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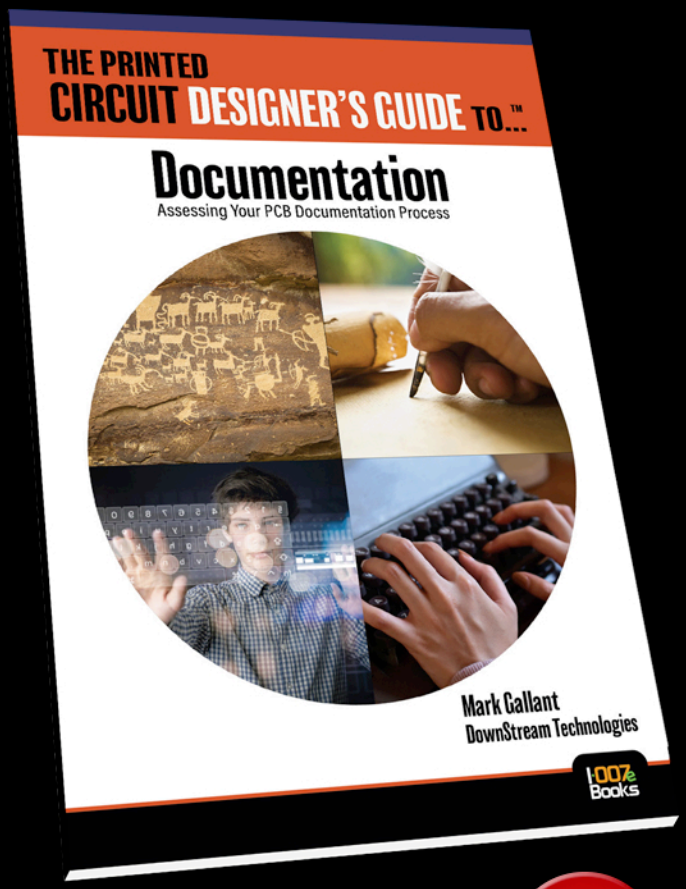

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What Are Your Priorities Now?

In the blink of an eye, priorities can change. In January 2020, the industry was enjoying a sustained growth path, but that was a very different 2020 than the one we live in today. While it's too soon to say what will be our new equilibrium, in this issue, we explore how priorities have changed.

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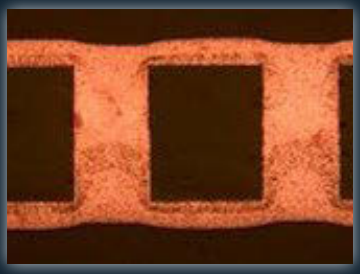

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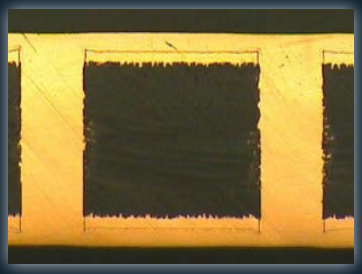

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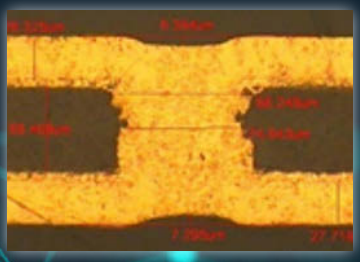

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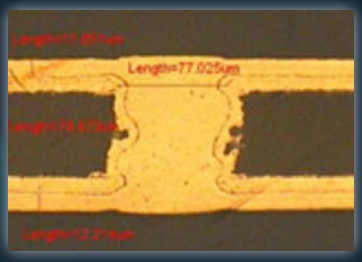

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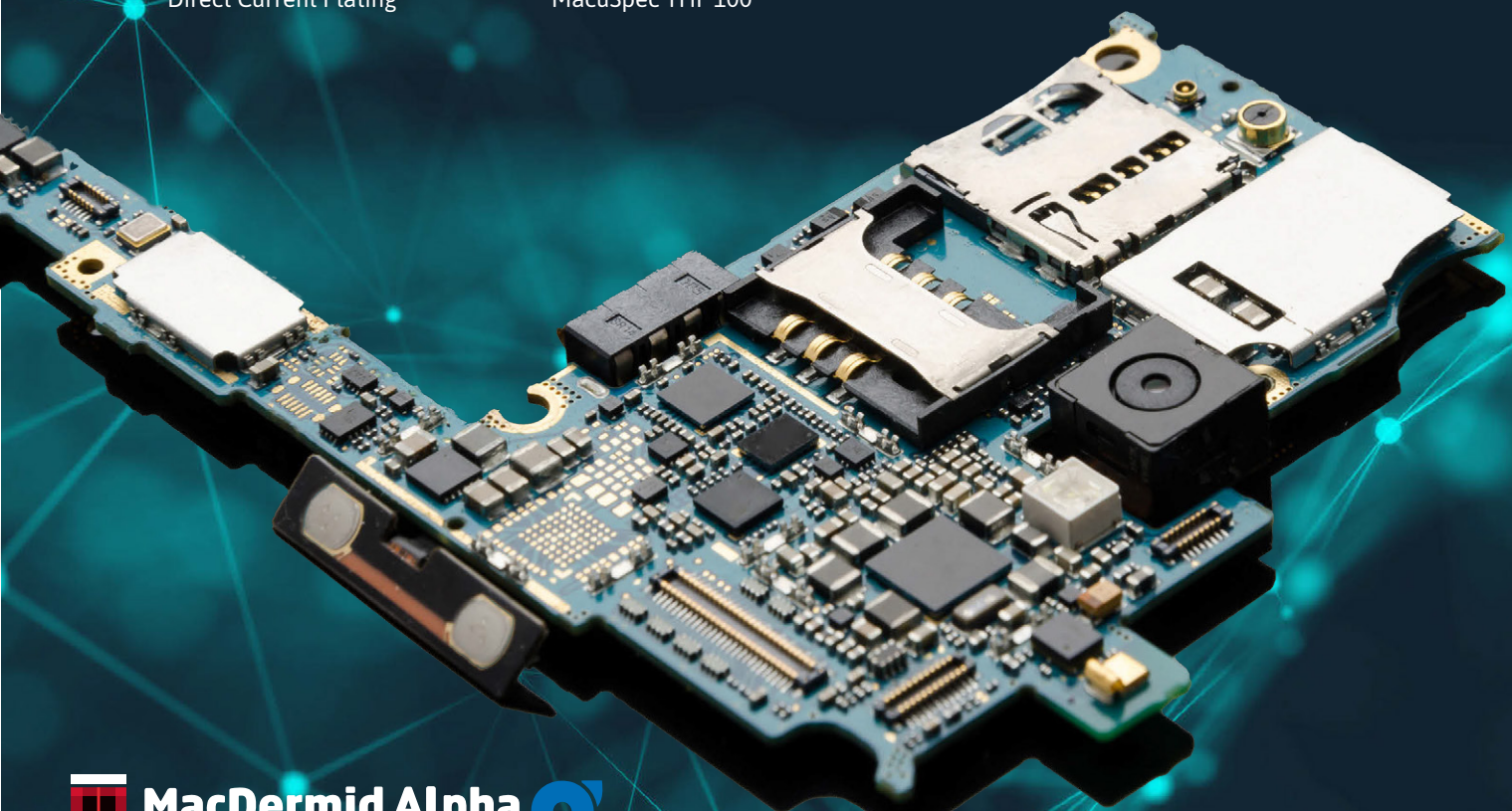

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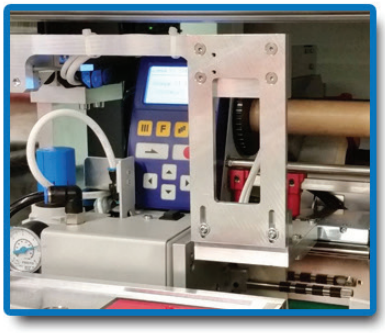

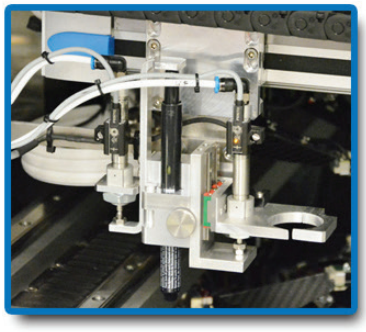

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What Are Your Priorities Now?

