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This month, we bring you articles and interviews with show organizers, committee leaders, and instructors. We even have one article designed to help you justify to your manager why you need to attend this show.

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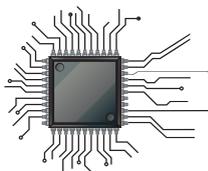
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On With the Show

The Shaughnessy Report

by Andy Shaughnessy, I-CONNECT007

It's almost 2023 and I keep asking myself, "Where did the year go?"

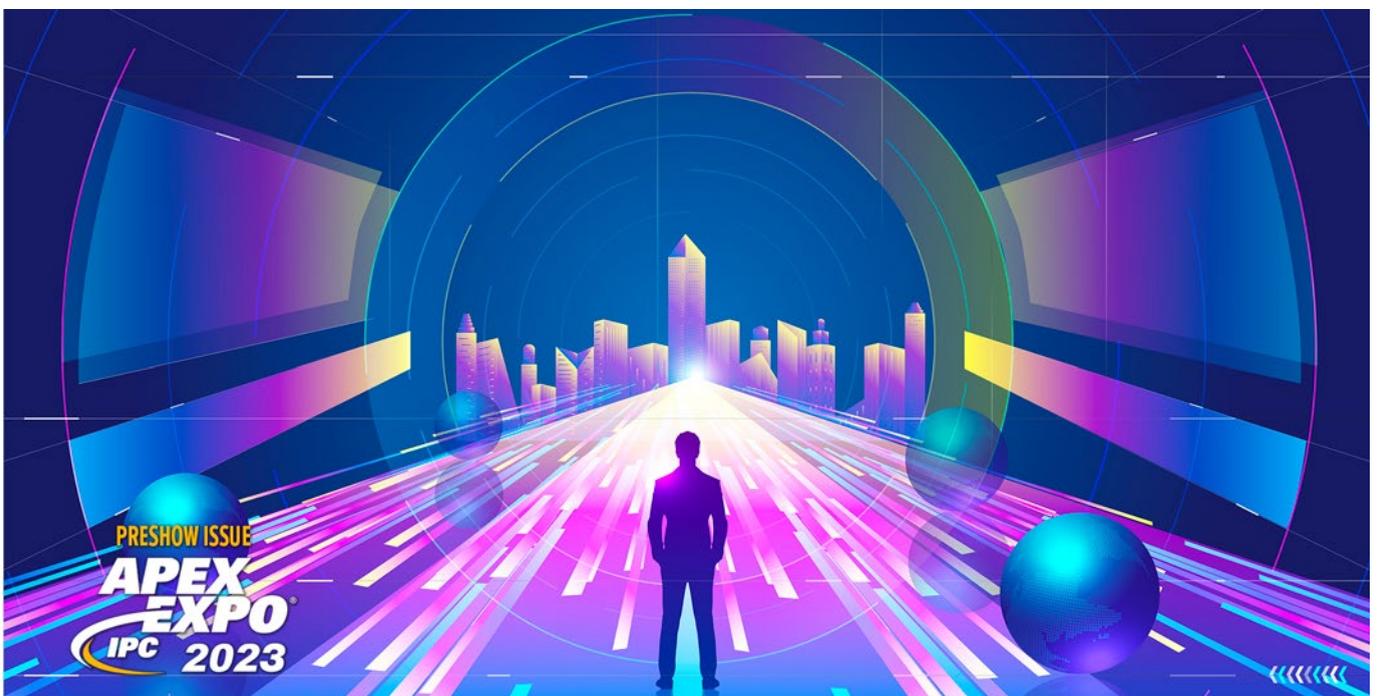
It's been a pretty good year all around. From conversations that I've had at conferences recently, I know that some of your companies have had great years, in spite of supply chain pressures, an old-fashioned shooting war near some of our manufacturing base, and some unfilled positions in your office.

You are taking care of business, and it's a great time to be in this industry. To that end, we're looking forward to meeting up at IPC APEX EXPO 2023, which takes place Jan. 21–26 at the San Diego Convention Center. In

some ways, this will be the first true post-pandemic expo.

Unlike the 2022 show, there will be no mask requirements this time. This will go a long way toward bringing back that feeling of community and camaraderie, a vibe that got lost when we all looked like bank robbers. It will be nice to see your smiling faces again, even if most of us likely won't win any beauty contests. I hope that elbow-bumping is passé now too. In for a penny, in for a pound.

I know a lot of huggers in this industry, especially in sales and marketing, and for them, IPC APEX EXPO 2023 will be like a return to



the good old days. I bet some of you are practicing in the mirror right now, saying, “Come on, bring it in, big guy!” (You know who you are.)

There’s a lot of excitement around this show, and the event is shaping up to match expectations. This year, IPC has about 365 exhibitors signed up, and more classes—with better content in the Professional Development and Technical Conference sections—than I can remember.

In this month’s issue of *PCB007 Magazine*, we bring you a preview of the big show. You’ll see articles and interviews with show organizers, committee leaders, and instructors. Julia Gumminger has a sneak peak of the special sessions at the show, while Alicia Balonek brings us details about the Women in Electronics Reception, and Gaurab Majumdar discusses the first-ever India Pavilion, which will showcase many of India’s PCB manufacturers. Charlene Gunter du Plessis of the IPC Education Foundation has details about the organization’s continuing drive to attract more students to STEM classes and careers, including a STEM event that takes place on Jan. 25–26.

As the new managing editor for *IPC Community*, Michelle Te discusses this industry-specific quarterly magazine that will be launched at the show. Copies of the publication will

be available throughout the show in digital and printed format. Hard to believe we hired Michelle in April 2020 and didn’t get to meet her in person until IPC APEX EXPO 2022. She really upped the ante among us editors, and she’ll be managing this new magazine.

We even have one article designed to help you justify to your manager why you need to attend this show. When you suggest traveling to a nice location like San Diego, your manager might give you the side-eye, but if you’re armed with the info in this issue of *PCB007 Magazine*, I think you can make a pretty good case for yourself.

To round our pre-show coverage, we invite you to stop by our state-of-the-art booth and chat with us. We’ll be there all week, greeting guests while our editors and guest editors will be conducting scores of *Real Time with... I-Connect007* video interviews with the industry’s top engineers, managers, and executives.

I hope you all have a fantastic holiday season, and I hope to see you in San Diego next month. Have a Happy New Year! **PCB007**



Andy Shaughnessy is managing editor of *Design007 Magazine* and co-managing editor for *PCB007 Magazine*. He has been covering PCB design for 20 years. He can be reached by [clicking here](#).



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Industry Innovation Starts Here

Article by IPC Staff

If it isn't clear already, your money, time, and effort will be well spent attending IPC APEX EXPO in January. Here, we've outlined the top six reasons why this event will be the highlight of your year. We've done all we can to make the event not only memorable, but a show that allows you to connect with industry peers, learn how to enhance your skills, help advance the industry, and discover new insights on products and strategies from industry innovators.

Connect

Advance your network on a global scale on the show floor, at social receptions, and at our new Career Networking Event featuring special guests from the Emerging Engineer program. Engage in a discussion on career development strategies and hear stories about best and worst career decisions.

Lead

Equip your business to be a leading industry competitor when you attend Factory of the Future track sessions, where you will learn to solve real business challenges and identify new technologies that modernize industry processes.

Build

At IPC APEX EXPO 2023, you'll interact with the latest innovators, meet world-leading manufacturers on the show floor, and discover how you can build electronics better.

Learn

This year's Professional Development offerings include 36 courses and a new business track featuring "Customer Contract and Legal Boot Camp for Engineering Professionals," led by Jeffrey Roth and Patrick Sebastia II, F&B Law Firm.

Advance

Be part of taking electronics manufacturing into a new era of excellence. Actively participate in the development, review, and updating of the industry's



critical standards and guidelines at our standards development committee meetings.

Discover

Discover new insights on products, strategies, and solutions from your peers, subject matter experts, and innovators. Take home real business solutions to address your challenges.

Making the Pitch

Bolster your formal request to attend IPC APEX EXPO 2023 to your manager. Every organization is different, so we have compiled a list to help persuade your boss to support your attendance at IPC APEX EXPO 2023. **PCB007**

Here's Something to Consider

Best rate: Visit the registration page and determine your rate. Note that all rates increase after Dec. 16. Did you know that becoming an IPC member can save you money on registration? Or that group rates are available?

Session Content: Identify specific Technical Conference sessions and Professional Development courses that are relevant to both your organization and your work. Create a list of how attending these sessions will positively impact your work.

Vendor contacts: Map out your visit by choosing exhibitors you want to meet with at the event. Discover the latest technologies and innovations on the show floor.

Investment: This conference isn't an expense, it's an investment. What is the return on investment (ROI) when you attend? You should be able to showcase the benefits/value to your organization in relation to the expense it will incur.



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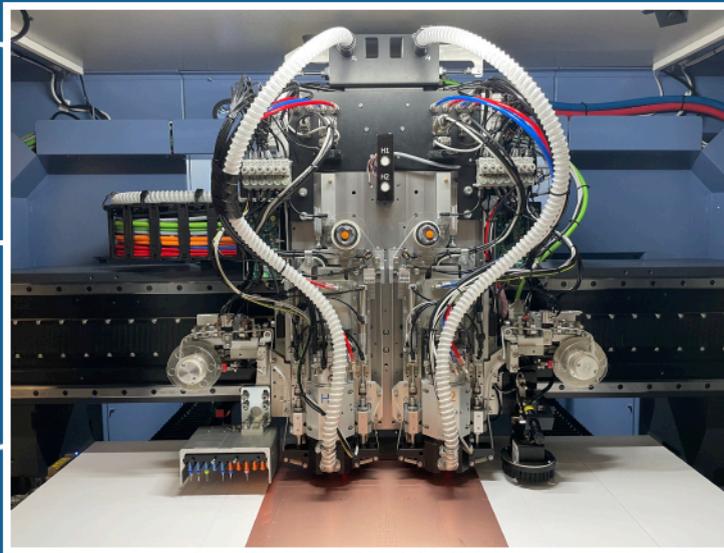
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Advance in a **New Era**

One World, One Industry

Feature Column by Dr. John Mitchell, IPC PRESIDENT AND CEO

At IPC APEX EXPO 2023, we look forward to connecting with you as we “Advance in a New Era of Electronics Manufacturing.” This year’s event will be one of our most exciting as we share ideas, insights, and new discoveries on topics ranging from substrates, packaging, and automation to data analytics, cybersecurity, and Factory of the Future.

IPC APEX EXPO is the ideal place for electronics manufacturing industry members to meet and collaborate with peers, leaders, and innovators from around the world, not only during educational sessions, but also on the show floor, in standards development committees, and at a variety of networking events and receptions.

What will you enjoy at IPC APEX EXPO this year?

The show floor will feature the largest gathering of exhibitors in North America from every step in the electronics manufacturing supply chain. Make sure to walk the show floor to meet the industry’s leading equipment manufacturers, suppliers, and innovators to compare solutions, connect with existing suppliers, and find new partners.

We’re excited to present three keynote speakers at IPC APEX EXPO this year, with two speaking during luncheons for the first time. We welcome Emily Callandrelli, mechanical and aerospace engineer and the host and co-producer of “Emily’s Wonder Lab” on Netflix, who will speak about the sustainability, economics, and advocacy of space exploration. Our second luncheon speaker is Shawn DuBravac, IPC’s chief economist, who will provide insight into

KEYNOTE SPEAKER:

EMILY CALANDRELLI

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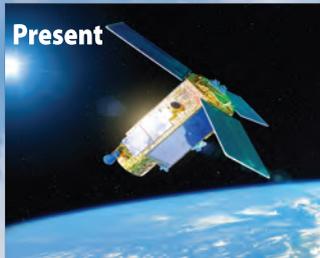
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The Sustainability, Economics and Advocacy of Space Exploration

January 24, 2023 | 8:30 am-9:30 am



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emerging technology themes and the micro trends defining the future of electronics; and I look forward to sharing more on workforce modernization.

For the first time, IPC E-Textiles, the international conference for the e-textiles industry, will be co-located with IPC APEX EXPO. This global e-textiles industry event allows product designers, technical experts, and company executives from around the world to collaborate on new ideas, view and get hands-on access to the latest innovations, and learn how to build reliable products.

The EMS Leadership Summit on Jan. 23 will bring together current and future industry leaders to solve problems, build business networks, and share insights on doing business better. Focused on high-level topics that drive business growth and financial success, leaders will gather insights from experts and discuss both their current and potential new best practices during panel discussions and roundtables. This meeting of minds inspires action and builds resources for participants, future leaders, and the greater EMS industry.

Our educational offerings at the show have always been unique and 2023 will be no exception. IPC's Technical Program Committee (TPC) created an expert lineup of speakers and instructors in technical education and professional development. Our carefully curated Technical Conference will include presentations featuring topical studies, new technologies, advanced materials, and the latest processes that help improve the efficiency and quality of your manufacturing. Attendees will have the opportunity to select from five hot topic tracks: Factory of the Future and future technologies; PCB fabrication and materials; quality, reliability, test, and inspection; assembly and materials; and high-density interconnects and microvias. Two special Technical Conference sessions will also cover advanced packaging and e-mobility. Professional development courses will include something for everyone, from

Join panel discussion leader Yolita Wildman Nugent, Betazip, for "Business and Economics Impacts—the Real World of Product Development," at IPC E-Textiles 2023.



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How do you ensure that embedded electronics are stretchable and flexible? Don't miss Jessica Stanley's presentation at IPC E-Textiles 2023, "Enabling Stretchable LED Circuits for Wearable Applications Through 3D Geometry," Jan. 23, 2023.



Jessica Stanley

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<https://hubs.li/Q01sJ5IZ0>

advanced classes exploring the details and depth of specific topics, to informative classes catering to engineers just beginning their careers.

If you're interested in actively participating in the development, review, and update of the electronics industry's critical standards and guidelines, attend some of our more than 100 standards development committee meetings. Standards committee meetings are the perfect place to meet and collaborate with new peers, industry leaders, and innovators.

For those visiting IPC APEX EXPO for the first time, we welcome you to the largest gathering of electronics professionals in North America. We are happy that you've chosen to spend your time with us. Be sure to take advantage of the many networking opportunities offered by signing up for educational sessions that are directly applicable to your work; there, you will meet manufacturing industry profes-

sionals from around the world who are facing (and solving) challenges like yours. For returning attendees, we welcome you back with open arms. One of the best things about it is the community we've built over the years, and we look forward to reconnecting with you again.

If you're active on social media, please use the hashtag #IPCAPEXEXPO on Twitter, Facebook, Instagram, and LinkedIn to share your experience, post photos, and continue the conversation with our social community.

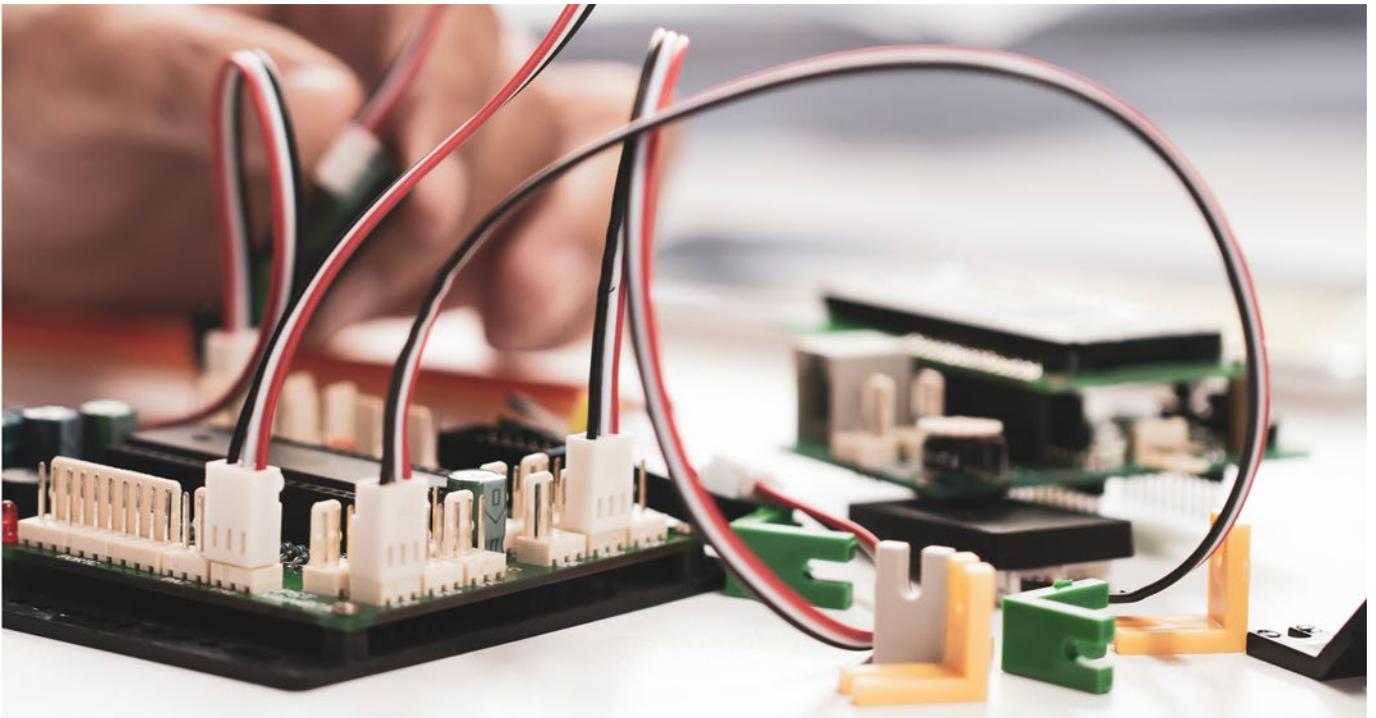
As one of our many attendees said, "I come to IPC APEX EXPO because the whole industry is here." We are all here, and we are looking forward to seeing you in sunny San Diego. **PCB007**



Dr. John Mitchell is president and CEO of IPC. To read past columns, [click here](#).

VIDEO: Download the IPC APEX EXPO 2023 Justification Toolkit





STEM Program: Evolving and Growing

Feature Article by Charlene Gunter du Plessis
IPC INTERNATIONAL

IPC has a responsibility to its current members but also in attracting and retaining new talent to the electronics manufacturing industry. This is no more evident than in the STEM event hosted by the IPC Education Foundation at IPC APEX EXPO. For the 2023 event, more than 500 students from nearly a dozen high schools are expected to participate in hands-on activities, touring the show floor, and learning from industry experts. The Career Panel Luncheon will expand across the in-person event as we broadcast and stream to schools across the United States.

Putting It in Perspective

The IPC STEM outreach event started in 2018 and more than doubled its size of that first year. We are very thankful for the support that we get from industry that allows us to bring this event to the San Diego Unified School Dis-

trict. We have made an impact and have collaborated with nine participating high schools over the past five years. To put some numbers in perspective, we started with about 50 students and now we have more than 500, which is also the reason behind expanding the event from one to two days.

Overall, the goal of the event is to create awareness, which is part of our mission statement to showcase the industry, and to educate and inform the students that there are different careers to consider and various career path entry points based on their skills when entering the electronics manufacturing industry.

Event Details

This year, the STEM event will take place on Wednesday, Jan. 25 and Thursday, Jan. 26. It is an immersive experience where students have an opportunity to connect with the industry



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by talking to industry representatives, exhibitors at their booths, and to learn specific skill development tracks which include hands-on soldering, PCB design, and engagement opportunities for students and industry to connect through the show floor tour, booth visits, career panel, and career roundtable discussion.

Soldering: The students will participate in a hands-on soldering, pin build activity. They are always very excited to showcase what they've soldered on a PCB board. It is a fun activity with interactive components such as LED lights that flicker. You'll see these flickering LEDs on their clothing as they walk around on the show floor, so be sure to acknowledge their soldering skills when you see them.

Design: We are very fortunate to have support from Altium and Arduino for the PCBBeTheChange design competition. The aim of this competition is to inspire students to consider a career path in PCB design while solving an environmental problem within their respective countries. We have approximately 210 different teams competing across 26 countries. We will showcase the winners of both the high school and university/college sections.

Show floor tour: Groups of students will tour the IPC APEX EXPO show floor. Those

who are familiar with this event know IPC attracts between 9,000 and 11,000 attendees as exhibitors, suppliers, industry representatives, and other interested parties. This is an amazing opportunity for students to participate in a very large event with a single focus. Students stop at assigned exhibitor booths, engage by asking career-related questions, and learn about the industry.

Career panel luncheon: Students will gather to participate in a lunchtime career panel discussion comprised of various industry experts such as our event sponsors and IPC Emerging Engineers who bring a variety of skills, backgrounds, and different career stories to inspire the students. I believe this widens the knowledge and decision-making aspects for a student to know: "If I really want to be an engineer, this is what I need to do." The panel will be moderated by IPC President and CEO Dr. John W. Mitchell. It will be recorded and broadcasted to many schools across the United States.

