APRIL 2025

I-Connect007

PCB007 MAGAZINE

VOICES OF THE INDUSTRY

Long-awaited Threequel

Get the highest quality out of your PCB designs

1007eBooks

PCB007 MAGAZINE

This month, we take the pulse of the PCB industry by sharing insights from leading fabricators and suppliers, getting their thoughts on the new U.S. administration, spending, the war in Ukraine, and their most pressing needs. It's an eye-opening and enlightening look behind the curtain.

INSULECTRO

WORLD-CLASS SUPPORT

Insulectro, the largest distributor in North America of materials used in the manufacture of printed circuit boards and printed electronics, provides game-changing support to our customers.

CALL 949.587.3200 FOR MORE INFORMATION

Welcome to Our Newest Suppliers

EMC
ELITE MATERIAL CO., LTD

For All Your 370HR & 185HR Needs and more

EMC laminates are designed for very complex PCBs, utilizing advanced building blocks from ultra-thin prepregs to highly controlled cores. Examples of applications include "Any-layer" PCBs, mSAP, IC substrate, high layer count (HLC)/ high speed digital (HSD) and radio frequency (RF).

RESIN SYSTEMS FOR PCB LAMINATES

- **EM-827(I)**
- **EM-370(Z)**
- **EM-528**
- **EM-528K**
- **EM-890K(A)**

ARLON
ELECTRONIC MATERIALS

P85HP - Tomorrow's Polyimide Today

Arlon specializes in Polyimide, Low Flow, and CTE-controlled PCB products.

Arlon is recognized for the highest quality standards in the industry and is positioned to support our customers most technological challenges through innovating technologies.

POLYIMIDES SYSTEMS FOR PCBS

- **85N (High Temperture)**
- **85HP (High Performance)**
- **86HP (High Performance)**

PREPREGS FOR RIGID-FLEX & CAVITY PCBS

- **37N (Low Flow Prepreg)**
- **38N (2nd Gen Low-Flow Polyimide Prepreg)**
- **49N (Multifunctional Epoxy Low-Flow Prepreg)**
- **51N (Lead-Free Epoxy Low-Flow Prepreg)**

PCB007 MAGAZINE

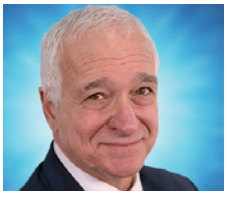
ARTICLES & INTERVIEWS

SHORTS

HIGHLIGHTS

DEPARTMENTS

COLUMNS



pluritec®

Advanced Technology for Printed Circuits Boards

DRILLING - ROUTING
FLASH/BEVEL PANEL PREP
BACKDRILLING - FLIP DRILLING
X-RAY OPTIMIZER
FACTORY 4.0
AUTOMATION SYSTEMS

PUMICE SCRUB
CHEMICAL CLEAN
DEV-ETCH-STRIP
SHADOW
OXIDE/BONDFILM

SPRAY COATING
SOLDER & RESIST
FASTACK OVEN
TUNNEL OVENS
U.V. OVEN

X-CUT

FROM LAMINATION TO
DRILLING IN ONE STEP

D.E.S.

"SMART" ETCHING CONTROL
AND ULTRATHIN 1 MIL
MATERIAL HANDLING

SPRAY COATING OVEN

COAT AND TACK CURE READY FOR
IMAGING IN 20 MINUTES

Can You Hear the Voices?

Marcy's Musings

Column by Marcy LaRont, I-CONNECT007

Tariffs, CapEx spending, the war in Ukraine, and domestic and global economies: I wanted to know what's on your minds as we launch headlong into Q2 2025. So, this month, I'm highlighting industry voices and how they feel about their businesses, the effects of a new U.S. administration, and where technology is heading. We hear from leaders within PCB manufacturing—TTM, CEE, Alpha Circuit, Accurate Circuit Engineering, and NCAB—as well as leadership among their suppliers, including Pluritec, Ventec, and Schmoll America. These contributors discuss a broad range of topics from strategy and growth to being nimble and resilient to creating strength in the supply chain. Their answers provide an enlightening glimpse into where our industry finds itself right now and for the remainder of 2025.

In this month's columns, Happy's Tech Talk #38 continues last month's surface finish discussion with his column on alternate metallization for UHDI. (For more on alternate metallization, I encourage you to revisit our October issue.) Since when is the etch process entertaining? It's been since Don Ball began writing The Chemical Connection. This month, he uses humor, as only Don can, to share some common misperceptions about etchant and etching.

New columnist and topic expert Simon Khesin of Schmoll America discusses PCB registration. Mike Carano enlightens us on plating voids that start in the pre-plating process and offers an insightful discussion on alkaline permanganate. CEE PCB's Tom Yang, who I had the pleasure of meeting for the first time at APEX EXPO, tackles redefining connection and responsibility in a digital transformation. Finally, PCBAA's Shane Whiteside declares

that now is the time for America to reclaim manufacturing leadership with a strong statement on where the industry and the U.S. government need to focus.

Also in this issue, Dan Feinberg continues his Hall of Fame spotlight series focusing on Jack Fisher, who passed away a few years ago but left IPC and our industry with a legacy to build upon. I recount my IPC APEX EXPO show experience and share some great photos of our week in Anaheim. With nearly 80 video interviews, audio interviews, written articles, and photos, make sure to check out our show coverage at www.realtimewith.com.

It's been a crazy, busy couple of months in Washington and the rest of the world. But, says one business leader, "Business is business, and politicians are politicians. In the end, commerce always wins out." I'm not sure truer words could be spoken. As you read the sentiments from today's industry leaders, compare these with your own, and let me know what you think. Are they getting it right? Dive in and find out. **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.

The Rise of Emerging Engineers: Tyler Richards, uFab

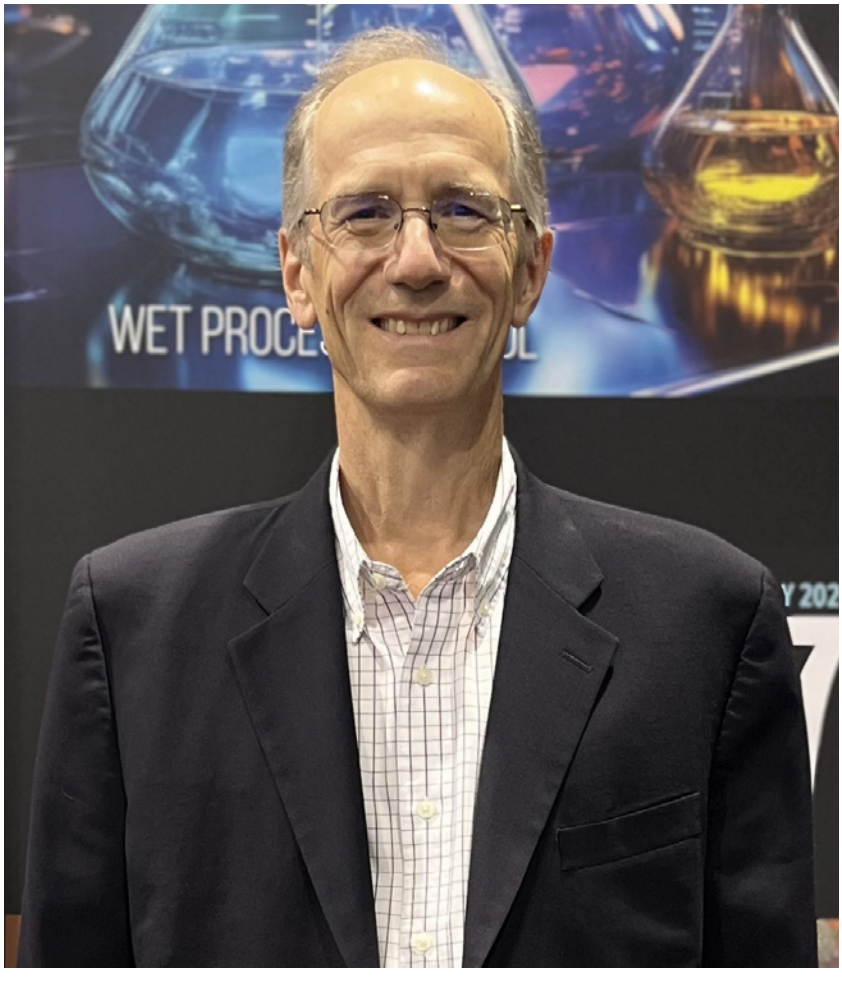
IPC APEX EXPO showcases a lot of new and innovative equipment every year. But it is not every year that one of those groundbreaking innovations is brought by a young engineer under the age of 30. But young Tyler Richards is not your average engineer. Having discovered circuit boards at 18, he is the founder of uFab and the creator of an all-in-one PCB fabrication machine that can provide prototype PCBs in as little as four hours. In this interview, he shares his journey from a passion for electronics to creating a prototyping equipment company. uFab targets customers in higher education, startups, and traditional commercial customers with their equipment.

Navigating Change, Mitigating Risk: We've Been Here Before

Feature Interview by Marcy LaRont
I-CONNECT007

At IPC APEX EXPO 2025, industry leaders gathered to assess the evolving economic landscape influenced by recent political shifts and global trade dynamics, in addition to exploring technology and process innovation.

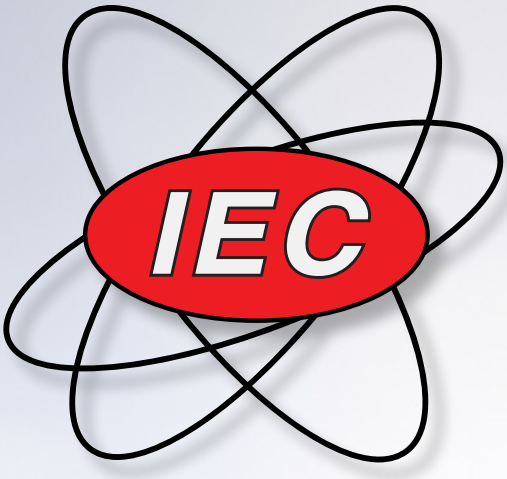
I visited with Tom Edman, president and CEO of TTM Technologies, and chair of the IPC Board of Directors. Tom candidly shares his insights into the implications of changes on the defense sector and the broader electronics manufacturing industry, especially concerning PCB manufacturing. With half of TTM's business tied to defense, Tom discusses the potential opportunities and challenges arising from government initiatives, tariffs, and supply chain complexities. His perspective highlights the importance of adaptability and collaboration with customers to navigate this intricate environment successfully.



Marcy LaRont: Tom, with the almost daily changes in Washington, D.C., what is the state of business for TTM?

Tom Edman: These changes are always interesting. Particularly as a company with almost half of our business in defense, we watch the happenings in Washington very closely. Of course, we think about the potential influence of the changes being made, of which I will highlight just a few.

One is the DOGE effort, which hasn't reached the Department of Defense yet, but it will. As DOGE and other efficiency efforts look at the Pentagon, there are several areas with opportunities for improvement that could benefit everyone. One in



International Electronic Components

ASS automation systems service

rbp

Eternal

atg LUTHER & MAELZER

ROGERS CORPORATION

KODAK

cemco

SIGMA

LAUFFER PRESSEN

DYNACHEM® Automatic Lamination Technologies

SÜSS MicroTec

Nordson MARCH

Echo Graphic

TEKENA

pluritec®

ieccan.com chuck.williams@iecus.com iecus.com

particular is tied to the federal government's purchasing process, which is really challenging today for our global competitiveness. It is something worth addressing.

Many of our customers are major prime contractors to the defense department, so depending on how hard that drive for efficiency is, these contractors may look differently at the choice of whether to outsource or build within their own captive facilities. To the extent that the pendulum swings toward outsourcing, and given our product capabilities, it could be an opportunity for TTM. That's an area that we're watching closely.

Two other potential opportunities for TTM are also worth mentioning. First, the Golden Dome project in the United States, which is planned to focus on missile defense systems, plays right into TTM's strength of radar technology. Second, increased defense spending outside the U.S. will likely have to significantly rely on U.S. prime contractors.

You also have tariffs, which is much more of a mitigation effort. During the first Trump administration, we learned not to panic and to prepare for different scenarios. When you look at imports directly into the U.S from China, TTM is down to about $50 million in revenue over the past year. Mitigating that $50 million from our customer's standpoint is relatively straightforward: Our customer owns the printed circuit board when they bring it into the United States.

That's an important distinction.

Exactly. Their ability to move their shipments to a contract manufacturer outside the U.S. depends on the part or the program.

We also have a superb manufacturing location in Toronto, Canada, with about $50 million of imports directly into the U.S. In this situation, our customers may have fewer options, though we can try to satisfy their needs out of our U.S. locations.

The final area of concern is raw materials. During the first Trump administration, we shifted much of our material supply out of China. Now, on our defense side, we have a little bit of exposure out of Canada that would be difficult to mitigate. That's a cost that we eventually would have to incorporate into our mission systems and pass on to our customers.

Are your customers working actively with you as partners, meaning that this is not your problem, but everyone's problem?

I think that's correct and well said. With our customers, we're addressing it as a mutual challenge that we need to take on, and as I said, they're used to it. For good or bad, in the first administration, we had to run many scenarios, and our customers had to engage in that. We learned together. It's not a daily challenge that we like to see, and it does have a constraining impact on capital expenditures from our customers. But we'll be adaptable, and address the challenge. We've done it before. TTM's footprint is global. We have a significant U.S. presence, as well as in Canada, China, and now Malaysia. So, we already have that supply chain resiliency strategy addressed. There really is no other PCB manufacturer in the world that has this combination of

scale and global footprint, a key differentiator for our customers.

With the Syracuse, New York, facility coming on, we'll be adding more defense capacity in the United States. If future infrastructure projects require it, such as some of the announcements around generative AI in the U.S. have indicated, we will be there to add to that capacity and supply chain capability.

How is the Malaysia facility going?

We are open and booking business. We're anticipating the start of real revenue in Q1, and need to ramp to about a break-even point, which is $30 to $35 million a quarter, by the end of Q3. It is a steep ramp ahead of us, but I was just there and saw that the team is coming together and very focused on yield, which, of course, is the swing factor for volume manufacturing of printed circuit boards.

Are you seeing the benefits of China Plus One?

There has definitely been increasing customer interest. We have four anchor customers in Malaysia. They are our priority in terms of starting up, but we have room for others. We have been talking to and sampling other customers as well. In terms of the original plan, we were a bit delayed getting up and into volume production, but now that we're there, I like what I'm seeing.

Most of the time, when setting up a complex manufacturing facility, schedules can shift. Too many things come up with such a complex facility.

I would say the biggest variable that we ran into was the complexity of what we're building. We're building 16- to 18-layer count boards. That's our average, but we're actually building boards with even higher layer counts. We didn't understand that our customers hadn't audited facilities with that kind of complexity before, so their schedules had to be redefined as they went through that process.

You can only hurry that process along so much.

That's it. It's certainly a learning experience. In Syracuse, we will be working hand in hand with major customers on how to effectively bring up that facility, get things documented, understand thoroughly the audit schedule, and so on.

Let's talk about substrates, and your Advanced Technology facility in Chippewa Falls, Wisconsin.

After we acquired the i3 assets, we moved all our substrate production to Chippewa Falls. The production facility is located in a separate building from our PCB production facility there. We just added significant equipment sets into the substrate facility specifically targeted at getting to customer requirements for substrates as they've shifted over time.

This is a small-volume facility focused on defense requirements, and I'm pleased with our progress there. We have continued to modify and grow that facility as customer demand has started to become much more real.

Now let's talk about your role as chair of the IPC Board of Directors. What can you share?

I've been involved in the organization for about 10 years. IPC has been growing over time, shifting from what has been viewed as a standards organization to a much broader and global representation of electronics manufacturing. I've really enjoyed being part of that.

As the CEO, John Mitchell has done a

MivaTek Global

DART Changes Everything...

Scan: *Measure up to 120 tooling locations in 3s*

Align: *Specialized algorithms for optimal registration*

Control: *Confirm and calibrate feature sizes post etch*

DART
Digitally Adaptive Rasterization Technology

Scan

- High population tooling provides optimal scaling & registration.
- Acquire up to 120 tooling locations in just 3 seconds
- Outer-layer, Sub-lam and soldermask applications
- Rasterize every panel to eliminate variance
- Throughput increasing technology

Align

- **Dart Scan:** Alignment algorithms significantly enhanced by high population tooling
- **Grid Registration:** Separate each drill stage into composite layers for independent alignment
- **Zone Register:** Create as many zones needed within the panel
- **Measure Mode:** Permits the user to perform CMM quality measurement of target positions

Control

- **Feature Size:** Ability to measure features post-etch to digitally compensate during imaging
- **First Article:** Confirm feature sizes post-develop, post-etch or post-plate prior to job processing
- **Process Control:** Systematic DES process control & verification at the operator level. Visual confirmation of clogged nozzle, A/B pressure imbalance

MIVA TECHNOLOGIES

Sub-1 mil UHDI Capability

High Throughput Automation Ready

- **15,6,4, and 1 µm available**
- **SAP proven to 10 µm**

UHDI Direct Imaging

NextGen

- 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.

Configurations Available

- **High Speed:** Up to 7 NextGen Light Engines
- **Flexible:** Mixed resolution systems
- **Automated:** Panel loading or reel-to-reel
- **Standard Format:** 24x30” imageable area
- **Micro Format:** 13x18” imageable area
- **Large Format:** 30x60” up to 48x80”

MivaTek Global, LLC, 6 Dickinson Drive, Suite 218, Chadds Ford, PA 19317 ● Website: www.MivaTek.Global
Contact: Brendan Hogan ● M (610) 620-3795 ● b.hogan@MivaTek.Global

great job of laying out that vision and moving beyond the status quo into so many other areas, whether it's sustainability initiatives or understanding and roadmapping the technology requirements of advanced packaging. These areas are very important to TTM and, ultimately, to our customers. I've loved everything about my involvement in IPC.

Tom, what are the most pressing issues for PCB manufacturers right now?

I'll give you two. First is the changing geopolitical environment and the resulting changes in global footprint requirements. You're dealing with an industry that was 60% in China and is now being asked to move outside of China and take that infrastructure with us. That's a significant challenge from the standpoint of managing your balance sheet, the customer relationships, and even the governmental relationships. There is a lot of strategic effort in really making sure that we're taking the right steps there. So, it's a big one.

The second one is the pace of technology change, which all started with the iPhone. If you think about what Apple drove in terms of innovation in the iPhone that, in turn, drove innovation in printed circuit boards, it is remarkable.

Now we're looking at a world that's being driven by generative AI. Regarding the basic requirements, we are always looking at size, weight, and power. We're now looking at significant shrinkage in circuit requirements while accommodating more components. This is a big challenge and places a big thermal load onto the printed circuit board. Speed requirements continue to increase at the same time. That means new material sets and new processing requirements. It is a pace of change that I haven't seen for a significant period of time. It is very exciting, but certainly, we're looking at technology requirements that are very challenging for the industry.

Will the PCB manufacturing industry become more like semiconductor manufacturing?

There are some similarities. This industry has always been a bit like the Wild West. Depending on where you are in the world, on your supply chain, and on your equipment and manufacturing processes, the variation is tremendous. It is a fascinating industry to be involved with.

If you look at where the semiconductor industry is in terms of process, consistency, equipment, platforms, and use of AI, the trends lend themselves to many facets of the PCB industry. We will use AI and other means to drive more process consistency in our business with some elements that will resemble semiconductor-like processing.

> **"I think 2026 will continue to benefit from technology changes primarily driven by generative AI requirements."**

Tom, what will things look like a year from now?

I think 2026 will continue to benefit from technology changes primarily driven by generative AI requirements.

We will also have learned a lot about the new administration's requirements related to PCB production. We could see significant developments in terms of footprint requirements, not just for PCBs but also for materials. I look forward to sitting down with you a year from now.

Thank you, Tom.

Thank you very much. **PCB007**

IPC BUILD ELECTRONICS BETTER

BUILD KNOWLEDGE. BUILD QUALITY.

BUILD THE FUTURE.

Accelerate onboarding and boost operator skills with a comprehensive training program designed for every stage of PCB fabrication—from inner-layer fabrication and lamination to via fill, drilling, and outer-layer processes.

WHAT'S COVERED

- PCB materials and how they impact performance
- Imaging, etching, and plating processes
- Drilling and routing best practices
- Quality assurance and testing methods

Start Learning Now

IPC EDGE | ELECTRONICS WORKFORCE TRAINING

Highlighting Jack Fisher

Article by Dan Feinberg

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

Many IPC members who have contributed significantly to IPC and our industry have been awarded the IPC Raymond E. Pritchard Hall of Fame (HOF) Award. Though many early HOF members have passed away and are unknown to today's IPC membership, their contributions still resonate. This special series on IPC 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.

John T. (Jack) Fisher, a prominent figure in IPC and a member of the IPC Hall of Fame, passed away a few years ago. After serving in the U.S. Marine Corps for six years and then as a Marine reservist, Jack worked at IBM for 30 years before retiring in 1995. Many industry veterans visited and worked with Jack dur-

all4-PCB®
NORTH AMERICA

Providing Advanced Via-Fill Processing Solutions

MASS
BEING PART

Vertical & Horizonal Via Fill Equipment

pola e massa

Conveyorized Planarizers
Single and Double Sided

SERIA
SERIA CORPORATION

Vacuum Screen Printer for
UHDI Via-Filling Applications

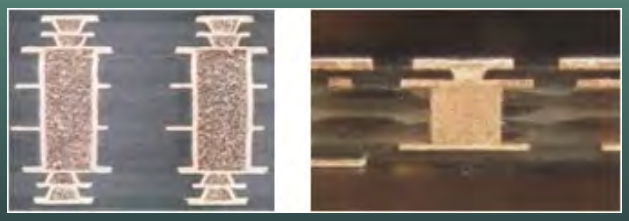
GP
群翊
GROUP

Thermal Curing
Batch, Conveyorized, Vacuum, &
Pressurized Ovens

SAN-EI

High Reliability PHP-Series Non-
Conductive Via-Fill Epoxy
& Gap Fill Material

TATSUTA
ELECTRONIC MATERIALS



Advanced Conductive Via-Fill,
Metallization and Specialized Pastes

YOUR TRUSTED PARTNER FOR INNOVATION, QUALITY,
AND SUPPORT IN THE PCB MARKET!

FOR INQUIRIES, VISIT: WWW.ALL4-PCB.US.

ing his time at IBM. He became well known at IBM as well as within IPC.

After "retiring" from IBM, he continued to work in the industry as part of several consortia groups and became even more well known by those he worked with and those who consulted with him, including industry suppliers such as myself. Recognized for his significant contributions, he was also appreciated for his friendliness and willingness to team up and contribute, in addition to being a strong leader.

His role was pivotal in driving the companies he worked for, targeting their growth and innovation in various sectors, as well as their partnership with their suppliers and the IPC. He became chair of the IPC Roadmap Committee in 2003 and created six different roadmaps, all of which were published and are known worldwide today simply as "IPC Roadmaps." The vital information and resources provided in the IPC Roadmap documents continue to help companies globally as they make strategic decisions for long-range planning.

At IPC, Jack held various positions responsible for overseeing departments and various projects. He received many awards over the years and developed many friendships including with myself. One of his favorite things to do was play golf, which he did often and with many of us, especially when traveling to an industry event. His strategic vision and management style were crucial in steering the company he worked for and IPC toward achieving its goals.

Jack is remembered for his inclusive and forward-thinking leadership style. He encouraged open communication, shared values, and input from all team members, which led to a highly motivated and productive workforce. Jack's goal regarding his involvement at IPC was to continue driving IPC toward new heights and expanding it into new areas. His focus on embracing cutting-edge technologies and maintaining IPC's position as a leader in the industry successfully helped enhance its position in the industry.

Jack's hallmark achievements include:

- Implementing innovative strategies that significantly improved operational efficiency
- Leading major projects that resulted in substantial revenue growth and market expansion
- Fostering a culture of collaboration and continuous improvement within each team he led or was a part of

Jack's tenure at IPC was marked by remarkable achievements and a positive impact on its path and progress. His dedication and expertise inspired those around him and helped pave the way for future success. Those of us who worked with him, who called on him in our work, and who got to know him personally, also considered him a good friend. **PCB007**

Feeling the Future: New Wearable Tech Simulates Realistic Touch

When it comes to haptic feedback, most technologies are limited to simple vibrations. But our skin is loaded with tiny sensors that detect pressure, vibration, stretching and more. Now, Northwestern University engineers have unveiled a new technology that creates precise movements to mimic these complex sensations.

While sitting on the skin, the compact, lightweight, wireless device applies force in any direction to generate a variety of sensations, including vibrations, stretching, pressure, sliding and twisting. The device also can combine sensations and operate fast or slow to simulate a more nuanced, realistic sense of touch.

Powered by a small rechargeable battery, the device uses Bluetooth to wirelessly connect to virtual reality headsets and smartphones. It is also small and efficient, so it could be placed anywhere on the body, combined with other actuators in arrays, or integrated into current wearable electronics.

The researchers envision their device eventually could enhance virtual experiences, help individuals with visual impairments navigate their surroundings, reproduce the feeling of different textures on flat screens for online shopping, provide tactile feedback for remote health care visits and even enable people with hearing impairments to "feel" music.

The study builds on previous work from Rogers' and Huang's labs, in which they designed a programmable array of miniature vibrating actuators to convey a sense of touch.

(Source: Northwestern University)

Choosing the Right Strategic Path

Feature Interview by Marcy LaRont

Tom Yang, CEO of CEE PCB, discusses the current economic challenges, noting reduced purchasing power post-pandemic. He highlights the growing demand for HDI in consumer electronics due to AI growth. Tom also expresses concerns about tariffs under the new U.S. administration, prompting CEE to diversify production locations, including new plants in Southeast Asia. He emphasizes the need for PCB manufacturers to adapt strategically amidst rising costs and fierce competition, particularly for mid-sized shops facing unique challenges in the industry.

Marcy LaRont: Tom, how are you feeling about the state of the economy and the geopolitical and geoeconomic climates?

