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## MAGAZINE

# Board Pricing Strategies

Contrary to popular belief, fabricators are in a strong position right now. There are currently fewer than 300 fabricators in North America and companies are willing to pay for a quality, reliable PCB. Washington is even singing our industry's praises—for now. Read on to learn from our expert contributors, who explain how to recalculate your pricing strategies, tune up your sales team and sales processes, and square up your margins.



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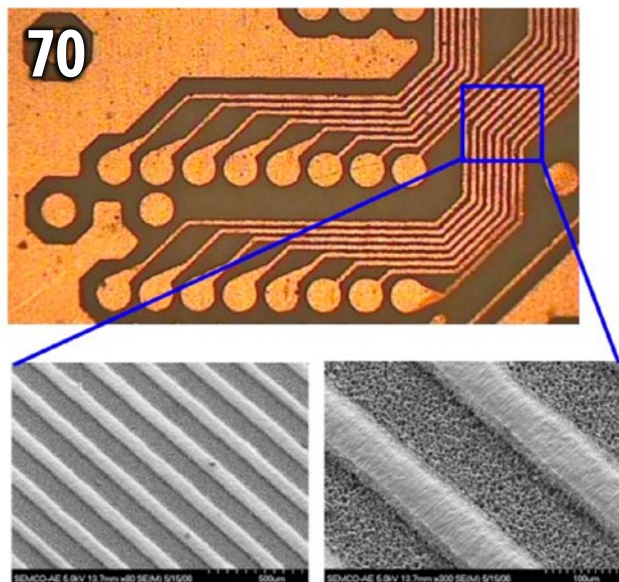
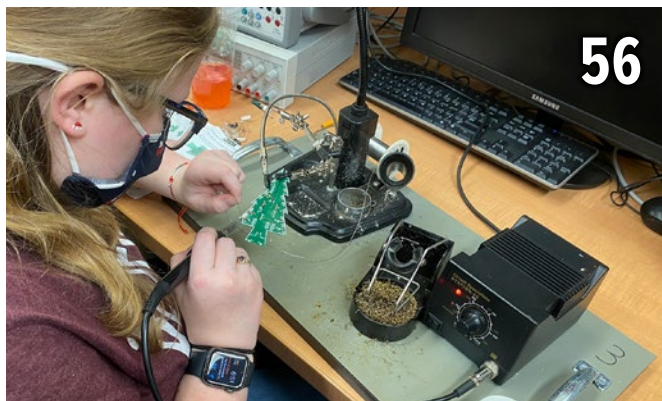
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# Tune Up Your Pricing Strategies

## The Shaughnessy Report

by Andy Shaughnessy, I-CONNECT007

If you're a fabricator, these are challenging days. But there are also plenty of opportunities available—if you know when to embrace them.

Sure, margins are still non-existent. Sometimes you feel like you're just trying to keep the lights on. Your suppliers have sent you an email explaining why their prices are going up—it's because everything is going up—and now you feel like you're stuck between a rock and a hard place.

But contrary to popular belief, fabricators are in a strong position right now. There are fewer than 300 fabricators in North America, and companies are always willing to pay for a quality, reliable PCB. Washington is even singing our industry's praises—for now.

So, it's time to raise your prices. In fact, if you don't raise your prices now, you're missing out. This is your chance. Actually, you should have raised your prices a year ago,



right? You've been eating your suppliers' increases for a while, and trying make your process even more efficient. But as Tony Soprano once said, "It is what it is."

None of your good customers are going to bolt. They're not going to ask you to open your books or try to tell you how to run your business. Your customers are driving past astronomical gas prices every day, so they're going to understand when you hit them up for a few more dollars.

You won't be lying when you say, "I don't have a choice." A few customers might complain at first, but they read the news. The cost of everything is going up: gas, shipping, laminates, adhesives, and

components. Even labor, when you can find it. It's all going up.

So, now is your chance. If you do this right, you won't wreck the relationships you've spent years building with your customers. They've probably already worked this into their budgets; they may be wondering why you waited so long to pull the trigger.

Of course, this is no reason to celebrate. You won't be able to increase your prices to



the point of making major profits, but at least you'll be able to claw back a little bit of what you've been losing over the past few years. God knows you're going to try to keep from raising them too much so you don't run them off.

Pricing is a job that you must pay attention to constantly. It takes communication up and down the supply chain in a way that we've never had before. You'll have to work with your sales team and develop a few strategies for price increases. But unlike any other time in recent history, your customers aren't likely to threaten to jump ship, because your competitors are all raising their rates too.

Yes, fabricators are in a strong position right now. So, in this issue of *PCB007 Magazine*, our expert contributors will explain how to recalculate your pricing strategies, tune up your sales team and sales processes, and square up your margins.

We start with an interview with Prototron Circuits President Dave Ryder and columnist Dan Beaulieu, who discuss pricing strategies for the current environment and tips for your sales team to remember when they're delivering unpleasant news to a customer. Then, James Hofer of Accurate Circuit Engineering explains how he's dealing with rising costs,

and why offering cutting-edge technology can help a fabricator weather this storm. Ventec's Alun Morgan shares his views on the price squeeze from a macro level, and he explains why the supply chain issue should improve, but not go away entirely, by the end of the year. Columnist Michael Carano gets down to the nuts and bolts of price increases, and he makes the case for cooperating with competitors for the greater good of the industry, much like the Space Race of the 1960s. And Carey Burkett of Flexible Circuit Technologies focuses on the economics of the flexible side of things, including rigid-flex, and FCT's plans for growth.

We also have stellar columns from Chris Bonsell, Hannah Nelson, Todd Kolmodin, and Happy Holden.

It's almost trade show season, and I'm ready to get back on the road. Until then, see you next month. **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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# Time for a Price Hike?



Feature Interview by the I-Connect007 Editorial Team

If you manage a fabrication facility, we don't envy you. You're being hit on all sides with price increases, but you're traditionally leery of raising your own prices. But you must do something. Do you raise prices, trying to squeeze out more efficiency, or is it some combination of both?

We asked Prototron President Dave Ryder and I-Connect007 columnist Dan Beaulieu to share their thoughts on the current fab pricing environment, the need for greater cooperation, and some pricing strategies for fabricators who are nervously eyeing their bottom line.

**Andy Shaughnessy:** Dave and Dan, welcome. We're here to talk about pricing strategies for

fabricators. What should board fabricators do when the price of materials, chemicals, labor, shipping, and utilities are all increasing?

**Dave Ryder:** We're getting notices from various suppliers every week about everything across the board going up. Sometimes it's not a big percentage, other times it's fairly significant. Back in January, after months of receiving these notices, we finally decided we couldn't shoulder the changes in pricing any longer. So, we came up with a reasonable percentage that we felt covered the surcharges or additional charges that we had been hit with. We pretty much raised prices across the board, but there's no additional profit in that number. This was simply just to cover the additional charges.





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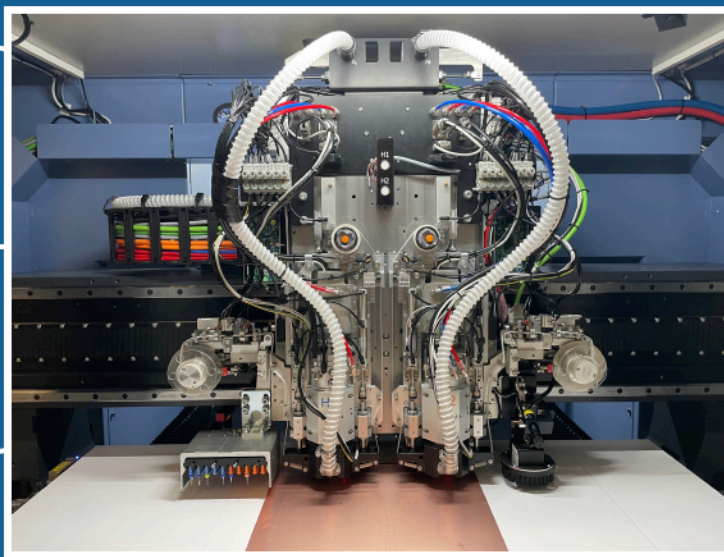
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Dave Ryder

**Dan Beaulieu:** And in the end, Dave, you're going to have a lot more. I mean, you have minimum wage issues, the gap with your employees, and insurance. I've seen this at every shop I work with, and I'm not working with billion-dollar shops. I work with shops from \$48 million in revenue all the way down to \$3 or \$4 million, and it's all the same. They've all been hit pretty hard. This isn't to put any other industry segment down, but if you're assembling boards, you have quite a bit more control. Assembling boards is basically about how well you can manage your supply chain, and how well you can purchase, that kind of thing. But on the board side, it's a bit of black magic. Dave, would you say there are about 120 steps in building some boards, especially when you're doing blind and buried vias?

**Ryder:** It ranges from about 35 steps to 120 steps or more, depending on the complexity. It isn't as simple as just changing suppliers for this or that, looking for a lower cost. We've got a formula that works with the products that we use. We can't randomly change vendors without disrupting our quality level.

**Beaulieu:** It's heavy on equipment and keeping equipment up. We've got the black magic of the plating line. There are a lot of moving parts that have to be controlled, and that's why we have all the quality systems, from AS 9100 and more. But still, it's 120 opportunities to screw up.

**Ryder:** It's heavily dependent upon the skills of the operators. Frankly, our biggest challenge isn't so much getting supplies—it's people. That's a terrible challenge, and we're not alone. Restaurants and on down the line are having those same issues. But in our particular processes, we're more heavily dependent upon people than we are having automated equipment.

**Beaulieu:** Regarding the price issue, it's tough for everybody. I just read the new book about Jack Welch called *The Man Who Broke Capitalism*. Welch had no interest in loyalty of employees; he was all about bottom-line money. He led the way to kill off American suppliers and take it offshore. That hurt us as well. It was all about cheap labor. While Americans back in the '80s and '90s were held to the highest standards, Asia was not. That has changed. I'm not saying that today, but that has changed. We've been behind the pricing eight-ball for decades, and it's been hard.

On the other side, you've got customers telling fabricators, "Why don't you just buy this LDI machine? Why aren't you investing in your company?" Well, it's really hard to invest when you've got minimum margins. That's really what affects the price. I remember when a contract manufacturer (CM) came into a shop with their team to tell them that they were pricing wrong and building wrong, simply because they wanted it to fit into the PCBA business model. I don't think there has been much sympathy for the pricing of PCBs. There have been alternate ways of beating the price of the domestic suppliers as well.

**Ryder:** That exact situation happened to us with our largest customer in the late '90s. They came in and tried to tell us how to price things based on how they price things as a CM. It's such a different world; it just doesn't fit. They tried several different board shops, ultimately firing the guy who was in charge of that program, and came back to us.

**Barry Matties:** What is the attitude of buyers when you are talking price increases these days?

**Ryder:** Right now, there's actually reasonable acceptance, because if you just go to the gas station or the supermarket, you're not surprised that everything you look at is now more expensive. Even if the price of, say, laminate wasn't higher, the price of delivering it to us would be higher. There's not much pushback.

**Matties:** We've talked in the past about the shift of the just-in-time (JIT) orders and that quick-turn work is gone, for the most part; that must have a real effect.

**Ryder:** Yes. It has been a significant issue for us. The demand for quick-turns is greatly reduced, and much of that is driven by cost. The other issue, which we're all aware of, is component shortages. There's no point in paying for a three-day turn on a 10-layer if you aren't going to have components for two months. So, definitely, our opportunity for the higher-dollar orders has been diminished just by the lower demand for the quick-turn.

**Matties:** Are the prices fluid, Dave? Are they adjusting monthly, or did you just make an adjustment?

**Ryder:** No. The last time that we made a significant adjustment was in January, and we've tried to just weather the storm since then. My philosophy is that after we get to a point where there are enough additional increases and they

look like they will stick, then we'll go back and adjust across the board. But we're not jumping in and adding a dime here or a nickel there.

**Matties:** Dan, what do you see as the trend? Are others more dynamic or are they fixed price once they've made this initial adjustment?

**Beaulieu:** It's incremental. You have several kinds of programs. First, there are the large ones, such as the defense aerospace programs. Dave is more in the incremental, quick-turn end of the business. But the guys who are doing the military programs must set their prices. They've got to fight about it with the company, and they keep it. But with the guys who are doing incremental pricing, I see fluidity in those things based on month-to-month increases in cost. It's not like, "Okay, this program with 150 part numbers," that's a one kind of a customer, and you do it across the board. But when you have a customer who's placing two jobs a month, I'm seeing that be pretty fluid.

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**The last time that we made a significant adjustment was in January, and we've tried to just weather the storm since then.**

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**Matties:** It looks like there's still plenty of work out there. What do you see? Do you think that's going to continue or will there be a slowdown?

**Ryder:** I'd love to be optimistic and say it's going to continue forever, but unfortunately, if you're following the news at all, it's pretty uncertain. It's hard to say.

**Matties:** On the consumer side, we have to spend money for food and gas at an inflated

rate, so we see that. On the industrial side, there's still a lot of movement for factory automation and equipment purchases.

**Ryder:** That is true. But as the costs increase, we will see reductions in those kinds of things too.

**Matties:** It's a vicious cycle.

**Ryder:** It is, and nobody's immune.

**Matties:** Exactly right. How often do you look at your pricing strategies? Is this something that you look at, maybe quarterly, because material costs continue to increase?

**Ryder:** Actually, Barry, we look at that every time a new letter comes in from one of our suppliers, and we calculate how that will hit us. If it's something we must act on, then of course we'll make that adjustment right away. But we try to shoulder as much as we can, for as long as we can, until it doesn't make sense anymore.

**Matties:** I've heard of some fabricators absorbing that cost. But ultimately, you will go out of business if you continue doing that.

**Ryder:** I agree, and certainly that's not our desired result.

**Matties:** No, that's not a win. So, with the supply chain shifts, we've had reports of larger order sizes coming to small lot manufacturers. If they were making a few hundred, now they're making 5,000. Do you see that trend?

**Ryder:** Certainly, we're seeing some of that. I'm

not sure exactly what's driving it, but there are several customers that are less likely to go to Asia as quickly as they were a few years ago.

**Matties:** Right. If you can reduce your job numbers, going to the facility, and maintaining a certain board footage, that has to help in your pricing strategies.

**Ryder:** To some degree, that absolutely is the case, Barry. But we are in a situation where some of the times it's the tooling and the setups of a job where we actually make the money, not so much just processing the laminate. Every job has its own quirks to it.

**Matties:** Are you seeing an increase in redesigns of boards to reduce their material consumption or reduce overall manufacturing costs?

**Ryder:** I think we've always seen that. That's not new, but we are seeing redesigns because they can't find a component that they need. When you start getting into RF or microwave, then the material cost is very significant. They try to scale back

on that as much as they can, but there's only so much you can do if you need a certain type of material.

**Matties:** Are there any particular technologies that will be an advantage? Are fabricators shifting the type of work that they're trying to bring in?

**Beaulieu:** No, I don't see that too much. Obviously, some are trying to bring in some of the higher-priced stuff. You're seeing some trend for the RF, the metal-backed boards, the more sophisticated stuff. The other thing I'd like to

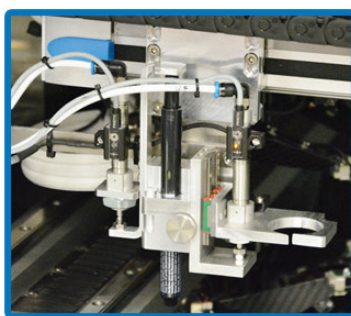




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Dan Beaulieu

**Matties:** Are you seeing any shift toward fabricators bringing in designers to offer design services?

**Beaulieu:** Yes. Right now, it's more of a handshake, but we're starting to see it. Of course, we have companies that do that, and have traditionally for many years. Almost all the companies I work for are looking at partnerships right now.

**Matties:** What does the next six months to a year look like? What advice are you giving your customers, Dan?

**Beaulieu:** I give the same story in every sales meeting I'm at, and it's optimistic. I tell them, "Buyers and engineers are looking for you. They're looking for domestic suppliers right now. Our job is to make sure you're found." I might have stolen that from you a few years ago, Barry. But there is business out there. More importantly, there's an inclination to buy domestically. No one is bragging about buying from China.

**Matties:** Dave, when you have a price increase on one side, you can raise your own prices. Are you also working internally to reduce cost?

**Ryder:** Absolutely, Barry. We're working hard on the quality side of things, and we're reducing the amount of overage that we build. We've gone to basically two panel sizes. You just look at all the things that you can do to reduce the overhead. Unfortunately, we're at a point where people can get \$18 an hour at McDonald's, so it's hard to limit the cost of labor. You have to do that through efficiencies.

**Matties:** Dan, do you see the fabricators reaching or searching for more automation now? And are they serious about implementing it?

**Beaulieu:** The intent is there, and I'm seeing shops try to do it. One of the companies I

say: Companies like SpaceX and New Horizon that are building products of the future must form better partnerships with domestic board shops. There are a couple of reasons: One, keeping it close to home for the intellectual property security; two, for new product introduction.

This is not dissimilar to when I was much younger, working with military companies, and they were all over us. They lived at the shop, worked with us, and bought the laminate. It was a cooperative effort. For example, not that long ago, a company would need some extremely expensive material. I would advise the owner of the company to say, "I can't afford this material," and the customer would buy it for them. We woke up one day and said, "Holy crap, we can't build a respirator in this country? How much did that \$29 DVD player cost us, anyway?"

You're seeing a lot of what I call makeshift partnerships. I know Dave has some customers who want the whole enchilada, what we used to call total concept. The customer actually wants design, fab, and assembly on one PO, and that's another example of cooperation.



work with sells automation equipment, which is basically material handling. Nothing as sophisticated as GreenSource Fabrication, but everybody wants to. It's a matter of being able to afford it. Everybody understands it's automation, that we're probably not going to get the luxury of the labor force we once had, and it's going to be a no-touch or minimum-touch manufacturing process. That's only logical.

**Matties:** Do you see interest from capital coming into the industry? Are there investments being made in circuit board fab?

**Beaulieu:** Yes. You see that, but more in buying companies out. For example, if Dave said, "I want an influx of \$5 million, and I'm willing to give 25% of my company," we're not seeing that. On my M&A side, I'm not seeing that. In the headlines, you see the Summits and people like that, who are vacuuming up the board shops. They're not interested in owning half a board shop. It's not like, "Hey, I want to buy some equipment. I'll sell you 20 shares of Prototron." I've had people ask me about that. We did research with PE (private equity) sources and found out that's not going to work. There's no interest in it.

**Matties:** Are we seeing a trend of no quotes based on poor file data coming in across the industry, Dan?

**Beaulieu:** As Happy Holden has said, only about 10% of data packages coming into board shops are complete.

**Shaughnessy:** Or even less than that. With new customers, is that about accurate, Dave?

**Ryder:** That's a good point. After a customer has maybe a half a dozen or a dozen part numbers under his belt with you, then suddenly things get a little easier. They understand terminology. I guess you get a better working relation-

ship. You become an extension of their R&D, and they trust you.

**Matties:** Do fabricators need to be much more selective about the work that they're taking?

**Ryder:** Certainly, you must be super cautious of that. Maybe at Prototron, we're overly cautious of that. You must watch out for the bottom-line numbers, but you also need the top-line numbers.

