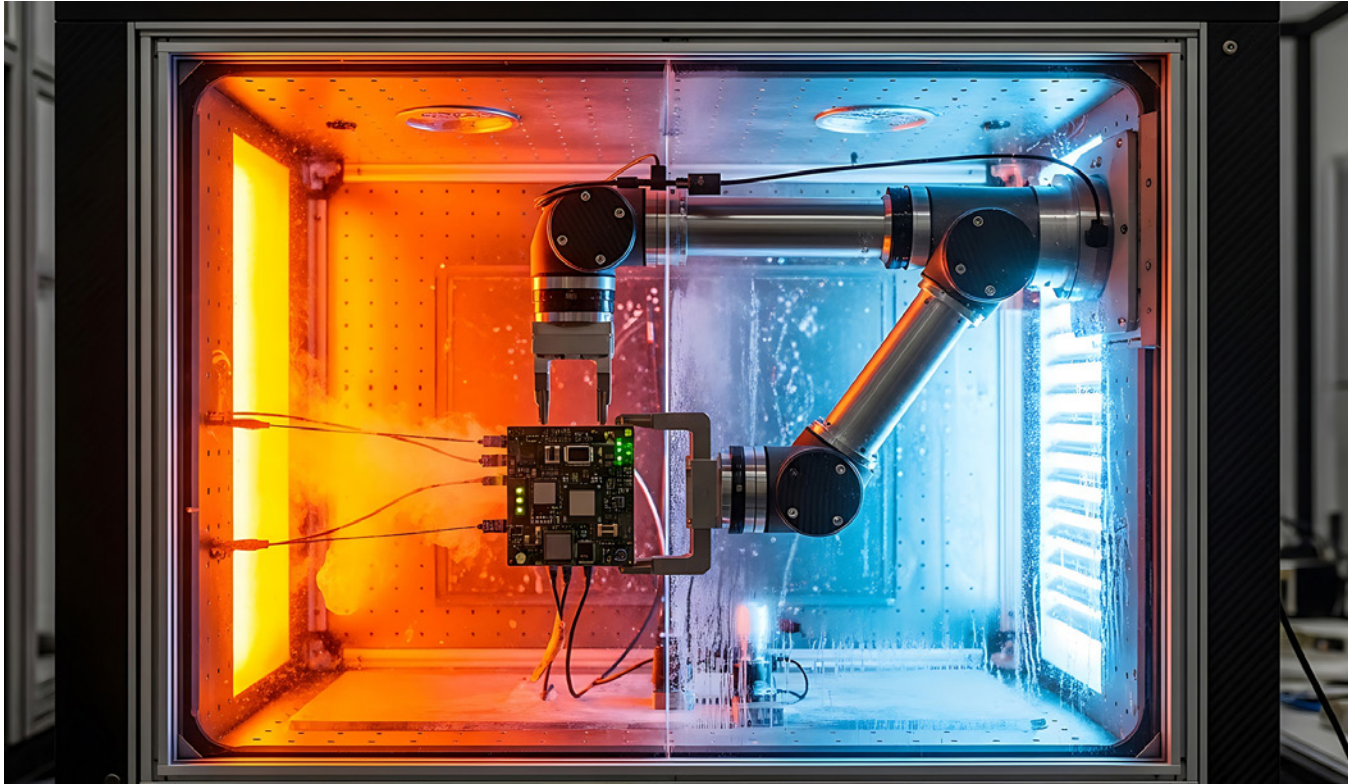
At the end of the day, any business's decision to expand is calculated to maximize its probability of achieving its best market advantage in the long term, but some moves may help you achieve your endgame more quickly than others.

As U.S. electronics manufacturers navigate the complexities of diversifying their supply chains beyond China, both Vietnam and Thailand present compelling opportunities. Vietnam's youthful workforce and rapid rise as a manufacturing hub offer significant appeal, particularly for companies seeking a dynamic labor pool. On the other hand, Thailand's established infrastructure and robust policy incentives for training and investment provide a stable foundation for growth. Ultimately, the choice between these two markets will hinge on individual business strategies, workforce requirements, and the evolving landscape of trade regulations. **PCB007**

Resources

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Pushing Boundaries in Measuring Board **Warpage**



Akrometrix is a key player in metrology equipment. It focuses on accurately assessing warpage and strain in PCBs and PCBA's and prospers through continuing R&D and local sourcing. I recently met with Neil Hubble, president of Akrometrix, and Paul Handler, director of sales, for a tour of their Georgia facility. We discussed the growing challenge of quality measurement for advanced products and denser designs, and the need for industry standardization.

As the demand for smaller and more powerful PCB and interconnect footprints grows, the need for robust quality control has become even more critical. This puts Akrometrix front and center in an industry where its service has, perhaps, been more quietly utilized and appreciated in the past.

Marcy LaRont: Gentlemen, it is great to be here and to tour your facility. Let's start with some his-

tory of the company. What's your core mission, and what problem do you solve for the industry?

Neil Hubble: We came out of Georgia Tech about 30 years ago. As an OEM, we're the industry leader in thermal warpage and strain technology. We build and provide service on a test and measurement tool that physically heats electronics components, mainly surface-mount, that can dynamically measure their shape and shape change as they are exposed to high temperatures, emulating what happens in a reflow oven.

I know that you have some different techniques available to manufacturers that can be incorporated into one of Akrometrix's machines. Paul, tell me about the technology behind this type of metrology.

Paul Handler: As far as applications, our machines measure anything from printed circuit boards to



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components. We deal primarily with OEMs and the top OSATS. That's our core business.

We have three different types of optical measurement techniques. One is our Shadow Moire, which was created and developed within Akrometrix. We're the only manufacturer of this technology. It

uses camera light, glass, and mirrors to reflect the shape of the different things being measured. We measure components or PCB warpage, whether it's at room temperature or under specific thermal conditions.

Another technique is our digital fringe projection, which is used for sudden height changes. It can be used

for components mounted on the boards or a fully populated

board, both at room temperature and under thermal stress, although it's mostly used in thermal applications. It can be localized, and using the fringe technique is mostly application-dependent.

Our third technique is called DIC used to measure CTE, meaning in-strain plane measurement. It involves measuring the thermal expansion of the component or thing being measured. It's a two-camera setup, which allows us to maintain location and so forth. Some of our competitors only use one camera, which we feel does not provide good accuracy.