Roundtable discussion: We realize that it can be difficult for students to ask very personal questions during the Q&A part of the career panel and therefore we have implemented this opportunity for students to engage with industry members. It is an honest, transparent, and open setting where students can receive real answers organically. They need real answers from real people sharing real stories. We feel that authenticity is needed to change the perception that people might have about electronics manufacturing.

You Can Be a Sponsor

We are very thankful for the support from TTM Technologies as the premier sponsor of the overall STEM event. We always have sup-

port from Weller Tools, whose members will dedicate their time and support with the soldering track. Altium and Arduino, as I mentioned, supporting our design track, and Magi-Ray sponsors the Breakfast for Champions. In addition, we have collaborating sponsors, including Mycronic, which has been a past supporter as well. We could not showcase the impact that we are making in the lives of these students and teachers without the support from I-Connect007 as our official media sponsor, and we are very thankful for that.

We have detailed information at ipcef.org under the Events tab where we mention the sponsorship opportunities still available.

Why This Is So Important

This event supports the industry by developing a pipeline of new talent. It resonates the mission of the IPC Education Foundation because to build and support the industry, you must create awareness of the various types of careers available: opportunities, positions, entry points, and skills needed. This STEM event touches on all these aspects. We feel that if you can create awareness or “access points to knowledge share” with content, hands-on experiences, and engagement opportunities with industry, you can steer them toward pursuing a career in the industry.

Since we started the STEM event in 2019, we have conducted surveys before and after the event. We wanted to gauge the interest of students considering a career in electronics manufacturing and it has been proven year over year that the event contributes to their decision-making. Besides maintaining a 95% to 100% overall satisfaction rate, we learned that there is a 33% increase in students who now will consider pursuing a career in this exciting industry.

A Pipeline to New Talent

Through strategic activities like this we can provide valuable information to the industry and will dedicate our efforts by incorporating opportunities to test responses by the participants through the event.

Whether you are in high school, have an associate degree, are a recent graduate from an engineering school, a veteran, or someone who wants to consider making a career change, there is ample opportunity available. As the Foundation, we are very proud to have an event mainly focused on high school students. We have other designated programs available to students in college and university such as the IPC Student Chapter program

that offers students with industry-relevant content, connections through facility tours and speaking engagement opportunities on or off campus, as well as scholarships.

Of Special Note

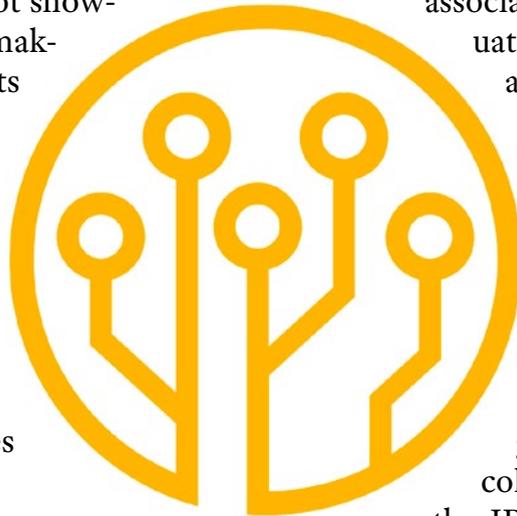
Every year we meet a diverse group of students and among them there will be a dedicated group of 25 girls who form part of the Girls in STEM at Olympian High School in Chula Vista, California. It's exciting to see such a large group that is specifically female focused.

The Foundation will focus on exciting opportunities to continue connecting talent with industry in 2023 and we cannot wait to share what we've been working on with everyone.

If you have further questions, would like to volunteer for a roundtable discussion or to be a sponsor, please contact me. **SMT007**



Charlene Gunter du Plessis is the senior director of the IPC Education Foundation.





Standards Committees:

Moving **Faster**, Working **Better**

Feature Interview by the I-Connect007 Editorial Team

Standards committee work is where much of the heavy lifting takes place for industry standards. To the inexperienced eye, the committee process can also seem as perplexing as it is crucial. In this conversation, Teresa Rowe, IPC's senior director of assembly and standards technology, highlights what to expect from standards committee sessions at IPC APEX EXPO 2023. New committees, revisions, leadership, awards, and thoughtful pauses to celebrate achieving milestones are all part of the IPC APEX EXPO standards committee experience.

Nolan Johnson: Teresa, looking ahead to IPC APEX EXPO 2023's committee work, what is meaningful and compelling for attendees?

Teresa Rowe: From a standards development perspective, we have new projects. First, we have a new project on magnification, as well as

projects for Factory of the Future. We have a lot of leading-edge technologies, and we have some celebrations for the completion of some of our documents, IPC/WHMA-A-620E being one of them. We're continuing our work to release more things that industry is anxiously awaiting in 2023. It's an opportunity for us to see each other face to face and, as I like to say it, "families" getting together and having reunions.

Johnson: Is there a sense that committee work is accelerating?

Rowe: Yes. There is a demand from industry for standards to be on the top of their game and it's a well-known fact that it takes a long time for some things to get into the documents. We must look at test data; sometimes we set up tests ourselves or with the groups and work through what that means for industry. But

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at the end of the day, industry's expectation is that we provide them with the standards requirements that are accepted by that same industry, so that they can build for their customers.

Johnson: Let's walk through some of the committee work you just highlighted, such as magnification.

Rowe: We've had a standard for a very long time. It's very old; IPC-OI-645, which is referenced in one of our very popular documents. We realized that it needs to be updated. The standards group has taken an action item to start looking at the older standards in our library and to either reaffirm, revise, or withdraw them and make them obsolete. Because of the conversation with that group, they realized they also needed a guidance document that helped industry to use magnification. Things are getting smaller, and people can't see them, so there's a whole new effort with that. In addition, factory of the future has two new magnification projects for AOI and AOX and we're planning to bring those on board.

Johnson: That's a nice segue to the factory of the future. What's happening there this year?

Rowe: We're just getting our committees formed, and sometimes the most difficult part is to get a project off the ground. We're looking for anyone who might be interested in working on these projects, those who want to dedicate their time to help themselves, their company, and industry to reach consensus on what's needed.

Johnson: What's the best way to get involved in a committee?

Rowe: Please [click here](#) for more information and to make a request. All requests are



Teresa Rowe

reviewed by technical standards staff. Volunteers are added to the groups, the staff liaisons will set up meetings, and you'll get access to IPC Works.

Our communication tool for our standards development projects is through IPC Works. This platform provides an opportunity for networking and building industry relationships. It all starts with coming to IPC's website, where you can sign up and ask to join a committee.

Johnson: The idea of joining a committee and getting involved in standards work might seem just a little bit daunting or scary to some. What can they expect their experience to be like?

Rowe: I was one of those people a long time ago, so just give it a try. Think of when you tried something new, like jumping into a swimming pool. Were you a little scared? Absolutely. Standards development might not be for everyone, but at the same time, you might find you love the chase. Not only do you join technical people talking about technical stuff, but you learn things you can take back to your job.

When you're new to a committee, the best thing is to come into the room, walk up to a leader and say, "Hi, can you introduce me to someone I can sit by so I can learn the ropes?" The longtime task group members really enjoy taking new members under their wings and helping them navigate. They'll explain what voting means, the rules for discussion, and so forth. So, just come up and say "hello." Ask a question or two. Everyone is new the first time; the second time you'll be a pro.

Johnson: What can IPC members expect in upcoming releases of standards?

Rowe: We have several standards scheduled to release in 2023. Most notably, we have IPC-A-600 and IPC/7711/21 on the list, as well as

IPC-A-610 and J-STD-001. Those are four very popular industry documents. Of course, there are design documents being worked on, and we have the greener cleaners document, IPC-1402, that was released recently. There's a lot of change coming up for our industry; in terms of standards, IPC APEX EXPO will be an opportunity to see what's out for review of the new revisions.

I want to mention, the IPC/WHMA-A-620 task group will not only be having a party, but they have started on the next revision, due out in 2025. That team already has a series of questions and comments to work on and will be meeting for a whole day to keep moving forward.

Johnson: When do committee meetings start and end? What's the period in which they run?

Rowe: They run all day Saturday, Jan. 21, through Thursday, Jan. 26. In many cases we have as many as a dozen meetings happening at one time. To make everything fit, IPC standards committee staff and volunteers are sometimes concurrently running meetings.

To be more sequential, standards committee meetings would otherwise need a month or two and does anybody have time for that kind of commitment? The tradeoff is that we run concurrently for a week. It's very busy, but it works.

Barry Matties: I'm curious about the Emerging Engineer program and their participation in the standards committee work. What are you seeing as far as participation and are you integrating them in by design?

Rowe: The Emerging Engineer program has been an exciting and refreshing opportunity for us. Many of our emerging engineers, who have either finished the three-year program or they're somewhere in the second half of their three-year program, have started to take on leadership roles.

We have leaders who have been in task group leadership roles for a while; they're stepping aside, and emerging engineers are taking those roles. They are bringing fresh ideas, and energy in some cases, to projects that we've been working on. They not only come to the program to learn, but to be mentored. The mentors are those who have been in standards development for years and they guide the young engineers through the process of taking on those leadership roles so that they can become fully engaged in their IPC contributions.

Johnson: Any surprises?

Rowe: For many years, IPC has given committee service and leadership awards. We wanted to look at having our standards development people help with the recognition of those who have done their best with their contributions.

This year, we are introducing a new awards program with two key awards. Everyone on a task group will receive a certificate that says they've participated in that revision activity when that revision or that document is finished.

Going forward, anyone who worked on those committee projects for the previous year can be nominated for two new awards. One is the Committee Leader of the Year and the other one is the Committee Member of the Year. These awards have names, but we will not be revealing the names until the show. The nomination period for the 2023 awards is now closed and our nominations selection committee will be providing their recommendations for the winners of those two awards.

When people realize who the awards themselves are named after, and see how they're presented, I think they will understand that we have really changed this up. This is exciting for us.

Matties: Thank you so much, Teresa.

Rowe: You're welcome. I'm always happy to talk about standards. PCB007

Women in Electronics Reception

Feature Article by Alicia Balonek

IPC INTERNATIONAL

Emily Calandrelli, IPC APEX EXPO's opening keynote speaker and featured speaker of our Women in Electronics Reception, is an MIT engineer turned Emmy-nominated science TV host. She's the host and co-executive producer of "Emily's Wonder Lab" on Netflix, she's featured as a correspondent on Netflix's "Bill Nye Saves the World" and an executive producer and host of FOX's "Xploration Outer Space."

Emily's educational background is in engineering and policy. At West Virginia University she received a bachelor's in mechanical and aerospace engineering. While at WVU she was awarded the Goldwater scholarship for research and Truman scholarship for policy work. She received her master's from MIT in aeronautics and astronautics as well as technology and policy.

Emily was invited to deliver the keynote for IPC's Women in Electronics Reception at IPC APEX EXPO as her mission and goals align with IPC's dedication to support of Women in STEM. Although just like IPC, there are many other groups supporting women once they enter such a field, how are we encouraging younger females to join a field commonly dominated by men?

In an interview with Sabrina Doyle on the Jasper Venture Beyond blog, Emily addresses the issue head on and shares her personal thoughts on why encouraging more women to go into science, technology, engineering, and mathematics is so important.

This issue is important to Emily because she is a woman in STEM and could be considered a minority. There are many factors that make this so, and she's interested in identifying those factors and changing the barrier into STEM for the next generation.



Emily explains we need to normalize the idea of women in STEM through books, TV, movies, and in the media. We need to have just as many STEM toys advertised to girls as we do for boys (or more that are simply gender neutral). We need for people to acknowledge the bias they have in hiring and promoting. There's a lot of work to be done, but it's currently underway and she's hopeful that meaningful change is coming.

Emily is addressing this issue through her own efforts by authoring the picture book, *Reach for the Stars*; the science experiment book, *Stay Curious and Keep Exploring*; and the science chapter book series, the *Ada Lace Adventures*. The third book in the series was launched to the International Space Station through the Story Time from Space program.

Her website has an entire page of resources available for young girls who are interested in STEM which include: YouTube channels, television shows, books, Twitter, and Instagram influencers and even toys.

The Women in Electronics Reception at IPC APEX EXPO is from 6 to 7:30 p.m. Jan. 24. We certainly hope you join us to hear Emily's insights on how we can play a more active role in introducing the young females in our lives to the unique opportunities that are available to them for a career in STEM. **PCB007**

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How Networking Opens Doors

The New Chapter

Feature Column by Hannah Nelson, VALPARAISO UNIVERSITY/IPC STUDENT DIRECTOR

As we prepare for IPC APEX EXPO 2023, I want to reflect on the unique opportunities of this event. Every year, it creates a space for industry leaders from around the world to solve real-world problems together. Networking in this innovative setting can launch many individuals toward the next steps in their careers. For me as a college student, networking has completely changed the trajectory of my career.

A 2016 LinkedIn survey of approximately 3,000 job seekers revealed that as many as 85% landed their most recent job via networking, making it a crucial component of any job search¹. For those thinking about growing their career, here are three things that networking has done for me.

1 Networking opened doors to career opportunities.

Before attending the show last year, I had assumed that electrical engineering would lead me to a job developing programs or analyzing circuits for companies. I had no idea what printed circuit board (PCB) design was or what the process for manufacturing PCBs entailed. But by networking with exhibitors and mentors at the show, I found myself immersed in everything the industry has to offer, from PCB design to how to apply layers of solder mask onto a PCB.

I learned that this industry is vast and continues to grow. Through mentorship, I also discovered that there are no limits to the paths you can take. Networking with exhibitors



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taught me that this industry consists of passionate people who are determined to create meaningful change in the world. Seeing such passion kindled my own interest in and dedication to this field. Not only did networking help my career path feel more meaningful, I gained a better sense of potential careers as I learned about the many opportunities available in this field.

Networking is the key to making the manufacturing process as efficient and successful as possible.

2 Networking introduced me to a world of new ideas.

Those who enter this industry are yearning to change the world, but the drive to create change is not enough; we need everyone to bring together their specialized skill sets if we want to start a revolution. Creating solutions means uniting the expertise of all the sectors in this industry, from solder mask to design. Networking is the key to making the manufacturing process as efficient and successful as possible.

At IPC APEX EXPO, industry experts share their newly discovered specialized knowledge through professional development courses, committee meetings, and even networking socials. Industry professionals can build relationships and educate themselves on subjects that may be unfamiliar to them. Attending and participating in these activities gave me the information I need to stay on top of today's hot industry topics. Networking with experts in the technical realm has opened doors to possible joint ventures. Remember that by growing your network, you not only become a more

valuable employee, you enrich the wider industry because you equip yourself with skills and knowledge that can be shared with others.

3 Networking gave me more confidence in my abilities.

Before I entered college, I was incredibly shy and reserved. As I advanced through the years, this anxiety began to fade, but I still felt insecure when talking about technical subjects with my professors and peers. I felt like my opinion on technical topics did not and could not matter. But when I attended my first networking event at IPC APEX EXPO, I learned just how valuable my voice was to the industry. I met with the I-Connect007 team, for example, and learned that established industry professionals need to hear the voices of the next generation. The I-Connect007 team invited me to write this column so that the industry could hear about the struggles and pursuits impacting today's young professionals. This platform has really built my confidence. It has taught me that I can present my ideas to my peers and show them just how important this industry is to our future.

Further Thoughts

Although networking can be the overall key to success for many professionals, some individuals believe that networking is too much work or that it's just self-serving. These are common misconceptions that can hold professionals back from advancing their careers. Sometimes, it can feel like you are putting so much work into networking and not getting results. When this happens, consider whether you might be putting too little effort into the network that you already have. A network can't grow unless both parties remain in contact and equally engaged.

For those who believe networking is a self-serving activity, try thinking about how networking might allow an individual to give back to their industry community. Networking involves the interchange of ideas, with

both parties playing an equal role; each person is looking to gain information from the other. Through successful networking, both parties benefit by gaining new knowledge and expertise from each other.

Networking is helping me launch my career, share ideas, grow professionally, and strengthen business relationships. Just this past month, I was offered my dream job thanks to the doors opened to me through networking. It has taught me that there is no reason to settle for a career that is not benefitting my professional growth, and I know it can do the same for you. If you're looking for inspiration to advance your career,

maybe it's time for you to think about attending IPC APEX EXPO 2023. **PCB007**

References

1. "New Survey Reveals 85% of All Jobs are Filled Via Networking," by Lou Adler, LinkedIn.com, Feb. 29, 2016.



Hannah Nelson is a student at Valparaiso University, part of the IPC Emerging Engineer Program, and an IPC student director. To read past columns, [click here](#).

Kirk Lockett of IEC USA Remembered

Kirk T. Lockett, former president, owner, and operator of Intermountain Circuit Supply, passed away on Dec. 7, 2022.

Kirk spent 30 years of his career with DuPont, where he had been a member of its senior management. That was followed by 12 years leading Intermountain Circuit Supply, which was later purchased by IEC USA in 2012. Kirk retired from IEC and the PCB industry in 2021.

In announcing his passing, IEC released the following statement:

"As we move through our lives, there are those unique individuals who make a monumental impact in just their very presence and ability to make us feel cared for, at ease, and important. For those of us who had the pleasure of working with him at IEC, we experienced that Kirk was one of those people. There are no words, and not enough letters in the alphabet to convey how much we care for Kirk and his lovely wife Judy, nor to illustrate how wonderful a person Kirk was."

The company noted his encouragement to his associates, his kind and gentlemanly ways, and "the twinkle in his eye, matched only by his sideways grin." Thinking about Kirk "always brings an avalanche of happy

memories, and in this moment, tremendous emotion of a loss of one of the greats."

Funeral arrangements are pending from Kiesinger Funeral Services Inc., 255 McAlpine St., Duryea, Pennsylvania. More details will follow on the IEC LinkedIn page.



From 2021 (left to right): Judy Lockett, Shawn Stone, Chuck Williams, and Kirk Lockett Sr.

The First India Pavilion



Feature Article by Gaurab Majumdar

IPC INTERNATIONAL

For the first time, IPC APEX EXPO will host an “India Pavilion,” showcasing 16 Indian companies promoting India’s electronics manufacturing capabilities. The initiative was undertaken by the Ministry of Commerce & Industry, Government of India, and implemented by the Indian government agency, Electronics and Computer Software Export Promotion Council (ESC) India.

It is the Indian government’s goal to introduce Indian companies to the global market. Indian companies representing EMS providers, wire harness manufacturers, material suppliers, design companies, and PCB manufacturers will be part of the India Pavilion at IPC APEX EXPO 2023. The government of India places a high priority on electronics hardware manufacturing, as it is one of the crucial pillars of “Make in India,” “Digital India,” and “Startup India” programs, all geared to ensure that India becomes a global design and manufacturing hub.

India’s electronics manufacturing production is led by mobile phones, IT hardware

(laptops, tablets), consumer electronics (TV and audio), industrial electronics, automotive electronics, electronic components, LED lighting, strategic electronics, wearables, and telecom equipment production. India is poised to become a global manufacturing hub and is expected to export approximately \$120 billion by 2026. This market-size explosion has been catalyzed by COVID-19-led growth of digital consumption. Electronics manufacturers are also seeking diversification of global value chains, so it makes sense for India to be a focus area. The policy of “Make in India” and the large OEMs looking to “Buy in India” have helped the EMS industry grow and solve supply chain issues. The Indian ESDM industry is focusing on PCB manufacturing within India and large companies are looking at investment opportunities within the country.

Supply chain disruptions during the pandemic forced many companies in the United States to rethink their sourcing strategies to reduce dependency on one country for their supplies. Today, the EMS industry is being

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Table 1: Indian Companies Participating in IPC APEX EXPO 2023

Company Name	Sector	City	Website
Zeal Electromech Pvt Ltd.	PCB Assembly/Rework	Pune	zealelectromech.com
Fine Track Systems	PCB Fabrication & Assembly	Gandhinagar	finetracksystems.com
Aimtron Electronics Pvt Ltd.	Electronics Design/EMS	Vadodara	aimtron.in/electronics-manufacturing-services
Cyronics Instruments Pvt Ltd/	Electronics Test & Meas.	Pune	cyronics.com
Vinrox Technologies	Electronics Design/EMS	Vadodara	vinrox.com
Om Circuits Pvt Ltd.	PCB Manufacturer	Delhi	omcircuitboard.com
Advantek Fuel Sys Pvt Ltd.	PCB Assembly	Delhi	
Wuerth Elektronik India Pvt Ltd.	PCB Design & Solutions	Bangalore	we-online.com/web/en/wuerth_elektronik/start.php
Kaynes Technology India Ltd.	Electronics System Design & Mfg.		kaynestechnology.co.in
Tescom	PCB Design/EMS	Bangalore	tescom.co.in
Rossell Techsys	Wire Harness Eng. and Mfg.	Bangalore	rosselltechsys.com
BPL Limited	Consumer/Medical/PCB Mfg.	Bangalore	bpllimited.com
Sahasra Electronics Pvt Ltd.	PCB Design/Assy/Wire Harness	Delhi	sahasraelectronics.com
UKB Electronics Pvt Ltd.	Electronics Product/Wire Harness	Pune	ukbelectronics.com
Protolab Electrotechnologies Pvt Ltd.	Printed Electronics/Devices	Mumbai	protolab.in
Siena ECAD	PCB Analysis/Design Engineering	Bangalore	siennaecad.com

hit with component and raw material source shortages, particularly for bare PCB boards. Trade wars with certain countries have brought these challenges to the forefront. Electronics manufacturers are also seeking diversification of U.S. value chains, resulting in India becoming a focus area. IPC APEX EXPO 2023 will provide a great platform for participating IPC members in India to forge strategic partnerships with U.S. companies while providing exposure for investing and opening operations in the United States.