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**You must watch out for  
the bottom-line numbers,  
but you also need the  
top-line numbers.**

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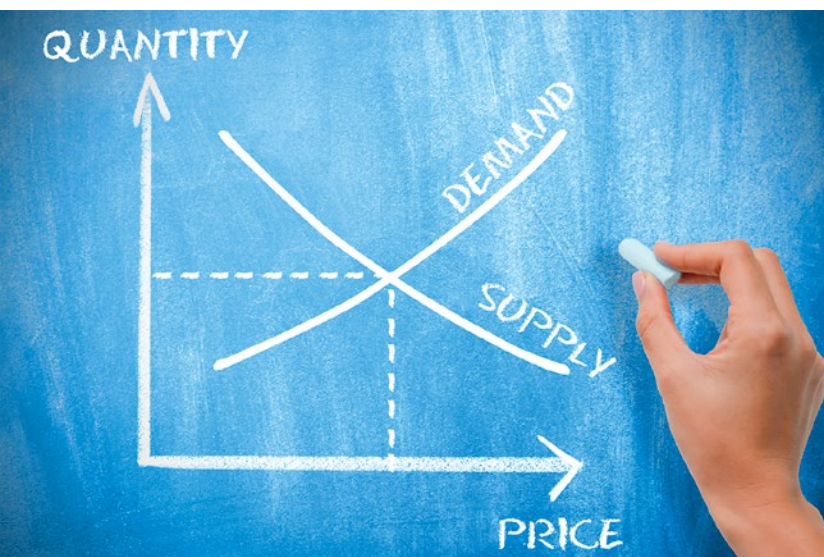
**Matties:** But as we know from the past, and as you just mentioned, you can take a job and you would've been better off just not even turning the factory on because you're giving \$20 out with every board you ship.

**Ryder:** That's right. We've taken on jobs before, where we would've been better off writing them a check before we even took the PO.

**Matties:** I'm thinking you have to be extra vigilant about the type of work that you bring in.

**Ryder:** To Dan's point, we got a lot of negative feedback that it could take quite a while to get a quote out. But at the end of the day, I'm confident that I could build that board, and that board is what the customer is looking for when we deliver the quote. After a while, the customers come to understand there's serious value in that extra time.

**Matties:** With the reduction in the quick-turn market, are buyers more likely to accept a six-



or eight-hour quote vs. a 45-minute quote? Is that urgency gone now?

**Ryder:** I think the truth is, if it's a buyer vs. an engineer getting the quote, the buyer wants it in 45 minutes because they're just processing orders. The engineer has complete understanding of what you're doing, and usually the engineer is thankful that you are taking that approach.

**Matties:** Are you seeing a trend where there are fewer purchasing agents vs. engineers in the quoting process?

**Ryder:** Honestly, that depends on the customer, so I don't have a definitive answer because it's all over the place. Every company is different in how it does things. We have some customers where it's the owner who calls; he may not be the designer, but he's the guy who calls because he thinks he's a master negotiator, that kind of thing.

**Matties:** I guess there are two sides to this: One is negotiations, and the other is making sure the technology is being built correctly. It seems like the latter would be more important.

**Ryder:** Well, it certainly would be, because if you build something that isn't going to be func-

tional, I think you would have a pretty upset customer.

**Matties:** At the end of the day, they will blame you, right?

**Ryder:** Absolutely. That's the case. Unfortunately, in a lot of situations, the buyer who's strictly a buyer doesn't have any technical background or knowledge about this. You hit a dead end when you're trying to talk to them about some of these issues.

**Matties:** The approach is different whether you're dealing with a buyer or an engineer on the quoting process. Whereas a buyer may want it in 45 minutes, an engineer will want a more detailed quote that could take six or eight hours, and the exchange of questions and such.

**Beaulieu:** Because they're interested in the product, not the price.

**Ryder:** That's exactly right. Although, there are exceptions to everything like that. Sometimes you'll get an engineer who's certain his design is beyond reproach. Normally they're not, but there are different views from every customer we deal with. On the prototype side of things, they're doing a prototype to make sure that when they hit production, that it's really the design they want. They should put a little more emphasis on the front end of this, the prototype stage.

**Matties:** Are you looking at streamlining the quoting process with software? Are there market opportunities for fabricators to upgrade their software?

**Ryder:** It's a hard question to answer because, frankly, there aren't more than maybe a couple of companies that design software for fabricators. There wouldn't be a lot of room in there



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# COMPETITIVE PRICING



for a software developer to make money, so you pretty much have to go with a custom software package at this point.

**Matties:** Which may be well worth the money too, as an investment point in this climate.

**Ryder:** Yes, it certainly could be.

**Matties:** Do you have any final thoughts around board pricing today? Dan, let's start with you.

**Beaulieu:** For the good of the industry, we must respect the pricing. We must respect one another. Like we said, our customers must realize that they need to make an investment in us, and that the rock-bottom pricing has not gone very well. We're trying to be American independent companies, and it's made us dependent on some countries that are, at best, frenemies. We have to look out for that on the other side. Right now, pricing is not margin-based. It is cost-based, and I think it will continue. I don't know of any board shop that I've ever worked with, and believe it or not I've worked with over 100, that gouged their customers, ever. By the same token, I've not known companies that were so fat with cash they could just buy any piece of equipment they wanted. We've got to look out for that. Pricing is changing, just like the labor market

is changing. Pricing will change, and I hope for the better in terms of supporting the American PCB industry.

**Matties:** Dave, any final thoughts around board pricing?

**Ryder:** You just really have to stay current on the trends, as far as what we're seeing from our suppliers. I don't think that there are big swings from one board shop to the next as far as the pricing goes, because we don't hear about that from our customers. The exception of that would be, "Well, you're three times the price," and you go back and pressure them, and you find out that they're offshore with that quote. Be diligent about watching your cost.

**Matties:** Especially when you have a problem post-production and you've got to deal with a company in different time zones that speaks different languages.

**Ryder:** Yes. We do some of that.

**Matties:** All right, gents, we certainly appreciate your time today.

**Ryder:** Always a pleasure, Barry. PCB007



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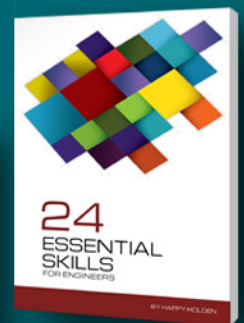
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# Board Pricing Challenges and Opportunities

Feature Interview by Andy Shaughnessy  
I-CONNECT007

The cost of everything is on the way up, and fabricators are feeling the squeeze. They may hesitate to raise their prices because they don't want to scare off business, but what options do they have?

We asked James Hofer, general manager of Accurate Circuit Engineering, to weigh in with his thoughts on this conundrum.

**Andy Shaughnessy:** James, with the cost of materials, shipping, and electricity rising, have you had to increase your prices?

**James Hofer:** We did raise prices at the beginning of the year. However, despite current

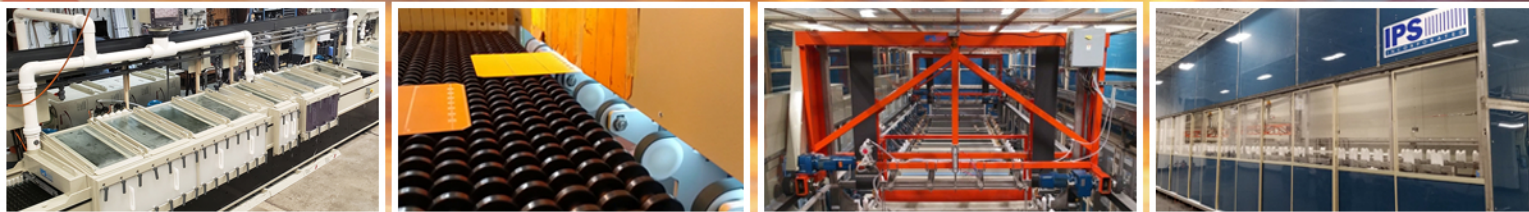
costs changing on a daily basis, we have not revisited our pricing. It is my intent to hold pricing through at least end of the third quarter to see if things stabilize.

**Shaughnessy:** What are your customers' attitudes about price increases? Are they more accepting now because they've maybe just paid \$7 a gallon for gas?

**Hofer:** There has never been a time that customers are pleased about cost increases and resisting increases is part of the job for buyers. As we have held pricing through mid-year, I cannot really comment on that. However, I am



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more understanding of increases and I believe that our customers should be as well. But wow, the increases I see are much more frequent and larger than what I would consider fair.

**Shaughnessy:** What steps can fabricators take to keep from raising their prices?

**Hofer:** Unfortunately, there is not much a fabricator can do except buy larger quantities in an attempt to utilize volume discounts and attempt to hedge against future increases. Another option we are discussing is a temporary “surcharge” that can be removed if the market stabilizes.

**Shaughnessy:** You work with a lot of newer, cutting-edge technologies. Do you think that this helps your company absorb costs?

**Hofer:** Absolutely. ACE is a quick-turn shop, and that is an extremely sought-after premium right now. Our margin is most definitely reduced due to the current situation, but it also most certainly helps reduce the impact of the material cost increases.

**Shaughnessy:** Do you have any final comments on these challenges?



James Hofer

**Hofer:** These times are certainly very challenging. Is the phrase, “Please, Lord, make it stop,” considered a comment?

**Shaughnessy:** That’s a great stopping point, James. Thanks for speaking with me.

**Hofer:** Thank you, Andy. PCB007





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# Alun Morgan: Price Increases Are Here to Stay

Feature Interview by the I-Connect007 Editorial Team

Barry Matties and Nolan Johnson recently spoke with Alun Morgan, technology ambassador at Ventec International Group and president of EIPC, about global supply chain challenges, as well as efforts by government and industry to mitigate some of these issues. Alun discusses the need to have more than one source, pricing strategies for fabricators who are facing increases in costs across the supply chain, and why we all need to work together to help the industry in times like this.

**Nolan Johnson:** Alun, we're seeing legislative efforts from governments around the world to help get this industry back on its feet and build a more resilient supply chain. Do you think this will have any sort of impact in Q4 2022?

**Alun Morgan:** It has taken decades to get to where we are. There is no chance of a quick and permanent fix by government action. A major issue is that governments act nationally; they don't act globally, and we have a global issue. The effects are disproportionately

affecting North America and Europe. Having said that, it's a valid initiative that may, in time, yield some benefit or at least raise awareness of the importance of supply chain resilience. I went through this in the UK many years ago, with a similar discussion. The problem, in the end, is how many votes depend on it?

Our industry does not have that many votes anymore.

If your industry employs five million people, you're going to get a lot of help and attention. If you only employ 5,000 people, then forget it. They're probably not even going to talk to you. That's brutal, but that's the way they think. But now it has been recognized that strategically there has to be access to PCB and silicon technology. Silicon stands out as one

that you can really understand; it can actually cause huge damage to economies. So, if the U.S. couldn't get chip sets and we couldn't get them in Europe, because they're all being consumed in Asia, that would have a massive impact on our economies.

Governments can provide things like financ-



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Alun Morgan

ing, tax holidays, or help with training. They are quite good at that and I hope it will lead to providing some very practical help. We're not short on innovation or ambition; we're absolutely not. The issue, in the end, will be capital structures, how we can invest, who we can persuade to invest, and take the investment risks. Let's see where it goes. I think it's come to an extreme case where you require government to support your industry, so if government can help, then let's go for it. But it's not going to be within 90 days, that's for sure.

**Johnson:** Let's focus on Q4 2022. There is still a demand to be filled under some challenging economic situations over the next 180 days. You've pointed out that first you must figure out your supply chain, and then share your forecast with that supply chain. But once you get your supply chain in order, there needs to be some sort of investment or planning to respond to this. What does that look like in your mind, Alun?

**Morgan:** The real issue is that even with the best forecast and the best planning, you still

can't get goods. Look at the situation in China. Coming out of a lockdown, Shanghai has basically stopped all goods being shipped from those ports. They're going to hit the ports on the West Coast of the U.S. and places like Rotterdam. We're going to see a meltdown in those places because there will be container ships anchored as far as the eye can see because they can't get offloaded quick enough.

We're being very practical about this now. We see the lockdowns easing now in China to some degree. But thinking about that, suddenly all those ships can dock, get loaded up, and then start coming here. This is within three to six months, by the way. When they all hit, that will cause absolute mayhem. There is no way those ships can all be offloaded in a week or two. It will take months to get those ships unloaded and sent back again.

You need to make sure you have more than one supply opportunity for critical things. This is good advice, but generally we haven't been doing this. Of course, it's going to cost more money to have a second source. Now, that second source possibly might be local. That's also a potential. I mean, why not? Why couldn't you have a local source for some materials? It will cost you more money, probably a lot more. You will need to qualify a second source, which is not easy and takes time. But it's much better to do that than to end up in the position we are now, with many producers not having any raw materials to process, which is the worst possible situation you could be in.

If you don't have any raw materials, nothing else matters. Even if someone said, "I'll give it to you for 10 times the price," you'd probably take it; but when you've got nothing, it doesn't matter. One clear consequence of all of this: It will cost more for everybody—the consumers as well. We've already seen that in Europe.

We've certainly seen the cost of food and energy rising massively. Some people here are saying, "Oh, we can blame this on Brexit." It's just nonsense. I mean, this is a global situation.

**Barry Matties:** To your point, I think our energy costs are up 38% year-over-year.

**Morgan:** Yes, and it's even higher in Europe, believe it or not. It's quite phenomenal. Even things like basic foodstuffs cost significantly more. Construction materials also. Timber prices for building in the UK has almost doubled in the last two years.

**Matties:** In terms of pricing, that has needs to be dynamic and fluid. How is Ventec handling pricing?

**Morgan:** The only responsible action is to ensure that selling prices reflect cost increases. Right now, it is important to secure the basic raw materials for the laminate industry and we have had to pay more for nearly everything. Looking back, crude oil was in the \$10 a barrel range, but then for a long time it was \$30 to \$50 a barrel. We have been around \$100 a barrel for a while now. It peaked at nearly \$130 a barrel. This is important because oil is a basic source of many resins used in our industry. Copper is somewhat down from its all-time high earlier this year, however, the issues of supply chain migration to Asia and alternative markets such as EV battery production still loom large and increasing energy costs for conversion are a new threat to stability.

**Matties:** Alun, as a raw material supplier, what forecast or expectations are you setting for your customers? Are you telling them to expect a range of, say, 10-30% increase until the end of the year? We all know it's going to increase.

**Morgan:** I can't give you an exact percentage; it depends on the product. We will certainly pass on the best information that we have. Keep in mind that in the printed circuit board industry, the laminate manufacturing industry has a pretty high percentage cost of raw materials in its product. So, we are especially influenced. Silicon is another story; it doesn't carry

that same load. But in our business, it's raw material-loaded. That means we feel it quicker than other people do. I can't comment exactly on what Ventec is doing, but certainly I know there are producers who are looking to buy contracts ahead, and future contracts right now are pricey.

**Matties:** To that point, it's not just Ventec, but generally across the spectrum of materials. Fabricators must figure something out. Prices will be fluid, especially if it's a 90-day delivery window.

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**Keep in mind that in the printed circuit board industry, the laminate manufacturing industry has a pretty high percentage cost of raw materials in its product.**

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**Morgan:** Yes, and that is something that people must get used to as well. It's quite common for us in the West to have fixed-price contracts, but those days are gone. By contrast, the Asian market is based on spot pricing far more than we've ever been in Europe and the West. The reason for that, of course, is that things change quite quickly. Everybody is trying to reasonably pass on the cost increases they've gotten. I'm sure there might be some who want to take advantage of the position, but most of us have our heads down just trying to supply our customers. The customers who give us the best forecasts have the best chances because we can plan to some degree. We can't plan everything right now, but for the guys who expect stuff tomorrow, that is going to be a huge challenge for them.

For those who spend time with their suppliers and start working on the supply chain, at



least the next time around there will be ground-work for better planning. That is the message I want to give everybody: Please sit down with your customers and your suppliers, try to join up the supply chain, and share what you possibly can together.

Understand this is not a matter of taking individual advantage. It's a matter of trying to do the best we can as an industry for our consumers and our customers. We have a duty, of course, to our shareholders. We have also a duty to keep our supplies running in our markets. We don't stand alone; it would be a tragedy if we were to take actions that made things worse in North America and Europe. We've already reduced the supply base substantially. I think we've got a duty to do the best we can to keep it going.

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**Please sit down with  
your customers and your  
suppliers, try to join up  
the supply chain, and  
share what you possibly  
can together.**

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Don't forget we are strategic suppliers: there are defense, aerospace, and medical supplies that we like to have in our local backyard. The way the charts look now, though, we see a reduction over the years without an uptick. That's the fear, that there could be a step-change again in our industry and move down by another notch in terms of local manufacturing and localization.

**Johnson:** You were talking about working with your customers and your suppliers to forecast better. I know I'm asking you to oversimplify, but on average, typically, how much forecast detail do you get from your customers?

**Morgan:** It's a great question. Years ago, I visited a customer and asked, "How's business?" They replied, "Oh, fantastic. We've got a firm, three-month order book and we've a good view, six months ahead." I had a young sales guy with me in the meeting, and he said to them, "I'm really pleased you're so busy, but why do you only give me three days of forecast?" It was a good question. They knew their business at least three months firm out and even six months tentatively, but they only gave us three days. Customers need to share what they have. Sometimes they have a lot of information or a very small amount of information, but if they share what they have, we can start to plan.

Automotive will go to the supply chain and give that information, whatever they've got. Other parts of industry just don't do it at all. Defense is probably the most secretive. Even if they have the information, they won't give it to you because they feel it's secret, which I suppose it is. We've got to see us all being in this together, though. If you can pick up the phone to three or four different suppliers and always get the goods you need, it doesn't really matter. But when you get in the position like we are now, when it does matter, then this bit of extra effort in that area is required.

If our customers don't have the skill set, or even the willingness, to share that information, it will come as a rude awakening when they run out of materials, and they have to start learning to plan and trust suppliers a bit more. If you've got an order booked for a product, you know you need that supply chain.

**Johnson:** I'm getting the sense that the story is getting more sophisticated about your forecasting. That seems like that's the only way through this. There is not much else you can do other than be clear about your forecast, is there?

**Morgan:** Yes, and I think that is the message, because we're not going to build new factories

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in 90 days. That's not going to happen. All you can do is just share the information to make planning better. In many areas there is a lack of understanding that this is necessary. A linked-up supply chain is something that you'll find the automotive guys have been talking about for decades. And they do it. They really do try to link the supply chain up to pass information up and down the chain to reduce waste, because there's nothing worse than having warehouses full of goods that nobody wants. That is wasteful, but if you can tell what you actually need and when you need it, then you help the situation. Yes, that's probably all we can do right now and be prepared to cope with price instability.

**Matties:** What I see happening is that going from good to bad will eventually make us great.

**Morgan:** That's the kind of discussion that we're having, actually. The spirit of "build back better" is just that, isn't it? Things are going to get torn down, so when we build it all back again, we can make it great, rather than make it good.

**Matties:** Yes. That was a good point to wrap up on. Alun. Thank you so much, sir. It's always a pleasure speaking with you.

