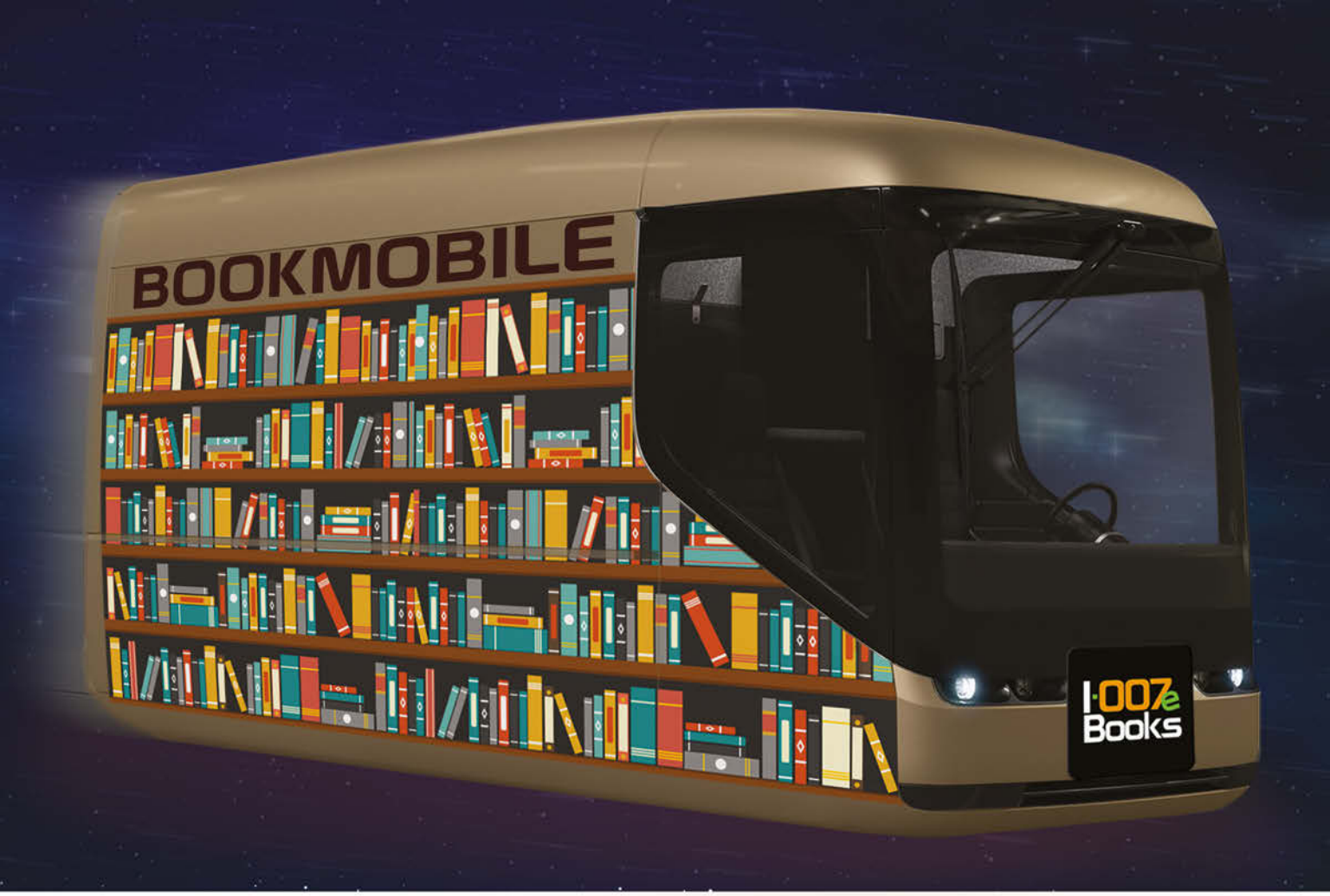
JANUARY 2019

I-Connect007

PCB007 MAGAZINE

Supply Chain: The Ripple Effect



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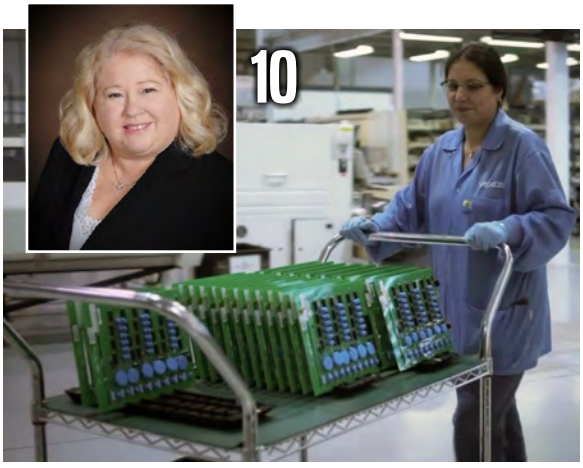

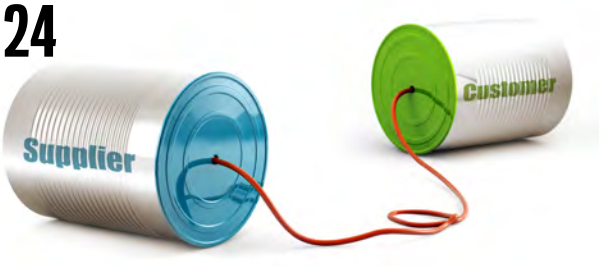

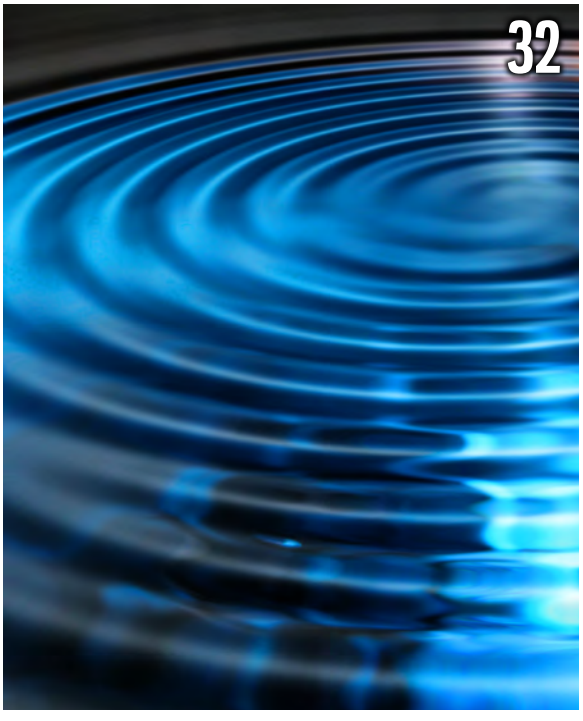

Supply Chain Ripples

Understanding the ripple effects in the electronics supply chain will be key to managing the supply chain crisis and keeping your fabrication facility running smoothly. In this issue, we bring you timely conversations with industry experts to help position your company's offerings to the greatest effect.

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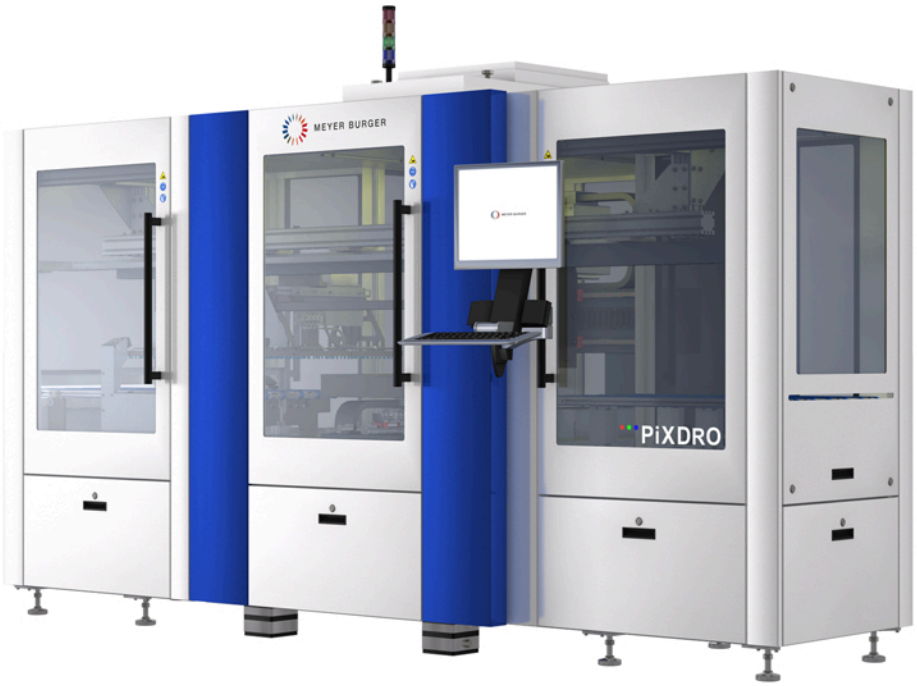

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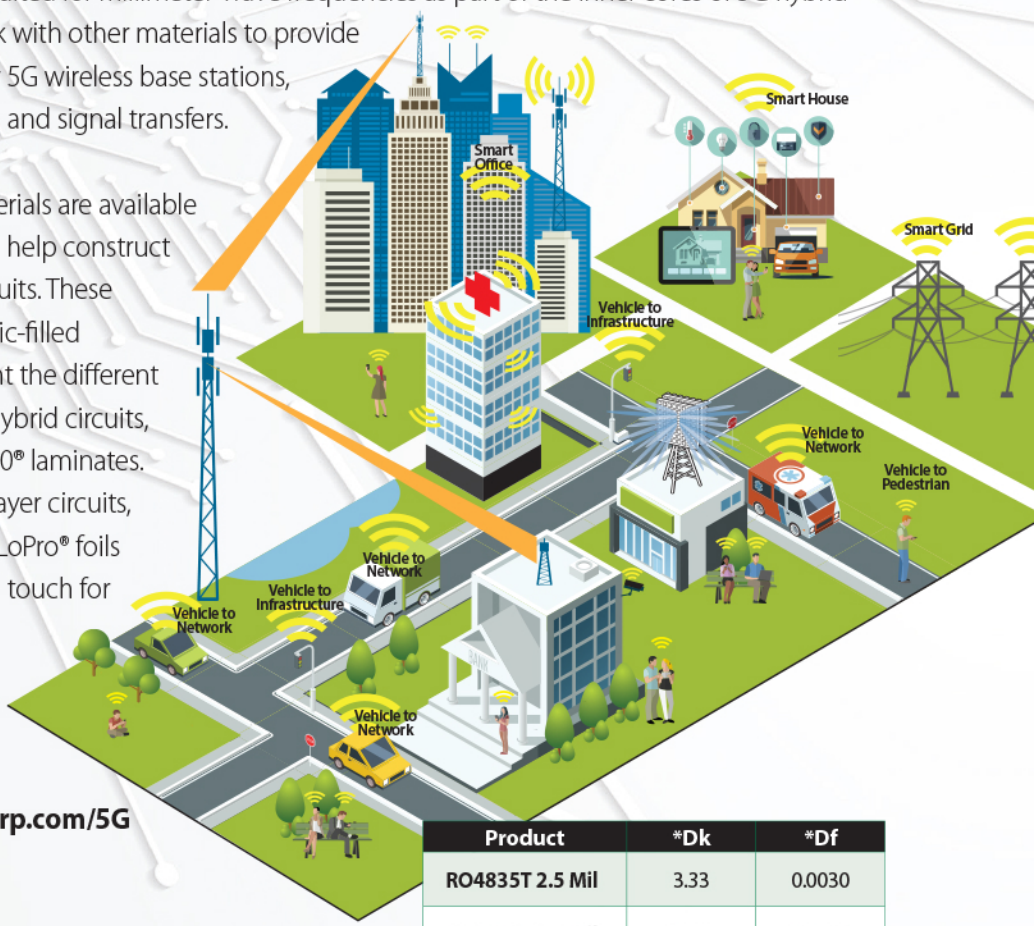

5G is coming! Do you have the right circuit materials?
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RO4450T 4.0 Mil	3.35	0.0040
RO4450T 5.0 Mil	3.28	0.0038

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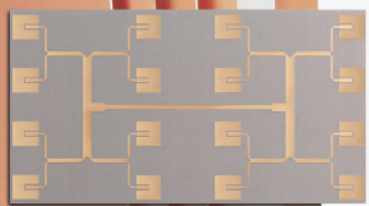

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Reflections on Supply Chain Issues

Nolan's Notes

by Nolan Johnson, I-CONNECT007

Years back, one of my friends was the proud owner of a late '60s Volkswagen van—a "microbus" we called them, although your name for them might have been different. My friend's microbus had a faulty fuel gauge; the float inside the tank was sticky and sometimes got hung up. Eventually, a bounce or a jostle would knock it free, and it would return to proper working order. Even though the issue was pretty easily resolved, the thought of opening up the gas tank to replace the float seemed daunting enough that the problem never rose high enough on her priority list to get fixed. Instead, she'd drive along, seemingly on a full tank, only to hit a couple of potholes and watch the gas gauge plummet to nearly empty all at once. It could be a shock to any of us friends who watched this for the first time during our turn behind the wheel. More than one of us was convinced the gas tank had ruptured suddenly!

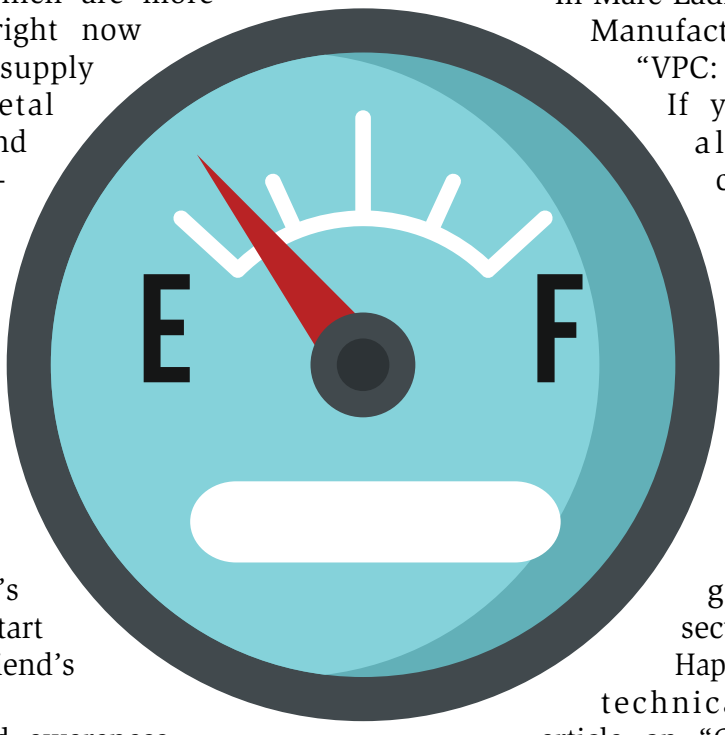
All of this was no big deal until it WAS a big deal as in the moment the tank read half full, and then the engine would cough, sputter, and die, fuel-starved. Not to date myself, but this was during the Arab oil embargo in the 1970s. Back then, with the even and odd license plate guidelines and endless lines at the pump, running out of gas might mean being without a car for multiple days. Yes, it could be darn inconvenient.

We learned to cope. One of us might pop underneath the rear end to knock on the tank with a knuckle. Did it sound full or empty? What did the gauge say? Did anybody know when it was filled up last? How many miles did we think we needed to drive? What was our guess on whether we had enough gas or not?

We paid attention to the gauge because when it worked, it was accurate. We just never knew whether it was telling us accurate information or not, and the consequences could be very sudden indeed. We'd carry a few gallons of extra fuel in a can, just in case.

There are parallels in the PCB fabrication industry right now. PCB fabrication is a lot like that VW microbus. Everything is running just fine while the supply is there. However,

the materials supply pipeline is becoming increasingly unpredictable. Forecasting for materials purchases depends on customer purchasing levels, which are more volatile than ever right now thanks to component supply shortages, raw-metal supply challenges, and the changing international trade landscape. Laminate suppliers are working hard to smooth out the flow and hold inventories steady, but that may not last forever. When market volatility finally catches up with materials, your factory's inventory might start to act just like my friend's sticky gas-tank float.



Communication and awareness are going to be key to manage the supply chain crisis and keep your fabrication facility running smoothly. In this issue, we bring you a number of timely conversations with industry experts to help position your company's offerings to the greatest effect. To that end, our columnists this month concentrate on the fabrication techniques necessary to build boards to the current supply chain trends we've been discussing in this issue.

We lead off with an extended conversation with Stephanie Martin, senior VP of supply chain at Vexos. Stephanie is well positioned to have a wide view of the supply chain dynamics, and she shares her assessment with the I-Connect007 editorial team.

Next, we talk with Wayne Antal, a key account manager at NCAB Group. In this first part of a two-part conversation, Wayne and I discuss how NCAB helps their customers weather the storm.

In the number-three slot, I dig into SMT market news and analyses on supply chain in "Perspectives on Supply Chain Ripples."

A product development R&D manager at MacDermid Alpha Electronics Solutions talks 3D additive processes with Happy Holden in "Roger Bernards on MIDs and Automotive."

In Marc Ladle's column, "Ladle on Manufacturing," he discusses "VPC: The Future of Plating." If you haven't read up already on virtual continuous plating, Marc's column is a great place to start.

Eduardo Benmayor, general manager with Aismalibar, discusses new thermal management substrate materials specifically for use in the rapidly growing automotive sectors.

Happy Holden, I-Connect007 technical editor, posts an article on "Chemical Recycling as Part of a Zero-effluent Strategy" related to the GreenSource Fabrication facility in New Hampshire.

While we don't immediately think of it when discussing supply chain and the digital information that makes it run, John Vaughan's column this month certainly does. John's "The Fourth Pillar of Defense Acquisition: Cybersecurity" is required reading.

Part three of Michael Carano's multi-part column continues this month in, "Trouble in Your Tank: Moving Microvias." In this installment, Carano's thesis is that fabricators misjudge "the scope of HDI and what his manufacturing strategy truly entails. Here are a few common mistakes to avoid."

So, strap into your seat, tap on the gas gauge, and let's talk supply chain for 2019. **PCB007**

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.

Stephanie Martin: Component Supply Challenges From the Catbird Seat

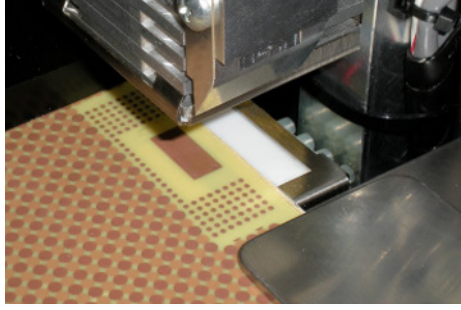
Feature Interview by the I-Connect007 Editorial Team

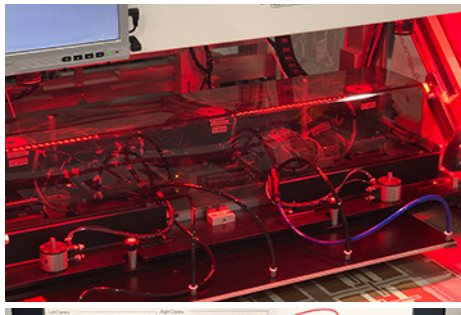
Vexos Senior Vice President for Global Supply Stephanie Martin gives the I-Connect007 editorial team a wide-ranging and insightful overview of the current parts supply situation from the perspective of procurement at a contract manufacturer.

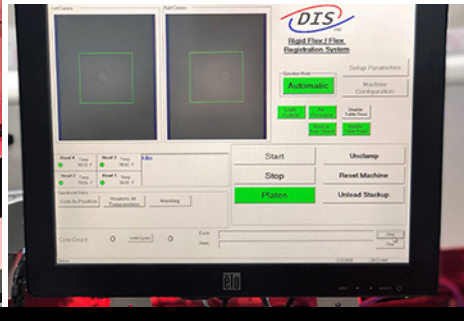
Stephen Las Marias: First, Stephanie, can you please tell us more about Vexos and your role at the company?

Stephanie Martin: Yes. I'm the senior VP of global supply for Vexos. Vexos is a high tier-three, low tier-two contract manufacturer. It is a combination of two different companies that were purchased by Center Lane Partners, a private equity company; EPM based out of Markham, Canada; and STACI Corporation based out of LaGrange, Ohio. We have four facilities that do contract manufacturing. We have the Markham facility, which focuses more on high tech, fine pitch. Then, we have the facility in LaGrange, Ohio, is the Cleveland area that does medical, some automotive, and lower-tech products. We have two facilities in China: one in Shenzhen, which usually matches what Markham does—more fine pitch and higher-tech products—and one in Dongguan, which does automotive, medical, a lot of lower-tech products, and quite a bit of other manufacturing that is not based in electronics.

Then, we have another portion of our business we call the "custom material solution." We are a trading company and represent a number of supplier partners for custom-built products like PCBs, cable assemblies, displays, heat sinks, metal fabrication metal machine parts, and plastic injection molding. We believe we're the only tier-three player in our space that offers not only a global solution but a full spread of components where we can supply everything from the outer housing, whether you do the electronics assembly or not. We can







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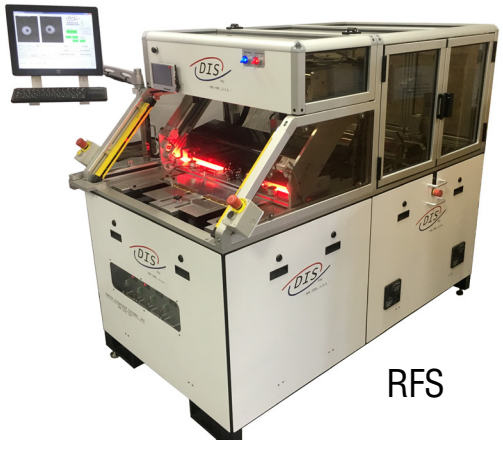

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Las Marias: From your perspective as an EMS provider, what are the greatest challenges that you face or that you experience when it comes to supply chain?


Stephanie Martin

Martin: Well, we're in the supercycle for allocation, so we're heavily into the supercycle that we're dealing with. It started with the memory product, which we're coming up on three years now. And then last summer, around this time, MLCCs started getting tight. By November, we were in full-board allocation. We struggle like all EMS companies, particularly with MLCCs. The lead times are over 52 weeks with most manufacturers, if they will even take orders.

The second- and third-tier manufacturers will no longer cross your components, and for distributors, the inventory position is low. So, it's a challenge every time we get an order to find the MLCCs. We're also seeing tantalum shifts. A lot of those are now going on allocation. We have MOFSETs across the board that are running on full-board allocation over 40 weeks. Then, we have IGBTs and TV, Zener, and Schottky diodes, which are all in the 38-week range.

In the resistor arena, we have the Vishay CRCW series at 80 weeks now. The Panasonic ERJ series are at 40+ weeks. Generally, all mainstream resistor manufacturers are now 26–29 weeks. It has become quite a challenge. We spend a lot of time talking and working with our customers trying to get them to approve alternates quickly so that we can find materials and expand their AVL, and we spend a lot of extra time sourcing trying to just find inventory. It has become quite a challenge in this market.

Las Marias: You mentioned supercycle. Have you experienced this sort of extreme shortages when it comes to electronic component supply before?

Martin: I've been in electronics since 1989, so I've been in it a long time. I've been through a number of cycles. I believe this is the tenth inventory cycle that we're in from what I can tell. The closest that we've ever come, and the last time we went into a shortage situation that affected passive components, was in 1999 right before the dot-com crash. At that point in time, we had problems with panels and capacitors. That's the last, and in my career, the only time that the passive products have been an issue.

Typically, the market follows some new must-have device, whether it was a pager, cellphone, or laptop computer. This market cycle is very different. This one is not any single device. This market segment is really what we're calling "the electrification of everything." There's a huge change going on. A lot of pieces of our life that were never electronic are now becoming electronically connected to our phones and smart devices. We even have one customer that we're talking to that wants to make furnace filters smart, so they remind you to replace them.

