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MAGAZINE

Inflation—Supply and Demand

As the world emerges from pandemic disruptions, we find that market balances have changed. In this issue we look at the conditions that are shifting supply lines as well as product costs.



10



20

10 **FEATURES**
Riding the Wave of Copper Inflation Pricing
Interview with Mark Goodwin



20 **Feeling the Supply Chain Squeeze**
Interview with Joe D'Ambrisi



28



28 **The Demand for Copper**
Interview with Michael Coll and Chris Stevens



36 **Economic Drivers Take Us 'Up, Up, and Away!'**
by Shawn DuBravac



40 **DFM for Your PCBs**
Interview with Greg Link



40



68

54 **Navigating Current Market Dynamics**
Interview with Mark McMeen



68 **Isola Responding to the Market**
Interview with Travis Kelly

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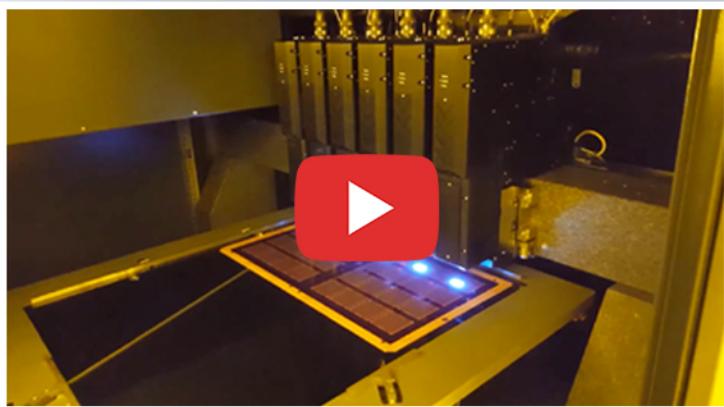
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SHORTS

- 39** NASA's Curiosity Rover Finds Patches of Rock Record Erased
- 77** Hire or Be Hired at jobConnect007
- 88** New I-007 eBook Highlights System Analysis

FEATURE COLUMNS

- 50** Working Through Shortages
by Anaya Vardya
- 64** A Series of Questions on Price Increases
by Michael Carano
- 78** The PCB Limbo—
How Low Can You Go?
by Todd Kolmodin



COLUMNS

- 8** Inflation and the Changing Supply Chain
by Nolan Johnson
- 84** Leadership 101—The Laws of Respect, Intuition, and Magnetism
by Steve Williams

DEPARTMENTS

- 93** Career Opportunities
- 110** Educational Resource Center
- 111** Advertiser Index & Masthead



HIGHLIGHTS

- 48** EIN007 Industry News
- 62** PCB007 Suppliers
- 82** MilAero007
- 90** Top 10 from PCB007



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Inflation and the Changing Supply Chain

Nolan's Notes

by Nolan Johnson, I-CONNECT007

It hasn't happened since 2008, the news sources at CNBC reported ^[1]. Headline consumer prices rose 5% in May 2021, higher than Wall Street expected. That bump also represented the fastest pricing adjustment in the Consumer Price Index since 2008. Prices were up across the board, due to a variety of factors, ranging from pandemic shutdowns ricocheting through the supply chain, to shipping delays, to increased demand from new market sectors.

Tellingly, it was surging car prices that seemed to be the biggest single driver of the inflation gains. CNN Business reports, "Massive job losses and a shift to working from home caused a 30% plunge in auto sales, the biggest quarterly decline since the Great Recession," but continues with, "Now sales are booming...but that demand is coming at a time when auto plants around the globe are closed or running at reduced production due to a computer chip shortage. New car production in North America is down about 3.4 mil-

lion vehicles in the first three months of this year, according to Cox Automotive."^[2]

If you're reading the industry news, then you're undoubtedly already familiar with the semiconductor supply chain issues. We devoted an issue or two to the supply chain back at the start of 2019, in fact. If your job includes procurement of the components, you may be nursing an ulcer from the experience lately. Talk with the experienced folk and they'll tell you they've never seen anything quite like this before. The combination of the shutdowns and the huge demand for components in the automotive and auto infrastructure industries are



massive drivers. The “Exchanges at Goldman Sachs” podcast series released an episode in May 2021 titled “Copper Is the New Oil.” Copper is now strategically the most important raw material on the planet.

Mine supply investment is, at best, just beginning. Goldman Sachs suggests that the supply gap for copper is approximately 8 million tons. But it takes at least five years to build out a copper mine, and there have been no new applications for copper mines in the last 18 months.^[3]

Meanwhile, SEMI reports that there are 19 new semiconductor fabs slated for build-out in 2021, and an additional 10 in 2022, a total build cost of about \$140 billion.^[4] Government and industry attention is on the chips; everyone pays attention to the semiconductors. No new copper, however, and no new PCB fabricators to speak of. Just as the automobile industry comes to a screeching halt when the chips aren’t available, the industry will also be forced to stand down should PCB fabrication be unable to keep up. And that day is coming.

All these market factors exert their pressure on our supply chain—especially the raw materials. Copper is a common theme in this issue, what with a rapidly changing market situation. In fact, while we were preparing this magazine, China released a series of industrial metals—as reported by Reuters—from its national reserves to stabilize market prices. Authors and interviewees have worked right up

to the deadline to keep the content in this issue as fresh and accurate as possible.

In this issue, copper market perspectives (along with commentary on glass fabric and resin supply shortages) come from Mark Goodwin at Ventec and Michael Coll at Denkai America. IPC’s Shawn Dubravac weighs in with a high-level market analysis. MacDermid Alpha’s Joe D’Ambrisi discusses the supply chain squeeze in chemistries. Greg Link from WUS and I-Connect007 columnist (and ASC president) Anaya Vardya discuss the pressures on fabricators to work through the current shortages.

There is no easy answer to these new dynamics but what we can conclude is that this will be our new norm for some time. **PCB007**

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Nolan Johnson is managing editor of *PCB007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To contact Johnson, [click here](#).

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Feature Interview by the I-Connect007 Editorial Team

In this interview with Ventec's Mark Goodwin, he discusses the rising inflation hitting the electronics industry at the same moment as shortages of copper and other raw materials. He believes that, while the PCB industry has endured cycles like this before, this one feels different.

Nolan Johnson: We're seeing indicators that we can expect a cycle of inflation in our industry and the wider economy in general.

Mark Goodwin: Yes, I think it is wider than our industry.

Dan Feinberg: And I think it's more than expecting. I think we're in it.

Goodwin: Absolutely correct.

Johnson: For people who have been in the industry fewer than 20 years, they've never seen a cycle like this in electronics.

Goodwin: Those who were here in 2000 have seen it. This comes around every now and then in our industry. I think this one's slightly different, though. The last one was driven purely by an uptick in demand. This one is an uptick in demand, but the demand uptick is going to get worse. Just look at 5G. We have a lot of 5G infrastructure-type things going on now with the rollout. There will be more devices being built, and they will all need PCBs as well. This is not going away anytime soon. At the same time, I worry about copper foil because, while we have the whole decarbonization of global economies and a move toward e-vehicles and green energy, we need to store that energy in batteries.

I've seen some frightening figures on the disparity between the requirement for copper for all of these things and the availability of copper. We already know that copper foil production is pretty much in balance with supply and demand. But the demand is going to go up far faster in the next three to five years than the capacity, and there are some real constraints on capacity. There are only really one or two companies in the world that make the plat-

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BY TAIYO



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ing drums for copper foil, and the lead time for these drums is 18 months to two years. I'm sure they've got a lot of orders already from the guys that are building capacity for ultra-thin foils for batteries. And the foil guys want to make battery foil. It's five microns, it's nine microns. It doesn't have treatment on the back. It's easy for them, and the [battery] guys are prepared to pay for it.

Feinberg: I've been in this industry since the late '50s and I've been through probably three or four of these cycles. But this one may be just a little different. This time I'm seeing a confluence of factors that are hitting us all at the same time.

Johnson: What are these factors?

Goodwin: In our business, the demand for PCBs is growing. The layer count in PCBs is going up, thus the need for more copper. Other industries are demanding copper, but they're also demanding glass fabric. Wind turbines use glass fabric, and there's a lot of investment and government policy driving in that direction. There's also post-pandemic logistics, which is still horrible, but I think it's the least of the worries. Prices for shipping goods from Asia to Europe are three to four times what they were pre-pandemic, and Asia to the U.S. is four times more.

Happy Holden: Don't forget electric vehicles, which need 4-ounce to 12-ounce copper.

Goodwin: There's something like four times the amount of copper required in an electric vehicle compared to an internal combustion engine vehicle. This is just electronics, but there's demand outside of electronics for all these commodities as well. Today, I got some things over my desk with regard to the price of wood, and you think, "What's wood got to do with printed circuit boards?" But wood is used in drilling printed circuit boards as a drill backup ma-

terial. Wood prices have increased dramatically because the crop yield is low due to issues around global warming. I don't know whether that's true, but that's the message.

On the one hand, we have anti-dumping tariffs being implemented on aluminum shipments from Asia to Europe. On the other, the European guys can't keep up with the demand. We tried to buy aluminum in Europe, and there is a 22-week lead time. I can get it faster from China. The anti-dumping tariffs are a blunt instrument. They hit things—the high-end things—that are manufactured in Europe and the U.S. They also hit the low-end things that we want from China and then cause another roadblock to what we're trying to do.

Feinberg: Everyone must start planning for price increases—as one person plans for it, the next person in the supply chain has to plan for cost increases as well. Because of this, you have to think about ways to reduce your other costs so that your price increases don't go up as much as your competitor's. Otherwise, not only does your price go up, but your market share goes down.

Goodwin: Here are some other things to consider. First, we started talking to the market about this back in December, and it's been happening. The real start was the middle of 2020, with the real impact felt in Q4 2020, and it's just gotten worse. China and Asia have been exporters of deflation for 25–30 years, and for the next period, they will be an exporter of inflation. The price of rigid laminate is still, in dollar terms, around the price I was selling rigid laminate in 1995. That's not inflation-adjusted; that is in real dollars. So, to some degree, people need to get used to this. There is a real reset going on, and there will be a period of adjustment until such time as supply outstrips demand again; prices will continue to rise and now is the time to think about it and factor it into your decisions.

The fact is, we can sell every square meter of laminate we make; pricing in Asia now is higher than pricing in the U.S., and higher than pricing in Europe. Certainly, when you volume-adjust, the size of the orders you're processing is a better business in Asia than it is in the West right now for the Asian laminators. Everybody in the U.S. and Europe says, "It cannot be that laminate prices have gone up like this." At least in Asia, they work with a commodity mentality, so they know when markets are tight or imbalanced or to expect increases, and they'll do things to mitigate it. They will try to stockpile, and manage supply and demand. They'll try to give you bigger orders. They'll try and give you visibility.

One thing we're still not getting enough of is any kind of visibility from a European and U.S. customer base, and that doesn't make it any easier. In fact, it makes it a whole lot worse, and I keep hearing people talk about how we'll bring it back onshore. Who's going to make that investment? Where are they going to get their raw materials? It's not happening. Offering quick-turn manufacturing solutions in key regional locations close to customers makes sense to me. But having a volume manufacturing facility—why now? Because in real laminate volume terms, there is no volume anywhere but Asia.

We're saying we don't want to make rigid laminate anymore because we can sell all our capacity making thin laminate, and just look at the relative price today. Rigid laminate is still underpriced.

Feinberg: And that's another factor. We have this pull to raise prices that has been delayed. Once that rubber band snaps...

Holden: Why should boards be 0.062”?

Goodwin: You tell me. I tried 20 years ago in Europe to get people away from 1.6 mm, 0.062”. Why not make them all on 1.2 mm and get rid of two plies of glass fabric? There are no edge



Mark Goodwin

connectors anymore. It's not like the old days where it all used to be driven by edge connectors. That's all gone. The product is still rigid enough to support the components, and it saves two pieces of glass fabric. Will anybody do it? No.

Holden: People are going to say, "What's the easiest way to cut costs or material usage?" Well, make the board thinner. What's important is the distance between signal and ground or power and ground. If you arbitrarily just put cores in there to make it 1.6 millimeter or two millimeters, then you're just wasting money on something that is not buying you any performance.

Johnson: Do you see this confluence creating a drive for new technologies or new manufacturing techniques? Moving to additive rather than subtractive is one way to save, it seems. Changing the thought patterns with respect to laminate specification is another. Then there's redesigning so you're using less material, copper, or laminate by having fewer layers.

Goodwin: The technologies exist today, but the question is how to get the market to adopt them. There are things that we could all do to-

day, but people in this business are conservative. They just do not like change. We're talking about overall thickness; forget multilayer circuits for a minute. Let's just think about a double-sided rigid circuit. Why 1.6? Why not 1.2? Why not 1.4? You could take one or two pieces of 7628 fabric out, and the board would still be rigid enough to support the components. Why not?

Johnson: Can we list out what some of those adjustments could be? There is a list of things that can be done to change how you approach the material selection to improve this. What can the designer do to help reduce the use of resources and spread the copper, so to speak?

The one I would be fundamentally worried about for the next five years or more is copper. I think copper is going to be a real problem.

Goodwin: To be honest, thinner coppers, thinner layers, the thinner overall thickness of a printed circuit board. It's so obvious, but I'm a materials guy. I'm not an electronics guy. I can't tell you how easy it is for some of these things to be done. I'm sure some things can't be done, but I'm pretty sure there's a number of things that can be done to conserve resources. The one I would be fundamentally worried about for the next five years or more is copper. I think copper is going to be a real problem.

Barry Matties: What's your worry behind that, Mark?

Goodwin: Everybody wants copper. The whole world is trying to take carbon out of its infra-

structure. You need copper for electric vehicles. You need copper for the high-layer count infrastructure boards for 5G. Then you've got all the internet-of-things devices that will be developed to go on that 5G that are going to need copper. People want to store energy from the sun when the clouds come along, or they want to store energy when the wind turbine stops turning, and for this we need copper for batteries. The demand for copper is everywhere; it is well-published. For example, Goldman Sachs is saying "Copper is the new oil," and they called a bull market in copper at the end of 2020 for the next five to 10 years. We're seeing a little bit of fluctuation at the moment. That's where people are taking some profit in speculation, but the run on copper is not over, and it's going to be a huge problem in my opinion.

Matties: Are you seeing an increase in mining for copper?

Goodwin: It's starting, but that's copper, and then the other problem in this industry is we've got to have plated copper, electrodeposited copper foil, that's also required. The demand for batteries is far higher than the demand in our business, the lead time for building these plants to produce copper is very long, and the demand is increasing far faster than the manufacturing capacity to fulfill that demand. I think the pressure on copper is going to be there between now and when I finish in this business.

Matties: How much increase in pricing do you expect over the coming year?

Goodwin: You've seen what the LME has done. The LME broke the 2011 high, and I've seen numbers where Goldman Sachs and these guys who know better than me say they think raw copper can go at least 50% higher than it is today. So that's huge, but then you've got conversion costs of copper as well. And if it's easier to produce battery foils and thinner foils

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than those demanded by our industry, and if we're to convince these guys to do the things we need them to do, we're going to have to pay the price. Copper foil factories don't spring up overnight; the lead time and the investment is huge. You've got to think that the foil guys are also going to enjoy their day in the sun a little bit because, of course, all the OEMs want more capacity, so prices come back down. These guys will want to fulfill demand at just about the right pace, so they get a good return on their investment for some time.

Matties: Of course, all of this is going to translate into higher board prices. In the U.S., we're already seeing the inflation and it looks like it's here to continue.

Goodwin: There may be a little bit of pressure to come off on glass fabric, resins, and things like that, as increases start to slow. But copper foil has a long way to run as the price of 0.062" rigid right now, in dollar terms, is the same as it was in 1995 without any inflation adjustment. So, people are talking about prices going up, and prices are still relatively low.

Feinberg: The price is the same, but what's the cost?

Goodwin: That's a good question, the cost is higher. The margins in the business 20 years ago were great as a laminator. Margins for laminators right now are a little bit better than they were one to two years ago, but they were really bad then.

Feinberg: That's exactly my point. If, in fact, you're selling everything you can make, why wouldn't you raise prices? People are going to start to get that idea, and that's going to be another accelerator and all these acceleration factors on pricing are coming together at the same time. That's a little bit scary when you're talking about inflation.

Goodwin: I think the U.S. is behind Europe in understanding what's going on in Asia right now in terms of the raw materials and laminate. And that is because people have started to understand that it's now about securing your supply chain as well as about negotiating the price. Of course, they're still negotiating the price, but the continuity of supply is as important now as a discussion about price because without flour you can't make bread.

Matties: And it's a seller's market. The negotiations are clearly in your favor.

Goodwin: Yes, but we also recognize that we will come out the other end of this, so we try to mitigate cost with efficiencies.

Feinberg: If you're concerned about market share and you have to increase prices, you're going to keep them to the minimum. If you're not concerned about market share, then that takes away one of the brakes on price increases. And as different competitors raise prices so will the others—either that, or their stockholders are going to fire them.

Johnson: Mark, you made the point that the copper pressures are going to be here for five years or more. What other pressures concerning materials, raw materials, finished goods, do you see here in the next two years?

Goodwin: Glass fabric is still a big one. There are a lot of industries using glass fabric other than ours. In the UK now there is a major shortage in building materials, and there's a lot of glass fabric in the construction industry. The green economy requires glass fabric for wind turbine blades and these kinds of applications. The pressures are everywhere.

Feinberg: Another factor of copper is the use of electroless copper for through-hole interconnect. Happy, what's the variation in cost of direct metallization vs. electroless copper?

Holden: Half the price. Not only half the price, but now we have tests to show it is higher reliability. In other words, we're going to put in millions of dollars of American taxpayer money to try to figure out what's wrong with electroless copper when we already know that direct metallization doesn't have the failure mechanism of electroless copper. But the U.S. government and the U.S. Air Force don't allow direct metallization, so until the military switches and comes up to the 21st century, they're going to spend taxpayer dollars to try to figure out what's wrong with electroless copper.

Goodwin: This is the problem. This time around my belief is that the market is going to have to accept some technology change because this one's going to go on longer than all of the others. The question is when will that thought lodge in people's minds and they start thinking that we've got to do some things differently now?

Johnson: Mark, a lot of this conversation has suggested current standards are behind the times. In your opinion, where should we be right now about laminates and processes?

Goodwin: Our belief is specification should be driven by performance, not resin chemistry, for a start. That could be performance in many ways—reliability, electrical, thermal—but as long as the chemistry is, should we say, environmentally and health and safety compliant, that should be left with the polymer chemists to deal with.

It's performance that is interesting to everybody but, from my perspective, that's not anything to do with the supply chain. On the supply chain question, I still don't think people are grasping that there is a fundamental change this time, and this is just the first wave.

The second wave is once we've got all this 5G infrastructure, smart people will build lots of devices to talk to each other. When IoT happens, everything's going to have a printed circuit board in it, and that all requires an interconnect of some sort. At the moment the interconnect of choice in our industry is copper.

This story is just so much bigger than our industry. That's the bit that some people aren't getting. We've all been here before when our industry has had a bit of a crunch and that's been sorted out by adjustments in capacity, but we are now competing with other industries. And these industries are prepared to pay more, or they have easier fulfillment requirements for the suppliers than our industry does. We must give our suppliers reasons to do business with us.

Johnson: Is now a good time to be getting into this industry?

Goodwin: Yes, if everybody accepts what's going on and understands that, in the end, we're all going to be paying more for our electronics. We've had a deflationary cycle in this business for 30 years or more. China has been exporting deflation. My feeling is that wave has hit the back of the pool and it's coming back the other way now, and we're going to have inflation driven into our business for a period of



time. What I don't know is how long that period of time will be.

Holden: The trend to higher layer and thicker copper means it's going to be more and more copper being etched.

Goodwin: If you read all the economics around copper, big chunks of it talk about recycling and reuse. And that is going to be a big part of fulfilling the gap between supply and demand for copper. But even with that, they reckon the shortfall in mined copper is going to be enormous.

Matties: Happy, do you think that we're going to see an acceleration in the additive process?

Holden: Yes, I think so. If you can get it done fast enough additively or semi-additively, then you don't have that waste, and waste turns into cost.

Matties: I would think that you would see more of that, Mark. As the confluence and the fundamentals are shifting, you're going to see more of that than you will see people trying to recycle etchant.

Goodwin: I think both are going to have to happen. Additive technology from just an environ-

mental standpoint has made a lot of sense for a long time, but it's never really taken off. The technology exists, but how fast do you think our industry will adopt it? Maybe this time it will. It depends on how painful this gets. We'll supply a substrate quite happily for people who want to add copper to it.

Holden: There may be a need for a laminate that was designed to have additive metallization because right now the A-SAP process starts with a half-ounce copper foil, and you etch it all off to get the proper teeth in the resin surface. And that's wasteful.

Goodwin: What they need to do is to come and speak to a laminator. A specialist laminator to start with, because it's not a volume requirement at the moment. And then you've got to ask yourself if the timing is good for that at the moment?

I think there is a chance this time that we could drive some real technological change in our industry. I've been through three of these cycles. This one feels fundamentally different, and it's going to be longer-lasting. **PCB007**

Mark Goodwin is COO of Ventec International Group.



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Feeling the Supply Chain Squeeze

Feature Interview by Nolan Johnson

I-CONNECT007

Nolan Johnson speaks with Joe D'Ambrisi of MacDermid Alpha to gain insight into what he's seeing in the market from his perspective as a specialty chemicals and materials provider.

Nolan Johnson: MacDermid Alpha touches so many different parts of the electronics manufacturing industry. Overall, what does MacDermid Alpha see with respect to pricing changes?

Joe D'Ambrisi: I'm sure your readers are very familiar with the current disruption in the supply chain. It's apparent in not just the electronics industry, but in a host of other industries as well. We are certainly not insulated from a lot of the issues that we see in the supply chain. As primarily a specialty chemicals and materials provider, we're most interested and concerned with the chemical markets where there has been a significant amount of disruption, which can be traced to a number of different factors. First, we're still feeling the impacts of the Tex-

as freeze in February, where some of the basic commodity chemistry producers of ethylene and propylene are located. Those commodity chemicals are the building blocks for many of the specialty chemicals that MacDermid Alpha uses to produce its products.

When you think of all the applications for specialty chemicals in not just the electronics industry, but in many different industries around the world, we're actually a relatively small consumer of those specialty chemicals. While we have seen significant price impacts as a result of some supply and demand pressures in the industry, we have maintained a supply of every critical raw material that we need to produce products for our customers. To help us mitigate the potential impacts of being relatively small consumers of these specialty chemical raw materials, we have a global supply chain that is very well interconnected, and we have a program of providing both primary and secondary raw material sources for our most critical raw materials.

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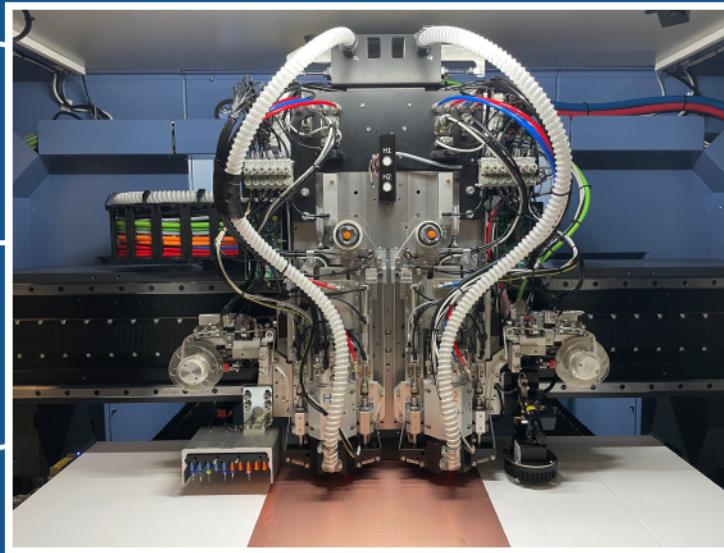
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Joe D'Ambrisi

raw materials, it's challenging and expensive to stay ahead of it, but it can be done. I'm not so concerned about shortages or our inability to supply specialty chemicals and materials to our customers, but we are seeing significant price impacts to be able to maintain that supply chain.