We talk a lot about thermal properties and how technology is pushing the boundaries of what traditional manufacturing can build. What has changed regarding thermal warpage? Are there new requirements?

Hubble: It always changes and quickly. The industry has faced many challenges over time. Head-in-pillow was a big driver for a long time in the mobile space. One driver that has always existed in electronics is being smaller, thinner, and lighter. That will always be a driver for this industry. How small can you make your features while still keeping them flat enough to have adherence? It's new in that it just keeps getting smaller. It keeps pushing that boundary.

In some cases, it's changed how we test warpage, even against industry standards for package warpage and BGAs. How do we measure the board or component, and from which side do we measure, which can vary from the norm? We've been working with many OEMs and ODMs so that we're all on the same page as they communicate back to their OSATS on how we do the quality control.

The other extreme is large packages. There's so much data in the world these days. AI is a data hog. We have these massive packages that we are, as an industry, trying to put down onto very large server boards. Can these big packages use the same rules for package warpage? How much does the printed circuit board side play into that equation? Frankly, the board side of warpage, in terms of local area, has been somewhat ignored. We've always known it to be a variable, a potential problem, but it's becoming a variable that just can't be ignored.

That is what we see for these packages and the roadmap for where they're headed.

Let's talk about standards. Are they where they need to be?

Hubble: What is there is strong and established, but there is a real need on the board side. There will definitely always be that discussion between the manufacturer and the designer about where that number should be. We know that many manufacturers will need to go beyond any industry standard. But as an industry, there is a significant lack of standards on the board side, and we're currently working with industry leaders to respond to this.

Things change at such a rapid pace now. Roadmaps can be tough to pin down. How do you manage that variable when it comes to creating the standards you operate by?

Hubble: Responding to shifts is part of our company culture. We call it being "quick and nimble." We don't look that far ahead in terms of roadmap because we know the industry demand from our customers will change pretty quickly.

Maybe the biggest change is with these massive components. The challenge is how we can heat these massive components effectively. An important variable in our tool is how to get that heat energy into these large assemblies, just as a reflow



Neil
Hubble

oven does. Our units don't have 13 different zones of convection. We have a single location where the heat energy is generated, and the heat cycles are simulated. Our core technology is around emulating that reflow. We will continue to work with this industry to help establish where the good thresholds are for printed circuit board warpage, especially with surface mount.

Handler: From the PCB side, it's a 25-year-old standard way past due for an update. As Neil said, technologically, we're working in both extremes: very thin miniaturizations as well as large, thick boards. Not enough work has been done on the PC board side of things, so, you never know how the boards will react.

I agree. The more technology pushes the manufacturing envelope, the more important standards become. How are you working with industry associations to improve the standards?

Handler: This is an important technology that will increase in importance, especially with the way AI is developing bigger chips. Bigger is good, but it also creates warpage. Things need to be defined and standardized to better deal with the technology challenges that new and advanced applications are presenting to manufacturers. We are working with the Global Electronics Association in a committee on standards. We are working with the different stakeholders to best define a baseline for manufacturers.

Thank you for your service to the greater industry. It's so important that companies with expertise engage for everyone's benefit. Now let's talk about what you're seeing regarding AI and hardware development.

Hubble: AI is driving much of the new demand. People usually think about AI from a software perspective, but anytime you hit one of those big engines, a massive CPU somewhere is driving it. When we talk about big boards and big chips, we know that AI is driving market growth. I don't think we will be using AI less in the next few years, so we need a lot of these massive servers that must work reliably and over a long period of time. Practically speaking, there is pulling on the solder joints each time a CPU heats up during use. Most of our testing is on the

reflow of the initial assembly, but you can also get into the reliability cycles of temperature.

Both PCB fabricators and contract manufacturers have an installation base for this type of metrology that is often more product-specific or problem-driven. They're having yield issues, or their OEM is aware of the challenges of thermal warpage and will stipulate certain criteria for their suppliers directly, even without industry standards. With AI in play, we expect that requiring some of this testing will become more the norm.

For PCB fabricators specifically, large boards are where we see most of the new demand.

You have the three main techniques that you offer in your machines, and they can be modular. Plus, Akrometrix also offers test as a service. Where does that demand come from?

Handler: We have some customers that have our equipment and still use our test services. Basically, our test services come into play when a company has a product and needs to do a quick analysis or check on a handful of things to make sure that their process is operating correctly and meeting all their requirements.

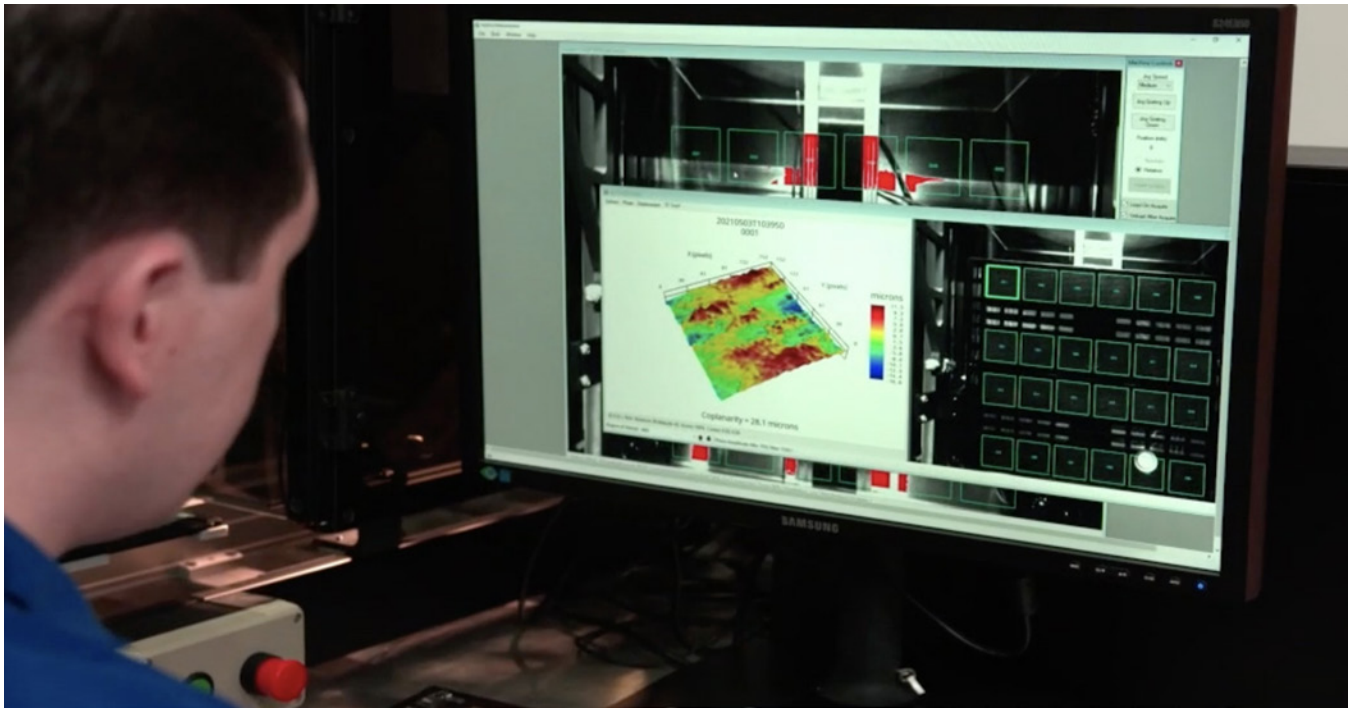
We also do some sampling, even for customers that have our equipment in house. They use us as a sort of gold standard to test against. They're looking for a comparison or a benchmark to tell them that what they think they are seeing is objectively true.