**Johnson:** Thanks, Alun.

**Morgan:** You too. Thanks, guys. PCB007

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## Scanning Tool Could Make Websites Less Vulnerable to Hacking

An international team of researchers has developed a scanning tool to make websites less vulnerable to hacking and cyberattacks.

The black box security assessment prototype, tested by engineers in Australia, Pakistan, and the UAE, is more effective than existing web scanners which collectively fail to detect the top 10 weaknesses in web applications.

UniSA mechanical and systems engineer Dr. Yousef Amer is one of the co-authors of a new international paper that describes the development of the tool in the wake of escalating global cyberattacks. Cybercrime cost the world \$6 trillion in 2021,

reflecting a 300% hike in online criminal activity in the past two years.

Remote working, cloud-based platforms, malware, and phishing scams have led to skyrocketing data breaches, while the rollout of 5G and Internet of Things (IoT) devices has made us more connected, and vulnerable, than ever.

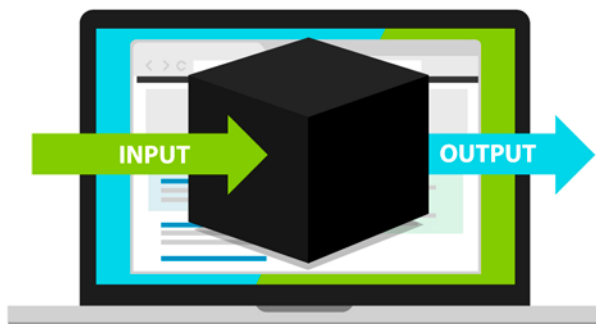
Despite a projected \$170 billion global outlay on internet security in 2022 against a backdrop of escalating and more severe cyberattacks, existing web scanners are falling way short when it comes to assessing vulnerabilities, according to Amer.

"We have identified that most of the publicly available scanners have weaknesses and are not doing the job they should," he says.

Nearly 72% of organizations have suffered at least one serious security breach on their website, with vulnerabilities tripling since 2017.

WhiteHat Security, a world leader in web application security, estimates that 86% of scanned web pages have on average 56% vulnerabilities. Among these, at least one is classified as critical. The researchers compared 11 publicly available web application scanners against the top 10 vulnerabilities.

(Source: University of South Australia)



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# Pricing Strategies With Michael Carano



Feature Interview by the I-Connect007 Editorial Team

We recently spoke with longtime I-Connect007 columnist Michael Carano, vice president of quality at Averatek, about pricing strategies for PCB fabricators. We're seeing some movement in this segment as fabricators, already dealing with some of the tightest profit margins around, find themselves having to either raise their prices or trying to massage more revenue out of their already streamlined processes.

We asked Michael for some pricing strategies for fabricators, and he shared a range of options for today's manufacturers who aren't afraid to rethink their processes and try new ideas. And, as he says, people will still pay good money for a quality, reliable PCB.

**Nolan Johnson:** Let's talk about pricing strategies for fabricators. What are you seeing?

**Michael Carano:** Let's step back and think about the price per square inch, or the selling cost. For example, with substrates, people are talking about paying \$6 per metal square inch per layer, and that's pretty darn good money. Now the question is, can you get the yields? If you put these chips up, let's say 300 on an 18"x24" four-layer, that panel could be an \$1,800 to \$2,400 panel and be only four layers if you make it in high yields.

Your material cost is about \$200 or \$300; there's some labor in that, and you can get pretty good margins on that. Now eventually at higher volumes, if you're building a hundred million of these a year, obviously it's going to go down to a dollar per square inch somewhere. But for the mid-range, which could be done here with the DoD, and then some of the high end, you can get \$5 or \$7 per metal square inch

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per layer. So, if you have all that in an 18-by-24 inch panel, you just add it up and have \$7. It becomes pretty good stuff.

**Johnson:** Under these current circumstances, for a long time, the fabs have basically had their margins squeezed down to the bare minimum. With this much demand, this much production, everybody this busy, and the supply chain the way it is, is this the time to start to claw back margin?



Michael Carano

**Carano:** Yes, they're grabbing margin. I think that's happening because the chemical cost around materials has gone significantly higher in the last year and a half too. That has to translate all the way down to laminate materials, photoresist, and what have you. A lot of times folks want to commoditize a circuit board and they want to get it priced that way, but it is not a commodity. It is a highly functional, critical device and, as I have said, chips don't float.

Those chips have no circuit board. You can make all the billions of chips you want. They're not going to go anywhere. Those packages are reliable and when that chip is attached to a BGA substrate that goes on the circuit board, the circuit board has to be reliable, and I think that the message here is we've got reliability. We can do higher layer counts, tighter tolerances, and give the OEM more functionality and greater reliability than they've ever had before. That has to cost something and you've got to pay something for that. It's time to get those margins back, especially now.

**Johnson:** Continuously increasing your capability, so that there's value for that.

**Carano:** Exactly. Again, with yield, you've got an opportunity. There are other things that aren't necessarily seen. There's the yield improve-

ment. Someone was telling me the other day, "Well, this is a very difficult board, but we get good money for it; it's a 70% yield." What if you've got him up to 80 or 85%? You'd capture all of that, you wouldn't even be remaking it. He said, "Oh no, he did the math; the math was phenomenal; that math went right to the bottom line." And he said, "That's the key, though."

I said, "Let's look at what you're doing in these var-

ious areas to help you improve that because what's causing it? Is it misregistration, drilling problems, maybe plating?" He said, "All the above." But yet, they make 70% perfect. Let's look at why, and that's where the process audit comes in, that's where the workforce training comes in. Why? When 70% comes out good, that's great. Why can't we get another 10 or 15 points? You must be doing something right 70% of the time. It's variation in the process. Let's cut that back and improve the technology. Ask, "How do we do this?" and go from there.

**Barry Matties:** Michael, is there a metric that you use to measure how the industry is doing collectively and how it's improving?

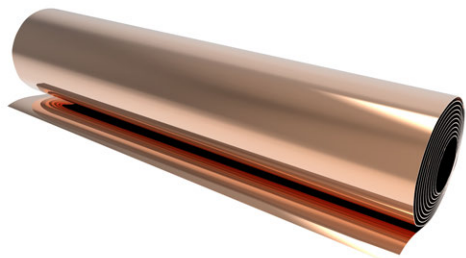
**Carano:** Not all fabricators take part in it, but at Conductor Analysis Technologies, Tim Estes and his team maintain the IPC PCQR<sup>2</sup> database, which is a benchmark that companies can subscribe to. They send in test vehicles for various evaluations, registration, reliability, impedance. Unfortunately, I don't see an area where we can see how these improvements are being made, at least not in a collective sense, but that's something worth looking into. Also, we still tend to hold things close to the vest, right? For instance, we've had this

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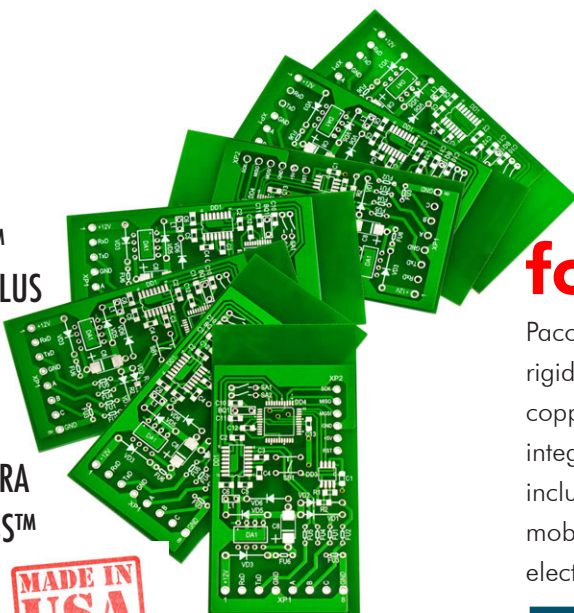


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issue with microvia interfacial fracture for the past few years, particularly on stacked blind vias, three or four stacks. It's been a big concern in the industry. You have folks who say, "We need some help on this." Others say, "Oh, I've already solved the problem." They don't want to be part of the group because they don't want to give anything away, but it's not solved; it's still out there, and it's still going to happen. There's more work that has to be done. At least some of the consortia out there like HDPUG, iNEMI, and the group with the European Space Agency are working together across the industry to solve technical problems. I particularly like to see those efforts going on.

One of my first papers with IPC's Thought Leader Program was about working across clusters and how we can leverage the current existing infrastructures in various pockets around the country: San Jose, Los Angeles, Orange County, Colorado, Chicago, Minneapolis, where there are groups of fabricators that can get together and maybe leverage their work by setting up a central laser drilling operation or working with universities to improve reliability.

But that's what it takes—a lot of cooperation. I think if you can do that with industry and academia, with the help of government, you could make a lot of improvements here and enhance reliability. I look for that cluster like they have in Silicon Valley. Suddenly it spawned all these companies, because it was a cluster, and everything grew from there. It was the same thing with automotive. Why Detroit? Because it was a cluster.

**Matties:** Is there an industry moonshot? When the U.S. was going to the moon, everybody knew what we were doing collectively across the country and the world was watching. Is there an industry moonshot that needs to be in play for this era?

**Carano:** I don't see one right now. But that's a great question. As I've said, why can't we get 10

to 15 of these companies that probably now are 50 to 60% of the North American market for circuit board fab? I'm talking about individual companies that have multiple sites; not all of them have multiple sites, but most of them do. You take that, that's a big chunk. And I think the moonshot needs to be that we get help from the department of defense, DARPA, and from Congress, saying, "We finally recognize what a precarious position our future defense and our future security is in, because this technology is not here in enough volume." I think that's the moonshot. That's the concern of what's on the other side and who we're going to have to deal with if we can't do this.

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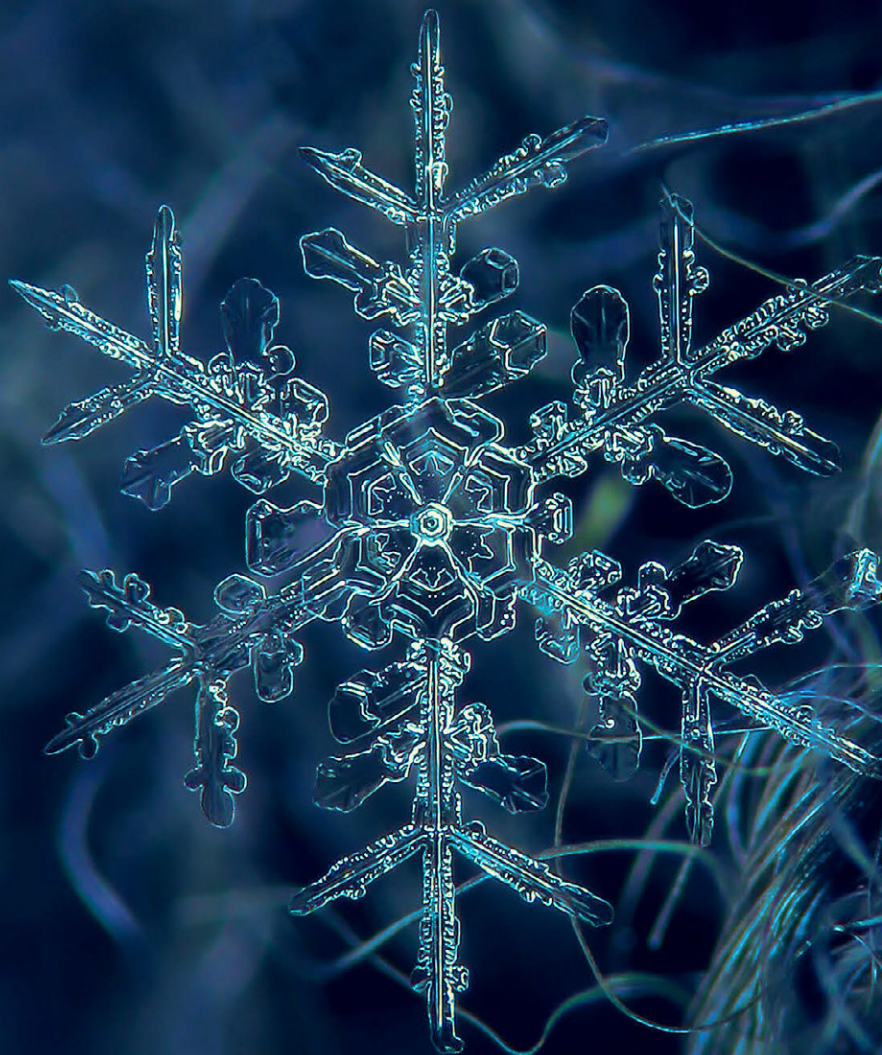
**I look for that cluster like they have in Silicon Valley. Suddenly it spawned all these companies, because it was a cluster, and everything grew from there.**

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**Matties:** That ties to the performance metric as well. Now, if you can connect the moonshot that has that higher purpose and the key measures of manufacturing performance, this becomes exciting as people see it happening and they want to become part of it.

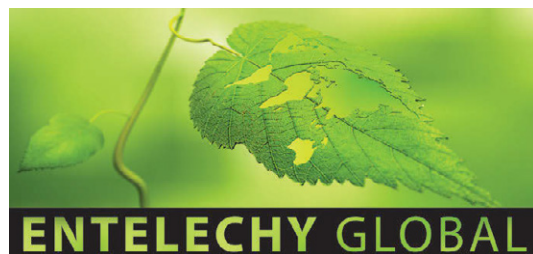
**Carano:** Well, that's a good point. And that's what happened too, when I saw some of these folks who joined iNEMI and others who got into HDPUG; they had people jumping in and they're still getting members to ante up and be part of this. It's not free, you've got to pay to get it and you've got to do some work, but people are looking at this and asking how we solve problems. How do we evaluate? For example, HDPUG probably did a great job on several iterations of evaluating different laminate

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materials. They've gone through six phases; they evaluated materials and  $T_g$ , CTEs, CAF; and they did this as a consortium and published the information so you can see where there's room for improvement. There are studies on reliability of BGA soldering, with different solder pastes in different formulas.

Again, that's the work that's being done in terms of consortia and that's the moonshot. Here's where we are. These are all these parts working together—assembly, bare board, and there's level zero, level one, and level two. You've got to have them all together. Call the circuit bare board level zero, call the chips and the components level one. And then everything else put together becomes level two. If they don't have those connections and understand how that ecosystem works, then we have a problem. I think it's about getting an ecosystem tied together where people understand exactly what it is.

**Matties:** Mike, do you have any advice for the fabricators out there right now?

**Carano:** For the ones that are small, maybe 50 or fewer employees, really work hard on finding ways to upgrade your equipment. If you're happy with your three-mil lines and spaces, and that's helping you, I understand that, but the money, future money, is going to be big, in

the sub-two-mil lines and spaces. You have to rethink what your processes look like two to three years from now vs. where they are today. That includes equipment, materials handling, and above all, training certification. In a nutshell, that goes with the bigger folks too.

But I think a lot of those are doing that. There are some companies that have several hundred, maybe a thousand, people certified by IPC for the Certified Interconnect Designer or assembly training programs, and those companies are doing things. IPC certification and training programs have increased significantly in the last five or six years—there's been a big push there. But we need some of the smaller companies to be involved in these training programs. It will help them immensely.

The big guys are already doing it and I think they saw the advantage to doing that. That's one of the reasons why they're able to be big and still stay in business. They've made those changes, improved their training, and their knowledge of their people. When their people get certification, they're proud of that. They feel like they've been part of this opportunity.

**Matties:** Michael, thank you so much. We greatly appreciate you taking time for us today.

**Carano:** Thank you. PCB007

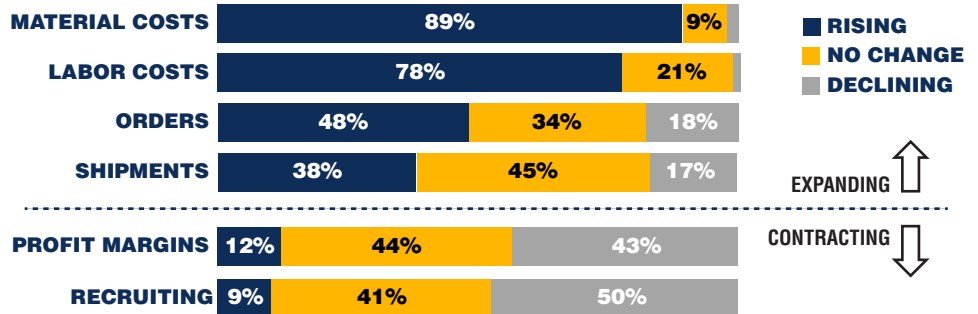




## CURRENT DIRECTION OF KEY BUSINESS INDICATORS

90% of electronics manufacturers are currently experiencing rising material costs, while 80% are experiencing rising labor costs.

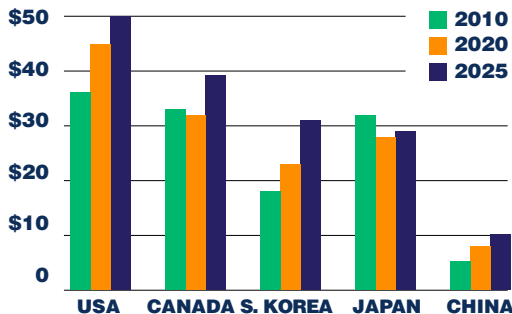
At the same time, ease of recruitment, profit margins, and inventories are presently declining.



Source: IPC Industry Survey, July 2022

### RIISING LABOR COSTS

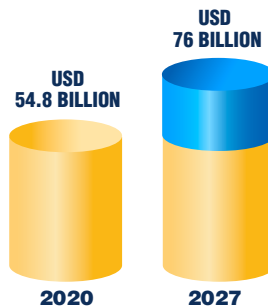
Average Hourly Wage (USD)



Source: The Economist Intelligence Unit

### GROWING MARKET

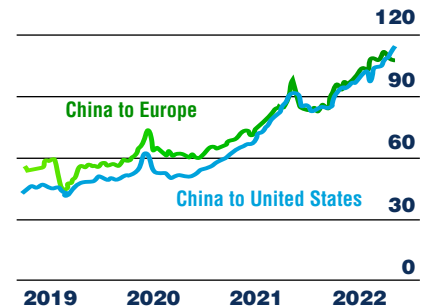
Growth will continue



Source: Research and Markets

### SLOWER SHIPMENTS

Shipping time (days)



Source: Flexport Research





# Supplier Highlights



## The Chemical Connection: Etchants of the Industry—Cupric vs. Alkaline ►

Chemical etching is a vital and complex process for manufacturing PCBs. Although it is complex, etching of copper can be narrowed down to a handful of etchants that PCB manufacturers widely use.

## Insulectro Exclusive North American Distributor for Kyocera SGS Precision Tools ►

Insulectro, the largest distributor of materials for use in the manufacture of printed circuit boards and printed electronics, welcomes Kyocera SGS Precision Tools to its family of world-class manufacturers.

## Atotech Successfully Starts Production and Officially Inaugurates the New Site in Querétaro/Mexico ►

Atotech, a leading specialty chemicals technology company and a market leader in advanced electroplating solutions, celebrated the inauguration of its new production site in Querétaro, Mexico.

## Ucamco's New Version of Reference Gerber Viewer Freeware ►

Ucamco is pleased to announce a new version of the online Reference Gerber Viewer. A brand-new formal syntax checker was added.