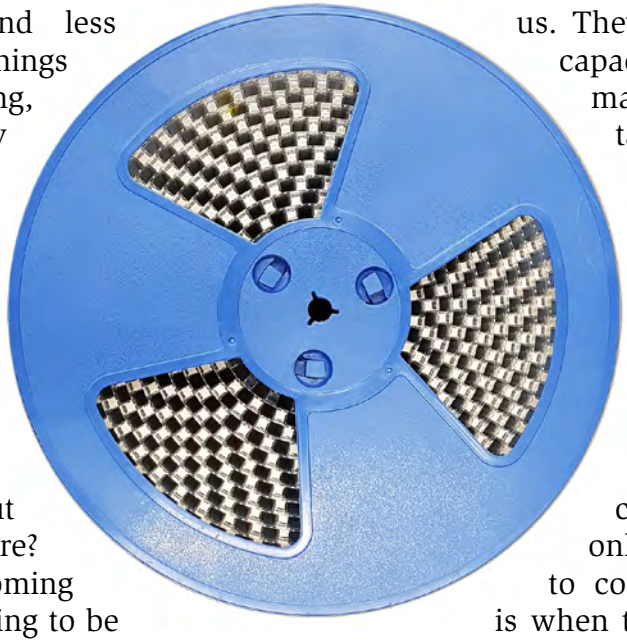
All of the devices, including IoT, smart devices, automotive content, and cellphones are hitting us at the same time. No one device will fix the market once it's satisfied. The only thing I believe is going to fix the market is when we can get some increased capacity through new manufacturers coming in. There's also a technology shift happening, which appears to be very close to what happened back in the mid-2000s during the RoHS time where we switched from leaded to non-leaded parts; this one is going from larger to smaller case sizes.

If you look at a 1206 capacitor, they can get approximately 80 0402 capacitors in the same space or 300 0201s. As the market is tighter, I believe the OEMs are going to be forced to redesign to smaller and smaller parts, and that will allow the manufacturers to produce more parts in the same footprint that they had before. I think that's more along the line

of what's going to happen. All the projections that we get from the manufacturers and the distribution channel tell us that the market will not see a relief until mid-2019 at the earliest, and several of them say it will be towards the end of 2019 for MLCCS in particular.

A number of things are going to happen. The Chinese are bringing up some new fabrications. Several manufacturers are pulling some of their fabrication back in-house, particularly in the U.S. Some third-tier suppliers are coming in and starting up, particularly in Asia. There are a lot of things happening, but it will take a while for the market to level out.

Dan Feinberg: I have to agree with you on the supercycle. It's the largest I've seen since 1960–1962 when we switched from point-to-point wiring to circuit boards. The industry was much smaller, and the demands were much smaller and less widespread. Some of the things that I'm seeing, and hearing, is that this supercycle may last considerably longer than 2019 because it's a supply and demand thing.



With such long lead times, and you've answered part of this, are you planning or expecting new facilities to come on board throughout the supply chain, and where? With the tariff issues coming on, it looks like this is going to be more serious than people had thought or hoped, at least in this industry. While the overall U.S. economy will probably benefit from it, this industry may or may not. These could be significant tariffs and could last for quite some time. Has that switched or changed where the expansions that have been planned may happen?

Martin: Let me answer that in two parts. The tariff issue is a whole different issue that we can discuss. When I've met with several manufacturers, I've visited the Vishay and Agile factories and several others in China and met with the Murata reps directly, so I've had quite a few conversations. The general feeling that I get or what I understand is that the parts that are in the greatest demand are what we would have called popcorn parts—the really low-cost penny parts. Over time since the dot-com crash in 2000, the prices have been depressed to the point where they're very low margins for the manufacturers, making their average selling price not profitable for them.

Feinberg: It's not attractive for expansion.

Martin: Yes, not attractive. So, it's unlikely that manufacturers will come in unless they're third tier, which would likely be in China. We're seeing a few third tier pop up in China, although they will not quote us. They said they're already at capacity. None of the main manufacturers that I've talked to are expanding in the larger case sizes. They are expanding in the 0201 and the 1005 case sizes, but they are not expanding in the 0402 and above. That's where most of the industrial sector is still located—in the larger case sizes. I think the only real relief that's going to come for those part sizes is when the OEMs decide to do a redesign into the smaller sizes.

Now, from what I also understand, these larger case sizes probably have no more than 0603 and up. They probably have no more than a three- to five-year lifecycle. When the automotive industry phases them out, I believe most of them will be gone, so that's what's going to drive it. We've been told that a current automobile has about 3,000 MLCCs in it, and an electric vehicle has 30,000 MLCCs. When they go through with this tight market designed to the smaller 0201 and below, then I

think you'll start to see relief and the few players that are left will be able to pick it up. But, in the larger case sizes, I don't see much new capacity coming on in those.

What we're doing in that sector is working with our customers. We're doing BOM analysis for them and giving them options for crossing. I'm meeting with a lot of them personally. We're encouraging them to look at redesigns based on the lifecycle of their products to make sure that they have coverage for their end-of-life parts. Murata put out a notice earlier this year on end-of-life a lot of parts; March of next year is the last buy. When that hits in March, there will be a big flood, and I believe the lead times will move out further than they are today when all the customers that haven't acted realize that they're not going to get these parts. Murata is the biggest player and has somewhere between 30–40% of the global market share. We've already received notice from other manufacturers like Temic and ABX that they're not pulling out of those parts, but that they can't handle the additional requirements that are going to be coming at them. So, I believe there's a major problem coming the first of the year.

Feinberg: I've had a few very slight indications that there are a few OEMs considering doing what was done back in the '60s and '70s and starting to do their own fabrication and assembly. That's something they went away from totally. Have you heard of any that are considering doing a little of that?

Martin: Yes, we've heard some pulling it on the semiconductor side. Now, the MOSFET MLCCs went on the semiconductors like the MOSFET-type products. We've heard that a couple manufacturers are pulling some back in; some CMs may be pulling some but in smaller amounts.

The other problem that we're hearing is that the three main fabrication manufacturers sitting in Taiwan are experiencing ingot shortages, so they're having some supply problems on their end. I just read a notice on TSMC, the largest, that they brought a new machine online. The machine had a virus, and they lost their whole run of wafers; it delayed the ViaLinks parts until the fourth quarter, so there are a lot of them. I think everybody's trying to go through the same type on the semiconductors so that they can pull those back in-house—probably easier.

Yageo, when I was there, told us the resistors are experiencing raw material issues, which may be driven by the Chinese environmental requirements that they've put in. They've been closing quite a few of their suppliers due to water and air purity requirements. They've had issues with the metal, paper, and substrates that they use. They've had quite a bit of issues just getting raw materials for the resistors. Yageo is your biggest resistor manufacturer, and Murata is your biggest capacitor manufacturer, so there are levels of supply chain issues all the way through. There are raw material and capacity issues. They're moving to support the higher needs of the automotive and handheld sets. They've shifted lines down away from the industrial sector, and there are a lot of different things happening all at the same time.

Feinberg: There's even a tremendous difficulty for getting laminate. There are long lead times for PCB fabrications to have laminate just to make the circuit boards.

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Base station

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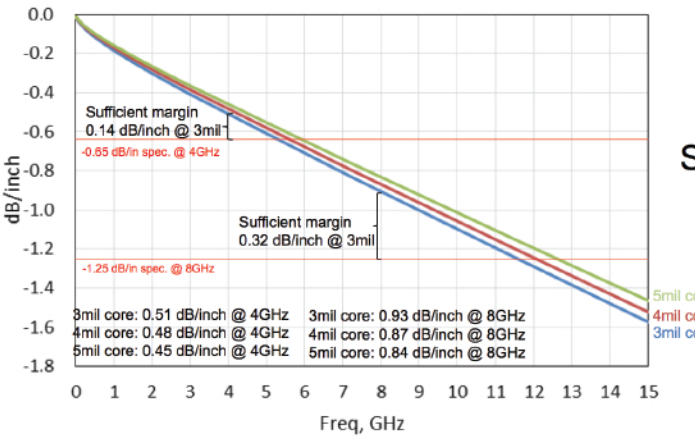
General Properties

Items	Methods	IT-170GRA1
Tg (℃)	DSC	180
T-288 (w/ 1 Oz Cu, min)	TMA	60+
Td-5%(℃)	TGA 5% loss	380
CTE (%), 50-260℃	TMA	2.4
Peel strength (lb/inch)	1 oz	7.0
Water absorption	D-24/23	0.1
Dk: 2-10 GHz	Bereskin	3.96 – 3.99
Df: 2-10 GHz	Bereskin	0.0073 - 0.0075

IT-170GRA1 Insertion Loss



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Martin: We had that problem last summer where they couldn't get the foil sheets to build the laminates because they were going toward batteries and electric vehicles. We haven't had a lot of fabrication issues recently. Most of our suppliers in China are back to near normal lead times—about six weeks for those. They had jumped up to over 10 weeks last summer, and prices escalated. The prices have come back down and stabilized a little bit and the lead times dropped down. Most of those, at least with our suppliers, have been fixed on that end. However, we continue to run into trouble with passives, resistors, capacitors, and discrete items like MOSFETs, diodes, and those types of devices. That's what's giving us a lot of hard work.

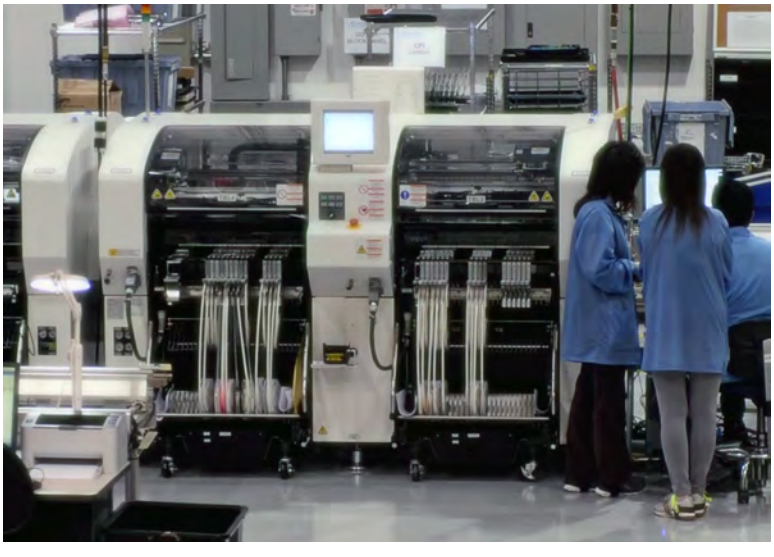
Barry Matties: Some companies anticipated the shortage for the capacitors and started stockpiling in early 2017—maybe even before. When you look out, what other shortages should we be looking at that people should consider stockpiling?

Martin: Right now, the resistors and MOSFETs are the next thing, which have just come up as being real problems (other than Vishay and Panasonic, which have been a problem all along). I think you're looking at the discrete items. Their lead times have jumped up a lot, which we're starting to see. We've had quite a few MOSFET issues pop up. I think those are more short-term problems, though. I don't think those are going to be a long-term issue for this.

The tariff issue has just really made a bad situation even worse. We track the tariffs because we're global and deal with tariffs from all different directions. One of the things we found out was since we're primarily a distribution customer is that all of the distribution inventory is warehoused in the U.S. Even though Canadian companies warehouse all of their goods in the U.S., that makes them subject to tariffs.

In our China facility—because we have U.S.-based customers—there is special manufacturing pricing that can only be obtained if we buy it through the U.S. We have some programs that we still have to buy parts out of the U.S., which are now subject to the tariffs. List 1 caught the electromechanical and the LED—not the diode, but the LED. List 2 has pretty much caught all of the electronic components out there, so it's now affecting all of them. Through the distribution channel, they are working on mitigation strategies for Canada, Mexico, and China, so they won't have the tariffs pass through. We have three main ways the tariffs are coming at us. Right now, we know of 14 manufacturers who are the importer of record and are embedding the tariff increase as a price increase.

We've seen price increases on some components as much as 80%, so they're putting the price increase and tariff together. We have some parts that the distributors are the importer of record. They are mitigating most of those through doing a free-trade zone, duty drawback process, or utilizing a warehouse in Guadalajara, depending on who the distributor is. The last way the tariffs are coming at us is that the manufacturers are the importer of record. They invoice the distributors, who invoice us. In that case, where it gets complicated is that the manufacturers that are invoicing are invoicing at the book cost—not the debited or final cost.



Where you may have a special price for 75 cents, the book cost is $1.00.

You're going to pay the tariff on the dollar—not the 75 cents—so it's a real challenge right now. We are capturing the harmonized tariff and HTS codes on all of the parts. We ask for the country of origin when we place an order. And if we have an option to use a country of origin other than China, that's where we're going, even if the price is a little higher.

We are hearing that the manufacturers who already have sites outside of China are looking at rescheduling their business for goods based in North America to sites outside of China. We haven't seen a lot yet, but we're hearing it's happening. For our U.S. facility, we'll be very carefully looking at who the manufacturers are and where it's coming from. If we have options to avoid this 25% tariff, that's where we're going.

Andy Shaughnessy: My readers are primarily designers. Let's say you have a product coming out next Christmas in 2019. Other than stockpiling, how do you plan for the future? What should they do to try to get ahead of this?

Martin: When I meet with engineers, I tell them if it's a brand-new product, design it in the smallest case size possible; 0201s and 0105s are your best bet. In those cases, if you can approve automotive grade, you have a better shot of getting parts. They tend to be a little higher priced, but you can still get parts in the automotive grade. If you can't design it, you need to offer as many alternatives as possible. The worst thing you can do is come out with one sole-source part because you will ultimately have supply chain problems at some point, whether it's today or later.

What we ask our customers to do before they stabilize and while they're in the process of design is to let us analyze their BOM. We use IHS Connect software as a predictive modeler. What we like to do is work with them while they're still in the beta stage. If you have a partner that you're going to work with to outsource your product, you need to give them the authority to place parts on order as soon as you qualify them, so that you can at least get in the pipeline. It's more successful to pull in parts once you have them pipelined than trying to start from scratch and pull in parts to wait for lead times.

Somebody needs to put those on order. The reality is that unless there are non-cancelable, non-returnable parts, you can cancel or reschedule within 45 days typically without any problems. If they're some of the really hot parts, you have no liability. There are a lot of strategies that you can go with if you have a design coming, but you have to think ahead on planning the supply chain.

Shaughnessy: It sounds like they just need to stay on the ball.

Martin: There's no silver bullet.

Las Marias: When it comes to supply chain, one of the issues is counterfeit components. Now that the industry is facing this severe shortage, do you expect an increasing number of counterfeit components in the market?

Martin: Absolutely. That's one of the things that we talk to the customers about. The grey market is actually drying up. A number of manufacturers have shut the back door for the grey market suppliers—the independents. Further, some distributors have shut the front door, so they can't order from their sites. The amount of inventory that's still available through the grey market is getting tighter and tighter, which means your risk of counterfeit goes up.

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We have a small set of approved independents that we've audited. Each of them has

Polymer technology, an MLCC alternative.

independent labs that they work with for quality checking. The distributors are now requiring that they are authorized to do destructive testing because of the high risk of counterfeiting. We haven't seen any counterfeit material yet, but we are very cautious and watchful for it.

Las Marias: What can you advise our readers when it comes to these issues in the supply chain?

Martin: They need to forecast. Even if it's not 100%, you need rolling forecasts for 52 weeks. We understand that customers do have that much visibility, but they need to give their partners as much visibility as possible. A 52-week lead time is pretty standard. Every BOM has components now that are over 40 weeks long—every one of them. That doesn't mean that we can't still find parts, but when the grey market, available inventory, and distribution channel dries up, there will be no parts. You'll be forced to wait for it. The customers who are in the best position are doing rolling forecasts. They update it monthly out 52 weeks.

When their partner gives them an alternate component, they need to approve it very, very quickly. Usually, if it's in the grey market these days, it's gone within 24–48 hours. If the customer takes a week to approve it, the inventory is gone. The next time we find it, the price may be up. I would suggest that they buffer critical stock components and authorize additional buffer stock on the allocated components. Then, look at a redesign for the smaller case sizes. If the lifecycle of their product has three to five years remaining, they may want to look at putting an additional buffer for the end of life. If their product lifecycle is eight to 10 years or more, then they really should look at redesigning the small case sizes so that they'll have sustainability.

Finally, they need to look at an alternate type of materials. On the MLCC, you can typically replace several ceramic chips with a tantalum chip. Although there are some lead time issues in tantalum, it isn't nearly as bad as ceramic, and there's the newer technology—the polymer. If they see their product is 35 volts or less, they need to look at potentially a different product other than ceramic. They can get a four to one placement on the polymers, but it only works if it's 35 volts or less. On the Vishay CRCW series resistor, if they can take the non-automotive temperature range, you can add a C to the end of the part number and those lead times drop to approximately 12 weeks from 80 weeks. There are a lot of things that they can do to help themselves.

Matties: Are there other strategies designers can use? You mentioned the lower case size, which makes sense, but are there other strategies the designers can employ to combat this?

Martin: Yes, if they generally just look for long-term production, there is a huge technology shift that's happening right now. We're at the beginning stages of it now. I think it's going to accelerate where the industry is going smaller. So, a designer needs to look at using the smallest size parts that they possibly can. Designers tend to use the parts that they're comfortable with. It is not unusual when we see a brand-new design that it has obsolete components.

That's one of the reasons we suggest to our customers to let us review their component list before they finalize the design. We can offer suggestions to them on alternative components given the same form, fit, function, and placement. It's designing for the supply chain. There are a lot of things that they need

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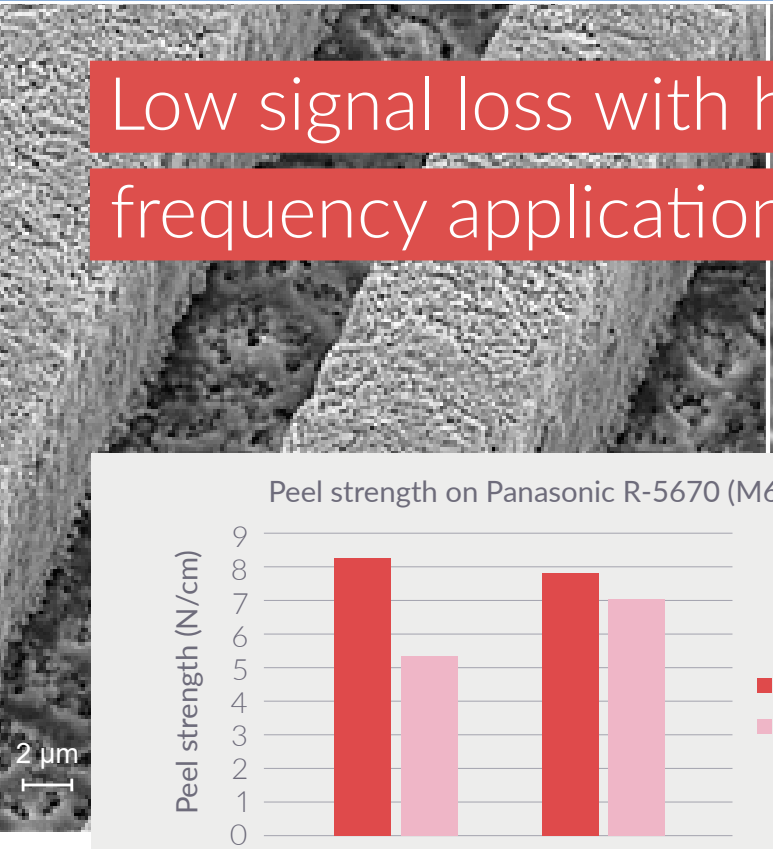

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to look at designing for the long-term supply chain. More and more devices are going to become electronic, so the market itself is going to continue to expand, making it increasingly difficult to get larger parts. That's what I would tell designers.

Matties: Do you have designers on your employee list as well, and do you offer that as a service?

Martin: No, we work with outside services if a customer needs design. I have component engineering on my side that reports to me. We do a lifecycle analysis on the component using predictive modeling, and it's on a scale of one to five. I tell designers that unless you're in the leading-edge technology, you want to stay away from parts in lifecycle one. Those are brand new parts, and they're not accepted in the market. The prices are very high, and there are very few manufacturers.

> **I tell designers that unless you're in the leading-edge technology, you want to stay away from parts in lifecycle one.**

If you're putting in a new design, you want to look for a lifecycle two to three and a half. A two means that it's starting to grow, more manufacturers are coming in, prices are dropping, and supply is higher. Lifecycle three is when the greatest number of manufacturers are there. It's at its lowest price point, and it gives you the largest supply chain opportunity. Once you start dropping below three and a half or four, the parts decline, manufacturers move out of the market, and prices go up. And, of course, five is obsolete.

If you're doing a new design, in the BOM analysis we do for customers, we show them the lifecycle of the parts and say, "You have to know the lifecycle of your end item. How long and how does it match with the lifecycle of the components?" But if you're in a new design and looking at components that are already headed towards the declining stage, you will have supply chain problems.

Matties: You're right. Designers should be aware of this fact at the beginning.

Martin: In my experience, most of the engineers are somewhat insulated from the supply chain so that they really don't know the lifecycle of those components. However, it's probably the most critical aspect in a new design to make sure you have sustainability on it.

Matties: How many designers contact you with the BOM review before they do their designs?

Martin: We've been pretty aggressive at doing these BOMs. We do two things for our customers including a BOM health analysis, where we do the lifecycle of the parts and show them the MLCC situation. On those MLCCs, I'm crossing Murata's end-of-life list to all of their components by the voltage, microreference, and dielectrics. We tell them which are going to be their troublesome long-term parts, and we also do an inventory and bumper stock model where we pull in the market lead times.

When I do these with customers, it opens their eyes. With the customers that we've done it with, they push pretty hard on their internal design teams to be very aware of what's happening and get ahead of the curve. It is effective when it's done.

Nolan Johnson: From where you sit, how would you recommend the designers get more of that information? Obviously, once they're doing the analysis with you on what they think is their finished design, any problems may cause them to have to go back and do a complete redesign. Hopefully, it's not that serious, but that's sort of the dynamic that's getting set up here. If they can make better decisions in the design tool and give you a better BOM and

design with up-to-date parts, where should they go to be effective in that?

Martin: With most of the designers, the distributors call on them. That's where they get their sample parts and that type of thing. They should ask their distributors for the lifecycles because they have that information. They can use a software service. There are two of them: Silicon Experts and IHS Connect. Both are excellent software. The distributors themselves have this information and should work with their supply chain if they don't have it.

What I used to do a lot of was have lunch-and-learn meetings when I was on the OEM side. I'd bring in distributors. But in this world, and the way the technology shift is happening, they have to get ahead of this. It is not design as usual. As I said, there is a huge technology shift that is picking up speed. If they don't know the lifecycle of the components, they will be looking at major problems very shortly.

Feinberg: First of all, let me compliment you. You're extremely knowledgeable about your topics and very well prepared. It's just a delight to have this conversation with you.

Martin: Thank you.

Feinberg: The other comment I have is on the forecasting. One of the things that makes forecasting so difficult is that a lot of the companies, the OEMs, don't and can't always talk to each other. Therefore, they kind of take each other by surprise, which they should do if they're trying to compete. I think a good example of that is Apple has just announced a set of new iPhones that are truly amazing in design, but they got caught a little bit behind Samsung, who is pushing 5G at a rate much faster than anyone thought would happen. All of a sudden, everything could change in the next 12 months on that end of the spectrum. This makes it difficult to do forecasting because the major pieces of information that would be very helpful with forecasting are being held very close to the vest by the big OEMs, as they should.

Martin: I can see that, particularly on some of your consumer goods. However, most of the types of products we work on are more industrial. They tend to have more forecast visibility. Most of them are not leading-edge technology. The handset industry drives the component market. Wherever they go, that's where the rest of us end up going too. But the rest of the customers—the industrial base customers—tend to have much more visibility or predictability than the latest designs. Most of them are not earth-shattering designs that come out. They're enhancements or improvements to what they've already offered.

Matties: Where are you located?

Martin: I'm physically located in Tampa, Florida. I work remotely and travel.

Matties: Good for you. We're a virtual company as well, so we have people on this call from all parts of the world right now.

Martin: I appreciate all of the attention we're getting, and I hope you find it helpful.

Matties: Very much so. Is there anything we haven't talked about that you feel we should cover?

Martin: As I said, we're fighting tariff issues. We're mainly waiting for manufacturers to move. I think there's going to be a big move on business out of China to other regions to mitigate the tariffs. It hasn't really had a huge impact yet, but I think it's coming. I think it's going to have a significant impact in a few months. Right now, the distributors have been really good. They're absorbing what they can't mitigate for us, so it's going to have a huge impact with the manufacturers on what they choose to design and which products we buy. That's coming at us. And then, come 2019, I believe the lead time for the larger case sizes of MLCCs is going to go out further than it is right now. That's going to be a huge problem.