Hubble: Our tools tend to last a very long time, so a lot of times we're comparing products that we run through our tool against a tool that was made 15 years ago. We have to be very mindful of that. We know we can't really compare two different tools and different levels of technology.

Can you take the lead position and educate them about why they're seeing those differences?



Paul
Handler



Handler: That is one of our challenges. We can if they say where they're getting their data from. If they are getting results from five different places and one's not coordinated, they may decide to go out to a test service to decipher what they are really seeing. It could be that the equipment is an older system and incapable, it may be an operator differential, or the samples they provided were at a different moisture level than their other product. There are a lot of potential causes for variation.

It's worth noting that smaller companies usually engage with us for test services. They don't have the opportunity to acquire an Akrometrix tool. They come to us and run a lot of products. We have some customers that do a significant amount of test services with us.

It's good that you can offer that service because, again, I believe that metrology will become a much higher profile issue. Maybe some of those people will end up buying tools.

Handler: Yes, we have some test services customers that do end up buying their own tool.

As I walked through your shop, I saw probably a dozen machines in the process of being built. Supply chain is a huge topic of discussion in the industry for many reasons. Since you do a lot locally, does Akrometrix struggle with supply chain challenges?

Hubble: Of course. Everyone has struggled with that for, say, the past five years. Strategy around dual sourcing is a big part of solving that. Our strategy around almost everything is to buy local. We source right here in Georgia and domestically. We aren't building volume. As a technology company, we don't necessarily have to go to another country to get a slightly cheaper version. That's just not the type of business we're in.

We sell our products internationally. We're in about 22 countries, and in Asia. But we are very homegrown and home-built. Even the cut metals and some of the raw manufacturing we can out-source to locals. We know the people working on it down the road. We can knock on their door if we have to.

Trade show season is nearly upon us. Where will Akrometrix be?

Handler: We just attended SMTA Guadalajara and will be at SMTAI and APEX EXPO, as well as several local shows like IMAPS. We may also have a presence at productronica in November. We are still deciding.

Gentlemen, it was a pleasure walking through your facility, talking to you both, and learning more about this type of metrology and what Akrometrix is up to.

Handler and Hubble: Thank you, Marcy. PCB007

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Electro-Tek: A Williams Family Legacy, Part 2

by **Steve Williams**, The Right Approach Consulting

(Editor's note: Part 2 concludes the story of one of the earliest and most enduring PCB manufacturers in the industry, and completes the story of the Williams family's contribution to moving the industry forward. As discussed in [Part 1](#), the closing of Electro-Tek after 56 years prompted Steve to tell his family's story.)

Smooth Sailing, Rough Waters

After bringing in additional equipment and PCB manufacturing talent, production, quality, and technology were finally coming together and the company was on the rise. But with the burden of the equipment and startup overhead debt, Electro-Tek



▲
Figure 1: Scott, Dad, and Steve in Electro-Tek softball jerseys.

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was still not making a consistent profit, and investors were becoming uneasy (remember the very optimistic business plan?).

Fun Fact #5: Years later, I had the rare opportunity to golf at two of the legendary Kohler courses and stay at the American Club. Sitting in the spa's hot tub and sporting a full beard, many confused employees asked if I needed anything while wondering why current owner Herb Kohler, Jr., was slumming it in the public spa.

Eventually, CSB decided to cut its losses and wanted to close the company in 1970, so my Dad, Chuck Williams, asked Harry if he had any other investors who might be interested in the business. Harry set a meeting with Jerry Klein, an entrepreneur with quite a colorful background. Klein made his fortune during Prohibition, smuggling liquor from Michigan into the Milwaukee area in a custom-built car with fake leather seats that opened to store the cases of liquor. At the end of Prohibition, he opened a company called Midland Plastics. After selling the business and retiring, Jerry was bored and looking for another investment opportunity. He was excited about the upcoming PCB business and bought Electro-Tek. With the equipment overhead now paid off, the business was profitable within six months, and Electro-Tek's reputation and customer base grew exponentially, including landing one of Wisconsin's earliest companies, Kohler, founded in 1873, just 25 years after Wisconsin became a state.

Electro-Tek truly was a family business, with my younger brother Scott working inside sales and my mom Toni running the office (billing, payroll, HR, accounting, and occasionally logistics). She later founded her own company, ALW & Associates, to manage these functions as an outsourced service. Then there's me, kicking off my 49-year (and counting) career in the industry. My sister Becki (the youngest) was the only one smart enough to go straight to college and stay out of the printed circuit board business.