Tom Yang: We cannot say the economy is an ideal situation. Generally, people are more hesitant to spend due to reduced purchasing power compared to pre-pandemic levels.

The demand for PCBs varies depending on our client base and product lines. One favorable news item is that the HDI market is gaining a larger share with the increasing use of machine learning (ML) computation and data centers spurred by AI growth. These end customers primarily operate in the consumer electronics sector.

Technology-wise, PCBs haven't seen major breakthroughs, but overall, HDI is becoming more widely used in various consumer electronics applications (especially smartphones, computers, and wearables) so there is more demand for HDI PCBs.

INSULECTRO

WORLD-CLASS SUPPLIERS

Insulectro, the largest distributor in North America of materials used in the manufacture of printed circuit boards and printed electronics, salutes our premier suppliers.

CALL 949.587.3200 FOR MORE INFORMATION

InduBond®

REVOLUTIONARY LAMINATING & BONDING TECHNOLOGY

InduBond® has long been respected for tight accuracy in registration, its lamination presses, automation (automatic loading/unloading), and its eco-friendly best practices.

InduBond® X-PRESS lamination presses utilize a different way of producing the heat required for lamination using standard pressing methods.

The innovation of this technology is that it produces heat on the laminated material, and only the laminated material, of each layer of the press pack at the same time, at the same temperature level, without any thermal conduction.

X-PRESS - Inductive heating is the revolutionary new way of PCB laminates

RFX - High-precision (<10 microns) layer-to-layer registration

230N - Next-generation inductive bonding machine

CAC

Proven Performance Partner with InduBond® Presses!
COPPER-ALUMINUM-COPPER & COPPER-STEEL-COPPER
Contact us for more information.

With the new U.S. presidential administration in full swing, what are you most concerned about? How does this play into your business strategy?

The primary concern is definitely tariffs. To prepare for potential new policies, we plan to build a new factory in Southeast Asia and are currently working on our facility in Malaysia.

What if the Trump administration imposes additional tariffs on those countries?

Production costs in Southeast Asia are at least 20% higher than China already. That is a concern and something we are monitoring. If that happens, board shops will have to negotiate with customers to decide whether those extra costs will be covered by the customer or whether it will simply create an even more cutthroat pricing environment and competition between suppliers.

What is your organization doing to be proactive in this challenging global economy and for the benefit of your customers?

The above uncertainty is a major factor in our multi-year planning, pushing us to diversify production locations. To remain competitive and help overseas customers mitigate their risks (e.g., tariffs, supply chain disruptions, and geopolitical tensions, including those in Japan and South Korea) setting up an additional plant in Thailand to shift more of our production capacity outside China will allow us to offer a real comprehensive solution, with higher layer counts, to support our clients and show less reliance on China.

What is the most pressing issue for PCB manufacturers in this age of electronics manufacturing?

The most pressing issue for PCB shops is surviving while choosing the right strategic path. Despite a slight increase in PCB prices due to recent year spikes in copper and gold costs, our bargaining power has been weak because of a surplus of boards prior to that. Generally, board shops are constantly working to cut costs by redesigning products, substituting precious metals without sacrificing quality, adopting high automation, or applying AI in manufacturing processes. This is easier for small factories with less diverse product lines, as they can control costs and risks more effectively than mid-sized shops.

We define mid-sized shops as those with annual turnovers of $150 to $450 million. They lack the agility of small shops and the resources of large giants, leaving them squeezed in the middle. They are more likely to struggle to survive because they must simultaneously attract more customers, reduce costs, invest in technology, and manage overseas factories. In China, a polarization is evident. Small shops thrive by specializing in niche industries, large shops grow through mergers and acquisitions and economies of scale, while mid-sized shops grapple with indecision over their direction.

With fierce price-based competition and thin profit margins, stronger and more profitable board shops will consolidate over time, dropping the number of rivals. This mirrors the consolidation seen in fragmented markets like laptops or electric vehicles, which once had hundreds of brands. The polarization forces mid-sized shops to either scale up or specialize, with few viable middle-ground options.

Tom, thank you for your thoughtful answers. We look forward to learning more about both your factory in Malaysia and what you intend to build in Thailand.

Thank you, Marcy. **PCB007**

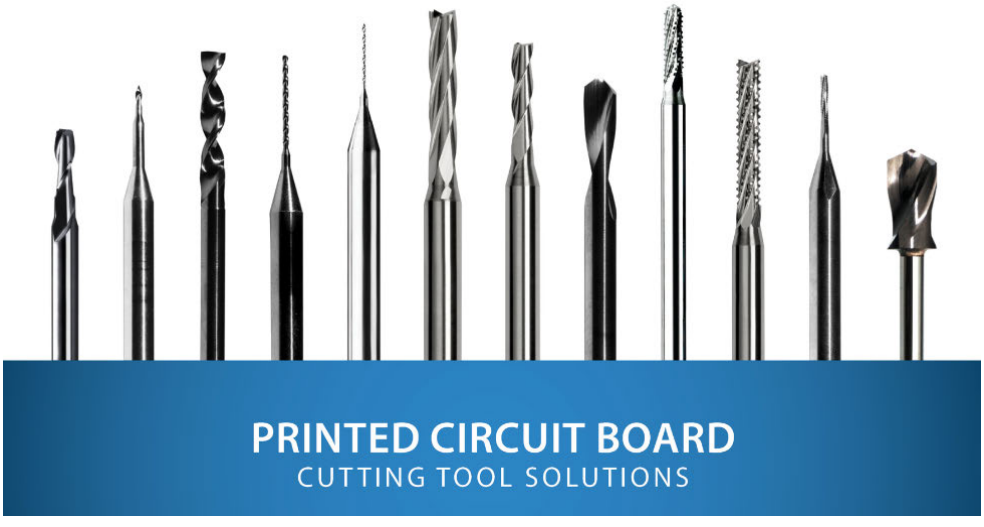
INSULECTRO

WORLD-CLASS TOOLS

Insulectro, the largest distributor in North America of materials used in the manufacture of printed circuit boards and printed electronics, provides game-changing precision cutting tools to our customers.

CALL 949.587.3200 FOR MORE INFORMATION

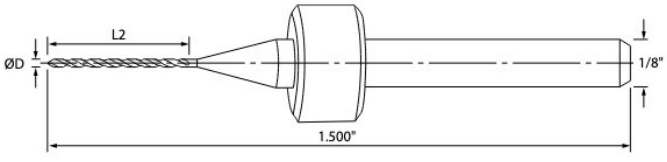
KYOCERA



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

Drills, End Mills, Routers, Specialty Tools

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



4 Facet Point Geometry

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

America, It's Time to Reclaim Manufacturing Leadership

American Made Advocacy

by Shane Whiteside, PCBAA

As an industry veteran of almost 35 years, I've witnessed the alarming contraction of America's microelectronics ecosystem. At the turn of the century, America boasted more than 2,000 printed circuit board manufacturers. Today that number has fallen to less than 150.

Like other microelectronics we invented and perfected, PCB manufacturing was offshored to Asia, which undermined our ability to participate fully in the growing global PCB market. Our steady decline in global market share comes with an additional cost: U.S. PCB manufacturers are increasingly being left behind in adopting the latest equipment and process innovations that are being introduced in Asia. This gradual decoupling challenges our ability to evolve with commercial design trends and will cause further decline in global share if not addressed.

The dominance of PCB manufacturing we see in Asian countries is no accident and didn't happen overnight. It is the result of focused industrial policy over decades. China, South Korea, Malaysia, and Vietnam provided significant government support and private investment followed.

Today as manufacturers explore a China Plus One strategy, countries like Thailand have followed others to add yet one more competitor in the world market.

America's leaders have seen the threat of foreign dependency and have begun to act, with

Innovation + Precision + Reliability

In-house lab available for customer testing

Wet processing equipment for all of your circuit board manufacturing needs, such as:

- Cleaning
- Developing
- Etching
- Stripping
- Conveyorized Plating

To learn more about our lab, contact Chemcut at sales@chemcut.net

CHEMCUT

BOUNDLESS INNOVATION | UNBEATABLE PRECISION

a strong first step in the semiconductor arena. Once policymakers realized that 13% market share in semiconductors was a threat to our national and economic security, a bipartisan consensus emerged to break ground on chip fabs here at home.

Anyone flying into Phoenix recently could not miss the forest of construction cranes as new semiconductor fabs rise from the desert floor. What is conspicuously absent is concurrent work on the rest of the microelectronics ecosystem. If America can manufacture cutting-edge semiconductors, we can also make the next generation of printed circuit boards, IC substrates, and raw and refined materials.

When it comes to creating effective national industrial policy, there are many levers the government can pull to increase American manufacturing. At the moment we're relying on tariffs. As the new administration implements these tariffs, our industry, like many others, is carefully monitoring the effects. When selectively applied, tariffs can be an effective tool to level the playing field.

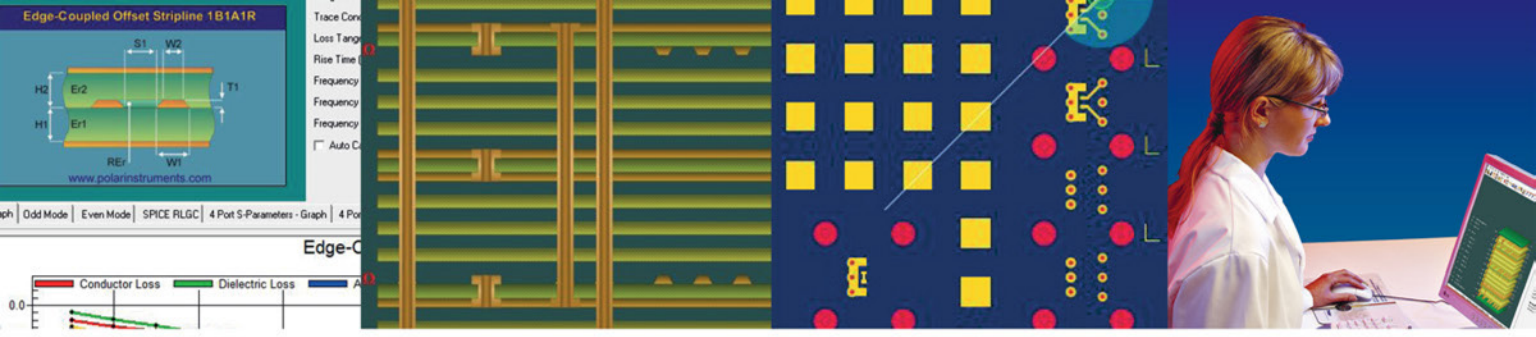
However, tariffs can be changed or repealed by a single political appointee and, therefore, do not always incentivize long-term investment in domestic production.

"... we find ourselves in a situation where we cannot provide the number of PCBs these American-made chips must be attached to."

There is more in the toolkit that Congress and federal agencies can use to promote domestic industry growth. Tax incentives and direct investment provide longer-term, structural benefits to U.S. producers. As we have seen in the case of semiconductor production, government support through the CHIPS Act attracted hundreds of billions of dollars in private investment alongside government money. What the PCB industry needs is the durable demand signal that will generate a stronger investment case for the domestic production of microelectronics. When it comes to Wall Street, Uncle Sam's endorsement is second to none.

The investments being made in semiconductor manufacturing are an important first step but, as PCBAA has said since our founding, "Chips don't float." While the U.S. and other nations are investing in chip production, we find ourselves in a situation where we cannot provide the number of PCBs these American-made chips must be attached to. Having staked our claim for semiconductor production, now is the time to build on that momentum and incentivize the rest of the technology stack and create the demand signal that will reverse decades of decline. **PCB007**

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.



Subscribe to the Polar Instruments YouTube channel for helpful impedance and stackup videos

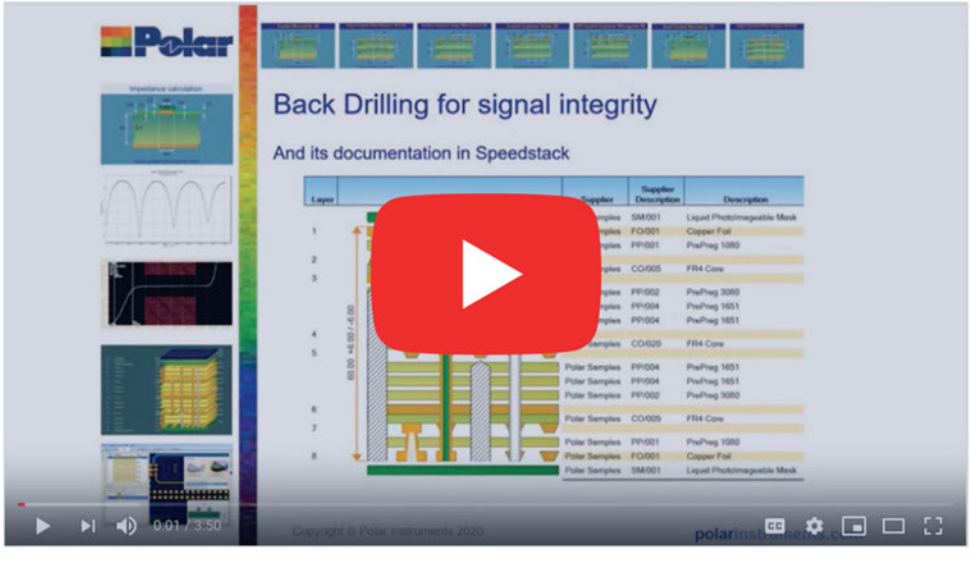
PCB Signal integrity tools for design & fabrication

- Impedance & insertion loss modeling with Si9000e
- PCB stackup design & documentation
- Test systems for controlled impedance & insertion loss
- Application notes on a wide range of Si topics

SUBSCRIBE

Add to your digital library:
The Printed Circuit Designer's Guide to... More Secrets of High-Speed PCBs

DOWNLOAD BOOK



polarinstruments.com

Ensuring a Strong and Reliable Supply Chain

Feature Q&A With Kelly Davidson
NCAB GROUP USA

Kelly Davidson, vice president of NCAB Group USA, discusses the company's stable performance in 2024 and positive outlook for 2025. She highlights NCAB's strategy of organic growth and strategic acquisitions amidst tariff concerns and global political uncertainty. Kelly emphasizes the importance of supply chain diversification, strong supplier relationships, and customer education, and notes NCAB's focus on defense production and maintaining a reliable supply chain.

Marcy LaRont: As we begin Q2 2025, what is the "state of the state" at NCAB?
Kelly Davidson: NCAB's 2024 North American business was more stable than 2023. While Q4 revenue fell just short of our expectations, order income for the quarter exceeded them. Overall, 2024 was solid, and we achieved our goals. I would say we were slightly ahead of the market, but there was still a cautious position from our customers—not knowing what would happen coming out of an election year, concerns about tariffs, and broader global political uncertainty.

For 2025, we are continuing to see a positive trend along with our customers. NCAB USA is gaining market share, consistently winning new customers, with a strong focus on quality and global supply chain diversification initiatives.

How do you see the PCB market evolving in the coming years, and what is NCAB's strategy for growth?

HDI & UHDI

This is Industry's Future – and MEC from UYEMURA is *Already There*

- Etchbond micro-roughening
- Anisotropic etchants
- Flash etchants for SAP
- Differential etchants for mSAP
- Micro via fill

We were surprised... When APEX visitors asked about **C100**, our Contact Plating Process for High Power Applications

C100 Silver graphite dispersion provides excellent conductivity, and resists fretting corrosion, oxidation, vibration, friction *and* high temperatures.

*Could it help with **your** application?*

UYEMURA

www.uyemura.com

Corporate Headquarters:
3990 Concourse, #425 • Ontario, CA 91764 • ph: (909) 466-5635
Tech Center:
240 Town Line Road • Southington, CT 06489 • Ph: (860) 793-4011

Looking ahead, we expect moderate organic growth, but the opportunity for increased investment in acquisitions will present itself this year. With supply chain shifts and tariff concerns, many smaller businesses will struggle to compete. In 2026, we predict stronger growth, possibly double what we anticipate for 2025.

However, the PCB market is dynamic, with increasing demands for advanced technology, supply chain resilience, and cost efficiencies. Our strategy is centered on both organic growth and strategic acquisitions. We are actively looking for strongly aligned, PCB-focused businesses with a quality-first approach to bring into NCAB Group, allowing us to expand our capabilities and strengthen our position in the U.S. market.

When we acquire companies, our main focus is on customers and employees. One of our greatest strengths from this approach has been our high employee retention rate. When we acquire companies, we focus on integrating the teams and providing long-term career stability and opportunity. This approach has been a big part of our success. For customers, this strategy translates into increased buying power, stronger supplier relationships, and enhanced technical expertise—making us an even stronger partner in the industry.

With a new U.S. administration, what are you paying close attention to? How does this weigh into your strategy over the next few years?

Tariffs are a major concern. Many of our customers are waiting to see what happens, particularly with potential tariff increases on products from China as well as other global trade policies. This is influencing the industry in numerous ways, and we are closely monitoring these developments.

Given the current political climate, diversification of the supply chain and developing strong relationships with our suppliers have become a key part of our strategic planning. We are investing significant resources in sourcing activities in Thailand, South Korea, Taiwan, Singapore, etc., and strengthening partnerships to ensure pricing stability, quality predictability, and a stable supply chain for our customers.

We are proactively negotiating and setting baseline pricing while weighing country-to-country costs, with and without tariffs, to ensure financial sense while mitigating supply chain risks. Additionally, we remain focused on educating our customers on new technologies and alternative production solutions outside China and the U.S.

Defense production is also a growing focus. Should domestic capacity for defense-related manufacturing become more constrained, we are ensuring that we have additional sourcing capacity as well as viable export control-compliant production options outside of the United States. NCAB USA has several Technical Assistance Agreements (TAAs) with specifically vetted and approved factories in Taiwan for some ITAR/Export Controlled production. These TAAs are approved and overseen by the U.S. Department of State. In fact, our recent public webinar on these capabilities had the largest turnout of any webinar to date, showing how top-of-mind this is for our customers.

What is NCAB doing to be proactive in this challenging economy for the benefit of your customers?

We develop strong relationships at all levels, deeply understanding customer needs and going the extra mile to exceed expectations.

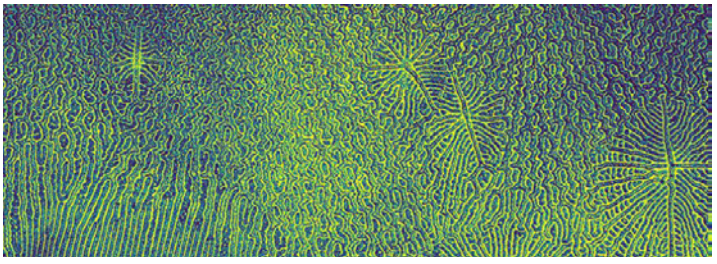
We have been developing strategic partnerships with like-minded customer partners where we support them throughout all levels of their PCB business as trusted partners and advisors. Business is conducted between people where trust is built daily. The strong relationships we develop and the personal service we provide make all the difference in these challenging times.

We are emphasizing supply chain diversification, logistics opportunities, and inventory management—ensuring that we are smart about sourcing and purchasing practices. Rather than NCAB or our customers funding and holding excessive inventory, we negotiate with our supply partners to maintain pricing stability and optimize delivery schedules, ensuring a reliable supply chain without incurring unnecessary costs.

Additionally, our technical team is a major differentiator, offering support that many of our competitors cannot. We invest heavily in PCB design education to support our customers, ensuring we are involved in the early phases of PCB design. This helps customers design for manufacturability, cost efficiency, quality, and sustainability—both in terms of product longevity and supply chain resilience.

By staying proactive in these areas, we position ourselves as a trusted partner for our customers, helping them navigate economic uncertainties while maintaining a strong and reliable supply chain. **PCB007**

Spinning, Twisted Light Could Power Next-generation Electronics



Researchers have advanced a decades-old challenge in the field of organic semiconductors, opening new possibilities for the future of electronics.

The researchers, led by the University of Cambridge and the Eindhoven University of Technology, have created an organic semiconductor that forces electrons to move in a spiral pattern, which could improve the efficiency of OLED displays in television and smartphone screens, or power next-generation computing technologies such as spintronics and quantum computing.

The semiconductor they developed emits circularly polarised light—meaning the light carries information about the 'handedness' of electrons. The internal structure of most inorganic semiconductors, like silicon, is symmetrical, meaning electrons move through them without any preferred direction.

But by using molecular design tricks inspired by nature, the researchers created a chiral semiconductor by nudging stacks of semiconducting molecules to form ordered right-handed or left-handed spiral columns. Their results are reported in the journal Science.

One promising application for chiral semiconductors is in display technology. Current displays often waste a significant amount of energy due to the way screens filter light. The chiral semiconductor developed by the researchers naturally emits light in a way that could reduce these losses, making screens brighter and more energy-efficient.

The semiconductor is based on a material called triazatruxene (TAT) that self-assembles into a helical stack, allowing electrons to spiral along its structure, like the thread of a screw.

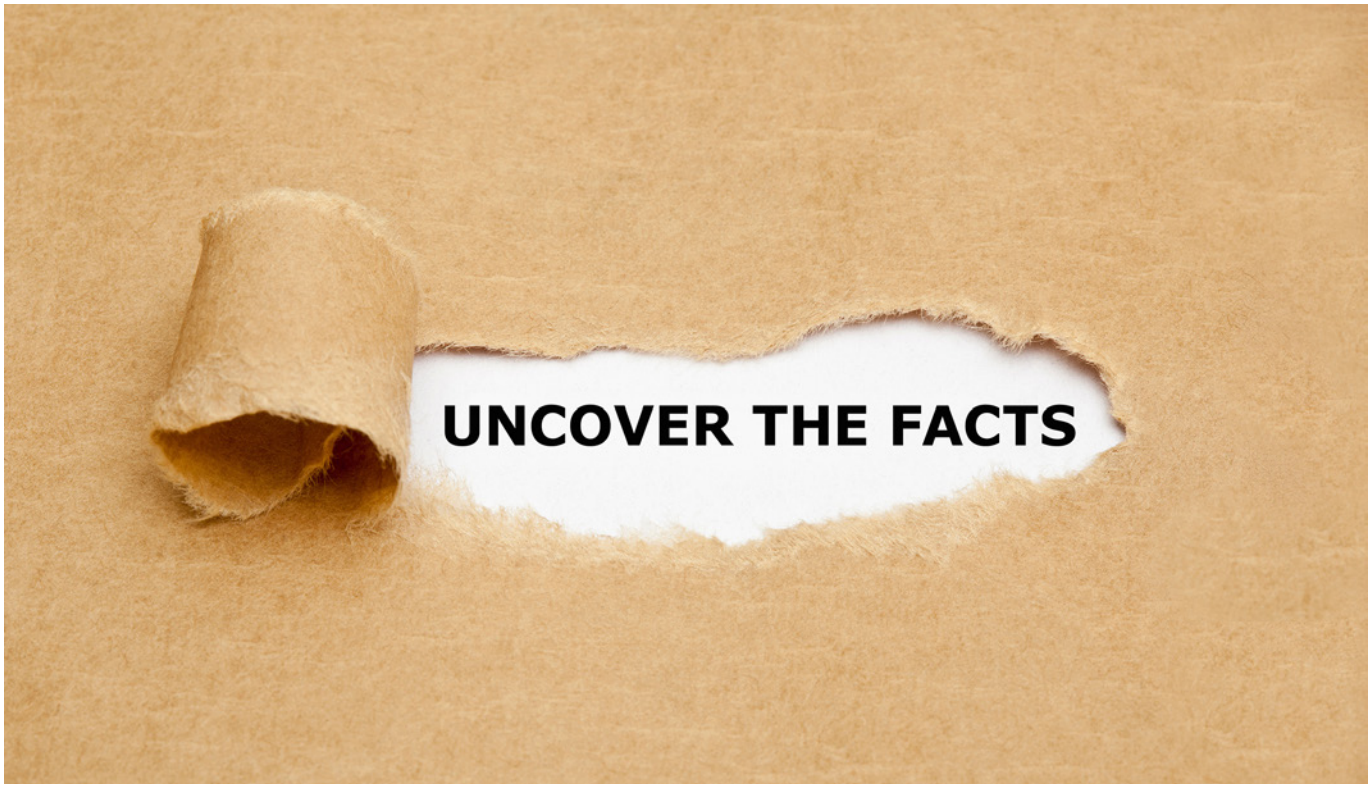
"When excited by blue or ultraviolet light, self-assembled TAT emits bright green light with strong circular polarisation—an effect that has been difficult to achieve in semiconductors until now," said co-first author Marco Preuss, from the Eindhoven University of Technology. "The structure of TAT allows electrons to move efficiently while affecting how light is emitted."

(Source: University of Cambridge)

Common Misconceptions in Wet Processing

The Chemical Connection

Feature Column by Don Ball, CHEMCUT



Initially, I thought an April Fool's column would be fun this month. I could highlight some of the crazier ideas and misconceptions I've witnessed over the years from potential customers and we could all have a good laugh. For example, there was a first-time buyer of a ferric chloride etcher (with no regeneration system) who was astonished to learn that he had to put fresh etchant in the system occasionally to maintain production.

Upon further reflection, I realized that a column that makes fun of one's potential customers might not be a particularly astute move. However, thinking about the misconception that the ferric chloride etcher would last forever made me realize there are many common misconceptions about etching and wet processing, which would make for a more worthwhile column.