Matties: It's not just manufacturing capacity alone, it's actually a shortage of the equipment to produce them. There's not enough equip-ment as well.

Martin: Yes. I was at Vishay in China this June, and they told me they had equipment on order for a year, and they had pushed it out because the manufacturer couldn't get parts.

Matties: It's a deeper supply chain issue beyond just the floor space.

Martin: Exactly. The manufacturers can't get the machines to make more parts because the machine manufacturers can't get the parts.

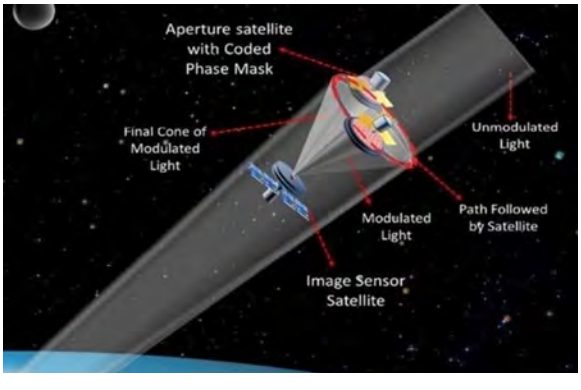
Matties: Thank you very much, Stephanie. This was very informative.

Martin: Thank you. **PCB007**

New BGU System Produces High-res Images at Low Cost

An article in the December issue of the journal *Optica* demonstrated that nanosatellites the size of milk cartons arranged in a spherical (annular) configuration were able to capture images that match the resolution of the full-frame, lens-based or concave mirror systems used on today's telescopes.

BGU Ph.D. candidate Angika Bulbul, working under the supervision of Prof. Joseph Rosen of BGU's Department of Electrical and Computer Engineering, explains the groundbreaking nature of this study, saying it proves that by using a partial aperture, even a high-resolution image can be generated. This reduces the cost of traditionally large telescopic lenses.



"We found that you don't need the entire telescope lens to obtain the right images. Even by using a partial aperture area of a lens, as low as 0.43%, we managed to obtain a similar image resolution to the full aperture area of a mirror or lens-based imaging system," says Bulbul. "The huge cost, time and material needed for gigantic traditional optical space telescopes with large curved mirrors can be slashed."

(Source: Ben-Gurion University of the Negev)

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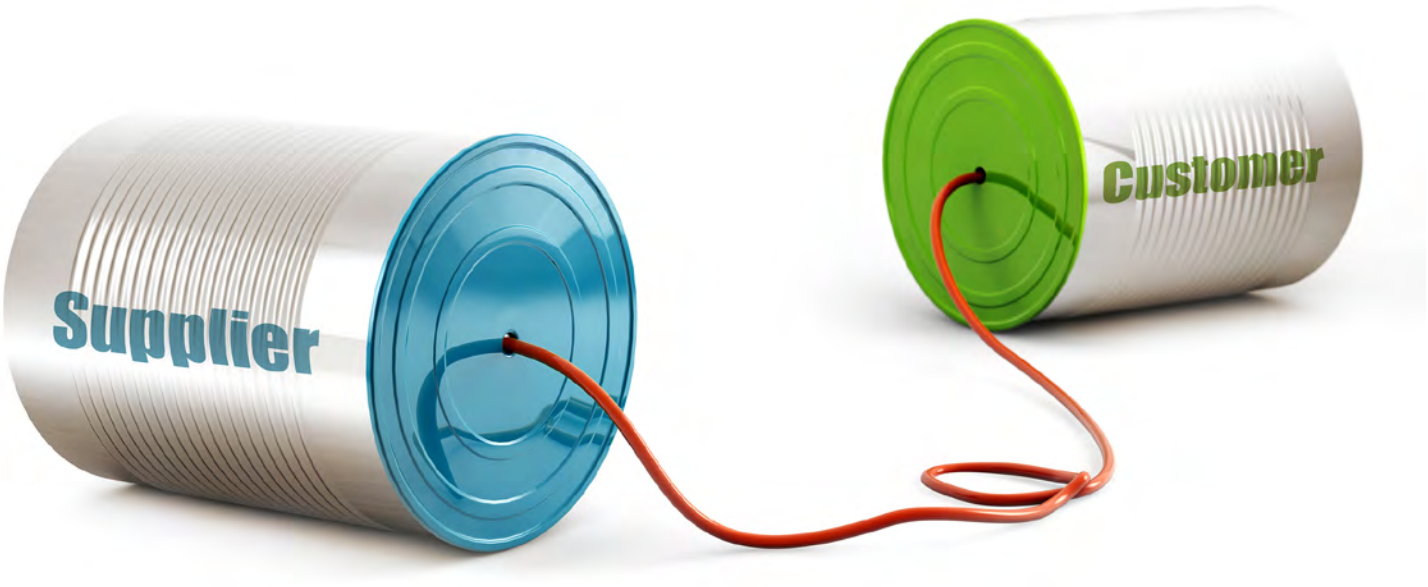

NCAB Group on Supply Chain Issues

Feature Interview by Nolan Johnson
I-CONNECT007

Wayne Antal, a key account manager with NCAB Group, discusses supply chain issues, the effect he sees on PCB fabrication channels, and how his customers are adapting to the new business dynamics. This is part one of a two-part conversation with Antal. Look for part two next month.

Nolan Johnson: Today, I'm speaking with Wayne Antal from NCAB. Wayne, could you introduce yourself and describe what NCAB is doing in the industry?

Wayne Antal: I've been with NCAB Group for about five years now. My industry experience goes back into the '80s just coming out of high school. I joined the military to start electronics training. After getting out of the military, I started working for various contract manufacturers and OEM companies. Before, I worked with CMs mostly as a program manager, and then in the last five years, I've gone to circuit boards only at NCAB. My time with NCAB being a key manager is an outside sales position, but I don't consider myself a prototypical salesperson; I'm more of a problem solver. The circuit board is the key component towards any electronics build; it's the platform that everything starts and moves forward from. From that standpoint, finding out what the customer's needs are is the main avenue we use to create a value-add within our customer base, and maybe it will pick me up some new customers.

Johnson: NCAB has seen a lot of success lately.

Antal: That's right. We've unlocked success. Our best customers are the most informed customers who know what they're looking for, especially the newer customers that I have; they come to me knowing what they want, what our capabilities are, they've done their homework, and they understand what the value-add is, which are always the best customers to have.

Johnson: As you talk to people—buyers, procurement, your front line people at customer sites, etc.—what are some of the issues

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Wayne Antal

that they're dissatisfied within electronics manufacturing and procurement?

Antal: Right now, the component lead times are tremendous, and that's what I'm hearing across the industry. Of course, associated with that is increased pricing, and the tariff situation does not help on top of that. What I'm seeing is that the industry is always very skeptical on increasing capacity especially if they don't think it's going to last. The swell in component purchases is going to last. That's the number one concern I hear—how long the lead times are on certain components that were traditionally off-the-shelf components. Now, there are tremendous lead times and a tightening of supplies throughout the industry on what my customers would consider standard components.

Johnson: I would have to think that when a buyer is trying to put together a finished assembly and the component lead times are now pushing up into the high double-digit weeks, that could affect scheduling for PCB fabrication as well.

Antal: What you see is very volatile purchases where you'll get standard purchases from a particular circuit board for the first six months of the year, and as the component issues tighten up, you start to see it become more sporadic. They might order every other month or every three months, or order three and four times the quantity because they have to catch up, and then holds or pull-ins. A lot of that depends on the type of customer that you have. Some of the OEM customers don't mind pulling in the whole volume of a board, whereas the contract manufacturers may not want to hold the inventory. You see that swell of a pinch in the contract manufacturers especially on the component lead-time side because they must. I do not envy them. I have one component and the circuit board, and they have an entire BOM that they have to come up with and try to find. It has been increasingly difficult to have it completed on a regular basis.

Johnson: For some of the sporadic work—especially the rush jobs that you run into—is it the trend that customers have been struggling to find some key components? Suddenly, they've been able to source those parts. Do they push through as many boards as they can simply because they have parts right now?

Antal: Yes. They find them in alternate sources. They will find components, and all of a sudden, they will break loose and will have tremendous months. For example, this month was a pretty good month for me. People are trying to head off the tariffs and Chinese New Year delays on circuit boards in January so they're getting their orders in before the end of the year. I have a double barrel here going on from a purchasing standpoint.

However, previous months—such as October—were tremendous. There was large, pent-up purchasing and a clog in the system that released from my customers at that time

frame where the orders shot through the roof for us. From my understanding, what has happened in the industry is each of the OEM customers, etc., had to decide where they were going to build and sell their product, so they don't get overleveraged on tariffs. Basically, they end up paying tariffs for products that are not going to be sold in the United States. Thus, they had to do a calculation to find out if it's cheaper to bring in the piece parts or the assembly into the U.S., and what percentage of their product was sold in the U.S. Before that, they held off on their purchasing. As we entered the third quarter, that started to release, and orders increased greatly.

Johnson: Given that the buyers are having to figure out product-by-product, company-by-company, how does NCAB help customers get through these parts availability analyses?

Antal: There are a couple of different things. We've added capabilities for offshore quick-turns, which competes with domestic. It's not going to compete with the turns under five days, but for those above five days, we're starting to get offshore quick-turn reliability. We will also take possession of the boards before they get to the customer site, so they don't get hit with the direct 10% tariff on the price; they only get hit with the 10% tariff on the cost, so we save them a little bit of money on that side. That's another value-add and selling point for us.

Johnson: Right. By working within NCAB and plugging in to their expertise, you can help customers be more cost-effective.

Antal: That's right. We get hit on the tariff on our cost versus their price.

Johnson: That must be of great value for some of your customers.

Antal: Definitely. When you think about, a lot of mid-tier companies are not in a good position with their cash flow to have more of their dollars tied up for one, two, three, or sometimes four months before they get that return back when their invoices are paid. That's where a lot of the companies with less healthy cash flow are really feeling the pinch. Some of them are struggling to survive right now because they don't have that cash flow to hold up. One of the things that we do is reduce that burden on them. We'll also hold inventory as well for them sometimes.

Johnson: NCAB can do that, but not all of your competitors are as able to do so.

Antal: Right. We have a warehouse in Hong Kong where we can hold inventory for a while and not have any tariffs on it until it actually ships to us. We have warehouses here as well, so it depends on how big the opportunity is and how sensitive it is to lead times. We have many different tools in our toolkit to help our customers try to mediate the traditional peaks and valleys of production.

We have many different tools in our toolkit to help our customers try to mediate the traditional peaks and valleys of production.

Johnson: Wayne, what's your opinion on the component shortage issues that are going on, whether this situation is long-term, or whether it's just a blip in the supply?

Antal: I plug into some of the major component suppliers. I bump into them at my customer sites and ask them similar questions. They don't see an end coming, and they don't know when the end of this will be. I spoke to people in the industry who have been doing this from a component purchasing standpoint for a long time, and they said this is the worst they've seen it. Some people have been in the

industry for 20, 30, or 40 years and say this is the most disruptive they've seen it happen at a time when there's a great expansion going on in the industry. So, it's not only that there's a disruption in components, but there's also a greater demand for it, which is why it's hitting too hard right now.

So, it's not only that there's a disruption in components, but there's also a greater demand for it, which is why it's hitting too hard right now.

The bellwether for me on if it's long term or not is with the component manufacturers. And what is short term? Is it one to two years, six months, or something else? I don't know, but that's really the bellwether. Since we sell into many different industries, we get a very good cross-section of where demand comes from. Is it coming from the actual equipment manufacturers? Some of the equipment manufacturers that we deal with have to do with the circuit board population. When we see orders going up in that area, we tend to think that there's going to be an expansion in the industry. For example, if someone like Universal Instruments increases their purchases, you expect that there would be an upswing in the market because they're anticipating more machinery to be sold, more circuit boards to be built, and more production. Meanwhile, if you go back a step further and look at the component industry, from what I understand, they're not expanding their capacity at the moment.

One side thinks that it's not going to last long, but from my side, there's turmoil in the market, which does not lend fuel to a growing market. I think we're starting to see some ups and downs on Wall Street, and the effects of tariffs on component lead times. It makes for a lot of uncertainty in the general marketplace. Overall, I think it's going to affect it in a negative manner. Does that slow the economy or the stock market down? That's yet to be seen, but it certainly leads me to believe that that's the direction it's going.

Johnson: We're hearing in the industry is that the three major drivers to this supply shortage for parts are cellphones and telecommunications, automotive, and aerospace.

Antal: Generally, we see a lot of larger companies moving their production out of the U.S. I've been hunting for customers—some of them are the largest customers in our industry—and I'm hearing across the board they're moving their production to Mexico. My guess is they've done the calculation and have figured out it's cheaper to bring in assemblies from outside depending on the industry. It's cheaper for them to bring the assemblies and then get tariffed as they come in based on what their demand is, whether they have them assembled here or shipped out of the U.S. to other regions of North America, Central America, or elsewhere. It's a disturbing trend because, from our government standpoint, that was not the intention of putting tariffs on or any of this other stuff; it's having an opposite effect.

Johnson: To clarify, it sounds to me like you're saying that for electronic manufacturers, by placing tariffs on things inbound to the U.S. and now facing tariffs on exports—retaliatory tariffs, if you will—part of the math is to determine how steep the tariff is in the target country you'll ship to from the U.S. Now, OEMs have to calculate both tariffs, and figure out how to stage up their final assembly to minimize the impact?

Antal: What I'm saying is that from the larger companies, they don't sell 100% of their product into the United States, so if they bring components into the U.S. and pay a

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tariff on 100% of the items, they don't think that's economically feasible to do. So, they move the production out of the United States so they don't have to pay tariffs, on a certain percentage of their overall spend.

Johnson: It's easier now to stage final assembly someplace in, say, Mexico, where you can think globally, and minimize the overall tariff burden by only paying the tariffs under terms for Mexico—not on China or U.S. terms.

Antal: Right, so they can have things shipped into Mexico at zero tariff, have the assembly built up, and if they're only selling 70% of their product into the U.S., they only pay a tariff on that 70% of stuff rather than on 100% of it coming in if they were assembling it in the United States.

Johnson: Makes sense.

Antal: That calculation is going on in all industries and in all levels that are being affected by the tariffs, which is just about everybody.

Johnson: For every product that's affected.

Antal: Yes, and that's where, to me, the rubber meets the road. Their decisions are being made based on that, so if their calculations show that it's cheaper to import an assembly into the United States, then they will build that product outside of the U.S. and import it in as an assembly versus importing the piece parts in at a tariff on each of those items and assembling it here. As I said, I don't know the pieces that go into that calculation; they are going to be product and industry specific as well.

Johnson: That's incredibly insightful. Thank you.

Antal: It's interesting how it plays out because I don't think anybody who I have spoken to recently knew how the full effects of the tariffs were going to play into this as well as the component shortages. That's another piece that has a tremendous effect.

Johnson: Is there anything that we should discuss?

Antal: NCAB has a very unique position here. Although this is a difficult time for the electronics industry itself, I think NCAB is positioned very well to help our customers and any potential customers as much as we can to mitigate a lot of the heartache they're facing from the circuit board side due to the tariffs and component issues. We work with our customers very closely. From where we stand, it's quality first, then strong relationships and full responsibility that build this company up.

We work with our customers very closely. From where we stand, it's quality first, then strong relationships and full responsibility that build this company up.

Part of doing that is helping our customers mitigate risk and being a team player. We are an extension of our customer's manufacturing, so we are a member of their team. As long as we stay that route, we will grow by helping our customers mitigate the challenges they face in the industry.

Johnson: I think that's true, especially in these times. A relationship and a perfect track record in helping mitigate risk is extremely valuable. Thank you for your time, Wayne.

Antal: Thank you. I really appreciate it. **PCB007**

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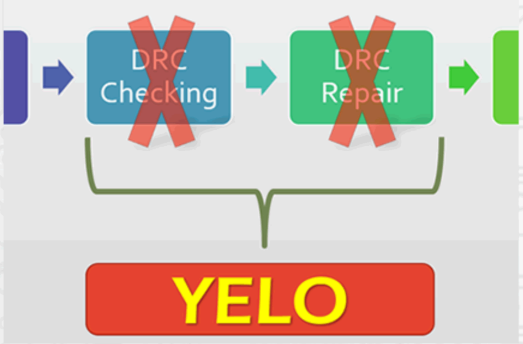

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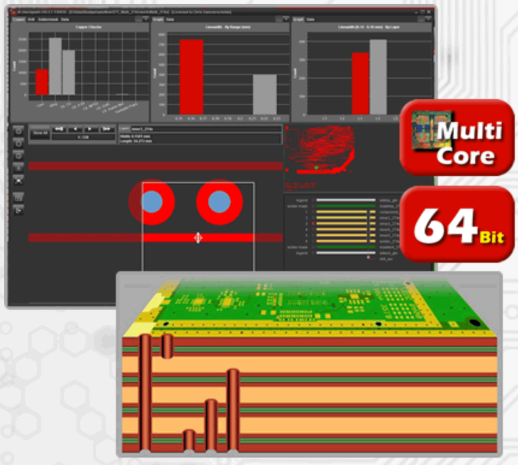

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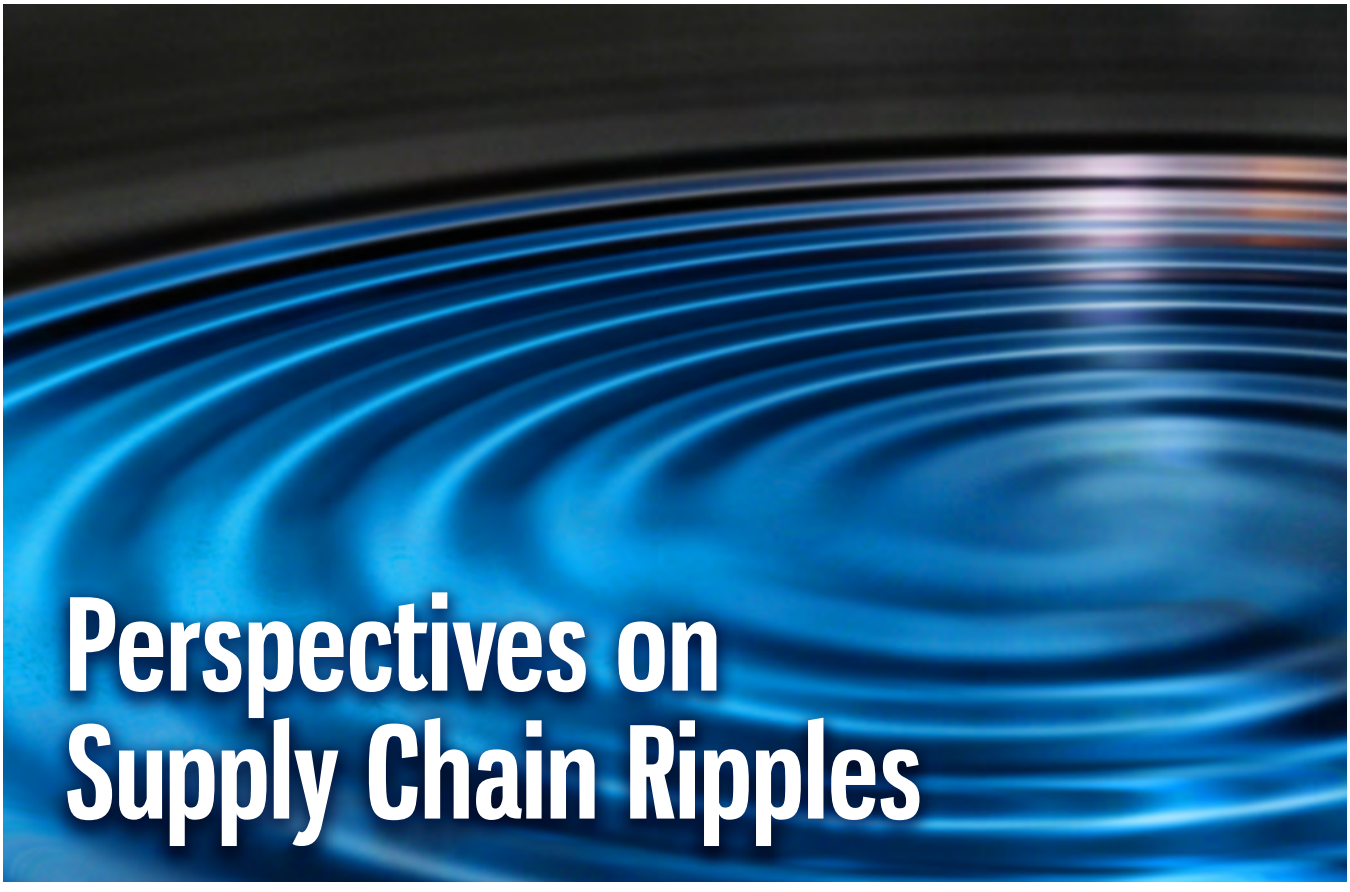

Perspectives on Supply Chain Ripples

Feature by Nolan Johnson
I-CONNECT007

The ripples start at the very front of the process when the engineering and design team make their first choices about the performance characteristics for their project, then select components to fit their performance windows. As the project proceeds, the team makes hundreds and even thousands of little choices about which capacitor, resistor, packages, etc. In a traditional design flow, the project team tends to use the parts they already know and for which they probably already have footprints—the parts may be a little long in the tooth, but they are well-known quantities with a solid supply chain.

Except these are not traditional times. It doesn't work the same way now; the market is much more turbulent. The PCB supply chain has changed.

"The parts that are in the greatest demand are what we call popcorn parts—the really low-cost penny parts. Since the dot-com crash in 2000, the prices have been depressed to the point that they're a very low margin for the manufacturers, making their average selling price not profitable," states Stephanie Martin, senior VP of supply chain at Vexos, a low- to mid-volume electronics manufacturing and custom material solutions provider. "None of the main manufacturers that I've talked to are expanding in the larger case sizes." She continues, "They're expanding in the 0201 and the 1005 case sizes, but not expanding in the 0402 and above."

This starts causing problems for those tried-and-true parts chosen in the design phase. Martin notes, "That's where most of the industrial sector is still located—in the larger case sizes. I think the only real relief that's going to come for those part sizes is when the OEMs decide to do a redesign into the smaller sizes."

What's the Cause?

Dave Doherty, COO at Digi-Key, shares this, "If you look across industrial, medical,

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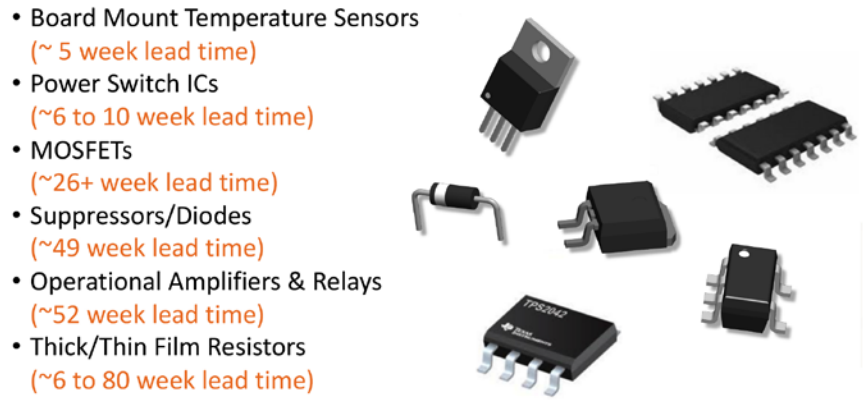

Common parts in short supply with typical lead times.

telecommunications, military, aerospace, and automotive, we're in a very robust part of the cycle where more electronics being put into more applications. However, I would say what's putting the strain on the infrastructure as much as anything is automotive."

In John Watson's recent article for the January 2019 issue of *SMT007 Magazine* titled "The Electronic Component Shortage Crisis: A Veteran Engineer's Perspective," he does the math for us. "It is estimated that approximately 1.5 billion smartphones will be manufactured in the upcoming year, and each flagship model contains roughly 1,000 capacitors. The current estimate is that there is a worldwide production capacity of three trillion MLCC capacitors. By those numbers, nearly 50% of the MLCC capacitors produced are already designated and used strictly in the mobile cellphone sector."

Watson continues, "A standard combustion engine car requires somewhere between 2,000–3,000 capacitors. An electric vehicle has up to 22,000 capacitors required in a single car. Furthermore, the higher temperatures inside the control circuits of electric vehicles mean that traditional plastic film capacitors are no longer suitable, so ceramic MLCCs are increasingly being used."