We had frequent employee celebrations, summer picnics, and annual Christmas parties. Electro-Tek was the founding sponsor of our softball team (Figure 1), with our logo and a PCB on the jerseys. Many employees were part of the early roster, and the core of our legendary teams played together for over 40 years and never had a losing season. Dad outlasted us all, playing in his last game at age 67. I retired from baseball at age 55, following the effects of 10 surgeries, and Scott played another few years before hanging it up.

The employees were like an extended family, spending time outside of work together and staying involved in each other's lives. Everyone genuinely enjoyed working together, and my fondness for this family-owned, small-business culture remains to this day.

Integrating Electronics Assembly

During this time, Rex Chain Belt asked Dad to consider building the electronics assembly associated with the PCBs we were providing. Despite not having electronics assembly experience, but seeing the market opportunity to vertically integrate, he agreed. Feeling stretched quite thin, Dad hired one of Louis Allis' colleagues to run this portion of the business, and took over an unused front of the second floor. Using Jerry's plastics expertise, they successfully built their first PCB and assembly enclosure. Word spread, and Generac and Kohler soon placed assembly orders.

The day Dad called on a small company called Electro Measure (EM) in Neenah, Wisconsin, would inexplicably link two industry icons—Chuck Williams and Pete Strandwitz—for over 30 years. Pete was EM's general manager, which was formed to provide electronics inventory management systems via the cash register for liquor dispensing in the restaurant and bar industries. The owner of a prominent local four-star restaurant in Appleton, Wisconsin, had complained to Pete that his bartenders were losing a large part of his liquor sales by “pouring heavy” for tips and buying drinks for friends. He wanted Pete to set up and run a company to produce an automated system to dispense exact volumes of ingredients based on the drink ordered via the cash register.

Leveraging EM's relationships with Cornelius



▲ **Figure 2: The second Electro-Tek facility at 4824 South 10th Street, Milwaukee, Wisconsin.**

Corp., a beverage dispenser, and National Cash Register (NCR), they successfully developed and installed the system throughout the industry, becoming particularly popular with bowling alleys. This was a precursor to the “micro-dosing” medication dispensing technology and Coca-Cola’s Freestyle systems, both of which Dad and I would be intimately involved in later in our careers. Electro-Tek was building all of EM’s circuit boards, and while it was a major customer, EM’s cash flow problems greatly affected Electro-Tek’s receivables. Probably heavily influenced by the amount of money EM owed, the idea was floated that it might make sense to purchase the highly profitable Electro-Tek to provide customers a one-stop shop for PCBs and assembly. Jerry Klein wanted to retire again, so after several months of negotiations, the company was sold.

The new entity’s leadership team, which basically comprised Dad and Pete, wanted Electro-Tek in a more professional facility, so Dad found a company completing construction of a multi-bay facility on 10th Street, south of Layton Avenue in Milwaukee, that allowed him to customize the interior of two bays to accommodate PCB manufacturing (Figure 2).

Everyone agreed it made sense to transfer the Electro-Tek assembly business to EM, which gave it a ready-made PCB customer base needing assembly services, particularly Kohler. As Electro-Tek grew, it brought in more PCB talent and equipment. It was in this facility that we had our first CNC equipment, an Excellon OPIC programmer and Mark IV drill/router.

I remember when the plant manager, who had come from the nearby Delco PCB operation, said, “Steve, come check this out!” In addition to the single-station bottom drills, we had a “quad drill,” which had four spindles manually controlled by an operator following a “roadmap” path in a manually bottom-drilled template. The operator would lower a stylus into a template hole and pull a trigger to initiate the drilling of a single hole in the four stacks of panels. The quad drill and the Excellon both had four stations, each with a spindle that would drill a stack of one to three panels. I saw the juxtaposition of the Excellon drilling 20 cycles in the time it took the quad drill to cycle once (240 holes vs. 12 in three-panel stacks). This was the first of many technology game-changers I was fortunate to be part of over the years. We then published our first four-page brochure featuring many of our employees hard at work.

Adding Design to the Mix

A few major events then happened that would change the landscape of the electronics industry, and the careers of our family. First, EM wanted to create a separate operation for its electronics assembly work and decided on a very creative name: Electronic Assembly Corp. (EAC), which folded in EM. Pete’s vision was always to offer a complete cradle-to-grave solution to customers for product development, design, and manufacture of electronic and electromechanical products, which checked off two of the three services. There was



Figure 3: Excerpts from the first Electro-Tek brochure. Scott (in the left photo), and Steve, sporting his Elvis sideburns, on the right.

a company in the Appleton area designing and installing electronic security systems, and Pete was familiar with the owners. The engineering group, “Technology Group Inc.” (TGI), and as part of EAC, finished the trilogy under Pete’s vision.

Both companies grew in revenue, employees, and technology, with Electro-Tek maintaining its family-oriented, small-company culture.

When Pete wanted to increase the mechanical engineering capability, he approached Norland Corp., in Fort Atkinson, Wisconsin. Norland wanted to break off its mechanical engineering group because it didn’t have a way to market its expertise, and it soon became part of TGI. Dad and Pete believed they needed to create a separate marketing arm to represent EAC, Electro-Tek, TGI, and the Norland Group, so Dad started a marketing office called Sequence near the Milwaukee airport for him and Mom to work from.

In 1979, Pete said he would like to have all these separate entities under the umbrella of a parent company. Like Electro-Tek, that name also became an industry icon: Plexus Corp. Business was growing for all divisions, but Electro-Tek far outpaced the others and was the cash cow keeping Plexus above water. Plexus sold Electro-Tek to Norland because it

needed capital to expand, and Electro-Tek was its most valuable asset. The deal returned the Norland engineering group, along with Electro-Tek, under a strict non-compete agreement. Electro-Tek had outgrown the current two-bay facility in Milwaukee, so Dad found a property about five miles south of the current location, designing and overseeing construction to greenfield the current facility in Oak Creek, Wisconsin—the first of the three Electro-Tek facilities built specifically for PCB manufacturing (Figure 4).

Years later, Dad said he regretted overlooking the proximity to the Delco PCB operations a mile away because Electro-Tek was often their training center, and we could not compete with Delco’s compensation pack-

age. Things ran smoothly until Norland executives decided they wanted someone from their company to oversee operations onsite and installed someone without PCB or manufacturing experience. This

Fun Fact #6: I think we only had one white smock, and had to pass it around to all the employees featured in the brochure.

was not only problematic for the business but also the beginning of the end of the Williams family’s association with Electro-Tek.