Nolan's Notes

by Nolan Johnson, I-CONNECT007

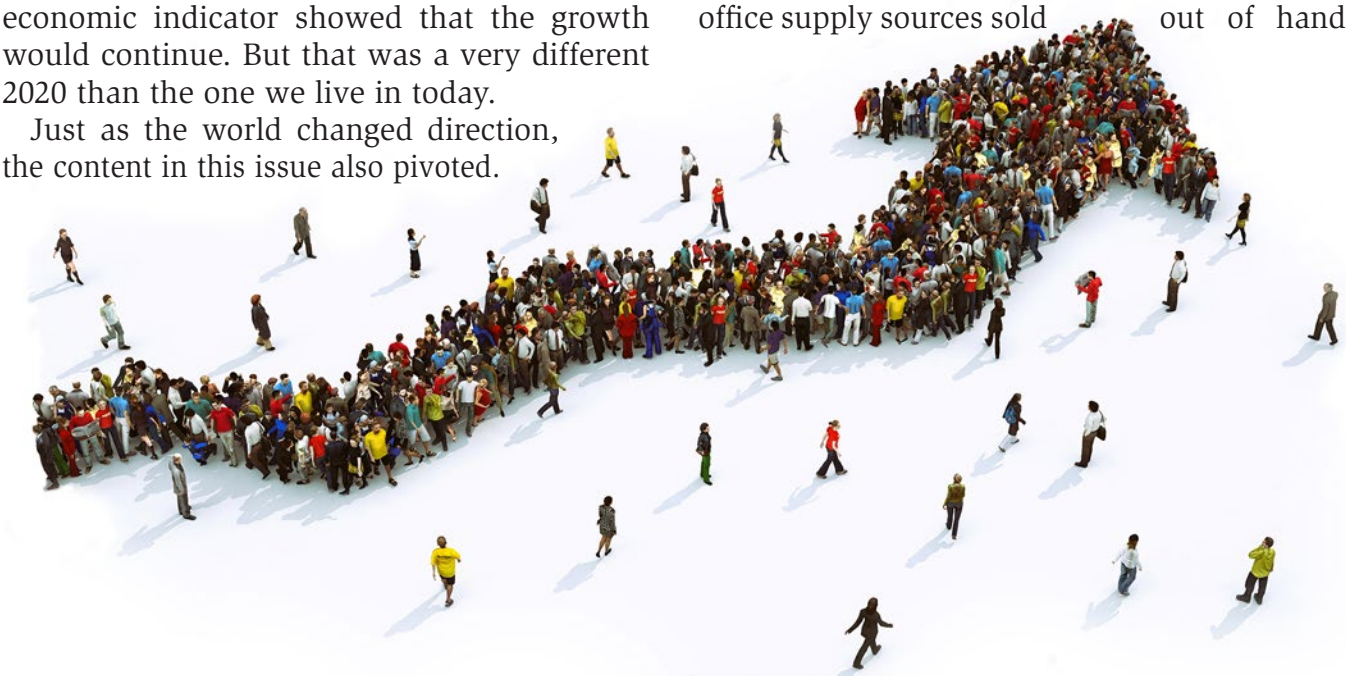
In Tom Kastner's most recent column, "Punching Out! Pivot Like MJ," he discussed making rapid shifts to changing conditions. Kastner's column may not be in this issue, but I argue it makes a good companion. I encourage you to read his column if you haven't already.

I won't go into too much of the details for our magazine planning process, but the I-Connect007 editorial team had settled on this month's theme, "What Are Your Priorities Now?" back in January as we were ramping up for IPC APEX EXPO. Had you asked us then what we thought the content would be for this issue, we would have told you it would likely be centered around transitions: shifting to smarter manufacturing, building your customer list, adding profitability, and perhaps even mergers and acquisitions. The industry had been on a sustained growth path, and every economic indicator showed that the growth would continue. But that was a very different 2020 than the one we live in today.

Just as the world changed direction, the content in this issue also pivoted. No longer were we thinking about strategic planning priorities; now, we were looking at survival. We were talking about saving lives: ours and those of our staff, families, customers, and the tens of thousands of people we don't even know who are sick and fighting for their lives. In light of this, what are your priorities?

Around the industry, companies, associations, and talented individuals shifted attention to respond to the outbreak. Qualified fabricators shifted to ventilator orders. Less stringent work, it has been reported, shifted to other fabs capable of that work, and—in the U.S., at least—virtually all of us found our businesses deemed to be essential and allowed to remain open.

But, it seems, that is where the hard work only began. Protecting staff became an entirely new supply chain to develop and monitor. With office supply sources sold out of hand



sanitizer and other supplies—and other normal vendors unable to fill orders for personal protective equipment (PPE)—the challenge became complying with health and safety regulations so that manufacturing could stay open.

Some company leaders responded in a typical fashion for a manufacturer by building their own. There's the equipment manufacturer who bought mask-making machinery and has been producing PPE for their staff worldwide. Multiple companies have added hand sanitizer manufacturing on-site, protecting workers and their families. Health and safety usually fall under the purview of human resources departments, which has now spun on the balls of their feet to defend against the opposition, so to speak. HR departments are at the forefront of this activity.

But our priorities are changing around. In this issue, for example, we talk with Rogers Corporation's Roger Tushingham about materials availability in the supply chain. Matt Stevenson from Sunstone Circuits documents a day in the life of a PCB fabricator adapting to the sudden changes, and Paul Benke and Michaela Brody from Zero Defects shine a light on the shift in the equation for engineering services; perhaps there is more opportunity in outsourcing this job function under the new constraints? Ken Michael from Dox Electronics, the cybersecurity experts, reminds us of the key fundamentals in keeping data and communications secure as we work in a more distributed model.

Our columnists pick up the priorities torch as well this month. Todd Kolmodin discusses "Down-shifting to the New Normal," Tara Dunn reminds us that "It's the Little Things," and Raymond Goh emphasizes how "It's All About Being Prepared." Ranging wider afield, Mike Hill puts a "twist" on military specs, George Milad dives into nickel corrosion in ENEPIG, Steve Williams continues his series on "Guerilla Tactics to Pass Any QMS Audit," and Mike Carano peels apart issues on lamination and delamination. Dr. John Mitchell also interviews Matt Kelly on the future of electronics.

Keeping you informed with technical information, this issue includes articles from Integrated Test Corporation's Brandon Sherrieb and Steve Karas on characterizing interconnect technology and Nikolaus Schubkegel on plasma use in PCB fabrication. **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.

Separating Hype From Reality: What's Next for the Future of Electronics?

One World, One Industry

by Dr. John Mitchell, IPC—ASSOCIATION CONNECTING ELECTRONICS INDUSTRIES

As IPC looks to the future of the electronics industry to determine what services to develop in the areas of standards, education, and advocacy, we will rely on a newly created role at IPC—chief technologist—to assist us in that effort. Matt Kelly, a familiar face in IPC standards development and widely recognized in the global electronics industry as a thought leader and an innovator, was recently hired as IPC's chief technologist. I sat down with Matt to ask him about his new role, as well as industry trends.

John Mitchell: When looking at something as broad as "the future of electronics," how do you focus on what trends will be the most critical to supporting IPC members?

Matt Kelly

Matt Kelly: That's a great question, John. As we can likely agree, predicting the future is a tough business—especially today, as emerging and disruptive technologies are rapidly evolving. To have a shot at getting this right, I focus on "cutting through the noise." With so much information at our fingertips and so many technologies advancing at the same time, I concentrate on separating hype from reality. To do this, I rely on the engineering and business experience I've gained over the past 20 years in the electronics industry.

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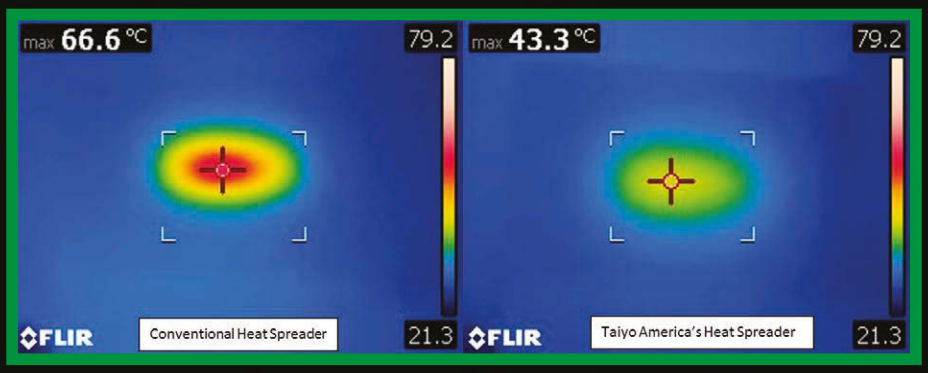

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To ensure I identify critical trends for IPC members, I use a two-step approach. First, I leverage my network to understand what is most important, focusing on gathering critical "voice of the customer" (VOC) input from subject-matter experts and IPC members from around the world. Second, I examine promising trends through a business value lens. I focus on ROI value delivery by identifying real business issues and then applying appropriate solutions, including base operations management practices and new Industry 4.0 technologies as needed.