Since 2010, IPC India has helped OEMs, EMS providers, PCB manufacturers, cable/wiring harness manufacturers, and electronics industry suppliers “build electronics better” through training and certification. IPC’s India office has certified over 11,000 professionals in the industry, helping companies enhance the quality and reliability of their products. Several Indian SMEs, exporters, and public sector organizations are engaged with IPC resources. In addition to training and certification oppor-

tunities, IPC India provides annual business networking platforms such as Integrated Electronics Manufacturing and Interconnections (IEMI) events.

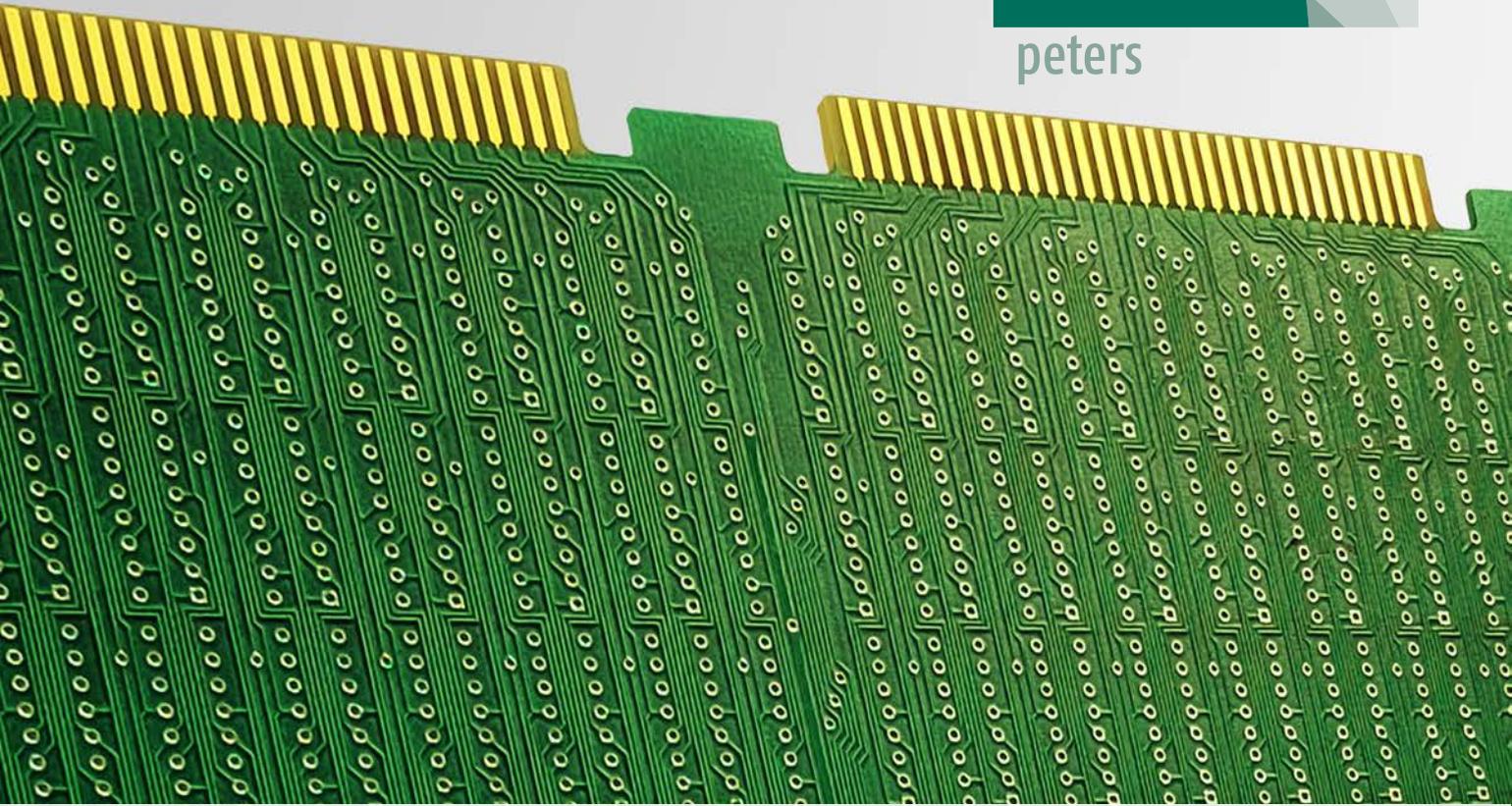
Electronics trade and investment have been growing quite significantly in India and IPC would like to support the government of India by providing opportunities that will help electronics manufacturers. In 2020 and 2021, COVID-19 impacted the electronics industry globally. But based on the rebound we have seen in 2022, especially during the second half of the calendar year, I believe 2023 will be the year to completely regain confidence and build new connections. IPC APEX EXPO 2023 will be an important platform for Indian exhibitors and delegates to look for new business opportunities, and I am very excited about this opportunity to showcase India’s manufacturing companies. **PCB007**

Gaurab Majumdar is executive director, IPC India.



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Now more than at any other time in our history, solid partnerships hold the key to success for all companies. We should all be looking for strong and cooperative partnerships where we all help one another to do things that neither of us could do alone.

Salary Budgets Rise Sharply in 2022 Says New IPC Wage Rate and Salary Study ▶

A sharp increase in salary budgets and use of flexible hours programs for North American electronics assembly companies are among the findings of a new study published by IPC.

Arlon Releases Revolutionary Product ▶

Arlon Electronic Materials, Rancho Cucamonga, Calif., is proud to announce the release of its newest polyimide material 86HP.

New Arizona State University School Strengthens Domestic Semiconductor Manufacturing ▶

Nearly 200 members of industry and Arizona State University affiliates celebrated the launch of the highly anticipated School of Manufacturing Systems and Networks at ASU's Polytechnic campus.

Kitron Selected as Main Electronics Supplier for KONGSBERG's Weapon Station System ▶

Kitron has entered into a long-term production agreement with an expected value of NOK

750 million with Kongsberg Defense & Aerospace AS for electronic modules that are part of KONGSBERG's remote weapon station system (RWS).

Purdue Defense Research Focuses on Expanding Knowledge of Nontoxic Alternatives for Circuit Boards ▶

Carol Handwerker's life's work is aimed at increasing reliability in everything from the largest Navy carrier to the family car. She does it by researching probably the most inconspicuous material: solder.

Collins Selected to Participate in Multiple EU Clean Aviation Projects ▶

Collins Aerospace has been selected to participate in seven projects under the European Union's Clean Aviation Joint Undertaking.

TTM Technologies Reports Fiscal Q3 2022 Results ▶

TTM Technologies, Inc. reported results for the third quarter fiscal 2022, which includes a full quarter's contribution from the acquisition of Telephonics.

One World, One Industry: Rallying Around a Robust Ecosystem ▶

After a multi-year advocacy effort, the U.S. CHIPS and Science Act has been enacted and the funding is now in place for its implementation. At a time in which it is easy to be cynical about Washington, the CHIPS and Science Act is further proof that U.S. political leaders can come together on a bipartisan basis and do big things.

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Let's Get Technical

Feature Article by Julia Gumminger
IPC INTERNATIONAL

IPC members are constantly working to move the electronics industry forward by developing new technologies, innovative processes, and testing methods—and working to find solutions to known technical challenges. The IPC APEX EXPO Technical Conference is the premier forum in North America where these challenges, solutions, and innovations are shared among colleagues and competitors alike.

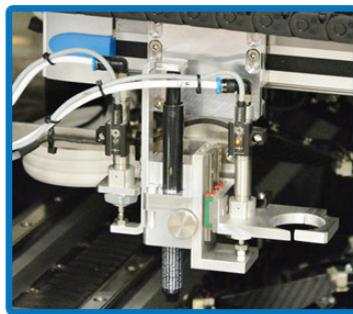
Sometimes the processes and methods used to organize such a conference require some innovations as well. Thanks to the many hours of dedication and attention to detail; an updated peer review process; and new tools utilized by the Technical Program Committee (TPC), which is chaired by both Dr. Stanton Rak, of SF Rak Company, and Dr. Udo Welzel, of Robert Bosch GmbH, the 2023 Technical Conference at IPC APEX EXPO 2023 will feature the highest quality technical program.

The TPC received over 120 technical paper abstracts during the open call for participation and reviewed them all in a double-blind peer review process. Eighty-five papers were chosen to undergo the next phase of the peer review process. Each TPC member contributed many hours of their time to review and offer feedback to the authors. The Technical Program Committee consists of subject matter experts from companies such as: Robert Bosch GmbH, NASA Goddard Space Flight Center, IBM Corporation, Collins Aerospace, Continental Automotive Systems, Bose Corporation, John Deere Electronic Solutions, TTM Technologies, Indium Corporation, Averatek, Northrop Grumman, Aegis Industrial Software, and others. Each paper submission was reviewed by at least two reviewers with areas of expertise similar to the authors. This ensured the technical merit could be reviewed as well as the novelty and potential impact of the data.

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An updated IPC Non-Commercialism Policy was strictly adhered to during this process, ensuring that the conference's technical presentations are truly "generic" in their technical data. Welzel shared, "An updated, comprehensive non-commercialism policy provided full transparency on this sensitive matter for both contributors and the reviewers from the Technical Program Committee, thereby avoiding misunderstandings and ambiguities."

Ultimately, the 70+ papers making up the 2023 IPC APEX EXPO Technical Conference represent the highest quality technical content from authors around the world. The TPC members are very excited about the upcoming presentations, which are organized into topical tracks.

"The combination of a broad coverage of different topics related to electronics assembly technology, along with the high level of technical depth and detail in these presentations, provides a comprehensive overview of the current hot topics, challenges, and solutions. This combination of 'breadth' and 'depth' is quite unique and will attract many attendees as well as contributors," said Welzel.

Rak said, "The 2023 Technical Conference will introduce two new technical sessions on 'High Reliability for Extreme Environments,' which is exciting for individuals working on Class 3 electronics applications. The 2023 Technical Conference has approximately 12 papers that have direct relevance to the automotive electronics space, e.g., design, test, reliability, simulation, and assembly. Many of the authors

are highly regarded industry experts in addition to some newcomers. The presentations are of high interest to me since I am active in the field."

Welzel is looking forward to learning from the conference presentations. He added, "Printed boards are now expected to operate in harsher and harsher environments. Being responsible for PCB technology development for automotive electronics, I am looking forward to those papers dealing with the quality and reliability of advanced printed boards, especially on topics like microvia quality and reliability."

The 2023 conference features five tracks on Tuesday and Wednesday, including:

- Factory of the Future and Future Technologies
- PCB Fabrication and Materials
- Quality, Reliability, Test, and Inspection
- Assembly and Materials
- High-Density Interconnects and Microvias

The diversity of the presenting authors is also impressive; 18 countries are represented by presenting authors. Fifteen authors are next generation (five years or less in the industry), and 27 presenting authors hold doctoral degrees.

"From the perspective of a long-time TPC member, I can say that this year has been by far the most organized and efficient IPC APEX EXPO planning process cycle I've participated in," said Todd MacFadden, technology development engineer at Bose. "This year, the committee used new tools and procedures to review and evaluate the technical submissions, and those tools were highly effective at ensuring consistent review metrics, facilitating edits, and tracking review progress. At the same time, authors were given better, clearer guidance than in previous years regarding paper format and expectations on content. As a direct result of these changes, the quality of the submissions is higher and more consistent, and the technical program is

tighter overall. Interesting point of note: There are more PhD authors this year than in any previous year.”

Additionally, the 2023 Technical Conference is piloting two special sessions on Thursday in the emerging growth areas of e-mobility/EV automotive and advanced packaging. The special sessions will be curated panel discussions designed to convey recent information in an audience participation format.

IPC APEX EXPO’s 2023 Technical Conference promises to showcase the latest original technical data from the world’s leaders in electronics manufacturing research. The

Technical Conference paper presentations will cover the newest and unpublished results, techniques, materials, processes, and trends. IPC APEX EXPO 2023 will address the biggest issues facing the \$2 trillion global electronics industry, including topics like boosting operational efficiency; improving product quality and reliability; innovations in advanced HDI and PCB HDI technologies; and the outlook for Factory of the Future trends. **PCB007**

Julia Gumminger is manager of professional development and events for IPC.

EMS Leadership Summit at IPC APEX EXPO 2023

EMS Leaders of Today and Tomorrow Helping Each Other and the Industry to Prosper
Monday, Jan. 23, 8 a.m. to 5 p.m., 6 p.m. Networking Dinner

The EMS Leadership Summit brings together current and future industry leaders to solve problems, build business networks and share insights to doing business better. Focused on high level topics which drive business growth and financial success, leaders gather insights from experts and discuss their own and potential new best practices during panel discussions and roundtables. This meeting of minds inspires action and builds resources for participants, future leaders, and the greater EMS industry. Relax and continue making connections at the EMS Networking Dinner after the summit adjourns. Dinner included with your summit registration.



Show Floor Highlights

Feature Article by Alicia Balonek,
IPC INTERNATIONAL

IPC APEX EXPO 2023, recognized since 2001 by Trade Show News Network (TSNN) as one of the largest of the 250 trade shows held in the United States, is also the largest event in North America for electronics manufacturing. Featuring leading equipment manufacturers, suppliers, and innovators from every step in the electronics manufacturing supply chain, IPC APEX EXPO has it all under one roof.

The Exhibitor Product Showcase Corridor will feature new, innovative, and compelling products that are leading our industry into another era. These graphic display panels located in Aisle 100 will provide an in-depth description of each product and you can see the product firsthand in the corresponding exhibitor's booth.

The Poster Presentations located in Aisle 100 will feature posters that describe significant results from research experiments, highlight new techniques or materials, and discuss cutting-edge trends and challenges facing the electronics manufacturing industry today.

Attendees can view the Poster Presentations anytime during the official exhibit hall hours and will have the opportunity to meet and network with these subject matter experts during the following times:

- Tuesday, Jan. 24, 5 to 6 p.m.
(during the Show Floor Reception)
- Thursday, Jan. 26, 11 a.m. to noon

Show Floor Reception

Tuesday, Jan. 24, 5 to 6 p.m.

The industry's largest networking event, the IPC APEX EXPO Show Floor Reception is your opportunity to network with industry colleagues and to connect with the industry's leading equipment manufacturers, suppliers, and innovators.

Ice Cream Social

Wednesday, Jan. 25, 2:30 to 3:30 p.m.

Satisfy your sweet tooth while networking with industry colleagues, subject matter experts, and the industry's leading equipment manufacturers, suppliers, and innovators.

3D Printing Metal vs. Plastic

Stop by Booth #3151 for an interactive demonstration on the capabilities of a 3D metal printer vs. a 3D plastic printer and see parts printed in real time.

Sponsored by Kurtz ERSA, Inc., this special display area will also feature items that have been printed utilizing these printers, including items such as key chains, pens, a fully functional rotational planetary gear, an impeller





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Connect with IPC by visiting us in Booth #833 to learn how IPC standards, education and training, advocacy, and solutions can help you and your company build electronics better through:

- **Standards:** Our more than 300 IPC Standards, covering every step in the electronics manufacturing supply chain.
- **Education:** The variety of education we offer to deliver consistent and effective training across your organization.
- **Workforce training:** Electronics workforce training is available 24/7 on the IPC EDGE Learning Management System. IPC's courses include detailed illustrations, video presentations, interactive activities, and practice quizzes, all formulated to make complex topics easy to understand and master. Each topic is carefully selected to align with the skills and competencies vital to advancing an electronics career at any level.
- **Advocacy:** IPC is the leader in global advocacy, together with its members, and strives to engage in global government relations and environmental policy advocacy that are in line with IPC's mission to both further the competitive excellence and financial success of its members while

protecting the environment. Whether it's engaging with policymakers in Washington, D.C., in the European Union, or in China, IPC and its members proactively seek opportunities to educate, inform, and influence policymakers on policies that spur innovation, growth, and competition while protecting human health and the environment.

- **Solutions:** By collaborating with the electronics manufacturing industry, we can identify and launch new products and services that address important challenges and leverage new opportunities. IPC's Factory of the Future is a new "solutions" program to lead, assist, and guide the electronics manufacturing industry through the next industrial revolution by solving real business challenges.

Show Floor Hours

- Tuesday, Jan. 24, 10 a.m. to 6 p.m.
- Wednesday, Jan. 25, 9 a.m. to 6 p.m.
- Thursday, Jan. 26, 9 a.m. to 12 p.m.

The Exhibit Hall Only (Event Essentials Pass) is free through online registration until Saturday, Jan. 21, 2023, and includes access to the Exhibit Hall and the following events:

- Tuesday's Show Floor Welcome Reception
- Opening Keynote Session
- Poster Presentations
- Newcomers Networking Reception
- Women in Electronics Networking Reception
- Exhibitor Product Showcase Corridor
- Ice Cream Social on the show floor

For a complete list of registration options and packages or to register today, visit: ipcapexexpo.org/2023-registration-options.

PCB007

Alicia Balonek is senior director for trade shows and events at IPC.

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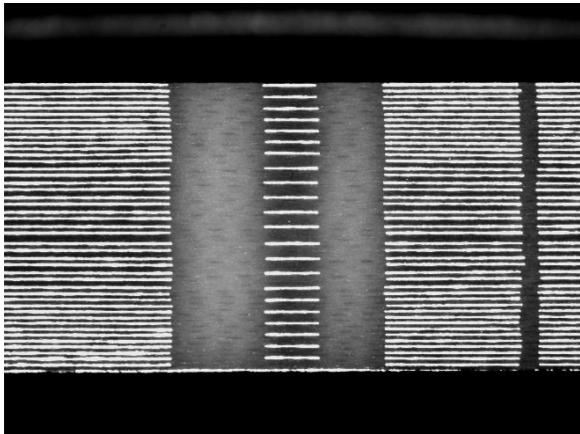
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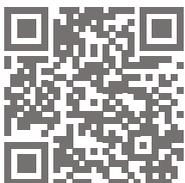
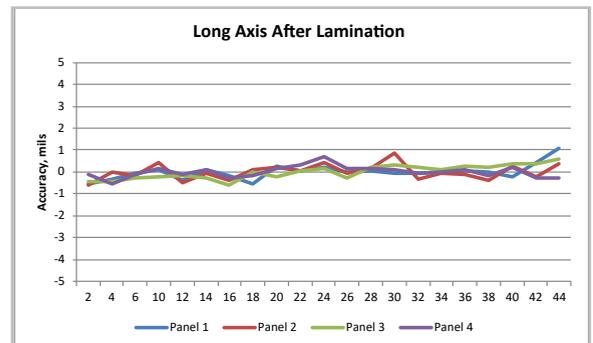


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Revisiting the Art and Science of Photoresist Stripping

Trouble in Your Tank

by Michael Carano, AVERATEK

Considerable progress has been made in the field of consumer and industrial electronics; today's devices are reasonably priced and efficient, yet small and portable. However, these advances create challenges for the manufacturers of the components necessary to produce these smaller, more portable devices.

PCB designers, for example, must attempt to squeeze increasingly more amounts of information onto a smaller board. In practical terms, this means that circuits are becoming more compact; circuit lines and the spaces between them are becoming finer. As the distances between these lines decrease, copper overplating is more likely to have a deleterious effect on photoresist stripping. The number of unstripped residues tends to increase at the very small distances between conductor lines on these new circuits. Under these conditions, conventional photoresist strippers are ineffective and the amount of photoresist remaining on the substrate after stripping increases. Complete photoresist stripping is needed to avoid shorts on costly fine-line PCBs. In addition, some fabricators lack proper control of the plating process. Coupled with thinner resist film, this leads to overplating—and overplated copper and/or tin will entrap resist under the heavily plated features.

Overplating and Entrapped Resist

An example of overplating is shown in Figure 1. The overplated condition, cou-

pled with tight spacing, will make clean resist stripping a major concern.