While Electro-Tek was doing well, there was constant pressure from Norland to grow the business faster. We all saw the writing on the wall: As with any business or sports team, any new leader at the top wants to put in their own players. First, Norland wanted to do all the bookkeeping and billing at its corporate offices, thus eliminating Mom’s position. I left next for a position with a competitor. Shortly after, Dad was unceremoniously forced out, with Scott following the same day. Not to be undone, and being a bit of an entrepreneur herself, Mom eventually got a degree in sales and marketing and bought a local Dunkin’ Donuts franchise, which she ran for many years, with Scott and Becki working part-time with her while they were in college.



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Figure 4: The third and current Electro-Tek facility at 7745 S. 10th Street, Oak Creek.



I remember getting the call from Dad one day, which was heartbreaking as Electro-Tek was my parents' baby. But remember that little assembly

Fun Fact #7: The last two buildings were coincidentally both located on 10th Street, one in Milwaukee and the other in Oak Creek.

company from many years ago? It had grown into a \$10 million design and contract manufacturer, and Dad soon rejoined his old colleague Pete Strandwitz there and served as vice president and execu-

tive officer of Plexus for the next 20 years until he retired in 2002. Under his marketing and business development guidance, Plexus became an industry juggernaut and is set to break the \$4 billion revenue mark this year.

Where Are They Now?

We recently celebrated Mom and Dad's 89th birthdays and 69th wedding anniversary. They are still traveling the world while having fun with their eight grandchildren and eight great-grandchildren. Scott has followed in Dad's footsteps in business development and is the vice president of a global con-

Executive Officers

▼ Figure 5: The Plexus executive team.



Left to right: **Paul A. Morris**, Vice President, New Business Information Systems Development **Lisa M. Kelley**, Vice President-Finance and Treasurer **J. Robert Kronser**, Vice President, Sales and Marketing **John L. Nussbaum**, President and Chief Operating Officer **Peter Strandwitz**, Chairman and Chief Executive Officer **Charles C. Williams**, Vice President **Thomas B. Sabol**, Senior Vice President and Chief Financial Officer **Dean A. Foate**, Executive Vice President; and President, Plexus Technology Group **Joseph D. Kaufman**, Vice President, Secretary and General Counsel

glomerate with over 50 brands. Becki has spent the past 30 years in director, VP, COO, and CEO positions with various divisions at one of the most prestigious financial services companies in the U.S. As for me, 2026 will mark my 50th year in the business: 22 years in PCB manufacturing leadership, 15 years as the global sourcing commodity manager for Plexus, and the 12th year serving the electronics industry with my consulting business, The Right Approach Consulting. My biggest regret is that my time at Plexus only overlapped with Dad's by a few years before he retired.

Conclusion

When Electro-Tek was founded, there were fewer than 80 PCB shops in North America, many extremely small and now gone. When I entered the industry full-time in 1976, there were over 2,500 shops. We're now approaching a full circle, as today we have under 150 shops. We are very proud that Electro-Tek was one of the early PCB pioneers and survived for almost six decades. Although the family has not been involved with Electro-Tek since the early 1980s, it will always be our family business, and its closing was emotional and bittersweet.

Dad doesn't like it when I compare him to Steve Jobs, but it is hard to overlook the similarities:

- They were visionary entrepreneurs who saw opportunities before others recognized the need
- Neither had a college degree
- They ran their flagship businesses out of their homes
- They created tens of thousands of jobs
- They changed their respective industries, one with technology and the other with love, grit, and determination
- They created companies that stood the test of time
- They were both forced out of the companies they created, only to move on to bigger and better things

That's not bad for two guys with only a high school education. I know I'm biased, but as I often say of Steve Jobs, the world needs more of Chuck Williams. **PCB007**



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

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Highlighting Larry Velie

Editor's note: Dan Feinberg continues his series on the Global Electronics Association Hall of Fame, spotlighting the achievements of past Hall of Fame members.

Many who have contributed significantly to the Global Electronics Association (formerly IPC) and our industry have been awarded the Association's Raymond E. Pritchard Hall of Fame (HOF) Award. Though many early HOF members have passed away and are unknown to today's membership, their contributions still resonate. This special series on Hall of Fame members provides a reminder of who was honored and why. As a bonus, for those who are still around, we get to find out what these talented individuals are up to today.

This month, we're featuring Larry Velie, an outstanding contributor to the electronics industry and printed circuit board manufacturing for almost three decades. In my humble opinion, he is one of the most deserving in the exclusive club of Association Hall of Famers.

Larry was chair of the Technical Activities Executive Committee from 1986 to 1988

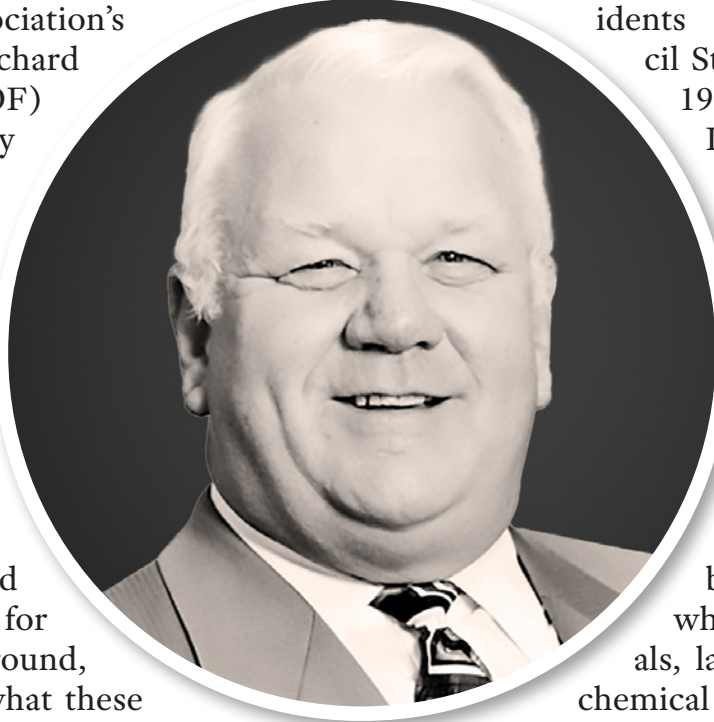
and president of IPC (now the Global Electronics Association) in 1990. He also started and led two round-robin test programs: one studying leading-edge technology and the other looking at and working to improve the reliability of small plated-through-holes. As IPC president, he launched the Designers

Council, formed the PWB Presidents Management Council Steering Committee in 1991, and represented IPC during the formation of the original World Electronics Circuits Council.