Johnson: You cite two major factors: lack of availability thanks to the fallout from the Texas freeze, and then supply and demand price pressures with your incoming supply chain.

D'Ambrisi: Correct. Global transportation issues have also added a significant amount of cost and what we believe is a temporary complexity to our business. This has been well-documented in the industry where there has been a shortage of containers for just about everything. For us, that impacts not only some of the raw materials that we source in one part of the world and what is shipped to other parts of the world where there are shortages to alleviate that, but some finished goods that we manufacture in certain parts of the world that we ship internationally, and they need to be shipped in pretty stringent storage requirements. This might typically be refrigerated containers or,

in the case of assembly materials, at sub-zero temperatures in which we ship these products around the world.

Johnson: How do you manage these pressures with your customers? What has been the approach up to now?

D'Ambrisi: Our approach up to this point has been to absorb many of these additional costs, where practical, and to pass some of these costs onto our customers. We believe some of these supply chain issues are temporary and short-term, and others will be long-term. The ones we believe are permanent, we will pass those increased costs onto our customers. The ones we believe are temporary, we've done a great deal of work, making sure that we simply absorb those costs in the short term and weather this like we believe many of our customers are doing.

Johnson: What sorts of costs do you see as permanent?

D'Ambrisi: There are certain specialty chemical costs where we believe we've got a fairly good understanding of the supply chain, how they're manufactured, and what the building blocks of those raw materials are. There are structural elements of these increases in costs that we believe are permanent. We believe others, like temporary supply-driven raw material price increases and shipping costs, are temporary in nature, so in many cases we have absorbed them.

Johnson: For your customers who are in managing these changes for their business, how are they doing that? What are their coping strategies?

D'Ambrisi: It's about having a scale and a scope that is beneficial to us as a company, and to our customers. In this particular case, big is better. You have the largest printed circuit board fabri-

cators, or the largest PCB assemblers or semiconductor fabricators who are very big and important customers of their suppliers, and they're going to be prioritized in how they get the important raw material inputs they need to build their end-products. That's certainly true for us. We're able to source raw materials from our suppliers better than some of our smaller competitors. I think just having scale and scope will help those customers. We do see a little bit of very conservative order patterns where customers are buying significantly more than they need in the short term.

That's a little concerning because it simply adds to an already disrupted supply chain. It causes us to carry more inventory. It causes our customers to carry more inventory, and that is adding pressure to pricing in the supply chain. With that in mind, we do our best to stay far out in front of potential supply disruption for all our products, and we work hard to communicate that very effectively to our customers.

We also have the benefit of being a large global company, so if we have supply constraints in a particular geographic area, we can work to source raw materials or finished goods from other areas, and ship them to where they're most needed. I know many of our customers have a similar ability to do that. I know that there are other supply chain constraints in the industry for printed circuit board fabricators, assemblers, and semiconductor fabricators. The news around semiconductor chip shortages is well-documented. Those customers are working closely with their critical raw material suppliers, but we're further down their list of concerns than possibly if you were manufacturing ABF film, glass cloth, or any number of other elements that are very tightly constrained right now.

We also benefit from a relatively low capital intensity in manufacturing, and we're able to react very quickly to changes in underlying demand at our customers, and to keep them adequately supplied. I don't think we're their biggest concern in supply right now.

Johnson: Do you think this current situation is as bad as it's going to get, or are there tighter constraints still to come?

D'Ambrisi: It depends on the segment of the electronics industry. For our semiconductor fabricators, I'm not sure that we've seen the worst yet. Semiconductor fabrication demand continues to increase. There will be a significant amount of additional capacity coming online, in both 200-millimeter and 300-millimeter wafer lines, and that will add significant capacity. If some of these other supply chain constraints are not sorted out by then, things could potentially get even tighter. From a printed circuit board fabrication and assembly perspective, this issue will last well into Q4 but should start to mitigate by the end of this year and the beginning of next.

I expect the seasonality demands that we typically see in Q3, and the industry will certainly be challenged by that seasonal increase in demand. I think it will be less of an issue on the chemistry and materials side, still an issue on the transportation side, and something that the semiconductor industry will be dealing with well into 2022.

I expect the seasonality demands that we typically see in Q3, and the industry will certainly be challenged by that seasonal increase in demand.

Johnson: In North America for example, there are a few very large shops, and a lot of small shops. Thinking back to your "bigger is better" observation, how does a small shop navigate this? How does one survive?

D'Ambrisi: From our perspective, because the size of the North American printed circuit board fabrication and assembly markets is relatively small compared to the overall global markets, we're able to serve these smaller customers and meet their needs. If we have supply chain disruptions in North America, we make those same products, just in larger quantities, in Asia that we can put on a boat and send to our American customers if we have to. That will help us make sure these customers are served and served well. So, I expect that supply, at least from a specialty chemical and material standpoint of MacDermid Alpha, won't be an issue for them.

Johnson: Sounds like one of the things MacDermid Alpha can offer your customers is the resilience in your own supply chain?

D'Ambrisi: That's exactly right. It's one of the benefits of having the scale and scope that we've talked about and having a global network of manufacturing locations and raw material sourcing.

Johnson: As you said, there's not a whole lot of complexity in chemicals compared to semiconductor manufacturing. Nevertheless, is this an opportunity for MacDermid Alpha to look for ways to implement continuous improvement?

D'Ambrisi: This is something that's always top of mind for us. We've been in the middle of a supply chain optimization exercise ever since we put the six legacy organizations together into one organization. These were former competitive companies that had very similar product portfolios, very similar manufacturing footprints in some respect, and we've had to continually optimize that supply chain. And that's been an ongoing challenge for us for close to five years now, ever since Elements Solutions acquired both MacDermid and Alent, which represent the MacDermid, Alpha and Enthone

brands. We've since acquired assets of the OM Group, Kester, and Hitech, a regional supplier of specialty adhesives in Asia. All of this has created significant overlap in our supply chain that we've been optimizing ever since. These current supply chain disruptions are just another hurdle in that. It's another opportunity to up our game in terms of supply chain optimization, and we believe that there's still opportunity for us to continue to do that.

We've had the opportunity to identify, in some cases, critical raw materials that were not efficiently sourced and potentially single-sourced. We have made a big effort at making sure that we don't have single-source raw materials, that there is always an alternative source that is approved by our customers, acceptable to our customers and to us that we can provide. With that comes a level of competition in our raw material suppliers that, we believe, will help hold down prices in the long term.

Johnson: What are your customers concerned about?

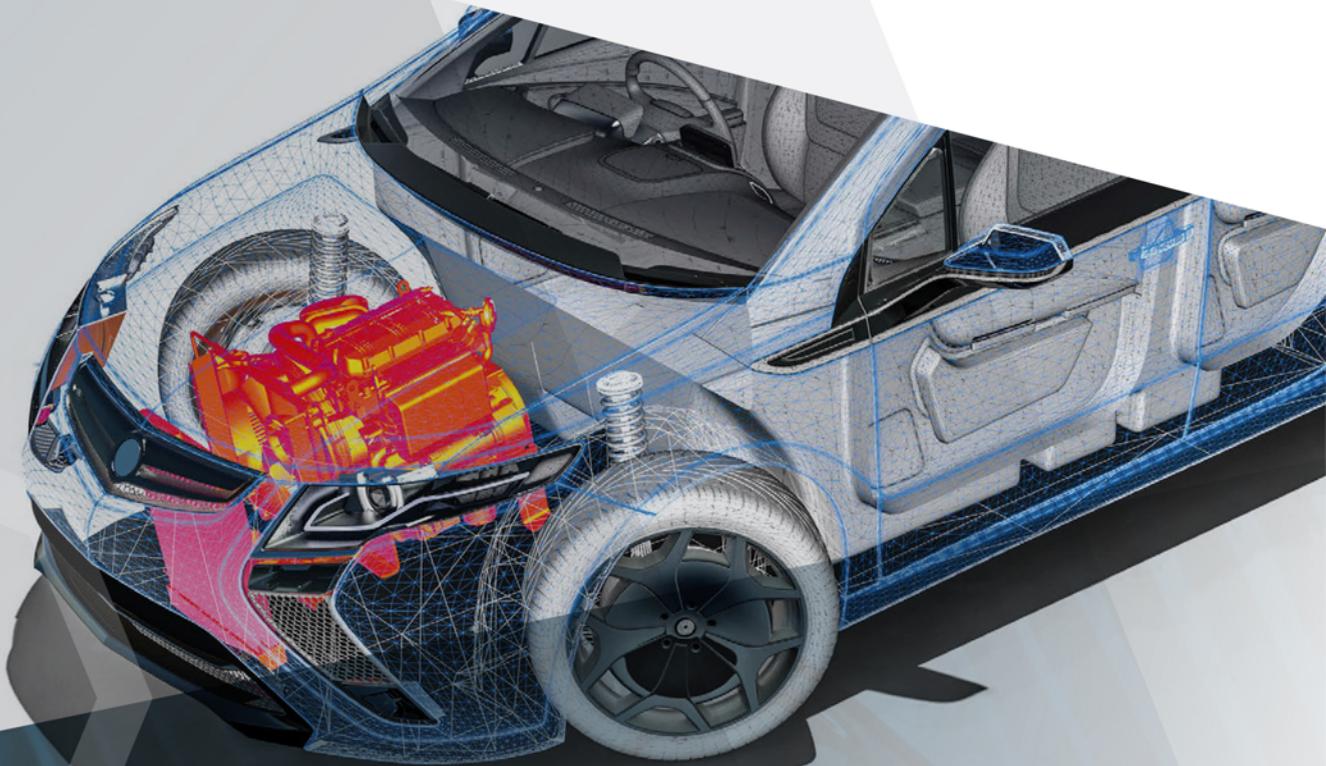
D'Ambrisi: We're not the biggest source of concern for them right now, but if you're getting a visit from your laminate supplier several times over the first two quarters of the year with a projected price increase, that has to be concerning for a printed circuit board fabricator. I'm interested to understand—and we ask our customers this all the time—how are they passing those costs on? We believe this is part of a general inflationary trend that ultimately will be borne by the end consumer. There's little way around that. It will be several years before we get to a much more fully competitive supply chain environment than we are in today, where demand will stabilize, and supply will improve and increase.

Johnson: There has been a lot of downward pressure on pricing, squeezing the margins from consumer prices all the way back up the supply chain to the PCB fabricators, the com-



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ponent suppliers, the whole market. It has been pressure to the point where some PCB fabrication shops are running on very, very slim margins because it's that or do no work at all. That's not sustainable. The industry has been squeezed down to the point where it's a starvation operation, and there needs to be more room for making money if we want this to thrive.

The North American printed circuit board fabricator, as an example, has adapted well to the changes that the industry has seen over the past 20 years.

D'Ambrisi: I certainly agree with that. The North American printed circuit board fabricator, as an example, has adapted well to the changes that the industry has seen over the past 20 years. I remember starting my career quite some time ago, where our business was largely one-third in the Americas, one-third in Europe, and one-third in Asia. And now it's well over 85% in Asia in our printed circuit board fabrication business. The North American fabricators have adapted well to that difference in the environment. There used to be many high-volume shops in the North American market, but now the market is focused on very specific end-use markets and quick-turn and prototype opportunities. They have adapted well, and we believe they can realize a significant premium for providing that type of capability to their customers.

There are actually quite a few very successful and very profitable printed circuit board fabricators in the U.S. market. I think they've done a great job capitalizing on markets and opportunities that are available to them. What

you said about profits being squeezed at some of the Asian manufacturers is absolutely true. There is a significant number of Asian manufacturers that are feeling that squeeze and frankly have closed their doors as a result. Places like China that were very attractive from a cost perspective in the past, are becoming a much more difficult environment to compete in. There are always lower cost manufacturing locations around the world. If it's not Thailand or Malaysia, it's Vietnam or India. We will continue to see that migration to lower labor cost areas around the world, and it will push some suppliers that are not as well-equipped as others out of the market.

Johnson: Do you see these trends as starting to level the playing field for North American manufacturers again? They have optimized into a certain kind of work and figured out, not only that they get a price premium, but if they've done it well, they've worked on becoming somewhat optimized with their labor and their equipment. As this shift happens with China and their labor prices continue to increase, the supply chain issues change here. Do you see that giving North American companies a chance to compete on the global market in large quantity again?

D'Ambrisi: Unfortunately not. I don't see the structure of the North American market and the way the printed circuit board fabricator in North America serves that market as changing significantly over the next five to 10 years. I don't believe that any of the changes we're seeing will change that or impact that. The North American market has been optimized to the way it is today and will continue to be that way for a long period of time. Unless it becomes significantly more cost-effective to manufacture volume in North America, I don't see that changing. That's in the printed circuit board fabrication side. In the semiconductor side, I see current initiatives to manufacture additional semiconductor products in the United

States and to have companies more evenly globalized in their supply chains if they're a semiconductor fabricator. I believe these changes are more driven by supply chain risk than anything else.

You potentially have areas of the world where there's large concentrations of semiconductor fabrication. And from a risk perspective, that is something that's concerning, I'm sure. You will see subsidized semiconductor fabrication grow again in this country. Outside of Intel and possibly GLOBALFOUNDRIES, leading-edge semiconductor fabrication hasn't grown significantly in this country in a long period of time, but I believe it will continue to grow in the longer-term simply to minimize and mitigate that risk of a high concentration of semiconductor fabrication in a small geographical area.

Johnson: You just mentioned subsidized semiconductor manufacturing growth. Do you see a similar amount of concern or attention to subsidize printed circuit board growth?

D'Ambrisi: I wish that were true, but I simply don't think it is. What the overall markets see is that the capital intensity of fabricating a semiconductor is orders of magnitude different than it is for manufacturing a printed circuit board. That will drive the need to subsidize some of these semiconductor fabs and to give companies incentive to diversify their supply chains away from the Asian markets. And given the perception that printed circuit board fabrication is a less critical component of the electronics supply chain, I think that we probably won't see similar assistance in printed circuit board fabrication as we're going to see in the semiconductor industry.

Johnson: Final thoughts, Joe?

D'Ambrisi: From our perspective as a specialty chemicals and materials provider, we're seeing the same supply chain impacts that the rest

of the industry is seeing, but I believe we're well-positioned to handle the global scale and scope of our business. The global nature of our business, and the fact that we are a relatively small consumer of the specialty chemical raw materials and building blocks that we need to put our products together and deliver them to our customers, puts us in a good position to minimize any disruptions at our customers. Our ability to do that will be challenged, but it shouldn't just be a supply issue, it's going to be an issue where we will have to pay higher prices, some for a much longer period of time than others. But our ability to supply is going to be, we believe, for the most part uninterrupted.

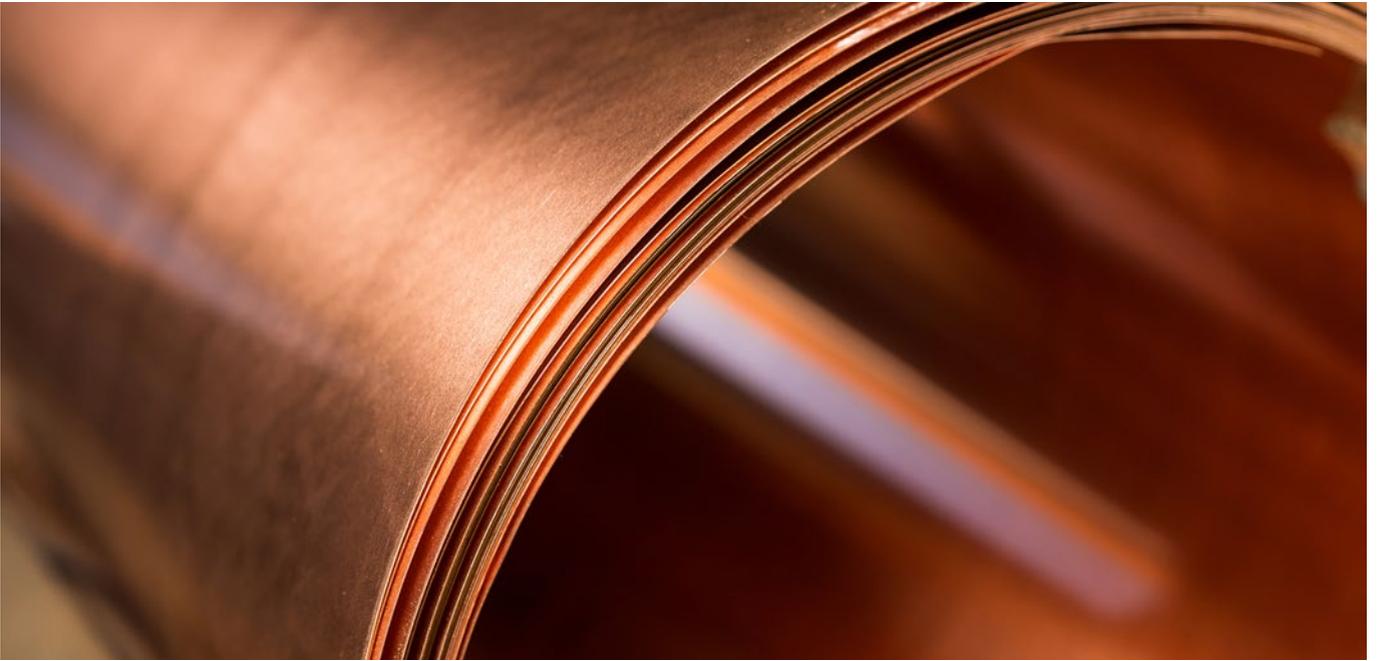
Our ability to supply is going to be, we believe, for the most part uninterrupted.

Johnson: A message of peace of mind for customers. If you're working with MacDermid Alpha, you're not going to be interrupted.

D'Ambrisi: Exactly. Because if you're working with a small local or regional supplier, they're going to have a much more limited supply chain with much more limited access to where they can get their raw materials. It would be much more difficult for them to source something from an entirely different geography than where they've been used to getting it.

Johnson: As always, it's insightful talking with you.

D'Ambrisi: Thank you so much. PCB007



The Demand for Copper

Feature Interview by Nolan Johnson

I-CONNECT007

Nolan Johnson spoke with Michael Coll and Chris Stevens of Nippon Denkai, home of the last-standing ED foil manufacturer in North America, about the demands and projections they're seeing in the copper market currently.

Nolan Johnson: There's plenty of news about the market demand for copper, that the demand far outstrips the current manufacturing, and that demand will only grow. You must have a good perspective on that. Can you give us and our readers an overview?

Michael Coll: Sure. We look at the copper market from the perspectives of both our supply and our customers' demand. Electrodeposited foil starts with dissolving recycled copper wire in acid prior to electroplating the copper into sheet form. The recycled copper we use comes from a large network of scrap vendors that we've worked with for well over 30 years. When we look at the supply side of the equa-

tion, we have not experienced any issues receiving the scrap copper that we need to meet customer demand.

Through the first quarter of the year, copper prices increased at an unparalleled rate, however, prices have declined rapidly due to the release of strategic reserves in China. While our supply is stable, our customers are communicating that the copper foil supply has tightened, specifically in Asia. This is due to the combination of increased orders in the electronics industry as we emerge out of COVID, combined with increase demand for lithium-ion batteries (LIB) for electric vehicles.

Chris Stevens: Our customers are clearly communicating that the emphasis on shifting copper foil production from PCB to lithium-ion batteries for EVs is putting a strain on the foil market. The two competing industries both have significant demand, and foil suppliers are looking at how to allocate their capacity between the PCB and LIB businesses. A big part of this is the excitement around EVs and the opportunities that the emerging market

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segment has to offer in the future. It is more attractive as a newer segment than what printed circuit boards have been historically, and we hear there is conversion of existing capacity for PCB applications going into LIB.

Johnson: Let's start with how most of your copper comes through the process of recycling.

Coll: We start with bare bright number one copper, which comes from end runs from wire mills and recycled industrial wire. It can be wire that was harvested out of buildings during remodels or from downed power lines—virtually any copper wire that is used for electrical transmission. We dissolve the wire in sulfuric acid to create the electrolyte used for plating the copper foil into continuous rolls.

We are the only ED foil maker in the U.S., so we are not competing against other foil makers; the same copper we use is also recycled into rolled copper, new wire, and tubing for plumbing. In terms of recycled copper demand, we have lots of competition. One of the areas increasing demand on copper wire is infrastructure build-out, and not just related to electronics, but to new home and building construction. We have heard of shortages in traditional Romex wire and cable for new home construction, as well as other large municipal investments. As we emerge from COVID and the overall economy grows, multiple industries will additionally strain the supply base. As I mentioned, there is not a lack of supply, but the demand is certainly forcing an increase on copper price.

Johnson: When lay people like me think about copper production, we naturally think about more mining. Where is the greatest potential



Michael Coll

to help increase our supply of copper into the overall market? Is there more potential for recycling? Or do we have to mine significantly more to add to the supply?

Coll: We do have some longer-term concerns when considering the astronomical growth projections for electric vehicles. This will have an incredible impact on the copper market as there are requirements for copper foil

for the batteries, charging cables, and the infrastructure for charging stations. This will require more copper to be mined worldwide. We understand there was quite a bit of difficulty last summer with some of the larger mines in Chile having worker issues due to the health and safety requirements related to the pandemic. Production appears to be returning to pre-pandemic levels, but to increase the capacity at a copper mine is a multiple-year effort. Additionally, some of the large mines report that the quality of ore is not as rich as it used to be, resulting in reduced output. We are concerned longer-term, especially, with the market projections which require doubling or tripling the amount of copper use annually to meet global needs for infrastructure improvements, in addition to growth in PCBs and EVs. We just do not know where all the copper is going to come from.

We are very interested in the concept Tesla has proposed: recycling all the components from old batteries to build new ones. Once the EV industry is at a steady state of battery production, this would be ideal. However, we are years away from steady state, so it appears that in the future a supply constraint will be inevitable.

Johnson: There must be pressure on manufacturers such as yourselves to respond to the de-

mand in other markets outside of electronics manufacturing. You have a limited amount of copper and this huge demand in markets for a finished product that is probably easier to fabricate than the foil. How do you balance that?

Stevens: We are not struggling with balancing the demand to non-PCB markets yet. This is something that is constantly on our minds as we see the market changing. As the only ED foil manufacturer in North America, we really feel that we have an obligation to the PCB market which we have been supplying for over 40 years. Our foil is used in a significant amount of North American PCBs. We are spec'd into a lot of military defense and aerospace applications, and we know that it is critical to continue supporting this business. Aside from PCBs, our foils are used in EMI and RF shielding applications, and lightning strike protection for composite aircraft. We have had to evolve our business in North America since the PCB market crash in the early 2000s. We have formed partnerships with our customers in all these markets, and it is our priority to continue these partnerships.

Johnson: Mike, can you quantify the demand for copper?

Coll: Current market estimates for the production of ED copper foil is around 600,000 metric tons per year. We have seen market reports that suggest the need for additional copper foil, specifically for EV batteries, will require a 50% increase, or another 300,000 metric tons per year by the end of 2025. ED copper foil factories are very capital-intensive, and there are a limited number of suppliers who produce ED copper foil manufacturing equipment. One of the most critical parts in an ED copper foil fac-



Chris Stevens

tory is the drum. The drum is the cathode, to which the copper plates, as it rotates in the copper-acid electrolyte. These drums are typically more than 2.5 meters in diameter, and the face to which we plate is a precision-ground titanium skin that is greater than 1.3 meters across. The foil typically used for EVs is only 8 microns thick and the rolls are 1,000 meters long, so you can imagine the limited supply base that has the

knowhow to manufacture the drums, the plating cells, winding equipment, and so on. The constraints to increase capacity to meet forecast demand will challenge all foil suppliers.