Another example of overplating and entrapped resist is shown in Figure 2. Of course, part of the issue here is tighter line-and-space requirements. This issue appears primarily in higher-density circuit designs driven by miniaturization. These difficult circuit geometries can result in overplating the copper, which increases the instances of resist residues. This in turn leads to various defects. If the photoresist stripping is incomplete, the photoresist left behind will protect the underlying copper from etch. This results in a circuitry “short,” where copper bridges an area between two circuit lines that were meant to be isolated from

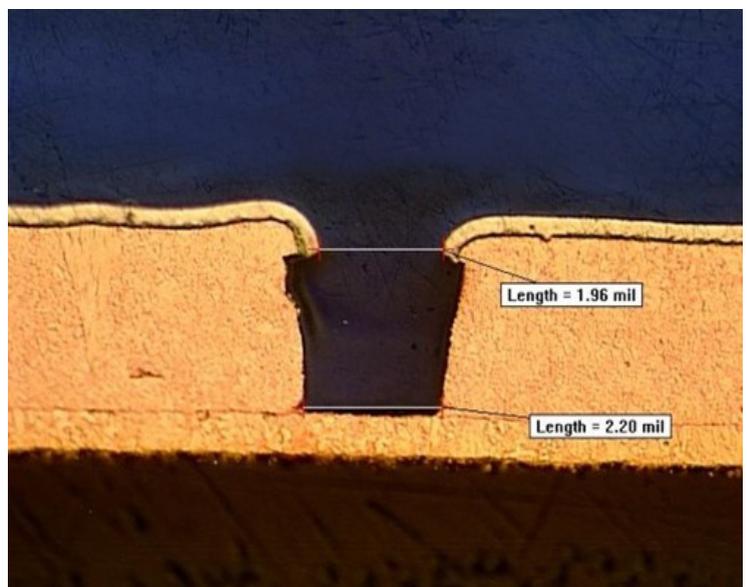


Figure 1: Plated copper “mushroomed” up over the resist.

Congress Needs to Support American Made Printed Circuit Boards



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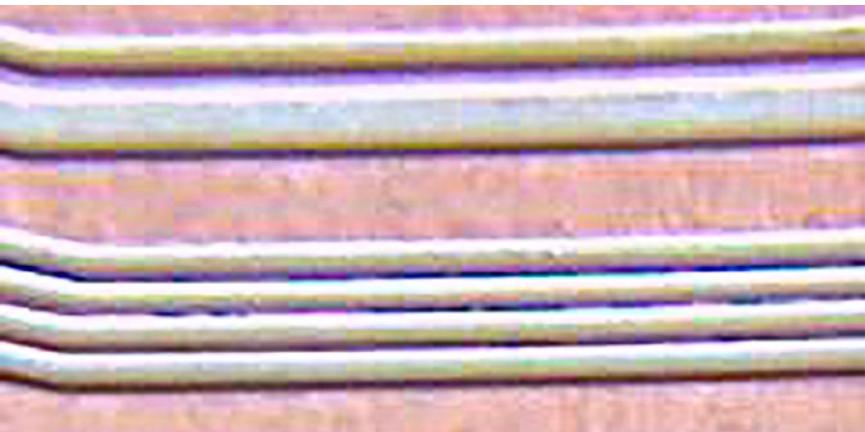


Figure 2: Example of overplated circuit features.

each other, leading to PCB failure and reduced yields. More effective photoresist stripping is needed to avoid these manufacturing pitfalls.

One way to remove these entrapped particles is to employ a phase-transfer catalyst (PTC). Quaternary ammonium salts (quats) are the compounds most commonly used as PTCs. These compounds transport free hydroxide ions (OH^-) into the photoresist polymeric structure, network, or interphase boundary with the liquid medium of the solvated catalyst. The hydroxide ions then serve to chemically break the photoresist network apart. Concentrations are critical, as are the selection of the additives to break up the resist into small particles. Thus, optimizing the resist stripper formulation is essential to ensure a smaller particle size. Regardless, overplated circuit traces will present a significant challenge in clean removal of entrapped resist. More on this later.

Perhaps high spray pressures in the resist stripping chamber or the final rinse will improve one's chances of entrapped resist particle removal. Other remedies (not necessarily recommended by the author) include a double pass through the stripper solution or having a separate offline tank with a resist stripping formulation capable of solvating small entrapped particles. Employing a plasma etch to successfully remove these particles is also an option. But due to the additional process times required to deploy these methods, there is a risk of attacking the tin etch resist, as pre-

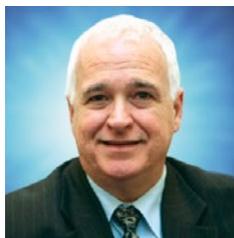
sented in [Part 2](#) of this series on resist stripping.

As for resist stripping effectiveness, effective stripping of a photoresist implies the chemical destruction of the photoresist's polymeric network. Through this chemical dislodging of chemical structures, removal of small photoresist particulates becomes feasible.

Most of today's photoresist strippers are water-based and contain multiple components, such as amines, solvents, and quaternary compounds. Many of these off-the-shelf products were developed prior to the need for these higher density designs. Most will deliver large particulates or lead to a sheeting of the resist. Because of this characteristic, they fail to strip photoresist from difficult geometries and cause an overall decrease of yields in PCB production.

We have found that it is possible to achieve such a dislodgment down to very small particulates with a water-extended concentrate. This involves the following:

A specific ratio of quat and solvent is necessary to achieve outstanding results. At the same time, the presence of amine in a specific range will facilitate very good results as well. Thereby, a PTC situation is achieved in the attacked polymeric structures of the photoresist, giving cause to an especially effective attack on the polymer network. This action allows for the exposed resist film to break up into finer particles. The spray action within the resist chamber and subsequent rinses help to further dislodge particles, effecting a clean removal. **PCB007**



Michael Carano is VP of quality at Averatek. To read past columns, [click here](#).

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States

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Employees

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2002: 26%



2022: 4%

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Shawn Dubravac:

WHAT'S NEW IN TECH



Feature Article by Shawn DuBravac
IPC INTERNATIONAL

Editor's Note: IPC Chief Economist Shawn Dubravac will deliver a keynote address titled "What's New in Tech: The Micro Trends Defining the Future of Electronics," at noon Jan. 23. Advance/separate registration required if luncheon is not included in registration package.

Technology is playing an ever-expanding role in every industry, from agriculture and healthcare to transportation. Each year, new concepts, prototypes, and product introductions are redefining what we know and expanding our imaginations about what's possible. How we experience the next decade as well as how we live, work, and play over time will be undeniably linked to technology developments. These innovations also have impor-

tant implications for the future of electronics manufacturing.

Here are a few areas to watch.

Innovation in Sustainable Materials

As the world grapples with issues like climate change, consumers and manufacturers are increasingly looking for ways to reduce environmental impact. This has led to a focus on fostering innovation in sustainable materials, renewable energy sources, and recyclable components. One example is CarbonX, a new carbon material composed of nano-sized carbon filaments that could help tire makers meet the increasing demand for sustainability.

Technology will play a pivotal role in this transformation and one sector set to see

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tremendous change is the auto industry. Numerous auto manufacturers are adding electric vehicles to their offerings, with some planning to shift their entire production to EVs in the years ahead. Jaguar plans to be all-electric by 2025, Alfa Romeo by 2027, and Mercedes, Lexus, Rolls-Royce, Volvo, Audi, and Cadillac have all committed to be exclusively electric by 2030.

In the coming years we will see new EV models, but this transformation extends well beyond just the vehicles being driven. The entire charging infrastructure is undergoing a massive change and that is having an impact on urban landscapes and garages everywhere. EV infrastructure companies are working to differentiate their offerings, develop new markets, and introduce new business models. We are seeing improved user interfaces, faster-charging capabilities, greater connectivity, improved ease of use and installation, and the ability to work directly with the electric grid on smart grid applications like vehicle-to-grid technology that enables EVs to charge during off-peak hours and even sell back to the grid during peak hours.

In the coming years we will see new EV models, but this transformation extends well beyond just the vehicles being driven.

The Prevalence of Autonomous Vehicles

Automation is increasingly prevalent in every industry. Autonomous vehicles are taking on diverse forms. Last year GM introduced its InnerSpace Autonomous concept vehicle, a two-passenger luxury all-electric autonomous vehicle. Hyundai Heavy Industries demonstrated an autonomous boat, equipped with depth sensors, cameras, and AI, then

announced it would be working to employ the technology in larger merchant ships. Autonomous Formula 1 race cars set new records as part of the Indy Autonomous Challenge.

Robots are showing up in a variety of places. Delivery robots like those from Ottonomy are automating last-mile delivery. Pittsburgh International Airport recently announced a pilot project with fully autonomous delivery robots, offering passengers a contactless delivery system for drinks and food orders. Autonomous vehicles from Starship Robots are ferrying items across college campuses to hungry students. Recently, Neubie partnered with Samsung to automate deliveries on golf courses. The beverage cart may never be the same again.

Some of the most interesting applications of automation are around automating decisions, especially when an individual is not able to make those decisions for themselves. Consider Korea-based ANSSil's sleepinbody mattress. It collects and uses sleep data to adjust temperature and mattress firmness to personalize and ultimately optimize one's sleeping conditions in real-time. These data are being collected and decisions are being made on behalf of the user while they sleep.

From Digitization to 'Datafication'

The rise of Smart technologies is reshaping how products are designed and created, and we see an introduction of many new product categories. Smart devices can sense their environment and often interact with other systems to perform tasks. Businesses are collecting huge amounts of data from the products they produce and the services they deliver, which is enabling them to create entirely new offerings. COVID accelerated digital transformations everywhere and now companies are working to make the leap from digitization to datafication.

The shift to "datafication" will usher in a myriad of new technology. Consider the COGNI from SimpleLabs. This small device is a wine

barrel monitoring system that continuously monitors temperature, humidity, phenol/guaiacol, acetic acid, SO₂, pH, alcohol, and fill levels. The device makes real-time data accessible to winemakers from anywhere in the world. Another example is the mySkin F.A.I.N., an AI-powered skin analyzer that offers medical-grade results through a smartphone and recommends specific skincare products based on unique scans of one's skin.

Personalization and Customization Changing the Scale of Manufacturing

Most are already aware of technologies like 3D printing that can create small batches of customized products on demand. 3D printing is a small part of a much bigger trend toward real-time customization and personalization. Electronics companies like Apple and Dell allow customers to customize their computers with various options, from the color of the case to the processor inside. In the apparel industry, shoe companies from Nike to Vans are enabling customers to design bespoke shoes. Smaller manufacturers are making entire production runs to order. As these trends accelerate, we may see the need for more decentralized and adaptive manufacturing capacity, allowing for more rapid iteration of new products.

Companies are also introducing new products that put the power of production closer to consumer end-markets and sometimes even in the hands of consumers themselves. For example, the Authentic Color Master by Tonework is a smart manufacturing system for producing customized cosmetic products. The system combines facial recognition technology and color science to provide color recommendations and then produces tailored, personalized cosmetics.

Healthcare Continues Expansion in Our Lives

Technology is helping to create a world of connected healthcare. Highly personalized medical treatments are beginning to emerge.

Wearable medical devices are being developed that can collect and analyze biometric data in real-time, allowing for more sophisticated health monitoring. For example, viQtor is a cutting-edge medical device that you wear on your upper arm. By monitoring a number of vital functions around the clock, it allows doctors and caregivers to check in remotely and intervene if necessary.

Wearable medical devices are being developed that can collect and analyze biometric data in real-time, allowing for more sophisticated health monitoring.

In many instances, technology is enabling new ways to treat patients. SOVN is a smart night guard that helps you relax your jaw whenever you clench or grind your teeth. Unlike a traditional mouth guard, SOVN is a smart wearable that monitors your jaw movement from the ear and interrupts the grinding/clenching as soon as it starts with soothing vibration.

The rise of on-demand healthcare will result in an explosion of new product classes and will require more sophisticated manufacturing capabilities. For electronics manufacturers, this could mean creating new products that integrate with these technologies.

Robots Taking on More Tasks

Autonomous systems and robots are showing up across almost every industry. Earlier this year John Deere introduced the world's first fully autonomous tractor. Netherlands-based AGXEED is also working to automate aspects of agriculture with a series of autonomous robots designed for things like spray-

ing, tilling, and mulching in orchards, where high precision and performance are key. One final example comes from Japan-based Agrist which created an agtech robot for harvesting bell peppers. The robot uses vision guidance and a SCARA manipulator to pick individual peppers.

Robots are showing up in consumer-facing applications, handling last-mile logistics and distribution. Starnus Technology is developing a highly flexible autonomous mobile robot to enable third-party logistics companies to deal with rapidly changing operations. Samsung C-Lab spinoff EVAR recently introduced Parky, the world's first autonomous EV-charging robot. The mobile robot can traverse parking lots to meet EVs in need of a charge. And some robots are introducing new infrastructure applications. French robotics company, ACWA Robotics, has introduced a water pipe mapping robot. The robot moves through the pipes while the water is running and can create a map of exactly where repairs are needed. This information helps the water utility to prioritize and execute infrastructure repair operations.

Conclusion

The years ahead are promising ones for electronics manufacturers. Innovation abounds and that will drive opportunity in a variety of places. The electronics industry is set to experience a period of significant growth in the coming years, driven by innovation and new opportunities. New products and services are being introduced across a wide array of industries. New business models are being born. Electronics manufacturers will need to focus on being agile and continuously adapting to the changing landscape. From healthcare to robotic applications and beyond, technology is expanding. **PCB007**

It's All in the App

by Kim DiCianni, IPC INTERNATIONAL

The IPC APEX EXPO mobile app provides everything attendees could possibly need for the event, including viewing exhibitors, sessions, speakers, and products. Need information on an exhibiting company? With the IPC APEX EXPO mobile app, you can look up exhibitors by company name and search by product category—it's that simple.

When an attendee registers and answers the demographic questions, the information enters their agenda planner and provides suggestions on exhibitors and sessions that may be of interest to them, which they can then add to their planner. If an attendee adds an event they are not registered for, the app will take them back to registration so they can add it. The planner will also notify attendees if they have any scheduling conflicts when adding events to their planner.

When an attendee creates their schedule in the planner, they can sign into the app and their schedule will show under "My Schedule." The app also has features including "What's on Now," which will show them any events taking place at the current time. App users can also see a list of other attendees (limited information) and can request connections with them.

The app also allows users to see all of IPC's social media channels to keep on top of what IPC posts during the event.

Although the printed show directory is a great resource, we all know that program changes inevitably happen as soon as the directory goes to print; with an app, users are always able to see the most up-to-date information. Changes to meeting room locations, additions or cancellations, etc., will be reflected within the app. The app also allows IPC event staff to send out push notifications during the event in case of any last-minute changes.

Use this QR code (right) to download the IPC APEX EXPO Mobile App.



Kim DiCianni, CEM, is director of trade shows and events for IPC.

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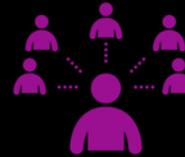
TOP 3 REASONS TO ATTEND

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Exposure to
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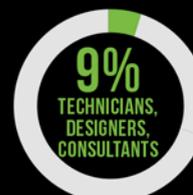
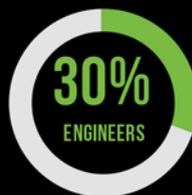


Network
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Training
and Education

WHO'S ATTENDING



The Value of Training Committees

Feature Article by Zenaida Valianu

IPC INTERNATIONAL

IPC APEX EXPO 2023 is right around the corner and the training groups are assiduously preparing for these meetings. IPC certification programs, built around IPC standards, play a key role in bringing value to the electronics industry. They are created and approved by training committees consisting of subject matter experts and trainers from around the world.

Committee members volunteer their time and expertise to improve the existing standards-based certification programs and to develop new programs based on industry needs. These committees support the IPC Education Team in developing, updating, and maintaining the training program materials, and provide industry expertise to the development, evaluation, and revision of the certification program.

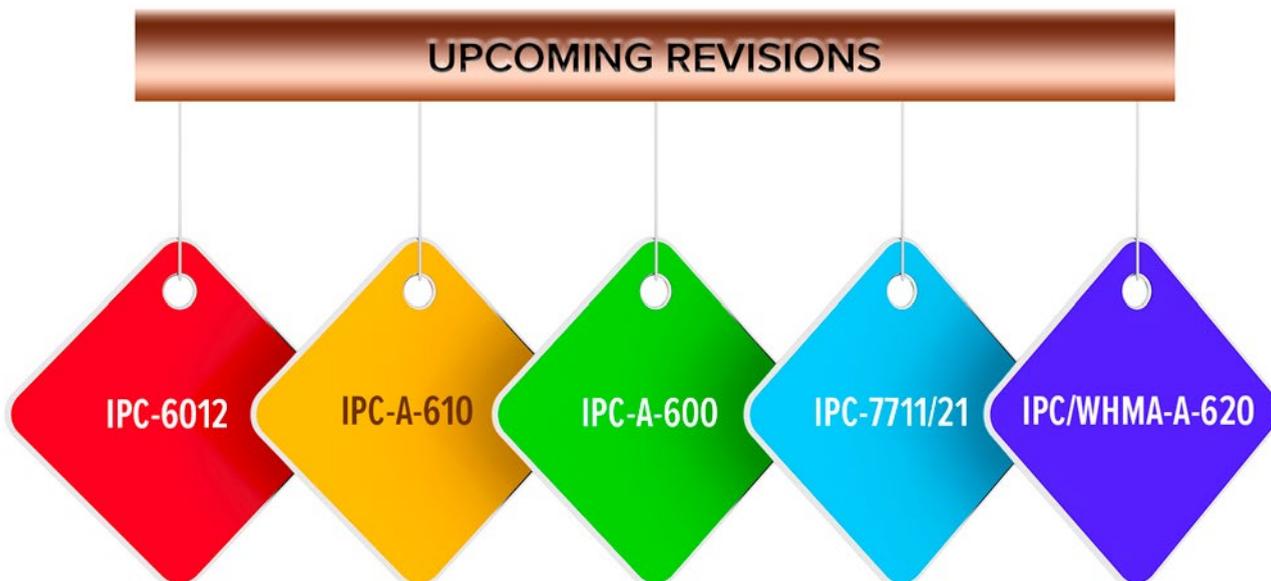
There are a few exciting activities for this year's training committee meetings.

Our first is the Training Programs Advisory Committee (TPAC) meeting on Monday, Jan. 23. At the beginning of each year, TPAC members review each training program commit-

tee's successes and challenges over the previous 12 months and discuss plans for the next 12 months. This will be followed by the election of new committee leaders. TPAC leaders serve two-year terms which expire in January at IPC APEX EXPO. Voting will take place during the meeting and the new leaders will be announced by the end of the meeting.

This year, four certification training committees will be revising CIT and CIS training materials to reflect the revisions to IPC/WHMA-A-620, IPC-7711/21, IPC-A-600, IPC-A-610, and IPC-6012:

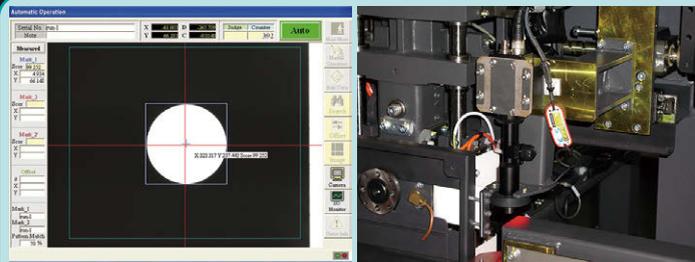
IPC/WHMA-A-620 (7-31FT) Certification Training Committee: Members are currently reviewing revisions to the training materials for the 620E certification program. We are thrilled to be working on yet another revision of the program that not only incorporates the changes in the standard but also enhances the content and overall course design, making it both more attractive and effective to both





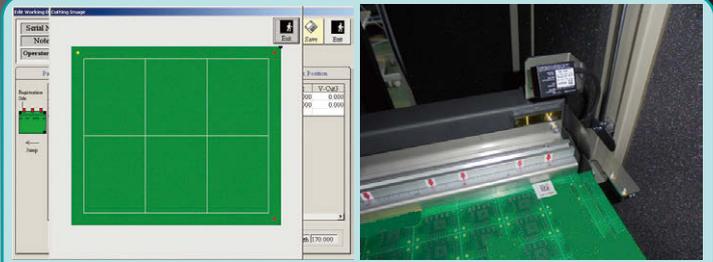
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1 Intro to Electronics Industry



2 Intro to PCA



3 Electronics Assembly & Soldering Processes



4 Safety



5 ESD & Product Handling

students and trainers. We are looking forward to publishing the 620E course in Spring 2023. The first full committee meeting is on Monday, Jan. 23.

IPC-A-610 (7-31BT) Certification Training Committee: Members meet on Tuesday, Jan. 24 to disposition user comments and follow up on open action items in preparation for the next revision of the IPC-610 standard in 2024.