One common misconception is that changing to a different etch chemistry will change the overall etch uniformity of the system being used. Some etch parameters, such as etch rate or etch factor, may change, but the etch profile across the width of the panel will not. Those areas that etch a little more or a little less than others on the panel will still etch a little faster or slower in the same places and with the same proportions, no matter the etchant. For a variety of reasons, the most common change is

Orbotech Neos™ Series

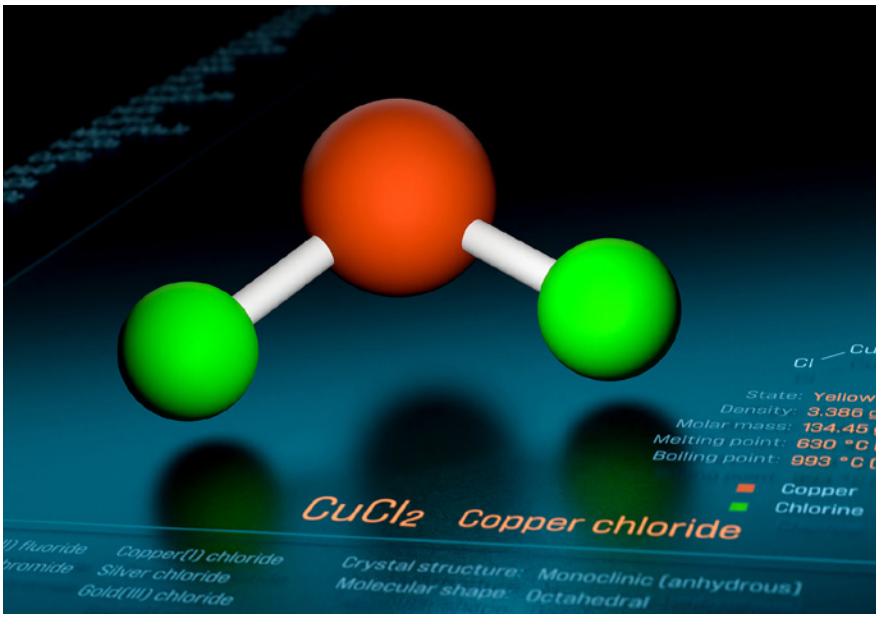
Field-Proven Inkjet Solution for Solder Mask

- Faster, Streamlined Operation
- Reduced Waste
- Lower Cost of Ownership

DotStream Pro Technology

Structural Printing Technology

For further information, please contact the KLA inkjet team
inkjet.info@kla.com | www.kla.com



from acidic cupric chloride to alkaline cupric chloride (alkaline etch). One may expect double the etch rate and better etch factors (although not necessarily), but not a smoother etch profile. This is more dependent on the physical rather than the chemical parameters of the etcher setup. There are reasons one might contemplate changing etch chemistries but getting a better etch uniformity should not be one of them.

Etch factors (the ratio of downward etch to sideways etch, or how straight the sidewalls are) have become more important with the trend toward narrower lines and spaces. Ideas to improve etch factors abound, but here are some of the more common misconceptions that are worth keeping in mind, as they could save you time.

Ferric vs. Cupric

An early misconception was that etching copper with ferric chloride produced better etch factors than cupric chloride. Early on, almost all circuit boards etched copper using ferric chloride because that's how it had always been done. As circuit board production increased logarithmically in the early years, most manufacturers switched to cupric as the etchant of choice because it could be regenerated, maintaining a constant etch rate and greatly reducing disposal costs. Almost immediately, the issue of which etchant provided the best etch factor was raised and still comes up in discussions today. However, in the mid-1990s, extensive design-of-experiment testing with a manufacturer of lead frames made it clear there was no difference in etch factor between the two. Later tests with circuit boards confirmed this. Sorry guys, simply switching to ferric chloride for your etch factor-critical boards will not solve your problem.

Fan vs. Cone Nozzles

Another misconception almost as old as the industry is that using fan nozzles rather than cone nozzles to deliver the etchant to the board surface results in better etch factors. Again, the lead frame tests showed no difference between the two nozzles. A test using fan nozzles to etch from the top and cones from the bottom revealed no difference in etch factor, either visually or microscopically. Again, sorry, but simply switching to a different nozzle won't solve your etch factor problem.

Is Alkaline Etchant Better?

While not a misconception, the idea that alkaline etchant will automatically improve your etch factor is not always true. You must run at the lowest pH possible, the highest specific gravity possible within the suggested range, and use a minimum ammonium chloride-to-copper ratio: 2 moles NH4Cl/mole Cu (typical chloride-to-copper ratio is 2.4 to 2.5: 1). This provides the best etch factor but also the slowest etch rate. As you raise the pH and lower the specific gravity to increase etch rate, you lower the etch factor until it is possible to have an etch factor as low as 1:1 (etching as fast sideways as downward). So, you do get a better etch factor with alkaline etch, but it's not automatic.

This lack of understanding occurred when we replaced an ancient alkaline etcher from a competitor at a company. We immediately received complaints that low etch factors on the new etcher were causing problems. We visited the company and discovered they had two major customers: one with boards with PTFE substrates, the other with normal fiberglass substrates that needed straighter etched sidewalls for whatever frequency those boards were controlling.

When the etchant was configured for the best etch factor (pH 8.0), the other customer's boards had a grayish coating left on the PTFE substrates. When they adjusted the etchant so as not to leave a coating on the PTFE after etching (pH 8.3), the etch factors were too low to pass specifications for the other customer's boards.

When I tried to explain this, I was told, "We never had this problem on the old etcher." The process engineer for the etchant supplier was called in and agreed with my analysis (a pleasant surprise). Again, we were told, "We never had this problem on the old etcher." We were both familiar with the old etcher and neither of us could see why it would get better etch factors than the new etcher. The problem was eventually solved by adding a mild acid rinse to the line to take care of the gray residue on the PTFE substrates. I later learned the reason they had never had a problem with the old etcher was because they never checked etch factors until they received the new etcher.

There are many more misconceptions about etching and other wet processing steps, but these are the ones I hear about repeatedly. **PCB007**

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

Redefining Connection and Responsibility in Digital Transformation

Global Citizenship

by Tom Yang, CEE PCB

The fusion of technology and global citizenship has fostered unprecedented collaboration and exchange. Digital tools offer new ways to connect but also challenges that require a mindful and ethical approach. While these technologies bridge gaps, enhance inclusivity, and encourage cross-cultural understanding, we must also consider the accompanying ethical responsibilities.

Digital tools allow businesses and individuals around the globe to collaborate seamlessly through a variety of tools, including videoconferencing, collaborative software, and project management platforms. This has proven transformative, particularly in education and professional development. For example, online courses allow individuals in remote areas to access high-quality education, while freelance marketplaces open up job opportunities worldwide.

Global collaboration also fosters a sense of inclusivity. Products, policies, and strategies benefit from the diverse perspectives shared on online forums. This strengthens cultural exchange and diversity and can offer comprehensive solutions to global challenges. Digital inclusivity provides for unique perspectives, making products and services that reflect diverse user bases.

Artificial intelligence (AI) has become a

Your customers require the best, so manufacture with the best.

WONDERWISE

- Alternative copper surface treatment
- Highly effective
- Cost-efficient/chemical-free

TiTAN HYBRID SYSTEMS

- Combined LED/LASER printing
- Fast print speeds on all resist types
- Best in class printing on solder mask

VCP-PAL

- Excellent plating distribution/through hole plating/via filling
- Consistent panel-to-panel plating quality
- Capable of panel, pattern and other plating processes

SLR 608 L/UL

- World leader in automation solutions
- Highest competency in process and software integration
- Factory trained U.S. service and parts

TECHNICA, U.S.A.

technica.com

CELEBRATING 40 YEARS

foundation for businesses and organizations seeking to understand and predict global consumer behavior. By analyzing large data sets, AI can help businesses customize their offerings to different cultural groups. From e-commerce to entertainment, AI algorithms personalize user experiences and help companies keep track of diverse consumer bases. For example, streaming apps like TikTok use AI to recommend content that resonates with individuals, but also adjust these algorithms for different countries based on local trends and preferences. This has enabled companies to reach wider audiences, creating a truly global impact. However, AI also raises ethical questions and privacy issues.

Social media has become a key driver of global citizenship, offering platforms for dialogue across cultures, with organizations, activists, and influencers using them to engage with audiences around the world. The ability of social media to amplify overlooked voices makes it valuable for inclusivity and social change.

Social media can also engage diverse audiences simultaneously. Campaigns like #ClimateAction have gained global traction because they resonate across borders. Social media platforms also enable people to learn about environmental issues, which fosters empathy and global responsibility. However, social media companies have a responsibility to prevent misinformation and respect user privacy, which is an ongoing challenge. Every online click and interaction generates data that is valuable to businesses but potentially invasive to individual privacy. Global citizenship in the digital age requires an ethical approach to data collection and analysis. Companies must take responsibility for how they gather, store, and use consumer data while still respecting individuals' rights and privacy.

The EU's General Data Protection Regulation (GDPR) is designed to protect data privacy. It has set a global standard, influencing other countries to adopt similar regulations. However, the challenge is how to balance using data for innovation while still respecting users' privacy. Individuals are demanding transparency and accountability from organizations. For businesses and organizations committed to ethical practices, respecting data privacy is not only a legal obligation; it's essential to building trust with global audiences.

Despite the promise of digital transformation, access to technology remains unequal. Billions worldwide still lack internet access or digital tools, especially those in low-income regions where infrastructure and resources are limited. For global citizenship to be fully inclusive, we must address these digital divides.

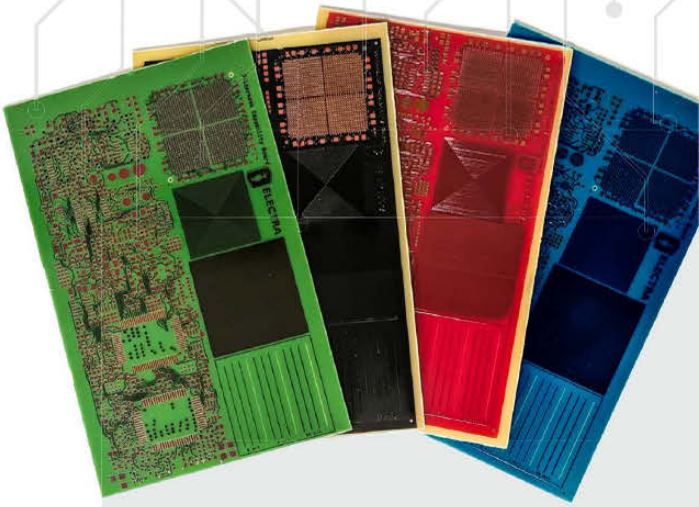
Governments, organizations, and tech companies are taking steps to address these gaps. However, achieving digital equity requires building sustainable infrastructure, fostering local tech ecosystems, and ensuring affordability. Only by dissolving these disparities can we create a digital landscape of inclusivity and equality, which is the core of global citizenship.

The World Health Organization's (WHO) use of digital tools during the COVID-19 pandemic demonstrates the power of digi-

ELECTRA

ElectraJet® EMJ110 Inkjet Soldermask

PCB Manufacturing with Proven Performance



ElectraJet® EMJ110 is the market-leading inkjet soldermask, delivering unmatched quality, robustness and reliability. Designed for modern PCB production, EMJ110 provides a streamlined, sustainable, and cost-effective solution for high-performance applications.

Available in Four Vibrant Colours:

- Green
- Black
- Blue
- Red

We Also Offer Flexible Soldermask:

- Green
- Amber

Key Features/Highlights

High Performance

- EMJ110 designed to meet all key performance criteria
  - IPC SM840, UL-94 V-0, no SVHCs, thermal cycling and heat storage

Robust Formulation

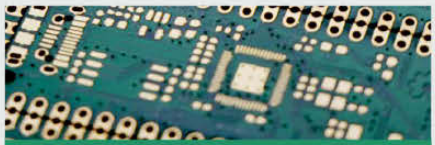
- Ink stable under a range of temperatures and environmental conditions
- No change in ink viscosity or particle size during use or shelf life of product
- Ink robustness critical for ensuring consistent printing with minimal problems
- Approved for use on leading inkjet printheads:
  - Konica Minolta – KM1024iMHE
  - Konica Minolta – KM1024iSHE
  - Konica Minolta – KM1800i
  - FUJIFILM Dimatix – Samba®

Reliability

- Waveform designed to reduce print quality defects
- Formulated to ensure high reliability jetting
- Minimal tool downtime during operation

Why Choose ElectraJet® EMJ110?

- **Proven Production Formulation** – Commercialised since 2019, extensively validated in real-world manufacturing.
- **Market Leader** – Electra is the global leader in inkjet soldermask, trusted by top PCB manufacturers worldwide.
- **Largest supplier** – Largest supplier of inkjet soldermask globally.
- **High-Performance & Reliable** – Meets strict automotive specifications, including high-temperature storage and thermal cycling.
- **Culmination of over 10 years of Innovation** – Developed through a decade of dedicated R&D in inkjet soldermask technology.
- **Eco-Friendly Solution** – Supports sustainable PCB manufacturing with reduced waste and material efficiency.



Join the Future of Soldermask Technology

Experience the benefits of ElectraJet® EMJ110 and take your PCB manufacturing to the next level.

Contact us today to learn more!

Info@electrapolymers.com | electrapolymers.com

tal transformation to create a global impact. Through social media, online portals, and data analysis, they provided real-time updates, debunked misinformation, and coordinated efforts to distribute medical resources globally, which saved lives.

Another example is IBM's blockchain technology to improve transparency in supply chains. IBM and its partners can track products from origin to consumer, ensuring ethical sourcing and reducing the risk of fraud, exemplifying how technology can enhance ethical practices. This benefits consumers and the environment.

These examples underscore how digital tools can extend the principles of global citizenship—such as transparency, responsibility, and inclusivity—into practical applications with far-reaching impact. As more organizations adopt digital transformation strategies, the potential for positive global change grows, but so does the need for ethical vigilance. AI, for instance, offers the potential to solve global problems, but also comes with risks as the biases inherent in AI algorithms can be discriminatory. In addition, the proliferation of surveillance technologies raises privacy concerns.

To navigate these ethical complexities, organizations must adopt frameworks that guide responsible innovation. For example, Google's AI ethics board, though short-lived, understood the need for accountability. Companies can also prioritize ethical principles by involving different voices in decision-making processes.

The balance between innovation and ethics also extends to environmental responsibility. Digital transformation has a significant carbon footprint. Data centers, cloud computing, and digital devices use a lot of energy, so individuals and organizations must consider the sustainability of their tech practices, adopt energy-efficient solutions, and reduce digital waste.

True global citizenship in the digital age goes beyond leveraging technology for convenience or profit. It calls for thoughtful engagement and awareness of our collective responsibility to the planet. By balancing innovation and ethics, we can foster a digital landscape that benefits all while upholding the inclusivity, empathy, and respect that define true global citizenship. **PCB007**

Tom Yang is CEO of CEE PCB. To read past columns, click here.

NEW ISSUE

IPC BUILD ELECTRONICS BETTER

Community MAGAZINE

SPRING 2025

LOOK INSIDE

IPC BUILD ELECTRONICS BETTER

Contact us to become an advertiser

Be Nimble, Quick, and Open to Change

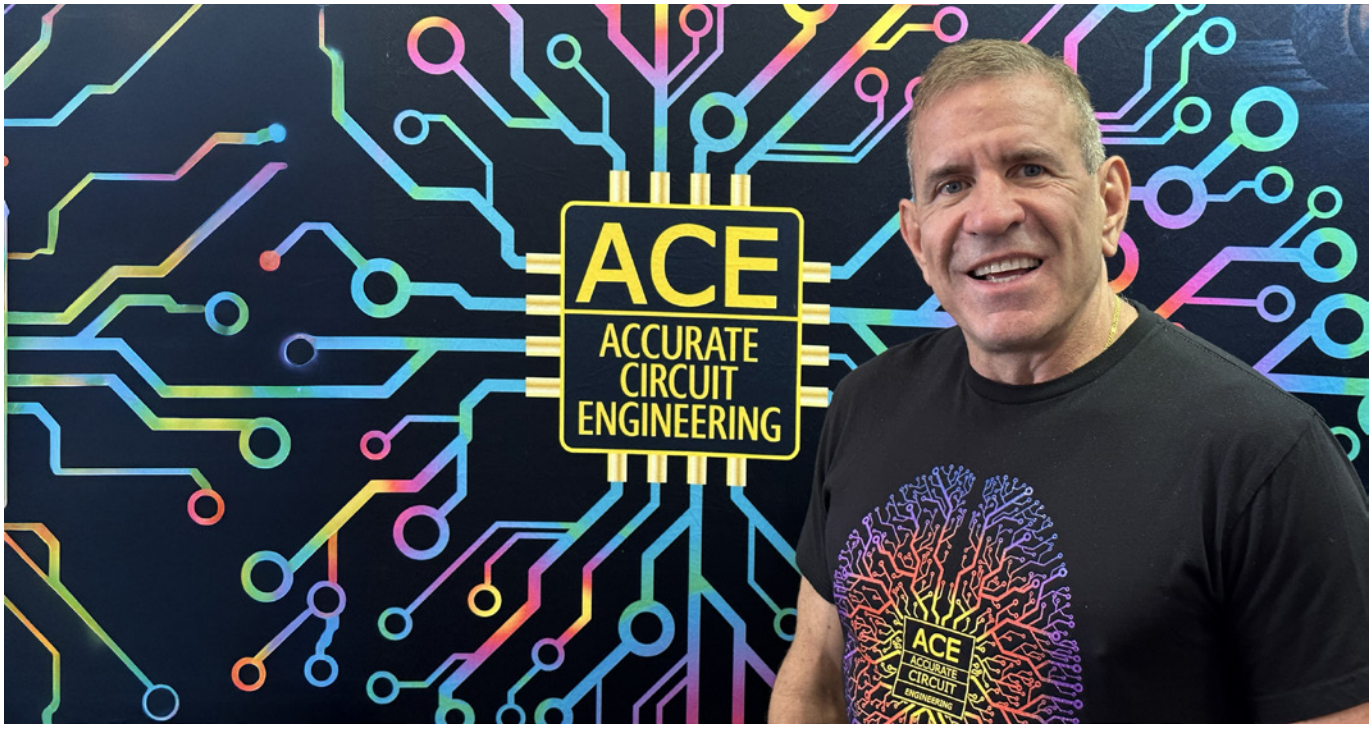
Feature Interview by Marcy LaRont
I-CONNECT007

James Hofer, general manager of Accurate Circuit Engineering (ACE) in Southern California, shares his insights about his specialty, quick-turn company, the market, and the interesting times in which we find ourselves. James remains optimistic about bringing manufacturing back to the United States and takes great pride in the work that ACE does to support military, defense, and aerospace. As James looks toward a prosperous 2025, he reflects on his 40 years in the business and learning that the secret to success is not trying to be everything to everyone.

Marcy LaRont: James, please introduce yourself and Accurate Circuit Engineering.

James Hofer: Hello, Marcy. ACE is a small business in Santa Ana, California, founded in 1983 and specializing in quick-turn, high technology, high-mix, low-volume printed circuit boards. We truly live up to our tagline, "Nobody does it faster."

I'm often asked how we manufacture our boards so fast. What works well for us is that we haven't tried to be everything to everyone. We do it better because we've stuck with our core competency throughout the past 40



Sarra

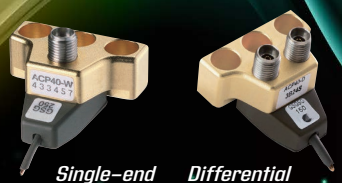
Automated VNA Measurement

Models Available

2-Probe: E2V6151

3-Probe: E3V6151

4-Probe: E4V6151



Single-end *Differential*

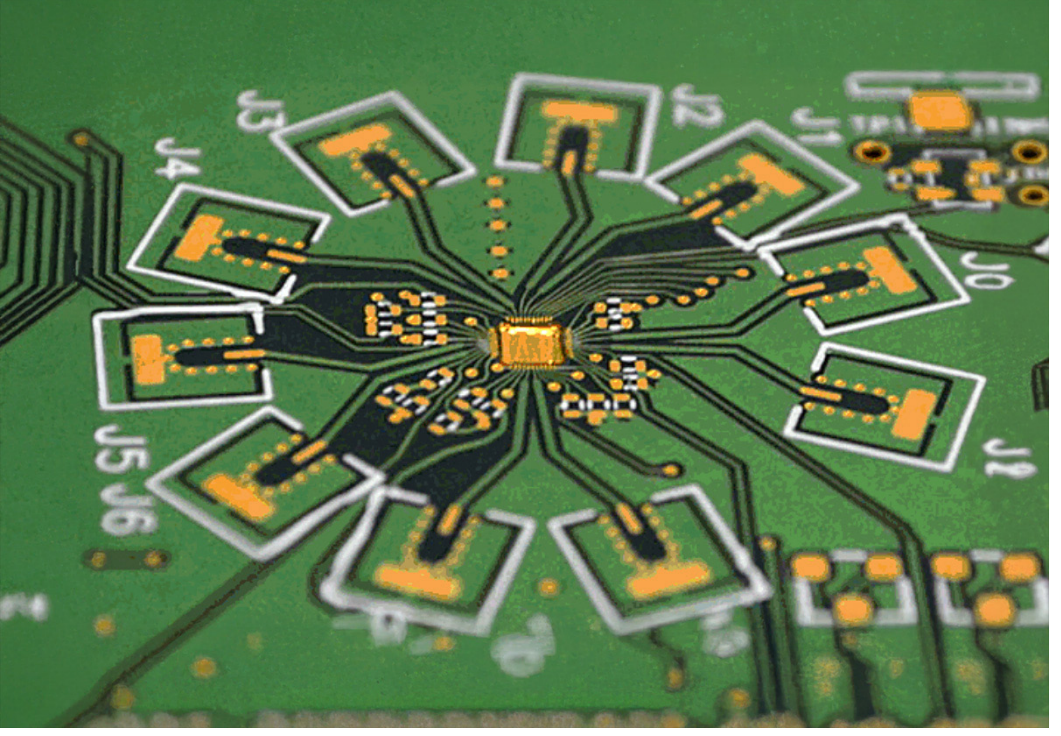
- ***High frequency probe unit***
- ***Short cycle time (3–5 sec)***
- ***High reproducibility***
  - » Accurate pressure control with newly developed touch down sensor
- ***Easy data preparation***
  - » Automated search for backdrill nets
  - » Automated pairing of differential nets
- ***Supported meters***
  - » Keysight Technologies: E5063A, E5080B, N5224B, P5007A/B, P5027A/B
  - » Rohde & Schwarz: ZNA40, ZNB40

Eye Diagrams

One major advantage of VNA measurements is the generation of Eye Diagrams, which make it possible to determine if the frequency bandwidth is ensured for high frequency transmission signals and how much noise and jitter are included in the signal.

www.usamicrocraft.com
sales@usamicrocraft.com

MicroCraft



years. When you do one thing for 40 years, you become really good at it.

We've had many opportunities to be bought out, and we are not interested in that. I believe there's a market for a single small, boutique-type shop. In shops like ours, you know who is building your product, and you know where it's being built. We don't try and mix in production with our quick-turn. We are quick-turn, period.

What technologies are you playing in?

Being a prototype shop, we do a little bit of everything. However, our real expertise is RF, microwave, high speed, and antennas. We don't build flex and rigid-flex. Therefore, we wanted to excel in a technology that doesn't compete with the low-cost shops out there, and that really is in RF, microwave, and antennas. It's also because we understand that frequency matters, and in RF and antenna it truly does. You have to be specialized and cognizant of the nuances of the manufacturing that goes into RF boards—and we are.

I understand the antenna market is quite robust. What have you seen?

Yes, absolutely. We've seen a real increase in phased array antennas, and we're doing them in six weeks, whereas the competition is taking 20+ weeks.

That certainly sounds like a market distinguisher. Let's talk about business and the market. How did it go for you in Q1?

We experienced a typical beginning-of-the-year slowdown, but things are absolutely back up to normal now, and we are expecting a very strong year.

It seems like everyone experienced that slowdown in January.

Everyone gets their orders in by the end of year, especially in the prototype market. It then takes a few weeks to a month, and even three months for some companies, to do all the testing and implementation before they release an update or revision or move forward with the project.

Why do you project that 2025 will be a good year for ACE?

With the current U.S. administration's aggressive stance on global business and trade, we expect the aerospace industry to be very robust this year. I think we will be swamped.

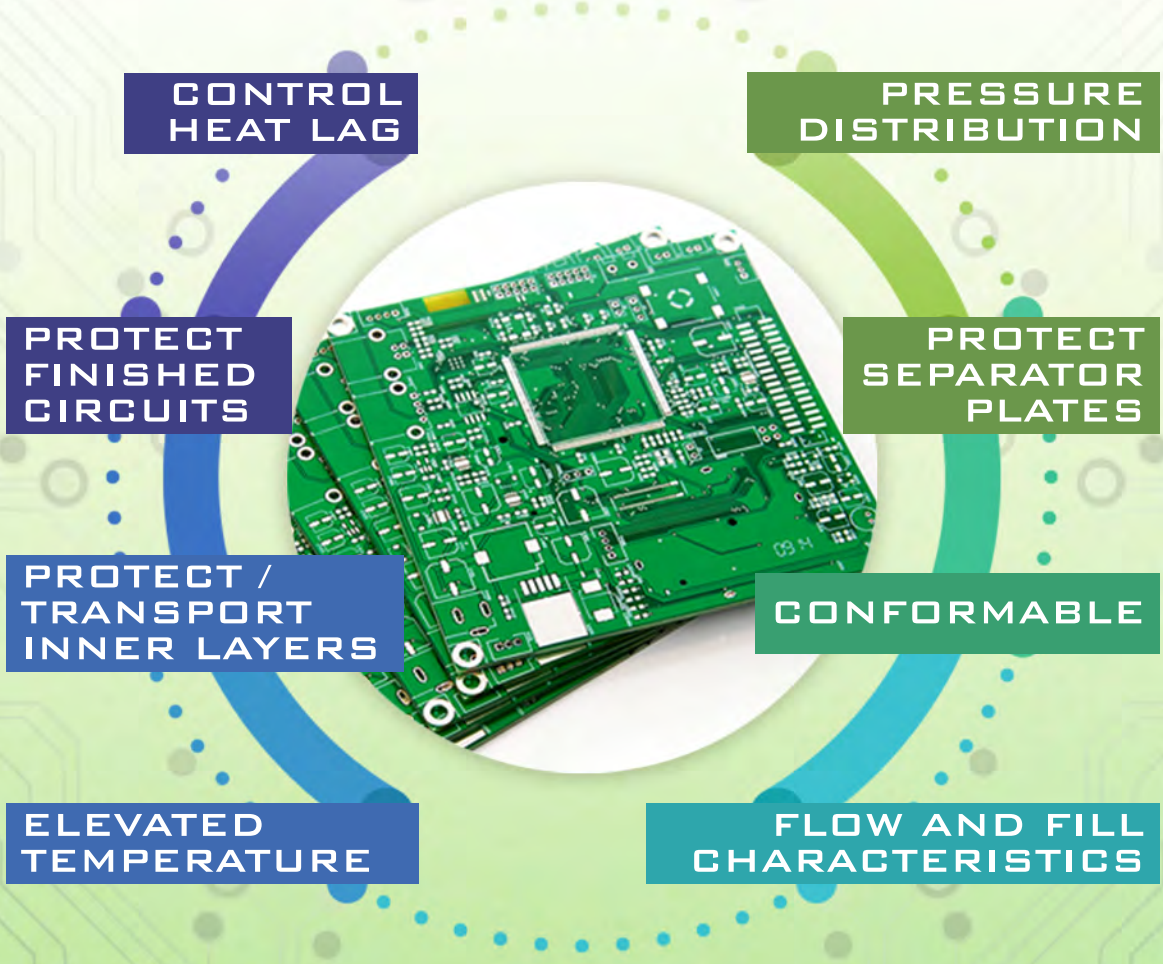
When it comes to military, aerospace, defense, and our domestic capacity to support it, are you concerned about U.S. shops not having enough capacity? Will you be turning customers away?