It's hard to imagine increasing the installed capacity of this industry by 50% in four years to meet the projected demand. While it is exciting to hear the aggressive plans that companies like GM has, turning their entire fleet to electric vehicles by 2035, it should cause some concern to the other industries that also need copper foil. Where is all the copper foil going to come from? I struggle to understand how the ED foil industry is going to meet the projected demand.

Johnson: From what I understand, a market watch report out of Wall Street made the comment that copper is the new oil.

Coll: We have read the same. Like oil and other natural resources, there's a finite supply of copper. Mines will become less productive, resulting in increased cost. And recycled sources will become scarce, resulting in increased cost. Copper prices will continue to increase.

Johnson: It could easily become much more of a strategic resource than we've seen before. It's interesting that the copper appetite for electric vehicles is exactly the same as the amount

that Denkai America provides to the electronics manufacturing marketplace.

Coll: For North America, we predict the requirement for copper foil for use in EV batteries will surpass that of the printed circuit board industry within the next two years.

Johnson: Right. Which leads back to my earlier question. If I oversaw a business making copper foil, it would be a tempting time to pivot.

Coll: There is definitely a temptation to pivot, but to what extent? The requirement to build a copper foil factory is very capital-intensive and the equipment, like the drums, are highly specialized. We will be celebrating 30 years of continuous operation next year in our South Carolina factory which was specifically built for PCB foils. We have plans to convert underutilized capacity from traditional PCB foils to manufacture lithium-ion battery foils. Our focus is to enter the battery space without sacrificing the relationships that we have built within the U.S. PCB and industrial markets.

There is definitely a temptation to pivot, but to what extent?

Johnson: The fact that it's hard to pivot should hopefully be comforting for the electronics suppliers, I'm sure.

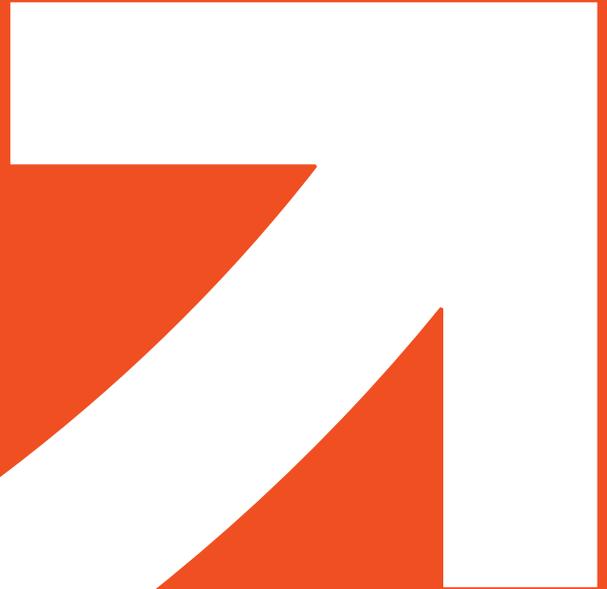
Stevens: We hope so. Our position within the U.S. electronics supply chain is incredibly valuable to us. There is no plan to be just a battery foil company. Our parent company, Nippon Denkai, is successfully growing in both the printed circuit board and battery foil markets. Our goal is to collectively maintain a presence in the PCB industry. We were only acquired by

Nippon Denkai a year ago, but we are already leveraging their PCB foil technology to create new opportunities for us in the domestic PCB market where there is a lot of room for technical differentiation in PCBs. Our CEO, Dr. Nakajima, has made it abundantly clear to our organization and to our shareholders that there's a place for us in both markets. There is no doubt that the battery foil business will drive volume, but when it comes down to it, our shared history is with PCB foils.

Johnson: For our readers, the fabricators using the laminates, copper foil, and copper in their processes, what should they prepare themselves for?

Coll: Continued price volatility and potential intermittent supply shortages. It is not just copper foil; these are the same issues that are impacting the overall global supply chain. The ripple effect from the backlog of global shipping lanes is clearly impacting everyone's supply chain.

Stevens: We are working with our customers to avoid panic buying our copper foil. As mentioned, we have ample raw material supply. However, we are working to build inventories, especially for overseas customers that are also impacted by the same shipping delays that are disrupting us. Copper price volatility will remain a big issue for the PCB industry to manage throughout the year, but we are not expecting an issue with supply. We expect some stability in the market by the end of the year. Beyond the end of the year, it's hard to forecast, mainly because of the rapid expansion of battery manufacturing in all the different regions of the world. But specifically in the U.S., Panasonic already consumes significant quantities of foil. SK Innovations in Georgia is starting up, and the new Ultium factories (the partnership between LG and GM) are not far behind. There are multiple other small battery companies that are installing gigawatt manufactur-



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ing capacity in the next two years. When all of these factories are up and running at full capacity there will be a considerable constraint. The U.S. requirements pale in comparison to the projections in China and Europe. This will force the foil manufacturers to make a tough choice between PCB foil or battery foil; regardless, it is going to cause the price to go up for everyone.

Johnson: And the challenge, of course, is that electronics are needed to control the electronics that make those other two parts work together. That requires copper also.

Coll: It just goes on and on. All the battery facilities are filled with robotics and the electronics to run the Factory X.0. All of these machines need PCBs, which need copper. The EV cars are charged through a cable that contains copper, which is attached to a charging station filled with more batteries or copper bus bars, attached to the electric grid, by more copper wire. It's all copper. And we are all going to be competing for that same resource.

Johnson: What advice do you have for fabricators? We have the immediate short-term issue with shipping channels (which really is a COVID-related delivery issue) but it's also showing us what we should expect. How does a fabricator prepare to survive this?

Coll: I wish I had the answer. The unprecedented issue for us is the change in the price of the raw material, and this commodity price flow through from our suppliers all the way up the supply chain. This is where the copper-clad laminators, and certainly some of the other distributors within that fabricator network, have done a very good job of trying to average out some of that price fluctuation over time and make it a little bit easier for the fabricators to absorb. This pricing volatility is something that we expect will continue.

Fabricators are in a tough spot. Aside from

the copper foil, they are getting hit with the volatility at copper plating as well. We are working with all our supply chain partners to better understand how to manage the rapid pricing changes. As quickly as the price of copper increased early this year, it is impossible for one member within the supply chain to absorb alone. Unfortunately, we don't see that this volatility is going to go away.

Johnson: Michael, how closely do you follow the emerging processes that are then using the foil and the laminates?

Coll: Overall, we have a fairly solid understanding of the printed circuit board fabrication process. We supply foils for copper-clad laminates and for PCB outer-layer applications. We work closely with our customers to make sure that we understand the performance requirements for the end use. Copper foil is one small component in board building. It is critical to partner with the copper-clad laminate makers as they look for new solutions for thinner and lower-profile foils for emerging digital and RF applications. There is more activity, recently around thinner foils, since most of the copper is ultimately etched off by the fabricator anyway.

Johnson: Especially if you're going to start talking about some of the additive processes, the first thing to do is strip it all off, put it in a solution, and then put it where they want it. It's a nice closed-loop system for them, but that takes away a lot of what you're doing.

Coll: The migration to thinner foils is not a concern for us if the increased adoption of build-up applications in North America continues. Thinner foils have value, with less to etch and improved trace definition. Our value is with the treatments and bond-enhancements, and the foil thickness is not a concern for us. Our partners in Japan excel at producing thin foils, so we are excited about the opportunity to use their capability to support this growing PCB

segment here in the U.S. The foils manufactured in our factory here in South Carolina are typically used in legacy military, defense, and aerospace type applications. We don't foresee the bulk of these applications changing in design quickly.

Johnson: Chris, how would you characterize this situation?

Stevens: We live this every day, and you hit right on the key points. For the PCB industry, especially, let's be patient. Please do not over-buy. Maintaining the strong relationships with your suppliers and working together on procurements will get us all through this. I don't want to be the guy to say this, but I believe supply is going to continue to be tight at least through the end of the year. As we see existing mines increase their production, copper availability will start to loosen up, but it's going to be a little while before we see anything stabilize.

Johnson: Picking up on your point there, Chris, "don't over-buy" is advice which makes a lot of sense. That does put the responsibility back on you to be a reliable supplier so that they don't need to over-buy. That's a lot of a responsibility in this current market situation.

Stevens: Yes it is. What we are trying to avoid is having customers make a large purchase, disappear for six months, then come back looking for foil. That just disrupts the whole balance. We are working with our customers to keep things nice and even. If you know what your forecasts are, work to your forecast. We understand that this can be a very difficult thing to do in this business from time to time. But it is the panic buys that are extremely disruptive to our manufacturing process.

Johnson: Based on some of the ongoing pressures, the urge to panic-buy in copper could easily happen.

Stevens: Yes, it could. And it's a trickle-down effect across the whole industry. Whether you're in ED foil or rolled annealed materials as well, ultimately, it's the base supply that's being consumed.

Johnson: Right. Well, that's good advice. Gentlemen, thank you.

Coll: Thank you. PCB007

Michael Coll is chief operating officer, and **Chris Stevens** is global sales manager, at Denka America Inc.



Economic Drivers Take Us ‘Up, Up, and Away!’



Feature Article by Shawn DuBravac
IPC

Long-time fans of DC Comics’ Superman will inevitably remember the oft-spoken words uttered by Clark Kent moments before flying off: “Up, up, and away!” As a kid, I was actually a bigger fan of the short-lived U.S. sitcom, “The Greatest American Hero,” which aired in the early 1980s. In the show, substitute teacher Ralph Hinkley is given a suit with superhuman abilities by a group of aliens. But Ralph doesn’t know how to use the suit properly, and while he can fly the suit, he can’t land it which results in a never-ending series of crash landings. (Hard to believe this show was cancelled after just two seasons, right?)

These juxtaposed superheroes sum up my current view on inflation. Prices are “up, up, and away.” And the big question we face now centers on the kind of landing we should expect.

More accurately I should say, prices are up, up, and... up! Copper, for example, is at an

all-time high—up 94% over the last year and up 69% compared to two years ago. But copper isn’t alone. We are seeing higher prices across the board. The IMF’s Non-Fuel Price Index, which includes precious metal, food, and industrial inputs, is up 43.6% over the last year and 44.7% over the last two years. Include fuel prices, and prices are up 70% over the last year. And that’s if you can even get the product you want in the first place, as shortages and longer lead-times abound.

Prices are up for three core reasons:

- Base-year effects
- Misaligned supply chains
- Pent-up demand

Let’s take a quick look at each of these.

Base Year Effects

In the early months of the pandemic, the level of average prices fell. Fast forward a year and higher prices feel even higher when comparing them to the low base of April 2020. In other words, year-over-year growth rates can

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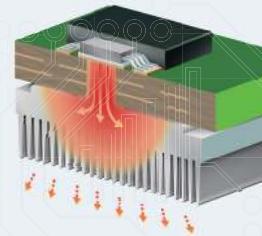
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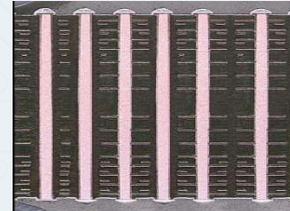


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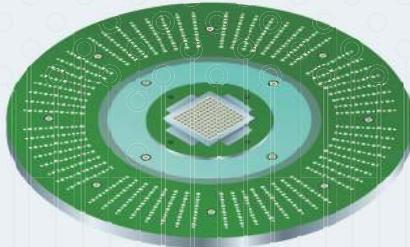


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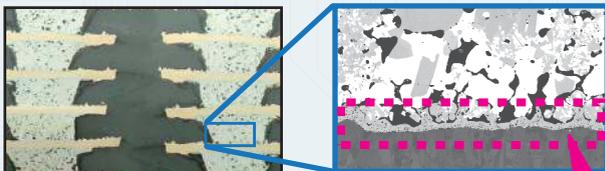


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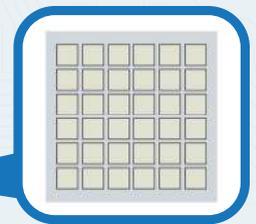
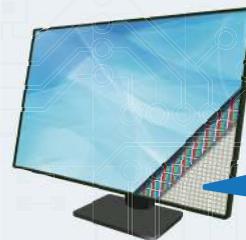
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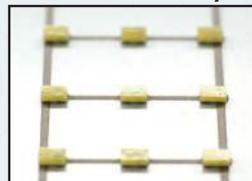
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misrepresent how quickly prices are accelerating. This effect will fix itself in the coming months as year-over-year comparisons normalize. It's also why I like to look at two-year-over-two-year figures.

Misaligned Supply Chains

As I illustrated above, year-over-year price increases (and therefore base year effects) are only part of the story. Supply chains in disequilibrium are another reason prices are up. This is especially true for transportation and logistics costs. Roughly half of airfreight capacity is in the belly holds of commercial airlines. When passengers stopped flying, and especially when international flights all but disappeared, airfreight capacity declined right along with it. Seat capacity is still down 40% globally. While domestic travel is picking up, it will be years before international travel returns to pre-pandemic levels.

Waterborne transportation costs are also up. The Shanghai Containerized Freight Index is up 291% over the last year and up 357% compared to two years ago. Container rates were never higher than \$3,000 prior to 2020, but the Drewry composite index exceeded \$5,000 for the first time in 2021. On some routes, like China-Rotterdam, the average rate has moved above \$10,000. I expect logistics and transportation costs will remain elevated well into next year.

Pent-up Demand

Normally during a recession consumers cut back spending on durable goods—things like cars, appliances, and electronics. Rather than replace these items, consumers often try to extend the useful life of these products when economic growth is slow. Think about getting an extra six months out of your clothes dryer or another year from your car. When money is tight, consumers typically have focused on services over goods. But this recession has been unique on many fronts. Services closed due to COVID mandates and while quarantining at

homes, consumers opted to spend on goods. Moreover, massive fiscal stimulus ensured that money was not tight in aggregate. Real disposable income is up 9% from pre-pandemic levels but is flat when government transfers are excluded. These forces combined to create tremendous demand for electronics. In the U.S., spending on durable goods has been above pre-pandemic levels since June 2020, only months after the pandemic hit. Spending on durable goods is 25% higher than it was pre-pandemic. Spending on services remain down 4%.

And remember, all this demand came at a time when supply chains were misaligned, and transportation networks were in disarray. This created shortages and pushed out lead-times. Excess demand combined with shortages and longer lead-times to push prices higher.

As the economy reopens, spending on services is coming back. Restaurants are filling up. Traffic is returning. Stadium attendance is growing to capacity. Broadway (NYC) is opening. The return of services could potentially slow the sale of consumer durables. The proverbial two-edged sword will cut both ways. Price pressure will ease but so will demand.

Already we've seen demand slow as supply constraints have curtailed production and led to higher prices. Some consumers are taking a wait-and-see approach. This is just one of the fallouts of higher prices. Higher prices can hurt demand temporarily if buyers decide to hold off until prices come down. The opposite is the case if consumers and businesses believe these price increases are more permanent in nature. When inflation is rising, and it looks like price increases are likely to be more permanent, buyers want to pull demand forward so they can lock in the lower price. It doesn't seem like this is currently the case, but it is something to watch for.

Another fallout of higher prices is weaker margins. While it's nice to suggest we can pass prices on, that isn't always the case. More realistically, manufacturers will at best be able to pass on some cost increases.

Prices are set to remain high through the remainder of the year and will likely remain elevated through the first half of next year. And that's when the landing comes in. Will we have an elegant Superman landing, or a Greatest American Hero sand-in-your-teeth landing? Right now, price increases look generally transient, and a graceful landing looks possible. But there is a real risk that higher prices will be sticky, and the Fed is already behind in the

battle to contain prices. If that's the case, interest rates will need to move higher more quickly which could, in turn, slow the economy and drive unemployment higher. **PCB007**



Shawn DuBravac is the chief economist for IPC.

NASA's Curiosity Rover Finds Patches of Rock Record Erased

Today, Mars is a planet of extremes—it's bitterly cold, has high radiation, and is bone-dry. But billions of years ago, Mars was home to lake systems that could have sustained microbial life. As the planet's climate changed, one such lake—in Mars' Gale Crater—slowly dried out. Scientists have new evidence that super salty water, or brines, seeped deep through the cracks, between grains of soil in the parched lake bottom and altered the clay mineral-rich layers beneath.

“We used to think that once these layers of clay minerals formed at the bottom of the lake in Gale Crater, they stayed that way, preserving the moment in time they formed for billions of years,” said Tom Bristow, CheMin principal investigator and lead author of the paper at NASA's Ames Research Center in California's Silicon Valley. “But later brines broke down these clay minerals in some places—essentially resetting the rock record.”

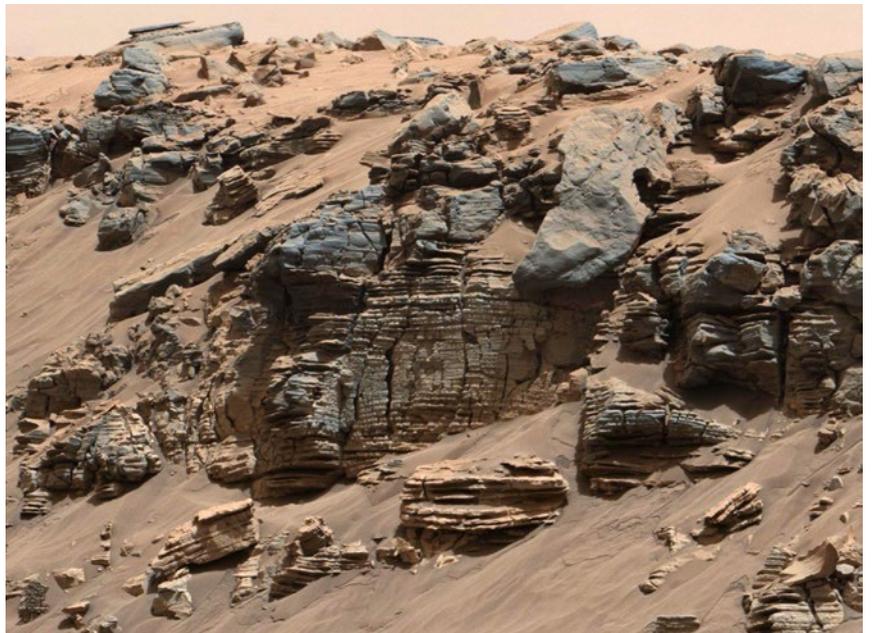
Mars has a treasure trove of incredibly ancient rocks and minerals compared with Earth. And with Gale Crater's undisturbed layers of rocks, scientists knew it would be an excellent site to search for evidence of the planet's history, and possibly life.

Using CheMin, scientists compared samples taken from two areas about a quarter-mile apart from a layer of mudstone deposited billions of years ago at the bottom of the lake at Gale Crater. Surprisingly, in one area, about half the clay minerals they expected to find were missing. Instead,

they found mudstones rich with iron oxides – minerals that give Mars its characteristic rusty red color.

Scientists knew the mudstones sampled were about the same age and started out the same – loaded with clays – in both areas studied. So why then, as Curiosity explored the sedimentary clay deposits along Gale Crater, did patches of clay minerals—and the evidence they preserve—“disappear”? (Source: Jet Propulsion Laboratory, NASA)

Photo below: This evenly layered rock photographed by the Mast Camera (Mastcam) on NASA's Curiosity Mars Rover shows a pattern typical of a lake-floor sedimentary deposit not far from where flowing water entered a lake. (NASA/JPL-Caltech/MSSS)





DFM for Your PCBs

Feature Interview by Nolan Johnson
I-CONNECT007

Nolan Johnson speaks to Greg Link of WUS Printed Circuit Co. Ltd. to gain a better understanding of where design for manufacturing (DFM) fits in from a fabricator's perspective.

Nolan Johnson: Greg, what we call DFM in the PCB world, the semiconductor community calls layout verification. The PCB industry refers to the software tools as DFM, and yet, I would posit that the software tools don't actually perform a DFM.

Greg Link: I agree.

Johnson: From a fabricator's point of view, where is the mismatch between what DFM should be and what the tools do in the market?

Link: DFM should be, by definition, designing to improve manufacturability, but most of the time, we fix an error here or an error there. The tool is not guiding us by saying that this is what

we want to do to improve how a board is made, this is how expensive it is to make, or how quick it is to make. Is this really what the customer needs? Those types of questions aren't really being asked. And I don't know how you do that in a functional world. I think this is the weakness.

Johnson: You're right. Philosophically, the goal is to give guidance that increases yields, simplifies the manufacturing steps, and maximizes your mean time between failure. If your goal is using design rule checks to make sure your trace and space parameters are sufficient, then that's a piece of it, but that doesn't get you to your goal.

Link: Right. It needs to be a separate tool that our end-customers need to run through. For example, I was just looking at a board that had four-mil line and spaces with PFE inside of a pitch; there were four lines together, and then suddenly there were two more lines that were spaced, six mils apart. You look at and say, "If six mils is okay here, and here, why is four mils



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Greg Link

needed there?” There’s really no reason for it when you talk to the customer and tell them, “If you look at this area, this four-mil pitch makes it feel really hard to do, so could you just space all these out?” But by that time, they’ve already done all their engineering to prove out that this is going to work like they want it, not like it’s manufactured to be made, but like they want it to do. With that extra cost that they have to apply, they may say, “We’ve already done the modeling, and everything seems to be fine. If you can make it this way, please make it this way. If you can’t, then we need to have other discussions.”

Johnson: That is part of the mismatch, right? In my opinion, the DFM tools should be called CFM, or “check for manufacturing,” because you’ve already done the design. The design has to be complete to start the determination whether it’s designed to be manufacturable.

In your experiences working with DFM tools, can you draw a correlation between passing the DFM analysis using the rule deck, and having increased manufacturability yields?

Link: Oh, absolutely. You can draw a correlation without a doubt.

Johnson: It does help, but it involves a great deal of human heuristic knowledge to make it work.

Link: Right. And sometimes at the expense of annoying the customers because you’re asking them questions that they didn’t really want to be asked. They want you to simply analyze their board and see if there are any glaring problems; they don’t want to be second-guessed on their design. It takes the PCB manufacturers out of that uncomfortable situation that says, “Hey, what if you did this and that?” We don’t want to be designing boards, we want to be building them. Sometimes those conversations can be pretty tricky to have.

Johnson: It seems in some cases, the engineers, and I’m probably being unfair, but they don’t want to be bothered with those details on the manufacturing side. I’ve heard it said, “I’ve done my design, here you go, just make it happen; make my vision work.” And yet you have to talk about these messy little details like situational areas of trace and space or the like. The CAM department at a fabricator brings up these details to increase their customers’ yields, or to decrease the customer’s manufacturing costs.

Link: Absolutely.

Johnson: What are some of the most common DFM errors that your team sees? You know that these are going to show up, so you’re looking for them immediately.

Link: Let’s talk about checks that we catch. The netlist doesn’t match up, hole counts are off, the dimensions are wrong from a fab print to a Gerber file. Those are probably the major ones. From a design, checks we catch might be gaps in reference ground plane. It could be line

spaces, like I just mentioned, where there's an inconsistency between how much space you have in area A vs. area B. It would be designing outside of what would be normal manufacturing. For example, they're asking for 1.5 mils of copper, and I have a 6-mil drill hole. You just don't have enough room to get copper through that area. Those would be common design for manufacturability things we might see.

Johnson: WUS does some complex work. Can you characterize that for me? What's the WUS sweet spot?