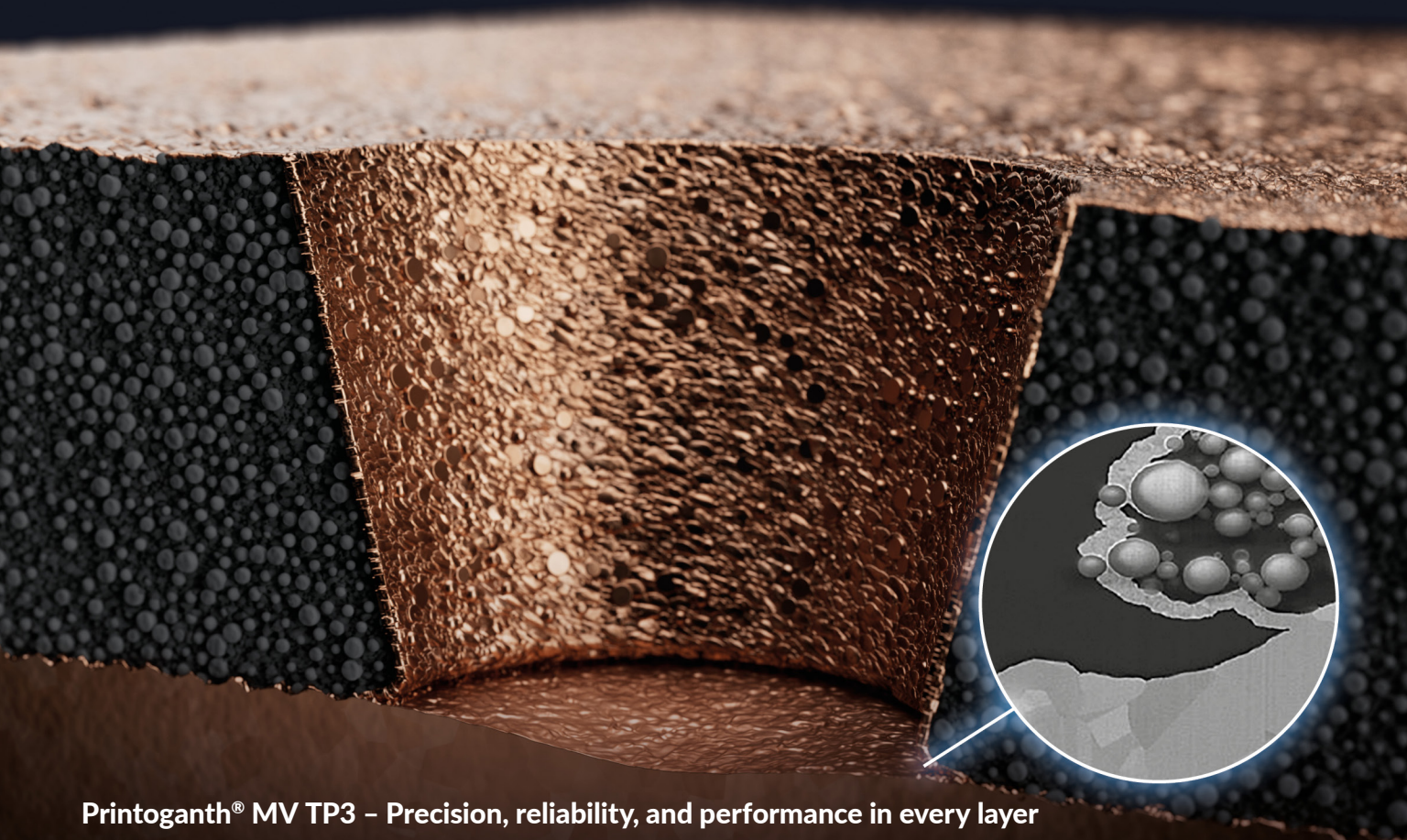
Larry founded Velie Circuits in Costa Mesa, California, in 1982 and was the chief technology officer. Anyone who did business with him—whether raw materials, laminate, or a process chemical supplier to Velie Circuits—quickly learned to respect

Larry's understanding of the processes and materials used to manufacture PCBs. If you wanted to show Velie Circuits a new product, you had to be ready to answer questions in detail and directly to Larry himself.

Process patents were granted in his name, including "Apparatus for depositing solder on PCB terminal pads, controlling thickness," and "Plating high aspect ratio holes in



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HALL OF FAME SPOTLIGHT SERIES



Larry Velie and Dieter Bergman in 1999



Larry Velie presenting the President's Award



1992 meeting featuring past Association President's Award Winners



IPC Leadership (L-R): Ray Pritchard, Thom Dammrich, and Larry Velie, president of IPC

circuits,” in addition to several others where he was named as a contributor or co-inventor. In 1993, Larry was involved in the IPC National Technology Roadmap and was a co-founder of the Technology Research Institute (ITRI).

As a man dedicated to his profession and giving back, Larry invested in our industry's future workforce by providing students or college-bound individuals with a monetary contribution toward a diploma or degree program at a community college, technical school, college, or university. This resulted in the establishment of the Larry N. Velie California Circuits Association Educational Scholarship program.

A long and storied career is not without its hiccups, and Velie Circuits' entry into Chapter 11 in 1996 only catalyzed the company,

bringing it into a strong financial and technical position. Though reticent to talk about certain details, Larry was open and willing to discuss how the company navigated through change management in its way of doing business to create success once again.