At the end of last year, we got close to reaching a level of discomfort, which I consider to be at about 90% of capacity, though we handled it very well. I do not expect there to be a capacity issue this year. I know that a lot of other shops have consolidated, and that's increased the manufacturing capacity in the U.S. I don't

EuroAssist™

PRODUCTS FOR PCB LAMINATION

EuroAssist products offer Lamination aids for Printed Circuit Board processing that spans operating temperatures from 370°F to 750°F.

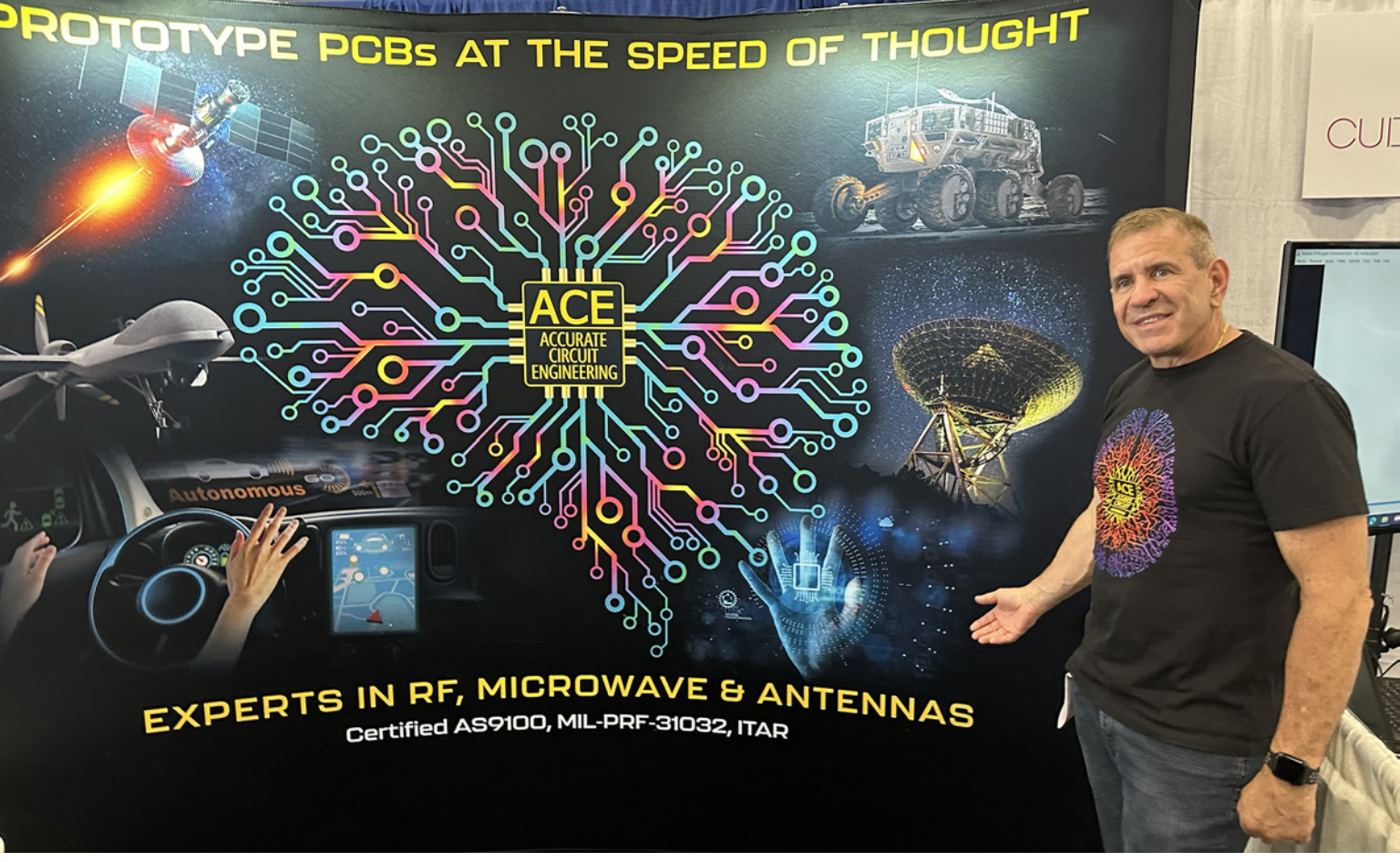


Click to learn more

MATRIX
CIRCUIT BOARD MATERIALS

1-800-668-5447 • www.matrixusa.us

TORONTO • SANTA ANA • SANTA CLARA • CHICAGO



expect it to be an issue, and I certainly hope not, because we need to bring manufacturing back to the United States, and keep it here.

With all that you're doing and all that's happening, how are you proactive for the benefit of your customers?

This past year, we put $2 million into equipment upgrades, and we're bringing on more equipment that will enhance our RF microwave and antenna capabilities and our ability to reach higher frequencies.

Are you engaging in much automation as you make equipment upgrades?

Yes, we are moving forward with some automation. However, I will stipulate that we are not moving forward with AI automation.

That's interesting. Can you explain?

I know there is a lot of discussion in the industry about how AI is affecting our businesses and how it will work. I believe AI can provide a lot of help, but it is not part of our prototype manufacturing space. I will emphasize that we will not use AI in any part of our prototype manufacturing space because I still believe data could be leaked, and we are very sensitive to data leakage.

Cybersecurity is a huge concern for everyone. What is your company doing around cybersecurity?

We are already at Level 2 and approaching Level 3 CMMC compliance, which we expect to achieve by early next year.

Level 3 compliance is significant. What surprises have you encountered?

We keep putting plans and systems in place, and then they change the requirements or fine-tune them, which has caused us to have to modify our plans and systems.

Is that just the reality in which we live now? Will we always be responding to rapid, constant change, like adjusting your SEO for Google?

Yes, I believe so. Let's face it: Today's reality is that all things, especially technology, are changing by the minute. In the past two years, I've seen more change than I've seen in the previous eight years. Technology, software, and hardware are all changing so rapidly. It's not possible to say, "Do this, and everyone will be safe." With CMMC changing so much, it's irritating and surprising, but it's necessary because every day we're discovering new things that could endanger us.

Look at the Chinese AI systems that have recently popped up. They are so much less costly to train than our onshore products. I wonder how many people are picking that up and if there's not a backdoor. We can talk about AI technology growing so rapidly in other countries as well as the United States, but it's not a good idea for ACE to bring AI into our processes.

So, part of your cybersecurity plan is not engaging in AI, thereby providing one less door for someone to find and open and do something harmful. Have you had to change your staffing to accommodate that?

Not yet. When you do something for 40 years, you get pretty good at knowing what you need in terms of staffing, which also somewhat addresses cybersecurity. Ours is a never-ending, always-growing system. We do what we do on every front, which is constantly improve and reevaluate our operations, including the personnel, training, and passion of our staff.

James, what is the most pressing issue for PCB manufacturers?

For the industry, the biggest thing is being nimble on our feet. We have to capitalize on and be open to change, accepting the change and not waiting for change to be pushed on us or to be a requirement. Instead, be eager and push for change, and look for opportunities to flex and grow. It's very much like going to the gym. If you work out the same muscle the same way all the time, you get one big muscle, and that's it.

We want to be on the leading edge of prototype technology, so we must aggressively look for new technologies and new ways to fit into our ever-changing market and do it quickly.

The biggest change for North American PCB manufacturers is just that Asia will exhibit a slowdown. Many Chinese companies are moving to India so they don't have to face tariffs. They will adapt to whatever we do. Our trick is just to keep changing before they adapt so that they start adapting to what we did yesterday, not to what we're doing today or tomorrow.

That's a very good point. Any closing thoughts on your experience in the industry?

I love what we do and what we do for the United States. It excites and thrills me, and makes the entire team at ACE proud. In this business, it's all about being nimble, and adapting and growing with the needs of your customers.

I just found an email from February 2024 from Southwest Microwave, a company that makes RF connectors. We have built all their boards for the past 15 years. In the email, they were asking for design guidelines because they were trying to do a 120-gigahertz board that they didn't think was possible to build. When I read it, I said, "Oh my gosh, that's got to be that project we did so well." The engineer said that we had talked at IMS earlier this year about their desire for an ambitious 120-gigahertz stripline board that I said was likely doable. He asked me to help him with the design rules. Today I sent him his original email and said, "I was just looking at this email from last year, and this is the project we killed it on. Correct?" He said, "Yes, sir, it was, and there is more to come."

When Southwest Microwave got the boards, they put their connectors on and sent me a screenshot of the results on the VNA. They told me, "We didn't even think this was possible in today's technology." It's testimonials like that that make us love what we do.

Thank you, James. **PCB007**

Novel Metallization for UHDI

Happy's Tech Talk #38

by Happy Holden, I-CONNECT007

I have been involved in high-density electronics substrates since 1970 when I joined Hewlett-Packard's RF semiconductor group after college. Figure 1 shows the difference between trace/space lithography for substrates and silicon starting in 1970. My projects involved sapphire circuits for RF devices, but the figure displays the state of PCBs and integrated CMOS circuits and their packaging, not discreet RF devices. Even then, semiconductors were 50X higher density.

HP's Involvement With Asia

I started in HP's advanced semiconductor group. HP was a leader like IBM. However, it used sapphire for many high-frequency and thermal performances. The process was called silicon-on-sapphire (SoS). HP used this to create the first single-chip 4-, 8-, 12- 16-, 32- and 64-bit microprocessors over the next 40 years, as seen in Figure 1's die size—driven by HP's SoS/NMOS3 process. Today, the gap has increased 1600 times, and HP's IC fab is now Broadcom.

This process led to HP's heavy investment in Asia for back-end fabrication, assembly, and testing in Singapore and Malaysia. When HP became involved in creating advanced multilayer PCB fabrication in Taiwan in 1984 (where I was in charge of the project), I included our new HDI laser drilling process and metallization, which was 20 years ahead of IBM and Europe.

What Drives Metallization?

One of the oldest metallizations for PCBs

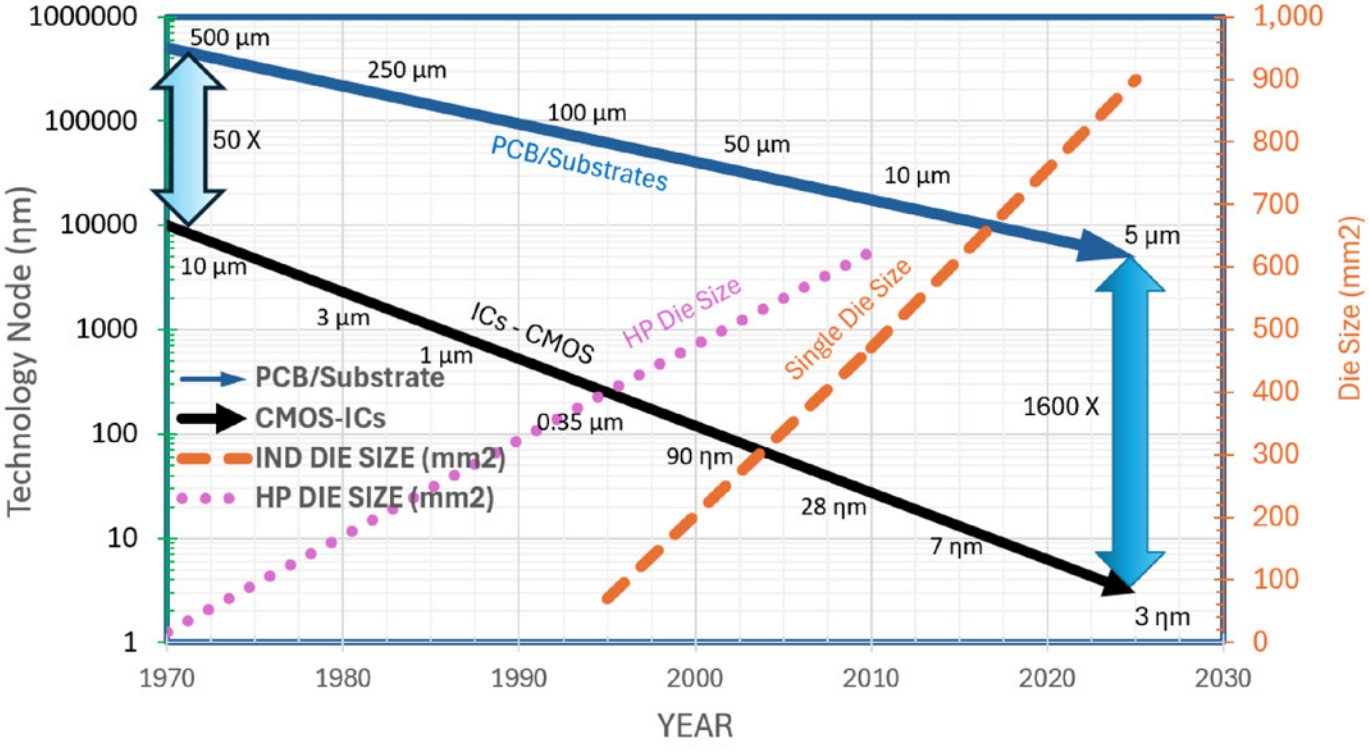
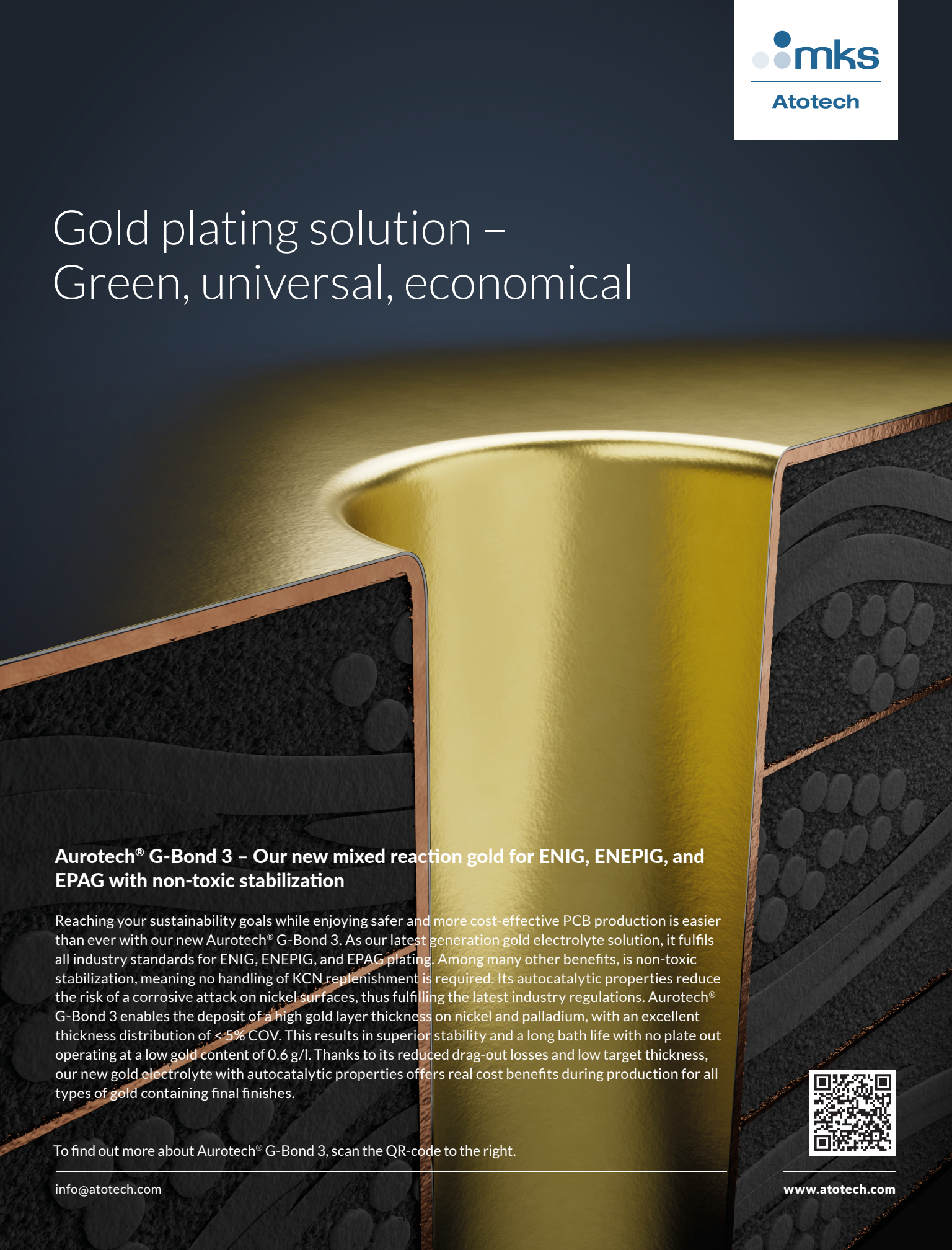


Figure 1: A comparison of circuitry photolithography used in PCBs/substrates and CMOS die vs. the timeline from 1970 until today, with die size as an additional boundary condition. (Source: HDPUG[1])

mks
Atotech

Gold plating solution – Green, universal, economical



Aurotech® G-Bond 3 – Our new mixed reaction gold for ENIG, ENEPIG, and EPAG with non-toxic stabilization

Reaching your sustainability goals while enjoying safer and more cost-effective PCB production is easier than ever with our new Aurotech® G-Bond 3. As our latest generation gold electrolyte solution, it fulfils all industry standards for ENIG, ENEPIG, and EPAG plating. Among many other benefits, is non-toxic stabilization, meaning no handling of KCN replenishment is required. Its autocatalytic properties reduce the risk of a corrosive attack on nickel surfaces, thus fulfilling the latest industry regulations. Aurotech® G-Bond 3 enables the deposit of a high gold layer thickness on nickel and palladium, with an excellent thickness distribution of < 5% COV. This results in superior stability and a long bath life with no plate out operating at a low gold content of 0.6 g/l. Thanks to its reduced drag-out losses and low target thickness, our new gold electrolyte with autocatalytic properties offers real cost benefits during production for all types of gold containing final finishes.

To find out more about Aurotech® G-Bond 3, scan the QR-code to the right.

info@atotech.com

www.atotech.com

Table 1: Liquid metal and MOD inks/pastes work with a broad range of dielectric materials[2]

Dielectric Substrate Type	Material	Manufacturer/ Source
Silicon	Generic	Various
Polyimide	Kapton	Dupont
PET	ST505	Teijin
Ceramic	Alumina	Calumet, Murata
Device package	Epoxy molding	Various, AMKOR
Glass	Generic	Various, Corning, Asahi
Epoxy w/glass reinforcement	FR3, FR4, FR5	Various
Flexible non-silicone	Beyolex	Panasonic
HF, halogen-free, Low-loss	Terra Green 400	ISOLA, NanYa
Resin film, HF, Low-loss	Epoxy, polyimide, Cy ester	Ajinomoto, AGC, Ventec
ABF	GL-102	Uyemura, LG Innotek
LCP	LCP	TE Connectivity
Thiolene based LCE	LCE	TAMU
RM82 Liquid crystal elastomer	LCE	TAMU
Plastic – PPO-BUF	Delrin/Tecanyl	Ajinomoto, AGC
Embedded silicon	Silicon	ASE, AMKOR
Device package	WP108 DK10.8	WavePro

was silver, first as a paste, then as an electroless conversion. This was later replaced when Shipley developed a reliable palladium/formaldehyde copper reduction process. Together with traditional sputtering and vacuum metal deposition, UHDI metallizations have increased to:

- Sputtering: Ti/Cu, Indium-tin-oxide (ITO), Carbon nano tube (CNT) (Plasma-LineD, Scheldahl-ViaThin)
- mSAP, amSAP, A/SAPTM with Cu foil (LQDX, ATOTECH, MacDermid, Uyemura)
- SAP with electroless copper Cu (ABF, AGC fastRise™)
- SAP with additive MOD inks (KDI)
- SAP with metallic conductive pastes (Ormet/TLPS, ALIVH, Bbit, PALUP, Parelec/PARAMOD, Namics/Unimac)
- Chemical vacuum deposition
- EHD: By Scrona allows inkjet printing of resin and metals with features down to 2 µm
- QCIATM (Hyperion QCPTM)

Table 2: Liquid metal and MOD inks/pastes work with a broad range of conductors[2]

Conductor Types	Material	Manufacturer/ Source
Foil	Copper	Various
Sputtered	Ti sputtered ABF	LG Innotek
Sputtered	Ti sputtered Si	Amkor
Plated	Ni plated on Copper	ASE
Foil	Iron	LG Innotek
Plate/sheet	Stainless steel	Various

Table 3: Properties of two specific Ag MOD inks working with four substrates[2]

Platform	Silver (Ag)	Gold (Au)	Platinum (Pl)	Nickel (Ni)
Use-Case	EM/RF shielding, antennas, micro-LED, mini-LED, metallization, e-textiles, MLCC, busbars	High-temp materials, hypersonics, medical devices, passivation	High-temp materials, hypersonics, medical devices, passivation sensors	Low-freq. electronics, magnetic shielding, MLCC, battery electrodes
Print Method	Screen, spray Digital: IJP,AJP,EHD, UV curable, thermal cure. All ambient processing	Digital: IJP,AJP, EHD, UV curable, thermal cure. All ambient processing.	Digital: IJP,AJP, EHD, UV curable, thermal cure. All ambient processing.	Screen, spray Digital: IJP, AJP,EHD, UV curable, thermal cure. All ambient processing.
Markets	Semiconductor packaging, mobility, display, solar, PE	Aerospace, biomedical	Aerospace, biomedical, semiconductor, industrial & consumer packaging	Mobility, passive components, semiconductor packaging
Key Attributes	World-leading performance for conductivity & reliability. Low temp. processing	World-leading performance print stability & purity of final Au film	World-leading stability, reliability & purity of final Pt film	Only metal-complex Cu ink on the market. Ambient processing

Platform	Copper (Cu)	Dielectrics	Resistive ink
Use-Case	TIM-thermal management, via metallization, PCB, busbars, e-textiles	High radio freq. antennas, sensors & filers. Low RF PCB, isolation, 3D structures support & adhesion host primer.	PCB resistor, sensors and conductive primer
Print Method	Screen, spray Digital: IJP, AJP,EHD, UV curable, thermal cure. All ambient processing.	Digital: IJP,AJP, EHD, UV curable, thermal cure. All ambient processing.	Digital: IJP,AJP, EHD, UV curable, thermal cure. All ambient processing.
Markets	Semiconductor packaging, solar, PE	Aerospace, Biomedical, Semiconductor and packaging	Semiconductor packaging, printed electronics, corrosion resistive, hypersonic
Key Attributes	Only metal-complex Cu ink on the market. Ambient processing	Low tangent loss & dielectric constant. Ambient processing & in-situ UV curable, high process temperature.	Flexible conductivity & good adhesion on substrates, corrosion resistive & good stability at high temp. non-carbon or polymer formulation

Table 4: Liquid metal and MOD inks/pastes: Materials, use-case, and differentiation[2]

Properties	EI-1149	EL-1150
Color	Colorless, translucent liquid	Pale yellow, translucent liquid
Viscosity @ 25 °C	6 cP	6 cP
Surface tension	29 mN/m	30 mN/m
Silver content	16% - 17%	16% – 17%
Shelf life – refrigerated	> 90 days @ 4 °C	> 90 days @ 4 °C
Resistivity – 180 °C curing	4 μΩ-cm	5 μΩ-cm
Curing at 180 °C and Curing w/365 nm UV	30 min. < 30 sec 9W/cm^2	30 min. < 30 sec 9W/cm^2
Adhesion (ASTM D3359)		
Glass	0B	0B
Epoxy molding compound	5B	5B
Polyimide	5B	5B
Solder resist	4B	5B

Metal-organic Decompositions (MOD) Inks/Pastes

The liquid metal inks and MOD inks/metallic conductive pastes are popular with newer additive processes for printed electronics. Their wide variety of materials and sources are seen in Table 1. The Ormet TLPS pastes have been around for a long time. I used them in the early 1990s, as did many other fabricators.

These conductive pastes were commonly used in Japan to develop HDI substrates without the need for electroplating. There were many processes developed, but all have fallen by the wayside as laser-drilling and various xSAP and AP have become dominant. Newer HDI processes, like VeCS3, which are true 3D in structure, are gaining popularity, especially in Asia.

The newer MOD metallizations have several advantages over older, traditional copper reduction chemistry:

- Significant size and weight reduction compared to current processes
- Improved reliability achieved through reduced layer count, microvias, and lamination cycles
- Reduced costs, specifically for complex, high-performance substrates
- Improved RF performance over traditional subtractive-etch processes
- Biocompatibility advantages of utilizing gold as a conductive metal

The ORMET-TLPS (OrmeLink) metallic paste has been used for the last 30 years to connect various multilayers to form HLC complex stackups.