Mitchell: There is a great deal of interest in the "factory of the future," implying that the current factory will be undergoing tremendous change soon. Can you explain what some of those changes might be and how they will affect the day-to-day operations of a factory?

Kelly: I first want to address timing expectations. We should expect a "factory of the future" transformation to be a gradual but steady transition with varying adoption levels by geography. In Europe, companies have been investing and transforming since 2008 (e.g., Germany—the birthplace of Industry 4.0). Companies in Asia have been working since 2014 and are now leading the way with large scale implementation of new Industry 4.0 advancements. Adoption in North America is lagging but is critical in ensuring manufacturing competitiveness moving forward.

As for new advancements in electronics manufacturing factories, I see companies first investing and implementing solutions in the following areas as they provide early ROI returns: digital transformation, secure cloud computing networks, and manufacturing operations/supply chain data analytics. This first group is likely to be followed by connected worker enhancement, cobot/robot automation, artificial intelligence/machine learning, and additive manufacturing.

Generally, these technologies are funded and implemented as individual solution blocks within a factory, as opposed to being installed as fully integrated end-to-end solutions. The main reason for this is the high CAPEX expense for new solutions. Thus, project-based installation is expected to continue.

From an employee perspective, as companies migrate to a factory of the future solutions, new technologies are not meant to fully replace the workforce; rather, these advancements will affect the workforce to change how they work. While there will be some level of workforce reduction, employees will be expected to upskill, be more versatile, and be responsible for several areas simultaneously. To do this, they will need to leverage data analytics, AI insights, and automation to help them manage many more activities in a day.

Mitchell: You most recently worked at IBM in Toronto as a senior technical staff member and master inventor, and you are widely published in technical publications. How do you see your creative background informing the work you will do as IPC's chief technologist?

Kelly: Engineers are notorious for their bad spelling and reluctance to write things down. They would rather be spending their time solving problems and developing new solutions. Early in my career, I was taught by my research supervisor at 3M a very important lesson, which I still use as guidance today: "Communication is the most important part of being an engineer. At the end of the day, if you don't write down what you've learned or observed, then you have nothing to pass along to others." I have never forgotten this advice, and it is the reason why I have written over 80 technical publications and 25 patent disclosures to the industry.

Moving forward as IPC's chief technologist, I plan to continue writing and communicating. I plan to work with trade publishers, issue IPC position papers to industry and government bodies, issue state-of-technology reports, and present at various trade shows and conferences around the world. The intent is to increase IPC's technical strength and visibility within the industry and our membership.

Mitchell: Part of your role will entail industry intelligence and the launch of an industry Chief Technologist Council (CTC). Can you explain what each of those initiatives will cover and how they will affect the industry and IPC members in particular?

Connected Factory Exchange (CFX)	IPC-2591
Hermes	IPC-9852
Cybersecurity	*New* IPC-1792
Digital Twin	*New* IPC-2551
Distributed Ledger (Blockchain) Council	Project Initiated
Model-Based Design	Project Initiated
Traceability	IPC-1782
PCB/PCBA MFG Data and Transfer Methodology	IPC-2581

Table 1: "Factory of the future" industry standards.

Kelly: The CTC is a collection of the electronic industry's top technology leadership spanning OEM, EMS, and PCB companies. Members consist of CTOs, engineering VPs, directors, fellows, distinguished engineers, senior technical staff, and chief engineers. Quarterly meetings will be held throughout the year, discussing various technology and "factory of the future" topics. The intent of the Council is to obtain VOC input, keep a pulse on the industry, and continuously monitor IPC member key plans regarding electronics manufacturing technology needs. Insights will be gathered and reported periodically to various IPC bodies. Council contributions will help shape IPC strategic direction and external communications to the industry moving forward. The CTC will hold its first kick-off meeting in Q2 of 2020, pending COVID-19 recovery.

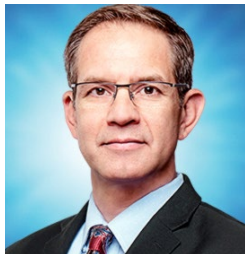
Mitchell: You've been deeply involved in IPC standards development, serving on several committees and earning a Rising Star Award for your efforts. What will your role be with committees now that you are on staff at IPC?

Kelly: As I've just come from industry, I'll leverage my network built over the past 20 years to obtain industry feedback and drive adoption of key technology standards moving forward. I will continue to be involved in IPC standards and council development, with a shift in focus toward new "factory of the future" technology standards. We are currently working on defining a new "factory of the future" standards category, which will include the following areas. It's a mix of brand new and existing standards as a grouped offering (Table 1).

Mitchell: We hear so much about standards and education addressing reliability and quality. From your vantage point, what are the similarities and differences between those two terms?

Kelly: Reliability and quality are related; however, there are important differences. The terms are similar in the fact that they are used to measure the "goodness" of a product (or service). Both are linked; we can ensure reliability by controlling quality. Both need to be assessed—not one instead of the other. The reason for this is that quality and reliability measure product "goodness" at different periods in time. Quality is measured as-built before initial use. However, reliability is measured during/after use. Think of quality as present-day and reliability as later in the future.

Quality is a static measure of a product meeting its specification as manufactured, whereas reliability is a dynamic measure of product performance. Quality is observed, whereas reliability is experienced. As a consumer, you buy based on quality. You come back and buy again based upon reliability. **PCB007**



Dr. John Mitchell is president and CEO of IPC. To read past columns or contact him, click here.


Roger Tushingham

Rogers Corporation Keeps Materials Moving

Feature Interview by the I-Connect007 Editorial Team

The I-Connect007 editorial team spoke with Roger Tushingham of Rogers Corporation about the company's current priorities with everything that's been changing recently, including his perspective on the distributing and manufacturing trends he sees as a global supplier.

Nolan Johnson: Roger, what's your role at Rogers?

Roger Tushingham: I am the VP of marketing and new business development within our Advanced Connectivity Solutions Business Unit. I've been with Rogers for three and a half years. Before that, I spent 25 years in the semiconductor supply chain, both at equipment manufacturers and specialty chemical suppliers. My main responsibilities include looking at what the market needs are from an OEM perspective, making sure we have our portfolio positioned correctly, and looking at what we can be doing as the needs of our current customers and our future customers evolve; these needs may be beyond the PCB laminate business that we're in now, and we want to satisfy those needs and ensure we have products that enable our customers to drive their technology roadmaps.

At Rogers, our short-term priorities have changed a little bit in the last three to four months, but the general strategic direction remains the same. Right now, our first priority is the safety and health of our people; it's the guiding light in all the decisions we're making. Our second priority is making sure we are not disrupting our customers' supply chain, and we've been doing a lot of work in the past few years that has prepared and enabled us to minimize any disruption right now.

Our third priority is to continue to drive our development portfolio so that we continue to release products that are enabling our customers to drive their technology platforms as the needs of the end consumer get more sophisticated. There are three purposes: safety, minimizing supply chain disruption in these times, and driving our development portfolio, so we're healthy for many years to come.

Johnson: Let's start with safety, and then we'll walk down the list.

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Tushingham: As soon as the situation started to evolve with COVID-19, we implemented site pandemic response teams that report up to an enterprise-wide pandemic team with oversight by our executive team. Globally, each of our sites has a response team that implements safety measures such as remote working. We've been remote working since the middle of March, apart from our operational staff. We are designated as an essential business, so our operations teams are busy every day, working to meet customer demands. But non-site essential staff, meaning people who don't have to be on-site, are not in the factories. For those people that are working in the factories, we were very quick to implement social-distancing policies. We shut down parts of our operations that required people to work next to each other immediately and then evaluated what PPE was needed and what precautions we could take before slowly reopening those areas once we deemed it to be safe to do so.

We're also performing temperature checks in our factories globally for everyone entering a site, as well as wearing masks and all necessary PPE. We also immediately increased our level of cleaning, so we're putting in extra cleaning staff and making sure everything's clean. That's our safety, and we are paying very close attention. Our executive team meets daily to talk about the latest guidance from the WHO and CDC, along with the various state and national guidance in the countries we operate in. As the situation progresses, we are starting to put together our reintegration plan, and we'll be conservative in how quickly we move people back into our facilities that aren't absolutely required to be there to maintain our supply to our customers.

We also implemented a lot of procedural changes, HR-wise, in terms of benefits and things of that nature to make sure people were not feeling pressured to go into work and that we were looking at both the social and the safety side. I'm very proud of the way the executive team and the whole organization's come together to put our people first in this situation.