Many of us who were highly involved in the Global Electronics Association in its more formative years worked with and became good friends with Larry. He was proud of his company and was always willing to take suppliers, their other customers, students, and just about anyone who was interested, on a tour of his company and an explanation of its manufacturing processes. He was open and willing to offer advice and answer questions, and continued to be interested in new developments and technology in PCB fabrication until the end of his days. **PCB007**

PCB007 TOP 10

Check out these highlights from PCB007.com

Alpha Circuit, Performance by Design: The Future of PCB Manufacturing in the Midwest



For years, Midwest PCB manufacturing was often viewed as a low-cost, high-volume business—good for standard builds but not for the high-reliability programs that demand tight process control. Defense primes and medical OEMs frequently turned to coastal or overseas suppliers for advanced work. That perception is changing.

HDI PCB Market Poised for Explosive Growth, Projected to Hit \$34.23 Billion by 2032

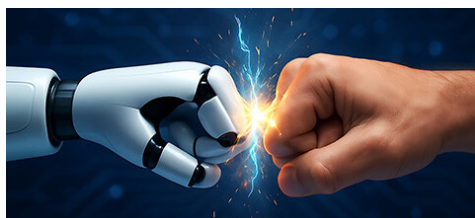
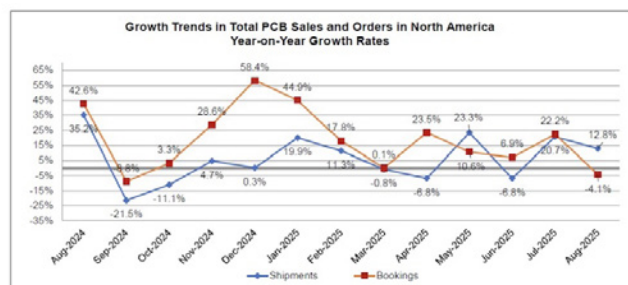
The Global HDI PCB Market is estimated to be valued at USD 19.59 Bn in 2025 and is expected to reach USD 34.23 Bn by 2032, exhibiting a compound annual growth rate (CAGR) of 8.3% from 2025 to 2032. The market for high-density interconnect (HDI) printed circuit boards (PCBs) is rapidly evolving, driven by the demand for smaller, lighter, and higher-performing electronic devices.

It's Only Common Sense: Stop Whining About the Market—Outwork It

Whenever the market hiccups or the industry cycle dips, I hear the same tired chorus: “The market is down. Customers aren’t buying. What can we do? We just have to wait it out.” Nonsense. If you think that by showing up, opening your doors, and waiting for the economy to smile kindly upon you, that success will follow, you are in the wrong business. Worse yet, you’re living in the wrong mindset.

North American PCB Industry Sales Up 12.8% in August

The Global Electronics Association announced the August 2025 findings from its North American Printed Circuit Board (PCB) Statistical Program. The book-to-bill ratio stands at 0.98. Total North American PCB shipments in August 2025 were up 12.8% compared to the same month last year and up 3.3% from July. August’s year-to-date (YTD) shipments increased by 8.3% year-over-year (YOY).



UHDI Technology and Quality 5.0

The convergence of ultra-high density interconnect (UHDI) technology and Quality 5.0 represents a transformative leap in electronics design and manufacturing. UHDI enables extreme miniaturization and enhanced performance, while Quality 5.0 delivers adaptive, intelligent human-centric quality systems. Together, they set the foundation for advanced electronics that are smarter, more resilient, and more sustainable.



PCB West 2025 Showcases Success

For more than 30 years, PCB West has served the PCB and design industries in Silicon Valley, bringing together engineers, fabricators, and designers for technical sessions and networking. Marcy LaRont spoke with show organizer, Mike Buetow of PCBEA at PCB West to learn firsthand about its origins and mission.

The Right Approach: Get Ready for ISO 9001 Version 6

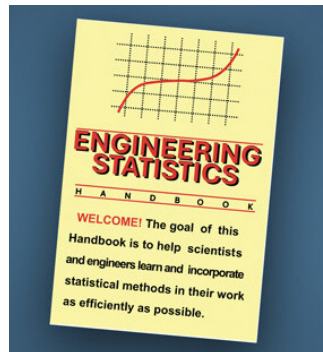


We are well past the normal five to seven years that a new revision of the ISO 9001 international quality standard gets released. It may be finished

toward the end of 2025, with implementation starting in 2026, and there will be as many significant changes as we saw in the current 2015 version.

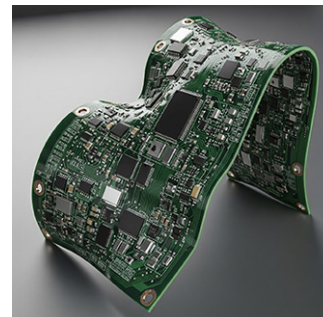
Happy's Tech Talk #43: Engineering Statistics Training With Free Software

In over 50 years as a PCB process engineer, the one skill I acquired in college that has been most beneficial is engineering statistics. Basic statistics was part of my engineering fundamentals classes, but I petitioned the dean to let me take the engineering statistics graduate course because I was creating a senior thesis for my honors focus and needed more training on Design of Experiments (DOE).



Driving Innovation: Mastering Panel Warpage

During the complex and multi-step process of PCB fabrication, a panel's flatness is constantly at risk. A host of factors can introduce warpage, bending, and unevenness, presenting a fundamental challenge to achieving high-precision results. This deformation (sometimes referred to as "bow and twist"), even on a microscopic



scale, can lead to critical defects during subsequent stages, such as component surface mounting (e.g., tombstoning, solder opens) and the PCB's long-term functional reliability.

The primary reasons for warpage are well known.

Connect the Dots: Evolution of PCB Manufacturing—Lamination

When I wrote *The Printed Circuit Designer's Guide to...™ Designing for Reality*, it was not a one-and-done effort. Technology is advancing rapidly. Designing for the reality of PCB manufacturing will continue to evolve. That's why I encourage designers to stay on top of the tools and processes used during production, to ensure their designs capitalize on the capabilities of their manufacturing partner.

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Candidates must have:

- 10+ years in electronics manufacturing
- IPC certification (current or past)
- Bachelor's degree or equivalent
- Strong communication, teaching, and organizational skills
- A practical, problem-solving mindset and commitment to student success

You'll deliver hands-on demonstrations, maintain a positive learning environment, and stay current on industry trends.

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With 24 locations across North America and headquartered in Salem, NH, EPTAC is a leading provider of Electronics Manufacturing Training and Certification. We offer a strong team culture, modern work environment, and benefits including healthcare, PTO, retirement savings, and professional development. Join us in shaping the next generation of electronics professionals!