Newer Methods of Metallization Application

Four of the newer methods, some still in development, are: laser ablation, direct printing, aerosol jet printing, and electrohydrodynamic

Geode™ G2

NEXT GENERATION GEODE PCB LASER DRILL HAS ARRIVED

INCREASED PRODUCTIVITY
Up to 65% faster

HIGHER UPTIME
Improved serviceability

IMPROVED ACCURACY
8 - 10 µm M + 4 sigma

FACTORY AUTOMATION
SECS/GEM

The Geode™ G2 Laser Drilling System is the next generation of ESIs most advanced CO_2 solution for drilling HDI microvias. Offering higher productivity and greater flexibility in processing both PCB and ICP materials. Combining a powerful CO_2 laser with innovative HyperSonix™ technology for advanced energy control capabilities delivering breakthrough productivity, precision, and yield.

Visit www.ESI.com to learn more

mks | ESI®

(EHD) jet printing. Examples are shown in Figure 2.

- **Laser ablation:** Popular with Amkor-Korea and Siemens, lasers can ablate circuit trenches and vias, making them easy to fill with silver or MOD inks.
- **Direct printing:** Also conducted with lasers or LED light sources. The laser catalyzes the photosensitive metallization to become conductive.
- **Aerosol printing:** Prints at room temperature with a resolution of 15 mm L/S. The Ag MOD has high conductivity and a short curing time at 120°C. Thick, 10 mm printing can be achieved with multiple passes.
- **Copper highlights:** The initial test shows a resolution of <100 mm but needs to be cured under nitrogen.

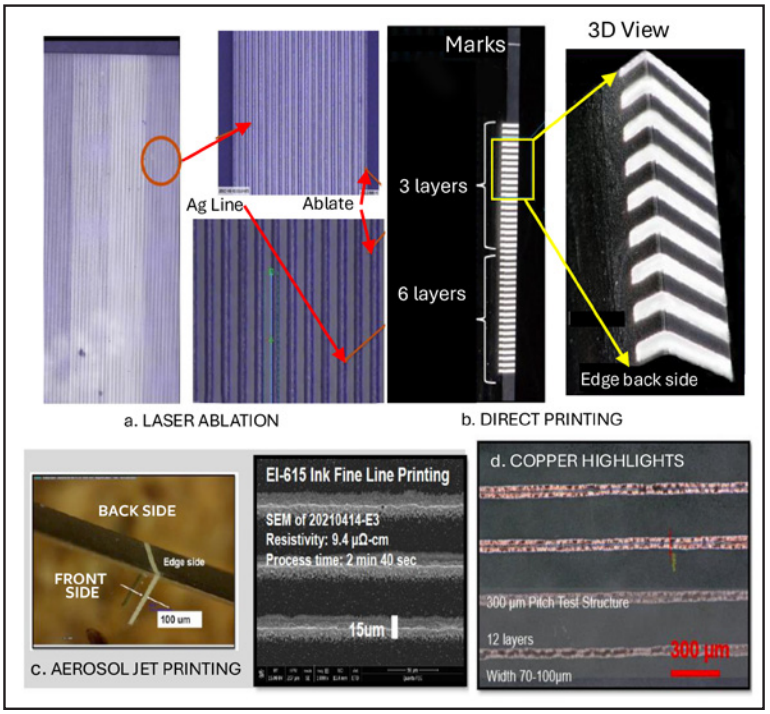


Figure 2: Newer methods of MOD printing: a) laser ablation and then filling; b) direct laser printing; c) aerosol jet printing of silver MOD; and d) aerosol printing of copper MOD[2].

Summary

There are many methods now available to metallize UHDI substrates. In addition to the long-traditional electroless Cu, graphite, or sputtering, we now have MOD inks and pastes, even for prototyping. Figure 3 shows a portable MOD jet printer available today. **PCB007**

Figure 3: An MOD inkjet prototype method of printing: the circuitJet[2].

References

1. "HDPUG Keynote-Advanced Packaging Substrate/Ultra HDI Update," by Gene Weiner, PCB West, October 2024.
2. SMTA Technical Knowledge, UHDI Symposium, January 2024, and UHDI Pavilion, October 2024.
3. Happy's Tech Talk #1: VeCS," by Happy Holden, PCB007 Magazine, October 2021.

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

PODCAST | SERIES 5

BONUS COMPANION GUIDE!

PCB Thermal Management

with Ryan Miller, NCAB

In I-Connect007's popular podcast, **On the Line with...**, Ryan Miller, NCAB, explains how strategies for managing heat start with PCB design.

ON THE LINE WITH... I-Connect007

Listen on Apple Podcasts

Listen on Spotify

LISTEN NOW!

MilAero007 Highlights

My Top 10 Highlights from IPC APEX EXPO 2025 ▶

Every year, I am reminded what an exciting and fast-paced whirlwind IPC APEX EXPO is—the friends you run into, the new people you meet, the innovations you encounter, and the fascinating discussions you dive into. Every year, I track the technologies, topics, and moments that capture my attention and distill them into my annual Top 10 APEX EXPO Highlights.

Statement from IPC on 'Liberation Day' Pressing for Domestic Manufacturing Strategy ▶

For decades, IPC has worked to restore U.S. leadership in electronics manufacturing, urging the government to recognize its strategic importance and invest in rebuilding critical domestic capabilities. We welcome President Trump's commitment to strengthening American manufacturing, particularly his focus on revitalizing the Defense Industrial Base. Electronics design and production are the backbone of innovation and industrial resilience across all sectors of the economy, and we stand ready to work with the administration on a bold strategy to rebuild this vital sector.

Photonic Selected for DARPA's Quantum Benchmarking Initiative Stage A ▶

Photonic Inc., a leader in distributed quantum computing, is pleased to announce its selection for Stage A of the Defense Advanced Research Projects Agency (DARPA) Quantum Benchmarking Initiative (QBI). In this effort, Photonic intends to demonstrate to DARPA that its large-scale quantum computing approach will reach industrial scale. Open to organizations around the world, QBI seeks to cut through the "hype" by evaluating approaches to utility scale quantum computing.

CACI Awarded $54 Million Task Order to Support the U.S. Army with Advanced Ground Sensors ▶

CACI International Inc. announced that it has been awarded a five-year task order valued at up to $54 million to continue supporting the U.S. Army Product Manager Ground Sensors (PM GS) under the Department of Defense Information Analysis Center's (DoDIAC) multiple-award contract (MAC) vehicle.

Connected Commercial Drone Market to Reach $37.3 Billion Worldwide by 2029 ▶

Berg Insight, a leading IoT market research provider, today released a new report covering connected commercial drones used for industrial and governmental purposes. The global market for connected commercial drones is forecasted to grow from US$ 18.6 billion in 2024 at a compound annual growth rate (CAGR) of 15 percent to reach US$ 37.3 billion in 2029.

Acquisition of MADES Strengthens Cicor's Pan-European Leadership in the Aerospace & Defence Sector ▶

Cicor Group announces that it has signed an agreement to acquire 100% of the shares of Spanish electronics company Malaga Aerospace, Defense & Electronics Systems S.A.U. (MADES). With this planned acquisition, Cicor continues to build the leading pan-European platform for electronics design and manufacturing services for the fast-growing European defence market.

DESIGN TIPS #124:

ETCH COMPENSATION

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

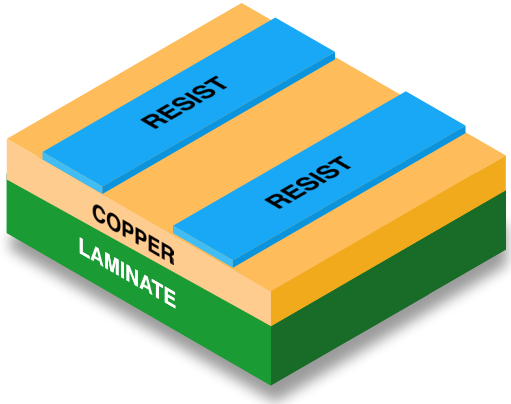
This is because we must do an etch comp on the traces in CAM to compensate for known etch loss. The space between traces after compensation will play a role in whether a board can be manufactured.

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

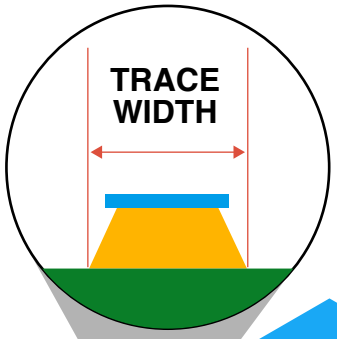
Design tips:

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

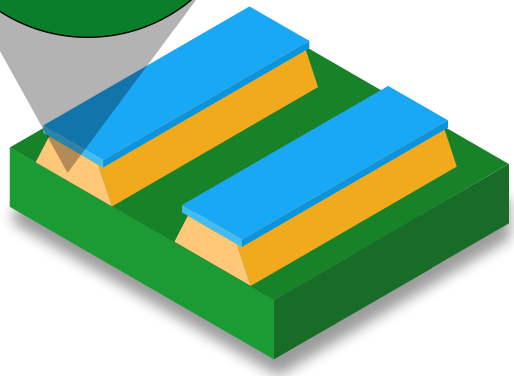
Before etching



After etching



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



Prototron Circuits
America's Board Source

prototron.com (520) 745-8515

Business Always Finds a Way

Feature Q&A With Prashant Patel
ALPHA CIRCUIT

Prashant Patel, founder and president of Alpha Circuit, takes a pragmatic approach to doing business: "Commerce always wins out," he says. How will potential tariffs and shifts in the economy affect PCB manufacturing? Prashant offers sound advice.

Marcy LaRont: Prashant, what is the "state of the state" of your business?

Prashant Patel: Our business is going quite well. As we get our new Tech Center in Schaumburg going, we are starting to fill it with high-end business. We are hearing from many new customers who are pleased with our Tech Center because it can handle their product today and in the future. Many new customers are bringing their latest technology to us, which is gratifying since we have made a huge investment in that facility. We still have the Elmhurst facility for our more standard technology.

Overall, things are good. I am no expert on the rest of the industry, but from what I hear from my counterparts, everyone seems to be getting busy.

With a new administration in Washington, what are you most concerned about? How does it weigh into your strategy for the next few years?

Business is business, and politicians are politicians. In the end, commerce always wins out. People, companies, and countries want to do business with each other. We need to do business with each other, and we always find a way.

If you are talking about the tariffs, I am not too concerned about that since we all have to pay them in one way or another. If there are tariffs on laminates, for example, all PCB shops are paying them, so it is still an equal playing field. My personal philosophy is to run my own race and stay in my lane. I care about what I can do something about, like my own company.

ventec
INTERNATIONAL GROUP

Special Applications & NF/LF Prepreg

Bringing Ventec quality, performance and value to specialist circuits.

Bring Ventec quality, performance and value to circuits with special requirements. Like those needing mechanical flexibility - whether formed once to allow installation during product assembly or flexing dynamically with moving parts such as a printer head or optical drive, our flex and flex-rigid formulas withstand reflow temperatures and maintain their structural integrity to prevent fatigue or corrosion.

Contact your local sales representative today.

venteclaminates.com

Wherever technology takes you, Ventec delivers

What is your organization doing to be proactive in this challenging economy for the benefit of your customers?

In the end, business is all about people doing business with people, so we try to help our customers in any way we can. I have learned over the years that the easier we make it for our customers to work with us, the better we will do. If our customers succeed, we will succeed, so we do all we can to make them successful. Our team works with our customers as if we were their technical consultants. That makes for longstanding successful relationships.

What is the most pressing issue for PCB manufacturers in electronics manufacturing?

Technology, quality, and service, as well as listening to our customers, understanding their needs, and finding ways to meet them. The most pressing issue is staying ahead of our customers' needs. They are always increasing their technological demands, and it is our responsibility as their suppliers to help them meet or exceed those demands.

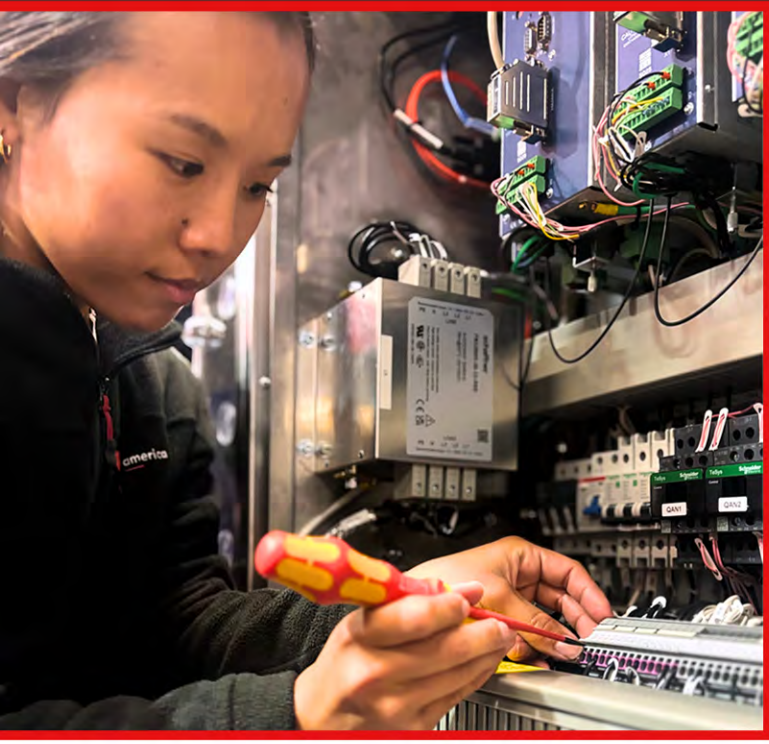
What is your driving philosophy?

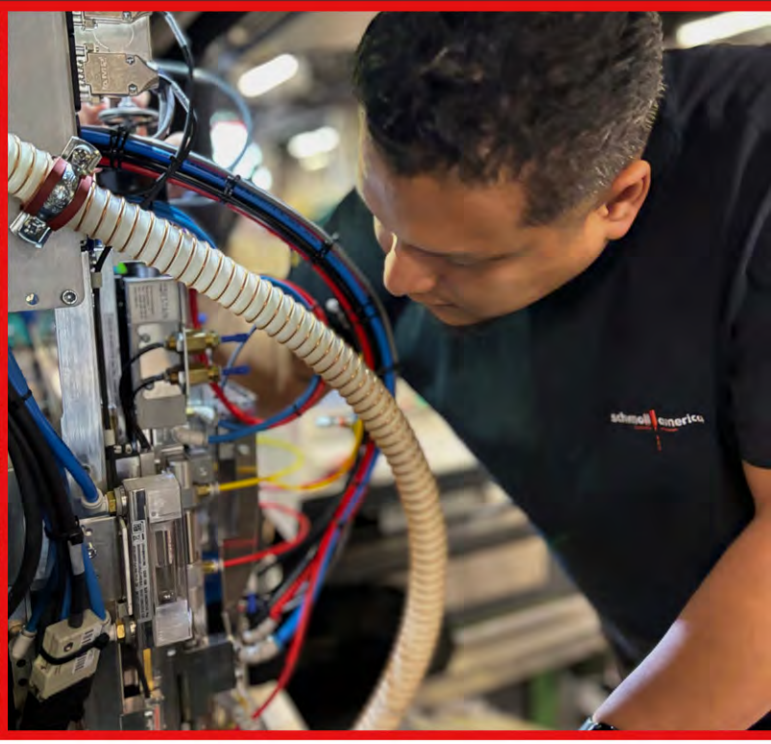
I believe that we all have to do the best we can with what we have. I get tired of people complaining about politics, other countries, our competitors, suppliers, or even customers. Business is pretty simple in the end: Give your customers what they want and they will work with you for a long time. **PCB007**

Schmoll America: Celebrating Their First Year

Kurt Palmer of Schmoll America and Stephan Kunz of Schmoll Maschinen GmbH look forward to a promising 2025 amidst current market challenges with plans for a new facility.

Exceptional Machines. Outstanding Service.





At Schmoll America, we know your success depends on more than great machines—it requires tailored, top-notch service.

With the expertise of Schmoll Maschinen GmbH behind us, we deliver:

- ◊ Minimal downtime
- ◊ Fast access to spare parts
- ◊ Expert guidance when you need it

We're dedicated to providing the support you deserve because the best machines should always come with the best service.

From quicker response times to customized solutions, Schmoll America ensures your operations run smoothly and effciently.

Let's elevate your production to the next level.

hotline:

Support@SchmollAmerica.com

+1 888-SAM-0321 or 1-888-726-0321

schmollamerica.com

schmoll america

... one step ahead.

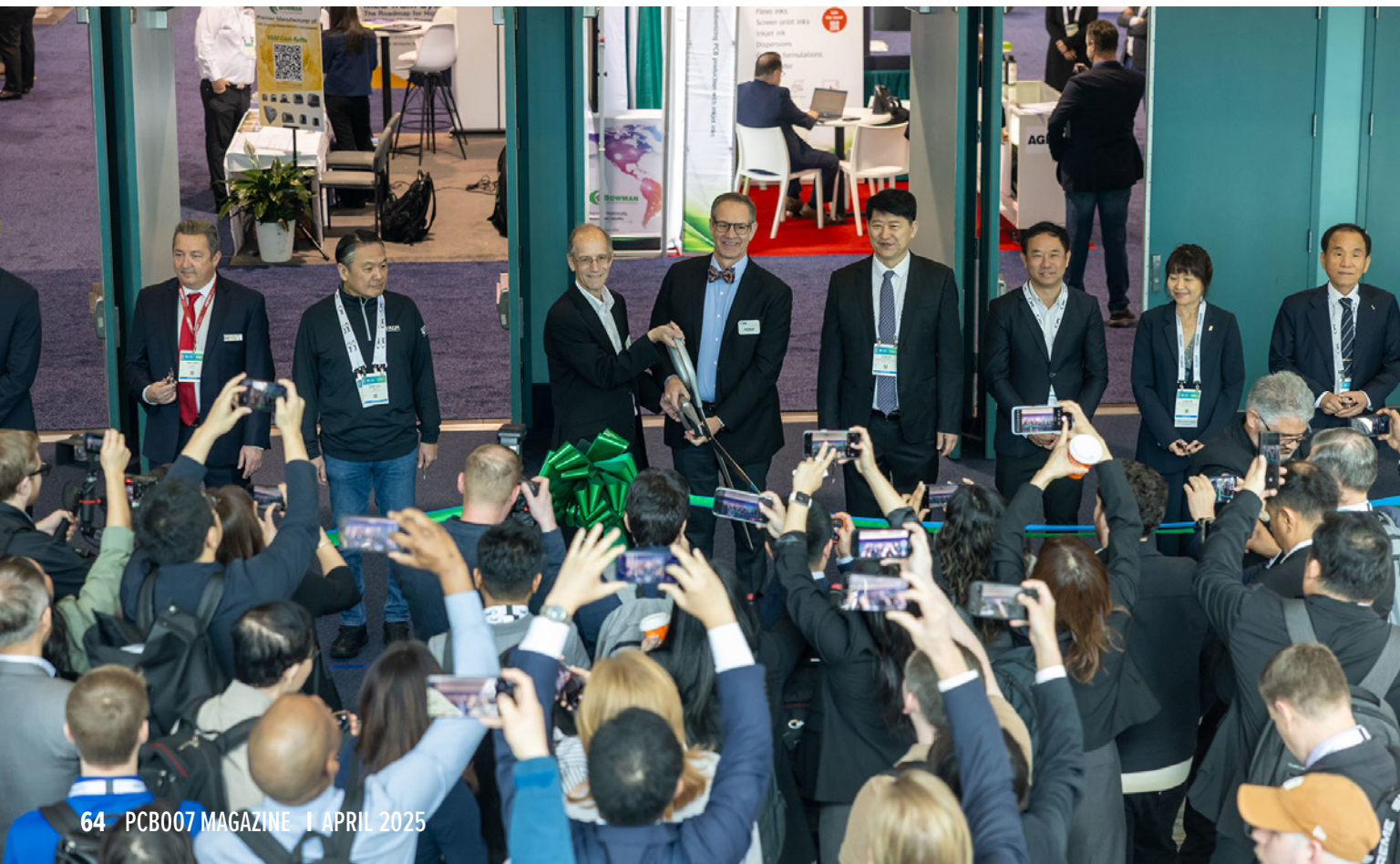
IPC APEX EXPO in the Rearview Mirror

Article by Marcy LaRont
I-CONNECT007

Now that IPC APEX EXPO 2025 has wrapped up, I've had time to reflect on a good week in Anaheim, California. As is true with any company that exhibits or attends the show in a meaningful way, there is much work to be done when the trade show dust has settled and you get back to your desk. We've been no exception.

High Energy All Around

If anything makes or breaks a trade show event, it is the perceived energy. If it's a good show, the energy should be visceral. By all accounts, IPC APEX EXPO 2025 was energetic. It kicked off Saturday on the upper levels of the Anaheim Convention Center with standards development committee meetings, followed by Professional Development classes on Sunday and Monday. When the Expo doors opened on Tuesday morning, APEX EXPO was in full swing. Speeches were made, and the big red ribbon was cut in front of a larger-than-average crowd. The show floor was solidly busy, and many exhibitors reported having

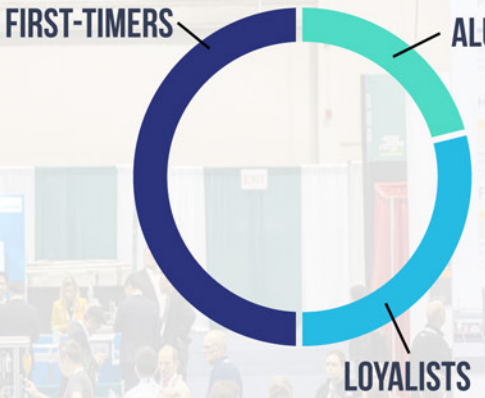


IPC APEX EXPO 2025
BY THE NUMBERS

I-007e FAST FACTS

ATTENDANCE

AUDIENCE LOYALTY



EXHIBITORS

402 EXHIBITORS

3,305 BOOTH PERSONNEL

132,100 NET SQUARE FEET

22,900 LEADS GENERATED

OTHER SHOW HIGHLIGHTS

- **18** Technical poster presentations
- **31** Professional development courses
- **79** Technical papers
- **31** Professional Development Courses

Source: IPC

more trouble leaving their booth this year to walk the floor—a sign that important business was being conducted. I heard that one exhibitor sold three machines while at the show.

Special Events and Receptions

I started my show on Saturday afternoon checking on the progress of our booth, peeking into the standards committee meetings, and attending the Emerging Engineer Reception that evening (a personal favorite). The third-floor balcony terrace is a lovely spot, and by the time these Emerging Engineers (and their mentors and colleagues) strolled into the space, it was clear that after a busy day in meetings, the refreshment and relaxation of the reception was most welcome.

I sat at a table with six Emerging Engineers and one of their mentors and was both interested and inspired by their experiences. They were unified in their exultation that being involved with standards was tremendously valuable for their professional development and their long-term careers. That was good to hear. There is a great need for mentors for this valuable program, and engineers with at least seven years of experience are urged to get involved. Mentoring young engineers contributes to the future of our industry and the development of these young engineering professionals. It may also be one of the most rewarding things you do. (Contact TeresaRowe@ipc.org).

Bravo for IPC's Technical Program

On Tuesday, the technical tracks got underway. Though I rarely get the opportunity to stay for a complete session, jumping in and out of several has its advantages. Attendance ranged from light to all-seats-filled, dependent upon topics and competing agendas. As hard as IPC works to create as few conflicts as possible in the show agenda, it is impossible to attend everything. This year's advanced packaging special sessions were intentionally expanded into two rather than one session based on early feedback. IPC is hopeful that this topic area will be well represented in next year's technical paper submissions.

The Technical Conference was very strong. There had been some questions as to how 2025 would stack up, given the gravitas added to the 2024 event when IPC hosted ECWC16. But it was a huge win for the Technical Committee, led by Udo Welzel of Bosch and Stanton (Stan) Rak of SF Rak Company, and nearly 15 other committee members. A big change this year was the opportunity for attendees to download proceedings at the conference. The increased engagement was evident as people looked at the presentations on their own computers and phones, made notes, and asked questions accordingly.

Keynotes

Keynote speakers draw large audiences. As their topics must resonate with everyone, it made sense that there was a clear focus on AI as a primary force pushing the electronics manufacturing industry and the world forward. On Tuesday morning, Kevin Surace's opening keynote was inspirational and thoughtful, with images across time and questions for us

BÜRKLE
NORTH AMERICA, INC.

PCB LAMINATION AND PRESS TECHNOLOGY SOLUTIONS

HIGH QUALITY AND POWERFUL PRESSES AND HANDLING EQUIPMENT

BÜRKLE PRESS SOLUTIONS FOR PCB INDUSTRIES

- **High temperature processing**
  Max. 385°C w/ thermal oil,
  450°C w/ electrical heating
- **Fully automated press line**
  Hot press, cold press, loading/
  unloading racks and carriage
- **MES support**
  High-leveled traceability

CONTACT US
4501 Green Point Drive #108
Greensboro, NC 27410, USA
+1 (336) 809-2706
pcb@burkleamerica.com

burkle.tech/us-en

FOLLOW US

YouTube

all to consider. A true pioneer and entrepreneur in the space, his title of "futurist" seemed well founded. I encourage you to check out his interview with Barry Matties after the keynote.

The following morning, Dr. Ahmad Bahai, CTO of Texas Instruments, graced the stage to elaborate on data centers and AI. "We are living in a data economy, so a massive amount of data is available to us, and how to process and translate the information requires a lot of innovative approaches (at all levels of hardware and software)," he said. Bahai emphasized that while the current pace of change and development is more rapid than it has ever been, it needs to be accelerated. AI will help propel us to those solutions.

The final keynote, by IPC CEO Dr. John W. Mitchell, was compelling. He asked, "How can we strike a balance between the growing push for protectionism and the undeniable need for global cooperation?" Mitchell acknowledged our global and political challenges but emphasized that collaboration is key to innovation, and that innovation is our only way forward. He also cautioned the audience: Embrace AI in your current roles and develop yourselves into what is next—or be left behind.