Johnson: How do you feel the productivity for the teams has been after making this shift?

Tushingham: There has been a slight impact, but I am pleased to say that the impact on customers has been minimal. Operationally, we've done a great job, and I can go into that in a little bit more detail when I talk about supply. In terms of the non-site-essential staff, it took a bit of an adjustment to be working from home. We operated with a lot of global teams prior to the COVID-19 crisis, so we have a good amount of remote people on our teams and are used to driving progress without all being in the same room.

It took an initial hit as we got used to settling into working at home, but we've picked up, and we're prioritizing actions that absolutely must get done to make sure we come out of this even stronger and putting off some of the non-essential, more administrative tasks, to be dealt with once we can focus a little bit more on those. But operationally and R&D-wise, we haven't seen any major hit because we have been able to leverage our global organization.

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Johnson: Do you see any trends in orders from your customer?

Tushingham: We have three major business areas for Advanced Connectivity Solutions. First is aerospace and defense; that's our foun-

dational business, and it has been unaffected. We haven't seen any drop off in orders or buying patterns in the aerospace and defense market due to this situation. With our wireless infrastructure business, the big needle move there are 5G deployments, and as we see China coming out of the initial impact, we saw a little bit of a push in Q1 to Q2 in the 5G deployments; however, the Chinese economy is using 5G to kickstart the economy again, so we're seeing that business picking back up nicely right now.

Automotive is the one area where we see a major drop off, as the automakers shut their factories, their demand has dropped off. Automotive is the main downside, but wireless is staying strong because of the 5G deployments. And aerospace and defense are good with steady growth.

Dan Feinberg: Do you see any changes to your supply chain due to the movement not to supply things from China?

Tushingham: Most of the materials made in our Asian locations are consumed in Asia, so we have not seen a great shift in the supply chain, in general. Over the past several years, we've been making changes to improve supply stability, and this has been very beneficial during the pandemic. We have a global footprint, so we have facilities in China, Europe, and both coasts of the U.S. About five years ago, we made a concerted effort to make sure that as many of our products as possible were qualified in multiple locations.

While customers might prefer them to be shipped from one location, we have the ability to ship to them from multiple locations. And as this COVID situation evolved, it was first in China, so our Chinese facility was impacted, but we were able to move the supply of that material that would have normally been supplied from China to our Arizona and Belgium locations. Then, as China came back online, in terms of the factory coming back online, the next concern was Europe. Our factory was impacted in Europe, but we were able to move that volume into our China and U.S. locations. Now, as more of the impact is in the U.S., we've been able to supply those customers that were buying from the U.S. from our Chinese and European locations.

We've always managed to pick up any of the reduction in supplies from any location through our other factories globally. It's helpful that we have this global, qualified capacity. With that qualified capacity, we've also made concerted efforts in the supply chain to have locally sourced raw materials, wherever possible. Our factories operate, to a large extent, with raw materials coming from their regions in order to minimize lead times and total supply lead time, as well as make things more efficient.

We've always managed to pick up any of the reduction in supplies from any location through our other factories globally.

The actions we've been taking for the last five years have paid dividends in this situation, and our customers have seen a minimal impact. We have pushed out lead times a little bit from some of our locations, but we saw China quickly get back to standard lead times. Belgium and Arizona are now back at standard lead times. The East Coast of the U.S. is the one area where we've had to push out the lead times at the moment.

Barry Matties: Your manufacturing is situated to where your demand is by region.

Tushingham: Yes, whenever possible. For example, if we sell to an automotive tier one, our design sales effort may primarily be in Europe with the designers at their facilities, but our sales could be to a fabricator in Taiwan or China. We supply those fabricators out of our Chinese manufacturing facilities. We haven't seen any impact from customers saying, "Thou shall not ship from China." In fact, most of them

want to ship from China because that's where most of their fabricator base is located, close to either China or Taiwan—outside of aerospace and defense.

Matties: When you look out into the near-term future, what indicators are you paying attention to in order to project your growth?

Tushingham: We're doing the blocking and tackling, staying in very close contact with our OEM customers and our fabricator customers to understand what they're seeing. We also use market reports to validate our assumptions. We're looking at 5G base station installations primarily driven by China because it's 80–90% of the global volume, so we're closely monitoring what's going on with deployments in China on the 5G side. For automotive, we're involved in almost weekly or bi-weekly podcasts with the industry experts, looking at potential scenarios for light vehicle shipments. Then, we have some modeling that we do based on light vehicle shipments to indicate how much radar content is going to be on those vehicles, and then we can project what we expect to see, in our volumes, from the automotive side.

There are three main segments that drive a significant portion of our business. The key macro drivers—light vehicle shipments and 5G infrastructure deployments—are the two main external factors we track, and then we are constantly keeping in touch with our customers and seeing what they're projecting so we can make sure we have the right material in the right place at the right time.

Matties: When you look at the 5G in China, what sort of time frame or pace do you think they're going to be moving at?

Tushingham: The market numbers vary wildly. Before the COVID-19 situation, we heard reports for 2020 installations of anywhere between 550,000 base station deployments globally for 5G to the top end around 850,000–900,000 base stations this year. We've consistently been forecasting in the 600,000–700,000 range. We were projecting that toward the end of last year, and that's still a decent range. It pushed out a little bit from Q1, but we see an acceleration in Q2 and Q3. China Mobile announced the results of a tender they put out. China Unicom and China Telecom are finalizing a tender, which we expect to be released any day now, which will see a big surge in deployments in Q2 and Q3. Everyone is stating they want to get most of these deployed by the end of Q3. That's a bit aggressive, and I expect we'll see deployments lead through the rest of the year. Overall, we expect 5G in 2020 to be in line with what we are forecasting toward the end of last year.

Matties: What's your expectation for recovery in the automotive sector?

Tushingham: This is one where there are different opinions depending on who we talk to; even different OEMs have different opinions. We're in the ADAS space, so it's complicated where light vehicle shipments could go down, but you got more ADAS content per vehicle, so our ADAS business grows at a higher growth rate than light vehicle shipments. The concern for us will be if some of the newer car models get delayed. OEMs canceling summer testing, for example, will push out new model releases, and new models typically have more radar content on them, which means more content for Rogers. While the light vehicle shipments is a short-term concern, such as a Q2 into Q3 concern, if there is a significant push out in new model releases, that could be a slightly longer revamp for us. We're predicting potentially not so much a V-shaped recovery, but more of a U-shaped recovery.

Even market analysts have five or six different models on automotive scenarios, with no one stating which one is most likely. Again, a concern is that even if factories open, is the consumer demand going to be there? Even if the consumer demand doesn't come back, if the factories are open and the R&D efforts turn back on, that's a positive for us in the medium or long term because it means they're working on the new vehicle releases again that do have the higher radar content.

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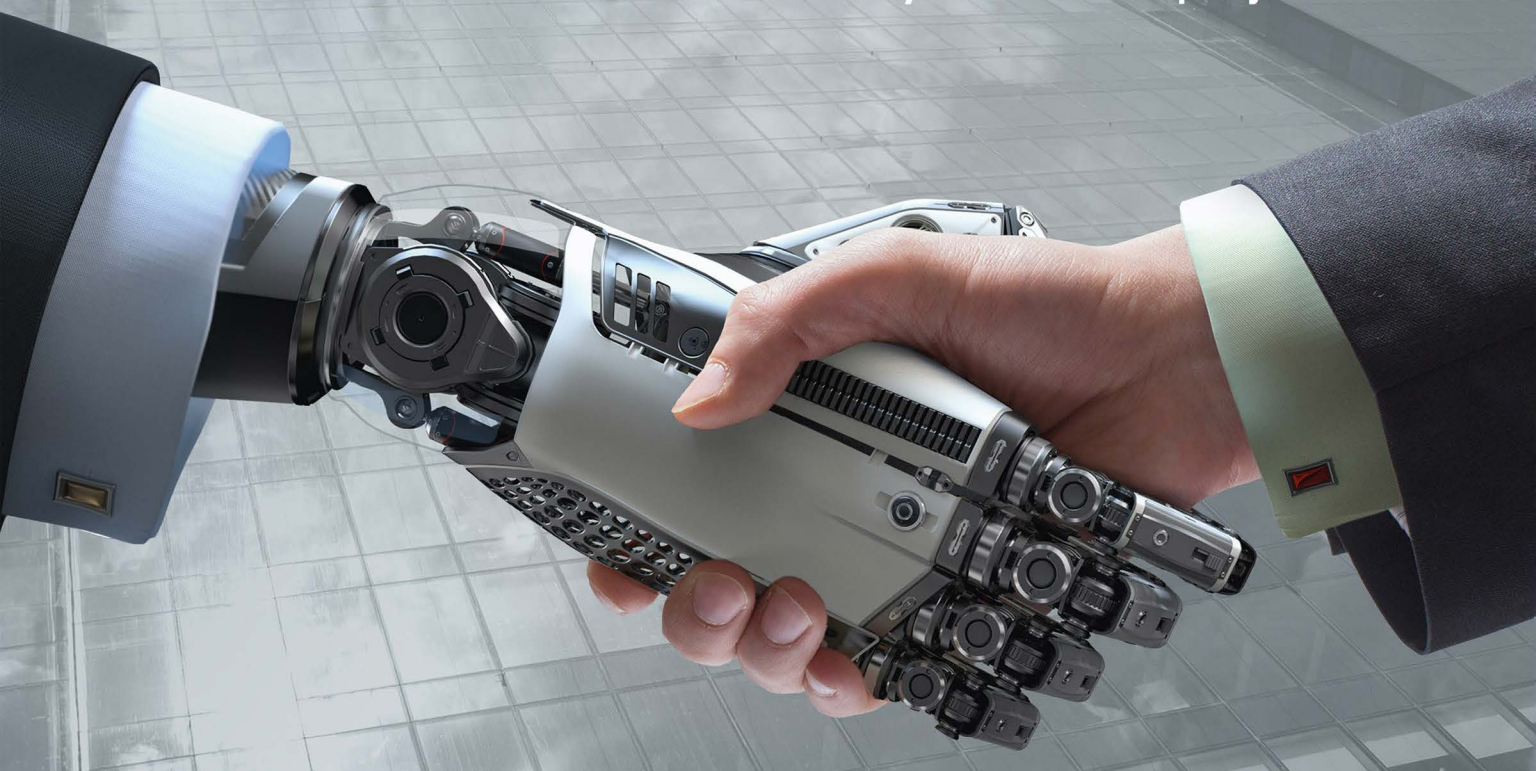