These two market trends alone start to put the situation into perspective. Martin characterizes it this way, "Typically, the market follows some new must-have device—whether it was a pager, cellphone, or laptop computer—but this market cycle is very different. This one is not any single device; this market segment is really what we're calling the electrification of everything. There's a huge change going on. All of the devices, the internet of things, and smart devices in general, as well as automotive content and cellphones are hitting us at the same time."

"There is a huge technology shift that's happening right now," notes Dave Doherty. "We're at the beginning stages, and I think it's going to accelerate. The industry is going smaller. Designers need to look at using the smallest size parts that they possibly can. Designers tend to use the parts that they're comfortable with. It is not unusual when we see a brand-new design that it has obsolete components."

Working Its Way Downstream

With the design completed, the design team passes the bill of materials, including components and the fabricated board, etc., to the procurement folks. The job is done for the design team, right? Not so fast. Some of those little component decisions—especially the ones to go with a tried-and-true, always-been-there, two-cent passive—may actually be little bombs waiting to go off in that BOM.

As procurement takes over and begins to go through the BOM line by line, they may discover that some parts are no longer able to be sourced (at least not through primary suppliers). Those time-honored, big-package discretes that the design team has relied upon forever have gone end of life! Procurement can't find anything in that size! By the time the buyer finds something that fits the performance specifications, chances are it's in a 0201 package—not the 0804 that the engineer's BOM specifies.

The net effect is that the procurement team is now sending two memos: one to the design team to alert them to the sourcing stalemate, and one to the product managers to tell them

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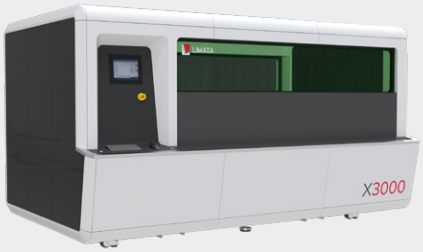

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the new product announcement schedule is now at risk. Then, procurement likely starts making a flurry of phone calls to try to source parts in non-primary channels, possibly even turning to grey-market sources.

If this sourcing issue resolves in procurement, the team still isn't in the clear. As fast as component availability is changing currently, things are no longer stable just because the project has moved into manufacturing. Those parts shortages could still arise during manufacturing or between the first and second production runs.

Watson notes, "Many of the part vendors have now switched over to allocation. In allocation, manufacturers divide the available inventory, so only a percentage of the stock is given to specific purchasers. The suppliers, of course, want to work with the companies that place the biggest orders."

Watson continues, "On the company side, allocation has caused an absolute panic. To make sure to have the available components, the new common practice is to double and triple order quantities, then stockpile these components for future use. This only puts a further strain on an already fragile system of supply and demand."

Doherty seems to think similarly, "Digi-Key is bringing in more inventory. I would challenge anybody to have physically just as much product as possible available on the shelf."

"The bellwether to me on whether it's long term or not is with the component manufacturers," states Wayne Antal, a key account manager with NCAB Group. "If they aren't increasing capacity, then they think it's shorter term. The question is, 'What is short term?' Is it one to two years? Is it six months? Is it something else?"

"I do not envy them," observes Antal. "I have one component—the circuit board—and they have an entire bill of materials that they have to come up with and try to find. It has been increasingly more difficult to complete the BOM under these circumstances."

PCBs Aren't So Sheltered

"From the PCB fabricator standpoint, we haven't yet seen any direct impact from the part shortages," says Matt Stevenson, director of marketing at PCB fabricator Sunstone Circuits. "However, when we quote a full turn-key job for customers, we do see delays and issues in getting those quotes turned, as well as not being able to quote the entire BOM in a feasible manner."

While the PCB fabrication step doesn't seem to suffer from component availability in such a direct way, the shortages still have an impact. Even laminate can sometimes be difficult to come by. Martin's recent experiences at Vexos illustrate the point, "Last summer, they couldn't get the foil sheets to build the laminates because the copper was going to batteries and electric vehicles." However, she notes that things may have turned around. "We haven't had a lot of fabrication issues recently. Most of our suppliers are back to near normal lead times—I'd say about six weeks for those. They had jumped up to over 10 weeks last summer, and prices had escalated. The prices have come back down and stabilized a little bit, and the lead times have also dropped down."

John Lee, VP at Insulectro, a materials distributor, picks up the thread, "It used to be that quick-turn was something that was an exception, and you charged a premium for it. Everybody was content with whatever the normal delivery was. Quick-turn is now the new norm; it's what's expected, and we don't charge a premium for it."

This quick-turn expectation for fabricators is likely driven by their customers' changing

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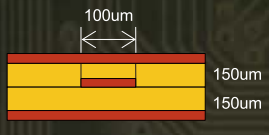

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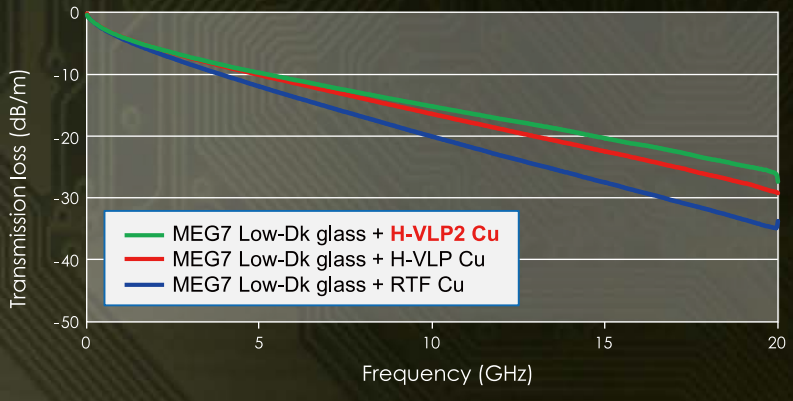

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requirements, which certainly puts laminate suppliers in the hot seat to keep the supply flowing smoothly. Lee notes, "For most materials that we sell, the fabricator must have them to begin a job—they have to have a laminate, and that's where it starts. If we're not managing the supply chain, we can hold up a job or cost a customer because they're not able to do the job."

As Martin and Doherty have pointed out, three very large markets right now seem to vacuum up the lion's share of the components in the supply chain: aerospace, electric automotive, and cellular telecommunications. Lee says, "On that point, automotive is all we hear about. A lot of our suppliers are looking to develop new products. I know Isola has a new laminate product they're launching in Germany specifically for automotive."

Lee does not leave out telecommunications, however, "Everybody's very curious about what 5G will bring and how that's going to disrupt the playing field." Lee continues, "Military and aerospace can be very demanding," and place even more constraints on the materials in the supply chain. "Another thing for us to manage is expiration dates" shares Lee. "We can't re-certify materials that are sold to military and aerospace even if the product is technically still good."

How Long Will This Ripple?

Dan Schoenfelder, VP of business development at Octopart, an online source for CAD tool parts definitions and parts availability information, notes, "From the data that we have available and the usage we have on our site, all indications are that the current trends are going to continue. It's hard for me to say from where I sit what's going to happen, even three, four, or five months out."

Jamey Mann, director of global supply chain at Kimball Electronics, sums it up with statistics in his recent article for *SMT007 Magazine* "No Rest for the Weary: Supply Chain Pressures are Here to Stay!": "Due to underinvestment on the capacity, along with increased content requirements of today's electronics, the majority of manufacturers in the MLCC space are operating under allocation rules. Even as many of the major players in this market are currently adding capacity that equates to an approximate 15% increase in output, the market is projected to remain allocated through 2019 and into 2020. Book-to-bill ratios are still running in the range of 1.5:1."

Watson provides the designer's perspective: "From the very first day of a new design, we are forced to question what components we use. The problem is that we don't know what the specific conditions will be from moment to moment. We have seen the problem from both sides in that components we originally thought would not be a problem have become a problem halfway through a design and vice versa. It has gotten so bad that on some occasions, once we located components, the parts would be already gone before we could fill out a purchase order."

"I could validate that observation is accurate" adds Doherty. "And for a lot of these suppliers, it's coming down to economics. The most standard commodities have been heavily impacted. The prices have been driven down into the mud, and manufacturers are asked to produce more and more product each year at less and less total resale. The model isn't sustainable."

Settling the Ripples

When asked what it will take to fix this, Martin states, "The only thing I believe is going to fix the market is when we can get some increased capacity through new manufacturers coming in."

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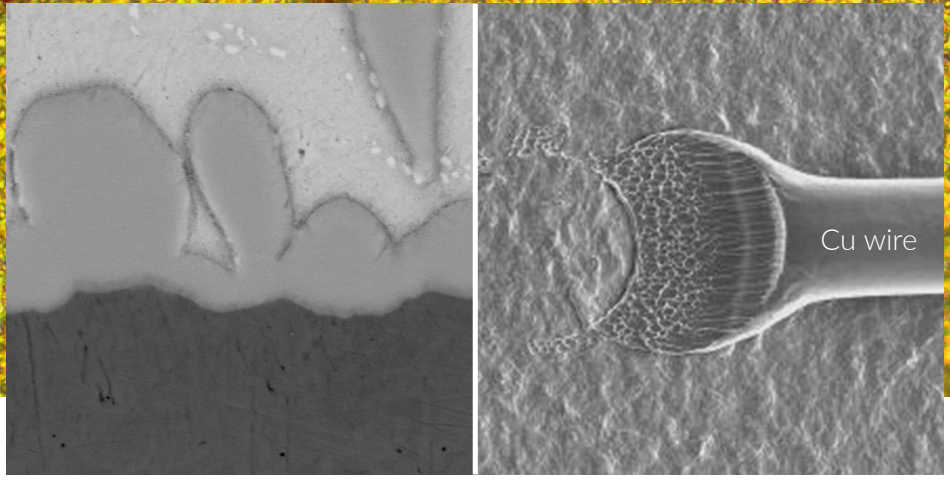

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component selections and skill sets in some cases to use the parts that will be available in the long term. Designers also need to pay attention to parts availability in the short term too. It may begin with the designers, and the designers certainly end up being held accountable to updating the design to keep the product current, but it takes the entire supply chain straight through fabrication to be in communication to keep everyone informed and in production.

Watson advises, "Stay informed. Many of the component vendors publish their component forecasts. Stay aware of trends in our industry. The sooner you know of the problem or the direction, the faster you can make a sound decision on needed changes. This will require reading electronic journals and news."

Doherty shares the Digi-Key point of view, "This isn't a fun time for some of these individuals trying to source and find products. However, we want to be that trusted partner still, and the one thing we do see is—regardless of the constraints—our customers still want to go to authorized sources."

Doherty offers this advice, "Our engineering staff is available to help consult. We have customers physically send us their BOM and ask us to score it when they're in the purchasing mode down the road. We want that to be an easy, hassle-free experience, and you can't impact it at the time of procurement. It has to be upstream in design, so start with a phone call, webchat, or an email. If not Digi-Key, then there are other services out there to subscribe to that I would say are worth their weight in gold in times like this if you can design that little extra flexibility."

Mann puts a number to it: "It is highly suggested to have your supply chain management team work very closely with both the OEM and supplier base to ensure that a minimum of a full year of demand is covered." He continues, "There is little to no ability for the market to absorb demand increases within this period. It is also highly suggested that you eliminate single-sourced commodity components as a single source limits flexibility in the supply chain solution."

Back to The Beginning

SnapEDA and other component library suppliers are working to help as well. "Since we have a large database of vendor specifications, we can make recommendations for similar parts," Baker points out. "For example, if a product is unavailable, SnapEDA recommends pin- and footprint-compatible alternates. This allows designers to use a different product in its place that has the same specifications without requiring any PCB layout changes and also keeps the project on schedule. It can even help with optimizing BOM costs."

Baker adds, "While we don't target procurement professionals explicitly, we've definitely seen adoption. Often, they use our proprietary aggregator for pricing and availability from distributors. Where SnapEDA really shines is when they begin to consider product alternatives."

Conclusion

As a key step in the manufacturing chain for electronic products, the PCB fabrication industry has been relatively protected from the supply chain ripples so far. With only isolated instances of material supply shortages, the largest impact seems to be in the form of more volatile customer forecasts driven by parts availability issues.

For now, at least.

As this shortage in supply continues, and the three most significant sectors continue their consumption of parts in the open market, it is possible that copper shortages could worsen, causing wider ripples than those noted by Martin. Furthermore, component shortages could create issues for fabrication equipment companies, potentially slowing the fulfillment of equipment orders for fabricators all while the PCB business continues to grow in volume produced.

In the meantime, fabricators might expect to see a large number of revisions on existing products as older, now-unavailable parts are designed out for newer, smaller components.

Yes, the ripples do reach far and wide. **PCB007**

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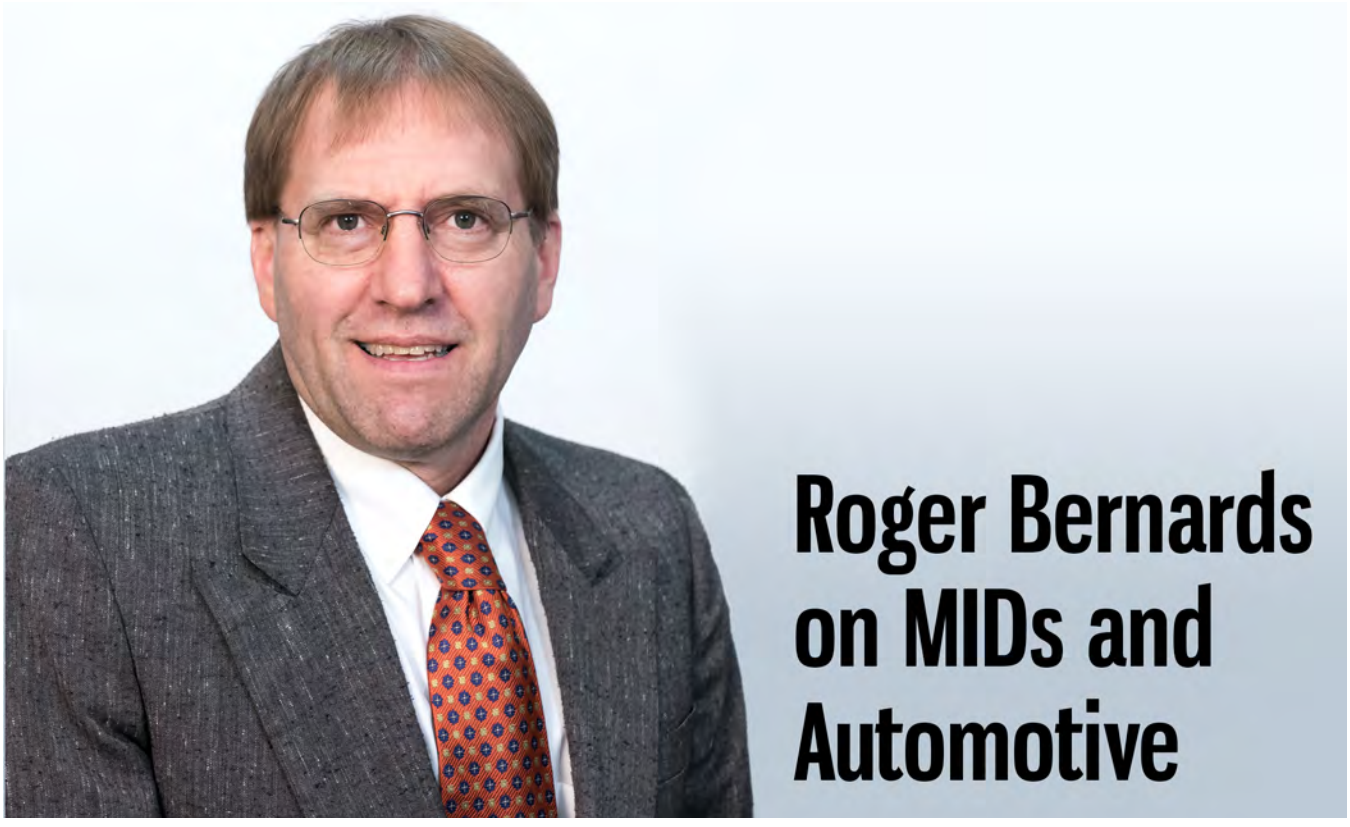

Roger Bernards on MIDs and Automotive

Interview by Happy Holden
I-CONNECT007

Happy Holden recently spoke with Roger Bernards, product development R&D manager at MacDermid Alpha Electronics Solutions, at SMTA International about molded interconnect devices (MIDs) and a new additive electroless copper bath related to the automotive industry.

Happy Holden: Roger, can you tell us a little about the plating of plastic MIDs for automotive applications?

Roger Bernards: The MID process involves laser ablation of a 3D plastic substrate to draw the pattern of the circuit and the metallization of this pattern with an electroless copper solution. There is no electroplating on the parts due to its structure and isolated circuitry. The typical deposit from an electroless copper bath is quite stressed and prone to cracking when subjected to physical or thermal shock. The automotive space has been reluctant to adapt MIDs for certain applications into their automobiles because of reliability concerns. What's needed is an electroless copper bath that can withstand the stresses of applications with the environmental extremes that you would experience in the automotive industry.

MacDermid Alpha has formulated a new additive electroless copper bath that produces a deposit with zero internal stress and a very high percentage of elongation on the order of over 12%. We feel that this new technology enables the automotive industry to utilize MID technology for things like sensors, headlight displays, or under-the-dashboard components. The new formulation has the proper physical properties that you would need for these types of environments that might be utilized in the automotive space. It is quite exciting.

Holden: Walk us through the process of manufacturing an MID. How's that different from conventional electronic applications?

Bernards: The plastic used to form the MID has an embedded catalyst. The circuitry pattern is directly lasered onto the plastic. The catalyst concentrates onto that lasered print, and provides a location for the initiation of the

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electroless copper deposition. You're creating the circuit directly; there's no etching. The circuit is built over the lasered pattern with a full-build additive electroless copper process. As I said, typically these processes have very low elongation, only 1–2% elongation to the copper deposit. The deposits are typically very brittle. Until now, this has been the challenge of this technology for higher reliability applications.

For more stringent applications in the automotive space, they need a copper deposit that can withstand thermocycling because the molded plastic will expand and contract as it goes through heat cycles. Essentially, what is required is a copper deposit that can withstand this thermocycling and have enough elongation to withstand that environment.

The new process from MacDermid Alpha accomplishes this task with a zero stress electroless copper bath. This means that the deposit doesn't want to blister off the surface; it will remain intact on the surface with excellent adhesion to the substrate throughout the life of the device. The deposit has high elongation so that the copper can stretch without cracking; thus, helping expand the amount of possibilities for MIDs in the automotive space.

The deposit has high elongation so that the copper can stretch without cracking.

Holden: You're talking about automotive applications, such as headlight displays on the exterior of the car probably near high heat sources. What kind of testing do you anticipate can handle a stressful application like that?

Bernards: One of the typical tests that we do is measure the percent elongation of the deposit utilizing ASTM E-345. For that, we simply deposit the copper onto a stainless steel sheet so that it can be peeled off. Then, we use an inch-round device to stretch the copper and measure how much you can elongate the copper before the deposit breaks. Another test would be a thermocycling test where you put MIDs into cycling chambers, subject them to a number of thermocycles, and then look for cracks in the circuitry.

Another simple test that we do is coat the plastic devices and bend the plastic. The plastic is bendable, so we just bend the plastic around mandrels and look for cracking in the deposits. If you perform these kinds of tests on a conventional full-build electroless copper that's used in MIDs today, they will not provide optimal results. Current commercial electroless plating baths are not formulated with these types of challenges in mind. But the new process that we are very excited about passes these tests very well with good adhesion to the substrate.

Another thing that is interesting about the new formulation pertains to plating fine-line MIDs with tight lines and spaces. Due to the amount of thickness required by a full-build application, typical electroless copper baths tend to get stray plating on the areas between these tight spaces. This new formulation does not have this problem. We've plated sub-50-micron lines and spaces with the full-build electroless deposit with no stray plating at all to the deposit.

Holden: In the past, we saw this with separate flexible circuits and assemblies. Are these enabling any new applications?

Bernards: Typically, they are using flexible circuits and connectors to go from position to position where it's a 3D situation not on one plane. MID technology actually eliminates the need to have flex circuitry and connectors all attached to a core circuit board. You can just put the circuitry right into the plastic that is holding the core components of the electronic device—for example, an automotive LED—and the circuitry can pass right through this molded part. It's quite a bit cheaper.

Holden: It sounds like an interesting technology. Will MacDermid Alpha have some kind of how-to book for people interested in the

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technology? As you said, since this is 3D, this is a whole new dimension to our planar, flat world of things that people will probably think is exciting, but how do we go about doing it?

Bernards: MIDs are largely used in the mobile devices industry right now for antennas or connecting electronics through parts of the casing. In that case, they don't really require a highly ductile copper deposit. The environment isn't quite as harsh and the product life cycle is comparatively short. We will be establishing best practices for how to apply this technology including where it is and is not suitable. We feel that the adaptation of the automotive

We will be establishing best practices for how to apply this technology including where it is and is not suitable.

industry to the MID will open up many new opportunities which might require extra reliability; it's going to be something that we're going to have to learn and work on together. The automotive industry has already adapted MID for a few applications; however, certain applications requiring higher reliability have not been attempted yet. This is going to be something new for them, and we will have to address all of the issues that come up together with our automotive supply-chain partners.

Holden: Does MacDermid Alpha supply the catalyst?

Bernards: No, it's something that's embedded into the plastic way upstream. We don't sell this catalyst; it's a copper chromite particle that's mixed in with the mold when the parts are molded. It's already there.

Holden: Is that an established technology with different plastics?

Bernards: Yes, it is. For different plastics like ABS and various other kinds of plastics. The catalyst has come a long way in the last five or six years. It used to be that they had a lot of issues with just getting the electroless copper to plate onto the catalyst, but they have improved the process quite a bit. It's not typically an issue to achieve plating with the catalyst, so there have been a lot of improvements in that. It's an upstream process that MacDermid Alpha is not involved in.

Holden: Are they using expensive metal like palladium in the catalyst?

Bernards: No, it's copper chromite. Palladium was used in the older two-shot processes many years ago when MIDs were made in a different manner. The copper chromite is a different animal, but with the initiation of the electroless onto it, you still need to have a bath that is properly formulated to initiate onto that catalyst. However, that's not a big roadblock right now.

Holden: Where do you think this technology can go in terms of future applications other than what we've shared?

Bernards: I think it could also be used for a lot of applications including flex circuits and fine-line flex circuitry perhaps where you'd want to have a full-build process, and your limitation is that you can't do any etching because of risk of undercutting; basically, very fine-line fully additive processing. I think it's suitable for anything where you'd want to use that kind of technology, including SAP panels where you want to have a full-build additive process to eliminate etching and undercutting, which allows you to squish lines and spaces much closer together.

Holden: I'm glad you could take the time to enlighten us on this. Thank you, Roger.

Bernards: Thank you very much. PCB007

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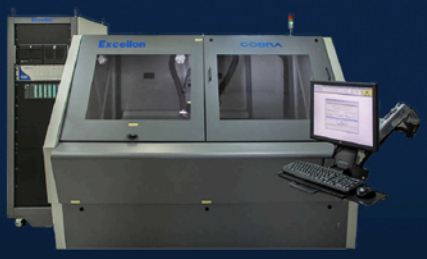

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Supplier Highlights

GreenSource Fabrication Announces Acquisition of AWP Group ▶

GreenSource Fabrication LLC has announced the acquisition of majority ownership in AWP Group GmbH with immediate effect. Terms of the agreement were not disclosed.

Rick Almeida Discusses DownStream's Latest News ▶

At the 2018 electronica exhibition in Munich, Rick Almeida, founder of DownStream Technologies, brings Editor Pete Starkey up to speed with the company's latest news.

John Hendricks on 5G Materials ▶

At the 2018 electronica exhibition in Munich, John Hendricks, product marketing manager for Rogers Corporation, discussed 5G materials including demands and trends.

Top 10 Most-read PCB007 Articles of 2018 ▶

Every year, we like to take a look back at the most popular PCB news and articles. These are the top 10 most-read PCB articles from the past year. Check them out.

It's Only Common Sense: Where Will We Be in Five Years? ▶

Recently, a good friend and U.S. PCB shop owner asked me what the North American market would look like in five years. It's a good question, isn't it? With everything going on in the world, it is a good time to stop and take stock.