Bullish Outlooks Despite Tariff Talk

I spent much of my time midweek in our Real Time with... IPC APEX EXPO booth, interviewing exhibitors. Somewhat unexpectedly, most exhibitors were bullish about the market and their businesses, especially in North America. They were surprisingly candid about tariffs and uncertain global trade scenarios. They expressed legitimate caution and a watchful posture, but indicated that they have been through this before and are working with their customers to do whatever needs to be done to keep business moving swiftly forward.

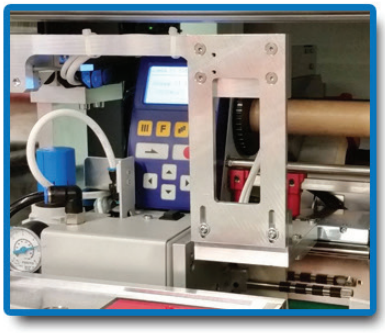
Thank You

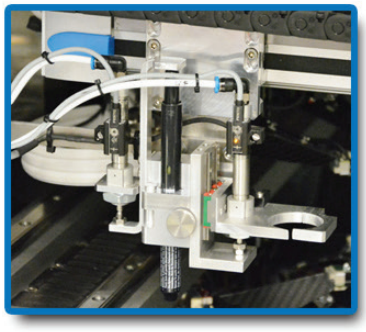
As I look back on another successful IPC APEX EXPO for I-Connect007 and all the friends and customers we spoke to during the week, I want to say a particular thank you to our Real Time With... IPC APEX EXPO 2025 sponsors: Blackfox, Burkle North America, KYZEN, Mycronic, and Technica USA, as well as our showcase sponsors, all4-PCB, IEC, KLA, Mivatek, Schmoll America, and Uyemura—all great companies with superb products and leadership. Many of our sponsors have been with us on the IPC APEX EXPO journey for some years. Please know that we appreciate you.

Finally, congratulations to IPC for 25 years. The show has evolved and changed in this past quarter-century, but for the better, and I look forward to another great show in 2026. **PCB007**

Unrivaled Test Speed with Full Automation

Introducing the newly designed atg A9a with 8 test probes and a new high speed “lights out” automation for unrivaled throughput.





Highlights:

- Small footprint (6 square meters)
- Dual shuttle pick & place automation
- High accuracy combined with high test speed
- Pen or label marking option

Watch video

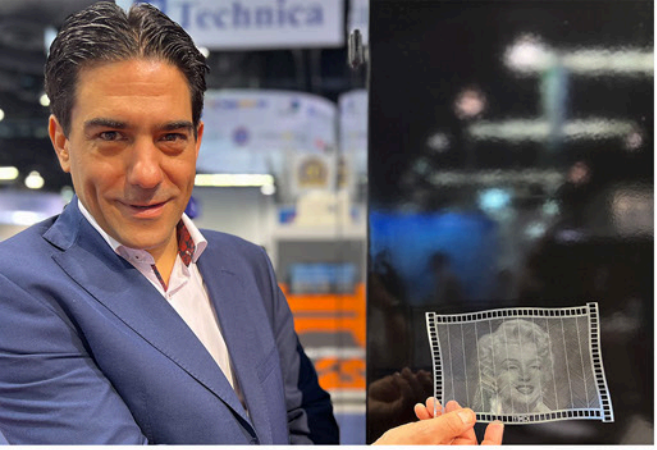
Get more info

atg

LUTHER & MAELZER

MYCRONIC

atg Luther & Maelzer GmbH
Zum Schlag 3 • 97877 Wertheim • Germany
Phone +49-9342-291-0 • Fax +49-9342-395 10
sales@atg-lm.com • www.atg-lm.com

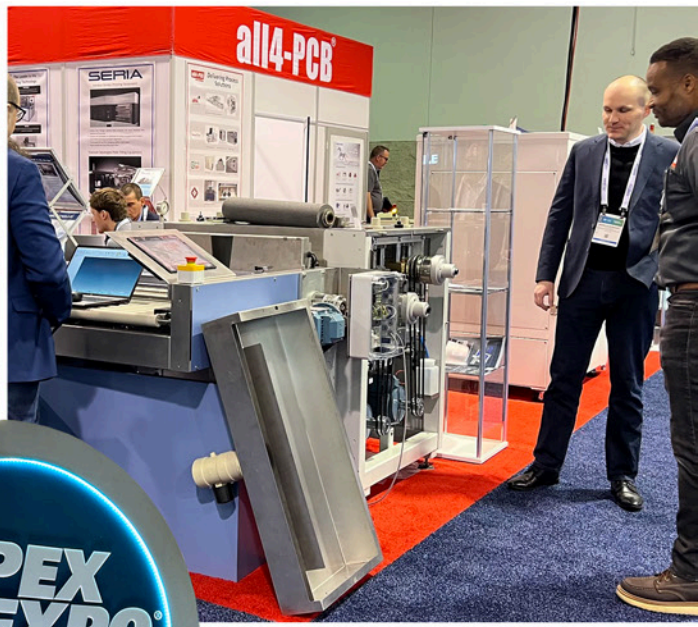



PCB LAMINATION AND
PRESS TECHNOLOGY
SOLUTIONS
BÜRKLE


rbp
SUSS
SIGMA


Technica
EMC
METRIX
Isola


RAIG
Zero
Corrosion
Technica
UYEMURA
USA
MEC from Uyemura
The Roadmap for High Density
and Ultra High Density Circuits


all4-PCB
SERIA


APEX
EXPO
IPC 2025


ventec
INTERNATIONAL GROUP
ventecla minates.com
technology
Ventec delivers


RLDWIDE . . . one step ahead.
schmoll maschinen
SCAN HERE
schmoll america


MATRIX
CIRCUIT BOARD MATERIALS


EMC
ELITE MATERIAL CO. LTD
MASS LAMINATION SERVICE

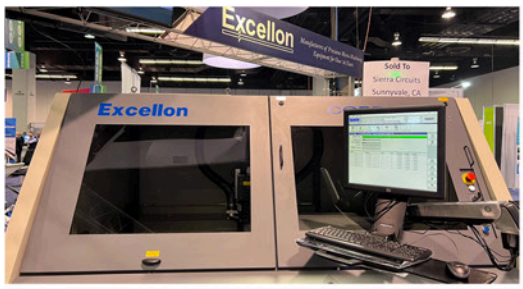

MicroCraft


DART
MivaTek


Polar


Community
Community


chemcut.net
Quality Control


Excellon
Excellon


mks | Atotech | ESI®


IPS
INTEGRATED PROCESS SYSTEMS
INCORPORATED
A Wet Processing Equipment Company
ips-vcm.com


APEX EXPO
IPC 2025
25TH ANNIVERSARY


MDI TT

Growth Depends on Developing Next-gen Products

Feature Q&A With Maurizio Bonati
PLURITEC

Maurizio Bonati, vice president of sales at Pluritec, says a new generation of products has driven strong business performance and a significant backlog. However, there's a concern about the potential negative impact of tariffs. Pluritec is taking proactive measures to minimize these effects by focusing on enhancing equipment capabilities, automating processes, and expanding customer support.

Marcy LaRont: Maurizio, what is Pluritec's "state of the state?"

Maurizio Bonati: Pluritec's business today is strong. At the moment, we have a significant order backlog, which is mostly related to new-generation products that the Pluritec group has developed to answer specific market requirements or concerns, which makes this a very exciting time for us.

What's most on your mind with the new U.S. administration? How does this play into your strategy for the next few years?

With President Trump back in office, what actually transpires with the trade war and tariffs could have a negative impact on Pluritec's business, as will certainly be the case with many businesses. Therefore, we are taking proactive measures to minimize any negative effects on our potential exports to the U.S.

How are you being proactive for the benefit of your customers?

We are focusing on multiple areas, including enhancing equipment capabilities to directly answer technology challenges and designing equipment that will allow optimization and streamlining of manufacturing processes to reduce the overall cost to manufacture for our customers. We are also working to automate more processes, to help customers overcome their labor constraints as they struggle to find qualified laborers.

On the service side, we have expanded our customer support team and optimized its struc-

PCBAA MEMBERSHIP GIVES OUR INDUSTRY A VOICE IN WASHINGTON

MEMBER BENEFITS INCLUDE:

- Legislative initiatives that impact your bottom line
- Unique networking opportunities with industry peers
- Access to senior government officials
- Weekly industry intelligence reports
- Communications and lobbying best practices

JOIN US TODAY

PCBAA.ORG

PCBAA

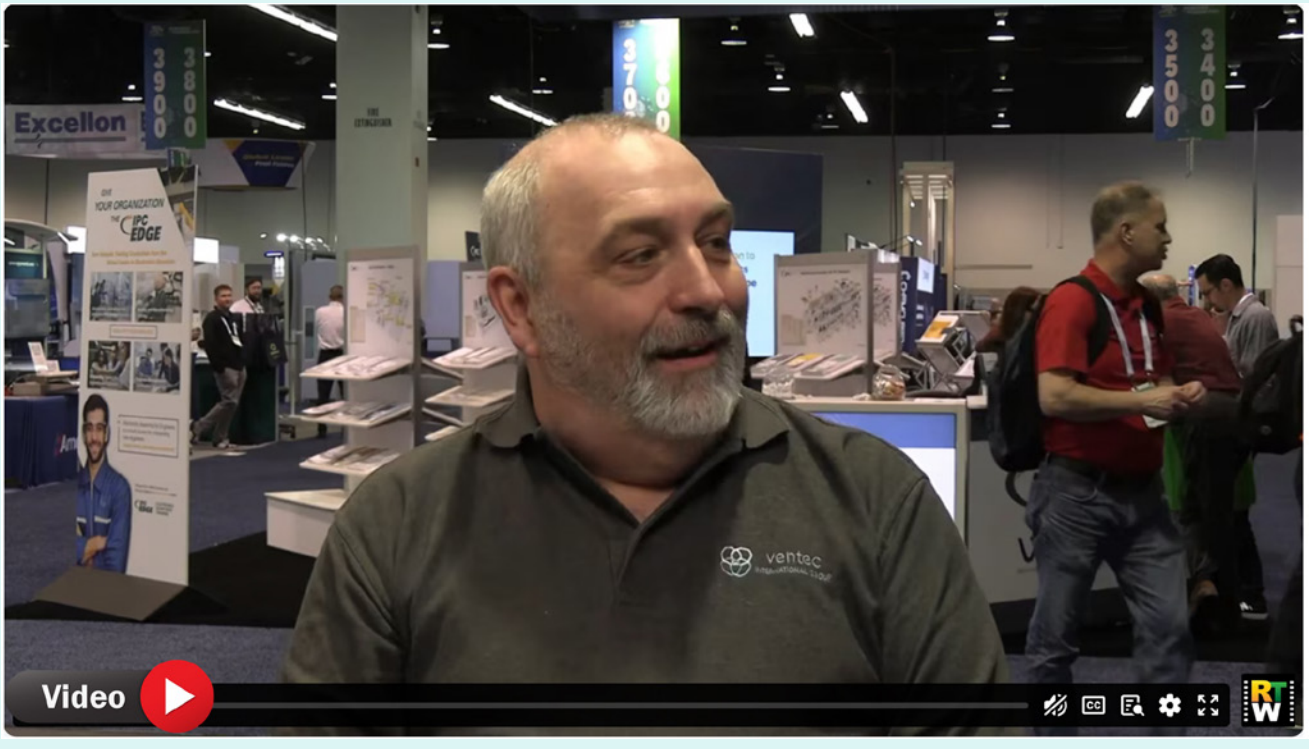
ture to ensure very high quality and timely and effective assistance. Today, we find ourselves in a uniquely advantageous position to offer personalized, value-added solutions to our manufacturers. As I said, we are excited about where we are today and the future ahead, regardless of the challenges. There are always challenges.

What is the most pressing issue for PCB manufacturers in this age of electronics manufacturing, or are they all equally important?

Marcy, there really are many issues, and they are all important. Since COVID, and in different ways, we have struggled with supply chain issues. The geopolitical landscape and the most recent tariff activity being implemented by the United States bring the supply chain back up to the top of our concerns.

I mentioned the lack of skilled labor, something we all struggle with, but nowhere more acutely than in PCB and EMS manufacturing. Much of our innovative work in equipment design and optimization will continue to be around automation to enable factories to need fewer workers to do the same or better quality of work.

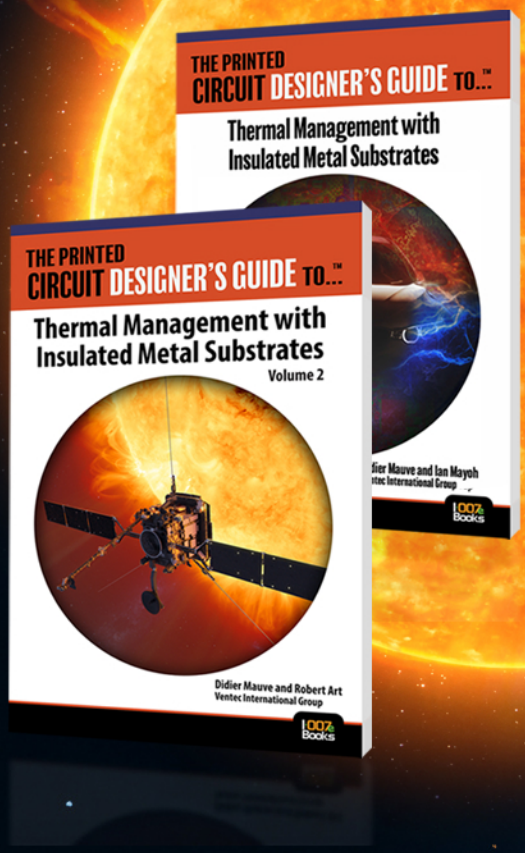
Finally, and this has garnered even greater attention with President Trump taking over the U.S. presidency, we struggle with what we see as unfair competition from the Far East, now both China and China Plus One countries. Both Europe and the U.S. are making more investments in their respective electronics manufacturing infrastructures, but when will that trickle down to the rest of us? We do not know. **PCB007**



Ventec: Exploring Material Innovation

Mark Goodwin highlights Ventec's global distribution network, recent expansions in service, equipment offerings, and the company's expertise in creating customized solutions for customers.

Companionship at its Best



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

Download Now

I-007eBooks

Registration in PCB Production Throughout the Process

Driving Innovation

by Simon Khesin, SCHMOLL AMERICA

PCB manufacturing is a fascinating industry where multiple disciplines—chemical, mechanical, and optical processes—intersect. Each field plays a crucial role, and missing even one step can significantly impact production and yield.

In the realm of mechanical and optical processes, one of the most critical aspects influencing the final result—especially in complex PCB designs—is registration.

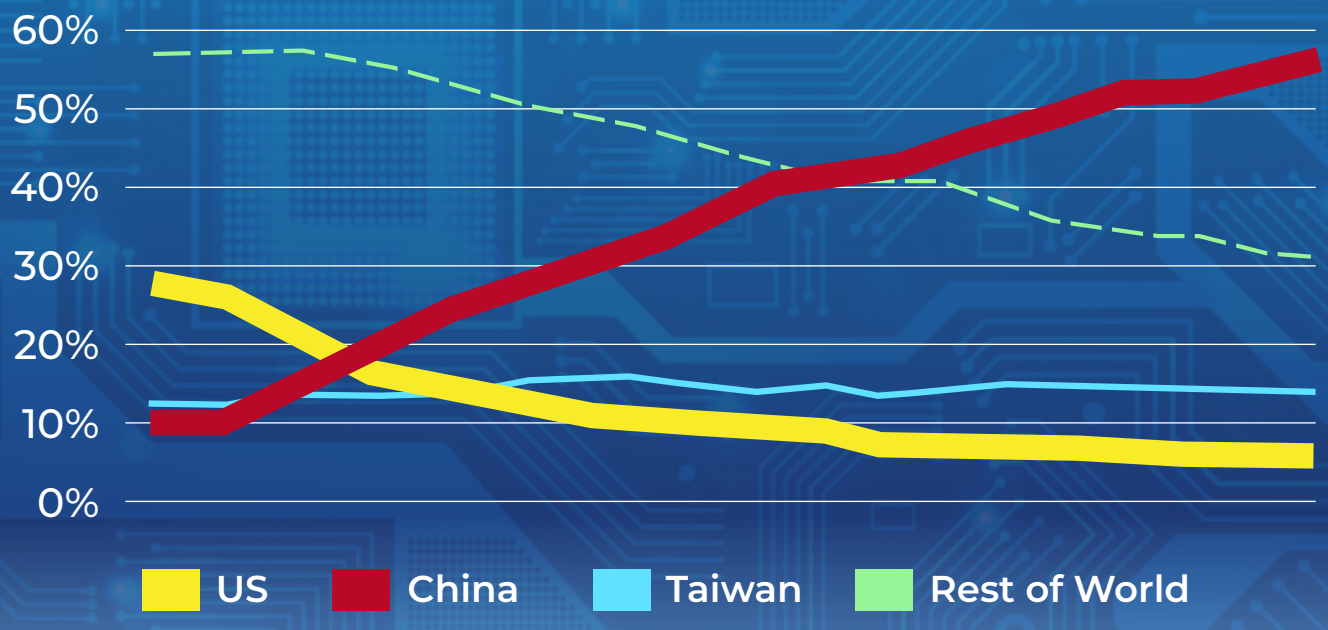
I often compare the PCB registration process to assembling a cheeseburger. You wouldn't want your tomato sliding off one side, the patty leaning in the opposite direction, and the cheese hanging unevenly. A well-made burger should be neatly stacked and precisely aligned so that every bite delivers the perfect balance of flavors. The same applies to PCB registration—inner layers should be aligned as well as possible. While achieving perfect alignment is impossible, the key is controlling tolerances to ensure consistency and precision.

This article will explore the fundamental questions:

- What are the critical registration points in PCB production?
- How can we improve alignment throughout the process?

CONGRESS MUST ACT TO RESTORE AMERICAN LEADERSHIP

Global Production of PCBs



Over the past three decades American-made PCBs shrunk from 30 percent to 4 percent of the world's supply

Congress must act by:

- Passing the PCBS Act (H.R. 3249)
- Investing in American companies
- Providing tax incentives for OEMs to buy American
- Accelerating efforts to secure critical supply chains

JOIN US TODAY

PCBAA.ORG

PCBAA

Inner Layer Exposure

Before the introduction of direct imaging (DI) machines, contact exposure was the standard method. This process relied heavily on the alignment of phototools, making the overall accuracy dependent on the phototool's condition.

With direct imaging technology, dependency on photo tools has been eliminated, but achieving proper alignment now relies fully on machines.

Since inner layers typically lack holes or fiducials—just copper—alignment must be established only by the machine itself. Modern direct imaging equipment uses small UV markers integrated into the table, exposing fiducials from the bottom side while the main exposure system processes the top side (Figure 1). These fiducials later serve as reference points after flipping the panel.

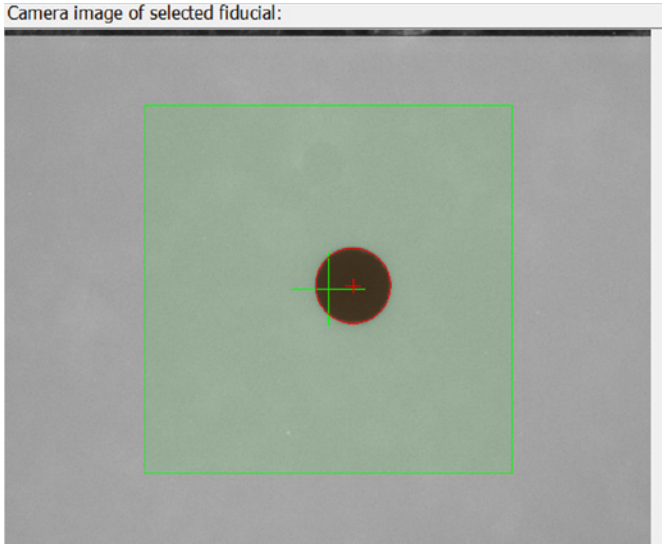


Figure 1: Inner layer alignment fiducial, exposed by UV markers in the table during top side exposure, and recognized by CCD camera alignment during the bottom side exposure.

Alignment of the Inner Layers

There are multiple methods for aligning inner layers before lamination. The three primary approaches are:

1. Pin-lam: Pins in the press tools hold layers in position during lamination.

2. Mass-lam (without pins in press-tools during the lamination): Layup before lamination could be done using:
   - › A fully automated lay-up machine
   - › A two-step lay-up process:
     a. First machine drills registration holes.
     b. The operator stacks the layers and pre preg on pins of second machine, then performs lay-up (via welding, riveting, etc.), and user removes the stack from the pins.

Each method is viable, but the choice depends on several factors:

- Required productivity levels
- Pre- and post-processing needs
- Accuracy requirements
- Panel sizes
- Compatibility with different materials
- Capability to measure inner layers before lay-up
- Maintenance requirements

This topic alone needs a deeper discussion, and we will explore it further in future articles.

X-ray

After lamination, if pin-lam holes are not available or not used, X-ray registration is

typically used to create base holes for alignment during drilling.

While some CCD-based methods exist, they require cutting through the top copper layer until the CCD can recognize internal fiducials—more common in prototyping or small production batches.

Why is X-ray Critical?

X-ray is the major control point in PCB production where we can analyze how layers behave after lamination. Misalignment can occur due to:

- PCB design factors (symmetrical or not, copper density, stack)
- Material properties (type of the material, new or stored)
- Lamination process settings
- Equipment used for inner-layer alignment and for lamination
- Pre-treatment steps (oxidation, thermal stabilization, etc.)

Fiducial Types in X-ray Registration

Two primary fiducial methods exist:

1. Pad-stack fiducials: Fiducials on all layers are stacked on each other. This is faster but doesn't provide individual layer data (Figure 2).
2. Layer-to-layer fiducials: Each layer is evaluated independently, offering better accuracy and process control, especially for complex boards (Figure 3).

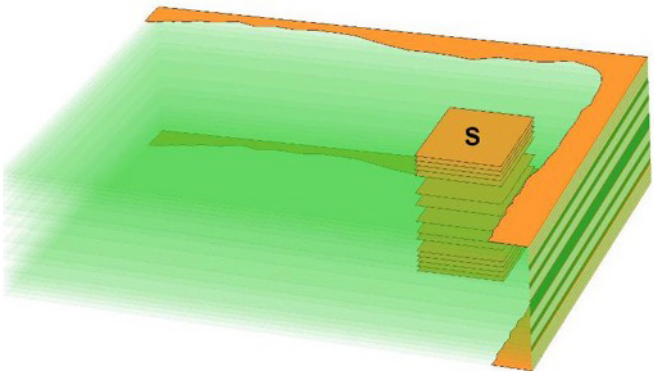


Figure 2: Pad stack fiducial type.

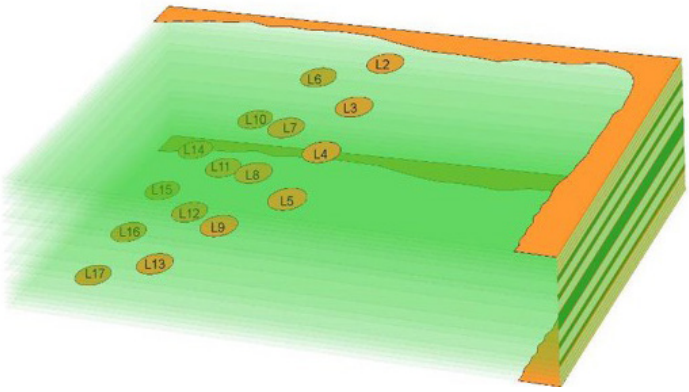


Figure 3: Layer-to-layer fiducial type.

Optimizing X-ray Detection

If you've ever had an X-ray at a hospital, you know that while the image is essential for diagnosis, interpreting it requires a trained specialist. Most of the time, it's difficult for an untrained eye to recognize details in the scan. However, in PCB manufacturing, an X-ray machine must be capable of quickly and accurately detecting fiducials without human intervention.

For the software to recognize fiducials efficiently, achieving high contrast and clear image quality is critical. Poor contrast can lead to misalignment issues, affecting the entire registration process. Several machine-specific factors play a role in optimizing fiducial detection, including:

- Machine construction to ensure stable and repeatable measurements
- X-ray source settings to enhance clarity and contrast
- Image processing algorithms for precise fiducial recognition

Figure 4a shows an example of fiducial detection on a 74-layer PCB with a 10 mm thickness, using layer-to-layer fiducials; an example of HDI board with pad-stack fiducial is shown in Figure 4b.

Another key function in X-ray registration is the ability to align to specific internal layers when needed. Ensuring the X-ray system supports this feature is critical for certain applications.

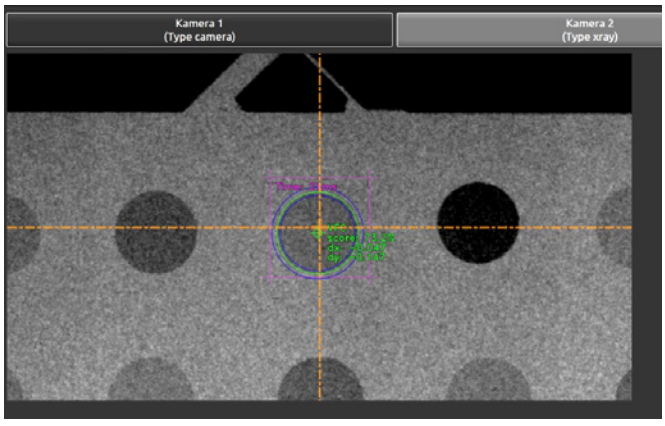


Figure 4a: Layer-to-layer fiducials on a 74-layer PCB with a 10 mm thickness recognized by X-ray.