IPC-7711/21 (7-34T) Certification Training Committee: Members are working on a major revamp of the program. This program has not been revised since 2017. The committee is evaluating the content as well as the relevance of the procedures for the course. The first full meeting of the year is on Wednesday, Jan. 25.

IPC-A-600 (7-31AT) and IPC-6012 (D-33AT) Certification Training Committees: This is a joint meeting at IPC APEX EXPO to discuss how they will collaborate on the revision of the IPC-600 and IPC-6012 training materials. The meeting is on Wednesday, Jan. 25.

J-STD-001 Certification Training Committee (5-22BT): Members are working on

improvements, comment resolutions, and action items. This committee will also disposition J-STD-001 Space Addendum user comments. The meeting will take place on Wednesday, Jan. 25.

About the Committees

The TPAC committee advises and supports the IPC Education Team with the development, maintenance, and implementation of standards-based certification training programs. This committee also reviews proposals for new certification training programs and advises IPC on scope, feasibility, development, and implementation. TPAC members also advise and support IPC to ensure compliance with that IPC standards-based certification programs comply with national and international standards and relevant accreditation requirements.

If you would like to join an IPC standards-based certification training committee, please send an email to zenaidavalianu@ipc.org for more information. **PCB007**



Zenaida Valianu is training manager at IPC.

NEW!



IPC Community Magazine is an exciting, new, quarterly publication with a strong editorial focus on members' success. Coming in January!



Special Session Sneak Peek



Feature Article by Julia Gumminger

IPC INTERNATIONAL

The IPC APEX EXPO 2023 Technical Conference at the San Diego Convention Center will feature two hot topics—Advanced Packaging and e-Mobility/EV Automotive—in custom and curated Special Sessions on Thursday, Jan. 26. Please plan your travel accordingly to attend these exciting sessions.

Advanced Packaging

Led by IPC's Chief Technologist, Matt Kelly, the Advanced Packaging special session will provide latest insights on IC substrate and packaging needs from industry experts.

The electronics industry is in the early stages of a new era, with unprecedented change already in motion. In this era of heterogeneous integration led by massive changes in semiconductor and advanced packaging sectors, the days of following Moore's Law are over. These fundamental changes in the semiconductor sector have significant impact throughout the rest of the electronics supply chain. As lines blur between IC substrate and HDI printed circuit board technologies and capabilities, the lines between OSAT and EMS manufacturers also blur. Please join us for this important Advanced Packaging Special Session focused on IC substrates and packaging assembly.

The session will be interactive with panelists providing top of mind priorities, followed by a panel discussion with interaction from attendees. HDI and ultra HDI PCB needs along with IC substrate and package assembly design, material, equipment, and process needs will be discussed.

E-Mobility/EV Automotive

Climate change, government policy, and consumers are all driving us fast and furious toward an electrified future. As our century-old, mostly mechanical modes of powering transportation transition to using electric powertrains, and with the ever-increasing use of electronic systems in advanced driving assistance and autonomy systems, the PCBA industry plays an increasingly important role in making sure that electronic assemblies can work harder, longer, and at higher operating temperatures. This provides opportunities for many consumer PCBA manufacturers to participate in the automotive industry for the first time, but also creates challenges for the industry around navigating new technologies and supply chains.

Whether building an infotainment or driving assistance system with processors running over 200 watts, or a charging station's printed circuit boards running at 1,000 volts, the industry is being called upon to help with design, material selection, and test in an environment where

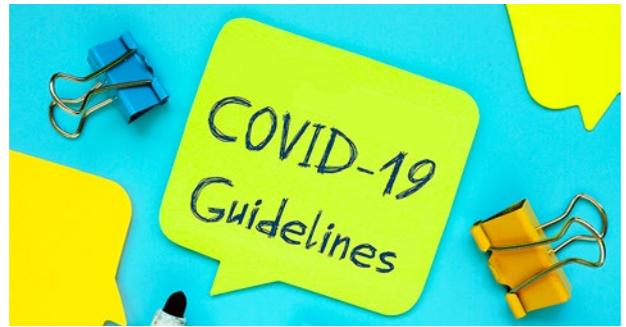
quality and reliability are challenged by requirements focusing on time to market. Meanwhile, specifications from design to test struggle to keep up. To further challenge the industry, EVs are part of a large rapidly developing ecosystem of charging stations that now require up to 97% uptime performance, and battery energy storage systems that require more than 20+ years of reliability, each with its own unique standards for design and test.

Co-chairs for the Technical Program Committee special sessions are Brian O’Leary, global head of e-mobility and infrastructure at Indium, and Jason Schwartz, business development manager at KYZEN. “The first part of the agenda will address the problems and challenges, with the second part addressing the solutions,” says O’Leary. “Our speakers will share a macro perspective about supply chain issues; a policy perspective about new government regulations and incentives; and a few technical perspectives from Tier 1, Tier 2, and OEMs.”

The e-Mobility session is supported by IPC’s e-Mobility Quality and Reliability Advisory Council and closely aligns with the council’s mission to help deliver e-Mobility quality, reliability, and safety while protecting the drive for innovation. IPC, in the first-of-its-kind event at IPC APEX EXPO’s e-Mobility/EV Automotive Special Session, will bring together stakeholders from OEMs, their supply chains, regulators, and policy and technology experts to discuss the many challenges as well as the collaborative-based solutions to those challenges.

The e-Mobility/EV Automotive session is a three-hour panel discussion with audience participation encouraged. Registration for this Jan. 26 session will be included in the “All Access” or “Full Technical Conference” packages, or it can also be added as a “Technical Conference Single Session Pass.” **PCB007**

Julia Gumminger is manager of professional development and events for IPC.



by IPC Staff

Masks

As of March 1, 2022, the state of California no longer requires masks, therefore masks will not be required while attending IPC APEX EXPO 2023.

Proof of Vaccination or Negative COVID Test

On April 1, 2022, the state of California lifted its requirement for vaccine verification or proof of negative test, therefore neither proof of vaccination status nor negative test will be required to attend IPC APEX EXPO 2023.

For Those Traveling From Outside the U.S.

Negative COVID Test

The CDC order requiring all persons to show a negative COVID-19 test result or documentation of recovery from COVID-19 before boarding a flight to the United States is rescinded, effective on June 12, 2022, at 12:01 a.m. ET. This means that starting at 12:01 a.m. ET on June 12, 2022, U.S. citizen air passengers and Lawful Permanent Residents (LPRs) will no longer need to get tested and show a negative COVID-19 test result, nor show documentation of recovery from COVID-19, prior to boarding a flight to the United States.

Proof of Vaccination

The CDC’s order requiring proof of vaccination for non-U.S. citizen non-immigrants to travel to the United States is still in effect. A booster dose is not needed to meet this requirement.

Above Guidelines as of November 2022

Please check the IPC APEX EXPO website at: www.ipcapexexpo.org/covid-19-information for the most current information or visit wwwnc.cdc.gov/travel/.

Coming Back to Life: Design Recovery

Testing Todd

by Todd Kolmodin, GARDIEN SERVICES USA

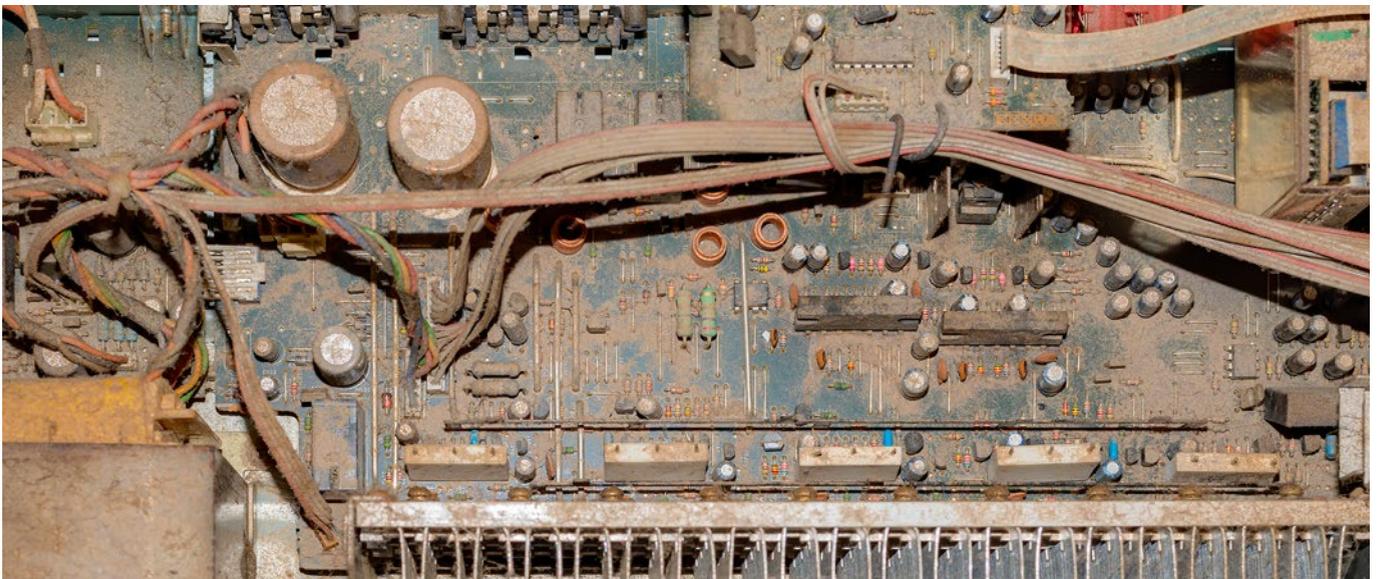
Although iconic, when I say “coming back to life,” I’m not talking about a Pink Floyd song, but rather about printed circuits. Bare boards have been in production for decades—from single- and double-sided breadboards to the impressive multilayer designs of today—and we all agree that the PCB is here to stay.

With today’s technology, designs are archived and realistically available forever. However, much of the legacy product of decades past is long forgotten. These rugged PCBs have been in service for years; their spare parts are full of dust on a forgotten shelf, ultimately obsoleted and scrapped.

In consumer electronics, this is less of an issue because technology is advancing almost daily and new designs and enhancements are continuously evolving. But what about those rugged, hidden, non-consumer products that

are keeping important infrastructure plugging along? Some of these high-reliability products are not thought about—until they fail. Then frantic calls for a replacement lead someone to discover that the dusty part on that long-forgotten shelf was obsoleted last Friday and is sunbathing in the landfill now. Farfetched? Unfortunately, truer than you think.

Now, as for what to do in such a situation: If you’re lucky, the PCB manufacturer may have a bare PCB in archive with an intact service agreement for long-term support. Or, they may have the phototools archived and can readily reproduce the PCB. But more likely, you’ll find yourself answering “no” when checking whether you have these options available to you—and then you’re stuck. You’re forced to look for an updated model or part for your historic equipment that likely doesn’t exist or does



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not have the necessary certification for the duty it must perform. However, all is not lost.

The design can be recovered. Currently, there are two main options available to reverse engineer or recover the PCB: netlist extraction and destructive scanning. Both options provide solutions to recovering the PCB.

Netlist extraction: If all phototools and design data are lost but a bare PCB remains, this is a lower-cost recovery option. A “golden” PCB is preferred but not necessary. If the bare PCB has a known fault, it can be dealt with post-process. In this process, the bare PCB is scanned utilizing a high-resolution flatbed scanner. This provides the “footprint” of the PCB. The two sides are then combined using CAM software and a “dumb” netlist as output. This file is taken to a flying probe with self-learn capability. The bare PCB is put on the machine and the machine is instructed to learn the electrical intelligence of the PCB. When this is complete, the information is then taken back to the CAM system where an IPC netlist or neutral net can be created. This can be sent back to the customer or design bureau to recreate the phototools to remanufacture the PCB.

Destructive scanning. Here we are using the principles of the first option to create the phototools for the customer. Just as in the first example, we are scanning the outer surfaces of the PCB; once the outer layers are completed, we will use precision sanding and/or milling equipment to either mill or sand the PCB to expose the next layer. This layer will then be

scanned. The process will continue until all layers have been captured. Each layer is scrutinized and carefully re-created electronically. Edits may include increasing trace widths to industry/customer requirements, fixing angles and terminations, or guaranteeing connections from the scanned images. Comparing the netlist created by the self-learn to the netlist created by the destructive scanning process is an important step to remember. This can identify a discrepancy between the scanning and the raw self-learn. If there are issues, design engineering can be consulted to identify the proper signature. Once this is complete, the layers can be electronically combined, and the IPC or neutral net created. In addition, the phototools, drill file(s), and other manufacturing-related files are created. This final package can then be sent back to the manufacturer/customer for remanufacturing.

All is not lost just because a manufacturer has obsoleted a legacy design. With some time, patience, and the right partner, the design can be recovered and that forgotten (but reliable) infrastructure can continue plugging along. No design is lost forever.

Happy holidays to all of you and your families. **PCB007**



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



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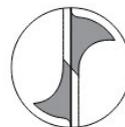
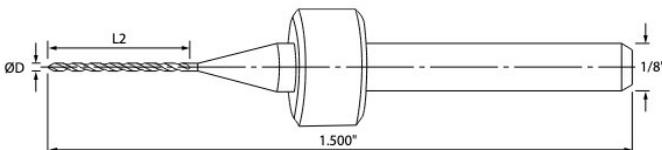


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Kyocera's renowned array of drills, routers, end mills, and specialty tools offer many benefits and advantages to customers for all their drilling and routing needs. Kyocera's tool reliability and design flexibility are key strengths of their products,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



4 Facet Point Geometry

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

Reconnecting the Social Network



Feature Article by Alicia Balonek
IPC INTERNATIONAL

If the past two years have emphasized anything, it would be the importance and value of face-to-face networking at events. Face-to-face interactions help create lasting relationships with new connections and help strengthen existing relationships with industry friends and colleagues.

Thousands of industry leaders, manufacturing innovators, and subject matter experts from across the globe will convene in San Diego for IPC APEX EXPO 2023, making it the place to be to help you connect with representatives from the entire electronics manufacturing supply chain. We have a full line-up of networking events planned for IPC APEX EXPO 2023 that you don't want to miss.

Show Floor Reception

Tuesday, Jan. 24, 5 to 6 p.m.

The industry's largest networking event, the IPC APEX EXPO Show Floor Reception, is your opportunity to network with industry colleagues and connect with the industry's leading equipment manufacturers, suppliers, and innovators. Included in all registration packages, *including the Event Essentials tier (Exhibit Hall-only registrations).*

Ice Cream Social

Wednesday, Jan. 25, 2:30 to 3:30 p.m.

Satisfy your sweet tooth while networking with industry colleagues, subject matter experts, and the industry's leading equipment manufacturers, suppliers, and innovators. *Included in all registration packages, including the Event Essentials tier (Exhibit Hall-only registrations).*

Newcomers Welcome Reception, Sponsored by SICK

Monday, Jan. 23, 5 to 6 p.m.

Maximize your time at IPC APEX EXPO with some advice from a few insiders while you enjoy cocktails and hors d'oeuvres with your colleagues and learn how you and your company can get the most out of your attendance at IPC APEX EXPO 2023. *Included in all registration packages, including the Event Essentials tier (Exhibit Hall-only registrations).*

Women in Electronics Reception

Tuesday, Jan. 24, 6 to 7:30 p.m.

"Where Are All the Women in STEM?"

Emily Calandrelli, mechanical and aerospace engineer, host and co-producer of "Emily's Wonder Lab" on Netflix, and executive producer and host of "Xploration Outer Space" on FOX will provide insights on how women in STEM can play a more active role in introducing young females to the opportunities available to them for a career in STEM. *Included in all registration packages, including the Event Essentials tier (Exhibit Hall-only registrations).*

Career Connections Networking Event (new this year)

Wednesday, Jan. 26, 6 to 7:30 p.m.

This networking event will provide an opportunity to meet your colleagues and peers in the electronics industry. Special guests from the Emerging Engineer program will lead a discussion on falling into your career by taking risks and looking for opportunities. Bring your questions and your colleagues to this event to either listen in or share your best (and worst) career decisions and how those decisions have both shaped where you are today and determined where you want to be in the future. *Advance/separate registration required. PCB007*

Alicia Balonek is senior director for trade shows and events at IPC.

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Next-level Professional Development

Feature Article by Julia Gumminger

IPC INTERNATIONAL

IPC APEX EXPO 2023 will offer a refreshed Professional Development Course program. This year's conference includes something for everyone, including informative courses catering to technical managers ready to level up their careers. Thirty-six courses will be offered on Sunday, Jan. 22 and Monday, Jan. 23.

Attendees will find both updated content from veteran instructors and innovative courses from new instructors. The diversity of educational content includes courses that focus on understanding and applying IPC standards; Factory of the Future technologies; quality and reliability; and a legal boot camp. Participants in these courses will gain new knowledge and real-world skills that will equip them to rapidly respond to changing demands for new technologies, materials, and processes.

As engineers progress in their careers and become the next generation of leaders in their companies, business and legal skills will likely become part of their job descriptions. IPC approached Allen Anderson and his colleague, Patrick Sebesta from F&B Law Firm P.C., with

a request for a course designed for engineers who have worked in the technical career track and now find themselves in management overseeing contracts and risk management issues. "Customer Contract and Legal Boot Camp for Engineering Professionals" is a brand-new course, custom-designed for IPC's audience.

"Whether you are a technical professional in an OEM, an EMS provider, a PCB, a cable or wire harness manufacturer, or any other electronics industry supplier, understanding key contractual provisions and associated legal ramifications is critical to every team member's role in negotiating and executing effective customer contracts," Anderson says. "This added dimension to a technical background helps enhance a manager's—and thereby the company's—ability to obtain and execute equitable agreements with commensurate risk for return, avoid significant compliance and risk pitfalls, and protect company assets and intellectual property."

Dr. Mo Abuali, CEO of IoTco, will be teaching another course meant to fill a gap in profes-



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sional knowledge and help leaders prepare for the factory of the future. “Leveraging Industry 4.0 Toward Zero-Downtime, Zero-Defects Manufacturing,” another brand-new course, will benefit not only executives leading operations of manufacturing companies, but also directors, managers, and advanced data science professionals.

Abuali says of the course, “Although some have already begun their journey, many manufacturers are still talking about digitizing their manufacturing floor and wondering if it’s a worthwhile investment. Industry 4.0 describes the evolution of industry toward interconnectivity, automation, advanced analytics, and basing decisions on real-time data capture from the shop floor.”

This course will provide attendees with a broad understanding of key Industry 4.0 solutions that marry physical production and operations with Smart digital technology, plant connectivity, artificial intelligence, and predictive analytics—all to create a connected ecosystem for organizations to level up their uptime, quality, and overall productivity.

Dr. Nahid Majd, associate professor in computer science at California State University San Marcos, will demystify the topics of “Blockchain, NFT, Cryptocurrency and Metaverse,” and discuss how these applications might be used in supply chain management for electronics manufacturing.

The opportunities are great in manufacturing, Dr. Majd says. “NFTs could provide trustworthy maintenance of digital data associated with each electronic product that has been manufactured, tested, and used

in an electronic device,” says Dr. Majd. “Also, because NFTs contain an immutable record of transactions on the blockchain, any third party can easily confirm the origin and ownership of a product.” This brand-new course will offer attendees another option for bringing their factories into the future.

Continuing the Factory of the Future course offerings, Michael Ford, senior director of emerging industry strategy at Aegis Software, will teach a course titled “Application of IPC

Smart and Secure Digital Transformation Standards.” Ford says, “The most important requirement for Smart manufacturing is the secure interoperability of data, with freedom to mix and match hardware and software solutions from chosen vendors.”