Top 10 Most-read PCB007 Interviews of 2018 ▶

Here's a list of the top 10 most-read PCB interviews in the past year. Topping the list is an interview by Publisher Barry Matties with industry veteran Gene Weiner, who talked about the market conditions in China, and any effect the new U.S. administration might have on trade relations going forward.

Gen3 Introduces AutoSIR2+ and AutoCAF2+ ▶

Gen3 has a continuous product development program to meet the ever-changing demands of both our existing and new customers. We are proud to introduce the new AutoSIR2+ and the AutoCAF2+ instruments.

Ventec Extends tec-speed 20.0 Series of Low PIM Antenna-Grade Laminates ▶

Ventec International Group Co., Ltd. has added four new low passive intermodulation (PIM) antenna-grade laminates to its tec-speed 20.0 ceramic-filled hydrocarbon thermoset material series.

MicroCraft Adds 8 Probe System with Full Automation ▶

MicroCraft has released its first 8-probe system with full automation, the E8M6151AL, as the latest addition in their EMMA series. One of the key features of the E8M6151AL model is that the tester can operate for 24 hours unattended with its newly developed auto loader/unloader.

Martin Cotton's Parting Shot ▶

Martin Cotton is a unique personality in the PCB industry. As Cotton says, "I'm a designer—look at my haircut!" Cotton gave the keynote at the Institute of Circuit Technology's 2018 Harrogate Seminar, challenging his audience to consider laminate dielectric properties in the context of power and cost in a presentation entitled 'The Effect of the Dk of a PCB Laminate on the Cost-effectiveness of Office Rental Space. Intrigued?' Read on!

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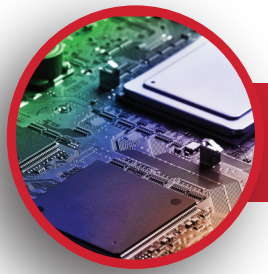

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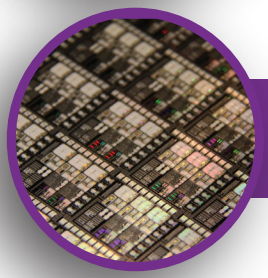

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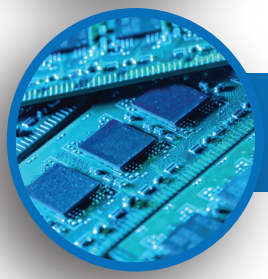

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VCP: The Future of Plating

Ladle on Manufacturing
by Marc Ladle, VIKING TEST LTD.

Electroplating copper has been a standard part of the PCB manufacturing process for more than 50 years. The basic technology has not changed very much in that time. Normal arrangements involve a series of chemical and rinse tanks into which panels are dipped first to clean the copper surface and then to electroplate copper onto the surface and through the drilled holes and vias. Some smaller manufacturers still use a manual process where an operator moves the panel(s) being plated from tank to tank to complete the process. Larger manufacturers use machines that may have a very similar arrangement of tanks but on a larger scale, and an automatically controlled transporter moves the panels.

The normal process options for the plating operation are either panel or pattern plating. Either way, the panels are prepared by drilling all of the holes required and then making a thin conductive deposit such as electroless copper or carbon/graphite. This will be used as the base for electroplating through the holes. If you panel plate, the whole of the surface is electroplated as well as the drilled holes. If you pattern plate, then a plating resist is used to make an image on the surface, and the copper is electroplated selectively.

Over the years, developments have been made from time to time that have helped to refine the process. For instance, floating shields within the copper tanks have helped to deal with panels of different lengths. Pulse rectification has enabled high aspect ratio panels to be produced with an even deposit of copper through the holes. However, if you had run one of the original processes back in the day, you would still recognise a more modern version of the process.

Even with the best available traditional plating line, there are still some shortcomings that are difficult to overcome. It is not efficient to plate panels one at a time—you would need a lot of plating tanks, and throughput would be pretty low. Most machines are based on plating

Figure 1: Copper plating cell.

Figure 2: Pulse rectifier enclosure.

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Figure 3: Robot unloads to horizontal clean line.

several panels at a time either using a jig to hold them in position or hanging them from top clamps in a long row. In both methods, each panel has a slightly different plating effect, and therefore, a different copper thickness. This variation in copper thickness means that circuit performance is compromised. The target should always be for each circuit produced to be exactly the same.

The vertical continuous plating (VCP) process offers a good solution to this problem of variation. Instead of dipping panels in a succession of tanks, the VCP process moves the panel in a linear motion through the critical process stages. In the case of the copper tank, this means that the panel is moved through a very long plating tank from one end to the other, and every panel in the batch has exactly the same process path; thus, the variation from panel to panel is absolutely minimal.

For some people, VCP is a real gamechanger. It opens up possibilities for automating the process as it can easily be joined with horizontal pre- and post-processes. It also offers opportunities to use the simpler panel plating process route for circuits that previously could only have been manufactured by pattern plating. This reduces the number of process stages and the overall cost of the PCB.

Additional benefits are that less copper is used as the variation in plated copper thickness is reduced. If you require a minimum of 25 microns of copper thickness in the hole and your variation across the panel is 10 microns, then you have at least 35 microns thickness in places. If you can reduce the variation across the panel to two microns, less copper is wasted. If you produce panels by the panel plating process followed by printing the image and etching, there is also an improvement in the possible etch speed and a reduction in the usage of etchant due to the same reduction in variation of copper thickness across the plated panel.

There are a few variations of the VCP process that allow the advantages to be applied to many different types of panels. For example:

- The machine can be formatted with a double track, which gives double the throughput from a similar process length
- The machine can be formatted for thin materials, which can be processed without having to use plating frames; materials as thin as 50 microns can be transported without external support
- Very long rigid and semi-rigid panels can be processed on a variant that has a completely linear transport system
- Many of the developments applied to conventional plating lines can still be used—such as pulse rectification—to improve copper distribution and deep through-hole capability further
- Insoluble anodes can be used that are zoned within the tank to improve flexibility for different panel lengths (e.g., switching off the bottom sections to match the panel length, which removes the requirement for bottom shielding)

There are, of course, some negatives for the VCP process. First, the size of the equipment can be a downside. There is no way to overcome the amount of time it takes to plate copper onto

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Figure 4: Vertical continuous plating (VCP).

the panel. For most users, the time it takes to plate an acceptable thickness of copper is 40-60 minutes. If you do the math, to achieve a process speed of half a meter per minute when the plating time is one hour, the continuous plating cell needs to be 30 meters long. This length does not include the pre-clean and rinse tanks that are required for the process. If you want to pattern plate, then the machine is longer still due to the additional process stages such as tin plate after the copper process. Some of the VCP machines made for Asia are more than 100 meters long, which is unlikely to suit smaller factories.

The copper cell in the VCP is usually split into a series of sections, each of which is controlled by an individual rectifier to produce the electroplating current. Often, these sections will be between two to five meters long, which adds a problem for small batch sizes. If you want to produce a single panel on the standard VCP line, then you will need to run dummy panels to fill the plating section of the line, so the rectifier current can stabilise before the production panel enters. You would also have to add the same dummy panels afterwards so enable the production panel to leave the plating section before the plating current can be switched off. This requirement for dummy panels each time there is a substantial change in process parameters is a major problem when applying the process to small batch manufacture. The machines are also relatively expensive when compared to traditional process lines.

Thus, on paper, the VCP process is not ideally suited to smaller factories manufacturing a few panels of each job, but further development of the process may change that. Plans to use small rectifiers applied to small sections of the copper tanks will greatly reduce the requirement for dummy panels to be applied between jobs requiring different process parameters (one of the larger stumbling blocks for this process).

If you have the flexibility to tailor your manufacturing method to suit the process, then it is a lot easier to apply the VCP process. I have been busy for a while working with a wonderful company in the northern part of

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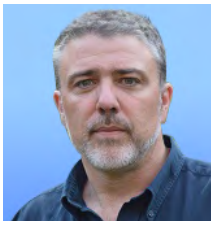
Figure 5: Robot loading.

New York that has installed an automated VCP line for their production using the panel-plate method. They manufacture all of their products on a single panel size, which means the batch size is much less relevant. The surface area for plating is basically the same each time, so the plating current does not need to be changed for different products to be run; this is ideal for the VCP process as there is no changeover loss between jobs. For them, the difference in the area due to variation in the numbers of through-holes is not enough to require a variation in the current. With robotic load and unload, they have a process that runs with very little operator intervention.

If you are considering updating your plating process, it would be wrong not to look at how you may be able to apply the VCP process to meet your production requirements. The potential improvements in capability are hard to ignore. If you need to plate exceptional products, then VCP may be the only way to achieve the result you need. **PCB007**



Marc Ladle is a director at Viking Test Ltd. To read past columns or contact Ladle, click here.

China Set to Impose Stricter Regulations on PCB Industry

China will implement a new set of strict regulations on the operations of the PCB industry on February 1, which may threaten the survival of small- to medium-size makers, according to sources from the related upstream supply chain.

In addition to having higher requirements concerning environmental matters, the new regulations will require makers to have technological patents for their products, to set aside at least 3% of their annual revenues for R&D, and to achieve annual utilization rates of over 50%.

The regulations impose specific requirements on different type of applications, but makers of PCBs for aerospace and military applications will not be affected by the new regulations.

The sources believe the China government is looking to strengthen the leading players' dominance in the industry as the new regulations will accelerate the elimination of small- to medium-size players that give priority to shipment volumes over technology development.

At the end of 2015, the China government implemented regulations to reduce metal pollutions caused by plating process, and since 2016, it has been tightening its control to protec the environment. Most of the top players have already installed facilities in compliance with the environmental regulations, but many smaller ones, unable to afford the high costs of such facilities, have quit.

Although over 50% of worldwide PCB manufacturing is conducted in China, only three of the global top-30 PCB makers were from China, according to research firm Prismark's figures for 2017.

Without government support, most China-based small- to medium-size PCB makers are likely to have difficulties continuing their operations, which is expected to accelerate the consolidation of China's PCB industry.

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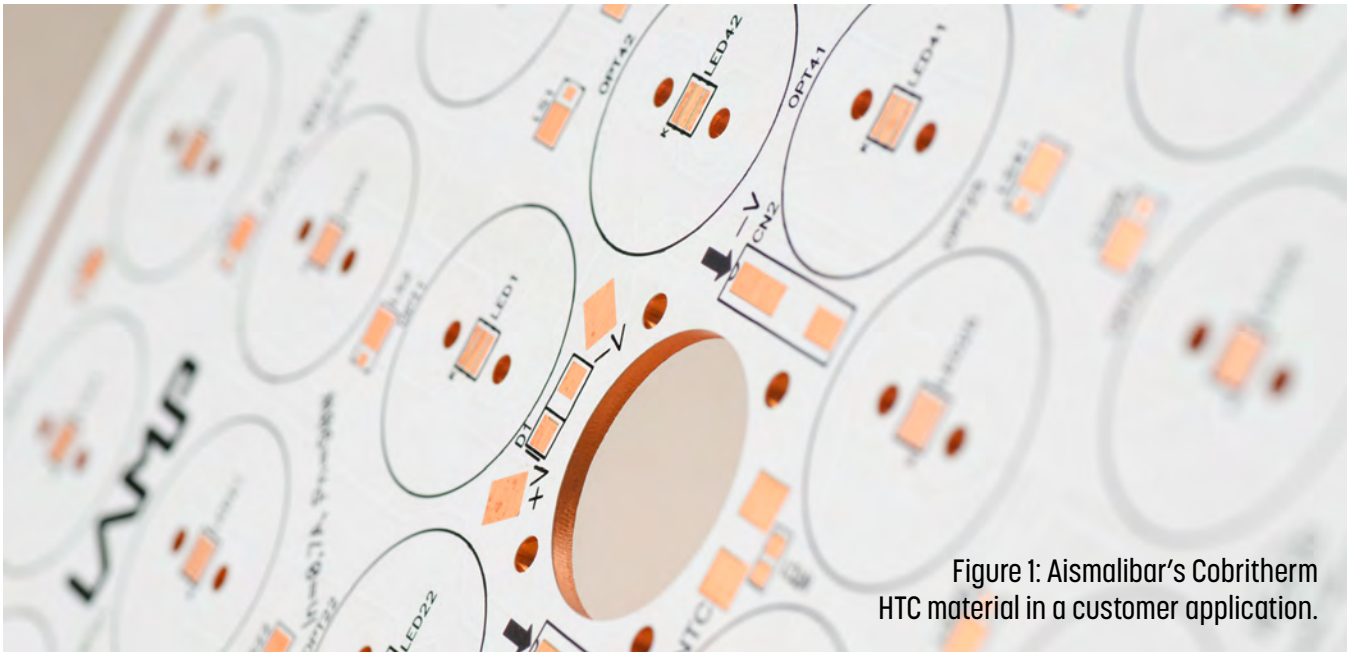


Figure 1: Aismalibar's Cobritherm HTC material in a customer application.

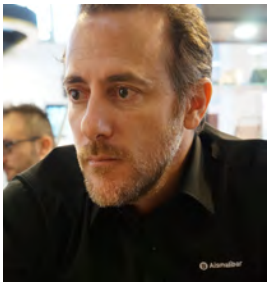
Aismalibar on Thermal Management Substrates and Automotive

Interview by Nolan Johnson
I-CONNECT007

Eduardo Benmayor, general manager, discusses Aismalibar's work on thermal management substrates, trends in the automotive industry worldwide and new product developments.

Nolan Johnson: Eduardo, would you be so kind as to start us out with a quick overview of Aismalibar, what you do, what products you deliver, and what markets you serve?

Eduardo Benmayor: Of course. Aismalibar is a very old company producing copper-clad laminates for the PCB industry for many, many years. It was one of the first companies established in approximately '36 in Europe, and started the production of copper-clad laminates in 1958 together with the starting of the PCB industry at that time. It was one of the first companies in Europe to produce copper-clad laminates in mass production for the European market.



Eduardo Benmayor

Since then, Aismalibar has developed different product ranges from XPC-FR2 at the beginning of the industry—a phenolic-based material. Then, we went to FR-4s, which were a more technical level. After, Aismalibar launched the CEM1 material. Aismalibar was very famous because of the CEM1 material; it was the first CEM1 lead-free to be launched in the industry, and still is one of the leading materials in the world. It's considered the best material for CEM1 substrates. Then, Aismalibar grew up and started to develop the CEM3 materials for plated through-holes. From there, we jumped into thermal management with aluminium substrates, which is one of our core businesses today.

Today, the Spain factory focuses on the very high-end materials dedicated to thermal management on PCBs. A release of temperature on the boards is very important, and it's a

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Figure 2: Aismalibar's Cobritherm Ultrathin material is well suited to automotive applications such as headlights.

main topic for designers—how to release the temperature from the components that get very hot. They need to cool them down to increase the speed or power that you can apply to the components.

Johnson: And it seems that you've had quite a bit of new product activity recently.

Benmayor: We have a lot of activity related to the automotive industry. Today, we are a big player for the automotive industries especially with headlights and LED applications, which require a lot of thermal release from the LEDs to apply higher power into the headlights, power models, and all of the electronics related to thermal dissipation.

Johnson: Eduardo, could you explain the challenges for thermal management in the headlight applications specifically, and how your products help address that?

Benmayor: Thermal release has been always a big topic in electronics, but it's getting more and more surreal right now because everybody tends to minimize electronics as much as they can and apply more power into the boards, and power means directly more temperature.

Releasing the temperature of the components will automatically benefit the functionalities on the board, and at the same time, extend the lifetime of the hole electronic module. The LED market today is growing worldwide, and due to the growth, many different electronic designs are being developed; a common factor in all of them is always thermal release. We need to release heat from the joint points of the LED to extend the lifetime. The lower the temperature of the LED, the longer the lifetime will be.

The question all engineering departments ask is, "How can I operate my LEDs on top of the board at a lower temperature to extend the lifetime? At the same time, if I am capable to cool them down, I can increase the power on the LED, and the light emission will be higher." That's the goal of all the LED and lighting industry today. Aismalibar tries to help on the development of thermal PCBs to benefit the designers and help them to release heat.

Johnson: How do you do that in your substrate products?

Benmayor: For these kinds of laminates, are we need to maintain two key principles. The first is to keep a high dielectric strength on a very thin layer, which is always a topic. Second, how do you fill the resins with mineral content to achieve the highest thermal conductivity without losing adhesion to the aluminum and copper? Today, we are producing substrates with 35-micron dielectric layers, and we guaranty a dielectric breakdown of 3.000 volts, which is really complicated. We also fill up the dielectric layer with 80% of mineral content, which adds an additional complexity.

Overall, the goals of today's technology are, "How do we make dielectric layers thinner, keep the electrical strength, and make it more thermally conductive?" The thicker the electrical layer, the better for the electrical strength, but it's worse for the thermal resistance. That's a challenge in the industry.

Johnson: There are a lot of constraints to balance.

Benmayor: It's driving completely opposite. If you want to achieve a higher electrical strength, you use thicker electrical materials typically, and if you want to have a lower thermal impedance, you need to make it the thinnest

possible. The challenge is how to make a very thin layer and keep the electrical strength from the functional copper to the heat sink whether it's made out of copper or aluminium.

Johnson: Specific to the application of headlights, do you see that being a challenge for automotive design and electronics in general?

Benmayor: Yes, it's a big challenge because everybody is trying to apply more power, but they have limitations. Don't forget that for the thermal stress of all the headlights, the automotive industry applies a big temperature on the whole set of the components, so they usually get the whole headlight and enter it into a chamber of 125°C, and the LED needs to operate inside that temperature.

So, it's not only the temperature generated by the LED component, but it's also the ambient where they test the whole set of the headlight. It's very challenging for them to dissipate as much temperature as they can to guarantee the output of the light coming out of the headlight. It's very challenging today.

Johnson: Those temperature extremes are commonplace throughout all of the automotive electronics as well, I would think.

Benmayor: Not only for the headlights. Now, there is a trend in the market going to the battery and the electric cars. Electric cars need power modules and battery chargers, which also generate a big amount of heat. Then, the heat needs to be dissipated from the charger to guarantee that the operation remains stable in the long term. Time power modules also require high current, which means thick copper on the circuitry. Releasing temperature on many parts of the electronics inside the car is a big issue today.

Johnson: And your recent product development is providing solutions for that?

Benmayor: We try to keep developing and figure out how to produce a thinner layer with lower thermal impedance. This is a never-ending development. We do this by doing a lot of R&D on the resin technology and mineral content to be capable of increasing the thermal conductivity of the layer and dissipating from one side of the copper layer—the functional copper layer—down to the heat sink.

Many aspects are influenced there, not only the thermal stress on the dielectric layer. You must also consider the maximum operational temperature (MOT) values and how long you can operate a substrate at a higher temperature without losing its initial properties. Don't forget that a dielectric layer is an organic layer, and because of this, higher temperatures over a long time will deteriorate its properties. So, MOT value is always a figure to pay attention to. Further, what are the coefficient of thermal expansion values (CTE) of the laminate? The minimum CTE, the better because on thermal boards, there is a big fluctuation on the temperature. An LED or power board can go from very low temperatures to high temperatures many times per day, and this affects the interconnects among others. CTE values are very important for high-end PCB producers and OEMs to keep the interconnects in between layers after temperature cycle testing.

Figure 3: An example design of an LED automotive headlamp using Aismalibar's Cobritherm Ultrathin HTC materials.

Johnson: That makes sense. Tell us a little bit about what Aismalibar is currently working on for new developments and products in that direction.

Figure 4: Material samples for Cobritherm from Aismalibar.

Benmayor: We have been working for more than one and a half years already trying to create a high-Tg material in the range of 180–190°C with a low CTE and 4 W/mk thermal conductivity layer. To achieve this goal, we had to put a lot of effort into our R&D with the epoxy resin technology in combination with the mineral filler type, particle size, and the combination of the reactivity in between them.

The particle type, size, and shape and how you disperse all the particles inside the resin is a very challenging thing to do because everything counts. If you don't use the right particle size and type, high thermal conductivity is very difficult to achieve.

Many aspects will drive you to the correct way to do the dielectric layer or to a level where you do not have any success or increase in the thermal conductivity. We have also been playing with nanoparticles inside the resin to reach better thermal conductivities. A lot of R&D is being made with the kinds and fillers to achieve these goals.

Johnson: Are nanoparticles paying off in R&D? Do they seem to have some potential for you?

Benmayor: There is very big potential with nanoparticles; the problem is the price. Nanoparticle technology is an incredible technology to use, but the price is a killing factor, you can achieve incredible goals, but customers may not be able to pay for the technology on mass production.

Johnson: It's very good technology, but not scalable to large volumes?

Benmayor: For the moment, nanoparticles are a reality, but they difficult to use in large scale due to the price. We are sure that this technology will develop and prices will be reduced, making the technology more accessible. Nanoparticles, with no doubt, will be a major player inside this thermal management technology.

Johnson: It seems like Aismalibar is going to have a whole series of different formulations with constraints that are in opposing directions that you're trying to achieve at the same time. There's going to be a need to change the recipe or dispersion to optimize toward one end or the other. Am I reading this right?

Benmayor: Perfectly. You have different segments in the electronics. Some customers need the thermal improvement on the boards, but they are not capable to pay the high-end products, and this is a huge volume today. For example, LED TVs are full of thermal laminates inside to release the heat of the LEDs, but these companies are not capable to pay a high-end product, so they are focused on mass volume and low cost. But there's a need for that in the market, and that market is still very big today.

On the opposite side, you have the high-end LED supplier for a stadium light or for a powertrain in vehicles, for example, and they are willing to and can pay for the high-end products if you offer them the right solution. Aismalibar is working today mainly on the high-end market to offer the best solution for the high-end market. This market is ready to pay a higher amount if you are capable to offer them a technical solution.

Johnson: And of course, products in the high-end market often find a way to get moved into the mainstream.

Benmayor: They always try to keep the technical goal at first. And once they are there, they start to see how they can reduce the cost. If they are capable to reduce the cost, they will make what they call a side evaluation of other products if the cost is reasonable for them.

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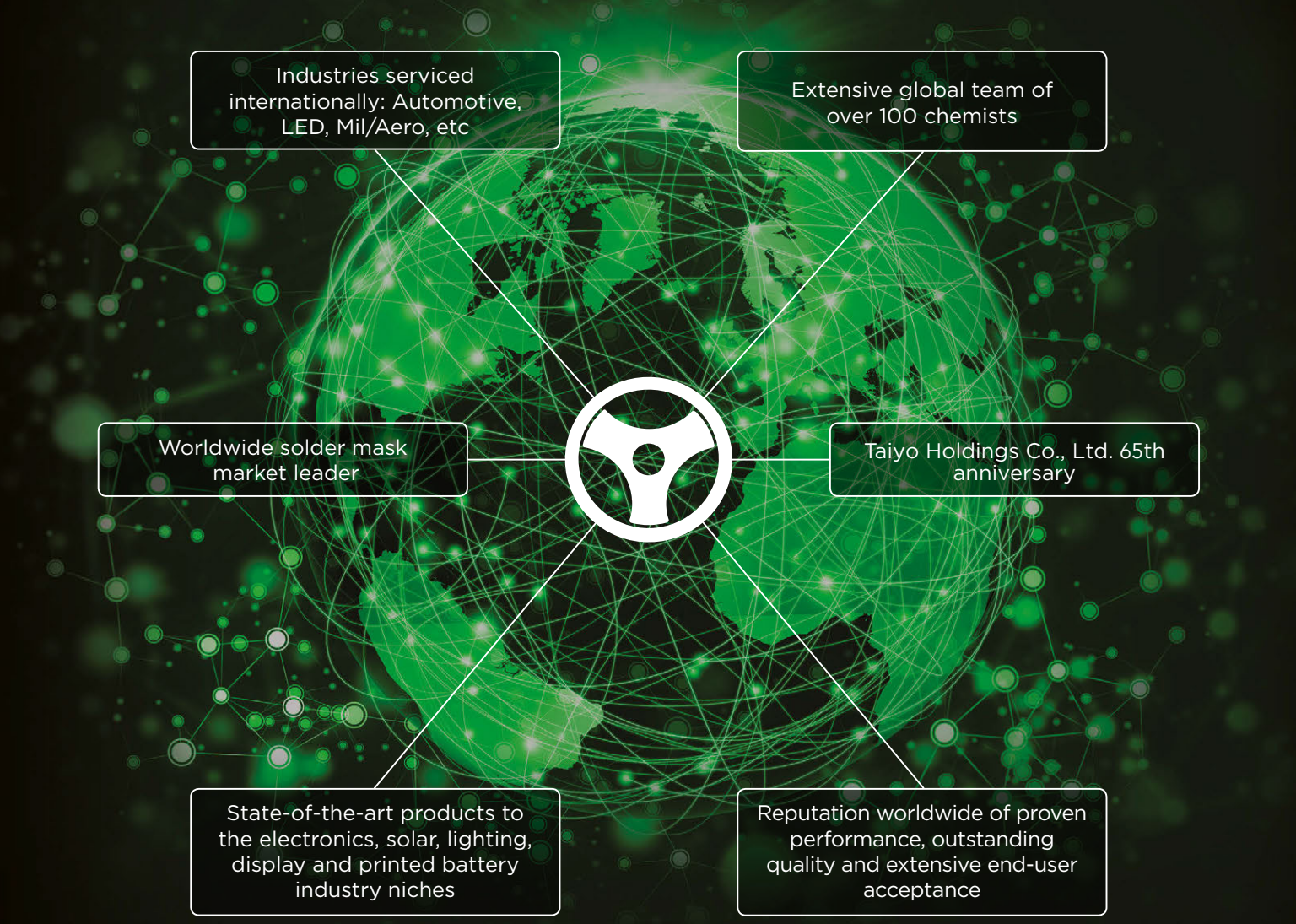

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Let's assume that they have developed a new headlight that requires a very big thermal conductivity, the price is prohibitive for them, so they can just evaluate in this platform. But if the price of that board goes down, maybe they are capable of saying, "I'm going to use the same technology for other kinds of lights that are also evaluated in other platforms." That's the normal mechanism in the automotive industry.