## Gov. Kemp: Denkai America to Locate New Manufacturing Facility, N.A. Headquarters in Richmond County ►

Governor Brian P. Kemp announced that Denkai America, the only North American manu-

facturer of high-quality electrodeposited (ED) copper foil used in printed electronics, will locate its new manufacturing facility and North American headquarters in Richmond County.

## Ventec Raises Global Production Capability, Control with Increased Prepreg Treating Capacity In Taiwan ►

Ventec International Group Co., Ltd. is investing in new prepreg treating capacity at its Taiwan facility to expand its global manufacturing capability, control, and supply chain flexibility.

## IEC Announces Sale of Flying Test Probe From atg Luther & Maelzer to Candor Industries Inc. ►

Toronto's Candor Industries Inc., an innovative PCB manufacturer, has installed a new atg A5NEO Flying Probe Test System from atg Luther & Maelzer GmbH with the help of IEC Canada. This purchase will further assist Candor Industries in qualifying and testing both their simple and highly complex circuit boards to ensure Candor's excellent quality standards.

## Equipment Technologies Inc Acquired by Redfern Companies ►

Hudson, N.H.-based Equipment Technologies, Inc. (ETI) announces it will be acquired by The Redfern Companies. ETI specializes in selling and installing new equipment and offering maintenance services to the circuit board industry worldwide. ETI product and service offerings will be supported by Insulectro, the largest distributor of materials and services for PCB manufacturers in North America.

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# FCT: Powerful Growth in the **Flex Segment**

Feature Interview by Andy Shaughnessy

I-CONNECT007

After the initial impact of the global pandemic led to a somewhat flat 2020, Carey Burkett, vice president of Flexible Circuit Technologies, explains how the company's growth took off in 2021, positioning it well for industry trends that continue to show great promise in medical, automotive, consumer, and more. In this interview, Carey breaks down the reasons behind the company's recent success and how R&D, and a new Zhuhai facility in Guangdong, China have positioned them for continued growth.

**Andy Shaughnessy:** Carey, will you talk about the environment that you're seeing?

**Carey Burkett:** It's an interesting time in this industry. To a large degree, whether it's

COVID, increased costs, global instability, and all the turmoil around us, many industries and businesses can be quite impacted. Yet we're fortunate, given that the need for electronic solutions just keeps growing across almost every industry. We've been in a good position because we specialize in specialty interconnects, particularly flex, flexible circuits, rigid-flex, and flexible heaters, where there are growing needs given continued industry trends.

Beyond growing needs for our products, customers continue to want more. We do EMS assembly all the way to product module and complete product box builds. Customers are often narrowing their supply chain, as they seek to identify suppliers that can do more, so we continue to grow in all aspects of our busi-

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ness. You look at the trends across industries, whether it's mobility, miniaturization, Internet of Things, connectivity, wearables, packing more electronic capability into tighter spaces—it all lends to the need from product developers for the type of specialty interconnects that we produce. Those trends are pushing people to our types of products and services.

With all our production facilities being in Asia, we focus on the commercial markets including medical, consumer products, automotive, industrial, telecom data, and more; and we see continued growth across all markets. The significant growth in the need for specialty interconnects has led to a shortage of true engineering design expertise within our industry. To help customers get to cost-effective solutions quickly, one must have an understanding of the materials and materials properties, including how they will function and perform. Further, how many projects, designs, successes, and failures does your design expert have related to specialty interconnect designs? The fact is, specialty interconnects are often utilized in challenging applications, and by having expert design support one will increase the project success rate while getting to a cost-effective design that performs within these challenging applications. Given these facts, some good questions a customer may want to ask include: Who is helping me with my design? What level of experience do they bring to my project?

Mark Finstad, our director of application engineering, is one of the top flex experts. He is vice chair for all the IPC flex circuit committees, a lead educator on flex, and a noted columnist. Mark has built a team here at FCT where all our senior application engineers offer 30-plus years of experience in designing flex, rigid-flex, and flex heaters. They under-

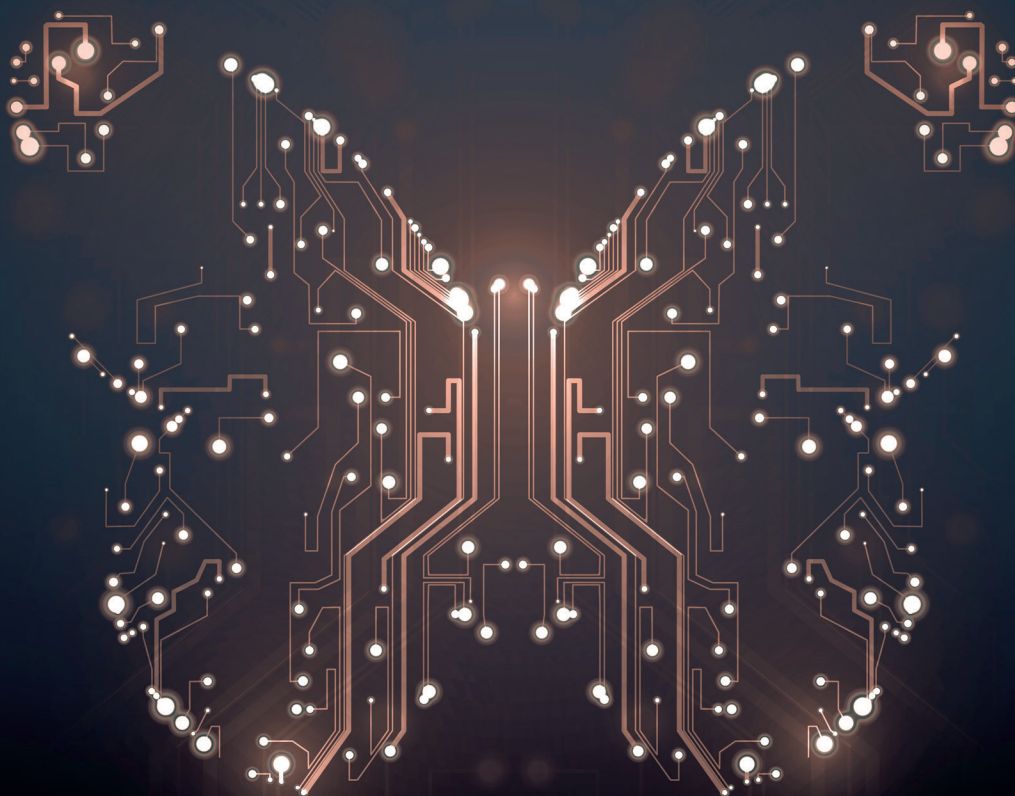


Carey Burkett

stand the materials, the material properties, and what can and can't be done; they've literally addressed thousands of applications. That expertise helps our customers get to cost-effective designs that will perform. From there, it is about delivering quality products at competitive prices, on time. Our FCT China team does an outstanding job, and our facilities offer the following certifications: ISO 9001, ISO 14001, ISO 13485, and IATF 16949 for automotive. Further, we perform product box builds for FDA-registered product programs for medical companies, where we must meet stringent traceability requirements. Our quality systems are robust, and we offer deep expertise as one of the top assembly-on-flex companies in the world. We have built our organization, FCT USA and China, together over the past 20 years. Our team in China works with an incredible sense of urgency and does an outstanding job of producing high quality products for our customers.

Certainly, expert design and the ability to build quality products that we deliver on

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time are keys to success, but providing highly responsive support to our customers is key as well. It's interesting, as many companies have moved away from where you can actually talk to a person when you are seeking support or assistance. At FCT, we believe in "being great at the things that don't require that much talent." This relates directly to providing our customers with outstanding support—pick up the phone, answer the email, provide our customers with an update, call the customer, and provide outstanding support. Many of our customers have provided us with great feedback related to how we care for them.

All this has led to very good growth for us. From 2015 to 2019, our company doubled in size. In 2020, the first year of COVID, we were flat. Last year, we experienced 25% growth year-over-year. That was a big growth year for us, which was outstanding given the challenges with components, dealing with COVID, and other issues. So far, 2022 has been an exciting year for us as well as we continue to attain strong results and we have an outstanding pipeline of opportunities that we are working on.

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**So far, 2022 has been an exciting year for us as well as we continue to attain strong results and we have an outstanding pipeline of opportunities that we are working on.**

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**Shaughnessy:** I heard you opened a new facility in China. Tell us about it.

**Burkett:** Yes, last fall, we opened FCT Zhuhai, a brand new, state-of-the-art, 400,000-plus-square-foot production facility aimed at flex, rigid-flex, and flex heaters. It has an R&D cen-

ter, and one of our goals over the next three years is to increase our capabilities each year—getting to tighter trace and space, smaller via structures, dealing with high-speed materials and on our way to what would be substrate-like PCBs. There will be continued and growing needs for miniaturization and making advancement in our capabilities as it relates to that direction. We also are positioned to meet growing needs for large-scale or large-format type of circuits. Getting Zhuhai up and running has been key for us. With improved capabilities, combined with significant capacity, we are well positioned to grow rapidly in support of our customers.

Having said all that, from a customer base, we're seeing mixed results. If you look at long-time production, depending on the industry, some are running a little softer, while others are growing rapidly. While we grew at a 25% clip last year, we'll see where we end up this year. But we are well positioned and optimistic given the trends in the industry and what our customers want. It puts us in a good position to grow. We have a commitment to long-term, mutually beneficial relationships with our customers, which helps fuel that growth. Now, with our new facility, a commitment to increased capabilities, and the added capacity, we're in a very good position to grow long-term as an organization.

**Shaughnessy:** You've mentioned before that relationships are a major part of your "recipe."

**Burkett:** Yes, absolutely. We started in 2000 as an internet-based company—responding to quotes and sending them out. It was a great strategy for a young startup. Back then, there weren't that many different suppliers doing flex, so we often would be found via an internet search and would respond with a quote. We certainly won our share of business and that business model led to our initial growth over our first 10-plus years in business. Today, we are much more mature as a company and

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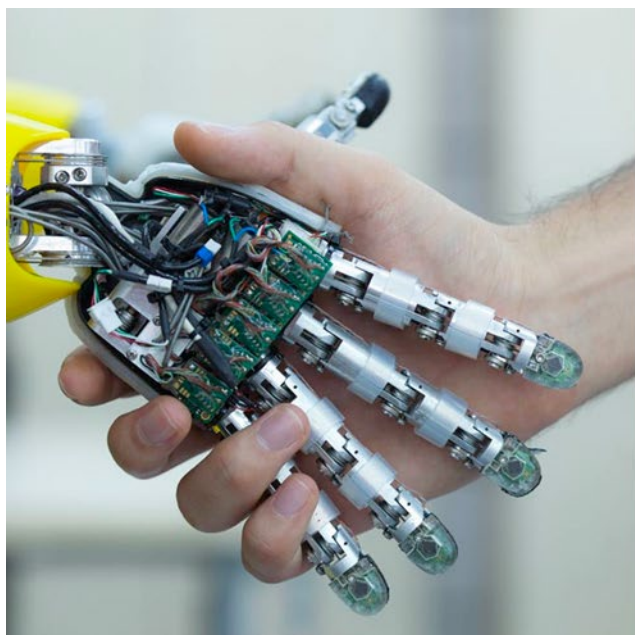
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have proven ourselves with many global OEMs where you must focus on the overall relationship, and gain an understanding for the organization, their needs, their technical roadmap, and more so that you can align your organization with the customer. This allows you to offer more value and that leads to a long-term relationship.

I go back to the design expertise. If we're pulling out costs given our design guidance, that can lead to 10, 15, 20, 25% savings that is providing the customer with significant value often far more than a piece price difference when moving to production. We've had cases where somebody comes to us with a rigid-flex design and we said, "You can do that, but we can move this to a flex design and cut your costs in half or even more." That's huge savings, offering significant value to the customer. When you look to build a relationship, you also must tout what you're doing for that company, so they understand the value you are bringing to keep that relationship going.

Further savings in design are critical today, given increased costs in components and with certain materials. At the same time, copper pricing is down which helps, and for us, wage inflation in Asia is not as impactful as other parts of the globe.

**Shaughnessy:** That's good. Anything on the rigid-flex side? We hear a lot of interest in rigid-flex.

**Burkett:** Yes, it continues to grow within our overall product portfolio and no doubt there are increased needs. Again, as with most specialty interconnects, attaining success with rigid-flex starts with getting to a design that is cost-effective and that can be built at higher yields. At FCT we do an outstanding job related to rigid-flex design that leads to improved success when going to production. While rigid-flex is a more costly solution, given trends and challenging applications, it may be the most effective solution dependent upon what the product design engineer is needing to accomplish. With our new Zhuhai facility, rigid-flex is one of the targets to, again, increase our capabilities. We already build rigid-flex in China in our facilities, but again will continue to push ourselves related to our overall capabilities that will allow us to meet broader and more complex needs.

**Shaughnessy:** Carey, thanks for the conversation.

**Burkett:** You're very welcome, Andy. **PCB007**



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# The Etch Factor

## The Chemical Connection

by Christopher Bonsell, CHEMCUT

One of the biggest obstacles that PCB manufacturers face is etch factor. In the past, I have touched on etch factor in my columns, but to refresh, etch factor is the ratio of downward etch to sideways etch. Etch factor poses challenges to PCB fabricators because it limits PCB design. It can determine how fine a line you can etch, and it can even affect how close together you can have features. For instance, if you wanted to use cupric chloride (etch factor of 3:1) to etch a fine line (3 mils or less), you might not be capable of doing that on panels with thicker copper layers. If you try to do that, you will likely receive inconsistent results throughout your panels. Inconsistencies will arise because there is a point

where the sideways etch will affect metal underneath the photoresist and etch it away. This phenomenon, where metal is etched from underneath the photoresist, is known as “undercut” (Figure 1).

In some cases, the undercut for fine lines is so severe that the photoresist will lift off the copper surface, thus exposing the metal to be directly attacked in the etcher and creating the possibility for that feature to be completely etched away.

### What Undercut and Etch Factor Have in Common

Throughout the industry, etch factor and undercut are terms typically used interchangeably, despite their differing definitions. This is likely because they are both the result of the one thing that PCB fabricators want to get rid of—sideways etch. Without sideways etch, etch factor and undercut are theoretically nonexistent. If you could remove sideways etching from the etch process, the translation between PCB design and PCB fabrication would have no limitations. You could etch down as far down as you would need without increasing the spaces between features and without decreasing the definition and accuracy of features. Unfortunately, sideways etch is not so easily controlled, and it is often accepted to be a limitation to etching.

### How Sideways Etch Has Been Challenged

Although sideways etch has been accepted as a normal obstacle, there have been efforts to combat it. Perhaps the closest copper etch-

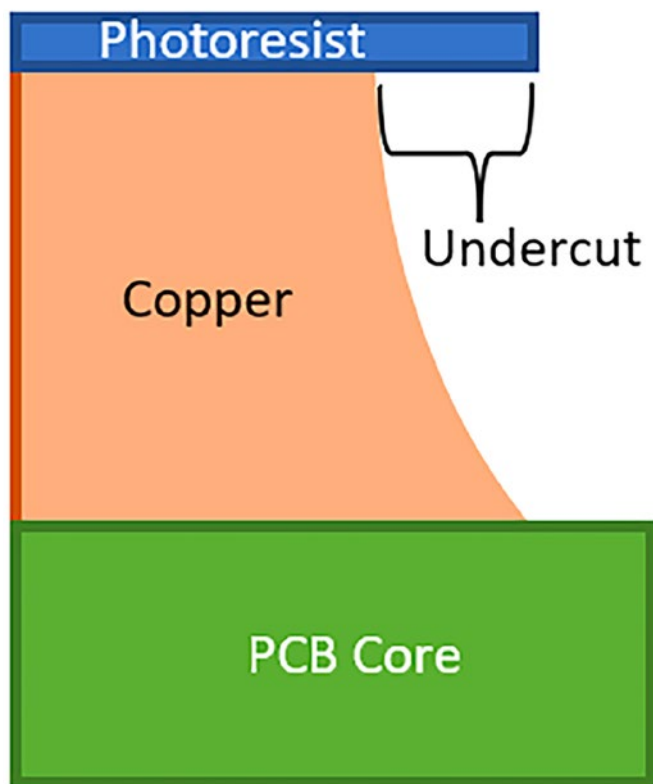


Figure 1: Diagram of undercutting on a PCB.

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ing has come to a nearly perfect etch factor was when the PERI-etch process was discovered. The PERI-etch process, also known as powderless etching, was a process that was developed by the Platemakers Educational and Research Institute (PERI) to improve the manufacturing process of copper letterpress printing plates<sup>1</sup>. This process consisted of an additive to an etching solution that would form a film to protect the sidewalls to prevent them from being etched. Powderless etching gave some promising results of sidewalls from nearly vertical to 30–40 degrees from vertical with no undercutting. Although it gave some promising results for the plate-making industry, some drawbacks limited its wide use in the PCB industry. It was primarily not adopted in PCB production because the additive was meant to work in ferric chloride ( $\text{FeCl}_3$ ).

Ferric chloride is an etchant that is sometimes used for PCB fabrication, but it is not often used because the regeneration chemistry is inefficient for large-scale PCB production. Since ferric chloride is based on iron, it is best suited for iron-based metals because it makes regeneration and waste treatment simple and efficient. With copper etching, regeneration of the ferric chloride would not be able to sustain a steady etch rate. As copper content accumulates in the ferric chloride, etch rates decline even with regeneration. Once regeneration becomes ineffective in a large-scale etch process, like PCB fabrication, the profitability of the etch process quickly declines. Since regeneration cannot be performed efficiently, there was never enough reason to justify using powderless etching in large-scale PCB production.

## What Could Ideal Etch Factors Mean for SAP?

If somehow you could get both the regeneration of cupric chloride and the vertical sidewalls of powderless ferric chloride etching, I think we would see a dramatic change in the PCB industry. Currently, using the semi-additive process (SAP) is the most practical way to

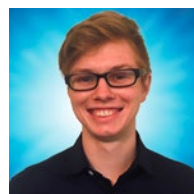
obtain fine features. However, if sideways etch can be efficiently inhibited in the etchants we use today (cupric chloride and alkaline cupric chloride), SAP may not even be necessary in most cases. If you are unfamiliar with SAP, it can be summarized as a process where a copper-plated panel undergoes a selective plating process to form desired features on top of the copper that was already present. Once the features are plated onto the base copper, that panel gets etched to remove the base copper, thus leaving behind only the features that were added. Finding a way around SAP would mean skipping many long and costly steps in the PCB fabrication process. Without requiring SAP to obtain fine features, PCB shops would require less plating equipment and fewer resources to perform plating (i.e., chemicals, trained personnel, time to plate, and operating space).