Several new IPC standards, including CFX, IPC-2581, HERMES, Digital Twin, Traceability, Cybersecurity, Model Based Design, etc., specifically define various requirements that together create this holistic manu-

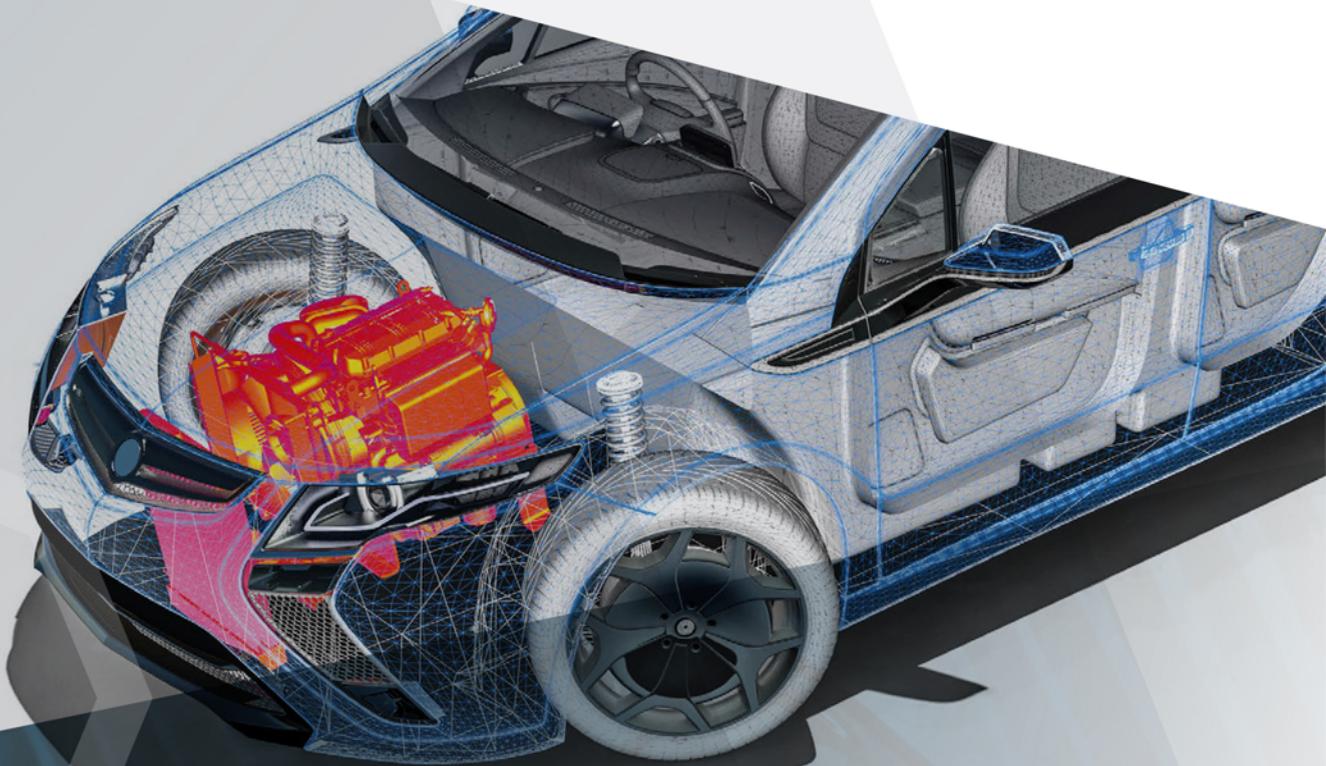
facturing and supply-chain ecosystem. Ford will be joined by a team of industry leaders from many companies across the industry who will explain how the adoption of solutions based on each of these standards can map out the most practical and cost-effective path toward Smart digital transformation. The course is geared toward managers and engineers of both OEM and EMS companies and will reach across all disciplines of design and manufacturing, including production, engineering, quality, supply-chain, maintenance, design, lifecycle management, automation projects, and finally, information technology.





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Kat Ermant, lead prototype technician with Peloton, is harnessing the power of a technology that some consider futuristic but that is very much a part of current manufacturing processes: additive manufacturing, or 3D printing. Ermant's new course, "3D Printing as a Tool: Harnessing the Language of Additive Manufacturing," will offer designers, engineers, and managers a common language to be able to work together utilizing additive manufacturing as a tool for rapid prototyping. This session will cover the fundamentals of office and user-friendly 3D printers; the software applications needed to operate them; the file prep for printable models; finishing requirements; and how to communicate with service bureaus, vendors, and technicians. Participants will learn to speak the same additive language as 3D printing professionals to increase efficiency, lower costs, and speed up lead times.

"Electronic Textile Evaluation Methods for Product Designers and Engineers," a new course by Madison Maxey, CEO and founder of Loomia Technologies, is another course meant to bridge the knowledge and communications gap for professionals who wish to understand and apply newer technologies in their work. Recommended for product designers, industrial designers, electrical engineers, mechanical engineers, and product design engineers who regularly look at new product development where unique electromechanical challenges may arise, this course will provide a primer on how to engage with electronic textiles for new product development. Attendees working in areas such as medical devices, wearables, automotive interiors, and robotics may all benefit from this course. Attendees will walk away with a clearer picture of when electronic textiles may be relevant to their engineering, which type of technology is ideal for their application, and how to thoroughly evaluate a technology when selected.

Dr. John Lau of Unimicron Technology Corporation will be leading the "Heterogeneous Integration (System-in-Package)" course. As

advanced packaging becomes more central to electronics manufacturing, this course will offer attendees an introduction to the technological terms, trends, and challenges facing heterogeneous integration.

Frank Uibel's "Press-fit Technology—Value Chain, Physics, Process and Standards," another course focused on assembly, will discuss updated IPC standards IPC-9797 and HDBK-9798. Insight into the production, design, and application of compliant press-fit pins and components will be covered, along with new materials and surface finish technologies being introduced to the market. Knowledge in stamping, plating, and press-in processes will be reviewed; along with testing and acceptance criteria, with a focus on high reliability, harsh environment applications, and the underlying physical contact mechanisms responsible for the quality of the pin to PB connection. Implementation of the standards and how they interact with other IPC documents will provide a holistic picture about high reliability press-fit technology. Attendance is encouraged from anyone in research, development, industrialization, sales, purchasing, or quality engineering with a background in assembling electronics or its components.

Professional Development Courses at IPC APEX EXPO 2023 will offer the highest-quality educational content delivered by experts in all areas of the electronics industry. As major world events impact supply chains and affect consumers' demand for products and materials, IPC's Professional Development Courses offer a venue to learn about best practices, lessons learned from challenges in the field, cutting-edge technology, and trends with updated IPC standards. **PCB007**



Julia Gumminger is manager of professional development and events for IPC.

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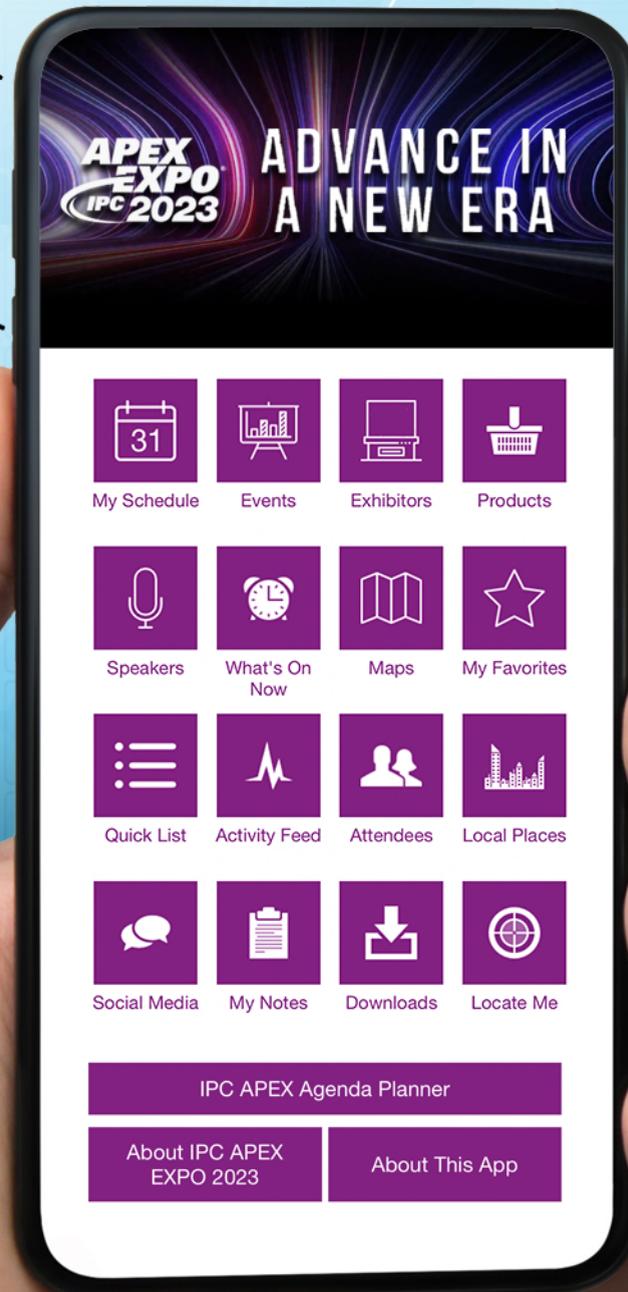
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Basics of Cupric Chloride Etchant

The Chemical Connection

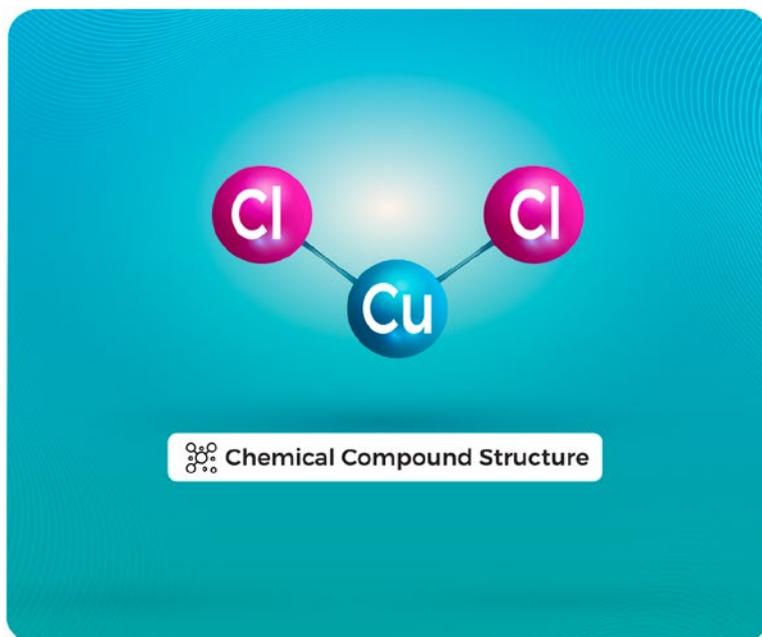
by Christopher Bonsell, CHEMCUT

Cupric chloride (CuCl_2) is an etchant that has capabilities that make it a great application in PCB manufacturing. Although it is not the most used etchant in the industry, it proves to be beneficial by being simple to maintain. Maintaining CuCl_2 is relatively forgiving in comparison to alkaline etchant because there are only a handful of parameters you need to monitor. If CuCl_2 seems like it would be an appealing etchant to use for your PCB etch process, here are some basic parameters that are key to understanding how to maintain it.

Specific Gravity

Specific gravity (SG) is a main factor that must be watched and controlled to maintain a consistent etch quality. I've mentioned in pre-

vious columns that as you etch more panels, the metal content of your etchant increases. This increase in metal content makes your etching solution have a higher SG, and SG and etch rate tend to have an inverse relationship; thus, the higher your specific gravity gets, the slower your etch rate will be. The maximum etch rate for cupric comes in between the range of 28 to 36 °Bé (SG: 1.2393 to 1.3303)¹. Thankfully, the normal CuCl_2 etching solution you will receive comes in the range of 32 to 36 °Bé. Although specific gravity is one of the key factors, unlike alkaline etchant, there are no critical risks to falling out of this range. If the SG gets too high, you can simply add more water to your etching solution; if it is too low, just simply add more cupric crystals or etch more panels.



Copper (II) Chloride





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Figure 1: A standpipe (clear glass tube) on a piece of Chemcut equipment. This standpipe is equipped with a specific gravity controller (gray device in the middle of standpipe).

Temperature

Temperature is also a parameter that should be controlled for consistent etch quality. The higher the temperature, the faster your reaction rate will be. The temperature of the etcher bath tends to have little effect on etch factor and only improves etch rate; thus, cupric etchers are typically run at the highest possible temperature. The standard temperature to etch at is 130°F. Controlling temperature is also simple because it is done through the etching equipment by monitoring the temperature with probes that will activate or deactivate the machine's heating and cooling systems as needed.



Figure 2: A basic ORP probe set-up for a beaker test.

Oxidation-reduction Potential

Oxidation-reduction potential (ORP) is a major factor to monitor with CuCl_2 . ORP can be understood as a measurement of how ready your etchant is to etch metal. It does this by measuring the ratio of Cu^{+2} ions (from CuCl_2) and Cu^{+1} ions (from CuCl —the spent form of the etchant). As you etch, the Cu^{+2} ions will decrease and the Cu^{+1} ions will increase, and thus the ORP value will drop. A low ORP is a sign that you need to add reagents to perform regeneration so that the Cu^{+1} ions will be converted back to Cu^{+2} . There are three main ways that you can perform this regeneration; if you wish to know more, please see my [November 2022 column](#), “Cupric Chloride Regeneration Options.”

ORP is measured via an ORP probe that provides a value in the units of millivolts. If you are curious where the millivolts value comes from, the equation is shown in Figure 3.

If you are a person who does not like math, no worries; what you mostly need to understand is that the ideal ORP range for CuCl_2 is

$$E = E^0 + \frac{2.303 RT}{n} \log \frac{Cu^{+2}}{Cu^{+1}}$$

Figure 3: Nernst equation for ORP in CuCl₂ etchant. E° is the standard potential of your electrode, R is the gas law constant, T is temperature (in Kelvin), n is number of electrons transferred per molecule.

540 to 560 mV. It is best to avoid overshooting ORP past the value of 600 mV because typically there are not enough Cu⁺¹ ions in a solution to absorb all the chlorine used in regeneration. This can lead to a chance of chlorine gas forming and being released into the atmosphere, which can be dangerous—so it is best to avoid high ORP values. If you are too low on ORP, you need to add more regenerating components so the regeneration reaction can replenish the Cu⁺² ions. If your ORP is too high, you can remedy this by simply running panels. However, if the ORP is too high and causes an unpredictably high etch rate, it is best to find some way to introduce copper into your etch bath to bring the ORP back down. Bringing the ORP down can mean running a piece of scrap copper through the machine or dissolving copper powder into the solution. If you are finishing a shift and you notice the ORP is running low, you can leave the etchant to rest during a break or overnight because as it sits, it will react with the oxygen and increase the ORP again.

Free Hydrochloric Acid Content

Another critical factor to monitor in your CuCl₂ is free hydrochloric acid (HCl) content. For CuCl₂ to etch efficiently, there needs to be a detectable amount of excess acid. This is because CuCl₂ is relatively insoluble in water on its own, and it needs to be in a highly acidic solution to prevent the CuCl₂ solids from precipitating out of the solution. The HCl also helps remove the copper oxide layer that is present on copper panels. CuCl₂ is not efficient at removing this, but with HCl present, that layer gets removed, allowing for easier access

to the copper surface. Without HCl, the etch rate of CuCl₂ is cut in half.

Typically, the higher the HCl levels, the faster the etch rate. Although higher HCl content increases etch rate, it comes with the drawback of increasing undercut. Since there are some drawbacks to higher HCl contents, it is recommended to keep the free acid in a range of 1 to 2 N HCl. One major consideration with free acid content is the difficulty of keeping a close eye on this parameter. This is because there are a lot of technicalities in trying to measure it. The only established, reliable method of doing this is through routine titrations.

Conclusion

Once you know the basics of maintaining CuCl₂, and both the spray pressures and total etch time you need to meet your PCB specifications, running your etching process should be fairly easy. To summarize the parameters discussed in this column, see Table 1 for the recommended parameter ranges for cupric etchant. PCB007

Parameter	Recommended Values
Specific Gravity	28–36 °Bé
Temperature	130°F
ORP	540–600 mV
Free HCl Content	1.0–2.0 N

Table 1: Summary of CuCl₂ parameters and their recommended values

References

1. “Process Guidelines for Cupric Chloride Etching,” Chemcut.net



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

Schedule at a Glance

Feature Article by Alicia Balonek, IPC INTERNATIONAL

Saturday, Jan. 21

8 a.m. to 5 p.m. IPC Standards Development Committee Meetings

Sunday, Jan. 22

8 a.m. to 5 p.m. IPC Standards Development Committee Meetings

Monday, Jan. 23

8 a.m. to 5 p.m. IPC EMS Leadership Summit
8 a.m. to 5 p.m. IPC E-Textiles (Advance/
separate registration required)

8 a.m. to 5 p.m. IPC Standards Development Committee Meetings

9 a.m. to 12 p.m. Professional Development Courses

12 to 1:30 p.m. Luncheon featuring a keynote by Shawn DuBravac, IPC Chief Economist (Advance/separate registration required if not included in registration package)

1:30 to 4:30 p.m. Professional Development Courses

5 to 6 p.m. Newcomers Welcome Reception*

Tuesday, Jan. 24

8:30 to 9:30 a.m. Keynote Session*
9:45 to 10 a.m. Ribbon Cutting Ceremony*

10 a.m. to 12 p.m. Technical Conference Sessions
10 a.m. to 5 p.m. IPC Standards Development Committee Meetings

10 a.m. to 6 p.m. Exhibits Open*
12 to 1:30 p.m. Luncheon | IPC Annual Meeting and Awards (Advance/separate registration required if not included in registration package)

1:30 to 3 p.m. Technical Conference Sessions
3:30 to 5 p.m. Technical Conference Sessions

5 to 6 p.m. Show Floor Welcome Reception*

5 to 6 p.m. Network with Poster Presenters on the Show Floor*

6 to 7:30 p.m. Women in Electronics Reception*

Wednesday, Jan. 25

8 to 10 a.m. Technical Conference Sessions
8 a.m. to 5 p.m. IPC Standards Development Committee Meetings

8:30 a.m. to 2:30 p.m. STEM Outreach Event
9 a.m. to 6 p.m. Exhibits Open*

10:30 a.m. to 12 p.m. Technical Conference Sessions

12 to 1:30 p.m. Luncheon Featuring a Keynote by: Dr. John W. Mitchell, IPC president and CEO (Advance/separate registration required if not included in registration package)

1:30 to 3 p.m. Technical Conference Sessions
2:30 to 3:30 p.m. Network with Poster Presenters on the Show Floor*

2:30 to 3:30 p.m. Ice Cream Social on the Show Floor*

3:30 to 5 p.m. Technical Conference Sessions
6 to 7:30 p.m. Career Connections Networking Event

Thursday, Jan. 26

8 a.m. to 5 p.m. IPC Standards Development Committee Meetings

8 a.m. to 5 p.m. PERM No. 53 (Advance/
separate registration required)
8 to 10 a.m. Advanced Packaging Special Conference Session

8:30 a.m. to 2 p.m. STEM Outreach Event
9 a.m. to 12 p.m. Exhibits Open*
10 a.m. to 1 p.m. e-Mobility/EV Automotive Technical Conference Special Session

Friday, Jan. 27

8 a.m. to 5 p.m. PERM No. 53 (advance/
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* = Event Essentials, included with registration.

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- ✗ EMS Leadership Summit
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- ✓ Event essentials**

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- Newcomers Networking Reception
- Women in Electronics Networking Reception
- Exhibitor Product Showcase Corridor
- Ice Cream Social on the Show Floor

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Alicia Balonek is senior director for trade shows and events at IPC.

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Launching IPC Community Magazine

Article by Michelle Te
I-CONNECT007

IPC is well known for its cutting-edge standards development, certification and training, advocacy, and industry intelligence reports that directly impact its members.

Now, IPC leads the industry in yet another direction—the launch of an industry-specific quarterly magazine, *IPC Community*, that celebrates member success while sharing the important work being done within IPC to better serve its members and the greater electronics manufacturing community.

In fact, when IPC President and CEO John Mitchell travels on behalf of IPC, his interactions with others often center on creating connections through a healthy global ecosystem. He wants those he meets to see and feel the importance of that message. With a mission to help members “build electronics better,” Mitchell wants them to understand they’re all working toward the same goal.

To further enhance that goal, *IPC Community* digital magazine will share and celebrate member success stories, committee and stan-



dards updates, education and workforce training developments, Factory of the Future solutions, advanced packaging updates, member profiles, and more. It’s news and information to help you be more competitive and profitable.

“We have so many good things going on within our organization, it’s challenging to deliver content where our members can easily read, consume, and share it in a single place,” says Brian Knier, IPC chief marketing officer. IPC effectively uses its website and social media channels, but was looking for something even more creative, with a way to tell great stories about what’s happening inside IPC and in the greater member community.

“We are a member organization and this is primarily a member magazine,” Knier says of *IPC Community*. “We also serve a larger community, so our hope is that when you read this, you will see all that IPC is doing to help the greater electronics community.”