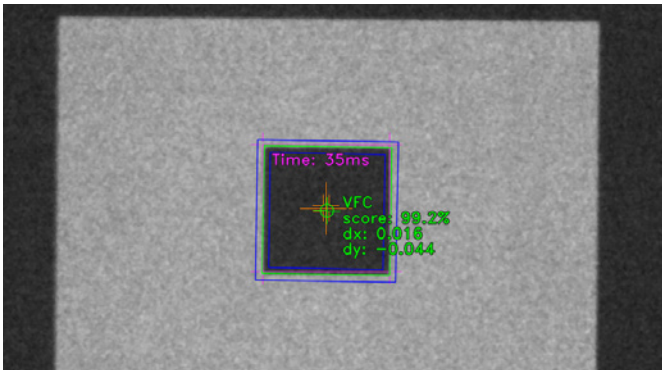


Figure 4b: Pad-stack fiducials on a HDI PCB recognized by X-ray.

How is X-ray Data Used?

Once X-ray measurement data is available, it serves two equally important purposes in the PCB production process:

1. Compensating inner-layer exposure for the next batch: By analyzing registration deviations, manufacturers can adjust exposure parameters in subsequent similar production batches to improve alignment and reduce errors over time.
2. Correcting the drilling program for the current batch: X-ray data is used to align the drilling process to the actual position of the inner layers, ensuring greater accuracy in via and hole placement.

While exposure correction helps refine the overall process for future batches, drilling compensation is essential for achieving high precision within the same production batch.

To perform corrections at the drilling stage, X-ray data (needed corrections for the drilling part program to better correspond to the position of the inner layers) must be somehow transferred accurately to the drilling machine. While data can be passed manually or through specialized software, these methods have limitations—they allow data to transfer to the drilling machine but do not enable per-station compensation.

Ensuring precise alignment at each station requires a more advanced process. In such a process, aside from drilling on X-ray two positioning base holes for the prism and slot, additional holes/fiducials for the individual alignment must also be drilled directly on the X-ray machine. This allows the CCD cameras on the drilling machines to recognize those reference holes at the panel alignment level or, if needed, within individual PCB zones. In such a process, the "data about the inner layers" (i.e., needed corrections for the drilling program) can be transferred to each individual station of the drilling machine indirectly via reference fiducials/holes that are drilled on the X-ray machine in positions which correspond to the inner layer misalignment picture.

For multi-zone alignment, where a single panel contains multiple high-accuracy PCBs, the X-ray system must support full-table measurement and drilling, ensuring optimal registration across the entire panel. If multi-zone alignment is used, fiducials should be drilled not only at the panel corners but also in corners of each zone, allowing zone-specific compensation.

Mechanical Drilling Alignment

Achieving precise registration on drilling machines requires CCD cameras for fiducial recognition (Figure 5). To achieve this on multi-station machines:

- Each station must have independent CCD
- A fully independent axis system is required

Figure 5: Two-station drilling machine with independent tables/stations and CCDs at each station.

Laser Alignment

Laser machines follow a similar registration approach when alignment holes are available. However, in cases where no alignment holes exist, a specialized process is required:

1. The laser skives the top copper layer, also removing a small portion of the dielectric.
2. The CCD camera of the laser machine then recognizes inner-layer fiducials for alignment and proceeds with the main part program drilling.

Process engineers must carefully adjust skiving parameters to ensure the laser does not penetrate deeper than the required reference layer (Figure 6).

Outer Layer Exposure Alignment

Outer layers are typically aligned using X-ray-drilled holes or holes created during main drilling.

However, when PCBs contain both mechanical and laser-drilled holes, an additional approach can be used. Combo targets are a mechanically-drilled fiducial combined with multiple laser-drilled fiducials to create a

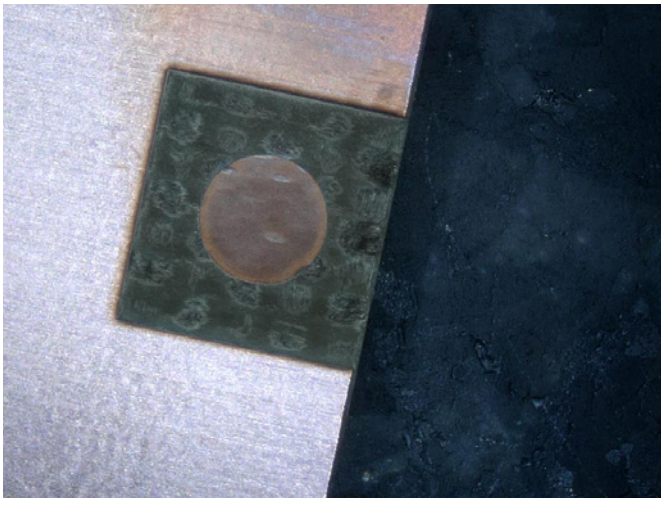


Figure 6: Fiducial on inner layer visible after skiving of the top copper layer by laser.

hybrid alignment point. The direct imaging machine then aligns optimally to both reference types for maximum accuracy (Figure 7).

Solder Mask Exposure Alignment

Solder mask alignment sometimes presents additional challenges due to:

- Low-transparency solder masks (black, white, etc.)
- Partial fiducial coverage by the solder mask

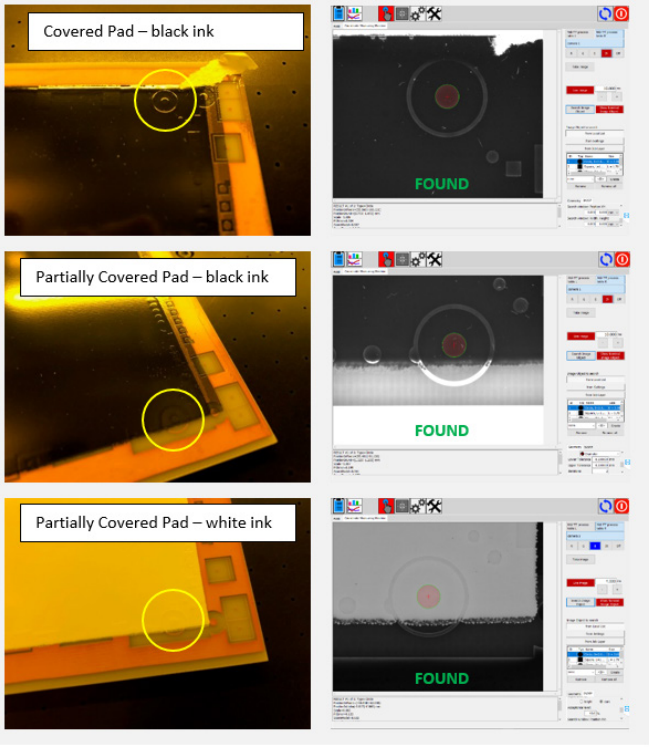


Figure 8: Recognition of pad fiducials under black and white solder masks with partial coverage of the fiducial.

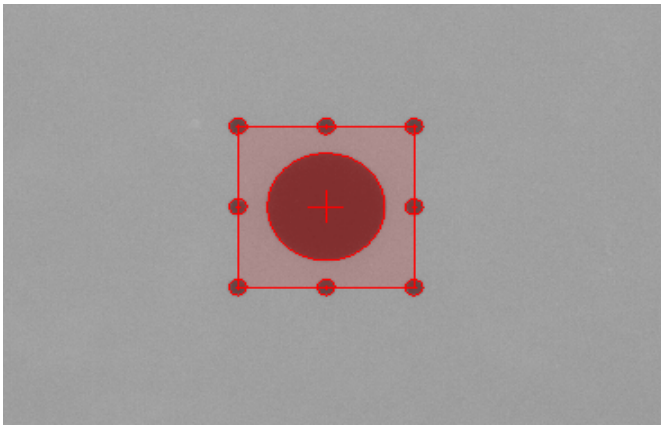


Figure 7: Combo target recognized by MDI at outer layer exposure stage.

Proper CCD lighting settings are crucial in overcoming these issues. With the right machine configuration and illumination adjustments, these challenges can be effectively managed (Figure 8).

Summary

In this article, we have explored registration in PCB manufacturing, a critical factor influencing yield and precision. Registration is interconnected with mechanical and optical processes, impacting nearly every step of PCB fabrication.

As PCB designs continue to evolve, achieving precise registration will remain a key challenge—one that requires both advanced technology and a deep understanding of process control. **PCB007**

Simon Khesin is the key account manager at Schmoll Maschinen GmbH. To read past columns, click here.

APEX EXPO® IPC 2026

3.14-3.19
meetings
& courses

3.17-3.19
conference
& exhibition

ANAHEIM CONVENTION CENTER | CA

To our sponsors, exhibitors, speakers, and attendees:

THANK YOU
for making our 25th anniversary event a huge success.

SEE YOU NEXT MARCH!

transform
TOMORROW
TODAY

...it
STARTS HERE.

TOMORROW'S electronics require that we rethink **TODAY'S** design, materials, and manufacturing processes. From silicon to systems, transformation begins here. Where the latest innovations, exclusive research, and nextgen technology solutions take center stage. A powerful forum for building relationships, sharing knowledge, and discovering new trends and technologies. It starts **HERE** … at the global electronics industry's largest exhibition, technical conference, and networking event in North America.

TRANSFORM YOUR FUTURE at **IPC APEX EXPO 2026!**

IPCAPEXEXPO.ORG | #IPCAPEXEXPO

Causes of Plating Voids, Pre-electroless Copper

Trouble in Your Tank

by Michael Carano, IPC CONSULTANT

In the business of printed circuit fabrication, yield-reducing and costly defects can easily catch even the most seasoned engineers and production personnel off guard. In this month's column, I'll investigate copper plating voids with their genesis in the pre-plating process steps.

Experienced engineers often say that many process steps and variables will influence the success or failure of obtaining a continuous void-free copper deposit in the hole. Everything in the process is critical to the success of the overall metallization process.

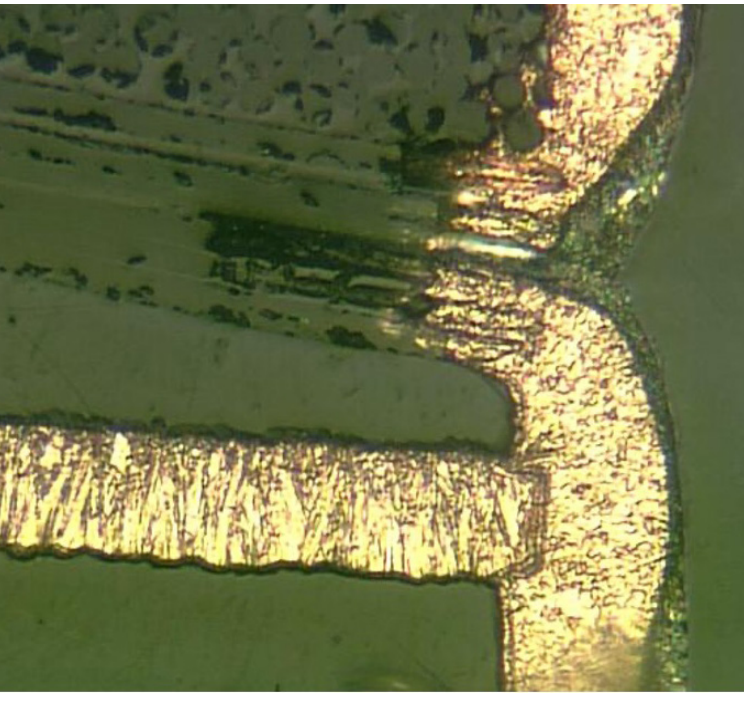


Figure 1: A rough hole wall, where glass fiber bundles were torn out exposing a deep gouge in the resin. Astonishingly, many feel the plating process should always compensate for such a travesty. A surface like the one shown here makes it very difficult to catalyze with the palladium-based activator from the electroless copper process.

One of the obvious causes of voids, or at least inadequate copper coverage, is the result of poor drilling. Figure 1 shows rough hole walls and torn-out glass bundles. A closer look at this section shows a very poorly drilled hole wall, with glass bundles protruding from the resin, as well. This is a potential cause of voiding. The rough hole walls with broken glass fibers make metallization with electroless copper challenging. The result is often a plating void or a significant thinning of the metal deposit. Later, this may lead to the electroless copper being etched away by the micro-etching step prior to electrolytic copper plating.

One should immediately investigate the drilling operation, looking at the following:

- Drill bit quality: How many hits and what is the overall condition of the drill tool?
- Spindle feeds and speeds: Is the drill tool punching its way through the stack?
- Slow up feed causing the torn-out glass bundles: It should be 2x the infeed rate.
- Check chip loads: Experiment with different chip loads to improve quality.
- Stack height: How many PCBs are in the drill stack? Consider reducing number to improve quality.

Figure 2 shows a horizontal section of a plated through-hole (PTH). Again, note the poor quality in the hole wall and its effect on the plating process.

The desmear operation is another potential

MADE IN THE U.S.A.

For more than 25 years, IPS has been your solution for the most state-of-the-art process equipment. All our systems are designed, tested and manufactured right here in America …and we wouldn't have it any other way!

IPS INTEGRATED PROCESS SYSTEMS INCORPORATED

U.S. Coast to Coast • Parts and Service Fast

ips-vcm.com · sales@ips-vcm.com · 435-586-1188

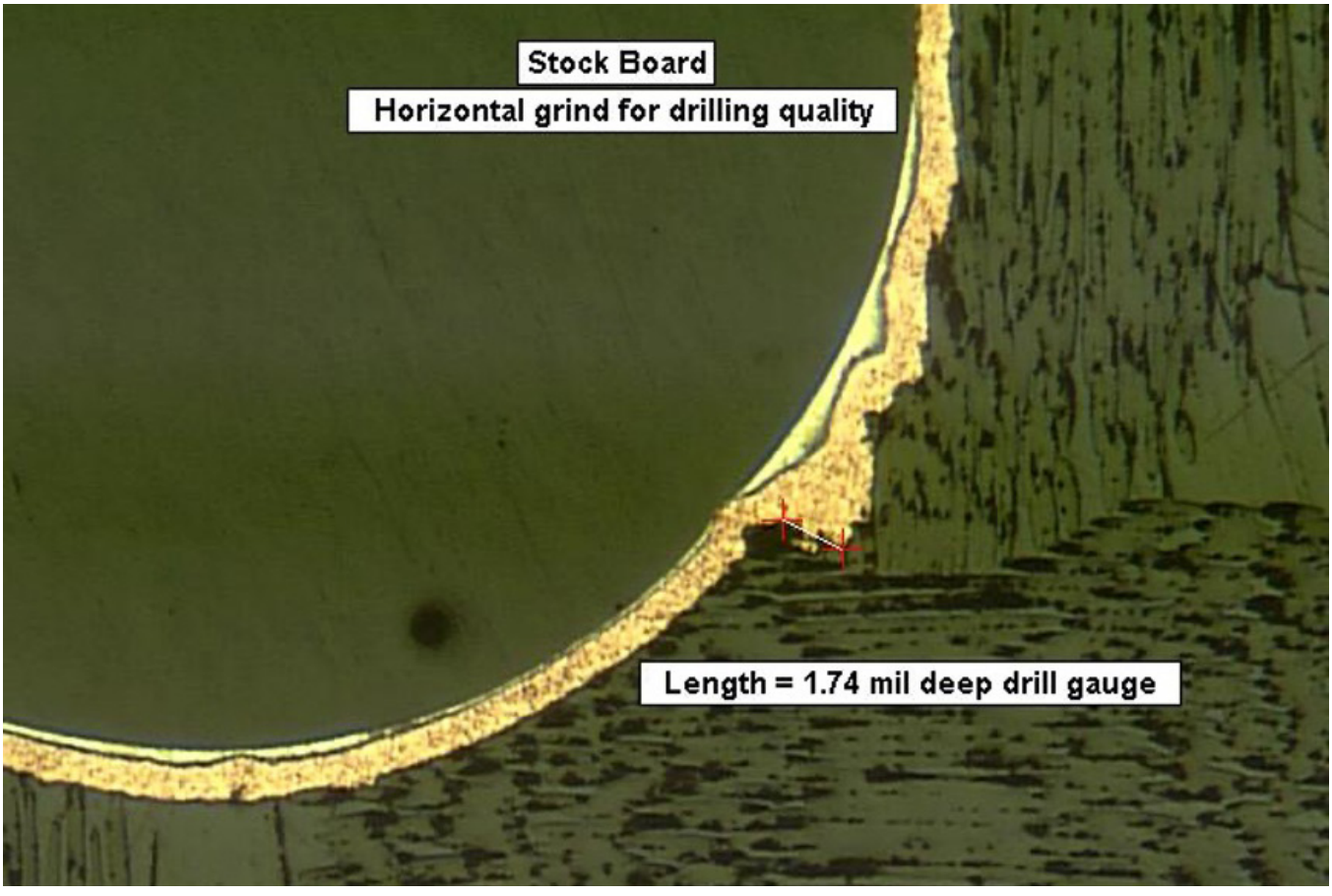


Figure 2: Horizontal section showing rough hole wall and voided areas.

cause of PTH voids. The most effective desmear process available today is based on alkaline permanganate. Although, with the development of new materials for the high frequency/low loss space and materials for improved longer-term reliability, adjustments in the desmear operation may be warranted. This would include the use of plasma desmear or a combination of plasma and permanganate. I will elaborate on this subject in a future column.

The use of alkaline permanganate for multilayer circuit boards has had a dramatic effect on copper coverage and adhesion in the plated through-hole. However, this process, if not controlled, can be a major cause of voids. First, the process consists of four main chemical process steps:

1. A solvent conditioner designed to penetrate the polymer matrix of the resin system and weaken the polymer-polymer bonds of the cross-linked chain.
2. The alkaline permanganate solution consisting of sodium or potassium permanganate and its corresponding hydroxide salt.
3. A neutralizer (possibly in combination with glass etch) for removing manganese residues.
4. Glass etch as a separate step to lightly roughen (frost) or more aggressively remove glass fibers that may be protruding into the hole due to etch-back.

If any of these four steps is not controlled, it can lead to voids. If this is the case, even the most robust electroless copper processes will not be able to compensate.

The effective alkaline permanganate process not only removes drill smear, but will microroughen the resin as shown in Figure 3. This texturing is often referred to as the honeycombed appearance. This is desirable for two reasons:

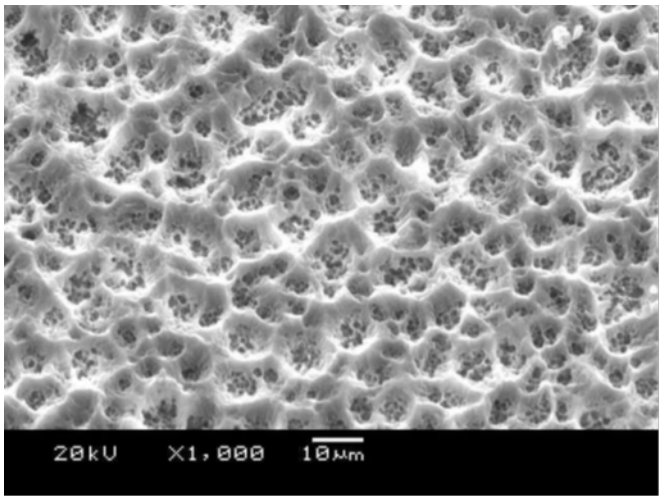


Figure 3: Preferred surface texture of resin after treatment with permanganate.

1. The textured surface promotes palladium catalyst adsorption which in turn promotes electroless copper deposition and coverage.
2. Surface improves copper adhesion.

This promotes improved solderability by minimizing or eliminating the occurrence of blowholes seen in the wave soldering operation. I will explain more about blowholes in a future column.

Regardless, if the texturing is inadequate, the possibility of voids exists. With insufficient catalyst anywhere on the via wall, the electroless copper deposition will fail to initiate, thus leading to a void in that area. Electroless copper processes require an adequate amount of catalyst on the hole wall in order to promote electroless copper deposition. Key questions to ask in the brainstorming session:

1. Is the solvent conditioner (swellant) making sufficient penetration into the resin matrix and is the solvent system compatible with the resin? Note that some of the higher Tg resins do not react the same as standard FR-4. The higher degree of crosslinking of the polymer resin makes it more difficult for the solvent to penetrate and thus weaken the polymer-polymer bonds in the resin. This, in turn, reduces the action of the permanganate solution in terms of resin removal and texturing.
2. Check the operating temperature of the alkaline permanganate solution, as well as the hydroxide and actual permanganate content. The hydroxide content aids in promoting the aggressiveness of the permanganate attack on the resin. The permanganate in the +7 oxidation state will perform the actual oxidization and breakdown of the resin. Manganate (+4) is a by-product of this reaction and will not participate in the resin oxidation. Manganate residue should be controlled and maintained below 20-25 grams/liter. Otherwise, as manganate builds up over time, the rate of resin removal and texturing will diminish. If solvent compatibility and degree of penetration is sufficient, then consider utilizing a higher concentration of permanganate. Sodium permanganate will allow for more actual permanganate in solution over the corresponding potassium salt.

Finally, review the neutralizer and glass-etch. A major cause of voiding is due to manganate residues remaining on the hole wall resin and glass. One should frequently renew this solution to ensure fresh working chemistry. Also, check the acid concentration. Lower concentration reduces the effectiveness of neutralization. Often, in order to reduce process steps, fabricators will combine the neutralizer and glass etch in the same process tank. (I prefer separate steps as the process is more effective). As the glass etch weakens due to continued use, the ability of the glass etch to roughen the glass fibers (referred to as "frosting") is reduced. This reduces the ability of the catalyst to adhere to glass. When this happens, voids are the result. **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. To read past columns, click here.

The ROI of Workforce Training

Interview by Marcy LaRont
I-CONNECT007

As the business landscape evolves, quantifying the effectiveness of training programs is crucial to rationalizing and securing ongoing investment, effectively addressing workforce challenges, and, most importantly, achieving the desired, tangible effects on productivity and bottom-line profitability. In this interview, Carlos Plaza of IPC and Tim Burke of Arch Systems explore the critical topic of workforce training and its ROI in the electronics manufacturing sector, based on a newly released IPC white paper, "Maximizing Returns: The ROI of Training in Electronics Manufacturing."

Marcy LaRont: Carlos, how did your team come around to an ROI discussion on workforce training?

Carlos Plaza: It came from the reality that the most important factor in business is ensuring that, wherever possible, revenues increase and costs decrease. With all the pressures on business today, this has never been truer.

Workforce training is a constant, and businesses are almost always, on some level, onboarding and training new people or upskilling existing workers to meet the demands of new contracts. But despite its acknowledged necessity, many businesses aren't following through on the return they are getting. How do they know their training is working? Are their costs decreasing? Are their efficiency and productivity rates increasing due to workforce training? Business requires that you tie the activity or initiative directly to revenue and bottom-line profitability.

To remain competitive amidst so many

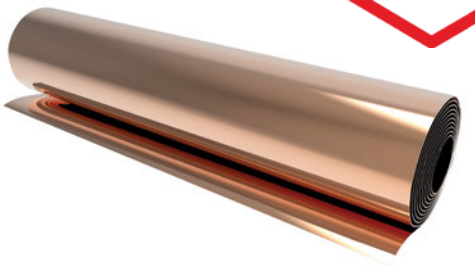
INSULECTRO

WORLD-CLASS SUPPLIERS

Insulectro, the largest distributor in North America of materials used in the manufacture of printed circuit boards and printed electronics, salutes our premier suppliers.

CALL 949.587.3200 FOR MORE INFORMATION

Manufacturer of IPC4562 B Grade HTE Copper Foils



CCP is a leader in the manufacture of high-quality electrodeposited copper for the printed circuit board industry. This privately held and Taiwanese owned has been supplying foil since 1987. They produce a full range of grade 3 HTE foils in both matte side and shiny side (RTF) treatments for high performance markets covering HSD and RF with foil profile options as smooth as <1 micron.

PACOTHANE TECHNOLOGIES

Conformal Release Film

MADE IN USA

Pacothane provides innovative lamination processing solutions including revolutionary PACO•CLUTCH™: decouples PCB panel from lamination separators, simplifies layout, improves scaling predictability, and improves yield for cap lamination, thin core multilayer, and sub laminations.

FOCUStech™

FOCUSTECH™ was founded on the belief that chemicals and control systems must work together to provide the most consistent and efficient manufacturing processes and has always taken a process control approach when formulating chemical products.

FOCUSTECH™ is the only supplier to the PCB industry that designs and manufactures both process chemicals and control systems. Products include cleaners, etchants, developers, and strippers plus control systems.

A Complete Line of Chemistry & Controllers used in PCB Manufacture & Metal Finishing

Precision is our specialty!

INSULECTRO 20362 Windrow Drive, Lake Forest CA 92630 • 949.587.3200 • insulectro.com


Carlos Plaza

business challenges, we need to continuously improve the operations of our companies, and, generally, we acknowledge that training is pivotal in achieving continuous improvement and greater efficiency. But the only way to see how well something is working is to measure it.

What is the distinction between knowing there's a cost-benefit or net-benefit balance and actually knowing your ROI?

Plaza: Cost-benefit is when you implement a training program and then use different levels of evaluation. For instance, the Kirkpatrick Model of Evaluation is an industry-standard that uses four levels of evaluation focused on reaction, learning, behavior, and results.

The first level is reaction, where you survey participants right after the training: Did they like it? Was it relevant? Did they understand everything? Can they use it in their jobs?

While these are common questions, business management does not actually care about them. They want to know whether downtime or defect reduction has decreased or how the training is affecting bottom-line profitability.

You are right. A CEO cares about what will affect productivity and profitability.

Plaza: The next level of evaluation is about applying what was learned. You institute accountability: Is the operator applying the training they received? Then, you evaluate whether it has made the intended business impact because, unfortunately, you can have both training and application and still not make a business impact.

How does a business measure that impact?

Plaza: That leads to the next vital step of evaluation, which is behavior. That's where Tim is helping us isolate the impact of training. If we saw a change, was it the only thing that moved the needle? Was it an effect of the training or because I made a change to the process?

Tim, how did you become involved in this white paper effort, and what have you brought to the party around ROI and workforce training?

Tim Burke: Carlos reached out to see if we could quantify the direct business impact on KPIs on the factory floor. Could downtime, throughput, and defect rates be tied to dollars, and could existing data and software achieve this?

In my company, we work with digital twins

Tim Burke

and digitizing information from the shop floor to provide this KPI-based view of what is actually causing downtime. It is an aggregate impact of many different things. In a factory, many things are constantly changing.