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Matties: You have done a good job of reaching out and marketing to the OEMs and getting your products specified into the blueprint, but there are a lot of changes in factories. What impact has the bare board process had on your materials, or what advice do you give the fabricators?

Tushingham: I'm pleased you acknowledge the job we've done on the OEM design side. That's a key part of our business model, and it has allowed us to be successful for many years. There is an increased level of fabricators that are more involved in more decisions now in the markets that we've been traditionally serving. We still have a way to go, but we're significantly upping our game in terms of the attention and the support we provide to our fabricator base. We've historically done a very good job of providing good technical support for those customers, once they've started to use our materials, but we're releasing some commercial products now that allow us to tailor the total service package that we provide to our fabricators because they play more and more of a role in the decision making.

We're not shifting away from our OEM model because that's going to be key for us. We're never going to compete on cost against an FR-4 company because that's not who we are. We have to retain that OEM design-in as much as we can, but we are also paying closer attention to how we can add value to our fabricator customers.

Matties: Deliveries are always a critical factor in the supply chain and getting materials from Rogers, it's in big demand, and there have been long delivery times. I am not sure what your delivery times are now, but that left a window open for fabricators to look at replacements. I'm glad to hear you are putting more focus there because that needed some attention.

Tushingham: It is true that in several instances in the past, there have been demand surges that resulted in capacity constraints, which in turn resulted in extensions of lead times to unacceptable levels. There still appears to be a perception that Rogers has extremely long lead times. One of the major reasons we started down this path of multiple site qualifications a few years ago was to try and address lead-time concerns. We also significantly increased our capacity in general, including the purchase of an Isola factory in Arizona a couple of years ago. We recognized that one of the biggest knocks against us was our lead times, so we've significantly increased capacity in the last two years—more than doubling capacity on some of our higher volume product lines.

We've done that, and if you look at our standard lead times now, they're approaching where I think our customers want us to be—in the 5–15-day-range—and, quite often, in our high-volume products, we're able to deliver more quickly than that. We're also making a concerted effort to improve our service levels. In North America and Europe, we've added distribution partners who are able to assist us in meeting the expected service levels from that segment of our customer base.

Matties: You recently signed IEC as your distributor. How's that working out?

Tushingham: Very well. It was a phased approach. We moved some of our more commercial products to them to start to get to know each other and make sure the model worked. As that became established and we knew it would work, we moved some of our more complex, custom-type products to them. It has worked very well. The customers in that specific segment see their service levels improve; it's something that Shawn Stone [IEC president] and his team are set up to handle, and it allows us to focus on what we're good at as well.

Matties: For clarification, they're handling all of North America now for certain customers.

Tushingham: Correct. We still have customers who buy direct from us, but IEC covers a segment of our customer base for all products across North America.

Matties: What concerns do you think the industry should have right now? What do you find most concerning out there?

Tushingham: It's the uncertainty of how quickly the economy is going to come back. The supply chain has been pretty robust from what we've experienced. We've had to do some things, like increase safety stocks of specific products, raw materials, and things like that, but the biggest question on our mind now is when will consumer demand and consumer confidence return? And the longer that goes on, the more challenging it becomes to operate as we operate today. We're spending a lot of time scenario planning and making sure that the different scenarios, in terms of how quickly and how hard this comes back, that we can manage our operations to be healthy long term. We've been around 188 years. We'd like to be around for another 188, so while we need to take care of the short term, we also need to think about how Rogers can come out of this in a strong position to support our customers long term as well.

Matties: Is there any concern about increasing cost, whether it's from shipping or raw material, copper, etc.?

Tushingham: The shipping side has had the most uncertainty in the past few months with both cost and scheduling. For raw material, we try to have multiple sources of copper qualified from local sources if we can. We're working to mitigate any underlying price pressure by continually looking for multiple source qualifications so we can manage that side of the business. So far, it has been manageable. I can't deny that we see a lot of competition from the people who were maybe more oriented to FR-4 and high-speed digital in the past who are now seeing opportunities in the high-frequency space. They have done a great job using low-Dk glass and high-performance copper to improve the performance of their overall solution.

We have a history of resin development, so we've typically driven the performance of our solutions through resin composition. We do not rely on high-performance glass and copper as much. As you've seen, in the past year, there have been shortages of high-performance glass. That has not impacted us significantly, even on our highest-performance products. Similarly, with copper, while low profile copper does give us a boost, often, we do not need it quite as early as some other companies do. More and more, we hear that high-performance glass is supply-constrained for some others, and, fortunately, it has not been an issue for us.

Happy Holden: I've used RF materials virtually from the first day I started in 1970 with HP's

test equipment. It's interesting that electrical theory keeps coming up with components and methodologies to make the lower-performance FR-4 work at higher and higher frequencies and decreasing rise times. It never ceases to astonish me what new electrical gizmo or technique allows them to squeeze a little more bandwidth out of what we've always had before.

Tushingham: We have to make sure that we're providing solutions that take into account not only the material versus material, but we're also competing against design and system design aspects. There are multiple ways a problem can be solved; high-performance CCLs are one way, but we have to constantly be aware of every other avenue. And a lot of our development effort now is beyond traditional CCL; it involves looking at overall system performance and how we can improve that for the antenna and radar designers that we work with every day.

There are multiple ways a problem can be solved; high-performance CCLs are one way, but we have to constantly be aware of every other avenue.

Holden: The one thing about 5G is that it has to have a line of sight capability, which means it works great for cities and high population density, but it must be a much bigger problem for a country like North America, where we're spread out across 4,000 miles.

Feinberg: It's going to mean a lot more sites.

Tushingham: It's frequency-dependent. That's why the T-Mobile strategy is pretty interesting. In rural areas, they're going to go at low band—even maybe 600 or 700 MHz 5G capability—and then as they get into high density, they're only going to deploy millimeter-wave in high-density, high-capacity areas, such as New York City; at those higher frequencies, it is very line of sight with short distances.

And then you have people with LEO things going on, and one of their value propositions is they can provide internet access; it may not be 5G, but it will be decent broadband internet access to rural areas as well. Many people are trying to resolve this issue of improving connectivity in an economical way, and we're playing in all those areas. It's fun and exciting to be part of all of that.

Holden: Unless the micro-satellites that SpaceX has launched turn out to be a cost-effective methodology, the first rollout will probably be along interstate highways because of autonomous trucking and vehicles. We may see rest stops that also have a 5G thing that says, "It's not only a rest stop, but this is 5G compatible parking lot that you can use."

Tushingham: And if you look in China, they're already starting to do that with some stuff like Huawei's working on roadside capability for 5G. I agree that there's a lot of work going into that area.

Johnson: Is there anything else you'd like to add?