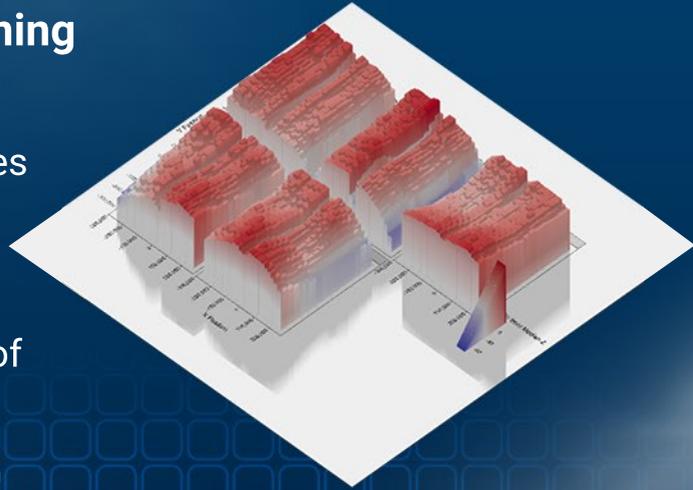
But it’s more than that, he continues, because it’s an opportunity to infuse “community”

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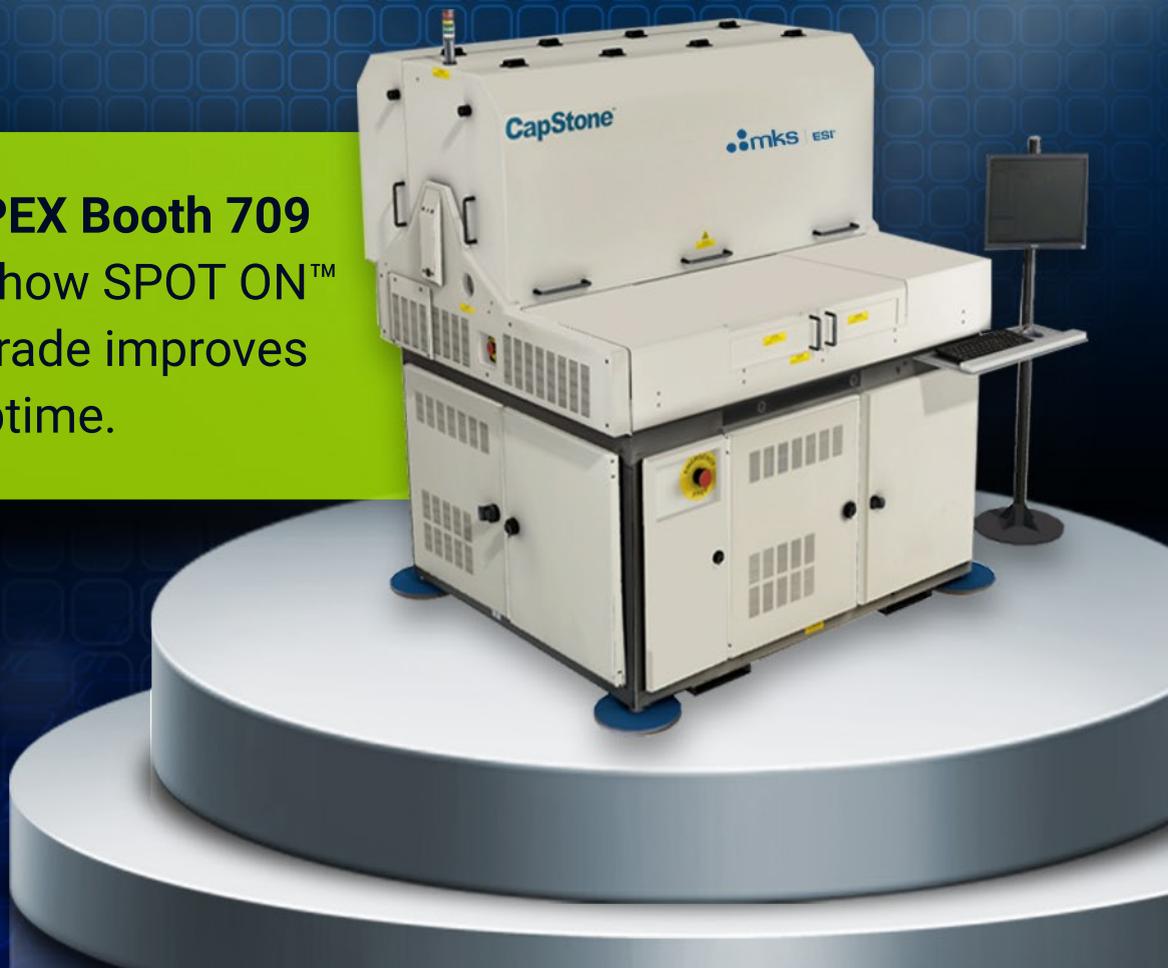
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into everything that IPC does. To help celebrate the success stories of IPC members, IPC turned to its new IPC Publishing Group (I-Connect007) to coordinate efforts. “It only made sense to



partner with I-Connect007, and it’s been fabulous so far,” he says. “This partnership is what has allowed us to create the magazine, and it’s been a pleasure to work together.”

Both IPC and I-Connect007 understand that it’s the members, and readers, that make every effort vital to moving forward.

“It’s our members that make IPC so strong,” Knier says. “We need to celebrate them, and for us to feel more connected to the very people who keep us going, who make all of this happen. When our members are successful, it helps others to be successful.”

In just one example, Teresa Rowe, senior director of assembly and standards technology, was bursting with pride as she related the cake celebration for one of her volunteer committees after three years of review before their standard was finally published. These committee members devoted many hours debating over the finer points of IPC/WHMA-A-620C [standard is now on E revision] before finally deciding it was ready to be published. It was the penultimate ending to some really important work. In each issue of *IPC Community*, we will continue to share success stories

like these between IPC and its members. I’m sure you’ll have some of your own.

But that’s not all the *IPC Community* will share. The IPC team knew an extremely valuable

resource would be content that directly affects the financial health and well-being of IPC members. To that end, each issue will feature an exclusive market report from Shawn DuBravac, IPC chief economist. Shawn will research and write this content exclusively for IPC members which may be crucial to your bottom line—right now.

“This will be ‘must read’ content that has a direct market impact,” Knier says. “It will be timely and relevant. We know this will be of high value and will be something you’ll be looking for in every issue. So, please, give us feedback. Let us know if this is something you want.”

At my core, I’m a storyteller, and I believe that no matter where you go in life, there are great stories to be told. What’s your story? What will you share with us? How will you help us celebrate your success? What can you share that might inspire someone else also working to stay competitive in this ever-changing, fast-paced industry?

I’m excited to manage this new publication, so please don’t hesitate to reach out with story ideas or to provide feedback after we launch the first issue. The magazine launches during the week of IPC APEX EXPO 2023 in both a digital and printed format.

To subscribe to *IPC Community*, [click here](#). This is something definitely not to be missed! To learn more about advertising opportunities, contact [Barb Hockaday](#). Download the media kit [here](#). PCB007

Michelle Te is managing editor of *IPC Community* and columnist coordinator at I-Connect007.

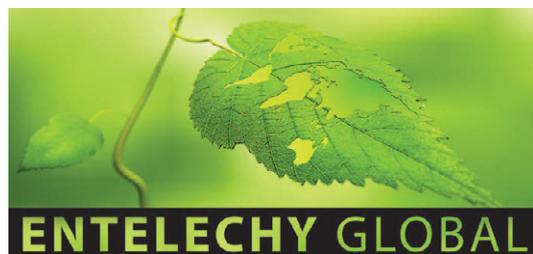


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The Three Essential Ingredients of Reshoring

American Made Advocacy

by Travis Kelly, PCBAA

Woven into almost every economic story these days is “reshoring,” a word most Americans had never heard just 18 months ago.

For decades, market pressures and foreign subsidies drove manufacturing of everything from socks to semiconductors overseas. Policymakers and economists called this “offshoring.” This shift was the natural consequence of an increasingly interconnected world, new trade agreements, and a period of unprecedented global peace and security.

Consumers reaped the benefits of offshoring in the form of inexpensive goods. But as the COVID-19 pandemic made clear, we paid a price for sending the production of critical technologies overseas. Disruptions to unpredictable supply chains and dependence on technology in far-off locations led to sudden price surges and empty store shelves. This should be a real wake up call for both gov-

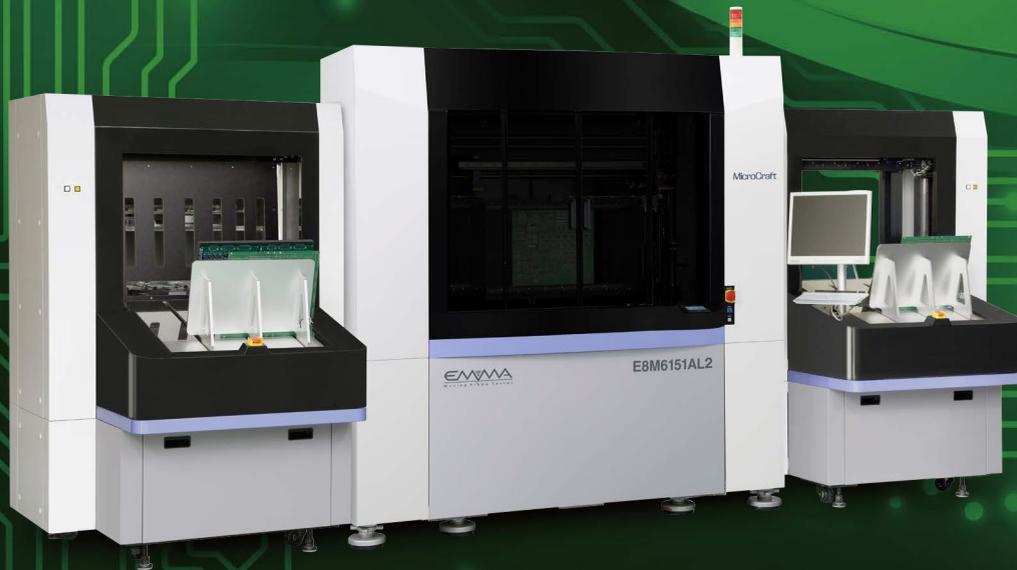
ernment and industry. Chasing the low-cost option without considering the broader long-term implications brought us to where we are today.

The effects of offshoring have been especially dramatic for the PCB industry. Two decades ago, nearly 30% of the world’s printed circuit boards were made in America. Today that number is just 4%. The number of PCB companies fell from 2,000 to fewer than 150. And while the loss of manufacturing is alarming, we have also lost intellectual property, capital assets, and the accumulated knowledge of thousands of U.S. employees.

The good news is that policymakers have acted to reshore select microelectronics by passing the CHIPS and Science Act, which will invest more than \$50 billion through grants and tax credits into building new facilities in the United States.



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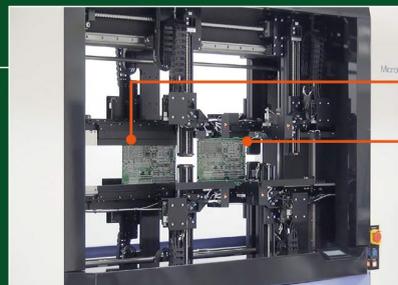
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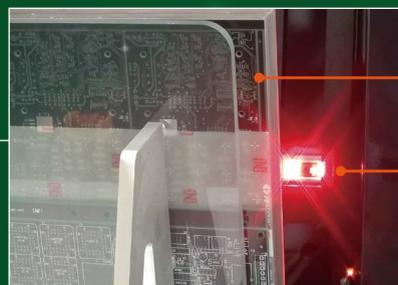


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Now we need to take the next step. Making chips in America doesn't solve the supply chain security and resiliency issues. Why not? Because when the new chips are made here, they will still rely on PCBs and advanced packaging done almost exclusively in Asia.

How can we restore domestic production of microelectronics? Here are three places where government and industry need to act:

Making chips in America doesn't solve the supply chain security and resiliency issues.

Innovation

Just as chips have evolved, PCBs have become highly complex microelectronics constructed with custom combinations of woven glass, copper foil, resin, and other highly engineered materials. PCBs are modern marvels, but as semiconductors evolve, so must the PCBs that support them. PCB manufacturers must invest in R&D to stay current. This past year, Congress started to address R&D for PCBs through HR 7677, the Supporting American Printed Circuit Boards Act, a bill that will re-emerge in the 118th Congress. Government support for R&D is important because the U.S. competes against countries that have been incentivizing innovation and low-cost production for decades. It is time for the U.S. to step up and do the same.

Talent

The men and women who design, build, test, and inspect PCBs are the most impressive people I've had the pleasure to work with. Unfortunately, their ranks have thinned as the industry contracted over the past two decades. When manufacturing and R&D migrated overseas, so did much of the know-how. As a nation, we

need to invest in the manufacturing and scientific skills we need to be competitive. This is a long-term issue. If we don't address the shortage of qualified workers now and provide them with clear career pathways, we will have a hard time attracting the next generation to this industry. The talent pipeline is just as crucial as any piece of machinery we might buy or any building we might erect.

Investment

Government incentives alone are not enough to scale up and sustain a robust and resilient microelectronics industry in the U.S. The present business case is challenging. To attract commercial investment, prospective investors need to see both the right conditions and a promise of future returns. Future returns depend on projecting aggregate demand. For example, if we were to put together the domestic demand for 5G, medical, finance/banking and telecommunications, and other critical infrastructure, I believe we would see a viable investment opportunity. Government and industry should agree on the critical infrastructure that requires domestically produced PCBs and other microelectronics. Then legislators and regulators could take coordinated action to support this industry and protect our nation's critical infrastructure.

Reshoring microelectronics manufacturing has a multitude of benefits, all of which make a compelling argument for government and industry action. As the Printed Circuit Board Association of America, our efforts in Washington, D.C., haven't gone unnoticed. We continue to educate, advocate and lobby for more government cooperation. Join us today as we work toward a stronger future for this critical industry. **PCB007**



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



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A Primer on Flexible Circuits in Printed Electronics

Happy's Tech Talk #15

by Happy Holden, I-CONNECT007

Introduction

The printed electronics sector is presently an area of great interest to many in the electronics manufacturing industry. Because of their incredible utility, printed electronics (PE) are poised to generate tens of billions of dollars in the coming years. Recent research indicates that the total market for printed, flexible and organic electronics will grow from \$41.2 billion in 2020 to \$74 billion in 2030¹.

The term “printed electronics,” with its relatively recent appearance in the industry’s lexicon, may seem to refer to electronic circuits comprised of conductors and various active and passive components (i.e., transistors, resistors, capacitors) printed directly onto a substrate of some type. According to this definition, printed electronics are clearly a significant departure from traditional approaches to

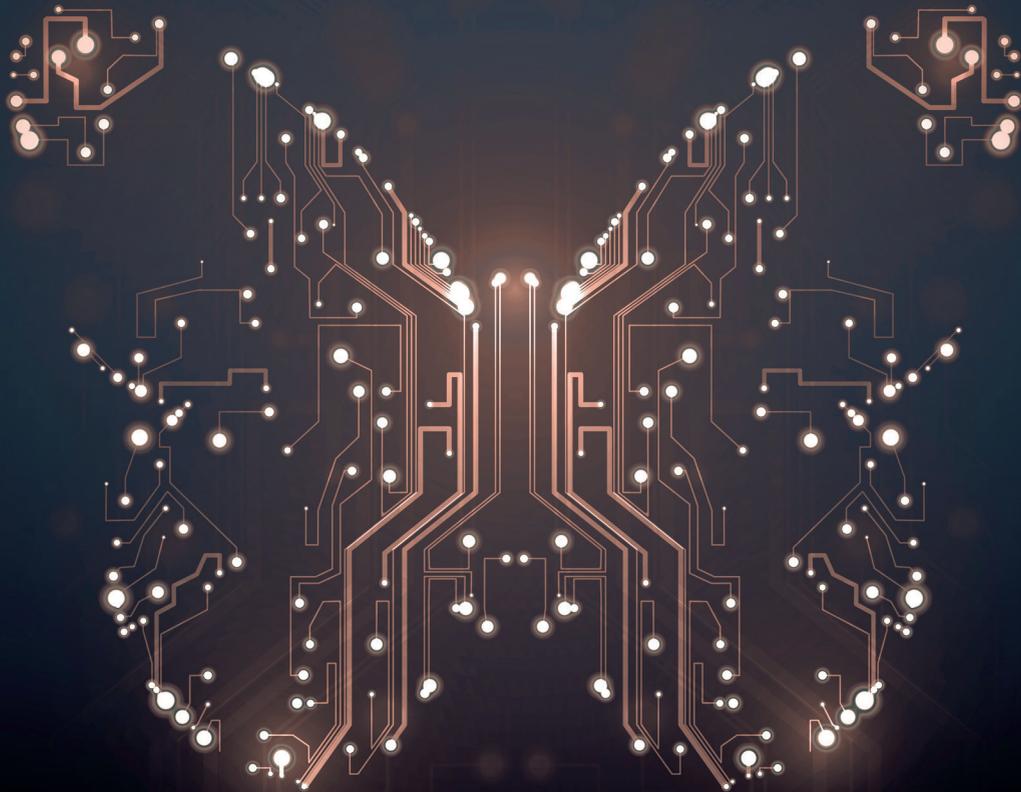
electronics manufacturing. However, marketers are trying to position a host of manufacturing solutions under the “printed electronics” umbrella to take advantage of the growing buzz surrounding the technology, which has created confusion around the term.

This confusion may be a factor in the sector’s slow growth rate. While there is presently a market for these devices, the growth rate predicted by exuberant market forecasters has not yet been realized. Barriers to exponential growth seem to be related to the current inability of suppliers to reduce costs to enable large-scale manufacturing of printed electronics. Every disruptive technology that has sought to surpass existing, highly competitive, and/or traditional technologies has faced this challenge. So far, printed electronics have replaced some existing applications but have made little



Figure 1: Some of the major potential applications of printed electronics².

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progress in creating new applications outside of radio-frequency identification (RFID) and organic light-emitting diodes (OLEDs). The latter is a true printed electronics solution that has successfully established a solid market presence. Other than that, no real “killer” app or paradigm shift technology has emerged from the current fray. The simple reality is that it’s especially challenging to displace incumbent products with entirely new design solutions that must first be developed, understood, and implemented.

Applications

Disposable electronics that can compete with paper are a compelling and intriguing prospect to marketers. However, before fully adopting this technology, we must consider the environmental impact of throw-away electronics and adequately prepare for end-of-life matters. Assuming that these factors are taken into consideration, there are a variety of intriguing prospects and processes being suggested for the next generation of printed electronics.

Further, thanks to its ability to rapidly print multiple conductive, insulating, and semiconductor layers to form electronic circuits, printed electronics technology offers the ability to produce a simpler and larger integrated circuit (IC) at a much lower cost than using conventional fabrication methods, albeit with less functionality per unit area.

The number of potential applications for printed electronics technology is growing:

Printing Methods

Deciding which printing method to use is determined by both the requirements of the printed layers and the properties of the printed materials, as well as the product’s economic and technical considerations. Presently, printing technologies are divided between sheet-based and roll-to-roll-

based approaches. Sheet-based techniques, such as inkjet and screen printing, are best for low-volume, high-precision work. Gravure, offset, and flexographic printing are more common for high-volume production, such as for solar cells, reaching 10,000 square meters per hour (m^2/h). While offset and flexographic printing are mainly used for inorganic and organic conductors (the latter also for dielectrics), gravure printing is especially suitable for quality-sensitive layers, like organic semiconductors and semiconductor/dielectric-interfaces in transistors, due to its high layer image registration quality. Gravure printing is also suitable for inorganic and organic conductors in terms of high resolution. Organic field-effect transistors and integrated circuits can be wholly prepared using mass-printing methods.

Altogether, there are presently eight key manufacturing image transfer technologies that are either being employed or are proposed for printed electronics production (Figure 2).

Traditional printing technologies:

- Screen printing
- Rotogravure printing
- Flexographic printing
- Offset printing



Figure 2: Printing techniques compared by resolution versus throughput. Arrow indicates soft lithography as a photo-imageable technique that is off the scale to the left³.

New wave printing technologies:

- Inkjet printing
- R2R photolithographic
- Plasma printing
- Direct laser imaging or ablation

Of these enabling technologies, screen printing has been around the longest and is still widely used in production today. Membrane switch technology, part of the printed electronics family, heavily relies on screen printing to make products. Technical details are shown in Table 1 for speed, resolution, film thickness, and ink viscosity.

Table 1: Popular printing methods for printed electronics and their technical attributes²

Printing Method	Speed (m/min)	Resolution (um)	Film Thickness (um)	Viscosity (Pas)
Flexo	50 - 80	20 - 50	0.5 - 2	0.05 - 0.5
Gravure	20 - 100	20 - 50	0.5 - 2	0.05 - 0.2
Offset	15 - 100	15	0.5 - 2	30 - 100
Screen	10 - 100	80 - 100	5 - 25	0.5 - 50
Inkjet	.5 - 5	20	100 - 500	0.002-0.025
Imprint/stamp	50 - 100	1 - 15	0.5 - 200	0.05 - 0.5
Plasma	.5 - 3	20 - 100	0.5 - 200	Post Metallize
Laser ablation	.1 - 1	.1 - 5	0.5 - 2	0.05 - 0.2
R2R Photolitho	5 - 50	1 - 100	0.5 - 5	0.05 - 0.2

Base Materials and Inks

Printed electronics uses flexible substrates, which lowers production cost and allows fabrication of mechanically flexible circuits. While inkjet and screen printing typically imprint rigid substrates like glass and silicon, mass printing methods almost exclusively use flexible foil and paper. Additional substrate alternatives include polyethylene terephthalate (PET), a common choice due to its low cost and higher temperature stability; polyethylene naphthalate (PEN); polyether ether ketone (PEEK), a colorless organic polymer thermoplastic used in engi-

neering applications; and polyimide (PI) foil. Paper's low cost and manifold applications make it an attractive substrate, but its roughness and absorbency make it problematic for electronics. Low roughness and suitable wettability, which can be tuned pre-treatment (coating, corona), are important criteria for substrates (Table 2).