For example, you might say that your top-level KPI is downtime, and the main causes are 30% material-related and 50% due to your pick-and-place machine. Knowing that, you select a specific training program to address those downtimes, and you hope that after training you'll see a corresponding 50% reduction in downtime.

So, you have already done your root cause analysis?

Burke: Yes, the idea is that in a factory, you have these systems that gather the data you need to run the factory, such as your MES, which knows all the products moving throughout the factory shop floor. Other systems may have a dedicated system that tracks downtime. But while you were collecting all this data, you likely weren't tying it to training. But with the right views, you see the root causes and commonalities. For example, you might tie the downtime directly to a line, a machine, or a shift. So, if you train that shift, you should see a downtime reduction that you wouldn't see in your other shift.

When you put it all together—the product being built, the process or operation being performed, who was working, what shift the downtime happens on more frequently—and you measure a process deviation in your digital systems, you can quantify the business impact.

Imagine you do the training and your issue goes away entirely. Imagine how big the return would be if, for example, you recouped five hours of downtime. What is that worth to you?

Many businesses collect data and don't know what to do with it, so this is exciting and speaks to a real need in our industry. How have you modified your program specifically for workforce ROI data measurement?

Burke: We hadn't explored it before we talked to Carlos, but it's a use case you could do with the existing system. We do not specifically have a workforce module, but depending on the training program, like the itemized root cause of downtime, we are prioritizing it. The information is there; it just needs to be pulled together in the right way.

Plaza: You probably don't need to measure everything. Approach evaluating the ROI of training from an 80/20 perspective, the way that you should approach everything else in business. What's the 20% that will give me 80% of the benefit?

If I have a skill gap problem that can be fixed with training, then I will bother going through the steps of evaluating, measuring, and maybe

mks
Atotech

Elevate your high-speed PCB manufacturing

NovaBond® PX-S2 – Revolutionizing high-speed signal transmission and adhesion promotion

Step into the future of PCB manufacturing with MKS' Atotech NovaBond PX-S2. This new process technology revolutionizes signal transmission and adhesion promotion by combining nano-roughening with chemical bonding to achieve unparalleled precision and reliability. NovaBond PX-S2 ensures a signal integrity for common applications identical to a non-treated conductor by applying only nano-roughening while maintaining trace geometry and line-width. It delivers superior bonding at the molecular level without compromising precision thanks to its hybrid bonding technology. In addition, its innovative adhesion promotor provides unsurpassed bond strength for superior performance in any environment. Driving innovation and reliability in PCB manufacturing, NovaBond PX-S2 sets the standard for high-speed signal transmission and bonding. Move into the future now with MKS' Atotech NovaBond PX-S2!

To find out more about NovaBond PX-S2, scan the QR Code to the right.

info@atotech.com

www.atotech.com

Revolutionizing high-speed signal transmission by promoting ultra-low roughness adhesion

The search for improved signal transmission capabilities while maintaining structural integrity is a constant challenge in the ever-evolving field of printed circuit board manufacturing. To tackle this issue, MKS' Atotech has developed *NovaBond® PX-S2* which is poised to revolutionize this dynamic landscape. The new process is a unique bonding enhancement technology that reshapes traditional high-speed signal transmission and ultra-low roughness adhesion promotion.

The *NovaBond PX-S2* chemistry seamlessly combines nano-roughening through selective etching with the benefits of chemical adhesion promoters. In contrast to conventional methods, this innovative approach preserves trace geometry and line width with unparalleled precision. The result is a signal integrity (SI) performance on par with untreated conductors, together with exceptional thermal reliability and bond strength – all essential attributes for applications that demand unwavering performance under various operating conditions.

Precision is key

Precision is the cornerstone of advanced manufacturing. The *NovaBond PX-S2* process achieves this with remarkable accuracy. Its hybrid bonding technique strikes a delicate balance that enables precise control of nano-roughening while maintaining line thickness. Innovative processes carefully create nano-cavities that allow for superior bonding at the molecular level without compromising line-width reduction. The unique capability enables manufacturers to easily meet the demanding requirements of today's applications by producing detailed components with unmatched precision and reliability.

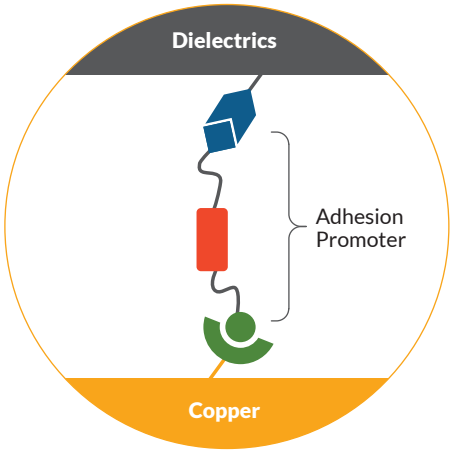
Outstanding bonding performance

Central to the *NovaBond PX-S2* solution is its highly oriented adhesion promoter – a true game-changer in improving bonding performance. The promoter ensures superior adhesion properties critical to a wide range of applications and facilitates optimal absorption of organosilane coatings. Its reliability in the most demanding environments is underscored by its resistance to even the most rigorous reliability tests. Through a synergistic blend of mechanical interlock and interfacial chemical bonding, it forms strong bonds that can withstand various stresses and conditions, thereby ensuring the longevity and reliability of the bonded structures.

High signal integrity – minimal loss

In the world of high-speed communications, signal integrity is crucial – and the *NovaBond PX-S2* process meets the challenge. Its ultra-low roughness results in significantly reduced signal absorption, a critical attribute for applications where minimal signal loss is essential. Maintaining signal integrity with minimal loss enables seamless and efficient communication between systems and devices, enhancing performance in critical signal reliability scenarios.

Overall, the *NovaBond PX-S2* process is a breakthrough technological innovation. It redefines the landscape of high-speed signal transmission and adhesion promotion in PCB manufacturing. Advanced performance, precision design, and unmatched signal integrity make this technology the foundation for innovation and reliability in electronics. As the industry marches forward into the future, *NovaBond PX-S2* is ready to lead the way into a new era of bonding enhancement technology that reshapes traditional high-speed signal transmission and ultra-low roughness adhesion promotion.



Thomas Thomas
Global Product Manager Surface Treatment Technology
Atotech Taiwan Ltd.
+886 965 816 781
Thomas.thomas@atotech.com

even nominalizing it. Even then, I would recommend that companies do a pilot program that they can refine as they go along.

The final critical piece of evaluation is ownership. This is key. Someone must own the plan—when and how you will measure, and how you will report the results. Figure that out before you create the training program.

Tim, how has this worked for Arch Systems?

Burke: In our businesses, we consider why someone might buy our system. Who's buying it, and what is its purpose? We found that, generally, it's the operations management chain in the factory. They want to know the KPIs because they're responsible for the factory's output: defect rates, units shipped, and on-time delivery. They're on the line for profit and loss, so they are most likely to already have data relevant to training programs, though they probably didn't think of it that way.

They already have all the data, they just don't know it has anything to do with ROI for workforce training.

Burke: Yes, so that's an opportunity. Although they often have all the data, they may need help seeing the bigger picture. When we put our system into factories, we connect existing data sources. In some sense, there's nothing new here, but there's always a moment when they see the full picture, and it hits them: "Wait a second, we've had six hours of downtime on this line a day." Then they ask someone to verify it, and they realize that it was true, but no one ever backed it up with data.

That's an opportunity to look at root causes, find one that is trainable, and then figure out a training program. We don't help with that, per se, but our customers do it once they get information on whatever the 20% is that has the most leverage.

Plaza: I am reminded of my work with the American Welding Society. Evaluating the cost of a welding job involves material and the time spent actually welding. Helmet downtime means your helmet is down and you're welding. When we asked welders how much their helmet downtime was, the average response was 80%. But when we looked at the data, it wasn't even close to 80%. When you start measuring every instance of a helmet being raised for things like taking a smoke or eating lunch, the helmet downtime was closer to 25%.

Burke: That reminds me of the importance of automating data collection and digitization and also of AI, which makes it easier to collect certain bits of data.

We think we can manually track whether a machine is down, and someone will notice if it's down for more than an hour. But when you track machine output on the computer, you see a one-and-a-half-minute stop, two minutes to change the feeder, then two and a half minutes and another three minutes for something else. Adding up those legitimate stops could mean close to four hours of downtime; they were just in little chunks, but the people running the machines thought they had a zero-downtime day. That's something a machine can track and that leads to huge opportunities for increasing ROI.

Carlos, in the paper you address the indirect benefits of training, which are valuable but harder to quantify.

Plaza: One critical intangible is long-term employee retention. While it's an intangible, you can measure it. You can easily know whether 100 people come in today but only 50 remain by the end of the year. You can calculate how much each of those training programs cost in hours and resources for the 50 people who left, easily showing the direct training investment that was lost. Add to that the productivity and downtime caused by the lack of workforce and training new employees. If you lose someone who's been there longer, that loss compounds over time.

Retention as a benefit of quality training holds a very high dollar value because people throw away a lot of money on poor training. However, studies by Deloitte, Gallup, and others have shown that people who receive quality training are much more likely to stay with the company.

Quality training that helps people excel in their job performance increases the likelihood they will deserve that raise or promotion and stay longer with the company. You should measure the effectiveness of your training because it will help you retain your workforce.

Another tricky intangible is engagement. How do you measure that? We survey trainees about how they like their jobs and how they can use the new skills they learned in their jobs. Those things are subjective, but in the aggregate, you get a picture of engagement. Training has been shown to increase engagement.

Another intangible is management buy-in. If the manager is not on board with training, they probably aren't right for the company.

We talk about retention as an intangible, but in a climate where we face a shortage of skilled labor, retention seems to be a significant tangible benefit, though perhaps it's harder to measure the ROI.

Plaza: We all need to train our managers. It's an aphorism now, but people do leave because of their bosses. Especially in a technical industry, it is easy to promote based on current job performance, but if someone moves into management and does not possess the necessary people skills, who is at fault?

I couldn't agree with you more. So, why is now the time to consider workforce training and ROI? Can IPC help companies embark on a workforce training ROI journey?

Plaza: It's always the time, but we only notice it when we feel pressure based on economic indicators and sales forecasts. That's when people start looking inward, and we know we need to do something. Now is one of those pressure points.

If you are in charge of training in a corporation, don't be fearful about measuring ROI. Many people fear measurement because they worry they will end up with data to show that their program or initiative is not working as intended. Most of the time, though, what you find is not necessarily about the training or the learning objectives but the application, the transference of the knowledge and skills gained in training. If it helps identify a specific manager who's not on board with the training, now you can address and fix the problem. Regardless of what the data says, you need to measure it continuously so you know where both the value and deficits lie.

"You should measure the effectiveness of your training because it will help you retain your workforce."

Tim and Carlos, thank you. You bring it right down to the things that manufacturers best understand, and care about most.

Plaza: You're welcome, Marcy, and thank you again for the opportunity to talk about it. **PCB007**

Click here to access the paper.

TOP TEN

EDITOR'S PICKS

A Look Into the Future With Futurist Kevin Surace

Futurist Kevin Surace might have been great as a writer for science fiction TV and movies where technology was just within the realm of imagination and great camera tricks, but he's actually spent his career learning and inventing technology in real life. In this interview after his keynote address at IPC APEX EXPO 2025, Kevin reflects on important lessons learned and how they shaped his own future. He also makes some bold predictions for the use of AI in PCB board design, fabrication, and assembly—and what the common household will look like in 10 years.

Gold as a Key Component in PCBs and IC Substrates

Gold has long been a cornerstone in the electronics industry, particularly in the surface finishing of PCBs and IC substrates. Gold plating is a critical step in several finish systems, including electroless nickel/immersion gold (ENIG), electroless nickel/electroless palladium/immersion gold (ENEPIG), and electroless palladium/autocatalytic gold (EPAG). This article explores different types of electroless gold plating electrolytes, their plating mechanisms, and their properties and capabilities.

Paige Fiet: From Emerging Engineer to Quality at TTM

Paige Fiet is a graduate of the IPC Emerging Engineer program and now works at TTM Technologies in Logan, Utah. She was an IPC Student Board Member and has been a columnist for I-Connect007. She is a stellar example and an encouragement to other young engineers about how to be successful in your early career. She shares, "My dad was an engineer and as a kid, I remember going to visit him at his factory. I distinctly remember the day they put in a robot arm and how excited he was."

Schmoll: Decades of Technology Evolution

My name is Kurt Palmer, CEO of Schmoll America, and with my colleague Simon Khesin, we are launching this column about driving innovation in mechanical and optical process. To begin, I will look back at Schmoll's history, building a business of manufacturing PCB drilling machines, examining key technological milestones, and demonstrating how challenges were addressed over the years. In future columns, we will discuss current industry challenges, technological advancements, and anticipated trends shaping PCB manufacturing.

Real Time with... IPC APEX EXPO 2025: Tariffs and Supply Chains in U.S. Electronics Manufacturing

Chris Mitchell, vice president of Global Government Relations for IPC, discusses IPC's concerns about tariffs on copper and their impact on U.S. electronics manufacturing. He emphasizes the complexity of supply chains and the need for policymakers to understand their effects. Access to critical components is vital for revitalizing manufacturing, while trade relationships with Canada and Mexico are crucial for a strong North American base. Future relations with China highlight the importance of trust in supply chains.

The Rising Term Premium: A Closer Look at the Implications of a Decade-high Surge

In recent months, financial markets have grappled with various conflicting signals, trying to reconcile strong economic performance with persistent uncertainties. While the U.S. economy appears robust and recession risks over the next 12 months have diminished significantly, several factors continue to drive an uncertain outlook. One key development of this uncertainty has been the behavior of the "term premium."

Punching Out: Fewer Than 150 PCB Shops Remain in North America

According to GP Ventures' database, the number of printed circuit board manufacturing companies in North America (including Canada), is now below 150. In 2020, it was around 200, and in 2022, it was 170. These figures do not include companies that only import or assemble boards. Please note that we are counting PCB companies and not facilities, so TTM Technologies counts as one, Summit as one, AdvancedPCB as one, etc. The total number of facilities is probably higher by around 30.

Observations on Palladium as a Final Surface Finish

Not much has been published about palladium as a final finish, but it's experiencing a renaissance as a liquid metal for metallization of copper in ultra HDI and as a final finish. It was very popular in the 1970s because of its corrosion resistance, as the only other final finishes were tin-lead reflow, Ni/Au, OSP, or immersion tin. Palladium was very popular with the automotive industry then and Photocircuits of Glenn Cove, New York, was a major supplier of boards.

Electroninks' MOD and iSAP Game Changers

Electroninks, a prominent player in particle-free conductive inks, recently announced an exciting new range of metal-complex inks for ultra high density interconnect (UHDI) technology. At the SMTA UHDI Symposium in January, Mike Vinson, COO of Electroninks, gave a presentation on this line of MOD inks, which are versatile and suitable for a range of applications that require ultra-dense, miniaturized, and high-frequency technology.

Global PCB Connections: A Field Engineer's Perspective on the Top 10 Trends to Watch

As a field application engineer for a major Chinese PCB company, I see firsthand the challenges and, more excitingly, the trends shaping our industry. Talking to engineers, designers, and procurement teams worldwide, one thing is clear: PCBs have come a long way, but we're barely scratching the surface of what's possible. Here are 10 trends I believe will define our industry over the next decade.

Find Industry-experienced Candidates at jobConnect007

For just $975, your 200-word, full-column ad will appear in the Career Opportunities section of all three of our monthly magazines, reaching circuit board designers, fabricators, assemblers, OEMs, suppliers and the academic community.

In addition, your ad will:

- be featured in at least one of our newsletters
- appear on our jobConnect007.com board, which is promoted in every newsletter
- appear in our monthly Careers Guide, emailed to 26,000 potential candidates

Potential candidates can click on your ad and submit a resume directly to the email address you provide, or be directed to the URL of your choice.

No contract required. Just send over your copy and company logo and we'll do the rest!

Contact barb@iconnect007.com to get your ad posted today!

+1 916.365.1727

I·Connect007
GOOD FOR THE INDUSTRY

smt007 pcb007 design007

Career Opportunities

TECHNICA, U.S.A.

Various Positions

For 40 years, Technica USA has been providing products, equipment, and services to the printed circuit board fabrication and assembly markets. Working with our worldwide partners, we offer our customers solutions through best-in-class product lines. Technica has offices in San Jose, Calif, and Rancho Cucamonga, Calif.

We are expanding and looking for highly qualified Business Development/Account Managers for both the PCB and PCBA markets.

We are adding to our growing national equipment service coverage and looking for experienced Equipment Service Technician/Engineers.

Are you a PCBA equipment applications expert with experience in component placement and inspection? We are looking for Equipment Product Specialists to work within our San Jose, Calif., PCBA Equipment Demo center.

Please visit www.technica.com/careers to learn more about these positions and submit your resume today!

apply now

all flex SOLUTIONS

Sales Applications Engineer

The Sales Applications Engineer is responsible for working with customers and managing inquiries to result in an accurate quote for business and ongoing customer support. The Sales Applications Engineer reports to the Application Engineering Manager.

Essential Job Duties:

- Interface with customers via direct contact, sales calls, email, and phone to determine need, provide design assistance and provide a quote for business
- Management of programs from key customers from initial purchase order to end of life
- Interface with customers regarding all aspects of a program
- Serve as liaison with All Flex regarding customer issues related to a specific situation

Qualifications:

- Degree in engineering, math or science or equivalent work experience.
- Prefer 5-8 years of product and/or manufacturing experience with flex circuits, flex heaters or circuit board industry
- Knowledge and understanding of concepts, contents, and application of ISO 9000 helpful
- Proficient in Microsoft Office applications and data entry. NetSuite experience preferred
- Must be a U.S. Citizen or U.S. Permanent Resident

We offer a competitive base salary in the $80,000 to $85,000 range, based on experience and qualifications, along with bonus and profit-sharing opportunities tied to performance.

If interested, please email resumes to joseph.janasz@allflexinc.com.

apply now

Career Opportunities

ARLON ELECTRONIC MATERIALS

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

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

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

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

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

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

apply now

American Standard Circuits
Sunstone Circuits

Sales Coordinator

Come join the sales team at ASC Sunstone Circuits in Mulino, Oregon, as our Sales Coordinator! This position is responsible for ensuring the seamless processing, tracking, and delivery of customer orders while providing exceptional client communication and internal coordination. Some of the duties include:

- Order processing
- Order tracking and status updates
- Customer communication
- Internal coordination with sales, production, and shipping
- Administrative support

Education & Experience

A high school diploma or GED is required for this role. In addition to the education requirement, a minimum of two years of related experience in an administrative or support role, within a sales or customer service environment, is required. An equivalent combination of education, training, and experience may satisfy these requirements.

Knowledge, Skills, and Abilities

The ability to adjust to new situations, environments, and changing priorities, to effectively convey information and ideas through written, verbal, and non-verbal means; and proficiency in Microsoft Office Suite or related programs are essential.

Benefits

- 401(k) matching
- Dental insurance
- Employee assistance program
- Flexible spending account
- Health insurance
- Life insurance
- Paid time off
- Vision insurance

apply now

Career Opportunities

PCB Manufacturing Technician

Join the Team at Accurate Circuit Engineering!

Located in Santa Ana, California, Accurate Circuit Engineering (ACE) delivers high-quality PCB solutions with a focus on innovation and precision.

Role: Accurate Circuit Engineering is looking for detail-oriented PCB Manufacturing Technicians for all areas in PCB manufacturing. Responsibilities include operating manufacturing equipment, performing quality checks, and documenting production data.

Qualifications:

- High school diploma or equivalent; technical training preferred
- Experience in PCB manufacturing or electronics assembly a plus
- Strong attention to detail and ability to follow instructions
- Familiarity with PCB manufacturing and testing tools is advantageous

What ACE Offers:

- Competitive wages and benefits
- Career growth opportunities
- Supportive work environment with comprehensive training

To apply, send your resume and cover letter to sales@ace-pcb.com with the subject "PCB Manufacturing Technician Application."

Accurate Circuit Engineering is an equal-opportunity employer and values diversity in the workplace.

apply now

Service Engineer: Chicago

Join the Schmoll America Team as a Service Engineer—Where Innovation Meets Customer Excellence! Are you a technical mastermind with a passion for solving complex problems and delivering exceptional customer experiences? Look no further than Schmoll America!

We're looking for engineers to work in the Chicagoland area.

As a Service Engineer, you'll be the driving force behind our customers' success, providing top-notch technical support and maintenance services for our PCB industry-leading equipment.

What you'll do:

- Install, commission, and maintain Schmoll equipment at customer sites
- Troubleshoot and repair equipment with ease and precision
- Provide technical training and tailored applications solutions to customers

What we offer:

- A dynamic and supportive work environment where your voice matters
- Opportunities for professional growth and development in a cutting-edge industry
- A competitive salary and benefits package
- The satisfaction of knowing you're making a real difference in our customers' lives

What we're looking for:

- Engineering degree preferred
- 3+ years of experience in an engineering role
- Strong technical knowledge of electrical and mechanical systems
- Excellent problem-solving and analytical skills
- Willingness to travel (up to 75%) to customer sites and HQ in Germany

If you're a motivated professional looking for a challenging and rewarding role, we want to hear from you! Please submit your resume and cover letter to HR@SchmollAmerica.com.

apply now

Career Opportunities

The Test Connection, Inc.

Sr. Test Engineer (STE-MD)

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

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

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

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

apply now

The Test Connection, Inc.

Rewarding Careers

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

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

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

Associate Electronics Technician/ Engineer (ATE-MD)

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

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

apply now

Career Opportunities

BLACKFOX
Premier Training & Certification

Sales Manager
Longmont, CO

This is a full-time, on-site role for a Sales Manager at Blackfox Training Institute in Longmont, CO. We are looking for a Sales Manager with a strong track record of B2B sales management experience. The Sales Manager will be responsible for day-to-day sales activities, developing sales strategies, building and maintaining client relationships, and achieving sales targets. Additionally, the Sales Manager will participate in industry events, represent the company at trade shows, and collaborate with the marketing team.

Qualifications:

- Sales Strategy Development, Client Relationship Management, and Sales Target Achievement
- Experience in B2B sales and a proven track record of meeting sales goals
- Structured and growth-oriented approach to Sales Leadership
- Excellent communication and negotiation skills
- Knowledge of the training or education industry a plus
- Able to work effectively in a team and independently
- Bachelor's degree in Business Administration, Engineering or related field
- Proficiency in CRM software such as Hubspot
- Services sales experience will be a strong plus

Contact Jamie Noland to apply:
jamien@blackfox.com

apply now

INSULECTRO

Are You Our Next Superstar?!

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

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

apply now

Career Opportunities

MivaTek Global

Field Service Technician

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

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

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

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

More About Us

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

apply now

eptac

TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

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

Qualifications and skills

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

Benefits

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

apply now

Career Opportunities

Prototron Circuits

Sales Representatives

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

Reasons you should work with Prototron:

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

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

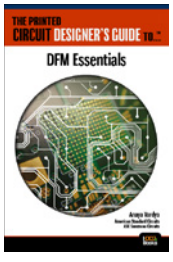
apply now

YOUR JOB AD HERE

For information, please contact:
BARB HOCKADAY
barb@iconnect007.com
+1 916.365.1727 (PACIFIC)

I-Connect007
GOOD FOR THE INDUSTRY

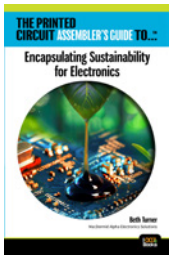
I-007eBooks The Printed Circuit Designer's Guide to...



DFM Essentials

by: Anaya Vardya, American Standard Circuits, ASC Sunstone Circuits

One of the biggest challenges facing printed circuit board designers is not understanding the cost drivers in the PCB manufacturing process, particularly the manufacturing of advanced technology PCBs. The guidelines offered in this book are based on both ASC recommendations and IPC standards. **Download your copy today.**



Encapsulating Sustainability for Electronics

by Beth Turner, MacDermid Alpha Electronics Solutions

This book discusses the growing demand for sustainable solutions in the market and highlights examples of bio-based resins and the demand from emerging technologies. **Read it now!**

PODCAST SERIES

ON THE LINE WITH... I Connect007

MANAGING EDITOR: **MARCY LARONT**
(480) 280-5229; marcy@iconnect007.com

EXECUTIVE ADVISOR: **BARRY MATTIES**
barry@iconnect007.com

EDITOR | COLUMNIST COORDINATOR: **MICHELLE TE**
michelle@iconnect007.com

CONTRIBUTING EDITOR: **PATRICIA GOLDMAN**
(724) 299-8633; patty@iconnect007.com

TECHNICAL EDITOR: **PETE STARKEY**
+44 (0) 1455 293333; pete@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **DAN FEINBERG**
baer@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **HAPPY HOLDEN**
(616) 741-9213; happy@iconnect007.com

BUSINESS DEVELOPMENT MANAGER: **BARB HOCKADAY**
(916) 365-1727; barb@iconnect007.com

MARKETING SERVICES: **TOBEY MARSICOVETERE**
(916) 266-9160; tobey@iconnect007.com

DIGITAL MARKETING MANAGER: **BRITTANY MARTIN**
brittany@iconnect007.com

ART DIRECTOR/PRODUCTION MGR.: **SHELLY STEIN**
shelly@iconnect007.com

MAGAZINE LAYOUT: **MARIEL EVANS**

AD DESIGN: **SHELLY STEIN, MIKE RADOGNA, TOBEY MARSICOVETERE**

CREATIVE TECHNOLOGIST: **BRYSON MATTIES**

COVER DESIGN: **SHELLY STEIN**

COVER IMAGE: **ADOBE STOCK © BrAt82**

PCB007 MAGAZINE

PCB007 MAGAZINE®
is published by IPC Publishing Group, Inc.
3000 Lakeside Dr., Suite 105N, Bannockburn, IL 60015

April 2025, Volume 15, Number 4
PCB007 MAGAZINE is published monthly
by IPC Publishing Group., Inc., dba I-Connect007

ADVERTISER INDEX

Problems solved!