Link: We have four different facilities, and each one has its own sweet spot, which is the way it should be. Our automotive plant is going to be six- or eight-layer board, with HDI/hybrid, possibly RF materials. They're usually smaller platforms. The Taiwan facility is a high degree of HDI, usually smaller platforms as well, and generally not the ultra-low loss materials—more like Megtron 6 or equivalent, and higher loss materials

The C3 facility is our most advanced facility, and the sweet spot would be 24-32 layers, HDI, backdrill. That generally makes six or greater materials. The C4 facility sweet spot is 10- to 12-layer board range of different materials with panel sizes that don't go past a 21x24 working panel size.

Johnson: That's four different facilities, four different sweet spots and setups, and four different rule decks, if you will. You must characterize each of your facilities uniquely within the design for manufacturability tool environment.

Link: Right. For most customers, we either only use one facility, or we know well in advance which facility it's going to go through. So, customer N might say, "Here's a 14-layer PCIE card," and we already know that's going to go into the C4 facility. If they talk about a 26-layer, HDI build, it's going to go in the C3 facility.

Johnson: Okay, so how do you assist your customers in doing that? Or are they even interested?

Link: They definitely are. With customers like that, we have periodic meetings with them to talk about details so it doesn't come up as a surprise. We are able to keep them aware of the types of technology available in the facilities. We do pretty good work from front-end engineering, working with the customer before boards are designed to completely be able to talk through issues that will eventually show up. We try to get them before it starts, basically.

Johnson: This can be time-intensive.

Link: It can be, yes.

Johnson: You're still working on a very manual process here for putting that information together. For example, there is no use of AI at this point to help with the process of thinking through manufacturability decisions?

Link: That's correct, and we want it that way. We give our customers a set of rules that say, "These are the rules that we want to be bound by," and then our competitor comes up with a different set of rules. Now maybe they're okay with 94% yield, and we were targeting a 95% yield. Suddenly, their rules look better than ours because they're willing to accept a little bit more loss in yield, or more risk to reliability. Because all suppliers don't have the same standards, they're gauged against it on paper: "Can WUS do this? Can XYZ do that? Oh, XYZ can do it, but WUS can't. Okay, we'll give them the work."

We like to have some of those discussions as well: "This is the way it is, but we can do it your way, and it's not black and white, because PCBs aren't black and white, right?" Reliability is parts per million, yield is in percentages, and unless everybody's held to the same stan-



WUS Printed Circuit Co. headquarters, Kaohsiung, Taiwan.

dards... I've always been careful about giving our customers a tech roadmap and then asking "What are you capable of doing? Can you do a three-mil line and space? Can you do a two and a half mil line space?" What does "can" mean? That's part of the problem, and that's why you can't necessarily have an AI-driven model. Eventually, you could, of course. If humans can think of it, computers can think it as well, I understand that. But I don't know how you deal with that product on a competitive basis.

Johnson: I'm starting to understand why this is different for PCBs. Semiconductors and PCBs share the same sorts of concerns, but by the time we got the chip going into the package, it's usable in multiple applications—whereas the printed circuit board is unique and specific to that one particular design, that one particular product. PCBs are much more customized.

Link: You could argue the same for semis: they're custom made for their particular application, but the volumes are so much greater that they're not going to make a semiconductor and make 20 pieces of it. It's going to be thousands or hundreds of thousands, or whatever. The volumes are significantly differ-

ent to be able to address. I've never been in that level of detail with the semis, so I don't know what they do from a design for manufacture standpoint. Do they revisit it and say, "We're going to run a test run and see what yields we get; we revisit the costing based on our yields?" I don't know. It doesn't happen for our industry.

Johnson: Semiconductor fabs might be running 300-millimeter wafers, squeezing as many components as possible

out of each individual wafer as they can. The quantities are such that half a percentage point in yield is a significant change to the bottom line. PCB is often a much smaller scale. So how do we bridge the gap? I suppose this is why it stays a fairly human activity, design for manufacture in PCBs.

Link: Yes, because the volumes are inherently smaller. Maybe you have Intel making the motherboard, and maybe that's a whole different discussion? Or maybe they have different tools that they've really worked on. I know that people like them will go out and constantly survey the industry and constantly ask what's capable here and what's capable there. They take many, many tours through PCB facilities to be up to speed with what reality is, but it would be interesting to see those types of guys and how they're dealing with that side.

Johnson: How do you work with a designer to describe average vs. cutting edge? Because if you can make a change that makes the board more manufacturable, then it's usually less expensive to produce. Is it different when you're consulting with somebody vs. when they walk in with a design?

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Link: It absolutely is different. If we get them beforehand, we can have a clear conversation with them to say, “Ideally, you’re going to be designing around this. When you’re figuring this stuff out, don’t make line widths less than that because of these conditions.” We can spell it out pretty clearly on the design phase. We’re working with a new customer now. It’s been this way from day one because they’re just developing boards and their designer was from the HDI industry. He’s not really up to speed on single lam with backdrilled structures, as opposed to just build up, and I’ll just build up wherever I want to go and deal with it. It’s been hand holding from day one to say where the design needs to be and how it needs to move.

It’s been hand holding from day one to say where the design needs to be and how it needs to move.

It’s significantly easier. Sometimes we talk about costs, sometimes we don’t. In the end it’s going to come back to a cost model that does or does not reflect what I’m actually telling them. Will it cost less or more? Well, the cost model doesn’t tell us that, so there’s a problem. Now, I get disconnected communication with the customer. We have to be very careful when we talk pricing. And unfortunately, I think that’s where I would probably put the AI on the cost, and just be able to say, “If I tweak this line from 4.3 mils to 4.5 mils, what does that do for my cost?” To have that driven by the AI would be much more effective than saying from a design standpoint as to which one is better. Actually, I’d put the AI in costing.

Johnson: How comfortable is WUS with sharing capabilities out to customers for use? For

example, do you give them rule decks? Anything like that?

Link: We have definitely shared the DRC rules, and we have shared specifications as far as where we are, what we’re capable of, what we’re not capable of. But we generally wait for them to ask for it. We’ll talk about technology roadmap and say that we’re improving from here to here, but we’re not stating that we can do A or do B; it’s that we’re making this transition, and we’re going through these improvements.

Johnson: As a fabricator, what do you want your customer to really understand about DFM? For example, if they could just do this or that, it would be so much smoother for everybody involved.

Link: I want them to understand that it’s not black and white. The most important message is that, when designing boards, it’s not “you can’t do this, you can’t do that.” It is, “This will impact my yield significantly, this will impact my yield less.” If I have one location on an 18x24, that’s three and a half mil spacing or if I have 5,000 locations that are three and a half mil spacing, it’s a very different dynamic. And maybe I can do one with 100% yield, but as soon as I throw in 5,000, now my yield goes down to 2%. It’s being able to react to that, because it’s not just black and white. There’s a trend line based on a number of instances, a number of potentials.

And if they’re looking for backdrill sliver protection, how many backdrills do I have? That’s an important question. Do I have 50 or 20,000? I have a much higher chance of having a sliver on one board with 20,000 than I do with 50. It’s the great the gray scales. And it’s not even a digital scale, it’s an analog scale.

Johnson: Right. It’s like baseball; shortstops usually have a lot more errors because their position means they have a lot more chances. If

you look at raw numbers, they have more errors, but if you look at from percentages, the perspective changes. Regarding the data packages and communicating that information, is there change underway that you see? Or is it status quo right now?

Link: I would say that it's probably still at the status quo, but I could definitely see it changing.

Johnson: What needs to change in your opinion?

Link: To get a more accurate reflection of the digital twin. Because, unfortunately, every shop has different ways they run things so I guess it would take a good grasp of the processes that the shop has created to build said boards and then integrate that into the board itself.

Johnson: Even within WUS, each of your four facilities has a unique intake process. That certainly does make it difficult to standardize the process. So, to be able to move toward something like Industry 4.0 in fabrication, is standardization of the facilities' intake process an important step?

Link: Yes, standardization as in what's important, not standardization as Shop A and Shop B have the same process, because Shop B might not need that process. Typically, a shop has created a process because of their customer's boards which demand that process. Shop B might not have that situation and so they're dealing with boards that would never use that process so why integrate it. Even if they use it, it's so rare that they're not going to buy a machine or set up a process to do a one-off situation.

Johnson: What kind of data packages do you guys use most often?



WUS Printed Circuit Co., Kaohsiung, Taiwan.

Link: ODB++. There's still some Gerber out there.

Johnson: Greg, do you think the whole DFM tool set is broken? Or is it running as best as it can?

Link: It's definitely not running as best as it can. As I said, call it DFM, but in reality, it's not. I think that I would like to see it actually be designed for manufacturability. And that should mean something like we took an old design, and we found that it had four-mil spaces and six-mil spaces. We ran it through our tool, we could utilize exactly the same space and get a product that was acceptable to engineering, SI engineering, and make it all four-and-a-half mil spacing. That would be how it should work. We looked at it and said, "I got a 20:1 aspect ratio." My DFM said, "I could actually make this 15:1 aspect ratio, you don't lose anything." Then that's done. That's the way it should work, and clearly, it's not working that way.

Johnson: Thanks for your time, Greg.

Link: My pleasure. PCB007

Greg Link is FAE account manager at WUS Printed Circuit Co. Ltd.

ein Electronics Industry News and Market Highlights



Siemens Acquires proFPGA Product Family from PRO DESIGN ▶

Building on the recent announcement of its next-generation Veloce hardware-assisted verification system for integrated circuits (ICs), Siemens Digital Industries Software has signed an agreement with Germany-based PRO DESIGN Electronic GmbH to acquire its proFPGA product family of Field Programmable Gate Array (FPGA) desktop prototyping technologies.

Q1 2021 Global Semiconductor Equipment Billings Increase 51% YoY ▶

Global semiconductor equipment billings increased 51% year-over-year and 21% from the prior quarter to US\$23.6 billion, SEMI announced in its Worldwide Semiconductor Equipment Market Statistics (WWSEMS) report.

NORBIT Enters Nordic Semiconductor IoT Partner Program ▶

NORBIT announces signing of Partner Program Agreement with Nordic Semiconductor, a Norwegian fabless semiconductor company specializing in wireless communication technology, to explore joint opportunities stemming from Internet of Things (IoT).

Energous, Atmosic Achieve Industry First Interoperability Energy Harvesting ▶

Energous Corporation, the developer of WatUp®, and Atmosic Technologies, an innovator of ultra-low power wireless for the Internet of Things (IoT), announced they have achieved the industry's first interoperability for radio frequency (RF) energy harvesting technology.

Atotech Experts Present at Global Semiconductor & Electronics Forum ▶

Atotech, a global supplier of specialty chemicals, equipment, software, held a presentation at the Global Semiconductor & Electronics Forum on semiconductor innovation in June.

SEMI Supports Introduction of Fabs Act to Spur Semiconductor Manufacturing Growth ▶

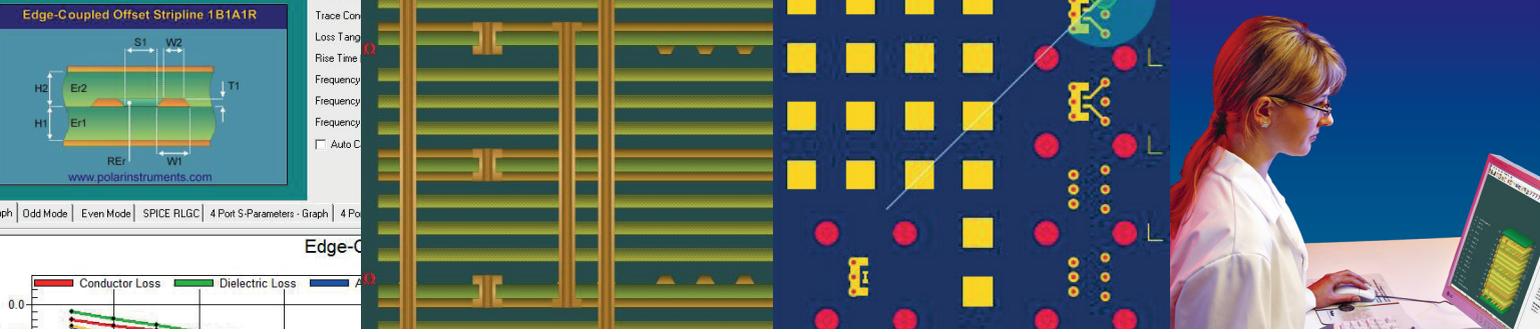
SEMI, the industry association serving the global electronics design and manufacturing supply chain, has expressed strong support for the Facilitating American-Built Semiconductors (FABS) Act.

KLA Launches Automotive Products to Improve Chip Yield and Reliability ▶

KLA Corporation announced the launch of four new products for automotive chip manufacturing: the 8935 high productivity patterned wafer inspection system, the C205 broadband plasma patterned wafer inspection system, the Surfscan® SP A2/A3 unpatterned wafer inspection systems, and I-PAT® inline defect part average testing screening solution.

Scientists Develop Transparent Electrode that Boosts Solar Cell Efficiency ▶

Developing new ultrathin metal electrodes has allowed researchers to create semitransparent perovskite solar cells that are highly efficient and can be coupled with traditional silicon cells to greatly boost the performance of both devices, said an international team of scientists.

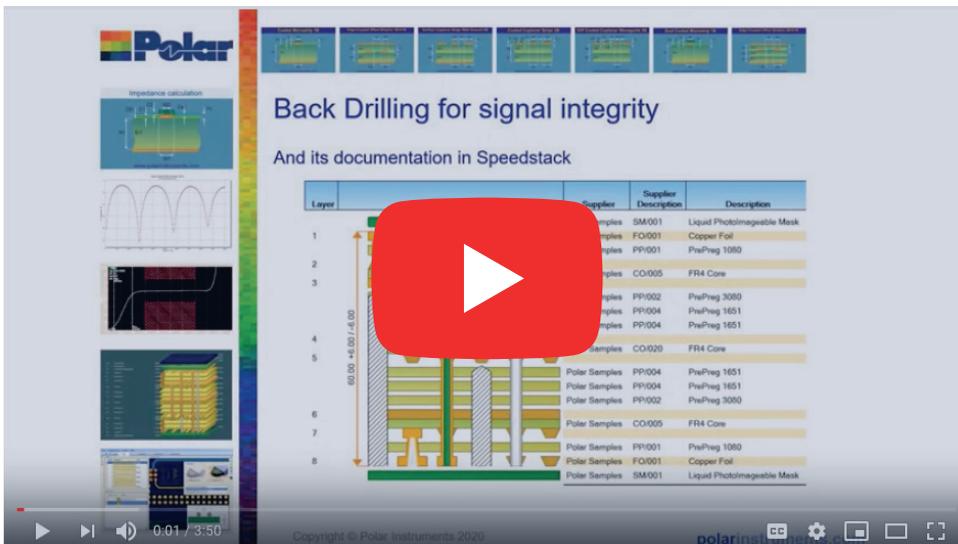


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Working Through Shortages

Standard of Excellence

Feature Column by Anaya Vardya, AMERICAN STANDARD CIRCUITS

Right now, we are all facing the same challenges of not having the right “everything,” from laminates in my industry to critical components in other related industries. As the result of the pandemic, severe shortages—both real and created—from our offshore vendors are making it difficult for us to build and deliver products on time.

That, combined with a sharp increase in product needs (especially new product development), has impacted the entire electronics industry, and I am certain it has impacted other industries as well.

If we are going to get through these hard times, it will require us to have a true cooperative relationship with our vendors. We need them now more than ever. And if they want to sustain a good relationship with us both today and in the future, they need to find ways to support us.

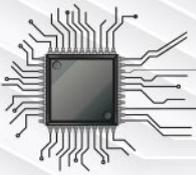
It is in challenging times like these that true long-term vendor-customer relationships are forged. But it takes patience, honesty, and cooperation from both sides of the desk when it comes to overcoming these challenges.

There is only one true way for this to work and that is for us to work together, not only with our vendors but with our competitors as well. We might have something that our neighbor needs and we might need something from them. Our vendors can help us with that.

If we have good vendors, if we have worked diligently over the last few years to establish a good relationship with them, then we will be able to trust them to help us get the products we need, even if we must get them from our competitors.

Here are five things we can do with our vendor partners to get us through these times of shortages.

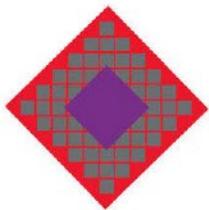




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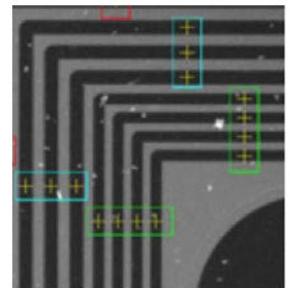
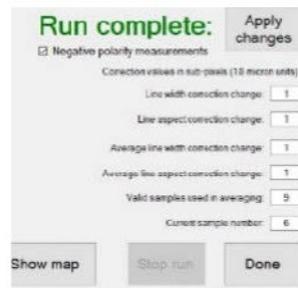
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1. Take down the silos. As we have heard so many times over the past 15 months: *We are all in this together.* This has proven to be the best policy of all. Let's all find ways to work together—vendors, customers, and even competitors—and find a way to share knowledge, experience, and technology that help us overcome the shortages we are facing today. Who knows, by working together during these hard times, maybe we will all get to like one another and start productively working together in the future as well. Now that would be something.

2. Work with your vendors to find alternative solutions, especially when it comes to products like materials/laminates. If you are a PCB fabricator, ask your laminate supplier for alternative substitute materials, ask him to talk to your customers to convince them that the substitute products will work as well as the products that are already spec'd in. If you are the PCB customer, work with your PCB vendors, their engineers, and your engineers, to either accept the laminate supplier's alternative solutions or come up with a more suitable solution of your own.

3. You should be open to trying new products. In times of great adversity comes great innovation. Maybe this is the time to try something new—a process, a type of substrate, a chemistry solution—that might help us get through these shortages. Nothing should be off the table. In the end we are all trying to meet and satisfy our customers' needs and maybe the way to do this is to open our minds to discovering and trying new alternate solutions to the problems we are facing.

4. Have grace under pressure. This is defined as the ability to keep your head about you while everyone else is losing theirs. Get-

ting angry and impatient with your vendors never helps, especially in times like these, when you need your vendors now more than ever. Work side by side with them to find a way to solve the problem together. Fighting and arguing at this point is counterproductive.

5. Be realistic. Assume that your vendor partner is doing their best and give them space to do that. Pushing and applying pressure will only intensify the problem rather than fix it. The best thing to do is work together. The more understanding you are about your suppliers' issues the sooner you will, together, find a way to solve the problem.

This is the right time to find out how solid your partnerships with your vendors are. It is always much easier to have a great relationship with your vendors when everything is going great. But it is much more challenging and difficult when times are tough. But the way you work with your vendors in these hard times will determine the kind of relationship you will be forging in the future.

Remember that this too, will pass and one day when you are at dinner with your vendor partner you will have a glass of wine (or maybe even a flight of wine) and reminisce about the good old days when together you overcame the great shortage challenges of 2021. **PCB007**

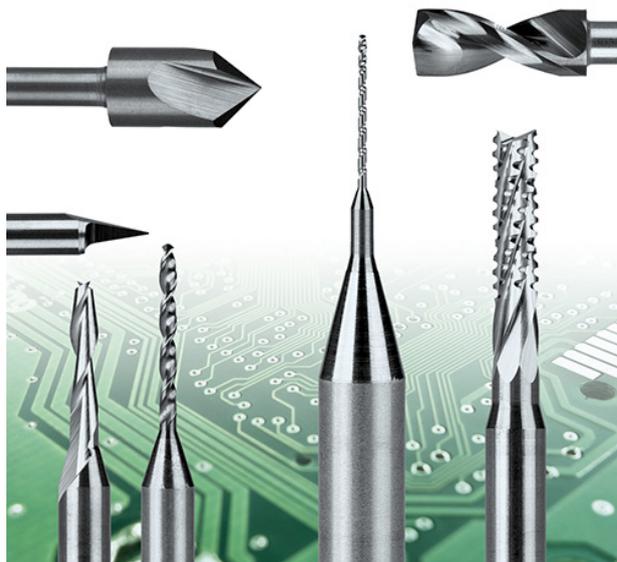


Anaya Vardya is president and CEO of American Standard Circuits; co-author of *The Printed Circuit Designer's Guide to... Fundamentals of RF/Microwave PCBs* and *Flex and Rigid-Flex Fundamentals*; and author of *Thermal Management: A Fabricator's Perspective*. Visit I-007eBooks.com to download these and other free, educational titles. He also co-authored "Fundamentals of Printed Circuit Board Technologies." Anaya regularly co-authors the column, *Standard of Excellence*, on PCB007.

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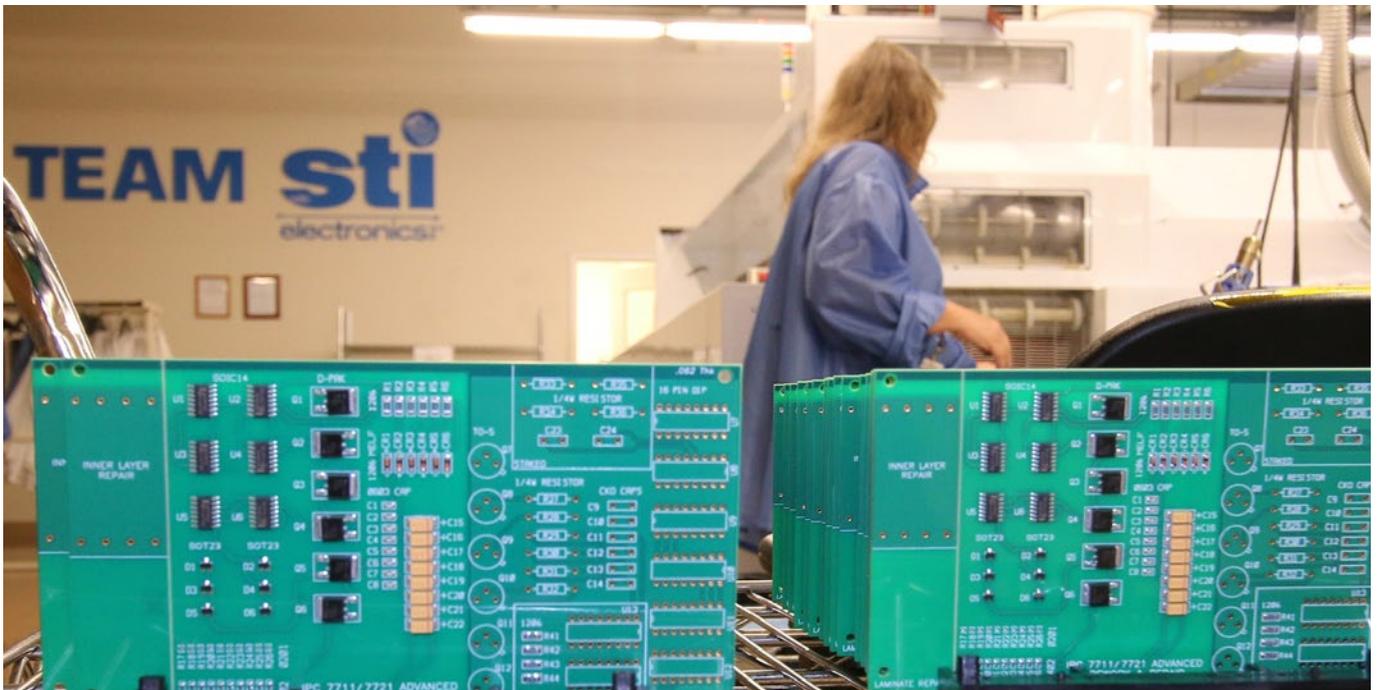
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Navigating Current Market Dynamics

Feature Interview by Nolan Johnson
I-CONNECT007

Nolan chats with Mark McMeen of STI who provides an overview of the complicated market dynamics in place due to material shortages and long lead times and describes what strategies OEMs and CMs are doing to survive this difficult stretch while also planning for an economy ramp up.