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Applications and Service Engineer (Field)

atg is seeking an Applications Engineer located in the Chicago area to join their U.S. team to support system installations, customer demos, and ongoing technical service. This role provides pre- and post-sales support, oversees machine setup and calibration, and troubleshoots on-site and remote issues. You'll work closely with customers, engineering teams, and product developers to deliver innovative solutions and influence future system enhancements.

Key Responsibilities:

- Perform software installs, machine setup, and calibrations
- Conduct demos, training, and system buyoffs
- Develop and optimize customer assembly processes
- Troubleshoot and resolve technical issues
- Document procedures and contribute to manuals
- Collaborate cross-functionally to improve products

Qualifications:

- Associate's degree in electrical engineering or related field
- 2–3 years in applications or field service engineering
- Experience in PCB testing or circuit board assembly preferred
- Strong knowledge of electronics, networking, and documentation
- Excellent communication and customer service skills
- Ability to travel up to 50%, domestic and international

Work is hybrid/home-based with travel. Must have valid passport.

Contact Klaus Koziol at
Klaus.Koziol@mycronic.com to apply.

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CAREER OPPORTUNITIES



Various Positions—All levels

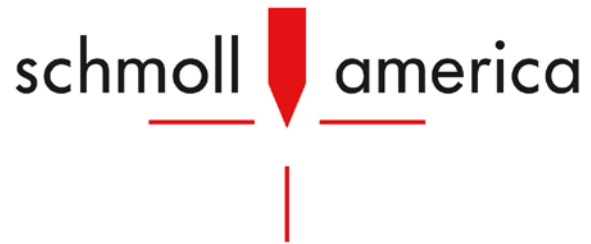
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Ideal candidates have electro-mechanical experience or a degree in engineering, excellent problem-solving skills, and a customer-first mindset. You will work independently and as part of a team to ensure top-tier service.

Responsibilities:

- Install and commission equipment
- Perform preventive maintenance
- Diagnose and resolve technical issues
- Maintain accurate service documentation
- Collaborate with customers and internal teams

Requirements:

- 5+ years in machine maintenance or a 4-year engineering degree
- Strong technical, communication, and interpersonal skills
- Valid driver's license and passport

Benefits:

- \$36–\$38/hour plus overtime and paid travel time
- Bonus potential
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CAREER OPPORTUNITIES



Quality Assurance Specialist—Bare Board PCB Manufacturing

Accurate Circuit Engineering seeks an organized, technically proficient Quality Assurance Specialist dedicated to bare board PCB production. You will champion compliance with industry standards, lead internal audits, manage certifications, and drive continuous improvement based on product performance data and customer feedback.

Key Responsibilities:

- **Standards Compliance & Certification:** Enforce IPCA600, IPC6012 (CIS/CIT preferred), and ISO 9001 quality standards throughout fabrication
- **Internal Process Auditing:** Conduct scheduled and ad hoc audits of incoming materials, fabrication stages, testing protocols (etest, AOI), and documentation traceability
- **Employee Training & Development:** Create and deliver training programs for inspectors and production staff on IPC standards, quality procedures, and inspection tools to maintain certification
- **Failure Analysis & Corrective Actions:** Investigate nonconforming boards—including internal findings and customer returns/RMAs—analyze root causes, and lead corrective/preventive actions (8D/CAPA)
- **Procedure Optimization:** Analyze quality trends and RMA data to update processes, inspection checklists, and control plans

Qualifications:

- Associate degree or equivalent experience in electronics manufacturing
- 3+ years in bare board PCB QA, with IPCA600/ CIS and IPC6012 certification
- Strong auditing, training, documentation, and cross-functional collaboration skills
- Proficient in rootcause failure analysis

Join us to ensure rigorous compliance, elevate fabrication quality, and continuously improve manufacturing standards.

Contact brandon@ace-pcb.com and James@ace-pcb.com to apply.

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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



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

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

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

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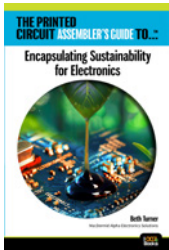
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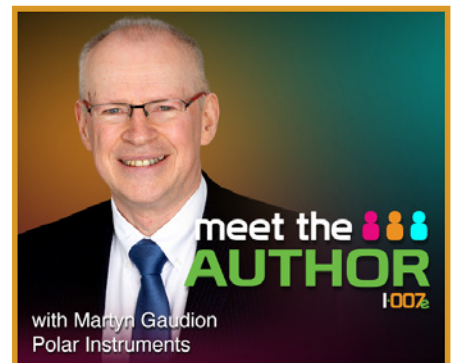


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Problems solved!

The collage features several magazine covers from the SMT007, PCB007, and DESIGN007 series, each highlighting different technical topics and dates:

- SMT007 MARCH 2025:** Features a glowing PCB with the headline "Do You Have X-ray Vision?".
- SMT007 MAY 2025:** Features a PCB with the headline "Intelligent Test and Inspection".
- PCB007 AUGUST 2025:** Features a portrait of a man with the headline "INVENTING THE FUTURE with Dr. Ed Schweitzer, S&P PAGE 10".
- PCB007 SEPTEMBER 2025:** Features a glowing PCB with the headline "Advanced Materials... Advanced Solutions".
- PCB007 OCTOBER 2025:** Features a stack of books with headlines: "Legislation 101", "NEW RULES", "REGULATIONS", "STANDARDS", "ROHS & REACH", "THE ART OF COMPLIANCE", "Policy and Politics", and "Weathering Turbulence".
- DESIGN007 AUGUST 2025:** Features a cityscape with the headline "Proper FLOOR PLANNING".
- DESIGN007 SEPTEMBER 2025:** Features a glowing cityscape with the headline "SIGNAL INTEGRITY".
- DESIGN007 OCTOBER 2025:** Features a glowing bottle with the headline "POWER INTEGRITY".
- SMT007 AUGUST 2025:** Features a cityscape with the headline "main S".
- SMT007 SEPTEMBER 2025:** Features a glowing mandala with the headline "SPOTLIGHT ON INDIA".
- SMT007 OCTOBER 2025:** Features a person working on a tablet with the headline "PRODUCTION SOFTWARE INTEGRATION".

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