Johnson: And from there, it can also often spread out into consumer products?

Benmayor: Consumer products is a very low-end market today. They need this kind of thermal dissipation, but they are okay with the low-end market. We also have to understand that the LEDs are more and more efficient every day. So, the LED manufacturers are capable of generating more light output with a lower temperature on the LED. This also helps to use a lower laminate technology to dissipate the heat.

For example, when the LED business started eight to 10 years ago, the requirement to dissipate the heat on the joint point of a standard LED of one watt was very big. Now, it's something very common in the market because they have been capable of producing LEDs with the same light emission but with much lower power, which means half of the thermal stress on the board.

Everybody is working on how to generate more efficiency on the light with a lower amount of power. The lower amount of power means a lower temperature and less technical requirements on the PCB to dissipate the heat.

Figure 5: Aismalibar's Flextherm material in an end-user application.

Johnson: And that also allows for your high-end substrates to push the boundaries even further up into higher performance and brighter.

Benmayor: Yes, because that's the normal market. Opposite to this, there are always engineers that say, "I want more LEDs on the board. I placed three LEDs on a specific PCB, but now I want six LEDs in the same PCB area." Once again, LED manufacturers improve the technology and reduce the power needs for the same light output, but engineers want to increase the amount of light in the same area. The heat problem never ends. The high-end market is always pushing for better solutions to dissipate the heat of the LED model.

Johnson: Eduardo, as you mentioned at the start of this conversation, Aismalibar has been present in the European market for a long time and has been moving into the North American market since around 2012. How has the U.S. market been for you? How do the challenges in the North American market compare and contrast to the European market?

Benmayor: They are very similar. We see the requirements of Europe higher than the Americans because I think that the automotive industry is pickier in Europe than America. And they are more on the leading edge of automotive technology. Normally, the European automotive market is the leader of the world today in technology. But of course, America tries to follow, and there are many European platforms built in America. Thus, much of the technology has to transfer there to achieve the same goals that the designers are making in Europe. Typically, the markets are very similar. Apart from this, we have seen a big demand on copper base IMS in North America, and Aismalibar is doing great in this segment due to its FASTHERM technology.

Johnson: What do you see as the overarching challenges for your market right now?

Benmayor: There is the never-ending discussion of diesel cars versus gasoline cars and hybrids

versus electrics, which is generating a lot of trouble inside the industry. We're having a slowdown in the automotive industry in the last quarter, which is driven by the uncertainty of the direction of the automotive producers versus the environmental protection in each country.

Every country is taking a different approach to this. Sweden is saying that they will not allow more diesel cars there in 2020. Germany is taking another direction. Japan is taking the complete opposite direction to all the rest of the world. We have the big impact of the Volkswagen group a couple of years ago with all the issues that they had with the emissions around the world.

This problem of contamination and the environmental protection around the world is challenging the industry. Many people are focused on the electric car, but those vehicles are not ready today to be launched massively to the industry because the infrastructure how to charge the batteries is not set in large cities, so you cannot say that everybody will swap from a gasoline or diesel car into an electric car right away. It will take a lot of years to develop and build infrastructure in these cities. It's a complex situation in the automotive industry, so we will see what will happen in the next three to six months, but I don't think it will be easy.

Johnson: It's surprising to think about being able to look three or six months out and see changes in the automotive industry; that's not normally the kind of industry that moves quickly, and yet, it seems to be doing exactly that. Even Volkswagen recently announced that they would stop producing gasoline engine cars.

Benmayor: Yes, we are hearing a lot of rumors in the industry about what they are going to do on that. Many rumors come from the political scene that they are going to increase diesel price, and other cities or countries say that they will not allow diesel inside the cities, etc. It looks like the new motors for the diesel cars are not fulfilling the regulation of the emissions, so they cannot launch any of these new platforms. However, nobody really knows what's going to happen. There is a huge amount of stock that is not being sold, so if you are an end user and need to buy a car today, nobody knows what you should buy, which stops the sales of cars around the world. Everything is a big mess today.

Johnson: And that just trickles down through the BOM to Aismalibar and substrates. That kind of uncertainty and R&D goes into the different automotive manufacturers to try to answer that question, come up with a solution, and keep selling products. I'm sure you're very involved in a lot of conversations at that level.

Benmayor: Technology is always walking on one path, and the market is walking on another. Engineering departments will continue to develop and improve technology. In parallel, you will have political issues, sales, volumes, and mass production in big factories. What are they going to do in the next couple of months? The uncertainty cannot last forever, and somebody will need to make a decision. We are talking about the biggest industry in Europe; it's not a small player in the game—it's a huge player in the game not only in terms of the car manufacturers but also the infrastructure surrounding the automotive industries (tier one, two, and three). It's a huge industry for the European economy, so the government will need to let us know what we should do to fulfill our regulations.

Johnson: Eduardo, is there anything that I have neglected to ask that you want to make sure we talk about?

Benmayor: I think we've covered a lot, but I'd also like to cover the new materials that we are launching right now.

Johnson: Let's talk about those!

Benmayor: We are working with producers of electronics that have nothing to do with the LEDs. Based on the thermal dissipation, they can be used on many other boards such as in computer microprocessors that work at high

Figure 6: Fastherm CuCu material from Aismalibar.

speed and generate a lot of heat. Companies want to increase the speed of the microprocessor clock, which generates a high temperature. These kinds of companies use multilayer boards and want low CTE, high Tg, and high thermal conductivity. Aismalibar has developed a new product range for producing thermal double-side and multilayer boards achieving excellent properties in the three key points.

The idea is to replace traditional FR-4 for our COBRITHERM materials(3.2 W/mk, 180 Tg) to achieve a better performance of a board. That's also challenging today in the market, and there's a big discussion of how we can increase the speed of the clocks of the microprocessors to have the higher output of the processor without heating up the microprocessor too much. Once again, a lower temperate will allow the board to run on a high clock speed. We are working a lot on this end also.

Johnson: I'm thinking through what you just said and what that means in the PC manufacturing environment. That is a big deal.

Benmayor: For example, all of the computing needed for mining technology related to the cryptocurrencies. There is a lot of calculation to be done there. We are working with a couple of the big players around the world today. By using Aismalibar COBRITHERM laminates on graphic cards or miners, they can decrease the temperature on the joint points 15–18%. This means large savings on external heat sinks as well as a 15–20% increase of the speed of the board can be achieved because they are capable to increase the clock speed. More clock speed means more calculation and output of the same board.

Johnson: So, there are plenty of places for your substrates to be put to use, obviously—not just automotive, but automotive certainly does seem to be the point on your spear.

Benmayor: That's right.

Johnson: Aismalibar recently announced two products under the COBRITHERM brand, an ultra-thin 3.2-W/mk laminate. Do you have further products that should be coming on shortly that your customers should look for?

Benmayor: First, we are launching in early January. We are already in production for the thin laminate for producing multilayers, which is based on the 3.2-watt material with a very low CTE value and high Tg mainly required in the boards going to be dedicated to the calculation for microprocessing boards, mosfet. Those companies normally need boards of eight to 10 layers with a lot of microprocessors on top of the board and the operation temperature of around 100–120°C, which is very high for a PCB. The goal is to release as much temperature there and keep the microprocessor as cool as possible to guarantee the long life of the board.

Johnson: Aismalibar is clearly stepping up to the task of doing thermal management in some very difficult spaces. I look forward to talking to you in the future as more products come out.

Benmayor: That will be nice. It takes time to produce a new product, and it's more challenging every year. We are in the requirements to do more high-tech products, so it takes longer from the time we achieve the technical goal until we can have something real and scalable in our hands. It requires more and more effort to increase the technology of the materials.

Johnson: Thank you for your time today, Eduardo.

Benmayor: Thank you. I hope to see you soon.

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MilAero007 Highlights

Standard of Excellence: Preparing Your Vendors for the Future ▶

Now, it's time to talk about the future with your PCB vendors. Referring to our previous columns, if you've done everything right so far, you will now have a strong working relationship with your PCB supplier. They understand all they need to know to fabricate perfect boards for you at this time. With trust and respect between you, you've truly formed a strong partnership going into the future.

Ventec's Marketing Strategy and Their Newly Appointed Technology Ambassador ▶

At electronica 2018, Mark Goodwin, chief operating officer at Ventec International Group, discusses the company's marketing strategy along with their newly appointed technology ambassador, Alun Morgan, and how he sees the world.

Artificial Intelligence Meets Materials Science ▶

A Texas A&M University College of Engineering research team is harnessing the power of machine learning, data science and the domain knowledge of experts to autonomously discover new materials.

NATO Members Drive Fastest Increase in Global Defense Spending for a Decade ▶

Global defense expenditure grew 4.9% in 2018, the fastest growth rate since 2008, according to the annual Jane's Defense Budget report, released today by business information provider IHS Markit.

Defense Speak Interpreted: PERM–Pb-free Electronics Risk Management ▶

In this column, we explore PERM—the Pb-free Electronics Risk Management Consortium. No, the group members do not all have curly hair! The name was chosen around 2008 by a group of engineers from aerospace, defense, and harsh environment (ADHE) organizations.

Sales of Military Antennas to Reach $1 Billion in 2018 ▶

The report forecasts a steady decadal growth rate of 4.9% for the military antennas market, with revenue slated to reach $986.8 million by the end of 2018.

Drones Can Now Flap Wings, Ride Wind Currents Like Birds ▶

The next generation of unmanned drones will act more like birds than machines, thanks to new research.

First Lockheed Martin-built Next-generation GPS III Satellite Responding to Commands ▶

A major milestone in the U.S. Air Force's plan to bring new technology and capabilities to the GPS constellation, the first Lockheed Martin-built GPS III satellite began "talking" with engineers and operators from ground control, as planned, following its successful launch this morning.

Marsquake Sensor Lands Safely on Red Planet ▶

A Marsquake detector designed in part by Imperial engineers is set to help reveal Mars' inner structure.

NASA Looks to the Future, Seeks Next Level Visionary Aerospace Concepts ▶

NASA is looking for trailblazing ideas that could one day change what's possible in space. The NASA Innovative Advanced Concepts (NIAC) program is seeking Phase II proposals for the continuation of Phase I research studies.

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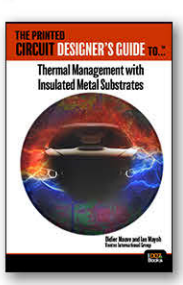

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Chemical Recycling as Part of a Zero-effluent Strategy

Article by Happy Holden
I-CONNECT007

Green manufacturing methodologies for PCBs are becoming a global shift. Green efforts have been underway in the European Union for quite some time. Likewise, in the United States, new PCB manufacturers are building zero-waste, zero-effluent facilities and gaining certification as such. Furthermore, in China, government mandates are transforming the amount of pollutants tolerated from PCB manufacturing down to nearly zero or face forced relocation from populated areas.

In this article, I will examine some of the key areas of improvement in chemical recycling that you should consider as you move your fabrication facility toward green and zero-effluent manufacturing. For the scope of this article, I will use GreenSource Fabrication's New Hampshire facility as our primary example.

New Example of Green for Printed Circuit Fabrication

To build a new PCB manufacturing facility in New Hampshire, GreenSource had to guarantee the government that they would be zero-effluent. While engineering the concepts of no effluents and being mindful of Six Sigma and Lean principles, the process is fully automated with minimal process delays and no handling by employees, thus being an excellent example of Lean PLUS green! The two go hand-in-hand.

The new facility does not require waste permits because there were no water emissions. Water is recycled, as are many of the chemicals, reducing costs. The totally automated process requires only seven technicians to monitor the machinery and a total of 17 staff people for the entire multilayer facility. As seen in Figure 1, the bulk of the PCB processing is conducted in numerous automated machines connected by conveyors or AGVs.

Figure 1: The main high-volume PCB processes are automated on several conveyorized systems from the materials warehouse (an automated storage and retrieval system, or AS/RS) through final solder mask and fabrication.

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The process flow for Lean manufacturing, automation, and CAD and CAM has cut the processing time for multilayers down to just two days from the typical three to four weeks. It has also cut the lot size to just one panel, down from the typical high-volume lot size of 200 to 1,000 panels. This gives GreenSource the flexibility to do prototype runs mixed with very high-volume production runs even when the product mix may include multilayer, HDI, two-sided, and metal-backed thermal boards. Different final finishes do not affect throughput or turnaround time.

The CAD and CAM automation utilize direct imaging in several new innovative processes such as direct digital imaging (DDI) of pattern- or panel-plating resist and etch resist, as well as inkjet printing of solder mask and legends. For fine-line and high-density circuits, digital-direct-exposure is used, which eliminates all artwork, inspection, handling, and storage.

Lower Costs by Eliminating Waste

Lean does not need to be limited to manufacturing alone. Lean is a principle that can apply to all our goods and services. The green strategy has six major systems:

1. Water use minimization in processes by innovative rinsing
2. Processes that accept volume make-up from capture rinses
3. Hermetically sealed equipment to eliminate venting
4. Venting processes locally with recycled DI water
5. Continuous chemical analysis and dosing to minimize concentrations and maximize controls
6. Chemical regeneration with make-up from rinse water concentrations

Table 1 details only part of fifteen innovations that contribute to the waste and water

Waste Reduction Actions	Impact
Reduce lot size to increase flexibility & lower inventory	Utilized single-spindle autoloaded drill/routers for lots of one panel
Auto-optical pinless layup for lamination	Eliminate pins, depinning, & caul-plate cleaning; reduces labor
Direct digital imaging	Eliminate precleans, developer, tin-plate cleaner, microetch, predip, & strip chemicals
Eliminate cleaners, microetches, predips, & antitarnishes	Decreased wastewater system & chemical costs
Inkjet for legends	Eliminate screening or photo processes
LDI for solder mask	No artwork required; increased registration
Closed-loop resist-strip process	>$20,000 in annual savings from chemical usage & treatment
Horizontal copper pulse plating with insoluble anodes	Huge waste reduction & improved thickness tolerancing; controlling roughness allowed elimination of microetching for adhesion
Rotary oxygen-plasma etch	Eliminate need for chemical desmear with solvents, permanganate, or plasma with toxic gases
Closed-loop copper-recovery system	Eliminate chemical costs for etching & yielded a positive cash flow from recovered 99.99% pure copper; stabilized etch rate to ±2%, eliminated venting of ammonia to scrubber & recovering etch-rinse dragout back to etcher
Convert all first rinses to static dragouts & increase the flow rate of cascade rinses to compensate for less cascade	Decrease IX regeneration by 70% while increasing concentrate waste dumps by 25%; net reduction in total concentrate waste volume by 30%
Increase temperatures of process baths if possible & replenish evaporated loss from dragouts	Decreased concentrate waste volume by 25%
Regenerate multilayer desmear & rinse waters	Implement permanganate regeneration
Zero liquid discharge (ZLD) waste treatment	Eliminate permits & save water
Eliminate fume scrubbing & vapor emissions	Hermetically sealed tanks with negative pressure & packed columns on ducts
Reduce the number & amount of chemicals used in processes; eliminate chemical handling & any safety issues	Monitor & replenish chemicals continuously; use reservoirs as shipped from vendors

Table 1: Fifteen specific cost reduction actions (Lean) and their impact (green).

minimization and quality focus of the automation.

Water Use Minimization

Figure 2 shows a system diagram of the waste and water recycling system. With water evaporation, the GreenSource facility has to use about 500 gallons of water per day, but the only waste is a pH neutral, environmentally safe dry cake of 60–80% solids for the sanitary landfill.

Processes That Accept Volume Make-up From Capture Rinses

The majority of processes at GreenSource are either Atotech or non-proprietary. These have been carefully formulated to have their volume make-up from dragout or evaporation supplied by the first captive rinse of a chemical process. In addition, significant improve-ment in dragout and solution carry-over from the panels traveling through the conveyors have been implemented. The improvement in machine design has permitted a facility expansion of this size while also requiring less water to be recycled than the original plant in 2016.

Hermetically Sealed Equipment to Eliminate Venting

The new generation of equipment is also engineered to be hermetically sealed, minimizing the need for ventilation and preventing any outside contamination of the PCB panels. New squeegee rollers and splash guards have been designed to prevent any dragout and puddling on the panels as they travel through the machines. There are strategically placed audit stations that the technicians can access the panels in case of a need, but normally, the conveyors are sealed and in their own microclimate.

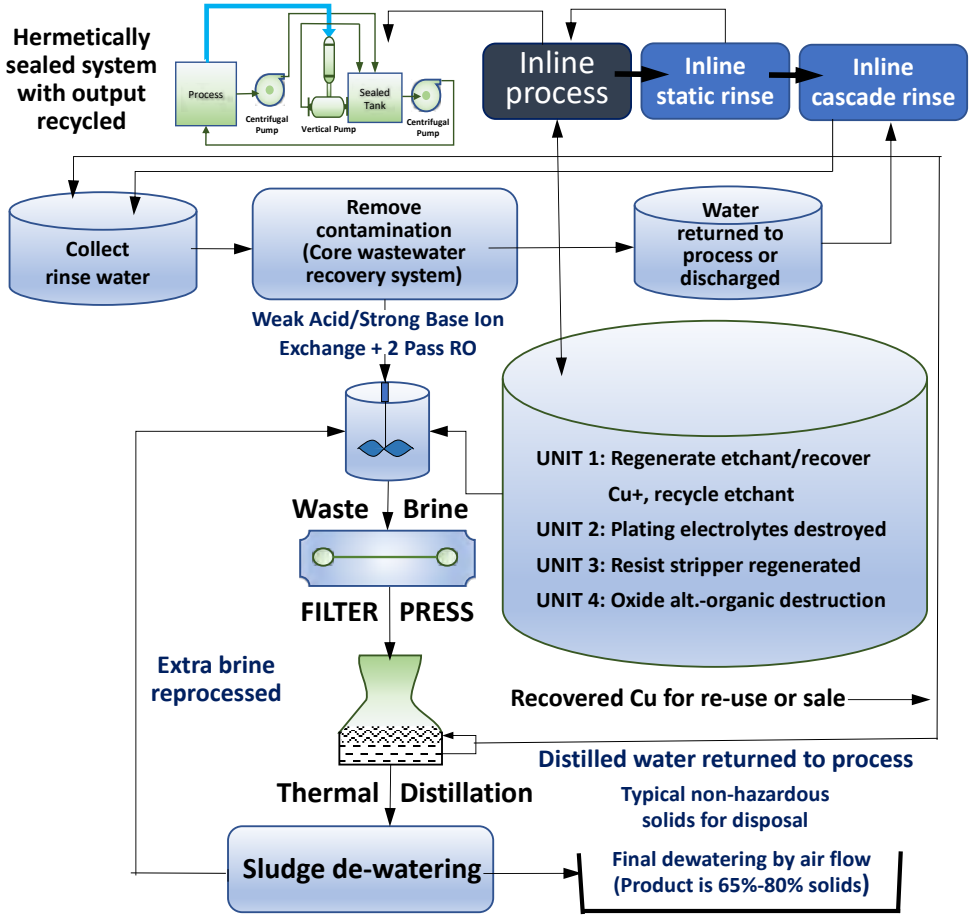


Figure 2: Recovery and regeneration of chemicals for processes along with total recycle of water including hermetically sealed ventilation systems that provide for a rapid ROI. (Source: Stepinski Innovations LLC [3])

Venting Processes Locally with Recycled DI Water

As seen in Figure 1, there is minimal venting, as much is recovered at the machine itself, but the minimal venting is handled locally by a scrubber and the deionized (DI) water is recycled with the other rinse waters (Figure 2).

Continuous Chemical Analysis and Dosing

The continuous analysis and dosing allow the facility to minimize concentrations and maximize process controls for higher quality, fewer costs, and lower dragouts. This is a major contributor to the Lean and green strategy (Figure 3).

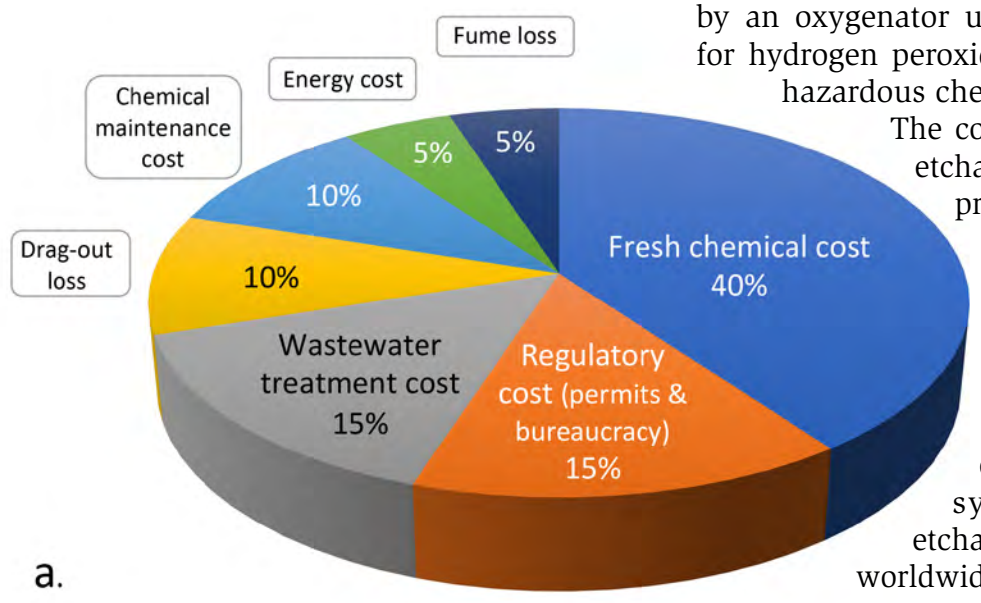
Chemical Regeneration

Chemical regeneration with make-up from rinse water concentrations also contributes to the zero-effluent strategy as well as lowering chemical costs and maximizing process controls. There are seven major systems (Table 2). Some of these systems are shown in Figures 3 and 4 as well.

Cupric Chloride Copper Etching

The cupric chloride etchant is utilized for the majority of inner layer, panel copper, and final outer layer etching. This cupric is analyzed and regenerated to provide a much more consistent etch rate than normal cupric chloride. It is regenerated with oxygen and hydrochloric acid by an oxygenator unit, eliminating the need for hydrogen peroxide, chlorine gas, or other hazardous chemicals (Figure 5).