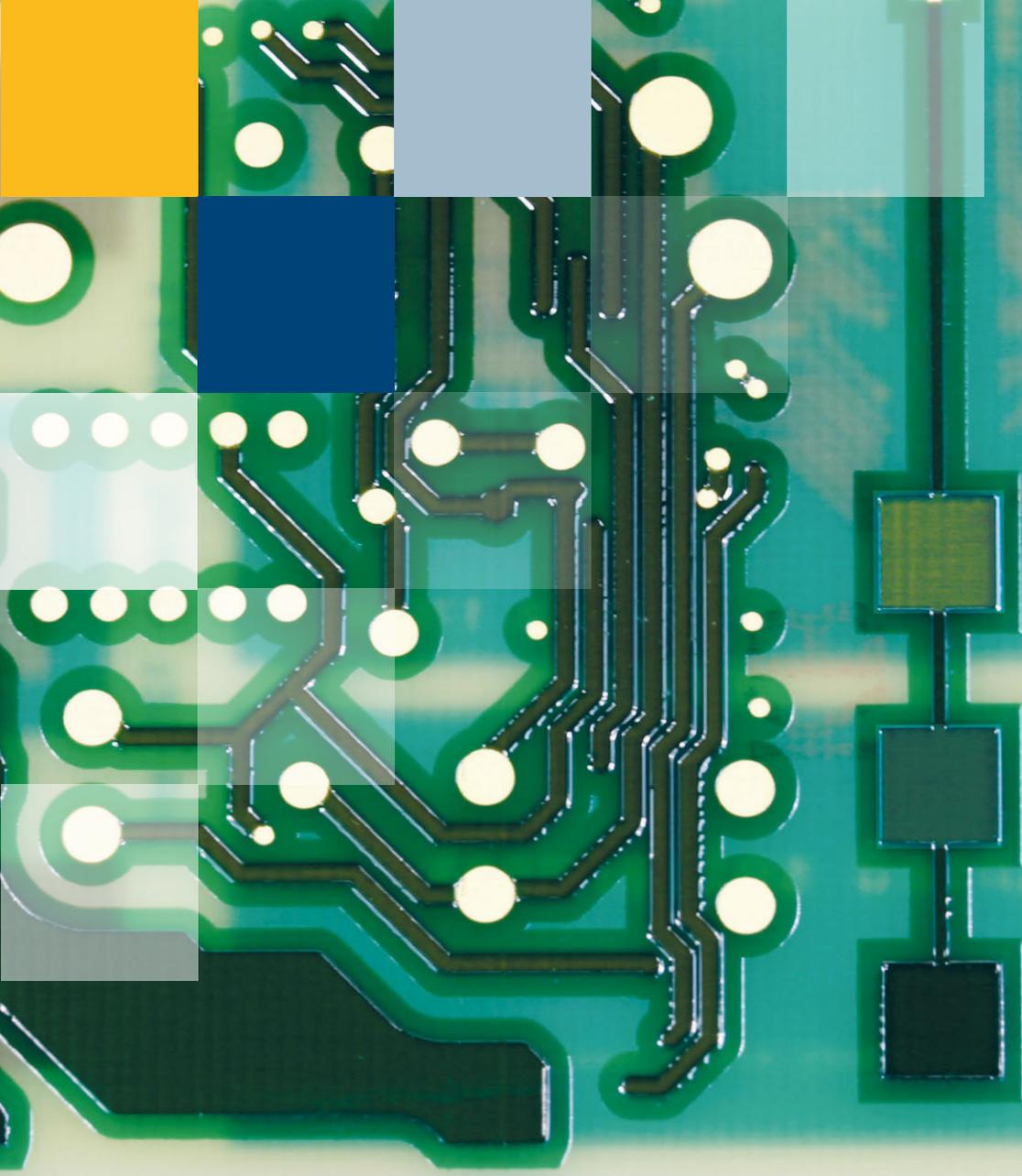
Nolan Johnson: The current market dynamics seem to point toward price and cost increases. You and STI have some interesting perspective. Mark, give us an overview of the dynamics that STI is seeing.

Mark McMeen: There are many variables in the marketplace as it relates to electronic components and electronic assemblies that are impacting the whole supply chain. The thing that's jumping to everybody's attention right now is there are both passive and IC components that are going way out with lead times. Lead times

that used to be four to six weeks have jumped to 26 to 40 weeks. On specialty capacitors that are used very commonly, they are jumping out 50 to 65 weeks. When you start to see this type of dynamic in the marketplace and the supply chain, there becomes a trickle-down effect down because not only contract manufacturers, but OEMs now must start thinking they can't wait a year to simply deliver to their marketplace or customer that far out.

People start looking for alternatives, and once you find an alternate, then you must redesign the boards to be able to handle those alternatives; not all alternates are drop-in devices for your existing printed circuit board layout. Those dynamics have a big effect from STI's contract manufacturing standpoint. We are doing a lot of redesigning of circuit cards around the component sets that are available so that you can continue to have your end product in the marketplace.

We're seeing new dynamics; everybody was expecting this pickup and rebound from the pandemic, but they didn't expect that the



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whole supply chain would be impacted. When we started recovering from the pandemic, suddenly everyone was buying up large amounts. Not just six months in advance, but 18 or 24 months. It keeps the supply in a shortage state, and now we must find alternates so that we can build your particular electronic hardware in an environment that has normal shortages.

You hear about this big economic recovery, and it's true, it's happening. All the businesses are heating back up; they're trying to produce to meet the marketplace demand. But the kicker is that, just like nobody knew how to prepare for the pandemic, nobody knows how to prepare for this recovery. And the one thing you don't want to do is be the guy who can't deliver a product during the recovery.

Johnson: Now that everybody is redesigning for alternates, that increases the demand for alternates. Now lead times are shifting for components that once had a more acceptable lead time. By the time the redesign is done, lead times have doubled.

McMeen: Exactly. This whole procurement cycle is out of balance because things that had never been on a shortage list are now becoming shortages themselves. If you're on the manufacturing side of components, you've got nice orders covering a long period, non-cancelable, and you're in pretty good shape. But this is going to trigger another out-of-balance sequence.

Right now, we have a shortage. Everybody is putting on capacity, and they have these non-cancelable orders. They're gearing up production, they're adding new lines, they're adding people, they're adding to this recovery. But remember, it's a false volume because it's an expected volume for the future. Your customer hasn't given you two years' worth of orders, he's given you their normal order demand and



Mark McMeen

you're expecting it to stay at this elevated run rate because we're in this massive recovery. At some point, we're going to go from being in a shortage to a surplus because we will have bought too many raw materials or component sets.

The shortages are going to drive inflationary pressure. Everybody will raise prices on their components because they're trying to get higher volumes through

their factories that had slowed or stopped during 2020. Now they are trying to get their front lines back up and they are finding these long run cycles because they have all these order demands. The supply chain will blow past equilibrium and go back into oversupply. This will drive the pressure economically to drop the price so that you can move your inventory.

At what point do we hit equilibrium and how well can we manage it when we blow past equilibrium and go to an oversupply? Nobody knows what the future is. We're in uncharted waters and everybody is just trying to maximize their revenue streams because we had a lean 2020 and now a bumper 2021. What will the next two years look like? How long will it take to come back into equilibrium?

Johnson: This puts responsibility on the component manufacturers to show restraint in their ramp-up, even if that means a slightly longer bump in demand to smooth things out, rather than to overbuild infrastructure just in time to have everything fall out from underneath them.

McMeen: Right. But the history in our industry shows a struggle to find that equilibrium and normal growth rate. Memory is notorious for this. There will be a run-up, and memory prices will be strong with strong margins. Suddenly, they'll hit equilibrium, but the factories are still churning. So, the memory prices fall be-

cause there's an excess amount of memory. At the same time, memory is increasing in its engineering and technological advantage.

The question is, do we have the right volume to be able to keep the market moving efficiently, both in its availability as well as fair pricing? It's going to be an interesting ride.

Johnson: What are your concerns in this current market?

McMeen: The worst thing I could do right now is not meet my customer's build objective. If everybody is hoarding because of an expectation that the parts are not going to be there in 20 or 30 weeks, that becomes a problem. But that's also why you're going to have a problem throughout 2021. In our case, we are redesigning to use products and components we can buy right now. And then we'll wait until the next cycle and decide whether we can buy the original part that was on the design or will we have to then try to do another buy of the alternate. You're going to have OEMs that are carrying two sets of designs.

The tier ones don't have this problem because they control so much of the marketplace. They've already got their forward contracts in place, and they are already getting preferential treatment because their contracts are already there, and their volumes are there. It's the smaller, medium-sized companies that cannot afford to put large amounts into inventory as a hedge for what the future is going to look like.

Johnson: That's an interesting dynamic. This pushes the active management of procurement and contract manufacturing all the way up to the design team.

McMeen: Correct. I've been doing this for over 25 years and it's the first time that I've seen people actually designing and creating alternates to be able to build the same thing, because they expect this shortage problem to go on for 18 to 24 months.

Johnson: Carrying two different flavors of the same product in your distribution channels—from an OEM perspective—brings additional risk with respect to field failures and field support.

McMeen: It becomes a challenge. But right now, you either do that or you hoard inventory. The whole auto industry had been built on the premise that we're going to build it just-in-time, everything is flowing in. But if you can't get the sensor components, for example, all you can do is either build and hold for retrofit later, or you schedule periodic shutdowns where you don't produce at all. And that's a very expensive supply chain.

And what about industrial devices, like air conditioners or water meters, things like that? Do I stop and wait, or do I build and then retrofit, or in some instances, do a redesign around alternates so that I can continue to build normally? Each industry is trying to figure that out. The whole global supply chain faced the same pandemic, and everything has been impacted, from the raw materials to the converted materials to electronic assemblies. Those assemblies go into full systems, and the whole full assembly or system now must have all the component parts and the sub-assemblies all working to be there so that you can deliver the finished goods to the customer. Just one shortage can prevent you from meeting your deliv-





ery obligation and it can be across a wide range of things. The ones that we see in the newspaper are just the ICs.

Johnson: Everybody thinks ICs are sexy.

McMeen: Because that's the high dollar item, that's right; it's the sexy one with the latest technology that allows us to do all these great things. But remember, there are all kinds of resistors and capacitors and inductors. There are a bunch of non-sexy components that still must be built. And the raw materials have to come out of the ground, and everything has to be converted and be in the pipeline so that it can flow to the converters, to the contract manufacturer, or the OEM, and this type of dynamic hasn't been seen.

Johnson: We're going to find potholes in the supply chain that we never anticipated. How do you recommend managing all of this? How do you help your customers smooth this out?

McMeen: Pricing is going to be driven by supply and demand. We can definitely see there's going to be inflationary pressure on the raw materials, from the most basic to converted raw materials. There's always this gradual increasing in pricing, but there may be a surge at first where tech goes into a premium, and then it

settles down, but it never settles back down to what it originally was.

So, your point needs to be viewed as two different things—labor and material cost pressures. Raw materials that have a tendency of increasing will have a slight decrease. Then we find this new equilibrium or new norm, but there's still this increase. Materials conversion, where we're converting and adding whatever we've got to do from that standpoint, also has an inflationary push because whether it's the adhesives or the electricity to convert the raw materials, it's increasing

as well. Whether you're building chemistries that are used as a subset to convert our materials, all of those are increasing. Those are inflationary pressures, just on the materials side of the house.

The labor side of the house is also increasing because we're under a new norm and the cost of living itself is increasing. Look what occurred in 2020 when we stopped eating out, we stayed home more, and we started buying more from grocery stores. We saw what happened to the wholesale food industry.

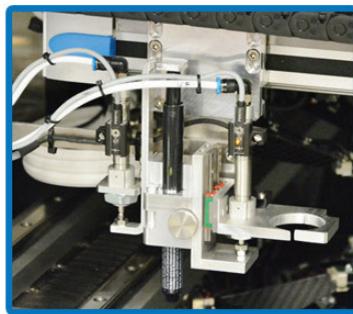
As grocery sales went up, we saw a change in our culture. You couldn't get cleaning supplies. Meat prices went up because those plants were struggling to keep people inside these processing plants so that they could convert the food to the grocery store so that we could live our new norm, which was staying home and cooking more. That put inflationary pressure on the cost of living. As the cost of living goes up so does the labor rate for people. As the cost of living goes up, then companies must raise their salary rates.

So how do we combat pricing pressure? We generally use forward contracts to try to control the prices for the components we buy. If you have a purchase volume and customer base that is very consistent, that's not too cyclical, then often you can just soften sudden downturns by pushing the delivery date to the right. What we're finding is, as we took the 2020 sales

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projections and shifted them to the right, now people are coming back and wanting their 2020 quantities, which were pushed to the right, but they also want to increase those quantities by 20 to 25%.

We use forward contract purchases to try to get that pricing. There may be an increase, but we let our supply base know our 2022 forecasts, that we'll be buying these components again, and that we need a fair rate. There will be the market increase, but you're not going to get what I call the "spot buys."

The pressure on the CM now is to add either more people or more capacity to their lines. Each industry is doing it a little bit differently, but each CM or OEM is trying to meet that pressure with some level of cautiousness; they don't want to overcapitalize and put in too many lines or put in too many people only to find out they overestimated where the new equilibrium ends up.

There will be this new balance of how long I keep my current design before doing an enhanced design. I believe that design teams used the pandemic to think about new products, but not necessarily launch them. Now comes the decision on how long to keep running with my current design before I do my new enhanced one.

In addition, we're finding OEMs trying to do both: bring the alternate to market, plus bring in their future designs earlier. OEMs approach it differently depending on what that impact looks like to them. Small companies developing products for niche markets are the ones struggling the most; others with an ongoing line of product may well defer design updates to the right so they can burn through their inventory. It's a pretty interesting dynamic and it's a multi-variable problem.

Johnson: Mark, do you see this as an opportunity for process improvement and optimization in internal operations? With all this volatility that threatens your margins, one place a contract manufacturer can have full control is

in the efficiency of the processes. Is that something you pay attention to?

McMeen: Yes. We view adding labor as one of the last things we want to do. We want to make our labor pool more efficient by giving them capital equipment that makes them more efficient and more effective at meeting the yields. We try not to throw people at the surges and changes, but rather spend the time to increase our yield capability by adding capital equipment that makes them more efficient or more effective at increasing their yield output. We are looking for ways to increase our yield by adding equipment that aids the production line but also aids the laborer or the technicians, and the skilled support staff and production engineering to make them more efficient to increase their yields, which makes them more valuable to the company, but also more effective at being able to handle our surges.

We are using design and industrial engineers to give us better yield efficiencies. And because of the lag in getting materials, for our long production orders, those particular lines are not impacted as much as are the orders we build once every few months. We pass the price increase to the smaller operations with a smaller order procurement because we're not doing long forward contracts with them.

It really depends on the type of customer, their volume, and what their product life cycle looks like over a multi-year period. Prices are going up, but exactly how depends upon who the customer is and what their product life cycle looks like. If you've got a smaller customer that's doing quarterly or monthly buys, those particular guys are seeing a much larger spike because we're not buying as far into the future.

It's interesting to watch this; we are seeing for the first time a big effort to redesign to the parts that are available. What used to be rare is becoming common practice. Design engineers are in a constant state of evaluating alternates and redesigning to keep their build cycles on some type of consistency.

Johnson: As management in contract manufacturing, it's almost like you don't know what the market's going to be when you walk in every day.

McMeen: It's a constantly changing landscape and all you can do is address each situation individually. Each design is unique and has its own component set. Your buyers need effective relationships with their distributors to know what the component pressures are likely to be. It's all based on trust. The distributor does not want to fail you because they know you will remember that once this crisis is over.

In the end, it's not just about making as much money as you can in the short term; you've got to take a longer-term approach. If that relationship fails, and the oversupply goes into practice, what will you do? As a customer, you will go to the supplier who was reliable and honest. Even with a shortage, if you felt you were treated fairly and received good market intelligence, you will continue to buy from them.

Johnson: Are we going to be looking at market consolidation, or is this one of those points in history where the industry starts to innovate again? Is this going to be disruptive?

McMeen: There are a couple of different variables and points to address here. One, the United States is going to view this as a national and safety challenge to itself. Congress will put incentives into place to bring ICs onshore so that we can produce our own integrated circuits and put pressure on the supporting industries, such as packaging. For every IC manufacturer like these big IC fab facilities such as Intel, TSMC, and GLOBALFOUNDRIES, they will be supporting the integrated circuits that we need here in the United States, so that it protects our core industries in electronics.

With that will come a surge in needing supporting companies. For every integrated cir-



cuit fab facility which costs billions of dollars, you're then going to have to take those ICs and test them and put them into packages. Now you're going to have these big packaging houses here. So, where we had gone global—most of them were in Asia—you're now going to see that being redistributed around the world so that we are not caught in the same dynamic. Even though the pandemic brought us to change, it is also a national security thing. The military uses a lot of ICs. National security will mean a redistribution of electronic component manufacturers to different parts of the world to mitigate risk from a DoD standpoint.

The same thing is going to happen with our raw material supplies, because if one country controls too much of the raw material basis—such as steel, iron, copper, or lithium—you could give a certain part of the world too much of an advantage. We're going to see a change in our procurement, in our way of thinking about managing risk on a global basis by redistributing processing plants and mining of the material sets to try to find some more equilibrium on a global basis.

Johnson: Mark, you just delivered an amazing overview of the situation. Thank you.

McMeen: You're welcome, Nolan. PCB007



Supplier Highlights



MKS Instruments to Acquire Atotech ▶

MKS Instruments, Inc. announced that they have entered into a definitive agreement pursuant to which MKS will acquire Atotech for \$16.20 in cash and 0.0552 of a share of MKS common stock for each Atotech common share.

Element Solutions Inc Announces Planned Acquisition of Coventya ▶

Element Solutions Inc, a global and diversified specialty chemicals company, announced that it has made a binding offer to acquire Coventya Holding SAS (“Coventya”), a global provider of specialty chemicals for the surface finishing industry.

Inkjet Solder Resist: Peters Collaborates with Atotech ▶

Peters is collaborating with Atotech for the development and testing of their new environmentally friendly and resource-saving technology in the field of inkjet solder masks. Atotech is one of the world’s leading suppliers of specialty chemicals.

Altix Receives Repeat Order for Direct Imaging Equipment ▶

Xiamen Guangpu Electronics Co., Ltd., a leading Chinese manufacturer of LED lighting, photoelectric sensors, IoT based hardware and FPC products, has expressed its trust in Altix by ordering multiple direct imaging machines.

atg LM Showcased Latest Generation Flying Probe Tester at CPCA ▶

atg LM showcased their latest technology, atg A9, at the CPCA show in Shanghai, China, earlier this month.

New LPKF CuttingMaster 2122 Improves Depaneling Efficiency ▶

LPKF has enhanced the performance of the proven and popular LPKF CuttingMaster depaneling system even more with a newly developed laser source. Initial applications demonstrate a significantly higher cutting speed and, as a result, an up to 25% higher output.

Nordson Electronics Solutions Introduces MARCH MegaVIA Plasma Treatment System ▶

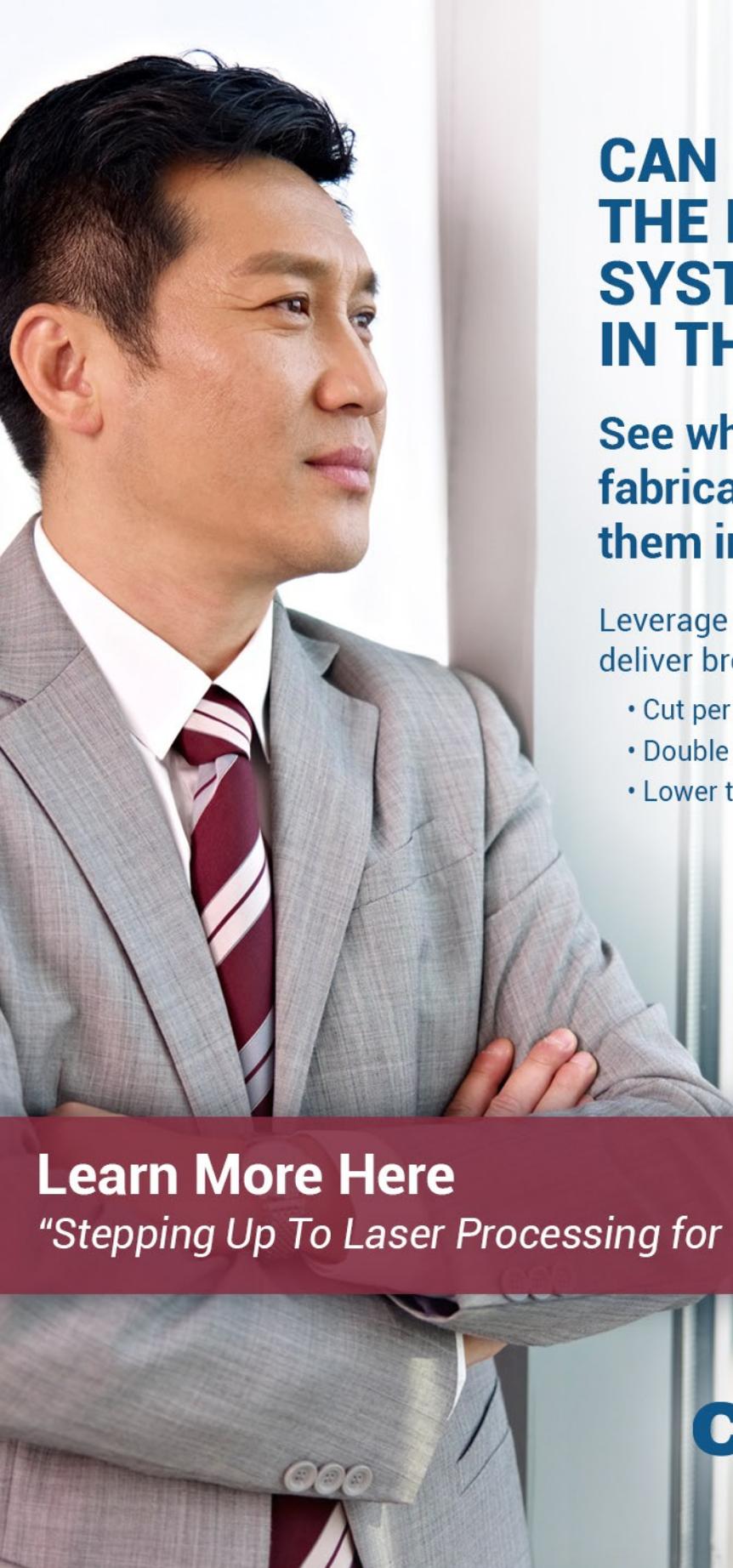
Nordson Electronics Solutions, a division of Nordson Corporation, a global leader in plasma processing technology, introduces the MARCH MegaVIA™ Plasma Treatment System with a 15-cell configuration for panel sizes up to 30 x 52 inches in printed circuit board manufacturing.

MacDermid Alpha Promoted Latest Technology Offerings at International Electronics Circuit Exhibition ▶

MacDermid Alpha Electronics Solutions, a global electronics chemicals process supplier, exhibited at the China International Electronics Circuit Exhibition hosted by the China Printed Circuit Association. The show was held July 7-9, 2021 at the National Exhibition and Convention Center in Shanghai.

Insulectro Promotes Ken Parent, Jason Shuppert, Felix Martinez Into Key Roles ▶

Insulectro, the largest distributor of materials for use in the manufacture of printed circuit board and printed electronics, has announced major changes in its corporate structure.



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Trouble in Your Tank

Feature Column by Michael Carano, RBP CHEMICAL TECHNOLOGY

(Editor's note: This special installment of Michael Carano's long-running column is excerpted from a Q and A session held by the I-Connect007 staff.)