## Conclusion

Although this would be a major game changer in the PCB industry, we seem to be far from obtaining a practical solution with ideal etch factors. The best etch factor with a PCB etchant is the 4:1 ratio you get from maintaining alkaline cupric chloride in its top condition. It begs the question of whether it is possible for copper etching to advance so much that you can get both efficient regeneration capabilities and near perfect etch factors. In the past, we have gotten close to obtaining ideal etch factors, but we did not have the right etchant. Perhaps we could get there with new efforts in chemistry research. If obtaining this quality of etchant is possible, could it ever be enough to replace SAP? **PCB007**

## References

1. "Member's Handbook," Platemakers Educational and Research Institute Inc. (Print)



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



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# With a Little Help From My (IPCEF) Friends

## The New Chapter

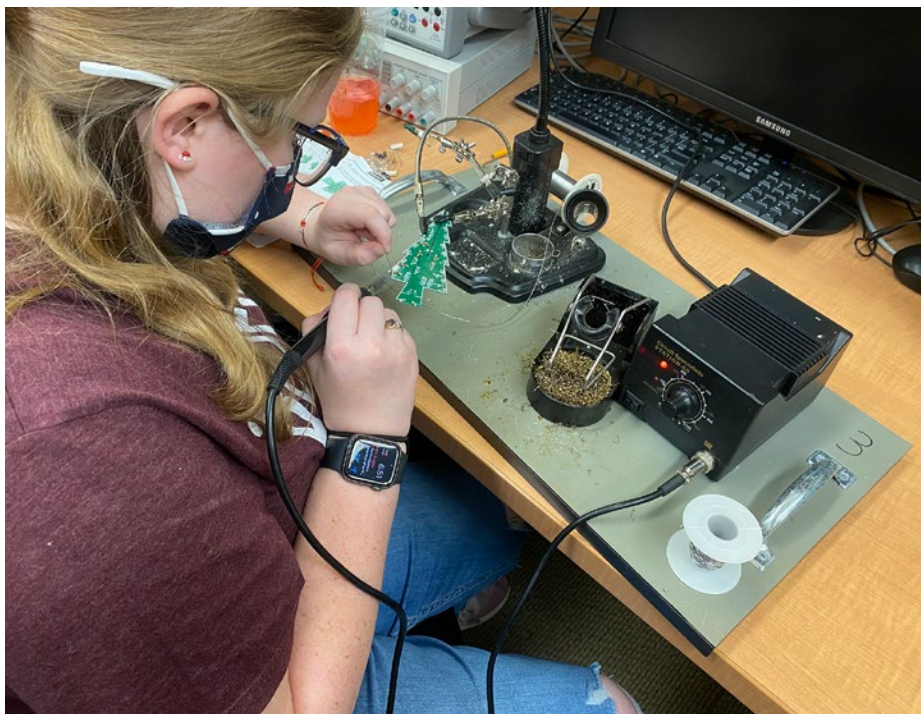
by Hannah Nelson, VALPARAISO UNIVERSITY/IPC STUDENT DIRECTOR

About a year ago, I decided to begin engaging in leadership activities that would both improve my skills and provide opportunities for others to flourish in the electronics field. Soon after, a friend asked if I would be interested in leading our IPC student chapter; I said yes in a heartbeat. Because of COVID shutdowns, our student organization had crumbled, and while I knew I could restore it, I had no clue where to begin. Our chapter advisor suggested I reach out to the IPC Education Foundation (IPCEF).

With that outreach, IPCEF soon became involved and excited about working with our chapter here at Valparaiso University. We discussed ways our students could grow through professional development, networking events, and technical skill advancements. We organized a kick-off meeting to determine interest and since then, our chapter has grown exponentially as students have learned the importance of engaging in the electronics industry.

As we began hosting campus events, I quickly realized just how important our organization was for students. We have a limited number of available courses, which means that informa-

tion and processes of the electronics manufacturing industry are not easily accessible to us. Through our connection with IPCEF, our chapter has bridged the gap between the university curriculum and the expectations and skills we need to work in the industry. IPCEF offers several courses in its mini library related to technical subjects; these are incredibly valuable to electrical engineering students. Because of what I have learned in IPCEF's video courses, I have been able to instruct my fellow students in chapter meetings about the electronic manufacturing process. Our students now know how to solder, design a PCB, and even create a wire harness because the Foundation provides the educational experience for students.







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## Taking the Next Step

I worked closely with IPCEF over several months. During that time, I was encouraged to apply for two opportunities: the student member scholarship and the Emerging Engineer position. Not long after applying, I was selected as a scholarship recipient and was invited to interview for the Emerging Engineer program. I was ecstatic. Not only was this an opportunity to continue pursuing my vocation through scholarship, but if accepted into the Emerging Engineer program, I could attend IPC APEX EXPO. I saw this as an opportunity to grow my technical skills and my professional network.

I approached my interview for the Emerging Engineer program with confidence regarding our IPC student chapter goals, which included expanding our membership and professional opportunities. As the interview concluded, they strongly recommended that I apply for the student director position on the IPC Board of Directors. I hesitated because I didn't think I had the qualifications. Just as I was about to let the opportunity go, IPCEF reached out to me again and encouraged me to apply. I realized that I was selling myself short and limiting my potential to grow in leadership. So, I applied, and when the votes were counted, I

was selected. Because the staff at IPCEF had faith in me, I knew I could provide the same level of faith and trust in my own leadership team and abilities.

It has been an amazing year for me. In early January, I was accepted into the Emerging Engineer program and attended IPC APEX EXPO 2022, where I networked with professionals from around the world, sharing the important work of IPCEF. I frequently spoke about my passions and investment in this industry. I attended committee meetings, board dinners, and several professional development courses—all increasing my awareness of the electronics industry. I learned just how vast the industry is by exploring the different processes that go into electronics manufacturing and standards. There have been several individuals who devoted their time, teaching me about the industry and helping me grow professionally. Being surrounded by individuals who want me to thrive within the industry has helped me focus on developing a similar culture within my own student chapter.

## Want to Help?

What IPCEF has done for me can and will happen for so many other students throughout the country. I know these students can follow their passions and create substantial change within our industry. They will fill the gap in the workforce with their skills, knowledge, and desire to build the industry. I know they will flourish in projects, leadership, course work, and their future careers. When I first started college, I was one of just two female freshmen pursuing a degree in electrical engineering. At first, I felt like an outsider, but once I connected with IPCEF, I found my purpose.



The IPC Education Foundation is committed to attracting a new generation of prepared & productive talent. To do so, IPC needs industry support to create AWARENESS of the careers the electronics manufacturing industry has to offer & to provide students ACCESS to knowledge, content & connections.

## How can you, an industry member / employer, help us close the electronics manufacturing skills gap?

- Present a virtual information session to share career paths at your company & other industry opportunities with college & high school students
- Host students at your facility for tours & other engagement events
- Serve as a panelist on a Career Paths Panel Discussion hosted by IPCEF
- Sponsor events, scholarships, or an IPC Student Chapter at a community college or university near you or from where you recruit
- Provide industry experts in various company roles/positions to speak about their jobs and skills needed that can be shared as content on our website in the form of quotes, videos, & pictures

If you are interested in any of the above opportunities – please reach out to:  
Charlene Gunter du Plessis, Sr Director of the IPC Education Foundation at [CharleneGunter@ipc.org](mailto:CharleneGunter@ipc.org)  
Wendy Gaston, Business Development Manager at [WendyGaston@ipc.org](mailto:WendyGaston@ipc.org)



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I plan to help other young women find that same passion. I've seen how a simple email to IPCEF started me on a path I never imagined as I have grown my passion for learning, teaching, and leading.

To students who are reading this, follow your passions, even if it seems out of the ordinary. Don't be scared to share your ideas because they might make a difference in your organization or the people around you. I know this because it changed my life. If you already work in the industry and want to help our next gen-

eration, please reach out. Wendy Gaston is the IPCEF liaison between companies and student chapters. She can be reached at [Wendy-Gaston@ipc.org](mailto:Wendy-Gaston@ipc.org). Let's all continue to move this work forward. PCB007



**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](#).

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## Book Excerpt:

# *The Electronics Industry's Guide to... The Evolving PCB NPI Process*

## Introduction

Thanks to marketing and advances in technology, we have all come to expect that the electronic products we buy will be closely aligned to our individual and specific lifestyle or business requirements. This expected variability in personal function and style, as well as regulatory compliance and a changing global economic landscape, has made designing and producing new products a challenging prospect. And, on top of the resulting "high-mix, low-volume" production cycles, increasingly more products contain electronic components in varying levels that heighten the complexity of design and manufacturing.

This situation means that printed circuit board (PCB) manufacturing has shifted from a focus that's primarily driven by the time it takes to build a single board on a single dedicated line to focusing on the changeover time between varying products on a single line or between multiple lines.

As part of this shift, PCB manufacturers moved away from the traditional practice of selecting pick-and-place lines from multiple vendors toward choosing a single vendor for their machine lines. An unintended result was that using the one vendor's machine software became the primary way to optimize the line because the key factors were known, and manufacturers no longer had to optimize across



multiple, differing machine platforms.

Then surface mount technology (SMT) came along, and these machines had greater feeder capacity. They were able to cover more types of component packages. SMT machines were more modular than pick-and-place machines so they could be put together to create the overall placement line. Despite this move to SMT, some pick-and-place machines, especially if they were legacy machines

that still functioned well and were too expensive to replace, were kept in a manufacturing line. So, a single factory still could have at least two, or more, different machine vendors across all lines. This made optimizing all the machines across a line or multiple lines complicated because they all had different software programs.

Because this setup is difficult to configure, companies such as Valor and Tecnomatix, both now part of Siemens Digital Industries, stepped in to deliver optimization strategies for these mixed vendor lines. One of the most popular mixed-vendor lines historically was the Fuji CP-Universal GSM line. However, most electronics assembly lines back then were typically mixed vendor of some type.

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## Ultra Selected in Six of Seven Categories for USAF ABMS \$950M IDIQ Contract ▶

Ultra has been awarded a \$950 million ceiling indefinite-delivery/indefinite-quantity contract for the maturation, demonstration, and proliferation of capability across platforms and domains, leveraging open systems design, modern software and algorithm development in order to enable Joint All Domain Command and Control.

## Ventec Expands Flex-rigid Material Range for Critical Military, Aerospace, and Ultra-high Reliability Applications ▶

Ventec International Group Co., Ltd. has added to its flex-rigid No Flow/Low Flow prepreg range with the introduction of tec-speed 4.0 (VT-462(L) PP NF/LF), a next generation no and low flow FR-4 prepreg material that offers high-Tg, low Dk, low loss, and excellent thermal reliability.

## Airbus Helicopters, VRM Switzerland to Develop the World's First H145 Virtual Reality Simulator ▶

Airbus Helicopters and VRM Switzerland are co-developing a Virtual Reality (VR) training device for the twin-engine H145 helicopter.

Containing the OEM data package, the H145 VR simulator, once qualified, will allow pilots to perform proficiency checks and receive training credits.

## FedDev Ontario Invests Over \$7M for FTG Green Operations ▶

Aerospace is a pillar of the economy and of innovation in Canada. It is one of the most research-intensive and export-focused manufacturing industries, employing thousands of highly qualified people in every region across the country.

## L3Harris, Air Tractor Sky Warden Team Selected for USSOCOM Armed Overwatch Contract ▶

U.S. Special Operations Command (USSOCOM) has selected L3Harris Technologies and Air Tractor Inc.'s AT-802U Sky Warden system for its Armed Overwatch program. Award of the Indefinite Quantity, Indefinite Delivery contract includes a cost ceiling of \$3 billion.

## FKN Systek's New Depaneling Saws for Low Stress PCB Singulation ▶

Now available from FKN Systek, the S300 multiple blade depaneling saw for use in singulating assembled PCBs. The S300 is a PLC controlled machine which can singulate up to 24 lines in one pass.

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# Breaking the Void

## Testing Todd

by Todd Kolmodin, GARDIEN SERVICES USA

Electrical test is best known for identifying routine opens and shorts. But what has plagued ET, and manufacturers in general, is the barrel void. These voids are breaks in the plating of the drilled barrel that result in circuitry “opens” that pass through the stackup from one layer to another. In some cases, the break in plating is severe and results in an immediate open condition that is detected during electrical test.

However, certain plating anomalies can be present that will go undetected during standard ET. What we must remember is that electricity must follow Ohm’s Law no matter what conditions exist. That is:  $V = I \times R$ , where  $V$  = Voltage,  $I$  = Current, and  $R$  = Resistance.

The most significant hidden plating anomaly to barrels is thin copper, sometimes known as “taper plate” as shown in Figures 1 and 2. This is a condition where copper may be acceptable close to the outer layers of the PCB but may become thinner as distance increases to the center of the depth of the barrel. Although copper exists, it is a dangerous anomaly that can routinely go undetected. Now I can hear the gallery saying, “Todd, how is this possible? The thin copper should blow like a fuse under the formula of Ohm’s Law.” Well, if Ohm’s Law were to be applied straight away, you would likely be correct, along with most circuitry in the board. The reason? Most small trace widths could not stand up to the abuse.

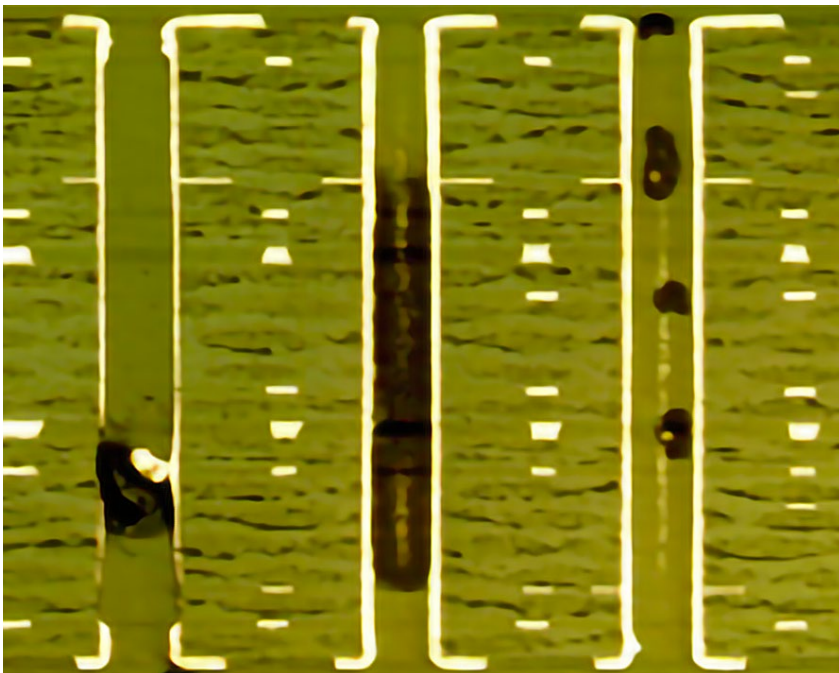
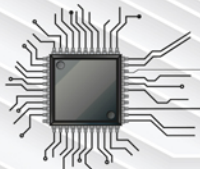


Figure 1: Taper plate voiding indicated (left barrel).

## ET vs. Ohm’s Law

This law cannot be broken. However, we can adapt to the law while still maintaining safety to the PCB and underlying circuitry. Many specifications call for test voltages to be applied during test. Industry and military requirements are 40V minimum, so let’s use that. Calculators ready? Okay, we see 40V. Let’s say the continuity resistance threshold is 20 ohms. Now plug those into Ohm’s Law:  $20V = I \times 20$ . Ohm’s Law can be simplified for solving any variable. For instance,  $V/R = I$  or  $V/I = R$ . Anyway, we have 40 volts and 20 ohms. Solving,  $V/R = I$  we see  $40/20 = I$ , or 2 amps.

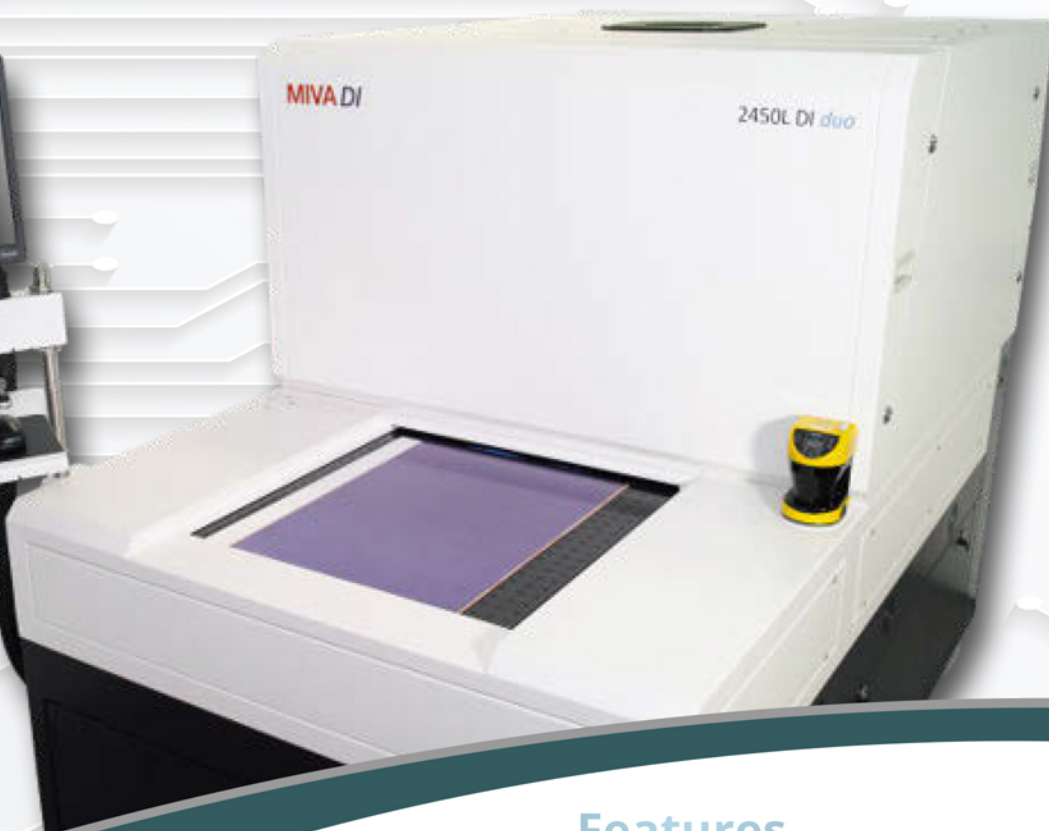


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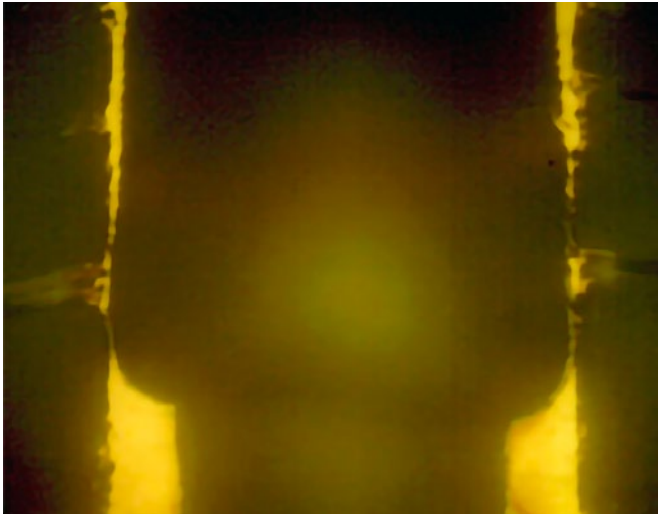


Figure 2: Thin copper (magnified) within the barrel that can pass ET.