Tushingham: I hope our efforts to increase underlying capacity, qualify multiple sites, and manufacture close to our customers whenever possible have addressed any concerns around Rogers' ability to meet customer demand even in these challenging times. We will continue to leverage our global operations, R&D, and commercial organizations to ensure we are delivering solutions that meet the needs of our customers for many years to come.

Matties: Thank you for your time today, Roger.

Tushingham: I appreciate it. Thanks for the opportunity. **PCB007**

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Down-shifting to the New Normal

Testing Todd

Feature Column by Todd Kolmodin, GARDIEN SERVICES USA

Today, we find ourselves in a place none of us ever thought we'd be. Entire countries are shut down, air travel is non-existent for the most part, and our daily lives have been disrupted to the point of only take-out and home delivery. Why? Not a war or a natural disaster but something most of us didn't consider—a biological threat, of all things! This microscopic virus has brought our planet to a halt.

We have all had to rethink our entire existence. We have to think twice about everything we do now. Can we do this or that? What's the risk? And the new term that defines the very essence of human nature—social distancing, which is an oxymoron if you really think about it. Let's be social but only at six feet or more. It's something I never thought I would see in my lifetime: hysteria over toilet paper, hand sanitizer, and the hordes wiping out grocery stores like we are on the verge of a zombie apocalypse.

Another new buzz phrase is "the new normal." From record stock markets to the biggest drop in a decade in less than five days to schools closed and parks and recreation areas off-limits, we are told to stay home. Some have faced job losses, there has been an exponential rise in unemployment, and we are told to wear masks. This down-shifting to the new normal has left skid marks on everyone's lives.

It makes us all think about what is really important now. COVID-19 is the first thing you hear in the morning and likely the last thing before lights out. Today, it dominates the news and our daily lives—politics and science in a daily battle of the economy vs. life. The economy can be repaired in time, but the loss of life cannot.

However, one thing it has taught us is to slow down. Look at a sunset or reconnect with your spouse or partner. It has given us a chance to really look at what is important to us now. Family and health need to be at the ut-

most top of our list right now. Material things can wait. Check on that loved one, neighbor, or friend. This, like all the challenges we have faced in the past, will end in time. We cannot bring those lost back. We cannot restart too fast and risk further loss.

The curve is flattening. What we are doing today affects those who might be infected tomorrow. It is not an overwhelming request—a few months of sacrifice to save many lives that will continue. My wife is in the healthcare field, and healthcare professionals are on the frontline every day. They can't social distance; they take this monster head-on.

Being this close in my circle gives me a huge sense of admiration for those doctors, nurses, and all those healthcare workers who have put their lives on the line to save yours. Doctors and nurses are sleeping in the garage or a backyard tent to save their families from possible exposure, fighting for your lives at the possible cost of their own. So, what is important today? Winning this battle over COVID-19 and giving all of us the chance to continue to thrive.

Science is telling us to slow down, keep your distance, wash your hands, wear your mask, and stay home when possible. This isn't forever, but losing a loved one to COVID-19 is. Take a moment to look in the mirror. Do you want to be able to look at yourself in a year, two, three, or 10? As I write this, someone out there just lost their chance due to COVID-19. You may not know you have it. You could carry it without symptoms. However, who you may give it to may not be as strong as you. Be a hero and downshift to the new normal for a bit. Life will not pass you by, and you could very well unknowingly save someone else from losing theirs.

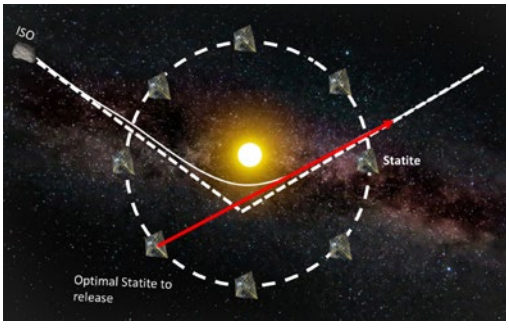
Stay safe, stay healthy, and God bless our healthcare teams of heroes. **PCB007**

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

To Catch an Interstellar Visitor, Use a Solar-powered Space Slingshot

In 2017, a telescope in Hawaii detected our first celestial visitor from another solar system—a big deal, since we haven't quite figured out how to visit them ourselves yet. Oumuamua, the cigar-shaped interstellar object (ISO) whose name roughly translates to "first distant messenger" in Hawaiian, will certainly not be the last visitor to pass through. Even a tiny fragment traveling a long way for a short visit provides a tremendous opportunity for scientific discovery. But we will have to catch it first.

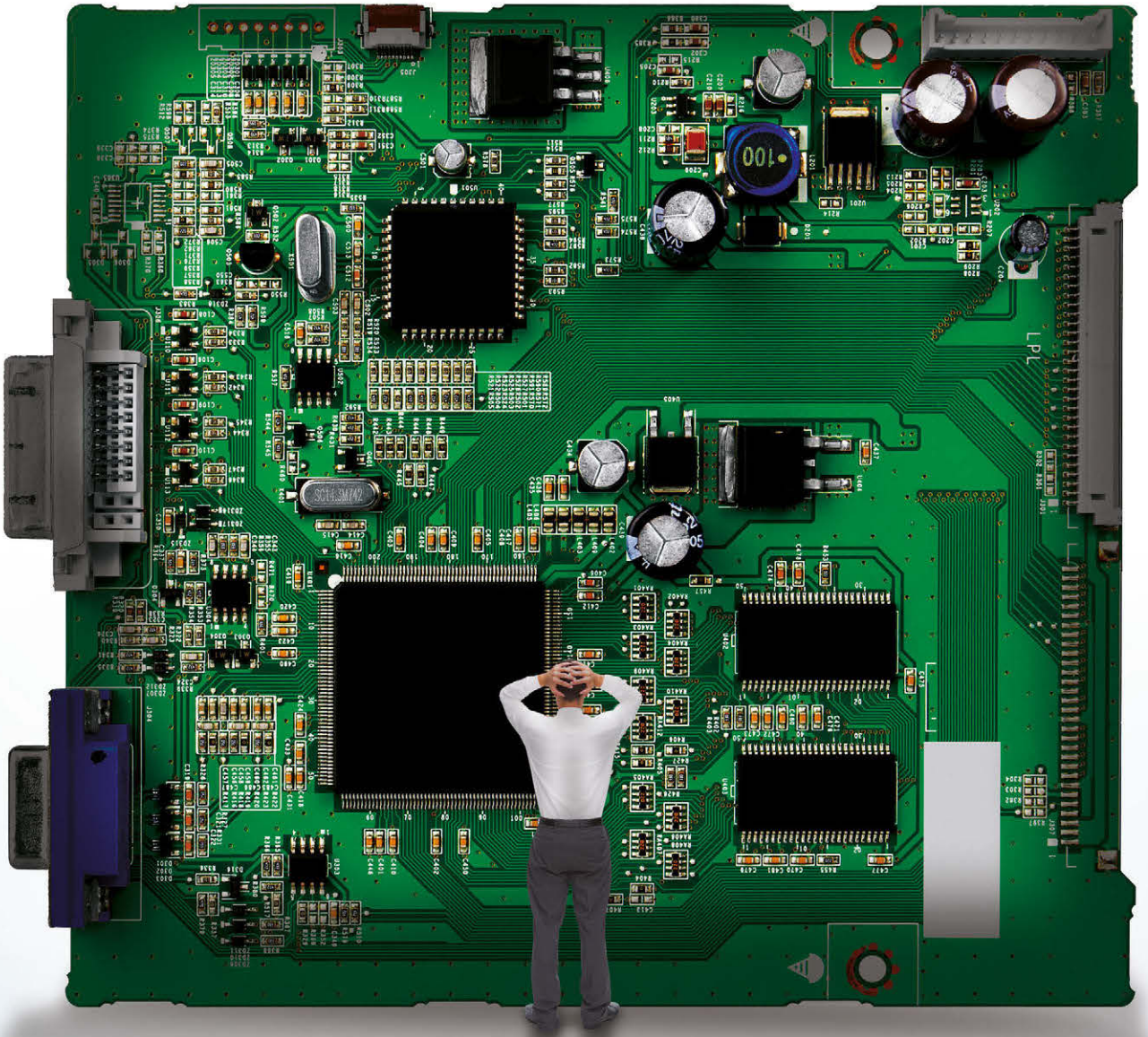
Richard Linares, an assistant professor in the Department of Aeronautics and Astronautics (AeroAstro) at MIT, developed a concept for a "dynamic orbital slingshot for rendezvous with interstellar objects." He outlined his idea in a research proposal that was recently selected as a Phase 1 study in the NASA Innovative Advanced Concepts (NIAC) Program.