Q: Happy Holden points out that direct metalization (DM) is more efficient, and more cost-effective than electroless. Is this the time to migrate?

Carano: DM has been around for 25 years. It is more efficient, easy to provide in a continuous horizontal fashion, and is environmentally friendly. Asia is way ahead of North America. We are starting to convince companies that DM is ideal for flex and HDI fabrication. Asia already understands this.

Q: What are the challenges right now?

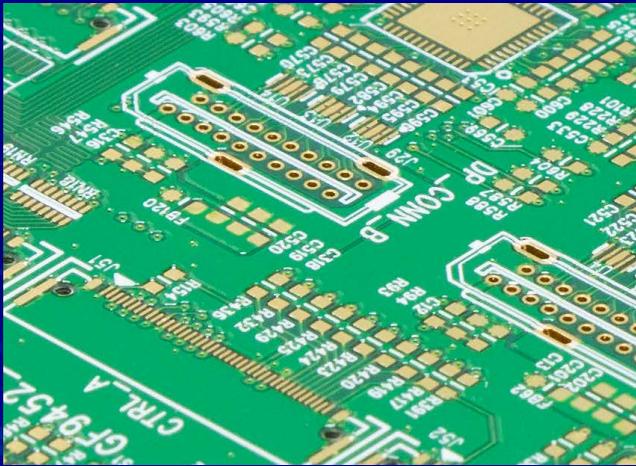
Carano: There are several—supply chain disruptions: price increases, low yields from the fabricator's standpoint, and an inadequately trained workforce, as well as aging or inadequate equipment needed to build high yield/higher technology product. The money will be made in higher yields and more complex circuit boards.

Q: What's new about those challenges?

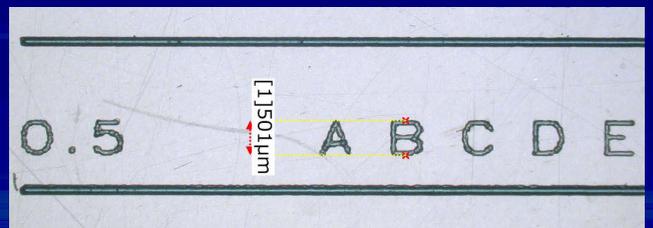
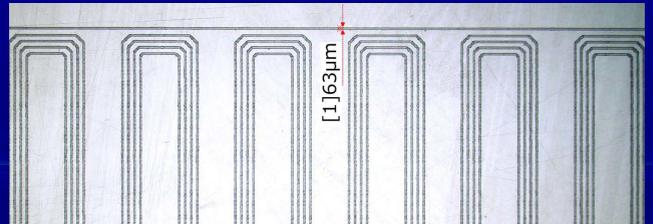
Carano: Mainly, the environment post-COVID is more challenging due to lack of ability to onboard workers; many line workers, so to speak, are poorly trained, and offered \$12–\$13 per



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hour. Really? My neighborhood McDonald's is offering \$15–\$16 per hour plus other enticements. Amazon is offering \$22–\$25 per hour plus benefits. No wonder the PWB fabricators can't find reliable employees. There's also a lack of government support for the PWB industry. They only see semiconductors as sexy, not recognizing that without a reliable board, the chips have nowhere to go.

They only see semiconductors as sexy, not recognizing that without a reliable board, the chips have nowhere to go.

Q: What do you anticipate for the next two years?

Carano: Without an awakening of our elected officials, the PWB footprint in North America will erode. The bigger firms (TTM, FTG, Summit Interconnect, Advanced Circuits) will find distressed fabs and acquire them as they have been doing.

Q: Dan Feinberg points out that price increases for the seller are cost increases for the buyer. Is this a good time to optimize processes to minimize your price increases?

Carano: I am a firm believer in process optimization, enhanced troubleshooting skills, use of statistical tools, training, and engineering. One should not wait to “optimize” processes. Optimization requires focus, commitment, and investment. Things as simple as automating the analytical procedures for the processes, training and certifications through IPC Training

Programs (much of the training modules can be taken online and on demand through the IPC Edge portal). Yes, most of the fabricators and assembly firms are not taking advantage of these offerings. Why? So much can be learned. Knowledge is power.

Q: How do folks down the chain from you mitigate the risk?

Carano: If possible, strike deals for material/chemistry supply with contracts. Also, lock in technical service from the supplier; however, that means paying a premium. The fabricators, instead of trying to beat down your price, should select the chemical material supplier on several other criteria:

- Innovation track record
- On-site tech support
- Being a partner with the supplier—to ensure steady flow of new ideas, best practices, analytical services

Q: Is this situation driving new product? Or is this situation causing a scaling back of product development?

Carano: We don't scale back product development; most of our competitors don't either. We continue to invest. That is the only way to help fabricators jump the technology curve. However, the fabricators need to change their way of thinking. We need to push the envelope a bit and invest in new technology and training/certifications. Process control, in many instances, is lacking or sub-standard. **PCB007**



Michael Carano is VP of technology and business development for RBP Chemical Technology. To read past columns or contact Carano, [click here](#).

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Isola Responding to the Market

Feature Interview by the I-Connect007
Editorial Team

This interview with Isola's Travis Kelly provides an overview of many important topics that the industry is facing, including how the global supply chain is being strained by materials, and what companies are trying to do to best manage the items within their control.

Barry Matties: We scheduled this interview to get an update on how things are going with Isola and your new facility, but with what's going on in the copper market and supply lines, we feel there's more to talk about. Travis, can you start with an update on the new facility and how that is coming online?

Travis Kelly: Thank you, Barry. The new facility in Chandler, Arizona is up and running. We have our R&D lab, which started many months ago. It houses many of the corporate executives, as well as shared services, such as human resources, finance, and IT. Also, we went live with our quick turnaround facility several

months ago. That's going well, but as you can imagine, there's a launch curve to that facility as we have tested the run-at rates on the equipment. Now we are producing revenue-generating orders. It's no longer just qualifications for customers, it's producing and fulfilling orders that are coming in from our customers primarily in the United States.

Matties: That's great timing; just as the market demands are increasing.

Kelly: Correct. It came to fruition at the right time. We have the other facility in Ridgeway, South Carolina, which is also extremely busy, but with having the QTA on the West Coast, we can service the West Coast more efficiently. We still have to go through several more qualifications for customers, but we're beginning to see many orders transitioning from Ridgeway to our new QTA.

Matties: With the shortage of copper and the demand increasing, do you think that the qualification process is going to be more efficient or expedited?

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Aerial view of Isola's new Chandler, Arizona facility.

Kelly: In terms of other qualifications for the new facility, some of the supply chain constraints that everyone is recognizing haven't really impacted that facility. That facility does not treat materials, so it is primarily pressing and finishing. We have ample room to move materials around, so when we think about Isola's global footprint, one way we can leverage that is by making sure we have the right raw materials in the right places at the right time. It's less about the supply constraints that the industry is facing and more about just getting into the new facility and qualifying our products on new equipment. That's happening very quickly. We expect to have most of the qualifications done over the next couple of months.

Matties: Travis, what are some of the lessons that you've learned, or surprises that came along, during that process?

Kelly: Ultimately, it is an advanced facility relative to the technology that's being utilized. A lot of the pressing capability is much nimbler. As opposed to having large presses with many openings, these are smaller presses so that we can do a high mix, low volume. We made a really good decision with the equipment we're utilizing. Some of the lessons learned relate to the

automation of the facility. If you look at some of our other facilities, you will see a lot more labor as opposed to what we have in Chandler because so many operations in Chandler are fully automated.

It takes a lot of time to debug. If you think about all the programmable logic control (PLC) on the machines, it takes a lot of time to debug those, especially as you get into high mix. You're looking at different panel sizes, prepreg sizes, and the finishing line. Ultimately having that knowledge and working toward having flexibility as it relates to such a high mix would benefit us in the future. We continue to roll out more automation amongst all our facilities.

Matties: With the price demands on copper now, that automation is certain to give you some advantage.

Kelly: Yes. Ultimately the goal is to be more efficient for our customers and have the optimal setting. Although we haven't realized any copper shortages, hyperinflation is happening right now, and hopefully, we can pull some levers by having more automated facilities to take some of that labor content out, to remain competitive in the industry.

Matties: Now we're hearing from manufacturers that material lead times are growing. Are you experiencing that? Are your customers feeling that from Isola?

Kelly: Lead times are growing across the world, not just in the U.S., but across our global footprint. Europe is extremely busy right now. Lead times have been stretched very far out. Although the QTA is running in North America, it's a launch curve, so we are still qualifying current products for customers as well as putting commercial sales into that facility. It's not 100% of where we expected it to be by July, so that's not helping alleviate some of the lead times. Our facility in South Carolina is extremely busy as well as our facilities around the globe. Once we get the QTA 100% operational and have customers qualified by July, we should see some of those lead times coming down.

Matties: With the demand for copper in industries that aren't so demanding in terms of performance and specification, how does that play into our industry? Given the global effect right now, do you expect lead times to come down?

Kelly: Copper is a number one topic. We're seeing inflation on most of the direct raw material inputs into our product. Copper is the biggest focus because it has the most transparency; you can see the price fluctuations on the LME. You can read about copper, almost daily, whether you're trading copper or using it as an input to manufacturing. We are also seeing increases in woven glass and resin systems; there are cost increases across the board. The interesting thing about copper is the amount of hyperinflation we're seeing, partly because copper is in high demand for the electrification of vehicles.

Charging stations also require a lot of copper, as well as the microelectronics market, PCBs, and laminate. We're seeing the price increase on copper almost daily, but there is con-

cern about supply constraint as well, as copper grows in demand. We must continue to work closely with our suppliers to ensure that we have that continuity of supply to satisfy our customer demands.

Matties: You're putting a lot of effort and focus on it, no doubt?

Kelly: 100%. We're in South Carolina today, visiting Ridgeway. We had a team go out to some of our copper suppliers, and they're working as diligently as possible to keep up with demand and make sure that we have the ample supply to satisfy our customers.

Matties: Where do you expect pricing to go? What should the fabricators be prepared for?

Kelly: I wish I knew because then I could trade the commodity, but ultimately, every day you're reading new projections around copper. I read an article saying that it could go up to \$20,000. Right now, I think we're hovering around \$10,000. I don't think anyone knows. People are very familiar with the increasing demand for copper, especially with the focus on the electrification of vehicles. That's only part of the equation, so I don't know where it's going to end. A lot of people wish they did. However, all we can do is focus on the things we can control. We focus on automation, looking at some of the ways we can at least offset some of the cost increases, using different manufacturing strategies. We do a lot of value stream mapping, Kaizen exercises, thereby removing waste out of our systems to try to offset some of those cost increases that we're all experiencing.

Matties: When you look at the efforts that you've made, do you have a percentage of gain that you could share with us?

Kelly: Yes. We use a lot of different key performance indicators (KPIs) to look at where we're able to become more optimal. I don't

have it quantified, but we see a reduction in overall lead times as it relates to certain product groups. However, once again, as we've experienced lead time increases, it's overshadowed by some of the other macro challenges that this industry is facing. We may see an improvement on our specialty line, but what does that improvement mean? We have industrial engineers look at work cells, and maybe we can expedite or reduce the takt time of a certain product group, and then we can see a reduction there.

However, it's overshadowed, especially right now, by some of the global supply chain issues. Think about what happened in the Suez Canal, and the container shortages that the entire global economy is facing when we can't get a container to ship material.

Matties: You're saying the lead time issues are supply chain and not capacity issues.

Kelly: It's all of the above. Ultimately, the industry is growing more than anticipated six or 12 months ago. There are macro issues relative to container shortages. If you can get a container, there's a lineup at the ports on both the East and West coasts to get your material into the country. It's an accumulation of numerous issues that are driving some of the lead times. It wouldn't be fair to say it's just one aspect of it.

Matties: Obviously, during a period like this, fabricators may look to stockpile material as much as possible. Are you seeing that behavior?

Kelly: It's hard to have visibility into who's stockpiling for inventory vs. who has an increase in demand. The velocity of orders coming in has been on a steady increase for many



Isola's new state-of-the-art manufacturing facilities.

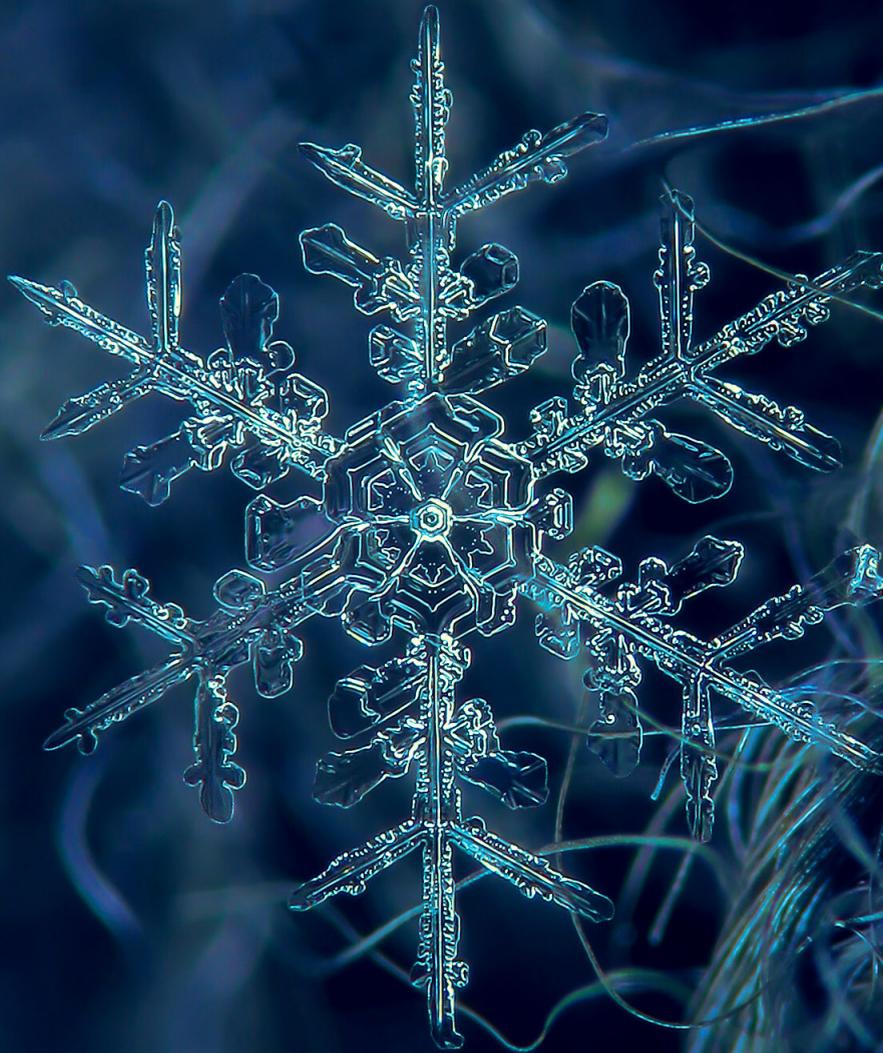
months, so that's a positive sign. To say how much of it is stocking inventory vs. how much is true demand gets a little bit blurry. We have seen consistent growth month over month, quarter over quarter, and year over year, so it's probably a bit of both. There is high demand for our products for different applications, and some people could be out there looking at stocking some of the inventory with the expectation that copper will become in short supply or that the cost increases will not go away any time soon. It's probably a bit of both.

Matties: When you look at the market and your projections, what do you see in the next year to two? Is Isola still projecting steady growth, or do you see sharp increases?

Kelly: We are still planning on steady growth and that's why we've had the investments both in Arizona and new treaters in Taiwan, and future growth capital deployment over the next 24 months in the United States. We continue to see and forecast growth; we're preparing and planning for it.

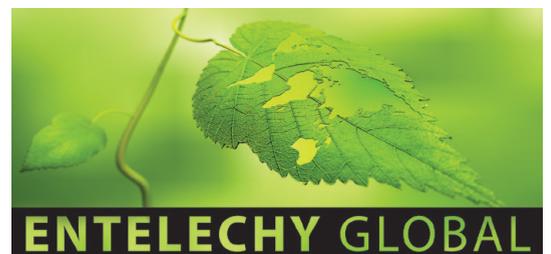
Matties: From a technical standpoint, Travis, it's the high-end specialty materials that might

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have the greatest amount of lead time right now. Is that the case?

Kelly: It all depends on what high-end specialty material you're referring to. Some of it depends on where it's being shipped. As mentioned earlier, those lead time issues may be because it's going into certain countries where there are container shortages or the ports are full; for the most part, it's just across the board. Right now, our issue is the ports are full. A ship was supposed to land five days ago, and it's out in the ocean waiting for a spot. So, I wouldn't just say it's HSD material or high specialty products.

Matties: In past conversations, you were referencing new products for some higher-end applications from Isola. Give us a quick product update of your portfolio, how that's going, and where you're at.

Kelly: We're very excited. I think you spoke to Michael Gay just recently about IS550H; that's getting a lot of momentum out in the industry. It's a very exciting product for the commercial sales team. TerraGreen 400G is a platform of products that should be out in the next several months, and we are excited about that one as well. TerraGreen 400G is being qualified and tested at numerous customers and OEMs who are excited about the capabilities of these products. They are being produced right now and we look forward to seeing the momentum build behind those products, because so far, the early adoption even exceeds our expectations, especially on IS550H.

Matties: And what do you have in the pipeline? What are you looking to in the future?

Kelly: We spend a lot of our budget on R&D and we call it big R. We have research and development, as a lot of our competition does. We must continue to be good business partners as we look at alternative materials. We do

spend a fair amount of money on big R, which is looking forward to the next five to 10 years and where we think the industry wants and needs to be. We have scientists not only in Singapore but here in the United States who are working together to develop those materials. We always have at least something in the pipeline; we're asking, "What do we want to do in the next two years? Where do we want to be in four?" And then we have a couple of scientists that look out five-plus years to determine where the industry is going to be and what it will need.

Matties: That must be interesting. And what do they see five years out?

Kelly: I can't tell you that, but I will tell you it is interesting for two reasons. There are different processing techniques, so we stay abreast and try to anticipate, "Will there be significant changes to the way material will be processed in the future?" Obviously, there are characteristics, such as signal integrity and thermals that we constantly look at based on where we think the technology is going. Isola also works closely with a handful of OEMs, on what their needs will be over the next five-plus years, to ensure that we're staying on the cutting edge of technology.

Johnson: Travis, regarding the pressures from copper, as we were discussing earlier, how do you see that pressure influencing what happens with materials? We hear about the need to move to materials that don't have copper attached, for example.

Kelly: Constraints spark innovation, right? Anytime you have a constraint in an industry that's not going to alleviate soon, that typically sparks innovation. We have spent a lot of time talking about the next material if copper continues to be constrained, what processes could be unique, where you don't have to use the same amount of copper that we're using today.



The Chandler, Arizona Isola production facility.

Those discussions are happening and that it is going to spark innovation. There must eventually be some changes if copper continues its current constraints; if we continue to see hyperinflation, it's going to cause innovation.

Matties: It seems like there's new opportunity for base materials specifically for that additive process. Obviously, you guys are paying attention to the additive process, so what's your take on that?

Kelly: It's very interesting. Actually, I worked with some people that are very close to that technology. Once again, with what's happening right now from a macroeconomic standpoint relative to copper and potential shortages and hyperinflation, companies need to look at new technologies as it relates to material processing techniques. That technology and others are being discussed very closely with the team we have here at Isola.

Matties: Now, with possible copper substitute materials, like graphene, are you looking at that sort of material at this point?

Kelly: We do have an alternative materials group. I don't want to call it a department, but we have several individuals who are tasked with looking at alternatives. It's not just a focus on copper; it can be a focus on woven glass or a focus on different resin systems and chemicals. So, that's exactly what we're constantly doing to challenge one another on—what the next five to 10 years will look like. Alternative materials, across the board right now, are the number one topic. Once again, it's not just focused on copper. There are a lot of different materials that can not only be more widely available, but can also enhance the characteristics of our products, especially some of the future products.

Matties: You've been with Isola now for going on three years?

Kelly: Almost three years.

Matties: And when you came in, what sort of transformation did you effect? Is R&D something that you really were passionate about and brought in, or was that already in place? What changes have you made since coming to Isola?



Isola's new visitor's lobby at the Chandler, Arizona facility.

Kelly: I've made several changes. First and foremost, we must have manufacturing excellence, so we spent a lot of time and investments optimizing manufacturing. We focused on investments in the quick turnaround facility, understanding that the market is shifting from low to high mix and shorter run cycles. Building and generating that QTA facility with a state-of-the-art R&D lab in the United States was a big investment; I believe it will pay dividends in the future.

We're also focused on R&D by looking at innovating new products, new process improvements to create products, as well as alternative materials. And then, ultimately, getting with our customers on the marketing side. We are focusing on the needs of OEMs and fabricators and how we can support them. Those three aspects of the business are where we spent a lot of time. And, based on our growth and what we're seeing now as an organization, it's paying dividends.

Matties: Travis, you mentioned the collaboration with OEMs; it seems like there's a huge need for more collaboration.

Kelly: Yes, and that's where we can play an important role. It's bilateral, we learn a lot from

not just the OEMs, but also the fabricators, and working hand-in-hand and sharing those viewpoints and the knowledge that they've accumulated will continue to pay dividends. IS550H is a good example of working with several OEMs and fabricators to understand heat characteristics and the thermal needs of our customers. Now that's a good product that can solve a lot of those problems, but the rubber meets the road by working very closely with our business partners.

We don't view our customers as transactional (not just buying and selling) but rather, from a relationship standpoint, understanding where those customers

want to be, and what we can do to make sure that we're innovating to support those customers. Customers mean the printed circuit board fabricators, as well as the OEMs. The material must keep up with the demands of the future, and that's why we do spend a lot of money on R&D, trying to stay on top of that curve, or at least alongside it.

Johnson: Travis, is direct marketing to the OEMs something that Isola concentrates on? OEMS are specifying the performance criteria, but the fabs are making the purchase decisions. Does that conversation, that dynamic, need to change? Do different people need to be in that conversation?

Kelly: No, I don't think so. First and foremost, we support the fabricators. We have an OEM marketing team. We hear feedback from the OEMs, but ultimately, we work hand-in-hand with the fabricators to understand what the application needs are, and then go through our suite of products to make sure that we can satisfy those needs.

Johnson: What works well for Isola in having a conversation with an OEM about their emerging needs?

Kelly: Well, there are already relationships. As you know, Isola has been around for 100+ years, and one thing I've learned over the last several years, it's a small industry relative to a subset of people that have worked together for a long time. Most of the connections and relationships are already in existence, and that allows us to have a good understanding of what those requirements are today and what they will be in the future.

Matties: What advice would you give a fabricator who must manage the material maze out there?

Kelly: There is a lot of volatility, especially around the continuity of the supply chain, regardless of what country you're located in. There's also inflation that we're all experiencing. Isola is always trying to figure out where we can improve our processes to reduce some of that uncertainty. Then there are other things that we don't control, such as the Suez Canal and container shortages. You just have to be flexible and focus on what you can control. And the items you don't control, try to develop contingency plans to the extent possible.