Not many 3- to 5-mil traces are going to survive that let alone the electronics in the test machine.

Now, what many may not understand about ET and how machines check for opens and shorts is that the “test voltage” requirement is not applied to the opens, or continuity test. The simple fact is that, as shown above, the excessive current would be devastating. Two different processes are in place during the opens test. First, the voltage is limited to a low value, typically 12–20V regardless of the test voltage requirement. This is simply because an open will be present at 10 volts, or the low voltage, thus the high voltage is not required. The second is that during the continuity test the machines use bypass circuitry to limit the current that is applied to the circuit under test. Parallel resistive networks in the machine will shunt the current away from the circuit, allowing only enough to safely take the continuity measurements. Pretty sneaky, huh? Indeed.

The higher voltages are applied during the shorts or discontinuity test. Once circuits are validated for opens, the higher voltage is applied to circuits to identify shorts. Again, Ohm’s Law is at play. However, with testing for shorts, we don’t just apply the voltage and hope for the best. In this case, we know

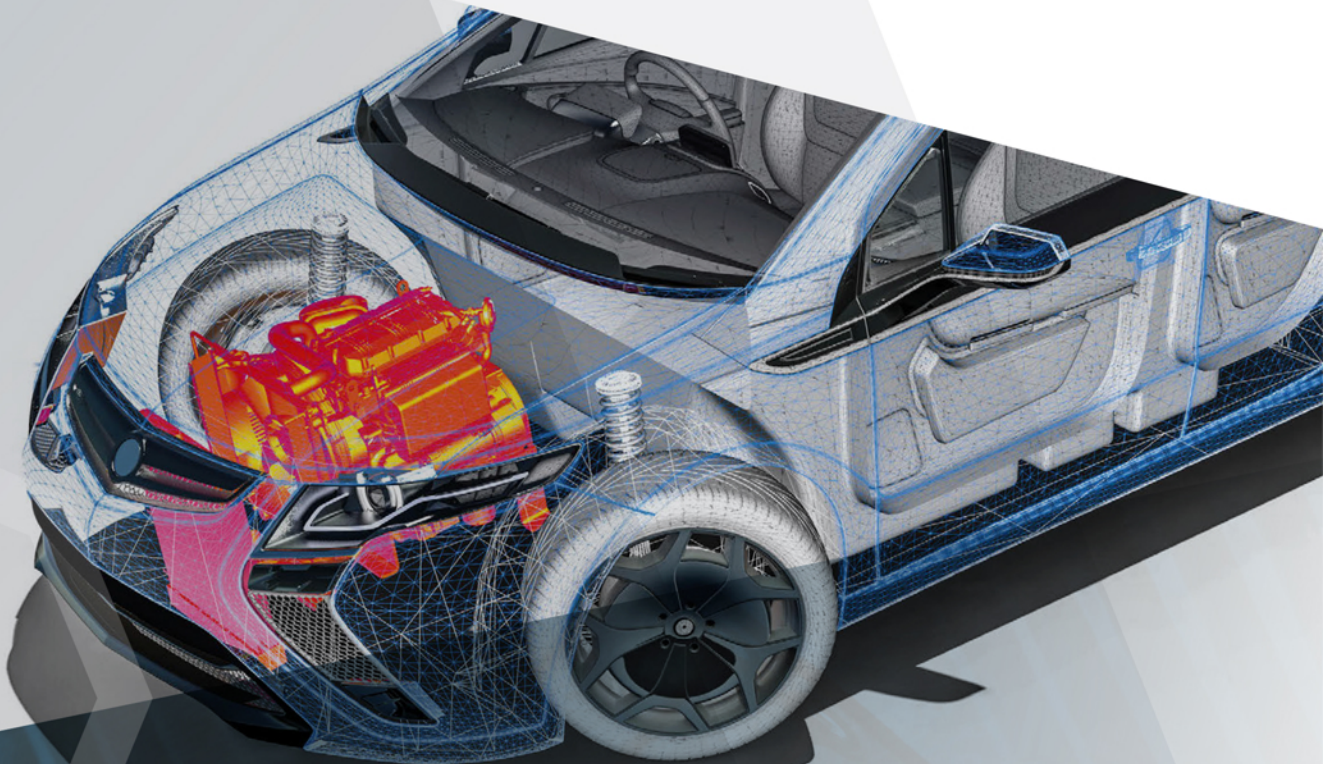
the voltage applied but the other variables are unknown. As we are testing network-to-network for possible shorts, the resistance value is expected to be very high to infinite. Using  $V = I \times R$ ,  $V$  is known, so in my example, I will use 100V. We don’t know  $I$  or current, but we do know the theoretical resistance  $R$ . However, we cannot use “0” or infinite as the law will not allow us.  $100 = I \times 0$ ? It cannot work when we know we have a known voltage value of 100. So, the shorts threshold must have a value in resistance. Most times it is 10 meg ohms or higher. Now the law works again.  $100 = I \times 10M$  or 10,000,000 ohms. Solving,  $100V/10M$  ohms = 0.00001 amps or 10 micro-amps. Now that is still way too much current to allow to pass between circuits if a short may exist. Current limit triggers are in place during the shorts test that effectively stop the test on the network when any current is detected between the nets. Therefore, it is relatively rare that a standard automatic electrical test can result in damage to the circuitry. In other words, don’t rely on ET to blow up shorts as, in general, we do not apply enough current to cause shorts to burn. The test can heat up the short momentarily before the fault trigger but usually will not cause the short to go away.

I digressed to theories, so let me come back to voids. Based on my long-winded explanation regarding how the opens and shorts tests work, we cannot lean on ET to detect all types of barrel voids. We limit current flow so that we are not blowing fuses (thin traces). Furthermore, the difference in resistance of a network with an acceptable signature compared to a network with a taper plate or thin copper wall will not be that different. These changes in resistance are usually in the milli-ohms. Most electrical test machines use a threshold with a tolerance of plus or minus a percentage. For example, 20 ohms  $\pm 5\%$ . That is like 1 ohm. A taper plate void scenario may only change the overall resistance of the network by 5–10 milli-ohm. This will not trigger a fault in the continuity test and thus go undetected.



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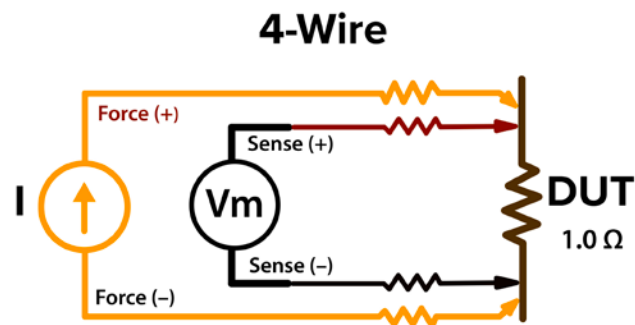
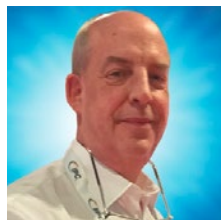


Figure 3: The Kelvin meter.

William Thompson to the rescue. If you are familiar with 4-Wire Kelvin testing, you might know that Thompson invented this test in about 1861. This high-resolution measurement system is based on the Kelvin Bridge which Thompson (later known as Lord Kelvin) invented (Figure 3). Using this theory, high resolution measurements can be taken while eliminating the stray or parasitic resistance of the leads and electronics. 4-Wire Kelvin can detect finite differences in resistance in the milli- and micro-ohm ranges. This test will detect taper plate anomalies and poor bonding of micro-vias.

It is common to perform destructive analysis on plated barrels during the manufacturing process. These potted micro-sections can identify plating anomalies if they are a systemic or gross error to the entire order. Remember that these sections are a sample of just a few holes and a PCB may have many thousands of holes. Therefore, this is not always a good indi-

cator of an isolated issue such as a low voltage flight bar in plating or a bad agitation cycle which results in an isolated set of suspect panels. This is where 4-Wire Kelvin can save time and money by detecting these types of issues. If 4-Wire Kelvin is integrated into your manufacturing theatre, a sampling of product with high aspect ratio drilled and plated holes is indicated. A random sample of panels from different flight bars should be tested to identify any possible anomalies. If an anomaly is found, that flight bar can be isolated and the panels fully tested under 4-Wire Kelvin guidelines to validate integrity. Conforming groups can be released for further processing. What this does is remove the threat of latent defects in the field due to poor barrel plating or bonding of the micro-vias. Although this might take some time in the manufacturing process, it far outweighs the cost of returned product and reputation damage with your customer base. Here, the cost of quality has a valuable argument against the cost of non-conforming product and loss of customers. This is especially true today when time to market is crucial and PCBs are increasingly more expensive to manufacture. **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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# Update on Inkjet Technologies

## Happy's Tech Talk #11

by Happy Holden, I-CONNECT007

Ever since the first inkjet printer appeared from Hewlett-Packard in 1980, engineers have been trying to use it in printed circuit manufacturing. The first successful application was by HP's PCB engineers in 1983, who created an inkjet printer mechanism to serialize each PCB with a unique S/N for traceability. They used one of the UV inks HP had developed and that worked well on circuit boards but was not suited for use on paper.

### Introduction

Karl Dietz wrote on this topic when it first began to appear as a method of solder mask application and legend printing to replace screen printing. Some of his columns<sup>1</sup> discussed the methods of inkjet printing, ele-

ments of the three types of inks (thermal, ultraviolet, and phase-change), and the printheads used by seven current machines on the market. Today, the applications, head technologies, software and inks/pastes have been improved significantly. Inkjet is one of the technologies used in printed electronics.

### Inkjet Printing

An industrial inkjet printer has four important elements, as seen in Figure 1:

1. The printhead(s)
2. The ink or paste
3. The print module-ink preparation or curing
4. System for CAM data preparation and head/substrate positioning

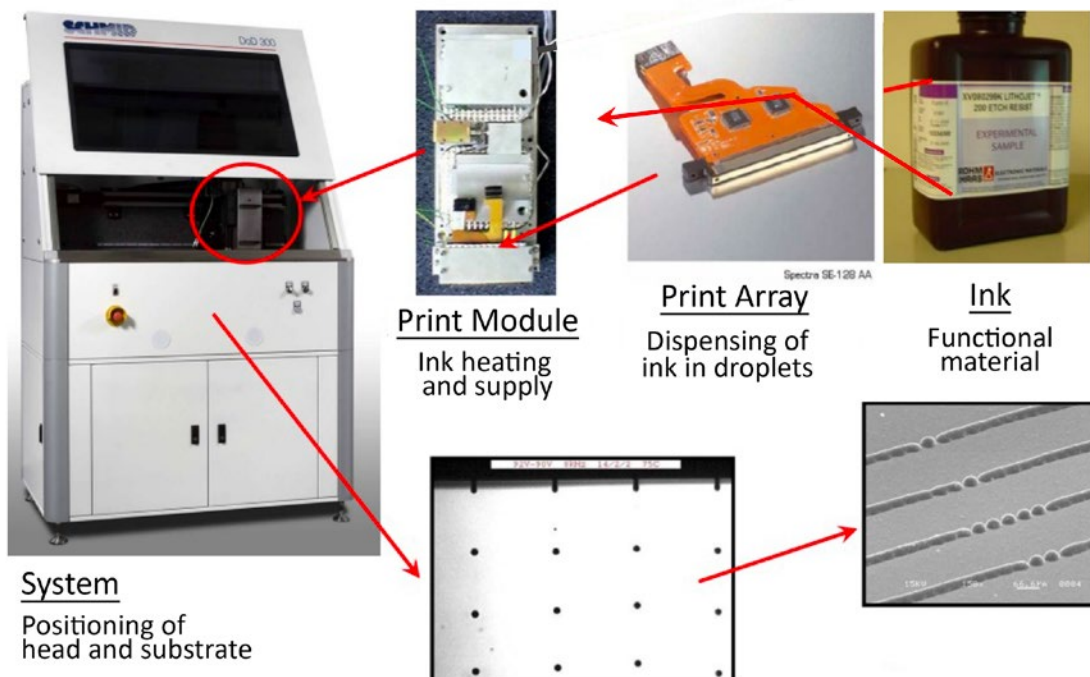
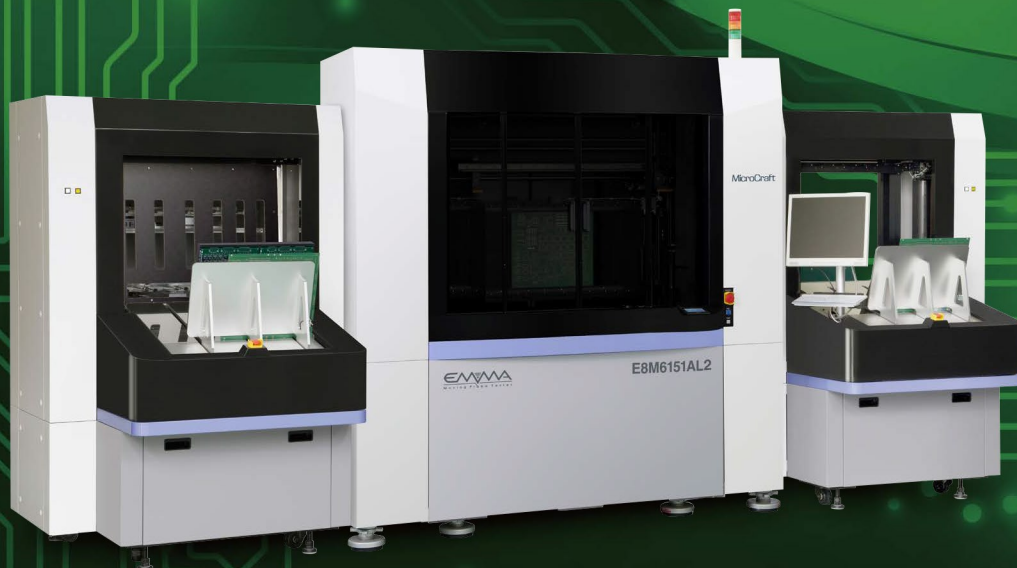


Figure 1: Inkjet system breakdown into four elements. (Source: Dow Electronics Materials)

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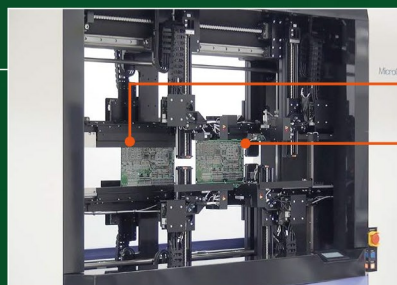
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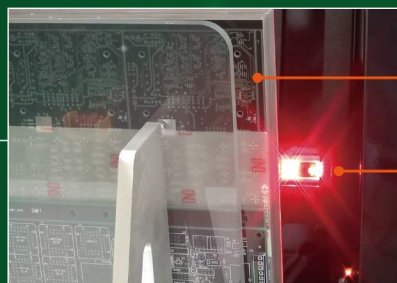
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Inkjet printing technology produces droplets of the ink contained in the fluid channel, with diameters ranging from 10 to 150  $\mu\text{m}$ , which approximately correspond to the diameter of the nozzle (Figure 2). The volume of the droplets is in the picoliter range. Inkjet printing is suitable for electronics manufacturing due to the following reasons:

- It is a non-contact process that selectively deposits a wide range of materials onto a wide range of substrates in a drop-by-drop manner
- The shop floor space requirements, the initial investment, and the time to get an inkjet printing setup running are lower than most other printing technologies
- It is suitable for a wide range of production scales, from prototyping to large-scale industrial production

- Ink consumption and material waste are minimal
- It is flexible regarding its positioning within a process chain
- It can produce patterned thin films. It should be mentioned however, that manufacturing of highly complex integrated circuits (ICs) has exclusively been performed by specialized techniques deviating from standard inkjet technologies.<sup>2</sup>

## Inkjet Printheads

The printhead is the heart of the inkjet printer. In addition to the original thermal thin-film printhead of HP's, there is also the piezo-electric head that makes up most of the additive-type of inkjet printing. Now comes the piezo-acoustic head and the continuous laser-assisted

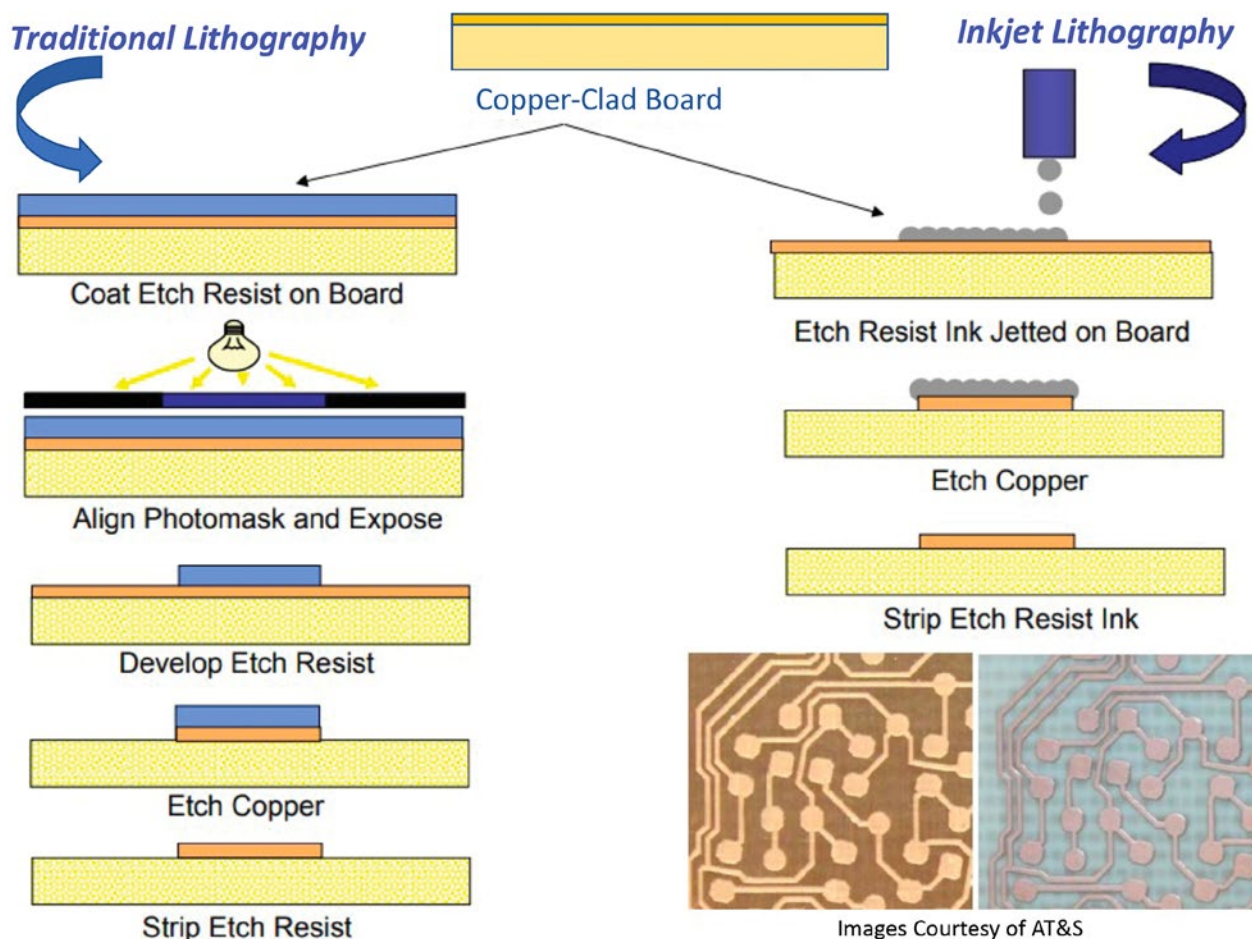


Figure 2: Simplification of inkjet printing process<sup>3</sup>.