"There are a lot of fundamental challenges with observing ISOs from Earth; they are usually so small that light from the sun needs to illuminate it in a certain way for our telescopes to even detect it," said Linares. "And they are traveling so fast that it's hard to pull together and launch a mission from Earth in the small window of opportunity we have before it's gone. We would have to get there fast, and current propulsion technologies are a limiting factor."

To eliminate these barriers, Linares proposes using "statites"—or static satellites—enabled by a solar sail constructed with just the right mass-to-area ratio. A thin-enough sail with a large enough surface area will create a propulsive force that allows the statite to hover in place indefinitely. Linares envisions deploying a constellation of statites to act as interstellar watchdogs along the edges of our solar system, lying in wait until roused by an ISO crossing our threshold.

(Source: MIT News)



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PCB Prototyping During a Pandemic

Feature by Matt Stevenson
SUNSTONE CIRCUITS

Facing unprecedented challenges, Matt Stevenson examines best practices for sustaining supply chains and meeting customer expectations.

A Big Change Overnight

Almost every aspect of our personal and professional lives has changed in the wake of COVID-19. How we do everything—from buying bread to conducting business meetings—constantly evolves, and the daily routine bears less resemblance to normalcy each day, both at home and at work.

The new abnormal has upended our industry and forced us to confront challenges never before faced. Many are unsure about the relative safety of any location other than our own homes, making on-site work seem risky for our employees. State and local governments race to establish guidelines to protect the public, but they change regularly and often leave businesses with questions about how to comply.

While our customers who are hit hardest by economic conditions pull back, others need more from us than ever. For example, businesses supplying electronic devices to the frontlines of the pandemic response rely on the timely delivery of quality boards as integral to their supply chains.

To keep our staff safe, stay in compliance with government mandates, and keep our commitments to customers, we would have to fundamentally change the way we work and be ready to adapt when conditions inevitably evolve.

How do we keep our business operating and sustain the quality of service in this environment?

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The Orders Keep Coming, and the Phone Keeps Ringing

Developing best practices for supporting remote work and socially distant manufacturing—on the fly during a pandemic—would not be easy. For that first week or so, circumstances were changing every couple of hours. Everything was a distraction, and no one knew when the next shoe would drop, making it the most challenging situation our leadership team had ever faced by far.

We knew our organization's pre-pandemic state of preparedness would inform our response to the rapidly changing environment. As we assessed our "go forward" strategy in those first hours, these questions were top of mind:

- Is our communications technology infrastructure capable of supporting an exponentially higher number of remote workers?
- Will our cybersecurity measures be ready for the increased threats that often accompany widespread crisis?
- Can we quickly adapt our manufacturing facility safety protocols to protect staff from infection?
- Do we operate with enough agility to make necessary process changes without sacrificing the quality of service?

Though these seem like binary questions, they are not. Being prepared for an emergency and being prepared for this emergency are two different things, so we proceeded with an open mind, ready to adapt in each of these areas as circumstances required.

Working Together Apart

As a manufacturer, we had to handle two separate solutions for our work. Those who could work from home needed protocols and tools. Those working on the manufacturing floor needed alterations to our practices that would keep them safe and productive.

The human element cannot be ignored in a situation like this. Moving staff from their offices into home offices involves more than just reliable internet. Everyone would be in a different environment with its own unique challenges, so we kept that top of mind as we made the transition to remote work.

First, we got the teams in sync, assigning immediate response tasks, and establishing workflows to accommodate a dispersed workforce. We brought customers into the loop at the same time by updating our website and sending out regular email notifications to keep them updated on how changes will impact them. We wanted them to know that we were working, but that some of the changes would affect how we interact.

For the employees working from home, across all departments, we already had everything in place in terms of technology and process. The organization has always been prepared to shift work off-site in the event of an emergency, so the big challenge was helping people acclimate to a different work environment. Would PCB and customer support quality be impacted if our service team could not walk down to the production floor to look at a board?

With the entire state under stay-at-home orders, daily remote work happens while locked in the house with spouses, children, and even extended family members. Recognizing this as a potential issue, we keep team meetings short and stagger work schedules to serve client needs and provide staff the opportunity to work when their full houses are less active.

Having the necessary virtual private network (VPN) infrastructure in place to allow remote workers to connect to the network was key to scaling the remote workforce smoothly.

Maintaining Data Security

We have always taken customer data security seriously, and that is reflected in our proactive approach to cybersecurity. We adhere to National Institute of Science and Technology (NIST) cybersecurity guidelines and follow Federal Acquisition Regulation (FAR) and Defense Federal Acquisition Regulation Supplement (DFARS) requirements as we implement compliance to these standards. In addition to third-party penetration testing and monitoring of our systems, we began reinforcing previous training on how to avoid phishing emails and other cyber scams.

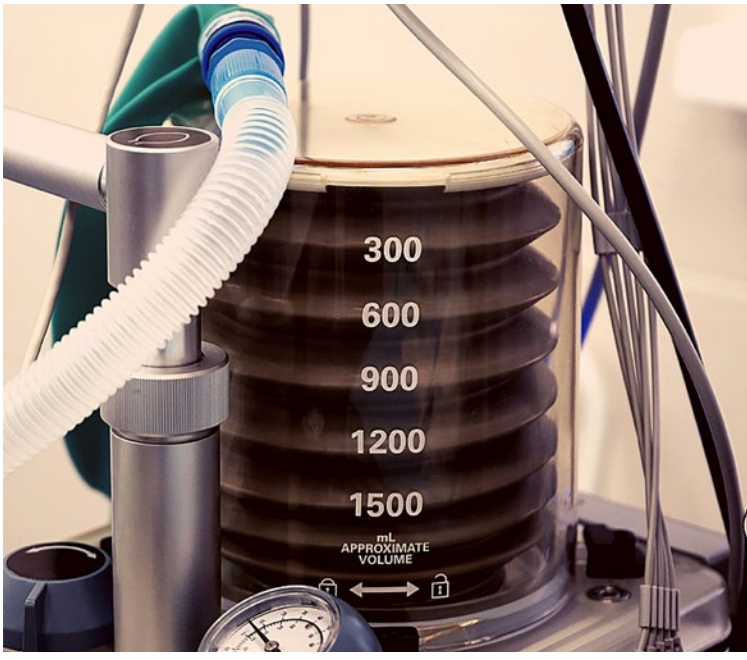
Skills-based training for staff is the key to maintaining data security. Anyone who can log into the domain or back-end system should be invited to do this type of training. We give participants quizzes on the material and even distribute false phishing messages to see if people fall for it. These drills could seem like traps, but our employees appreciate them, especially now that they are using the knowledge to protect their home networks as well.

Not Everyone Can Work From Home

After design, PCB manufacturing has to be done on the factory floor. Keeping our production crew safe on the floor has always been our top priority. The pandemic requires some enhancements.

Safety guidelines from state and federal agencies are always evolving and often conflict, so we continuously err on the side of enhancing safety, even if it complicates production. We routinely update guidelines and procedures to enhance the protection of the production team and minimize disruption.

Protective measures include adapting our production workflows to accommodate distancing guidelines and having key staff observe production to ensure six feet of distance between each person. We also conduct regular employee interviews to determine the likelihood of third-party exposure. We request anyone even suspected of having contact with the virus to self-quarantine. Those showing signs of illness, even allergies, are asked to go home on paid leave.



We also understand that during times of prolonged stress, employee wellness is about more than distancing guidelines and hand sanitizer. Some members of our team feel it is too risky to come in even with the safety measures in place, so we give them extended leave without penalty.

Prioritizing employee safety in this situation has enhanced our ability as an organization to respond to it. We communicate and train on new protocols for both remote and on-site staff quickly and effectively. Everyone at Sunstone is so far healthy, employed, and able to care for their families.

Continuous Adaptation Is the New Continuous Improvement

If you've already established a quality management system (QMS) and even achieved International Organization for Standardization (ISO) 9000 certifications, you will have a leg up during a crisis.

A good QMS helps keep you focused on exceeding customer expectations and creating value in every aspect of the production pro-

cess, constantly evaluating evolving customer needs. An established, holistic approach to the manufacturing process means you treat each production component as part of a larger production ecosystem and make it easier to adapt to individual processes and continue to deliver quality.

For example, the interaction between our service and production teams is vital to our manufacturing process. When we started working remotely, there really was some uncertainty about the service team not being able to visit the floor to inspect a board with a potential issue or peek around the cube wall to ask a question about a customer design.

We innovated. Production managers who want input on a board snap a pic on their phone and send it to someone on the service team. Empowering the team to make these on-the-fly process adjustments keeps production moving and ensures quality.