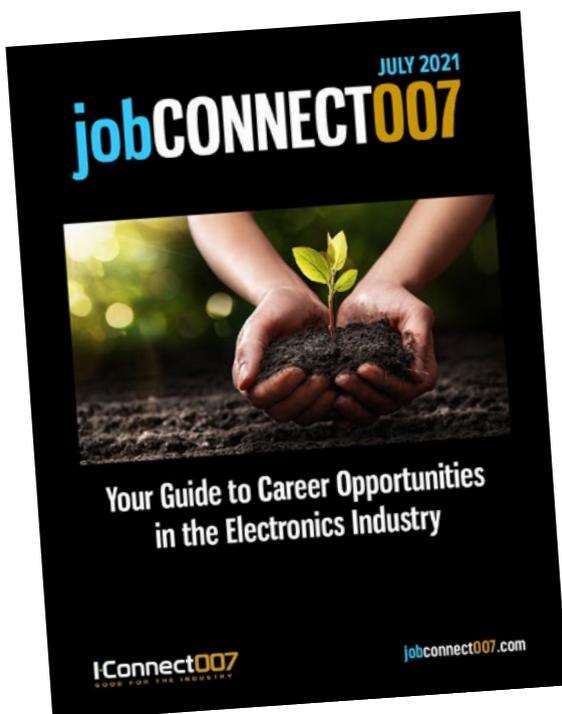
Matties: I would think that the greater visibility a fabricator can give to Isola and your sales organization, the better able you are at satisfying their need. The more lead time that they can give you, the better off they will be; we're living in a quick-turn environment and every day is critical.

Kelly: Every day, every hour, is critical. Visibility is the key to success, but we don't sometimes live in a world that's structured that way. With the chip shortage, automotive shutting down their plants, and taking potentially longer summer shutdowns, a lot of this information is truly hand to mouth. Yes, visibility would be great; if we could get 30, 60, 90 days visibility, then that would be very helpful. I'm just not sure right now that that would be realistic for a lot of our customers.

Matties: Thanks for making time for this interview and congratulations on coming up on three years, that's great.

Kelly: Thank you. PCB007

Travis Kelly is president and CEO of Isola Group.



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The PCB Limbo—How Low Can You Go?

Testing Todd

Feature Column by Todd Kolmodin, GARDIEN SERVICES USA

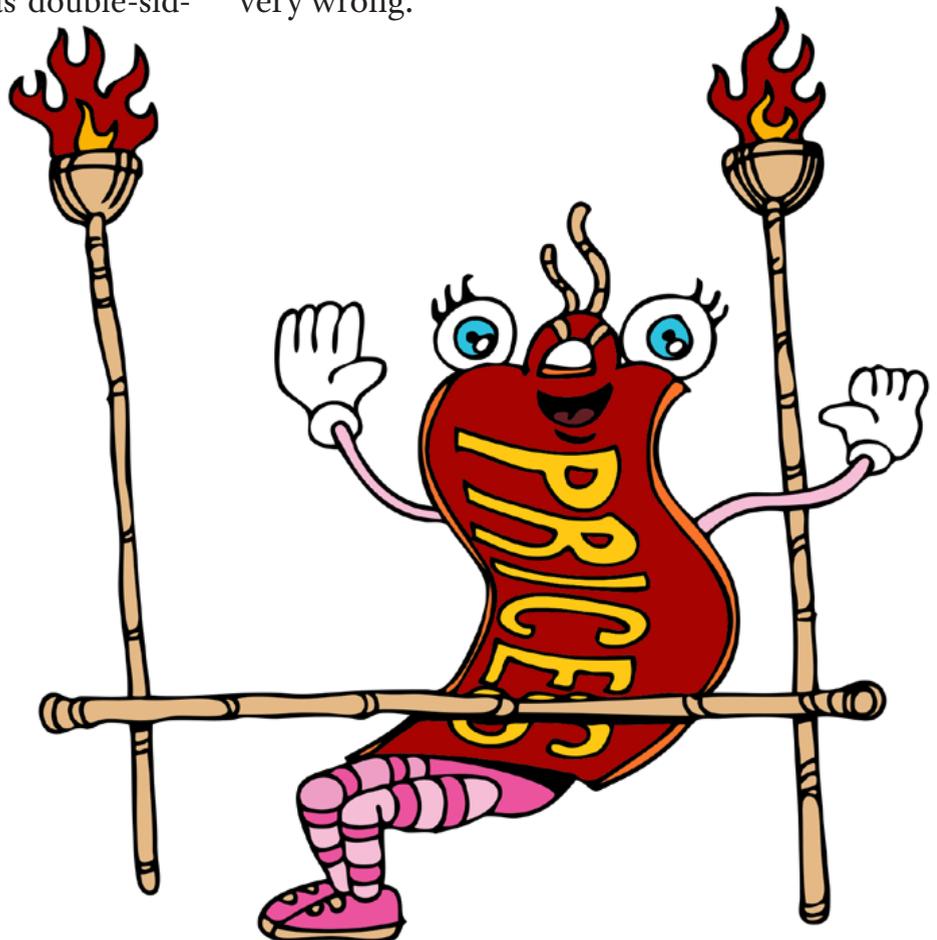
Welcome to the grand illusion. There I was, mid-1986, and in my first job with printed circuits. I knew what circuit boards were but had no idea about all the processes involved in their manufacture and test. Here in the Pacific Northwest, there were probably two dozen PCB manufacturers producing everything from double-sided to 16-layer stacks. All were PTH-only at the time. Surface mount technology (SMT) was not to make its debut for a year or two.

Fixture testers were 100-mil grids (0.100”) and there were no such things as double-sided testers. What? There was no need at this point as SMT was not active. Test fixture manufacture was simple. You could either use the production drill file or alter the tool sizes for the test pins and drill. Once complete you could lay the plate over film and X-out the vias. Or you could digitize the outer layer and optimize mid-points and vias. Either way, you would then assemble the fixture and it was ready for the tester. There were no netlists back then, only self-learn or “golden board” learn.

As time progressed, SMT appeared on the scene and changed everything. Technology had evolved, and the PCB industry had to react to new equipment, processes, and ways to manufacture. ET had to evolve as

well, such as with double-sided fixtures for single sided testers, and spring probes and wires translating the top-side fixture down through the bottom to the test field. This was expensive. However, the industry was booming on into the 1990s and life was good.

Everyone was enjoying the returns and competition was flourishing. Competition in an open market is good as long as margins remain safe and technology continues to advance. However, something went very, very wrong.



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In the late '90s, the industry started to pull back. Demand dropped with the tightening economy. The supply of manufacturers outweighed the demand, and the wars broke out. It became a consumer's market. Customers threatened to take business to other suppliers who offered discounted pricing. It was then that supplier XYZ would cave in and match the price. This is when the dominos started to fall.

As with any business, there are fixed costs: building/land, utilities, insurance, and taxes. These do not change, and in many cases some of them increase over time. Continuous pressure to reduce costs from the manufacturer started a practice of taking losses, in some cases, just to keep the business running. This worked somewhat during this time as margins could be made up on quick-turn or high-demand orders. The problem was that there was no lower control limit to stop the fall. This practice continued until smaller shops began to disappear, either crushed by the price-cutting competition or unable to keep up with the fast-changing technology with no margin to expand or upgrade.

Printed circuits are the building blocks to almost everything today. Even your toaster has one. The costs of production have not changed significantly. The same basic concepts still must be used to produce them. Yes, there have been efficiency enhancements and automation to lower production time, but these have also required capital investments requiring depreciation over time. The cost is fixed, yet the buyers and customers still demand price cutting. No one ever put the flag in the sand saying "enough." Margins continued to decrease and what was a strong diverse group of manufacturers in the Pacific Northwest no longer remains. They are gone, stamped out or purchased by the mega-manufacturers. Making matters worse is the outsourcing offshore where certain variables have been manipulated or compromised to reduce cost.

The problem is that now customers do not have a vast selection of manufacturing vendors to choose from. The much smaller arena of manufacturers still fight for the business and still compete against the mega-manufacturers. Some find a niche and can continue to thrive, but others are finding the end to a dream.

Now, throw in a pandemic and the workforce disappears, or shops are forced to close due to cases of infection. The government kicks in and helps those in need but overlooked the scenario that the help was providing higher wages than minimum for the jobs that needed filling. Now the manufacturers are in trouble as they cannot find workers for their paid wage scale. Human nature is keeping workers away as they are financially better off staying home.

How low does this bar go? Had someone kept an eye on the downward spiral the industry may have stayed buoyant. However, it did not happen and now margins are at a bare minimum and mostly below healthy model limits. Since fixed costs could not be adjusted, wages and employee counts were the variable that had to be adjusted. The industry is no longer appealing to the college graduates as future projections are unstable and personal growth is limited in many aspects. Another economical problem is now we are down to a supplier pool approaching a monopolization. This "eggs in one basket" approach is dangerous for obvious reasons. If those suppliers fail or have extended production interruptions, it will cause an immediate supply chain crisis.

How to recover in this industry to make it stable will be a challenge. Unless mindsets and models change, this "limbo bar" will stay where it is and hopefully not go any lower. **PCB007**



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

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Courses can be offered directly to employees or integrated into your training programs.

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



MilAero007 Highlights



Survey: Reasons U.S. Electronics Manufacturers May Exit Defense Market ▶

In a new IPC industry survey and report, 24% of electronics manufacturers say the costs and burdens of compliance with the Cybersecurity Maturity Model Certification (CMMC) may force them out of the U.S. Department of Defense's (DoD) supply chain.

Raytheon Technologies Working to Take Heat Off New Generation of Fighters ▶

The U.S. military has begun to define requirements for its future fighters. To conduct operations in advanced threat environments, next-gen fighters will need greater range provided by more powerful and fuel-efficient engines; better avionics; and advanced mission systems.

EIPC Technical Snapshot Review: Microvia Reliability Issues ▶

Since the mid-1990s, when they were developed for mass production in the mobile phone industry, microvias have become principal enablers for high-density designs, and have evolved from single-level to complex stacked and staggered structures. They are fundamentally robust interconnects, although some aspects of their reliability are still under investigation.

Defense Speak Interpreted: The U.S. Has a Space Force—JEDI Knights Next? ▶

Does the U.S. Department of Defense's JEDI contract mean it's going into a Star Wars production? Sorry, no Stephen Spielberg this time. Sorting out the good guys and bad guys in this cloud computing scenario.

The Government Circuit: Advocating for the Entire Electronics Supply Chain ▶

Here in Washington, we are encouraged by recent policy discussions that indicate a bipartisan commitment to U.S. manufacturing that is long overdue. European officials are also promoting a policy agenda that could be very positive for electronics. But there is still more work to be done to bolster the entire electronics ecosystem.

Adventures in Engineering: The Ecosystem of Autonomous Flight ▶

To be clear, autonomous flight is here, it has been done, the achievement has been made. Now, how do we create an ecosystem for this newly proven technology and how do we incorporate it into our lives?

Germany Latest EU Country to Introduce Due Diligence Rules ▶

On 11 June 2021, the German Supply Chain Act was adopted by the German Parliament by a large majority, introducing binding human rights and environmental due diligence obligations for companies.

Sypris Wins Electronic Warfare Program ▶

Sypris Electronics, LLC, a subsidiary of Sypris Solutions, Inc., announced that it has recently received a full-rate production award from a U.S. DoD prime contractor to manufacture and test multiple electronic power supply modules for a large mission-critical U.S. Navy program. Production is expected to begin in the second half of 2021.

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Leadership 101— The Laws of Respect, Intuition, and Magnetism

The Right Approach

by Steve Williams, THE RIGHT APPROACH CONSULTING

Introduction

Good leadership always makes a difference; unfortunately, so does bad leadership. This leadership truth continues as we will be talking about the seventh, eighth, and ninth of John Maxwell's "21 Irrefutable Laws of Leadership."

Respect Must Be Earned

Many people, when first put in a management role, think that now that they have some power and a title, respect also comes with the deal. "I'm the boss so my people must respect me, right?" These same people very quickly discover just how wrong they are. I have stressed numerous times while discussing the earlier laws that the title does not make the leader; the leader makes the title. People don't follow others by accident; they follow individuals whose *leadership* they respect.

Looking in the mirror, ask yourself these five questions:

1. Who *chooses* to follow me?
2. Does the answer reflect my perceived leadership level?
3. Will people respond positively if I request a commitment or change?
4. Do I have the qualities as a leader that earn respect?
5. Do those closest to me respect me?

If your answer to *all* of these is a resounding yes, then you are well on your way to becoming

a great leader. If you answered no to *any* of them, fear not. Respect *can* be earned.

The six steps to earning respect are very simple, but as with most things the devil is in the execution:

Step 1: Have respect for others. People won't respect someone who does not respect them.

Step 2: Courage. Have the courage to do the right thing, not the easy thing.

Step 3: Success. People naturally like to follow winners.

Step 4: Consistency. Nothing comforts people more than demonstrating consistency in everything you do as a leader.

Step 5: Add value to others. As we are learning throughout the 21 laws of leadership, helping others succeed is the fastest way to our own success.



Figure 1.

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Step 6: Pure leadership ability. Not all great leaders are born that way; but some are, and people can sense when this is a natural condition.

Intuition

Everyone possesses intuition, however, not everyone is intuitive in leadership. What we “sense” as a leader has a direct correlation to the degree of our leadership ability, or remembering our first law, our Leadership Lid.

“Who you are dictates what you see.”

—John C. Maxwell

The best leaders are those who have mastered “situational leadership,” adjusting their leadership style to best fit the current situation. A leader must read a situation and instinctively know what play to call. Unfortunately, intuition cannot be learned; what you are born with is all you get. However, you *can* learn to be more aware of the constraints and factors impacting a situation, and experience will teach *lessons learned* to improve your decisions going forward.

Let’s test your intuition; look at Figure 2 and describe what is happening in this situation.

The person on the right is obviously the person in charge and is counseling an employee on something, right? Actually, the leader is the one on the left and is listening to their follower

talk about something important. Great leaders listen more than they talk.

Magnetism: Who You Are is Who You Attract

I’ve shared an example from one of my clients in a past column on Lean about a small custom manufacturing shop run by an ex-Navy commander. What I didn’t share in the previous article was that most of his management staff was also ex-military. We attract who we are and surround ourselves with like-minded people. If you are unhappy with your career (or life), change who makes up your inner circle and be true to who you are, or want to become. When I am working with a client’s leadership team, training on the 21 Irrefutable Laws of Leadership, the first thing I do is have each member complete a self-assessment of what they feel are their leadership strengths. I tuck this away and a few sessions later I have them write down the attributes they look for when hiring a new person for their team. Then I pull out their self-assessment for comparison and have never had less than an 80% match between the two.

We Attract Who We Are

Now this is not the same as hiring a bunch of “yes men/women;” that dynamic is never a trait of great leaders. When I talk about magnetism I’m talking about things like your core val-



Figure 2: Who is the leader in this image? It might not be who you think.

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ues, social contract, integrity, and ethics. Surround yourself with people who believe what you believe but think differently.

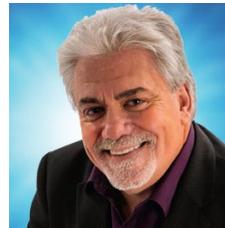
There are three common categories of attraction:

1. **Who you are is who you attract.** Magnetism can be generational or attraction by generation.
2. **Most organizations, groups, companies, and even departments attract individuals of similar age.** This is attracting from background.
3. **Personal circumstances and experiences that shape somebody's life.** This is attracting from attitude.

By now you should be noticing several recurring leadership themes:

1. Add value to others.
2. Being successful starts with helping others be successful.
3. Leadership is influence.
4. A manager does things right, a leader does the right thing.

These are foundational principles behind all 21 laws and should start becoming second nature as we continue through this leadership journey together. PCB007



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

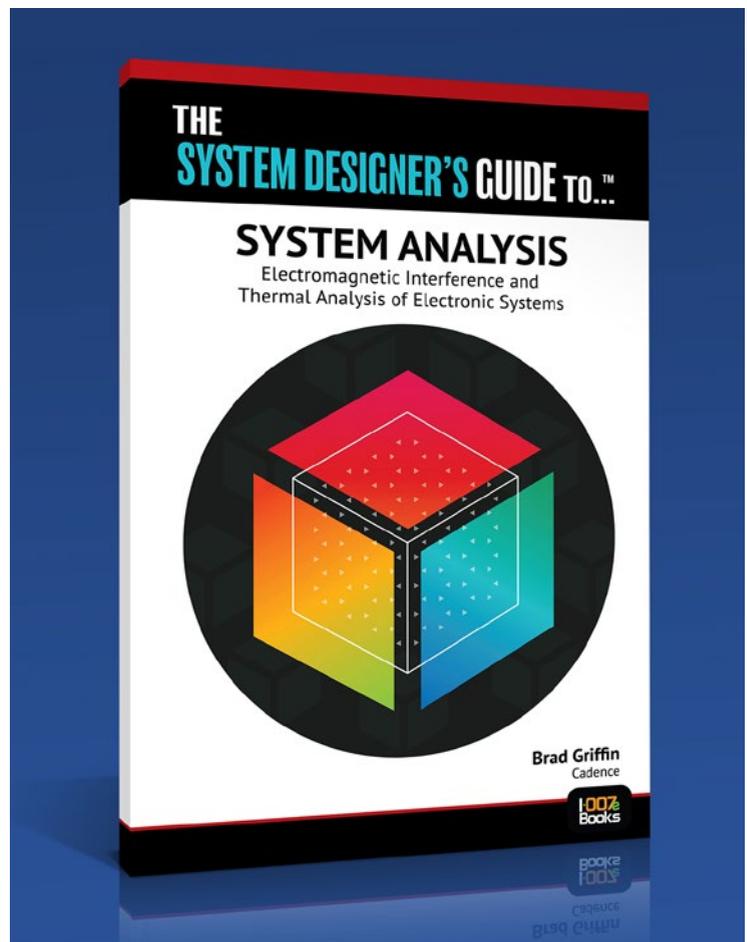
New I-007 eBook Highlights System Analysis

In this latest title from I-007eBooks, readers will learn how system-level analysis of complex and high-speed electronic designs is critical to solve electromagnetic, electrothermal, and electromechanical simulation challenges and to ensure that the system works under wide-ranging operating conditions.

According to signal integrity expert Lee Ritchey, founder and president of Speeding Edge and author of *Right the First Time: A Practical Handbook on High-Speed PCB and System Design*: “Author Brad Griffin offers readers a very good explanation of system-level analysis of complex and high-speed electronic designs. I highly recommend this book for those who are getting started with the design of PCBs and systems that are used in data centers.”

Download your free copy today!

You can also view other titles in our *full library*. *The System Designer's Guide to...* series is specifically dedicated to educating the printed circuit and systems design sectors and serves as a valuable resource for people seeking the most relevant information available.



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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.

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Dan (Baer) Feinberg



www.feinline.com



Editor Picks from PCB007

1 IPC Commends Biden Administration on 100-Day Review of Strategic Supply Chains ▶

IPC commends the Biden administration for completing its 100-day review of strategically important supply chains and for outlining bold actions to strengthen U.S. semiconductor manufacturing and ensure the availability of minerals critical to electronics manufacturing.

2 Atotech, Nabet India Launch COVID-19 Awareness Campaign 'Atotech Cares' ▶

Atotech, a leading specialty chemicals technology company and a market leader in advanced electroplating solutions, is joining together with National Association for the Blind (Employment & Training) (NABET INDIA), a non-governmental organization (NGO), based in Gurgaon, India, in order to increase the impact of our COVID-19 relief activities.



3 Catching up With Kusu's Pascal Delloue ▶

There are other countries in Asia besides China and Pascal Delloue intends to promote them. He has many years of experience in the global marketplace and his new company, Kusu Corporation, is poised to introduce SE Asian companies and the electronics products they can provide for the rest of the world.



Pascal Delloue

4 One World, One Industry: Responding to Questions about the Future of Electronics Manufacturing ▶

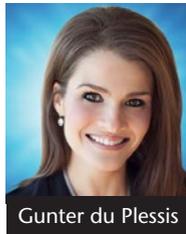
The questions I receive most frequently depend upon the individual or group asking the questions. For this column, I will focus on the different questions coming from the manufacturing industry and media.



John Mitchell

5 Foundations of the Future: IPC Education Foundation Lessons Learned ▶

Looking back on our second year, the IPC Education Foundation (IPCEF) takes pride in how we how we adjusted our engagement initiatives during the pandemic. We couldn't rely on our original strategy of hosting and attending a range of in-person activities and events.



8 American Standard Circuits Acquires Orbotech Ultra Dimension 800 ▶

West Chicago-based PCB fabricator American Standard Circuits has recently invested in Orbotech's Ultra Dimension 800 4-in-1 AOI solution.



6 AT&S Supervisory Board Approves Investment Project in Southeast Asia ▶

Lenthor Engineering, Inc., a California-based designer, manufacturer and assembler of flex and rigid-flex printed circuit boards, has purchased ESI's Geode CO2 microvia drilling system, including the optional automated loading and unloading stations.



9 Nan Ya PCB Posts 40% YoY Revenue Growth in May ▶

Taiwan-based PCB manufacturer Nan Ya Printed Circuit Board Corp. has posted sales of NT\$4.1 billion (\$148.1 million at \$1=NT\$27.68) in May 2021, down by 0.4% from the previous month, but up by 40% from May of last year.



7 MFS Technology Receives BOE Technology 2021 Quality Award ▶

MFS Technology, a PCB and FPC manufacturer from Singapore, has recently been given the Strategic Supplier Award from BOE Technology—one of the world's top display companies. MFS was also awarded with the "Excellent Quality Award" from the world's biggest automotive display maker, Tianma Microelectronics.



10 Testing Todd: Meet Mr. Henry and Do Not Blow a Fuse ▶

Columnist Todd Kolmodin explains the connection between electrical test and Joseph Henry. Can you figure it out?



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

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

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 manufacturing

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.

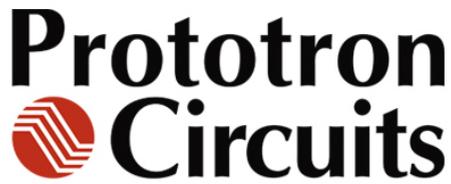
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This position is in our Duluth, Georgia, headquarters, where we serve our customers within North and South America. We offer health, dental, vision, and life Insurance with no employee premiums, including dependent coverage. Additionally, we provide a 401K retirement plan with company matching, plus a generous PTO policy with paid holidays.

Koh Young Technology, founded in 2002 in Seoul, South Korea, is the world leader in 3D measurement and inspection technology used in the production of micro-electronics assemblies. Using patented 3D technology, Koh Young provides best-in-class products in Solder Paste Inspection (SPI) and Automated Optical Inspection (AOI) for electronics manufacturers worldwide.

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

- Engineering
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- Various Manufacturing

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

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

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

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

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Location: Portland, Oregon or USA (remote)

Job Number: 242982

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- Strong writing and editing skills
- Education and/or experience in technology, science, journalism and/or English
- A technical background or experience (such as a BS or an associate's degree in engineering or computer science) is preferred
- 1-3 years of experience in writing about technology solutions
- Basic knowledge of online publications, digital platforms and social media is useful to meet project specifications in a fast-paced environment
- Ability to research and collect data, repurpose existing materials, collaborate with subject matter experts, and translate technical information into compelling marketing communications content that engage audiences

Creative materials will be used globally, in a high-energy environment, supporting the world's leading industrial software company.

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Inspects work-related conditions to determine compliance with prescribed operating and safety standards. Operates power-driven machinery and uses equipment and tools commonly used to maintain facilities and equipment. Replace filters, belts, and additional parts for repairs and preventive maintenance. Moves objects weighing up to 150 lbs. using a hand truck or pulley. Cleans work area and equipment. Works with cleaning fluids, agents, chemicals, and paints using protective gear. Works at elevations greater than ten feet, climbing ladders, while repairing or maintaining building structures and equipment. Assists skilled maintenance technicians/workers in more complex tasks and possible after-hours emergency repairs. Must meet scheduling and attendance requirements.

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Responsible for operating waste treatment plant, our operation that converts wastewater in drains and sewers into a form that's metal free to release into the environment.