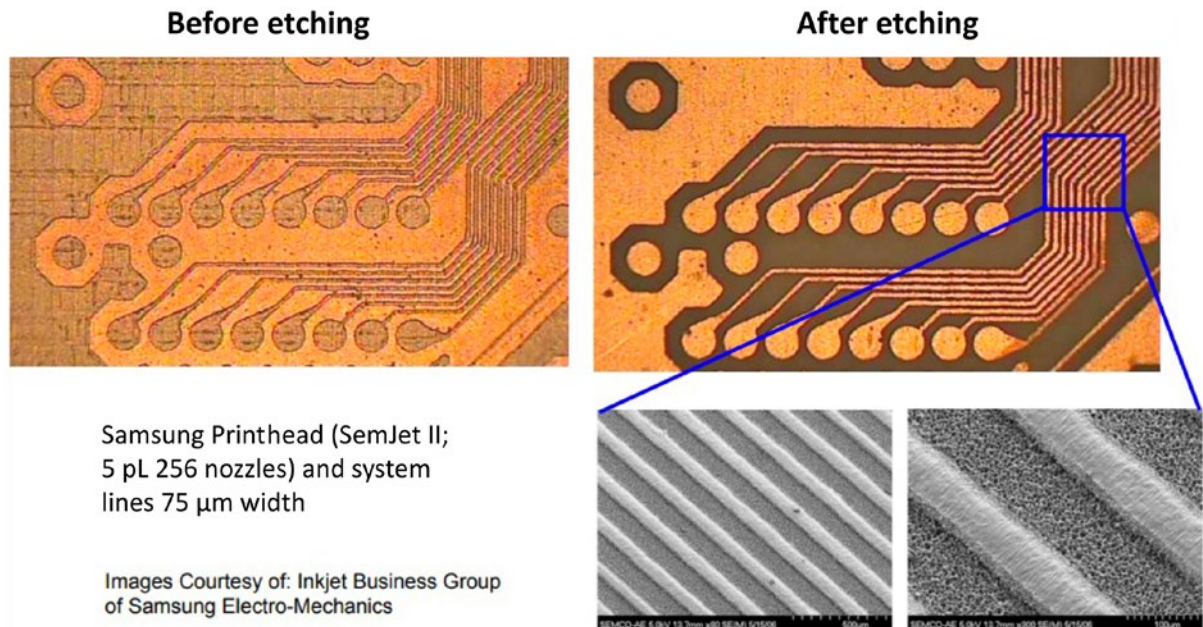


Figure 3: Another example of a production inner layer, before and after etching of 75/75-micron traces and spaces<sup>3</sup>.

system (LIFT), as seen in Figure 3. These new technologies extend the number of inks that can use inkjet printing. The capability of a head is a function of the droplet size, its overlap, and the frequency the head can achieve, now 80 kHz. This permits resolution of 5,000 dpi and resulting minimum copper line widths of 40 to 70 microns.

To improve both speed and density, inkjetting has taken a page from the DMD micro-mirrors exposure book and now uses multiple inkjet heads to achieve this performance. Figure 4 shows a test vehicle from the Center for Microsystems Technology (CMST) of Ghent University and imec with etched traces down to 40 microns.

Figure 5 illustrates this etching/plating resist capability on a Samsung panel with the Samsung printhead using five pl-256 nozzles.

## Ink or Pastes

There were numerous challenges with ink formulation, including adhesion, curing, and especially spreading after jetting. Figure 4 illustrates the difference between general inkjet printing on paper vs. inkjet printing on a PCB.

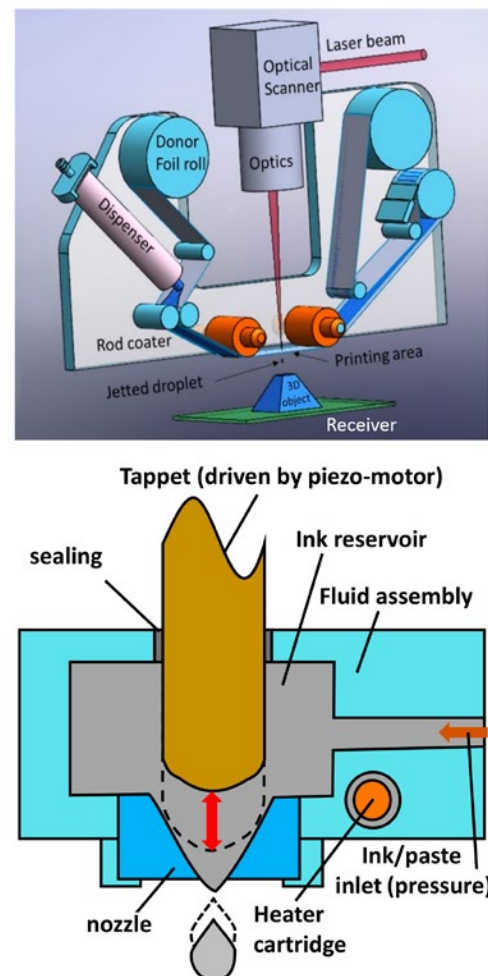


Figure 4: Laser induced forward transfer (LIFT) system<sup>4</sup> and new piezo-acoustic head<sup>5</sup>.



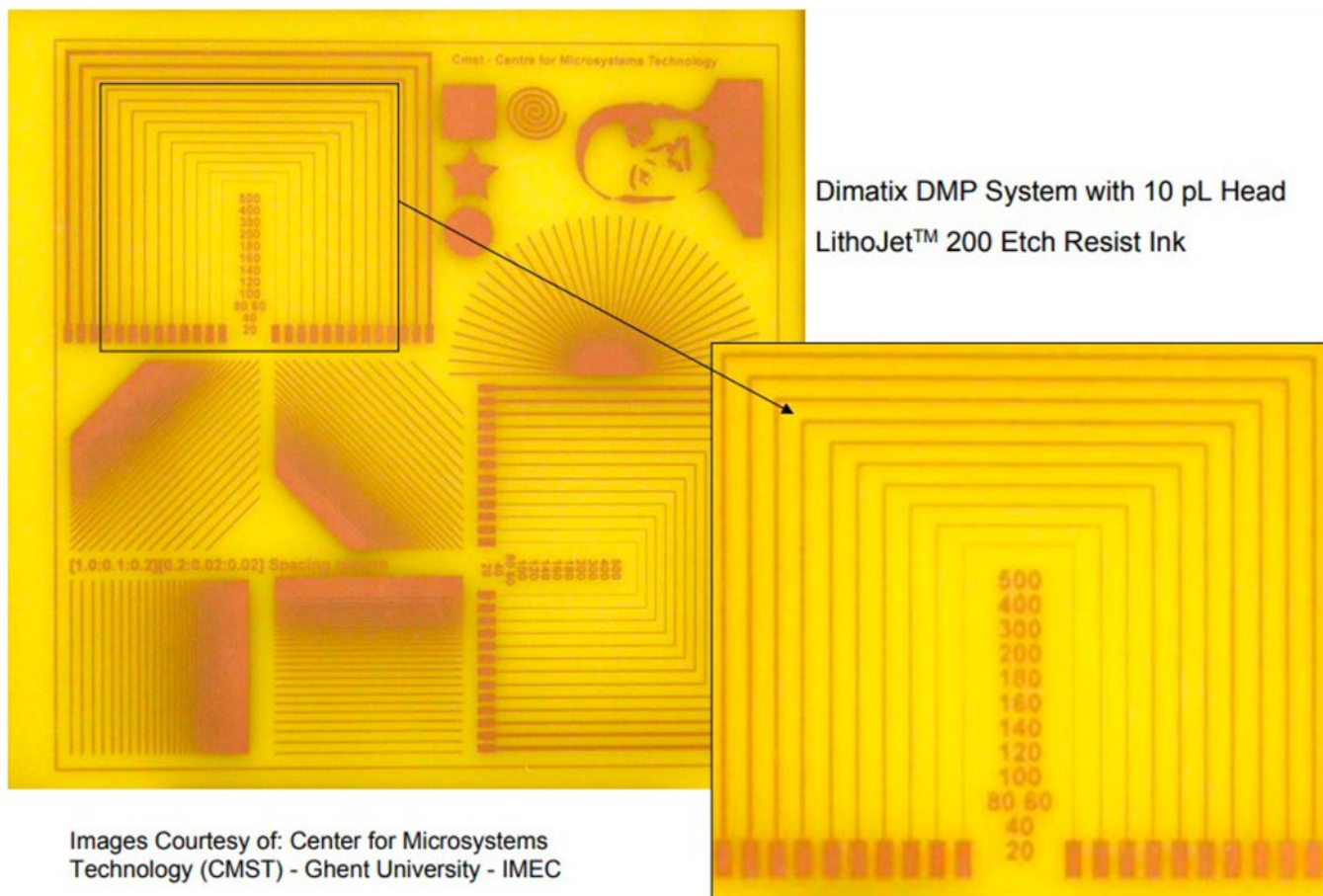


Figure 5: Test vehicle printed with the Dow LITHOJET 200-series etch resist inks using the Dimatix DMP materials printer with a 10-pico-liter head<sup>3</sup>.

## Ink Preparation/Curing

In addition to jetting the ink, the system may have to prepare the ink (by melting a hot-melt ink) or by curing a UV ink.

## System Software and Positioning

The additional system activities may include positioning of the inkjet heads and, particularly, the preparation of the CAM information to drive the inkjet heads and substrate positioning. Table 1 illustrates the printing time for a 75/75-micron traces on a 460 mm x 610 mm panel using only one head vs. 15 heads.

Input Parameters		Printing Requirements	
Target feature size (Line/space)	75 /75 microns	Required firing frequency for 1250 dpi (in scan direction)	10 kHz
Printhead Type	Konica-Minolta KM512	Required scan with one head	45 passes
Printhead drop volume	14 pL		
Resolution of printhead	360 dpi	Required scan with 15 heads	3 passes
Print width	36.1 mm		
Printing dpi (X and Y)	1250 dpi	Time to print with 1 head	~ 6 min.
Table scan speed	6 m/min.		
Panel size, single-sided	460 mm x 610 mm	Time to print with 15 heads	~0.4 min.

Table 1: Input parameters for a 460 mm x 610 mm panel of 75/75-micron t/s using one head vs. 15 heads<sup>3</sup>.

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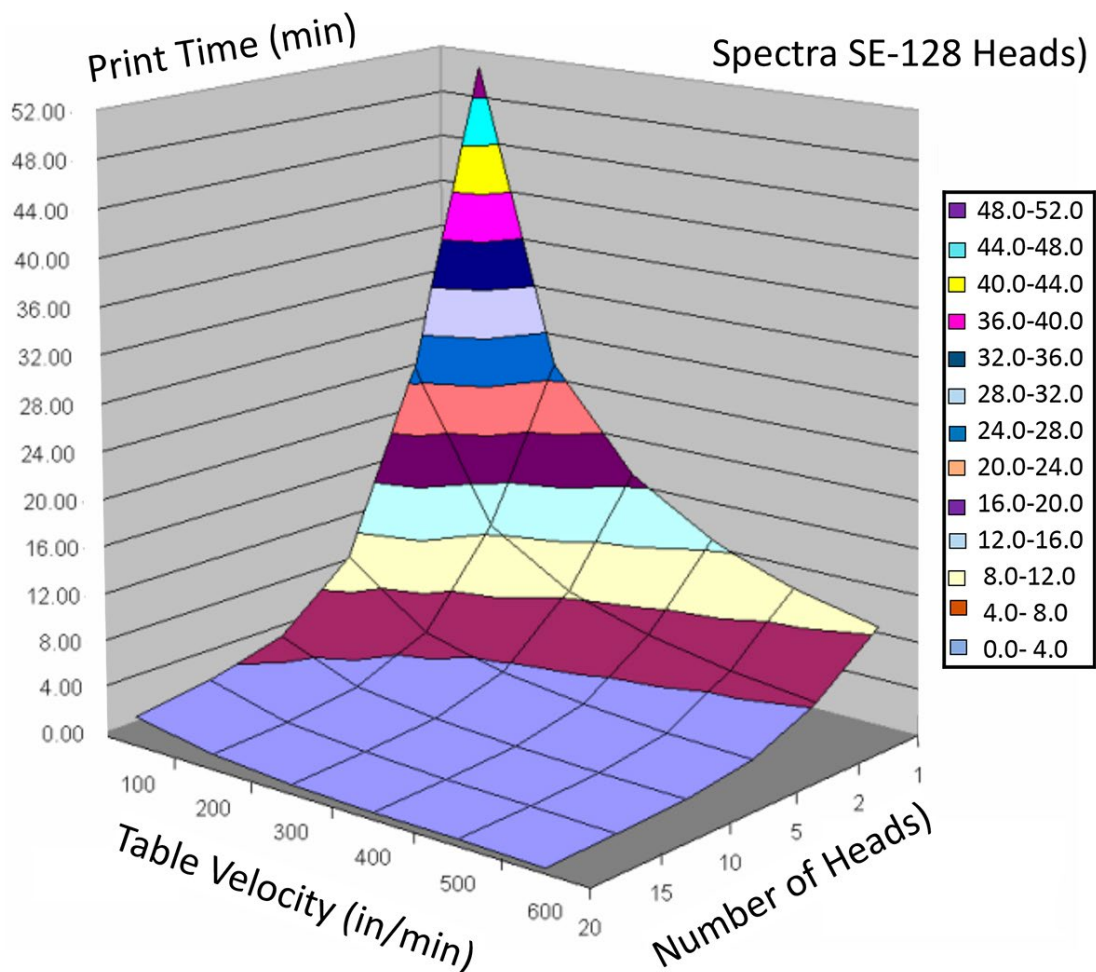


Figure 6: Various print times as a function of the table speed and number of printheads<sup>3</sup>.

The sensitivity of print time vs. number of heads is seen in Figure 6.

For advanced systems, large panel throughput can be:

- 17.0" x 22.8": 17 seconds
- 20.0" x 24.0": 27 seconds
- 24.0" x 30.7": 31 seconds

## Applications

The advantages of inkjet printing as a method of solder masking and legend printing are well established. As an etch resist for inner layer etching it has an advantage down to <70 micron traces and spaces. The growing application is for the additive printing of conductive traces. Silver nanoparticles now prevail but copper nanoparticle inks are growing, and carbon nanotubes will soon be here.

The market for inkjet printheads will grow to \$3.3 billion by 2024 (Figure 7).

## Conclusion

From its simple beginnings as a quiet way to print on plain paper, inkjetting has grown up. This is because the head technology is being modified to use a much greater variety of materials to jet. Here are 12 applications of inkjet technology, and the list is growing:

- Antenna: For example, wireless, mobile phones, IIoT, mil/space, CB
- Membrane switch: Keypads
- Capacitors, resistors, and inductors
- Shielding: For example, RFI and EMI
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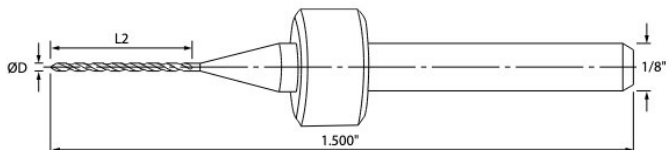


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**REPOINTING** will be a new service offered by Insulectro through Kyocera. The company has recently invested in automated, state-of-the-art equipment and all repointing will be done in Southern California.



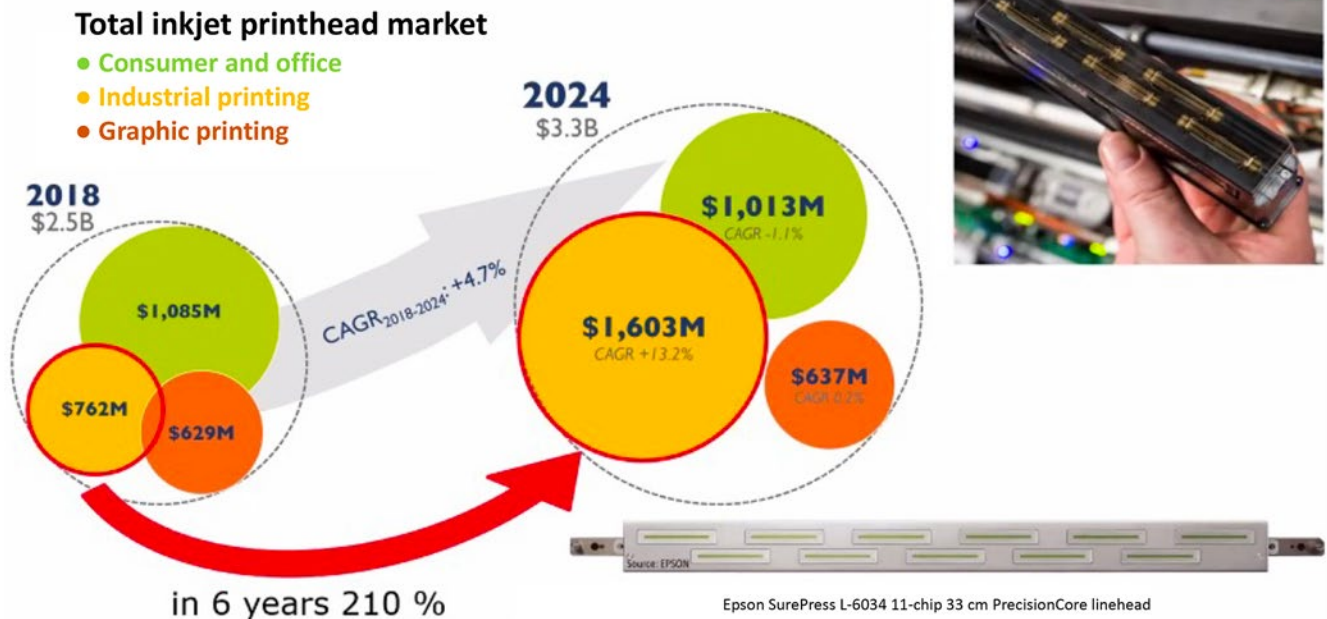


Figure 7: Prediction of the growth of inkjet printhead sales for consumer, industrial, and graphics printing. (Source: YOLE Development<sup>3</sup>)

- RFID inlays/tags and Smart cards, e-passport/ID cards
- Electroluminescence, touch panels and other displays
- Automotive and telecom
- Medical and diagnostic devices
- Heater circuits
- Replacement of gold plating on switches

As it competes with dry film photoresists, inkjet technology still has some significant challenges for the machine manufacturers to overcome, including making sharp corners (drops will always produce a curve), getting track edges as smooth and straight as possible, replicating standard industry practices such as tenting, and ensuring printhead maintenance programs to avoid nozzle blockages, but it's on its way. **PCB007**

## References

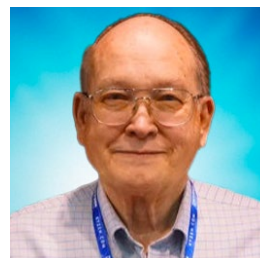
1. Columns by Karl Dietz in *The PCB Magazine*: Tech Talk #73, October 2001; Tech Talk #137, February 2007.