Organic and inorganic materials are both used for printed electronics. Ink materials must be available in liquid form for solution, dispersion, or suspension. They must function as conductors, semiconductors, dielectrics, or insulators. Material costs must be appropriate for the application.

Most of the attention given to materials has appropriately centered on conductive inks, especially silver. Silver is the most conductive commonly used metal for making circuit conductors. Membrane switch circuits, which operate at relatively high voltages and low currents, have been printed onto polyester base materials using silver inks for more than a few decades. The challenge has been getting these circuits to have the bulk conductivity associated with copper. Common inks have conductivities that hover around 10% of copper and are not generally suitable for higher performance applications that operate at lower voltages or may require more power. Several

Table 2: Base materials for printed electronics and their suitability²

BASE MATERIALS	Glass	Metal	Paper	PET	PEN	PC	PI	PEI	PVF
Smoothness	++	++	O	+	+	+	O	O	O
Temperature Resistance	++	++	O	+	+	O	++	++	++
Flexibility	--	++	++	++	++	++	++	++	++
Optical Transmittance	++	+	--	+	+	+	+	+	+
Barrier	++	+	-	+	+	+	+	+	+
Price	--	+	++	+	O	O	--	-	--
Score:	not suitable: -- - O + ++ :favorable								

Table 3: Suitability and characteristics of various PE inks²

Materials & Inks	Costs	Conductivity (S/cm ²)	Flexibility	Printability
Gold Ink	++++	+++	++	+++
Silver inks	+++	+++	++	+++
Copper inks	++	++	++	++
Tin inks	++	++	++	++
Graphite Inks	+	+++	+++	+++
Catalyst Inks	+	+++	+++	++
CNT Inks	++	+++	+++	++
Thin film Cu	+	++++	++++	-
Thin film Ni	++	++++	++++	-
Or-Semiconductors	+++	+	++	++
Indium Tin Oxide	+++	++	++++	+++
PEDOT:PSS	++	+	++++	++

PEDOT:PSS= Poly(3,4-ethylenedioxythiophene) poly(styrene-sulfonate)
 CNT=Carbon NanoTube

suppliers have attempted to address this problem by using a combination of new formulations of binders in the ink and nanoparticle silver; so far, results are promising. Table 3 shows materials and inks used in printed electronics.

Conclusions

Flexible materials are a key characteristic of printed electronics. Many products traditionally utilize glass to protect the active layers. To replace glass, the flexible substrates need to be an effective barrier against oxygen and water vapor, be sufficiently strong not to rip or tear and, if a cover, transparent to visible light. Many plastics, such as Mylar®, polyimide, PET, and ORMOCER® have these characteristics. Substrates can even be papers and paper hybrids.

Table 4 shows the suitability of various base materials to printed electronics applications. Important to the growing ranks of suitable substrate materials is “photonic soldering,” a new technology pioneered by NovaCentrix in their PulseForge® product line, which allows standard lead-free solder pastes to be soldered without heating the flexible base materials; this unique ability enables metallic

Table 4: Current suitability of base material substrates for printed electronics applications¹

MATERIALS & APPLICATIONS	Glass	Metal	Paper	PET	PEN	PC	PI	PEI	PVF
RFID (antenna only)			+	+	(+)	(+)			
RDIF (incl. circuits)				+	(+)	(+)			
Printed Memory				+	(+)				
oTFT/Display	+	+		+	+		+		
OLED/Display	+		(+)	+	+	+			
OLED/EL Lighting	+		(+)	(+)					
Printed Battery		+		(+)	(+)				
Organic Solar Cell	(+)	(+)		+	+				+
Sensors			+	+	(+)	(+)	+		
Clothing				+	(+)				
Signage	+	+	(+)	(+)	(+)	(+)	(+)	(+)	(+)
Score	Not Recommended:		‘blank’	suitable +		Preferred (+)			

inks to be sintered/cured without damaging the substrates². PCB007

References

1. “Flexible, Printed and Organic Electronics 2020–2030: Forecasts, Technologies, Markets,” IDTechEx.com.
2. “Chapter 11: Printed Electronics,” by Joe Fjellstad, *Flexible Circuit Technology, 4th Edition*.
3. “Photonic Soldering,” by Happy Holden, *PCB007 Magazine*, Dec. 20, 2021.

Resources

See “A Review of the Opportunities and Processes for Printed Electronics (Part 1),” by Happy Holden, a white paper originally published for SMTA International.



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

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Denkai America is a leader in the manufacture of high-quality electrodeposited copper foils for printed circuit board (PCB), industrial, and energy.

With the strength of domestic manufacturing, and backed by a global presence, Denkai America delivers both conventional cladding and application specific copper foils required by technology leading companies.



PACOTHANE®

PACOPADS®

TRIPAK®

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PACO • CLUTCH™

PACOTHANE® PLUS

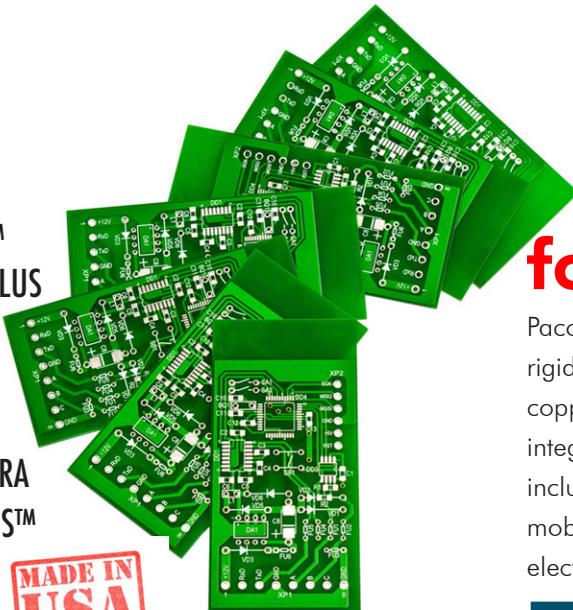
PACO • VIA

THERMOPADSTM

THERMOFILM™

PACOFLEX™ ULTRA

PQP QUICK PRESS™



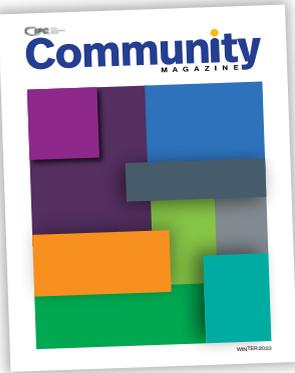
Lamination Assist for Flex & Rigid PCBs

Pacothane services the worldwide PCB market, which includes rigid multilayer, rigid/flex, cover-layer flex, flexible multilayer, copper and unclad Laminates. These circuit boards are integrated into a wide variety of applications and markets that include telecom, data communications, high-speed computing, mobile devices, military, smart cards, medical and effectively all electronic products.

American-made. Worldwide leader.

INSULECTRO

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IPC to Unveil New Member Magazine, 'IPC Community' at IPC APEX EXPO 2023

IPC, in partnership with IPC Publishing Group (I-Connect007) will unveil an exciting new publication, "IPC Community," at IPC APEX EXPO 2023, as a continuation of its commitment to better serve the electronics industry and provide additional value for IPC members.

MKS/Atotech Embracing Digital Solutions for PCB Fabrication

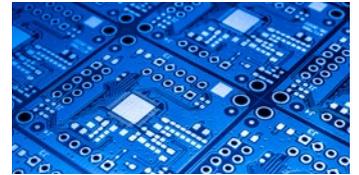


MKS/Atotech continues to develop and release digital solutions within the Atotech

product portfolio. In this conversation Stefan Stefanescu and Nolan Johnson, they discuss the work MKS/Atotech is engaged in, the problems to be solved, how this work will improve customer operations.

American Made Advocacy: The CHIPS Act is Just the Beginning

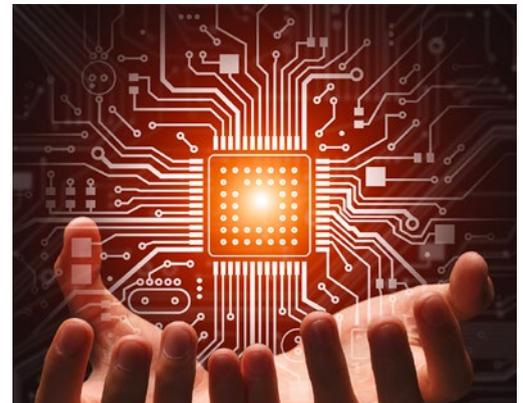
Now that the much-heralded CHIPS and Science Act has been signed into



law, the work to secure the entire microelectronics ecosystem must begin. We have a long way to go in restoring balance and resilience in our critical supply chains. U.S. dependence on foreign suppliers won't be reversed overnight, even by building semiconductor fabrication plants here.

The Plating Forum: Surface Finish Evolution from Conventional to Advanced

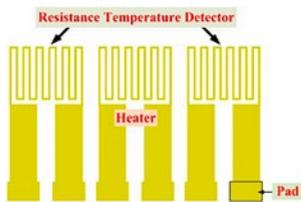
Surface finish is a critical component in printed circuit board design and functionality. Surface finishes form the interface between the component and the circuitry. As its most essential function, the final finish process is intended to provide exposed copper circuitry with a protective coating to preserve solderability.



EMC Gains License to Produce Arlon Products

Arlon Electronic Materials is pleased to announce the company has entered into a licensing agreement with Elite Materials Co. Ltd. (EMC), Taiwan. Under the terms of this agreement, EMC will commence volume production of Arlon's flag ship polyimide material 85N.

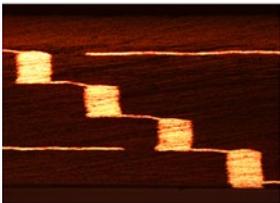
Testing Todd: Induction Junction, What's Your Function?



Historically electrical test has processed product with passive inductor features without really knowing what they were, other than causing continuity threshold violations. This is usually due to

the long traces that exhibit higher resistance than the 10- or 20-ohms threshold. Typically, these have been delaying traces or heater traces.

3D Electronic Devices With Additive Manufacturing



Imagine fabricating PCBs without the hassle of drilled vias and metal plating. Imagine PCBs with near-perfect registration. If we take it to the next stage, imagine drawing electronics in 3D space. There is a

way to do all this with additively manufactured electronics (AME). We just need to start to think in 3D.

Trouble in Your Tank: Success in Photo-lithography Starts With Surface Preparation

The photolithography process defines the circuitry on the panel. As one may surmise, the imaging process used in the fabrication of high density and ultra high-density circuitry has made significant advances over the last decade—and just in time. However, as is so true of many of the processes in PWB fabrication, up and down stream processes can and will influence what happens in a particular process.



NCAB Group Acquires Bare Board Consultants in Italy

NCAB Group has signed an agreement to acquire 100% of the shares in Bare Board Consultants Srl based in Codogno south of Milano in Italy. The transaction is estimated to close in January.

Electronica: Picking Up Where We Left Off

The productronica/electronica pairing of trade shows is an experience unlike any other; anyone who has ever attended is likely to back me up on that claim. This year's iteration of electronica, taking place in Messe Munich, Nov. 15-18, is no exception. I-Connect007 was onsite to gather the news and share our impressions of the show.



For the latest news and information, visit PCB007.com

Career Opportunities



Find industry-experienced candidates at jobConnect007.

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

In addition, your ad will:

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

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I-Connect007
GOOD FOR THE INDUSTRY



Career Opportunities



Test Engineer, Electronics Engineer, and Senior PCB Designer

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

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

- **Test Engineer**—You will assist in conducting electrical test engineering support involving automation, assembly, maintenance, and data collection.
- **Electronics Engineer**—You will work on a team creating electronic circuitry, writing firmware for microprocessors and interfacing with customer development teams producing a wide array of products.
- **Senior PCB Designer**—You will perform PCB layout and documentation of complex printed circuit assembly products as part of a project team including procurement, electrical & mechanical engineering, PCB fabrication, Assembly and Test engineering stakeholders.

To learn more and apply for any of these openings please visit keytronic.com/join-us or email your resume to: llitsheim@keytronic.com.

apply now



Regional Manager Midwest Region

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

DETAILS OF FUNCTION:

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

QUALIFICATIONS:

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

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

fernando_rueda@kyzen.com

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Career Opportunities



Formulating Chemist

Taiyo is the world leader in solder mask products and has extensive worldwide R&D resources to further offerings that include the latest in inkjet technology, specialty dielectric inks and via filling inks for use with microvia and build-up technologies, as well as thermal-cure and UV-cure solder masks.

PRIMARY FUNCTION

Formulate, develop new products, and modify existing products as identified by the sales staff and company management. Conduct laboratory evaluations and tests of the industry's products and processes. Prepare detailed written reports regarding chemical characteristics. The Formulator will also have supervisory responsibility for R&D Technicians.

ESSENTIAL DUTIES

1. Prepare design of experiments (DOE) to aid in the development of new products related to the solar energy industry, printed electronics, ink jet technologies, specialty coatings and additives, nanotechnologies, and applications.
2. Compile feasibility studies for bringing new products and emerging technologies through manufacturing to the marketplace.
3. Provide product and manufacturing support.
4. Provide product quality control and support.
5. Participate in multifunctional teams.

REQUIRED EDUCATION/EXPERIENCE

1. Minimum 4-year college degree in engineering or chemistry.
2. Preferred: Minimum 4-years' experience in chemical technologies and polymer science.
3. Knowledge of ink jet technologies, advanced materials and emerging technologies, including nano technologies.

Email: BobW@Taiyo-america.com with a subject line of [Application for Formulating Chemist]

[apply now](#)



Application Engineer

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

Responsibilities

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

Qualifications

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

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

[apply now](#)

Career Opportunities



Electrical Engineer

Located in State College, Pennsylvania, Chemcut, a world leader in wet processing equipment for the manufacture of printed circuit boards and chemical etching of various metals, is seeking an electrical engineer.

Objectives:

The electrical/controls engineer will not only work with other engineers, but interface with all departments (manufacturing, sales, service, process, and purchasing). The engineer will design customer systems, creating electrical and control packages, while focusing on customer requirements.

Responsibilities:

- Process customer orders (create schematics, BOMs, PLC programs, relay logic controls, etc.)
- Startup and debug customer equipment on production floor
- Interface with engineering colleagues and other departments, providing input & direction
- Provide electrical/control support to customer service
- May require occasional travel and overtime

Qualifications:

- Bachelor's degree in electrical engineering or an EMET degree
- Machine control design experience a plus
- Good communication skills working in a team environment
- Strong ability to work independently with minimal supervision
- PLC and HMI experience a plus (ex. Studio 5000 Logix Designer, Factory Talk)
- Experience with AutoCAD, Microsoft Word, and Excel

Chemcut benefits include: Medical, dental and vision Insurance, life and disability insurance, paid vacation and holidays, sick leave accrual, and 401K with company match.

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

[apply now](#)



Technical Marketing Engineer

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

Requirements:

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

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

Send Resumes to: resumes@ema-eda.com

[apply now](#)

Career Opportunities



Technical Service & Applications Engineer

Full-Time — Midwest (WI, IL, MI)

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

Responsibilities

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

Skills and Qualifications

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

Benefits

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

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MACHINES FOR PRINTED CIRCUIT BOARDS

Field Service Engineer

Location: West Coast, Midwest

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

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

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

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

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

Must be able to travel extensively.

[apply now](#)

Career Opportunities



ventec
INTERNATIONAL GROUP
騰輝電子

European Product Manager Taiyo Inks, Germany

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

Duties include:

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

Skills and abilities required:

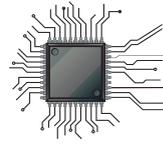
- Extensive sales, product management, product application experience
- European citizenship (or authorization to work in Europe/Germany)
- Fluency in English language (spoken & written)
- Good written & verbal communications skills
- Printed circuit board industry experience an advantage
- Ability to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

What's on offer:

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

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

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MivaTek

Global

Field Service Technician

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

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

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

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

More About Us

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

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Career Opportunities



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

- Engineering
- Quality
- Various Manufacturing

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

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

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

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

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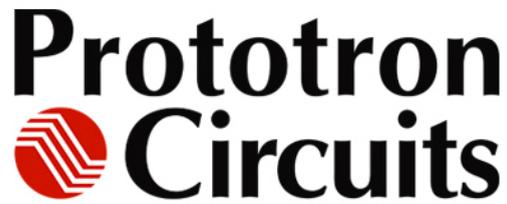
Are You Our Next Superstar?!

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

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

apply now

Career Opportunities



Sales Representatives

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

Reasons you should work with Prototron:

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

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

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eptac
TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

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

Qualifications and skills

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

Benefits

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

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Career Opportunities



Rewarding Careers

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

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

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

Associate Electronics Technician/Engineer (ATE-MD)

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

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

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Test Engineer (TE-MD)

In this role, you will specialize in the development of in-circuit test (ICT) sets for Keysight 3070 (formerly HP) and/or Teradyne (formerly GenRad) TestStation/228X test systems.

- Candidates must have at least three years of experience with in-circuit test equipment. A candidate would develop and debug our test systems and install in-circuit test sets remotely online or at customer's manufactur-

ing locations nationwide.

- Candidates would also help support production testing and implement Engineering Change Orders and program enhancements, library model generation, perform testing and failure analysis of assembled boards, and other related tasks.
- Some travel required and these positions are available in the Hunt Valley, Md., office.

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Sr. Test Engineer (STE-MD)

- 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.

We proudly serve customers nationwide and around the world.

TTCI is an ITAR registered and JCP DD2345 certified company that is NIST 800-171 compliant.

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Career Opportunities



BLACKFOX

Premier Training & Certification

IPC Instructor

**Longmont, CO; Phoenix, AZ;
U.S.-based remote**

*Independent contractor,
possible full-time employment*

Job Description

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

IPC instructors will conduct training at one of our public training centers or will travel directly to the customer's facility. A candidate's close proximity to Longmont, CO, or Phoenix, AZ, is a plus. Several IPC Certification Courses can be taught remotely and require no travel.

Qualifications

Candidates must have a minimum of five years of electronics manufacturing experience. This experience can include printed circuit board fabrication, circuit board assembly, and/or wire and cable harness assembly. Soldering experience of through-hole and/or surface-mount components is highly preferred.

Candidate must have IPC training experience, either currently or in the past. A current and valid certified IPC trainer certificate holder is highly preferred.

Applicants must have the ability to work with little to no supervision and make appropriate and professional decisions.

Send resumes to Sharon Montana-Beard at
sharonm@blackfox.com.

apply now



American Standard Circuits

Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

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

ESSENTIAL DUTIES AND RESPONSIBILITIES

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

ORGANIZATIONAL RELATIONSHIP

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

QUALIFICATIONS

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

PHYSICAL DEMANDS

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

apply now

Career Opportunities



U.S. CIRCUIT

Plating Supervisor

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

Competitive benefits package.

Pay will be commensurate with experience.

Mail to:
mfariba@uscircuit.com

[apply now](#)



APCT
Passion | Commitment | Trust

APCT, Printed Circuit Board Solutions: Opportunities Await

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

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

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

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

[apply now](#)

Focused on Solutions

We are setting new standards for PCB laser manufacturing.

The Schmoll Maschinen CombiDrill UV/CO₂ dual-laser drilling platform is a high-volume and stable processing solution for manufacturers looking to perform at the highest level.

schmoll  optronics



- + **Micro-via drilling 50-300µm diameter**
Cutting and structuring with UV and/or CO₂
- + **Space saving compact design**
Integrated loader / inline version also available
- + **Best power/size ratio in market**
10-20W UV-Power = Increased process speed in thicker materials
3kW CO₂ peak power = Less number of pulses required
Efficient optical train = No AOM required
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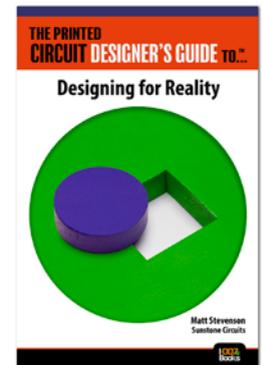
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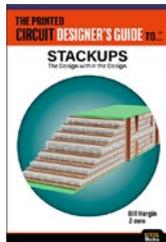
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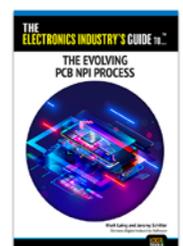
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