The copper is removed from the etchant and rinse water by a proven industrial technique called liquid-liquid extraction first developed at Hewlett-Packard for PCB alkaline etchants back in 1974. Over the last 35 years, over 200 of this type of recovery system (100 for PCB etchants) have been installed worldwide [2]. It is very common



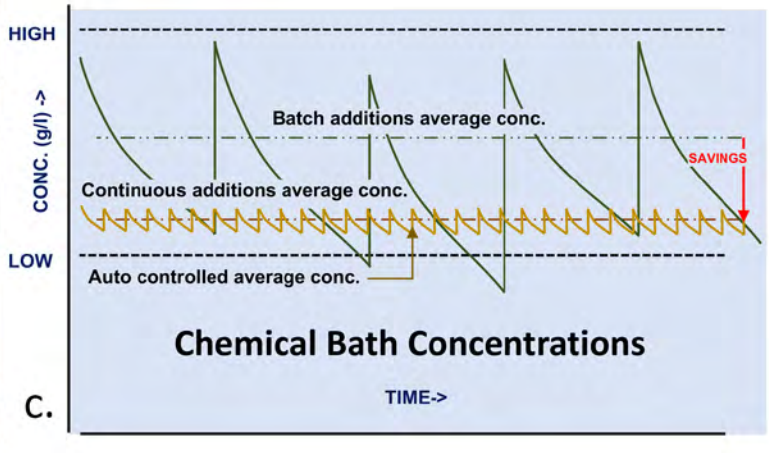


Figure 3: (a) Fresh chemicals represent only 40% of the total chemical systems costs; (b) automatic chemical dosing stations for processes; and (c) continuous monitoring and dosing allow the lowest level of operating chemical concentrations. (Source: Stepinski innovations LLC [3])

Process Bath	Recovery Method	Recovered Product	Capital ROI
Cupric etchant	Oxidation/galvanic copper	Fresh etchant & copper metal	6–14 months
Permanganate etch	Galvanic cell	Fresh etchant	6–12 months
Acid etchants	Oxidation/galvanic copper	Fresh etchant & copper metal	6–14 months
Plating electrolytes	Organic destruction	Electrolyte minus organic	2–3 months
Microetches	Galvanic cell	Fresh microetch & copper metal	4–6 months
Oxide alternatives	Organic destruction	Fresh chemical minus organic	2–3 months
Resist strippers	Membrane	Fresh stripper & contaminated brine	2–3 months

Table 2: Methods of chemical recovery to regenerate chemicals, minimize waste treatment and the ROI for such systems [1].

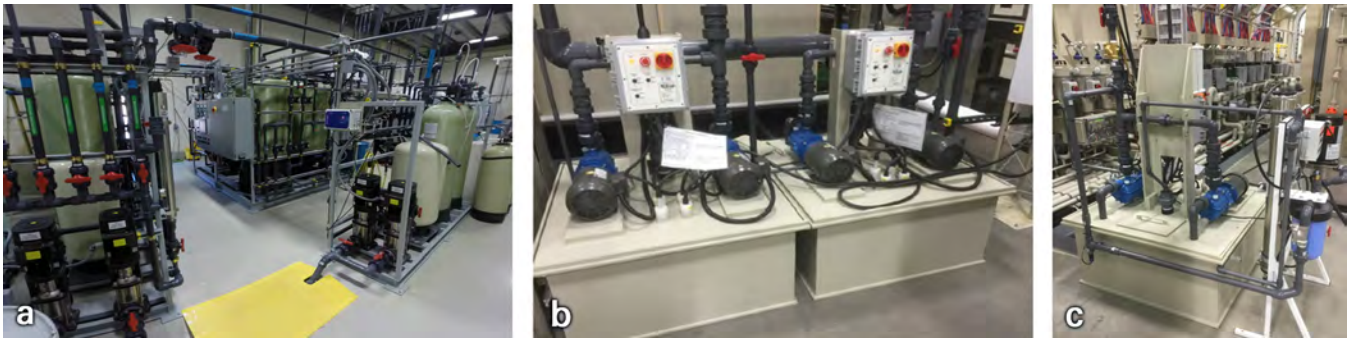


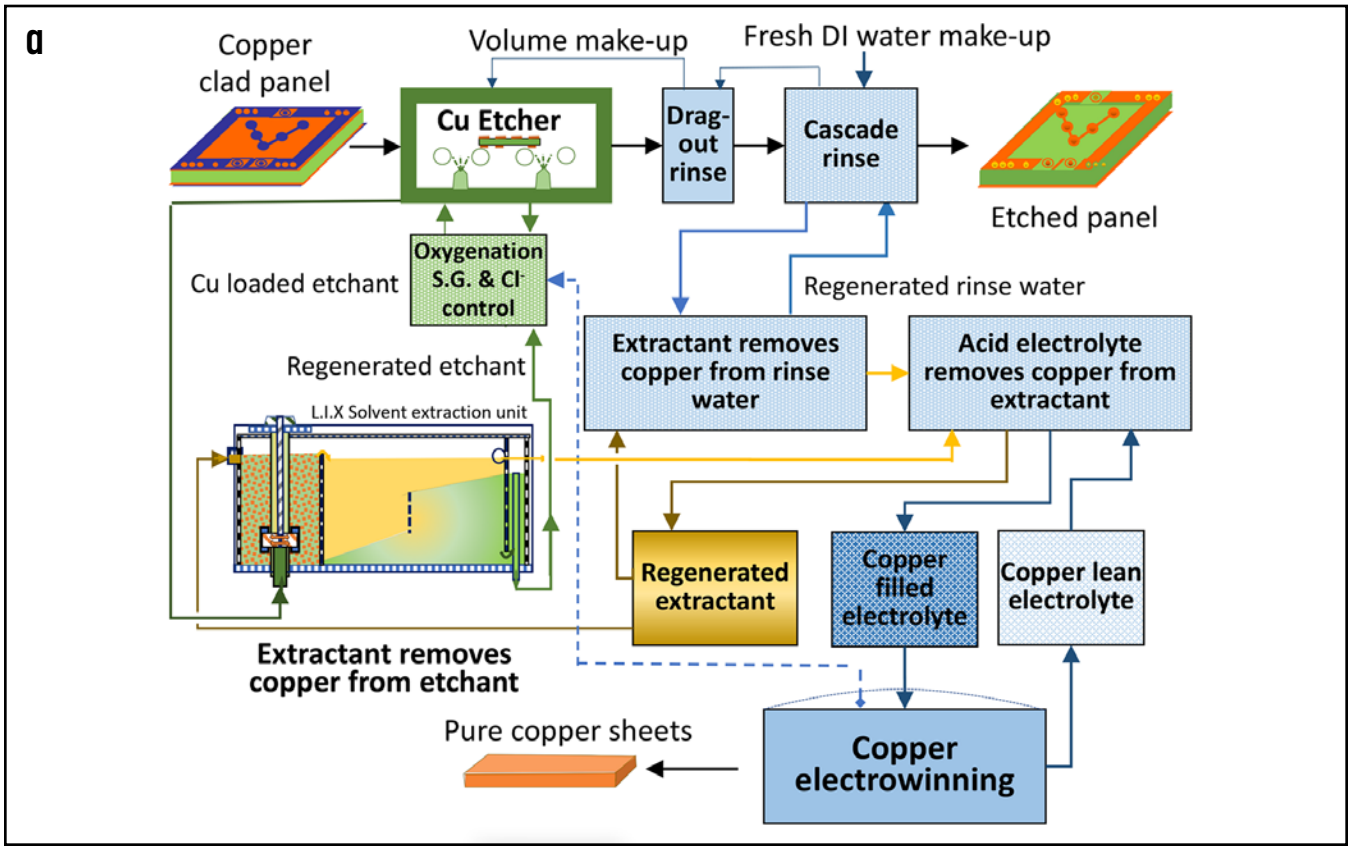
Figure 4: Key recovery systems of (a) ion exchange, (b) crystallization, (c) and reverse osmosis; evaporation, cupric chloride recovery, and peroxide copper-etch electrowinning are not shown. (Source: Stepinski innovations LLC [3])

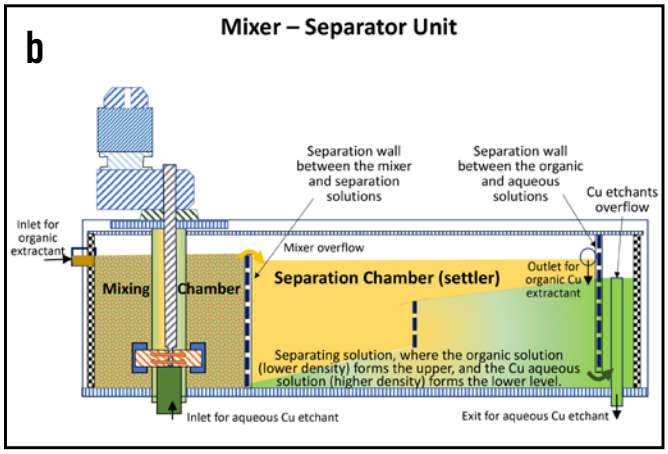
Figure 5: Cupric chloride etch control with oxygenation.

in copper, cobalt, nickel, zinc, and uranium recovery and purification.

There are many extractants for this type of liquid- ion exchange, but common for copper etchants is either alkaline or acid types are LIX64N and LIX54N made by General Mills extracted from wheat. This is a β-diketone or (7-ethyl-undeca-2, 4-dione) and is mixed with kerosene as the carrier and are the organic phases while the copper etchant or copper-bearing rinse waters are the aqueous phases. Figure 6a shows a flow diagram of the recovery and regeneration process for the etchant and its rinse waters.

Figure 6b is a diagram of a mixer-separator unit that shows the mixing and separating chamber where the organic phase is less dense and floats on the aqueous phase to extract the copper into the organic phase. Next, another mixer-separator unit can strip the copper into





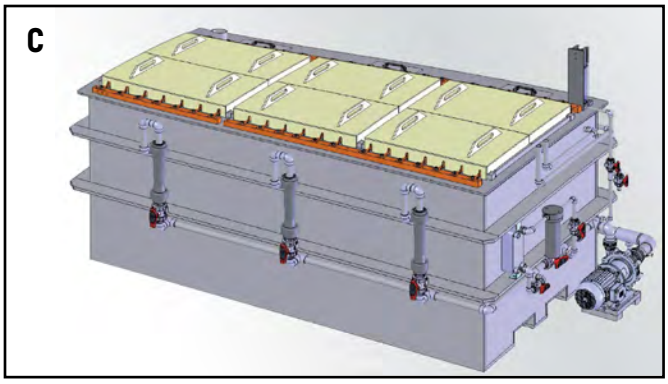


Figure 6: Etching systems including (a) etchage and water regeneration diagram, (b) extractant mixer-separator, (c) copper electrowinning illustration, (d) copper extractor, and (e) electrowinning unit. (Source: Sigma Engineering [4])

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CATEGORY	SAVINGS
Annual Savings from Elimination of Chemical & Waste Treatment	$243,050
Annual Savings from Reclaim of Copper for Resale	$371,000
ANNUAL TOTAL	$614,050

Process Step	Liters/day of waste	Annual Cost of Chemicals & Waste Treat Savings
Pre-clean	120	$14,300
Pre-clean Rinse	3,600	$4,100
Developer	310	$12,100
Developer Rinse	3,600	$3,500
Etcher	1,440	$182,400
Etcher Rinse	3,600	$4,900
Stripper	240	$17,700
Stripper Rinse	3,600	$4,050
TOTAL	**16,510**	**$243,050**

Table 3: Waste savings by not treating eight different types of PCB fabrication waste streams. (Source: Alex Stepinski [2])

an aqueous phase using sulfuric acid to form copper sulfate (Figure 6c). The electrolyte has the copper plated out as metal in the electrowinning unit (Figures 6d and 6e).

The annual savings by eliminating chemical and wastewater treatment for a facility of the size of GreenSource is estimated to be over $243,050 per year. The annual cost savings is illustrated in Table 3 along with the savings from the reclaiming of copper from etchants, which is estimated to be $371,000 based on the current cost of pure copper scrap. The copper is so pure (99.99%) that it also can be used in all the copper electroplating processes. No solid copper is used as anodes.

Summary

The example of GreenSource Fabrication LLC shows how Lean principles can go together with green principles. Fifteen new innovations in PCB manufacturing provide this advantage. The results are a zero-effluent facility with no need for recruiting direct labor, lower costs (one-third to one-half the cost from China), decreased lead times (from four weeks to two days), prototype flexibility on high-volume product lines, and improved quality with no final inspection needed because humans do not touch panels. This all occurs while utilizing the maximum technology design rules. **PCB007**

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Happy Holden has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa/Westwood, Merix, Foxconn and Gentex. He is currently a contributing technical editor with I-Connect007. To read past columns or to contact Holden, click here.

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Alun Morgan, EIPC President

Given that the PCB industry nowadays is what might be called a "close-knit community" in which everyone knows everyone else, and hears all the local news and gossip, it is always good to know that EIPC has organised another family "get-together". This year we have arranged for this to take place in the romantic Italian retail resort city, Milan–on Valentine's Day!

Program highlights include presentations and panel discussions on a wide variety of subjects. On the afternoon of Day 1 we have arranged for transportation to tour the Elga Europe Factory followed by a networking dinner at the Milan Centre.

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Electronics Industry News and Market Highlights

Test and Measurement Equipment Market Worth $32.3 Billion by 2024 ▶

The overall test and measurement equipment market is expected to grow from $25.7 billion in 2018 to $32.3 billion by 2024, at a CAGR of 3.90% during the forecast period.

Artificial Intelligence Meets Materials Science ▶

A Texas A&M University College of Engineering research team is harnessing the power of machine learning, data science and the domain knowledge of experts to autonomously discover new materials.

Panasonic Utilizes 100% Renewable Energy to Power the Consumer Electronics Recycling Plant ▶

Not only has Panasonic Group's consumer electronics recycling plant, Panasonic Eco Technology Center Co., Ltd. (PETEC) made efforts over the years to reduce the energy consumed, it has also implemented solutions to create energy and to procure electricity created by renewable energy.

European Spending on Digital Transformation to Reach $256 Billion in 2018 ▶

DX spending is expected to steadily expand throughout the 2017–2022 forecast period, achieving a five-year compound annual growth rate (CAGR) of 15.1%.

USMCA Will Strengthen Global Semiconductor Supply Chain ▶

The USMCA, if successfully ratified, will be the first U.S. trade agreement to incorporate many new and higher standard trade disciplines that will strengthen the digital economy and the global semiconductor supply chain.

India Smart Wearables Market Finishes Strong with 102,000 Shipment Units in 2018 Q3 ▶

The overall India wearables market saw a 17% year-over-year (YoY) growth in the third quarter of the year as vendors shipped a total of 897,000 units in the country.

Stronger Public Private Partnership Required to Drive Industry 4.0 in Malaysia ▶

The recent budget focused on the Industry 4.0 blueprint, titled "Industry4WRD," which aims to make Malaysia the prime destination for high-tech industries in the region.

Worldwide Semiconductor Equipment Billings Drop to $15.8 Billion in 3Q18 ▶

SEMI reported that third quarter 2018 worldwide semiconductor manufacturing equipment billings dropped 5% from the previous quarter to $15.8 billion but are 11% higher than the same quarter a year ago.

Southeast Asia Electronics Supply Chain Set Sights Towards Smart Manufacturing ▶

Southeast Asia is a region that is fast developing. It has evolved from an agricultural society to one of the fastest growing regions in the world within the span of a century.

Semiconductor Equipment Sales to Reach Record Growth of 9.7% to $62B in 2018 ▶

Worldwide sales of new semiconductor manufacturing equipment are projected to increase 9.7% to $62.1 billion in 2018, exceeding the historic high of $56.6 billion set last year. The equipment market is expected to contract 4.0% in 2019 but grow 20.7% to reach $71.9 billion, an all-time high.

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The Fourth Pillar of Defense Acquisition: Cybersecurity

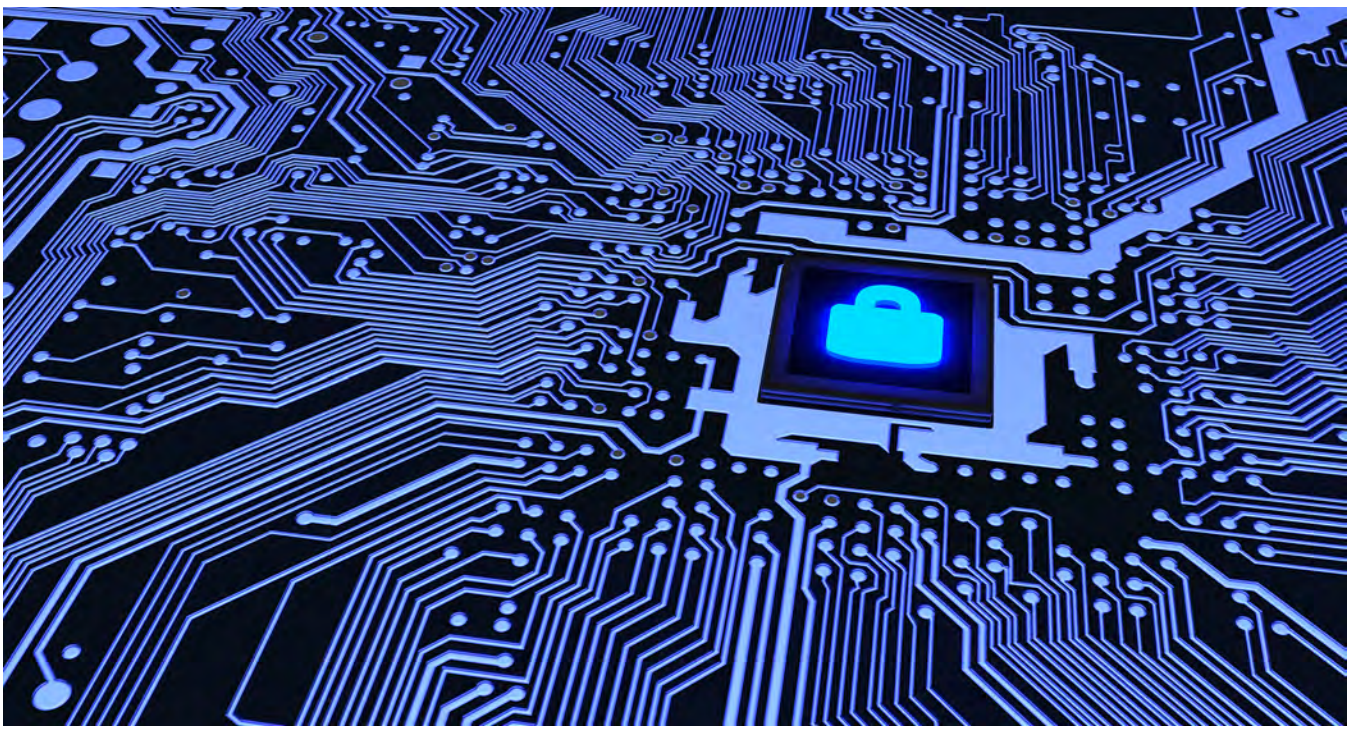
Mil/Aero Markets
Feature Column by John Vaughan, ZENTECH

If you are a provider of PCBs and/or electronics manufacturing services to the Department of Defense (DoD) and their prime contractors, you have no doubt noticed a significant increase in the number of Defense Federal Acquisition Regulation Supplement (DFARS) flow-downs, scrutiny of your data management, audits of your cybersecurity processes, and inquiries into the status of your compliance with a variety of cybersecurity initiatives.

There has been a constant flow of reports and initiatives over the past two years that point directly to increased emphasis on cybersecurity by the DoD within the Defense Industrial Base Supply Chain. These reports all coalesce around further strengthening critical cybersecurity programs and initiatives within the DoD and provide the roadmap to compliance and elevating your organization to position for continued participation in the defense sectors of our industry.

We have clearly entered a paradigm shift, with cybersecurity now joining cost, schedule, and performance as the Fourth Pillar of Defense Acquisition.

Referencing the DoD "Deliver Uncompromised" pilot program mandated by the National Defense Appropriations Act (NDAA) and the associated MITRE Corporation study from August 2018 [1], the first course of action (COA) detailed is to elevate security as a primary



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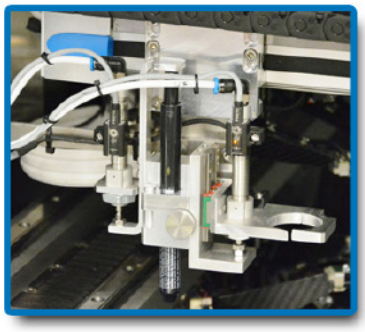

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metric in the DoD acquisition and sustainment process. The report states:

- It is vital to "Deliver Uncompromised" that security have equal status to cost, schedule, and performance
- The revision of DoD 5000.02 (Operation of the Defense Acquisition System) to make security the "Fourth Pillar" of acquisition planning—equal in emphasis to cost, schedule, and performance
- Utilize acquisition tools and contract leverage and reinforce the objective of "Deliver Uncompromised" through the use of positive and negative incentives

Encouragingly, there is also language in the report that recognizes there are hard costs associated with the DoD supply chain implementing the requisite cybersecurity measures, and several tax incentive measures are detailed for consideration, further analysis, and discussion to offset the costs.

The key takeaway is that all PCB fabricators and electronics manufacturing service providers providing electronics products to the defense sector need to immediately heighten awareness and proactively address cybersecurity if they desire to continue supporting the DoD and their prime contractors.

In terms of the actual gates in the evaluation process that all proffers to the DoD will soon be subjected to a "go, no-go" initial bid analysis that evaluates cybersecurity hardening as the first gate to pass through for offers to be considered before the long-standing DoD contracts analysis process evaluating quality, cost, schedule appears most logical to me.

In September 2018, the "Report to President Donald J. Trump by the Interagency Task Force in Fulfillment of Executive Order 13806" was released. Titled "Assessing and Strengthening the Manufacturing and Defense Industrial Base and Supply Chain Resiliency of the United States," it is an in-depth and fascinating look at the defense industrial base including PCBs and circuit card assemblies for DoD systems [2].

In Section VI of the report, "Ten Risk Archetypes Threatening America's Manufacturing and Industrial Base," we find more compelling direction and comment that underscores the threat that cyber-related crime poses to our national security.

Quoting the report, "The defense manufacturing supply chain flows goods and critical supporting information through multiple organizations of varying size and sophistication to transform raw materials into components, subassemblies, and ultimately, finished products and systems that meet DoD performance specifications and requirements. These supply chains rely upon an infinite number of touch points where digital and physical information flows through multiple networks both within and across manufacturers systems. In today's digitized world, every one of these supply chain touch points represents a potential product security risk."

In today's digitized world, every one of these supply chain touch points represents a potential product security risk.

In addition to data breaches, it is also noteworthy to point out that The Department of Homeland Security (DHS) reported that the critical manufacturing sector reported the highest number of cyber attacks on industrial control systems of any critical infrastructure sector with numerous threats emerging that had the potential to cause major disruption in manufacturing operations.

With the publication of the 2018 National Defense Strategy [3], U.S. Secretary of Defense General Jim Mattis stated, "Challenges to the U.S. military advantage represent another shift in the global security environment. For decades, the United States has enjoyed uncontested or dominant superiority in every operating domain. We could generally deploy our

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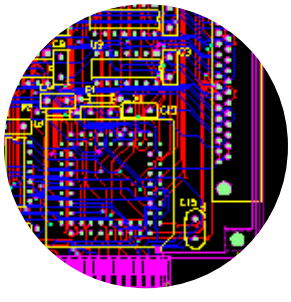

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forces when we wanted, assemble them where we wanted, and operate how we wanted. Today, every domain is contested—air, land, sea, space, and cyberspace."

In June 2016 (and as amended August 2018), the U.S. Secretary of Defense established the Printed Circuit Board and Interconnect Technology Executive Agent (PrCB EA) via DoD Instruction 5101.18E [4] with an original National Academy charter to develop a competitive network of trusted suppliers.

To this end—and in a collaborative effort between IPC, the PrCB Executive Agent (NSWC-Crane), DoD, and other government and industry partners—IPC-1791 was developed to complement and expand the integrity assurance offered by the Trusted Access Program Office (TAPO) for microelectronics to address integrity assurance vulnerabilities related to the design, fabrication, and assembly of printed boards with initial emphasis on defense requirements.

The IPC-1791 (August 2018) standard, "Trusted Electronic Designer, Fabricator and Assembler Requirements" provides minimum requirements, policies, and procedures for printed board design, fabrication, and assembly organizations and/or companies to become trusted sources for markets requiring high levels of confidence in the integrity of delivered products. These trusted sources shall ensure quality, supply chain risk management (SCRM), security, and chain of custody (ChoC).

Expect to hear a lot about the IPC-1791 standard at IPC APEX EXPO in San Diego (January 26–31). If your company is involved in support of military electronics manufacturing, I would highly encourage you to attend to learn more.

In closing, I have had the pleasure and honor to serve on both the National Defense Industrial Association (NDIA) Executive Order 13806 Electronics Working Group and the IPC Trusted Supplier Task Group over the past two years as many of these initiatives and standards have evolved. Serving with many others from the electronics industry, DoD, Commerce, and beyond, I have developed an incredible respect for all principals involved, and have witnessed first-hand their hard work, leadership, deep thinking, and unwavering dedication to providing a framework to protect our nation's most sensitive defense information.