2. "Digital and Environmental Circuit Board Manufacturing Based on Continuous Laser Assisted Deposition," Ralph Birnbaum, et al, IPC APEX 2022.

3. "The Use of Inkjet Printing Technology for Fabricating Electronic Circuits—The Promise and the Practical," by Thomas Sutter and Brian Amos, IPC APEX EXPO 2012.

4. "Customizable Capacitive Sensor System Using Printed Electronics on Window Glass," by Jan Frohlich, et al, SMTA Pan Pacific Symposium 2020.

5. "Inkjet Printing for Printed Electronics," by Ashlok Sridhar, Fraunhofer Research Institute for Electronic Nano Systems (ENAS), Material Matters, Volume 6 Article 1, 2019.



**Happy Holden** has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa Westwood, Merix, Foxconn, and Gentex. He is currently a contributing technical editor with I-Connect007, and the

author of *Automation and Advanced Procedures in PCB Fabrication*, and *24 Essential Skills for Engineers*. To read past columns, [click here](#).

# Why Choose Fein-Line?

Because there is a fine line between winning and the alternative.

**Fein-Line Associates** is a consulting group serving the global interconnect and EMS industries, as well as those needing contact with and/or information regarding the manufacture and assembly of PCBs. Dan (Baer) Feinberg is a 50+ year veteran of the printed circuit and electronic materials industries. Dan is a member of the IPC Hall of Fame; has authored over 150 columns, articles, interviews, and features that have appeared in a variety of magazines; and has spoken at numerous industry events. As a technical editor for I-Connect007, Dan covers major events, trade shows, and technology introductions and trends.

Fein-Line Associates specializes in:

- Management consulting
- Technology transfer
- New product market entry
- Merger and acquisition due diligence
- Market information and market research
- Expert witness assistance and seminars regarding all aspects of printed circuits
- Electronic assembly manufacturing and marketing

**Fein-Line Associates**

P.O. Box 73355

San Clemente, CA 92673

Telephone: (949) 498-7866

Email: [baer@feinonline.com](mailto:baer@feinonline.com)



Dan (Baer) Feinberg



[www.feinonline.com](http://www.feinonline.com)



# What's Going On in Congress?

## Your Handy Guide to PCB Legislation Headlines

by Michelle Te

The U.S. Congress is now in summer recess, so it seems like the perfect time to look back on how legislators finally addressed the needs of the microelectronics industry. We feel confident in saying there has never been a time when the floors of Congress gave our industry so much emphasis. For the past six months, there has been constant activity from lobbyists, legislators, semiconductor and printed circuit board associations, and individu-

als who want to bring more electronics production back to the United States.

We know you have so many questions about what the legislation means for you. Will there be funds to expand or upgrade my facilities? What about tax breaks? How will my specific needs be known? What will the current legislation mean for U.S. vs. China relations? Use this handy guide to get caught up, sort out the CHIPS from theUSICAs, and be that someone who talks knowledgeably at dinner parties.

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### I-Connect007 Exclusive Coverage

- [Is the U.S. Government Ready to Meet the Test of Technological Leadership?](#) a column by John Mitchell, president and CEO of IPC
- [Printed Circuit Boards: Past the Lobby and Onto the Floor](#), an interview with Travis Kelly, CEO of Isola Group and chairman of PCBAA, and U.S. Rep. Blake Moore, R-Utah
- [A Deeper Look at the CHIPS Investment Act](#), An interview with Chris Peters, executive director of USPAE
- [DoD is Unarmed Without the PCB](#), a column by Travis Kelly, CEO of Isola Group and chairman of PCBAA
- [What Happens in Washington Happens to Us All](#), a column by Travis Kelly, CEO of Isola Group and chairman of PCBAA
- [A Voice in Washington for American-Made PCBs](#), a column by Travis Kelly, CEO of Isola Group and chairman of PCBAA

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### PCB Semiconductor Legislation News

- [IPC Lauds Passage of 'CHIPS and Science' Act; Electronics Industry Calls for a Holistic Approach to Reviving Domestic Electronics Capabilities](#) (Published Aug. 9)
- [FACT SHEET: CHIPS and Science Act Will Lower Costs, Create Jobs, Strengthen Supply Chains, and Counter China](#) (Published Aug. 9)
- [IPC Commends House on Passage of CHIPS+ Legislation](#) (Published July 28)
- [IPC: Electronics Manufacturing Industry Applauds Senate Passage of CHIPS+ Legislation](#) (Published July 28)
- [SEMI Applauds Final Passage of CHIPS and Science Act of 2022](#) (Published July 28)
- [SEMI Applauds Senate Progress on Chips Act of 2022, Urges Timely Congressional Approval](#) (Published July 21)
- [IPC Urges U.S. Senate and House to Complete R&D Legislation Before August Recess](#) (Published July 20)
- [IPC: Over 100 Industry Executives Urge U.S. Congress to Strengthen Electronics Supply Chain](#) (Published July 14)
- [SIA Calls for House Passage of Legislation to Advance U.S. Technology Leadership](#) (Published June 30)
- [Senate Passage of USICA Marks Major Step Toward Enacting Needed Semiconductor Investments](#) (Published June 11)

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*Manufacturers of precision Micro-Machining  
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## **COBRA II Hybrid Laser**

*UV and CO2 lasers  
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*Low-cost, 4-station precision drilling  
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## **154L**

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Single station with vision options*



## **HS-2L**

*High-speed, 2-station drill or router  
w/populated board routing option*

**Move into the future with the latest innovations  
in Fabrication Technology from the Industry Leader!**



## One World, One Industry: Opening New Opportunities in Mexico

IPC and WHMA have long supported the electronics assembly and wire harness manufacturing industries in Mexico, but recent regional growth coupled with supply chain disruptions necessitated a closer relationship. Lorena Villanueva, the new director of IPC Mexico, will be based in Mexico City and her presence will help IPC provide better support, training, and engagement with Mexico-based companies and personnel.

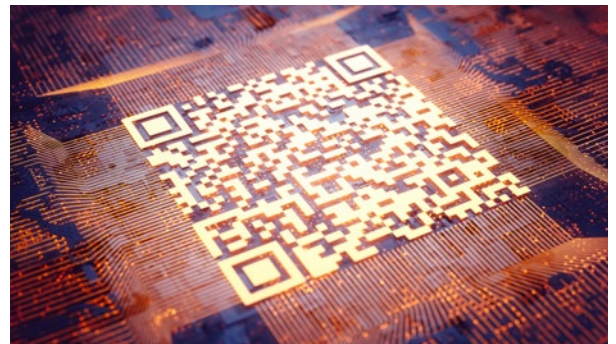


### NCAB Group Releases Q2 2022 Interim Results

Net sales increased by 47% to SEK 1,122.0 million (762.2). In USD, net sales increased 25%. For comparable units, net sales increased by 35%, and in USD 15%. During the second quarter, our good performance continued, and we are pleased to note strong net sales and very good cash flow. This is despite continued problems with component shortages that many of our customers are experiencing.

### Testing Todd: ET and the DoD

Building printed circuits can be a tricky business. There are many attributes that go into the production process—initially, the sales interface with the customer, and the receipt of the data for the initial quotation. Then there is the procurement process for raw materials. This has to be done to the customer specifications.



### IPC Announces First Standards Development Task Group in Japan

For the first time, IPC has formed a task group in Japan. The 7-31 BV-JP IPC J-STD-001/IPC-A-610 Automotive Addendum Task Group held its first meeting in June to introduce task group members, discuss the IPC Works standards collaboration platform, and create a schedule for future task group meetings.

## The Plating Forum: Plating in Electronic Applications

Plating occurs when the metal ion in an aqueous solution is reduced to the metal:  $M^+$  metal ion +  $e^-$  reducing electron =  $MO$  deposited metal. Plating can achieve numerous functional and aesthetic goals, including improve solderability, inhibit corrosion, increase hardness/durability, decorate objects (jewelry), reduce friction, alter conductivity, and improve IR reflectivity.

### Happy's Tech Talk #9: Radars, Missiles, and the World's Costliest Computer



What was the world's costliest computer and why? The answer is not today's supercomputers, nor computers built during World War II. Instead, it lies in a real-time air defense radar system

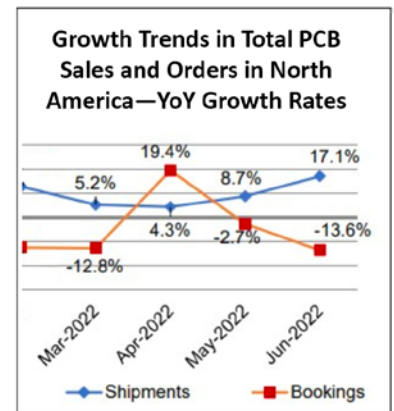
built during the height of the Cold War of the 1950s that had left the U.S. extremely vulnerable to a Soviet bomber attack.

### PCB Finance Class With Jeff De Serrano



Class is in session! PCB Technologies President Jeff De Serrano takes us through some of the struggles of the PCB industry over the past 30 years, how U.S. legislation seeks to level the playing field, and whether a “monopoly” of fabricators is healthy for our industry. In his chat with Nolan Johnson, Jeff gets out his investment playbook and talks strategy.

### North American PCB Industry Sales Up 17.1% in June



IPC announced the June 2022 findings from its North American Printed Circuit Board (PCB) Statistical Program. The book-to-bill ratio stands at 1.03.

### Additive Reality: Drop It, and Enjoy the Greenback

This last column will start by introducing the main change in the manufacturing compromise and then the general details on pay-back period. Presently, traditional solder mask has been a balance between accuracy and throughput. Inkjet brings one more dimension: the copper thickness.

### A Primer on M&A With Tom Kastner

Tom Kastner of GP Ventures is a busy man these days. He's been involved in several M&A deals, including a recent acquisition by Summit Interconnect. Tom spent some time with Dan Beaulieu to discuss what it looks like when a company is thinking of buying or selling—and how a consultant can help negotiate the best deal.



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



# Career Opportunities



## Is your team growing?

**Find industry-experienced candidates at I-Connect007.**

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:

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- appear in our monthly [Careers Guide](#), emailed to 26,000 potential candidates

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GOOD FOR THE INDUSTRY



# 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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## Electrical Engineer/PCB/CAD Design, BOM/Component & Quality Support

Flexible Circuit Technologies (FCT) is a premier global provider of flex, rigid flex, flex heaters, EMS assembly and product box builds.

### Responsibilities:

- Learn the properties, applications, advantages/disadvantages of flex circuits
- Learn the intricacies of flex circuit layout best practices
- Learn IPC guidelines: flex circuits/assemblies
- Create flexible printed circuit board designs/files to meet customer requirements
- Review customer prints and Gerber files to ensure they meet manufacturing and IPC requirements
- Review mechanical designs, circuit requirements, assembly requirements, BOM/component needs/and help to identify alternates, if needed
- Prepare and document changes to customer prints/files.
- Work with application engineers, customers, and manufacturing engineers to finalize and optimize designs for manufacturing
- Work with quality manager to learn quality systems, requirements, and support manager with assistance

### Qualifications:

- Electrical Engineering Degree with 2+ years of CAD/PCB design experience
- IPC CID or CID+ certification or desire to obtain
- Knowledge of flexible PCB materials, properties, or willingness to learn
- Experience with CAD software: Altium, or other
- Knowledge of IPC standards for PCB industry, or willingness to learn
- Microsoft Office products

FCT offers competitive salary, bonus program, benefits package, and an outstanding long-term opportunity. Location: Minneapolis, Minn., area.

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# Career Opportunities



**ventec**  
INTERNATIONAL GROUP  
騰輝電子

## European Product Manager Taiyo Inks, Germany

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

### Duties include:

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

### Skills and abilities required:

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

### What's on offer:

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

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

[apply now](#)



## Director of Operations State College, PA

Chemcut Corp., a world leader in wet processing equipment for the manufacture of printed circuit boards and chemical etching of various metals, is seeking a Director of Operations.

### Objectives of the Role:

- Collaborate with the CEO in setting and driving organizational vision, operational strategy, and hiring needs.
- Oversee manufacturing operations and employee productivity, building a highly inclusive culture ensuring team members thrive and organizational outcomes are met.
- Directly oversee manufacturing operations, production planning, purchasing, maintenance & customer service (product support) and partner with the CEO and controller on sales management to budget for sufficient investment capital to achieve growth targets.
- Aggressively manage capital investment and expenses to ensure the company achieves investor targets relative to growth and profitability.

### Qualifications:

- Bachelor's degree in mechanical, electrical, or related fields
- 5+ years' experience in leadership positions
- Leadership skills, with steadfast resolve and personal integrity
- Understanding of advanced business planning and regulatory issues
- A solid grasp of data analysis and performance metrics
- Ability to diagnose problems quickly and have foresight into potential issues

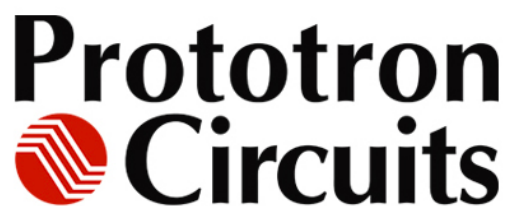
### Preferred Qualifications:

- Master's degree in business or related field
- International business experience

To apply, please submit a cover letter and resume to [hr@chemcut.net](mailto:hr@chemcut.net)

[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 New England 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.

[apply now](#)



## 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



## Regional Manager Midwest Region

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

### DETAILS OF FUNCTION:

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

### QUALIFICATIONS:

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

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

fernando\_rueda@kyzen.com

[apply now](#)



## 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



## SMT Field Technician Hatboro, PA

Manncorp, a leader in the electronics assembly industry, is looking for an additional SMT Field Technician to join our existing East Coast team and install and support our wide array of SMT equipment.

### Duties and Responsibilities:

- Manage on-site equipment installation and customer training
- Provide post-installation service and support, including troubleshooting and diagnosing technical problems by phone, email, or on-site visit
- Assist with demonstrations of equipment to potential customers
- Build and maintain positive relationships with customers
- Participate in the ongoing development and improvement of both our machines and the customer experience we offer

### Requirements and Qualifications:

- Prior experience with SMT equipment, or equivalent technical degree
- Proven strong mechanical and electrical troubleshooting skills
- Proficiency in reading and verifying electrical, pneumatic, and mechanical schematics/drawings
- Travel and overnight stays
- Ability to arrange and schedule service trips

### We Offer:

- Health and dental insurance
- Retirement fund matching
- Continuing training as the industry develops

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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

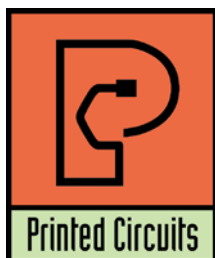
### Benefits

- 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



## Printed Circuits, a fast-growing printed circuit board fabricator, offers:

- Excellent opportunities for advancement and growth
- Dynamic manufacturing environment
- Excellent health, dental and other benefits
- Annual profit-sharing plan
- Signing bonus
- Additional incentives at the leadership level
- Clean facility with state-of-the-art manufacturing equipment
- Highly collaborative corporate and manufacturing culture that values employee contributions

## Laminator Technician

### Nature of Duties/Responsibilities

- Layup cover lay
- Layup rigid flex
- Layup multilayer/CU core boards
- Oxide treat/cobra treatment of all layers/CU cores
- Shear flex layer edges
- Rout of machine panel edges and buff
- Remove oxide/cobra treatment (strip panels)
- Serialize panels
- Pre-tac Kapton windows on flex layers (bikini process)
- Layup Kapton bonds
- Prep materials: B-stage, Kapton, release sheet
- Breakdown: flex layers, and caps
- Power scrub: boards, layers, and caps
- Laminate insulators, stiffeners, and heatsinks
- Plasma cleans and dry flex layers B-stage (Dry)
- Booking layers and materials, ready for lamination process
- Other duties as deemed necessary by supervisor

### Education/Experience

- High school diploma or GED
- Must be a team player
- Must demonstrate the ability to read and write English and complete simple mathematical equations
- Must be able to follow strict policy and OSHA guidelines
- Must be able to lift 50 lbs
- Must have attention to detail

## Wet Process/Plating Technician

Position is 3<sup>rd</sup> shift (11:00PM to 7:30AM, Sunday through Friday)

### Purpose

To carry out departmental activities which result in producing quality product that conforms to customer requirements. To operate and maintain a safe working environment.

### Nature of Duties/Responsibilities

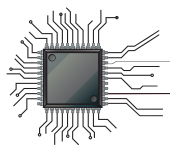
- Load and unload electroplating equipment
- Fasten circuit boards to racks and cathode bars
- Immerse work pieces in series of cleaning, plating and rinsing tanks, following timed cycles manually or using hoists
- Carry work pieces between departments through electroplating processes
- Set temperature and maintains proper liquid levels in the plating tanks
- Remove work pieces from racks, and examine work pieces for plating defects, such as nodules, thin plating or burned plating
- Place work pieces on racks to be moved to next operation
- Check completed boards
- Drain solutions from and clean and refill tanks; fill anode baskets as needed
- Remove buildup of plating metal from racks using chemical bath

### Education and Experience

- High school diploma or GED required
- Good organizational skills and the ability to follow instructions
- Ability to maintain a regular and reliable attendance record
- Must be able to work independently and learn quickly
- Organized, self-motivated, and action-oriented, with the ability to adapt quickly to new challenges/opportunities
- Prior plating experience a plus

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# Career Opportunities



## MivaTek

Global

### Field Service Technician

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

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

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

Do you have 3 years' experience working with direct imaging or capital equipment? Enjoy travel? Want to make a difference to our customers? Send your resume to [N.Hogan@MivaTek.Global](mailto: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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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](mailto: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](http://www.arlonemd.com)

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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.

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# Career Opportunities



## IPC Instructor Longmont, CO; Phoenix, AZ; U.S.-based remote

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### 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](mailto:sharonm@blackfox.com).

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**American Standard Circuits**

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## CAD/CAM Engineer

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

### ESSENTIAL DUTIES AND RESPONSIBILITIES

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

### ORGANIZATIONAL RELATIONSHIP

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

### QUALIFICATIONS

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

### PHYSICAL DEMANDS

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

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# 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.

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Pay will be commensurate with experience.

Mail to:  
mfariba@uscircuit.com

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## 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](http://APCT.com) and encourage you to understand our core values of passion, commitment, and trust. If you can embrace these principles and what they entail, then you may be a great match to join our team! Peruse the opportunities by clicking the link below.

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

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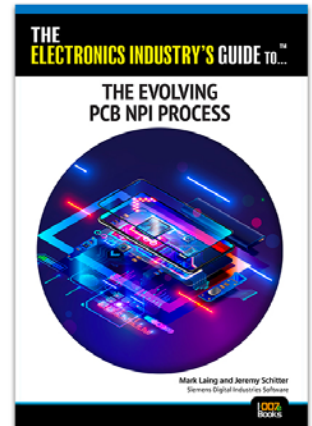
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# PCB007

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