Control equipment and monitor processes that remove metals from wastewater. Run tests to make sure that the processes are working correctly. Keep records of water quality and pH. Operate and maintain the pumps and motors that move water and wastewater through filtration systems. Read meters and gauges to make sure plant equipment is working properly. Take samples and run tests to determine the quality of the water being produced. Adjust the amount of chemicals being added to the water and keep records that document compliance.

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- Circuit simulation
- Schematic capture
- PCB layout
- Design analysis
- PCB fabrication
- PCB assembly
- PCB testing

Qualifications:

- Technical writing experience with a proven track record of independent research and content development. Experience in data sheet, report, or white-paper writing preferred.
- Electronic technician or engineering degree, ideally in electrical engineering, computer science, or mechanical engineering.
- Industry experience in PCB design, testing, or manufacturing.
- Punctuality, professionalism, and excellent time management skills.
- A reliable internet connection and computer

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- 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

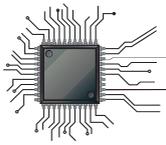
- A college degree or 5 years' experience is required. Good communication skills and the ability to work well with people is essential.
- Printed circuit board manufacturing knowledge.
- Experience using CAM tooling software, Orbotech GenFlex®.

Physical Demands

Ability to communicate verbally with management and co-workers is crucial. Regular use of the telephone 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



MivaTek

Global

Product Manager

MivaTek Global is preparing for a major market and product offering expansion. Miva's new NG3 and DART technologies have been released to expand the capabilities of Miva's industry-leading LED DMD direct write systems in PCB and Microelectronics. MivaTek Global is looking for a technology leader that can be involved guiding this major development.

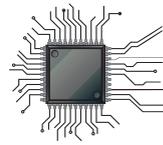
The product manager role will serve as liaison between the external market and the internal design team. Leadership level involvement in the direction of new and existing products will require a diverse skill set. Key role functions include:

- **Sales Support:** Recommend customer solutions through adaptations to Miva products
- **Design:** Be the voice of the customer for new product development
- **Quality:** Verify and standardize product performance testing and implementation
- **Training:** Conduct virtual and on-site training
- **Travel:** Product testing at customer and factory locations

Use your 8 plus years of experience in either the PCB or Microelectronic industry to make a difference with the leader in LED DMD direct imaging technology. Direct imaging, CAM, AOI, or drilling experience is a plus but not required.

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MivaTek

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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:

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

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

More About Us

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

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Career Opportunities



A Flex Company

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We are looking for people who demonstrate:

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- Passionate customer focus
- Thoughtful, fast, disciplined execution
- Tenacious commitment to continuous improvement
- Relentless drive to win

Positions in America include:

Project Manager – Northfield, MN

Candidate will provide timely cost estimation and project budget definition, be responsible for maintaining customer relations, participate in meetings, etc.

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Program Manager – Specialty Films

Candidate will work with our Specialty Films in the Aerospace, Medical, and Commercial Aviation markets providing timely cost estimation and project budget definition, maintaining customer relations, participate in meetings, etc.

[apply now](#)

Business Development Manager – North America

Candidate will provide leadership in the planning, design and implementation of customers' specific business plans and will provide vision, penetration strategies and tactics to executive managers in order to develop and drive external and internal senior-level relationships.

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A Flex Company

Sheldahl, a leading provider of flexible interconnect products and electronic materials, is seeking candidates to join their diverse and skilled team.

We are looking for people who demonstrate:

- Intense collaboration
- Passionate customer focus
- Thoughtful, fast, disciplined execution
- Tenacious commitment to continuous improvement
- Relentless drive to win

Positions in Europe include:

Business Development Manager – France

Seeking out-of-the-box thinkers to help us take the ordinary to the extraordinary by cultivating current customer relationships and developing new business opportunities with our European team, based in France.

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Business Development Manager – Germany

Seeking out-of-the-box thinkers to help us take the ordinary to the extraordinary by cultivating current customer relationships and developing new business opportunities with our European team, based in Germany.

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Career Opportunities



ventec
INTERNATIONAL GROUP
騰輝電子

Technical Support/ Sales Engineer, UK

We are looking to expand our UK technical & sales support team. As a technical support/sales engineer (home office/Leamington Spa) you will assist potential and current customers in appreciating the benefits of using—and optimizing the use of—Ventec materials in their printed circuit board manufacturing processes, and so enhance customer loyalty and satisfaction, spread the use of Ventec materials, and grow sales. You will provide a two-way channel of technical communication between Ventec’s production facilities and UK/European customers.

Skills and abilities required for the role

- HNC, HND, degree or equivalent in a technical/scientific discipline
- Sales experience/negotiating skills
- Printed circuit board industry experience an advantage
- Good written & verbal communications skills
- Ability to work in an organized, proactive and enthusiastic way
- Ability to work well both in a team and independently
- Good user knowledge of common Microsoft Office programs
- Full driving license essential

What’s on Offer

- Excellent salary and benefits commensurate with experience

This is a fantastic opportunity to become part of a successful brand and leading team with excellent benefits.

Please forward your resume to
anthony.jackson@ventec-europe.com

apply now



U.S. CIRCUIT

Plating Supervisor

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

Competitive benefits package. Pay will be commensurate with experience.

Mail to:
mfariba@uscircuit.com

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Career Opportunities

SIEMENS

Siemens EDA Sr. Applications Engineer

Support consultative sales efforts at world's leading semiconductor and electronic equipment manufacturers. You will be responsible for securing EM Analysis & Simulation technical wins with the industry-leading HyperLynx Analysis product family as part of the Xpedition Enterprise design flow.

Will deliver technical presentations, conduct product demonstrations and benchmarks, and participate in the development of account sales strategies leading to market share gains.

- PCB design competency required
- BEE, MSEE preferred
- Prior experience with Signal Integrity, Power Integrity, EM & SPICE circuit analysis tools
- Experience with HyperLynx, Ansys, Keysight and/or Sigrity
- A minimum of 5 years' hands-on experience with EM Analysis & Simulation, printed circuit board design, engineering technology or similar field
- Moderate domestic travel required
- Possess passion to learn and perform at the cutting edge of technology
- Desire to broaden exposure to the business aspects of the technical design world
- Possess a demonstrated ability to build strong rapport and credibility with customer organizations while maintaining an internal network of contacts
- Enjoy contributing to the success of a phenomenal team

***Qualified applicants will not require employer-sponsored work authorization now or in the future for employment in the United States. Qualified Applicants must be legally authorized for employment in the United States.*

[apply now](#)



Multiple Positions

Innovative Circuits, a quick-turn, high mix, low-volume PCB manufacturer located in Alpharetta, Georgia, is growing and looking for talented individuals to join the team.

Front End Engineering Manager

Oversee CAM, programming/production engineering and quoting departments. Ideal candidates will have 15 years' experience working in a printed circuit board front-end department with flex and rigid flex circuit board construction.

Process Engineer

Responsible for the implementation and maintenance of chemical and/or mechanical processes used to produce flex circuits, rigid flex and rigid printed circuit boards.

Third Shift Production Manager

Oversee third shift production workers, product schedule and reporting.

Wet Lab Tech

Perform all lab analysis using burettes, pipettes, pH/ion meters, atomic absorption spectrophotometer, laboratory balance, hydrometers, hull cells, CVS, and all other lab-related equipment.

CAM Operator

Inspect, modify, and contribute to the initial development of producing flex circuits, rigid flex and rigid printed circuit boards based upon customer requirements and data files.

Quality Inspector

Responsible for verifying that the product meets customer requirements prior to shipping.

Wastewater Technician

Operate, monitor, maintain and troubleshoot the wastewater treatment facility and its processes.

Production Worker

Machine operator and light chemistry in a PCB manufacturing environment.

Please visit the link below to view our opportunities and apply.

[apply now](#)

Career Opportunities

Now Hiring

Director of Process Engineering

A successful and growing printed circuit board manufacturer in Orange County, CA, has an opening for a director of process engineering.

Job Summary:

The director of process engineering leads all engineering activities to produce quality products and meet cost objectives. Responsible for the overall management, direction, and coordination of the engineering processes within the plant.

Duties and Responsibilities:

- Ensures that process engineering meets the business needs of the company as they relate to capabilities, processes, technologies, and capacity.
- Stays current with related manufacturing trends. Develops and enforces a culture of strong engineering discipline, including robust process definition, testing prior to production implementation, change management processes, clear manufacturing instructions, statistical process monitoring and control, proactive error proofing, etc.
- Provides guidance to process engineers in the development of process control plans and the application of advanced quality tools.
- Ensures metrics are in place to monitor performance against the goals and takes appropriate corrective actions as required. Ensures that structured problem-solving techniques are used and that adequate validation is performed for any issues being address or changes being made. Develops and validates new processes prior to incorporating them into the manufacturing operations.
- Strong communication skills to establish priorities, work schedules, allocate resources, complete required information to customers, support quality system, enforce company policies and procedures, and utilize resources to provide the greatest efficiency to meet production objectives.

Education and Experience:

- Master's degree in chemical engineering or engineering is preferred.
- 10+ years process engineering experience in an electronics manufacturing environment, including 5 years in the PCB or similar manufacturing environment.
- 7+ years of process engineering management experience, including 5 years of experience with direct responsibility for meeting production throughput and quality goals.

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Now Hiring

Process Engineering Manager

A successful and growing printed circuit board manufacturer in Orange County, CA, has an opening for a process engineering manager.

Job Summary:

The process engineering manager coordinates all engineering activities to produce quality products and meet cost objectives. Responsible for the overall management, direction, and coordination of the engineering team and leading this team to meet product requirements in support of the production plan.

Duties and Responsibilities:

- Ensures that process engineering meets the business needs of the company as they relate to capabilities, processes, technologies, and capacity.
- Stays current with related manufacturing trends. Develops and enforces a culture of strong engineering discipline, including robust process definition, testing prior to production implementation, change management processes, clear manufacturing instructions, statistical process monitoring and control, proactive error proofing, etc.
- Ensures metrics are in place to monitor performance against the goals and takes appropriate corrective actions as required. Ensures that structured problem-solving techniques are used and that adequate validation is performed for any issues being address or changes being made. Develops and validates new processes prior to incorporating into the manufacturing operations

Education and Experience:

- Bachelor's degree in chemical engineering or engineering is preferred.
- 7+ years process engineering experience in an electronics manufacturing environment, including 3 years in the PCB or similar manufacturing environment.
- 5+ years of process engineering management experience, including 3 years of experience with direct responsibility for meeting production throughput and quality goals.

apply now

Career Opportunities



Sales Account Manager

Sales Account Management at Lenthor Engineering is a direct sales position responsible for creating and growing a base of customers that purchase flexible and rigid flexible printed circuits. The account manager is in charge of finding customers, qualifying the customer to Lenthor Engineering and promoting Lenthor Engineering's capabilities to the customer. Leads are sometimes referred to the account manager from marketing resources including trade shows, advertising, industry referrals and website hits. Experience with military printed circuit boards (PCBs) is a definite plus.

Responsibilities

- Marketing research to identify target customers
- Identifying the person(s) responsible for purchasing flexible circuits
- Exploring the customer's needs that fit our capabilities in terms of:
 - Market and product
 - Circuit types used
 - Competitive influences
 - Philosophies and finance
 - Quoting and closing orders
 - Providing ongoing service to the customer
 - Develop long-term customer strategies to increase business

Qualifications

- 5-10 years of proven work experience
- Excellent technical skills

Salary negotiable and dependent on experience. Full range of benefits.

Lenthor Engineering, Inc. is a leader in flex and rigid-flex PWB design, fabrication and assembly with over 30 years of experience meeting and exceeding our customers' expectations.

Contact Oscar Akbar at: hr@lenthor.com

[apply now](#)



Senior Process Engineer

Job Description

Responsible for developing and optimizing Lenthor's manufacturing processes from start up to implementation, reducing cost, improving sustainability and continuous improvement.

Position Duties

- Senior process engineer's role is to monitor process performance through tracking and enhance through continuous improvement initiatives. Process engineer implements continuous improvement programs to drive up yields.
- Participate in the evaluation of processes, new equipment, facility improvements and procedures.
- Improve process capability, yields, costs and production volume while maintaining safety and improving quality standards.
- Work with customers in developing cost-effective production processes.
- Engage suppliers in quality improvements and process control issues as required.
- Generate process control plan for manufacturing processes, and identify opportunities for capability or process improvement.
- Participate in FMEA activities as required.
- Create detailed plans for IQ, OQ, PQ and maintain validated status as required.
- Participate in existing change control mechanisms such as ECOs and PCRs.
- Perform defect reduction analysis and activities.

Qualifications

- BS degree in engineering
- 5-10 years of proven work experience
- Excellent technical skills

Salary negotiable and dependent on experience. Full range of benefits.

Lenthor Engineering, Inc. is the leader in Flex and Rigid-Flex PWB design, fabrication and assembly with over 30 years of experience meeting and exceeding our customers' expectations.

Contact Oscar Akbar at: hr@lenthor.com

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Career Opportunities



SMT Operator Hatboro, PA

Manncorp, a leader in the electronics assembly industry, is looking for a **surface-mount technology (SMT) operator** to join their growing team in Hatboro, PA!

The **SMT operator** will be part of a collaborative team and operate the latest Manncorp equipment in our brand-new demonstration center.

Duties and Responsibilities:

- Set up and operate automated SMT assembly equipment
- Prepare component kits for manufacturing
- Perform visual inspection of SMT assembly
- Participate in directing the expansion and further development of our SMT capabilities
- Some mechanical assembly of lighting fixtures
- Assist Manncorp sales with customer demos

Requirements and Qualifications:

- Prior experience with SMT equipment or equivalent technical degree preferred; will consider recent graduates or those new to the industry
- Windows computer knowledge required
- Strong mechanical and electrical troubleshooting skills
- Experience programming machinery or demonstrated willingness to learn
- Positive self-starter attitude with a good work ethic
- Ability to work with minimal supervision
- Ability to lift up to 50 lbs. repetitively

We Offer:

- Competitive pay
- Medical and dental insurance
- Retirement fund matching
- Continued training as the industry develops

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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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Career Opportunities



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 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.

View our opportunities at
Insulectro Careers ([jobvite.com](https://www.jobvite.com))

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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



BLACKFOX

Premier Training & Certification

IPC Instructor

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

*Independent contractor,
possible full-time employment*

Job Description

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

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

Qualifications

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

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

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

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

apply now



APCT

Passion | Commitment | Trust

APCT, Printed Circuit Board Solutions: Opportunities Await

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

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

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

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

apply now

Career Opportunities



MANUFACTURERS OF QUALITY PRINTED CIRCUIT BOARDS

Pre-CAM Engineer

Illinois-based PCB fabricator Eagle Electronics is seeking a pre-CAM engineer specific to the printed circuit board manufacturing industry. The pre-CAM Engineer will facilitate creation of the job shop travelers used in the manufacturing process. Candidate will have a minimum of two years of pre-CAM experience and have a minimum education level of an associate degree. This is a first-shift position at our Schaumburg, Illinois, facility. This is not a remote or offsite position.

If interested, please submit your resume to HR@eagle-elec.com indicating 'Pre-CAM Engineer' in the subject line.

apply now

Process Engineer

We are also seeking a process engineer with experience specific to the printed circuit board manufacturing industry. The process engineer will be assigned to specific processes within the manufacturing plant and be given ownership of those processes. The expectation is to make improvements, track and quantify process data, and add new capabilities where applicable. The right candidate will have a minimum of two years of process engineering experience, and a minimum education of bachelor's degree in an engineering field (chemical engineering preferred but not required). This is a first shift position at our Schaumburg, Illinois, facility. This is not a remote or offsite position.

If interested, please submit your resume to HR@eagle-elec.com indicating 'Process Engineer' in the subject line.

apply now



JOHNS HOPKINS

CAM / Process Engineer

The JHU/APL PCB Fabrication team is seeking a Computer Aided Manufacturing Engineer to support front-end data processing of APL manufactured hardware. You will directly contribute to hardware fabrication in support of National Security, Military Readiness, Space Exploration, National Health, and Research related to fundamental scientific advancement. This position includes a variable mix of core CAM work scope with additional opportunities for hands-on support such as bare board electrical testing, laser drilling, and mechanical CNC drilling and routing.

Responsibilities:

1. Computer Aided Manufacturing for rigid PCB, rigid-flex, and flexible circuits
 - a) Perform design checks, panel layout, coupon generation, file generation, stackups
 - b) Support manufacturability reviews with internal APL engineers (customers)
 - c) Generate work travelers
 - d) Communicate status to supervisors and internal customers
2. Support transition of software tools (Genesis 2000 to InCAM Pro)
 - a) Edit design rules checks and generate automation scripts
 - b) Develop new ideas to further the technical progress of our product
 - c) Develop CAM area through continuous improvement initiatives
3. Interface and inform APL Engineers on PCB design for manufacturing guidelines
4. Operate bare board electrical tester
5. Backup operator for CNC drilling, routing, laser drilling (on-site training)

For more details and to apply:
<http://www.jhuapl.edu/careers> and search for CAM.

apply now

Career Opportunities



U.S. CIRCUIT

Sales Representatives (Specific Territories)

Escondido-based printed circuit fabricator U.S. Circuit is looking to hire sales representatives in the following territories:

- Florida
- Denver
- Washington
- Los Angeles

Experience:

- Candidates must have previous PCB sales experience.

Compensation:

- 7% commission

Contact Mike Fariba for
more information.

mfariba@uscircuit.com

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For information, please contact:
BARB HOCKADAY
barb@iconnect007.com
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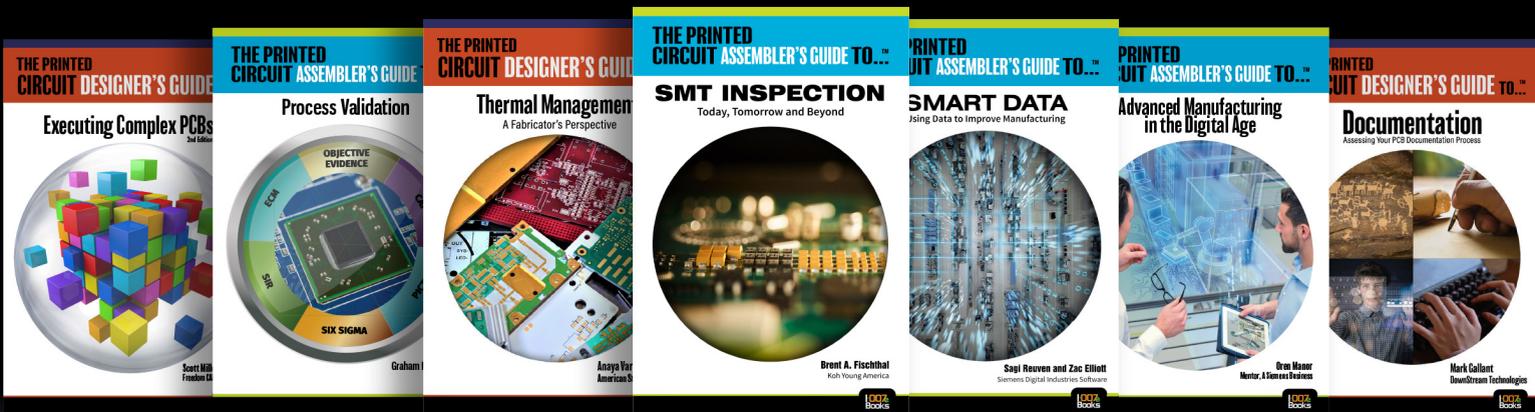
Our books are written by recognized industry experts. At around 8,000 words, they are unique in that they are able to be incredibly focused on a specific slice of technology.

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Stephen V. Chavez
PCEA Chairman, MIT, CID+



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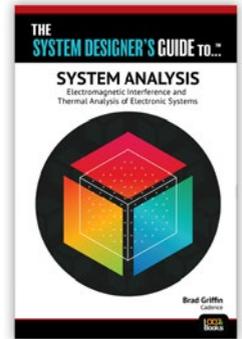


Introducing:

The System Designer's Guide to... System Analysis

By Brad Griffin, Cadence

In this latest title from I-007eBooks, readers will learn how system-level analysis of complex and high-speed electronic designs is critical to solve electromagnetic, electrothermal, and electromechanical simulation challenges and to ensure that the system works under wide-ranging operating conditions. [Get your copy now!](#)



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



Thermal Management: A Fabricator's Perspective

by *Anaya Vardya, American Standard Circuits*

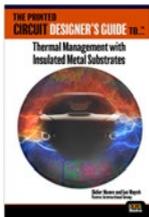
Beat the heat in your designs through thermal management design processes. This book serves as a desk reference on the most current techniques and methods from a PCB fabricator's perspective.



Documentation

by *Mark Gallant, Downstream Technologies*

When the PCB layout is finished, the designer is still not quite done. The designer's intent must still be communicated to the fabricator through accurate PCB documentation.



Thermal Management with Insulated Metal Substrates

by *Didier Mauve and Ian Mayoh, Ventec International Group*

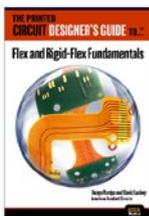
Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.



Fundamentals of RF/Microwave PCBs

by *John Bushie and Anaya Vardya, American Standard Circuits*

Today's designers are challenged more than ever with the task of finding the optimal balance between cost and performance when designing radio frequency/microwave PCBs. This micro eBook provides information needed to understand the unique challenges of RF PCBs.



Flex and Rigid-Flex Fundamentals

by *Anaya Vardya and David Lackey, American Standard Circuits*

Flexible circuits are rapidly becoming a preferred interconnection technology for electronic products. By their intrinsic nature, FPCBs require a good deal more understanding and planning than their rigid PCB counterparts to be assured of first-pass success.

Our library is open 24/7/365. Visit us at: I-007eBooks.com

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PCB007
MAGAZINE

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ADVERTISER INDEX

all4PCB.....	37
Altix.....	5
atg Luther & Maelzer GmbH.....	59
Atotech.....	29
Burkle North America.....	15
Chemcut.....	69
DB Management.....	67
Electra Polymers.....	45
Elite Materials.....	41
Entelechy Global.....	73
Excellon.....	79
Fein-line Associates.....	89
Gardien.....	33
I-007 eBooks.....	2, 109
I-007e Roundtables.....	3
IPC.....	19, 81
Insulectro.....	7, 53, 87
MicroCraft.....	65
MivaTek Global.....	51
MKS ESI.....	63
Pluritec.....	21
Polar Instruments.....	49
Prototron Circuits.....	83
SÜSS MicroTec.....	55
Taiyo America.....	11
Ucamco.....	85
Ventec International Group.....	25

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THE NUTS & BOLTS OF MANUFACTURING EXCELLENCE

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You Asked...

...We Answered!

DESIGN007 MAGAZINE MAY 2021

Design Challenges

L	A	I	T	N	E	R	E	F	F	I	D	V
R	P	H	A	O	P	I	F	I	D	M	T	C
I	N	E	C	D	O	E	Z	E	I	T	A	O
T	R	O	Y	Z	M	H	B	Z	D	E	I	T
E	T	F	N	O	W	L	R	E	S	A	A	
T	I	U	I	O	Y	B	I	N	S	O		
S	O	I	B	E	A	R	M	R	S	O		
I	N	G	A	R	D	E	F	F	R			
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A	N	I	M	I								
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U	O	F	A	P	U	G	N					
N	L	I	B	R	A	R	Y					
R	I	T	Y	W	H	C	P	U				

challenges?
ation • Crosstalk • Data Transfer
rics • Laminates • Land Pattern
ility • Backlog • Termination

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THESE ARE THE VOYAGES OF THE PCB DESIGNER.
THEIR ONGOING MISSION:
TO EXPLORE STRANGE NEW VIAS...
TO SEEK OUT LAND PATTERNS...
AND NEW BASE MATERIALS.
TO BOLDLY GO WHERE NO PCB DESIGNERS
HAVE GONE BEFORE!

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SMT007 MAGAZINE JULY 2021

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