Electronics, and the associated electronic manufacturing supply chain, are key components of all military systems. As such, our industry has a responsibility to both embrace and solve for the challenges associated with secure management of the vast amount of sensitive technical data that flows through our organizations' networks and within our supply chains.

Our nation's security depends on the electronics industry performing at a high-level regarding cybersecurity, and there is compelling evidence to suggest that the ability of your company to continue to support DoD electronics manufacturing also depends upon it. **PCB007**

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John Vaughan is VP of Zentech (Baltimore, Maryland) and is a widely recognized subject matter expert (SME) in military C5ISR electronics. To read past columns or contact Vaughan, click here.

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Moving in Microvias, Part 3

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

If we have learned anything about moving into HDI manufacturing, it is that it takes a great deal of thought and discipline to be successful. Unfortunately, as the following bullet points delineate, all too often, the fabricator underestimates the scope of HDI and what this manufacturing strategy truly entails. Here are a few common mistakes to avoid:

- Bootstrapping it
- Designers treating microvia technology like small through-holes
- Being afraid to invest in process improvements
- Failing to bring the "total package" to the end user
- Continuing to do the same things for the last 30+ years
- Thinking HDI is only for smartphones

These are common mistakes that companies, engineers, and managers make, and are left wondering why they are not participating in the HDI market successfully. These misconceptions lead many firms to miss the HDI opportunity. So, let's frame up the strategic choices, and begin by discussing desmear and metallization.

Desmear and Metalization

Not a whole lot is different here. It is all about removing drill smear and any laser drill debris from the capture pad, and ensuring that subsequent plating adheres to the resin and copper surfaces. Essentially, you should strive for the quality of the plating (Figure 1). There is no evidence of plating adhesion issues or defects or debris at the capture pad.

However, notice the lateral resin removal where the capture pad meets the side wall of the vias. This can be controlled by adjusting the via formation parameters, desmear chemistry concentrations, and operating temperatures. Note the shape of the via. Yes, it is preferred for quality plating purposes to ensure a "V" shape to the blind via. If the via is more or less shaped like a coffee cup, plating is challenged. If the via has a smaller diameter at the top, then widens as the opening leads down to the capture pad, uniform plating will be difficult if not impossible to achieve. Figure 2 shows an excellent guide with respect to via shape.

We will discuss more on plating issues related to via shape in a future column. I

Figure 1: Blind via properly drilled and plated.

Figure 2: Preferred shape for blind via formation. Left is optimal, the middle is okay, and Right is not good.

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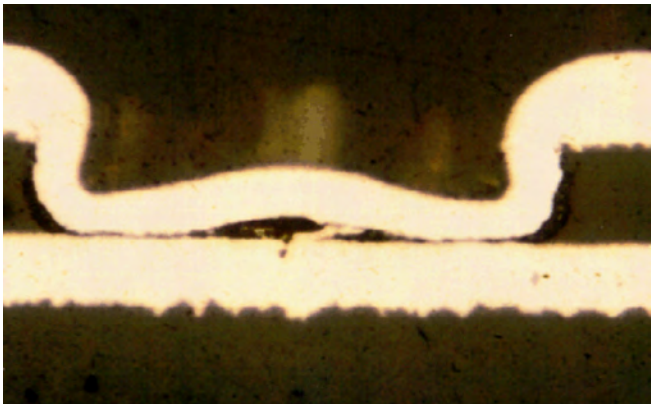

Figure 3: Inadequate desmear after laser ablation. Note the separation of the plated copper from the capture pad due to resin remaining.

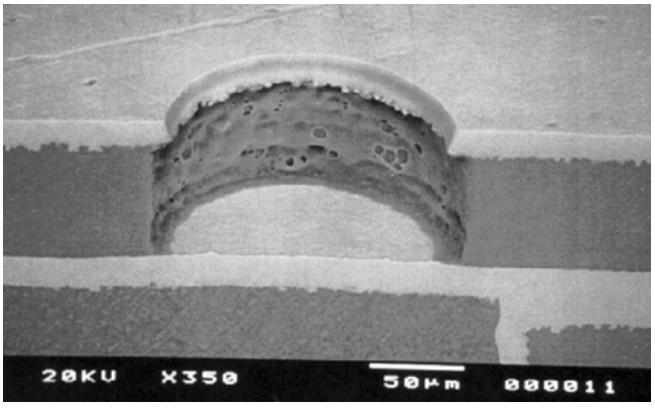

Figure 4: Resin-coated foil after laser via formation with no desmear.

cannot overemphasize the importance of having a clean capture pad devoid of residue. With the situation as depicted in Figure 3, the plated copper will at best form a very weak bond with the capture pad. Some fabricators institute a plasma cleaning cycle to ensure a clean capture pad. At the very least, alkaline permanganate should be utilized to not only remove smear but also to microroughen the resin material.

In Figure 4, you can see that the resin after laser ablation is quite smooth and not conducive to plating adhesion. Depending on the resin system and its Tg, the engineer may need to investigate different desmear parameters. This should include different solvent swell chemistries as well as variations in alkaline permanganate concentrations and dwell times. A less than optimum topography on any resin system as shown in Figure 4 presents problems with respect to the subsequent metalization process. Smooth topography has less surface area to attract both the catalyst from the electroless copper process or the conductive coatings used in the direct metalization processes.

High-Tg resins are more chemically resistant to certain desmear systems. The solvent conditioner must have the ability to penetrate the polymer resin matrix and weaken those polymer-polymer bonds. This interaction is sometimes referred to as a swelling action. Once weakened or swelled, the bonds are more easily attacked (oxidized) by the alkaline permanganate solution. Certain resin systems will respond more profoundly to pure solvent systems, while others will swell more effectively with butyl-caustic combinations (Tables 1 and 2).

In Table 1, note that the weight loss with a butyl/caustic system on high-Tg material is less than optimum. In Table 2, notice the modified

		0.1–0.12 mg/cm2 wt loss
Hole Swell	Commercially available or butyl/caustic system	2–3 minutes at 175°C
Permanganate	80 g/l $KMnO_4$ 45 g/l NaOH	10 minutes/175°C
Neutralizer	Commercially available	5 minutes/115°C

Table 1: High-Tg FR-4 (170 Tg), standard solvent system.

		0.25–0.32 mg/cm2 wt loss
Hole Swell	Modified solvent system	5 minutes/160°C
Permanganate	80 g/l $KmnO_4$ 45 g/l NaOH	15 minutes/175°C
Neutralizer	Commercially available	5 minutes/115°C

Table 2: High-Tg FR-4 (170 Tg), modified solvent swell system.

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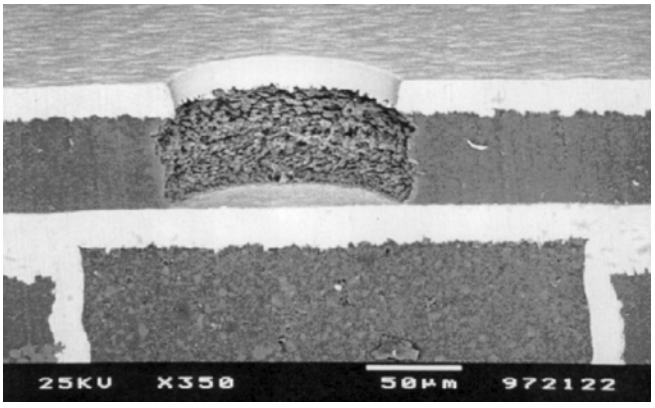

Figure 5: Alkaline permanganate with modified solvent swell with well-defined topography.

solvent system improved penetration on the high-Tg material, enabling the permanganate to increase the degree of resin removal and sufficiently roughen the resin to enhance the subsequent adhesion of the metalization layer. When the optimal solvent swell/permanganate system is utilized, you can expect the topography imparted to the resin (Figure 5).

Summary

Never assume that one desmear system or a single set-up will be sufficient for all types of resin systems and under all lamination conditions. In some cases, combinations of plasma and permanganate may be required. Regardless, ensure a clean capture pad and sufficient surface roughness for plating adhesion. **PCB007**

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

Global PCB Market to Witness a CAGR of 4.2% during 2018-2024

The global printed circuit board (PCB) market was valued at $60.42 billion 2017 and is expected to reach $80.38 billion by 2024, at a CAGR of 4.2%. Factors driving the growth of the market are: rising adoption of automation in various end-user industries, growing demand for wireless devices, increasing miniaturization of devices, surging need for more efficient interconnect solutions, and rapid growth in flexible circuits. Owing to the implementation of processors and sensors in smart gadgets, the size of the PCB has reduced to 74%. Additionally, usage of flame retardant chemicals in PCBs to ensure fire safety, and increasing capital investment is further augmenting the market growth. Moreover, huge growth in global PCB market is also led by the increasing demand for smart tablets and smart phones in IT and consumer electronics sector. Growth in wearable electronics is emerging as a key opportunity in the growth of the global PCB market.

With the rapid development in technology, electronics products will continue to emerge. But, massive production of PCB is becoming unfriendly to environment, due to the usage of wet chemicals while manufacturing. Moreover, lack of recycling ability also degrades the adoption rate of printed circuit boards. And to ensure less toxic emissions into the environment, inkjet printing technology is invented. This technology enables the cost-effective manufacturing of thin, flexible and disposable electrical devices. Moreover, Taiwan-based manufacturer (Wistron) is also looking to relocate a PCB manufacturing plant in Bengaluru, and has invested about $1 billion.

Global Printed Circuit Board (PCB) Market—Regional Insight

Geographically, the global printed circuit board market is segmented in Asia-Pacific, North America, Europe, and Rest of the World. Asia-Pacific is dominating the global PCB market in 2017 (77%), followed by North America. The growth in APAC region is attributed to the presence of many semi-conductor manufacturers, growing adoption of smart devices. North America is expected to hold the second largest market during the forecast period.

(Source: Globe Newswire)


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Editor Picks from PCB007

1 Ventec's Marketing Strategy and Their Newly Appointed Technology Ambassador ▶


Starkey, Goodwin, and Morgan

At electronica 2018, Mark Goodwin, chief operating officer at Ventec International Group, discusses the company's marketing strategy along with their newly appointed technology ambassador, Alun Morgan, and how he sees the world.

2 Unimicron Says ABF Substrate Demand Remains Robust ▶

Demand for ABF (ajinomoto build-up film) substrates continues to be strong while demand for other IC substrate and PCB products is being affected by seasonal factors, according to Unimicron Technology.

3 Flexible Thinking: Achieving Continuous Flexible Circuit Innovation ▶

Since their introduction, flexible circuits have continued a steady climb from relative obscurity to center stage in the world of electronic interconnections. Today, they are among the most popular choice for solving challenging electronic interconnection problems. Those who use this technology on a regular basis are familiar with the many reasons for the popularity of flex.

4 It's Only Common Sense: The "It" Factor—Are You a Dedicated Salesperson? ▶

As 2018 ends and the new year is almost upon us, we should all do a little soul searching and self-evaluation; a tune-up to make sure that we still have "it." We should strive to find the "it factor" that makes us great salespeople, causes us to wake up every morning ready to go and make those sales, and drives us to be successful even when we don't feel like it.

5 Flex Talk: The Myth About Rigid-flex Costs ▸


Tara Dunn

Do you cringe when you think of the option of rigid-flex? It is not an uncommon reaction when talking with designers and engineering managers about using rigid-flex to solve a packaging problem. Why? The most frequent answer is, "They are so expensive." While it is true that a rigid-flex PCB is typically more expensive on the surface when compared to rigid-board solutions with cables and connectors, a lot is being missed with that mindset.

6 Upcoming 2019 Trade Show Season in the USA ▸


Dan Feinberg

A look back at Dan Feinberg's predictions made a year ago, and a preview of what we might see at CES 2019 along with some new projections. CES—the first, largest, and most influential and predictive of global electronics trends of this group of trade shows.

7 The Shape of Things to Come: Curved, Flexible, Stretchable, and Three-Dimensional Electronics ▸

The seamless integration of electronics into flexible, curved, and even stretchable surfaces is being requested for several markets, such as automotive (dashboards, lighting, sensors), smart buildings (lighting facades, air quality, solar panels), medical (health patches, X-ray, analysis), and smart clothing (position tracking, sports).

8 FLEX 2019 and MSTC to Highlight SMART MedTech, Transpo and IoT ▸

Flexible and printed electronics innovations and autonomous mobility sensors will take center stage as more than 700 attendees gather for 120 market and technical presentations, 70 exhibits and four short courses at the co-located FLEX 2019 and MEMS & Sensors Technical Congress (MSTC) in Monterey, California, February 18-21, 2019.

9 Summit Interconnect Acquires Streamline Circuits ▸

Summit Interconnect, Inc. announces the combination of Summit Interconnect and Streamline Circuits. The addition of Streamline increases the Summit group to three California based operations. "The Streamline operation significantly enhances Summit's PCB capabilities when time and technology are critical," said President and CEO Shane Whiteside.

10 Successful Flex Circuit Design and Processing Guidelines ▸


Tuan Tran

With the use of sensors and technology in everything from mobile phones to refrigerators, automobiles, and wearable medical devices, circuit boards are a component in many different types of products. In today's world of electronics, any product with an on-off switch contains a circuit board.

Career Opportunities

Pssst! Are You Looking for Someone?

Place your notice in our Help Wanted section.

For just $500, your 200 word, full-column—or, for $250, your 100 word, half-column—ad will appear in the Help Wanted section of all three of our monthly magazines, reaching circuit board designers, fabricators, assemblers, OEMs and suppliers.

Potential candidates can click on your ad and submit a résumé directly to the email address you've provided. If you wish to continue beyond the first month, the price is the same per month. No contract required. We even include your logo in the ad, which is great branding!

To get your ad into the next issue, contact:
Barb Hockaday at barb@iconnect007.com or +1.916.608.0660 (-7 GMT)

I-Connect007
GOOD FOR THE INDUSTRY

smt007 pcb007 pcb design007

Career Opportunities

Sales Partner / Agent for North America

TSK Schill GmbH is a specialized partner in horizontal wet process equipment for the printed circuit board and chemical milling industries.

We are looking for a sales representative in North America who will support us in the sales of our HMS Höllmüller by TSK wet-process machines in the market.

Job responsibilities:

- Acquire customers in the field of chemical wet process
- Ascertain customer needs
- Support customers in the PCB/PCM business
- Spare parts support for horizontal wet process machines

Candidate profile:

- Company or individual contributor
- Experience in the field of chemical wet process
- Communication and organization skills
- Sales attitude

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Manncorp™

SMT Operator
Huntingdon Valley, PA

Manncorp, a leader in the electronics assembly industry, is looking for a technician to operate our new in-house SMT LED assembly lines.

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

Requirements and Qualifications:

- Prior experience with SMT equipment, or equivalent technical degree preferred
- Basic computer knowledge
- Proven 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

We Offer:

- Paid training period
- Health and dental insurance
- Retirement fund matching
- Continuing training

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Career Opportunities

Manncorp™

SMT Field Technician
Huntingdon Valley, 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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ventec
INTERNATIONAL GROUP
騰輝電子

Technical Support Engineer, Germany

We are looking for a technical support engineer to join our team at our German facility in Kirchheimbolanden. The successful candidate will assist potential and current customers in appreciating the benefits of using and optimizing the use of Ventec materials in their PCB manufacturing processes, enhance customer loyalty and satisfaction, spread the use of Ventec materials, and grow sales. The technical support engineer will provide a two-way channel of technical communication between Ventec's production facilities and U.K./European customers.

Skills and abilities required for the role:

- Scientific and technical educational background
- Experience in the PCB industry in engineering and/or manufacturing
- Strong communications skills (German and English) with the ability to write full technical reports for group or customer distribution
- Ability to work in an organized, proactive, and enthusiastic way
- Ability to work well both in a team as well as an individual
- Good user knowledge of common Microsoft Office programs
- A full driving license is essential
- Willingness to travel regularly throughout Europe and occasionally to Asia

We 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
applytoventec@ventec-europe.com

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Career Opportunities

ventec INTERNATIONAL GROUP 騰輝電子

Technical Sales Engineer, Germany

Want to advance your career by joining our globally successful and growing world-class CCL manufacturing company and help drive that success? Tasked with driving sales in the German-speaking markets, you will be a key member of the technical sales team. Your focus will be on Ventec's core market segments: military/aerospace, automotive, and medical offering a full range of high-reliability materials including polyimide, IMS, and thermal management products.

Skills and abilities required for the role:

- Seven to 10 years of experience in the PCB industry in engineering and/or manufacturing
- Strong communications skills (German and English)
- Project management experience
- Detail-oriented approach to tasks
- Ability to manage tasks and set goals independently as well as part of a team
- Knowledge of Microsoft Office products
- A full driving license is essential.
- Willingness to travel regularly throughout Europe and occasionally to Asia

We 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
applytoventec@ventec-europe.com

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pluritec

Field Service Engineer West Coast

Pluritec North America, ltd., An innovative leader in drilling, routing and Automated Inspection in the Printed Circuit Board industry, is seeking a full-time Field Service Engineer, located on the West Coast.

This individual will support service for North America in Equipment installation, training, maintenance and repair. Candidate must be able to handle trouble shooting electronic and mechanical issue's as well customer applications in the field. A technical degree is preferred, along with strong verbal and written communication skills. The position requires the ability to travel 2-3 weeks per month.

Please send your resume to:
Carolina.zeppieri@pluritec.org

apply now

Career Opportunities

Sales Personnel, Japan

The Gardien Group is looking to expand the sales team in Tokyo, Japan, and seeking highly motivated team players with a positive attitude. Prior experience in the PCB industry is an advantage but not necessary for the right candidate.

The role involves working closely with the customer to identify their needs and deliver the right solution. The candidate should be able to offer a high level of customer satisfaction to ensure ongoing sales.

Training will be provided along with a competitive benefits package, excellent growth opportunities, and periodic bonuses.

Interested candidates, please contact us at careers.jp@gardien.com with your resume.

Kindly note only shortlisted candidates will be notified.

apply now

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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Career Opportunities

MivaTek Global

Multiple Positions Available

Want to work for a fast-growing company? MivaTek Global may be the place for your next career move. 2018 has brought significant growth, increasing sales and revenue. And, we are just getting started! To support the current customer base and fuel further expansion, we are looking for bright and talented people who are energized by hard work in a supportive and flexible environment.

Open Positions:

- Technical Service Technicians
- Regional Sales Representatives
- Regional Leader for Asia Sales and Support

Proven experience in either PCB or Microelectronics and willingness to travel required for all positions.

More About Us

MivaTek Global is a distributor of manufacturing equipment with an emphasis of Miva Technologies' Direct Imager, Mask Writer, Flatbed Photoplotter imaging systems and Mach3 Labs X-Ray Drills. We currently have 45 installations in the Americas. Expansion into Asia during 2018 has led to machine installations in China, Singapore, Korea, and India.

To be part of our team, send your resume to n.hogan@kupertek.com for consideration of current and future opportunities.

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MacDermid Enthone
ELECTRONICS SOLUTIONS

Global Application Specialist Waterbury, CT

Qualifications: Bachelor's in Chemistry, and seven years progressive experience in related field. Expertise preferably in ENIG and ENEPIG. Global travel required: up to 40%.

Responsibilities

- Chemical analysis and experiments of final finish chemistries; characterize new processes from research prior to beta site installations, establishing operating parameters, problem solving tools and analytical guidelines.
- Recommend product, process, and analytical method improvements; including changing composition of compounds.
- Develop final finish product line. Install products at beta sites; collect data.
- Lead technical teams during beta site installations of new products and problem-solving groups at customer locations.
- Train personnel.
- Set up tests of final finish chemistries and products for laboratory personnel to identify customer problems, analyze result to resolve customer issues, and communicate results to customers.
- Oversee laboratory analysis and processing of customer samples through our global technical centers; summarize data, make recommendations and write reports.
- Document technical bulletins.

MacDermid Enthone is an E-Verify Company and provides reasonable accommodation for qualified individuals with disabilities and disabled veterans in job applicant procedures. "Equal Opportunity Employer: Minority/Female/Veteran/Disabled/Gender Identity/Sexual Orientation."

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Career Opportunities

ELECTROLUBE
THE SOLUTIONS PEOPLE

We Are Recruiting!

A fantastic opportunity has arisen within Electrolube, a progressive global electro-chemicals manufacturer. This prestigious new role is for a sales development manager with a strong technical sales background (electro-chemicals industry desirable) and great commercial awareness. The key focus of this role is to increase profitable sales of the Electrolube brand within the Midwest area of the United States; this is to be achieved via a strategic program of major account development and progression of new accounts/projects. Monitoring of competitor activity and recognition of new opportunities are also integral to this challenging role. Full product training to be provided.

The successful candidate will benefit from a generous package and report directly to the U.S. general manager.

Applicants should apply with their CV to
melanie.latham@hkw.co.uk
(agencies welcome)

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ZENTECH

Zentech Manufacturing: Hiring Multiple Positions

Are you looking to excel in your career and grow professionally in a thriving business? Zentech, established in Baltimore, Maryland, in 1998, has proven to be one of the premier electronics contract manufacturers in the U.S.

Zentech is rapidly growing and seeking to add Manufacturing Engineers, Program Managers, and Sr. Test Technicians. Offering an excellent benefit package including health/dental insurance and an employer-matched 401k program, Zentech holds the ultimate set of certifications relating to the manufacture of mission-critical printed circuit card assemblies, including: ISO:9001, AS9100, DD2345, and ISO 13485.

Zentech is an IPC Trusted Source QML and ITAR registered. U.S. citizens only need apply.

Please email resume below.

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Career Opportunities

Mentor®
A Siemens Business

PCB Manufacturing, Marketing Engineer

Use your knowledge of PCB assembly and process engineering to promote Mentor's Valor digital manufacturing solutions via industry articles, industry events, blogs, and relevant social networking sites. The Valor division is seeking a seasoned professional who has operated within the PCB manufacturing industry to be a leading voice in advocating our solutions through a variety of marketing platforms including digital, media, trade show, conferences, and forums.

The successful candidate is expected to have solid experience within the PCB assembly industry and the ability to represent the Valor solutions with authority and credibility. A solid background in PCB Process Engineering or Quality management to leverage in day-to-day activities is preferred. The candidate should be a good "storyteller" who can develop relatable content in an interesting and compelling manner, and who is comfortable in presenting in public as well as engaging in on-line forums; should have solid experience with professional social platforms such as LinkedIn.

Success will be measured quantitatively in terms of number of interactions, increase in digital engagements, measurement of sentiment, article placements, presentations delivered. Qualitatively, success will be measured by feedback from colleagues and relevant industry players.

This is an excellent opportunity for an industry professional who has a passion for marketing and public presentation.

Location flexible: Israel, UK or US

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BLACKFOX
Premier Training & Certification

IPC Master Instructor

This position is responsible for IPC and skill-based instruction and certification at the training center as well as training events as assigned by company's sales/operations VP. This position may be part-time, full-time, and/or an independent contractor, depending upon the demand and the individual's situation. Must have the ability to work with little or no supervision and make appropriate and professional decisions. Candidate must have the ability to collaborate with the client managers to continually enhance the training program. Position is responsible for validating the program value and its overall success. Candidate will be trained/certified and recognized by IPC as a Master Instructor. Position requires the input and management of the training records. Will require some travel to client's facilities and other training centers.

For more information, click below.

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Events Calendar

48th NEPCON JAPAN ▶
January 16–18, 2019
Tokyo, Japan

IPC APEX EXPO 2019 Conference and Exhibition ▶
January 26–31, 2019
San Diego, California, U.S.

DesignCon 2019 ▶
January 29–31, 2019
Santa Clara, California, U.S.

SMTA Pan Pacific Microelectronics Symposium ▶
February 11–14, 2019
Kauai, Hawaii, U.S.

EIPC 2019 Winter Conference ▶
February 14–15, 2019
Milan, Italy

China International PCB & Assembly Show (CPCA Show 2019) ▶
March 19–21, 2019
Shanghai, China

MicroTech 2019 ▶
April 4, 2019
Cambridge, U.K.

Medical Electronics Symposium 2019 ▶
May 21–22, 2019
Elyria, Ohio, U.S.

Additional Event Calendars

Coming in February to *PCB007 Magazine:*

SELLING YOUR SERVICES
The dynamics of the marketplace have shifted.
What sales strategies are working for PCB companies?

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