To stay successful as a manufacturing company in this environment, you have to always be adapting and improving. Not doing so leaves you vulnerable to changing conditions, ill-prepared to face new challenges, and less able to deliver quality products and services to your customers.

That innovation is as much in culture and organization as it is in tooling and process. Our long-running, employee-led committees, such as the Wellness Committee, were important parts of our decision making and execution.

Meeting Changing Customer Expectations

In this environment, assurance is a big part of providing value and delivering quality. A lot of our active customers are building products vital to dealing with the pandemic, so reliability is key. An automated reply or a confirmation number is not enough for them right now. If you are trying to produce medical devices on an accelerated timeline, you can't toss an order into a digital void and hope someone 5,000 miles away builds your design to specification or helps resolve potential issues with it.

Our quote volume has stayed roughly the same since the pandemic took such a big bite out of productivity, but the way we receive quotes has changed. Historically, two-thirds of our orders were made online and only resulted in human contact if there was an issue. Now, two-thirds of the quote requests are phone calls and emails sent to sales and support.

By developing and adhering to best practices in a crisis, you can demonstrate the ability to dependably deliver quality and service and become the strongest link in your customer's supply chain. **PCB007**

Matt Stevenson is the VP of sales and marketing at Sunstone Circuits.

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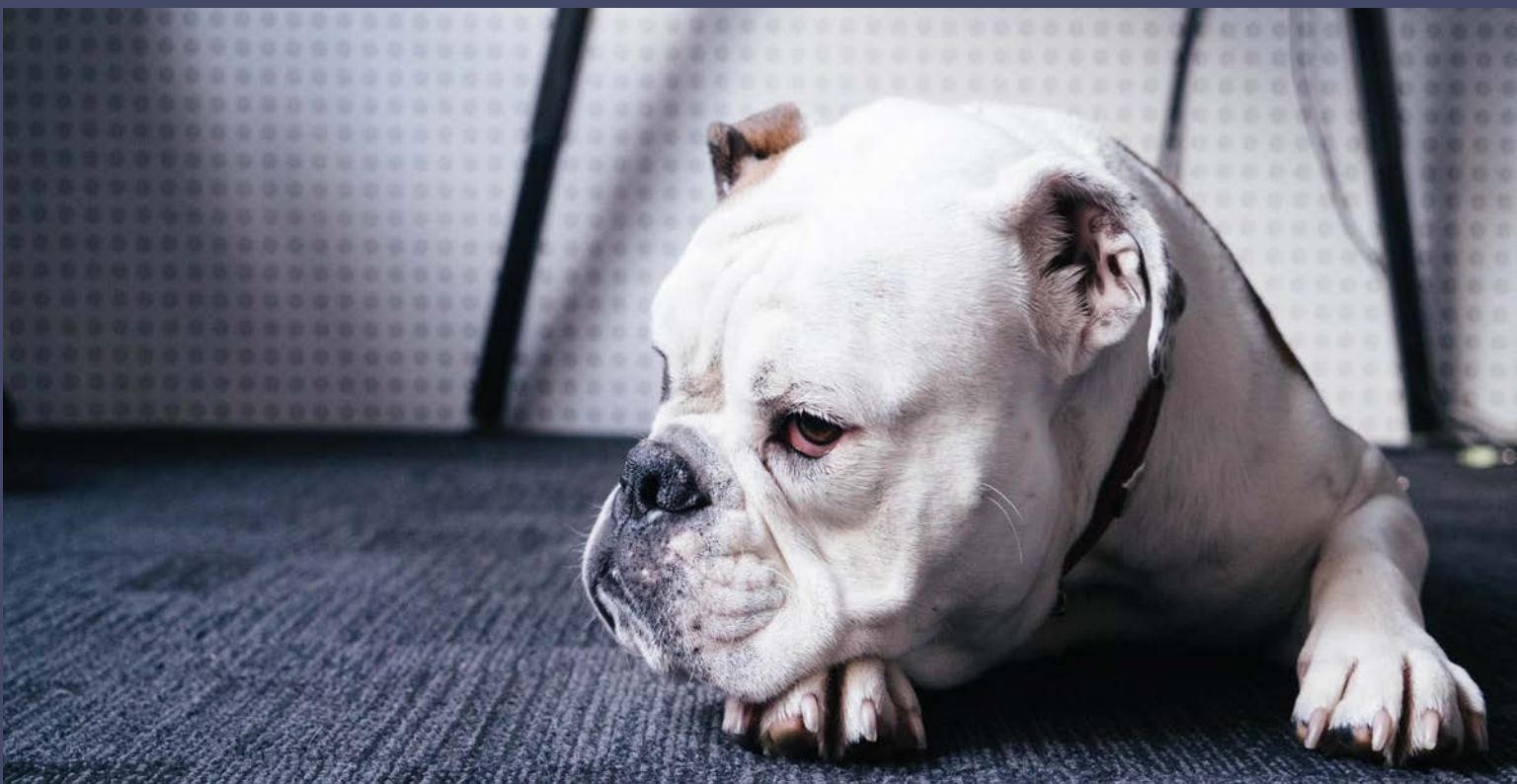

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It's the Little Things

Flex Talk

Feature Column by Tara Dunn, OMNI PCB

Let me share a personal moment. Shortly after we started staying home and socially distancing, I came down the stairs from my home office and noticed something colorful on the sidewalk. Keep in mind that I live in Minnesota, and anything colorful is extremely eye-catching while in stark contrast to the winter grass and leafless trees. Looking closer, someone had colored big, beautiful hearts all along my sidewalk and driveway, leaving a fun message at the end of all those colorful hearts. That simple act of kindness made me smile for days, anytime I looked outside and saw the chalk drawings and messages. It also reminded me that in the midst of uncertainty and life being unsettled, one small thing could make a significant impact.

Sidewalk chalk is a fun example of neighbors supporting each other, and there are countless examples of people in our industry doing the same. Designers and engineers are working around the clock on new designs and products to support the medical industry, manufacturers are shifting capacity from other products to be able to support this surge in demand, and chemistry manufacturers are shifting resources to provide disinfectants. You do not have to look far to find stories of ways our industry comes together to support each other.

IPC, as always, strongly supports and advocates for our industry. Among so many other things they are doing to provide support right now, IPC hosts a weekly call, both providing information and facilitating discussion between business owners and executives. Maybe even more memorable to me than all of those colorful hearts in my driveway is the way that people are openly sharing and discussing best practices, lessons learned, and general thoughts and opinions on how to deal with issues of worker safety, social distancing, and workforce-related challenges through this unique situation—even with their competitors. This collaborative effort renews my passion for

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the electronics industry and makes me proud to be part of this community.

As time passes and stay-at-home orders are starting to be lifted, the way we work and do business throughout the electronics industry is going to look different, and I don't think any of us really know exactly how that will play out. Will more people work from home? Are people tired of working from home and eager to get back to the office? Will pay cuts and furloughs be temporary or long-term? How will business travel be handled? When will we be able to meet face-to-face? What will trade shows and conferences look like going forward?

There are so many unknowns, and I certainly do not have the answers or even a solid, educated guess as to how things will roll out over the next few months. But what I can do is to remind myself and encourage others to remember two things. First, the big impact that even the little things can have, and second, when things are overwhelming or uncertain, focus on how you can make small impacts.

The colleague that asks to move a conference call to 6:30 a.m. or 8:00 p.m. to help relieve some of the stress of juggling working from home with young children and home-education will surely appreciate the small act of kindness when that request is accommodated. On that topic, when family members accidentally walk into the video call, say hi and move on. Yes, that was me; I completely mortified my son by barging in on his video call with new co-workers.

The manufacturer that must deliver the news that your product is being delayed is likely dealing with many pressures that you are not aware of. A moment of kindness, a deep breath, and a collaborative discussion on how to best solve the problem will absolutely be welcomed.

Salespeople historically rely on a significant amount of face-to-face communication—whether that is on-site meetings with customers, "lunch and learn" technical trainings, trade shows, or social engagements. These things have all changed as well. Take a minute to help those salespeople that support you understand the best way to communicate while we can't meet in person. Trust me; that is appreciated.

Employers are working hard to set up safety guidelines as manufacturing re-opens, and people start coming back to work. How can you support those efforts? Feedback and collaboration.

Many in the electronics are now offering free webinars, training sessions, consulting, videos, and blogs, stepping in to help those with a little extra time gain some valuable training, as well as those who are working from home have access to technical information.

The list could go on and on. All these little things, collectively, will surely have a big impact throughout the industry. This is just one reminder that our industry is strong and resilient, and when things are hard, we will continue to be successful by working together. **PCB007**

Tara Dunn is the president of Omni PCB, a manufacturer's rep firm specializing in the PCB industry. To read past columns or contact Dunn, click here.


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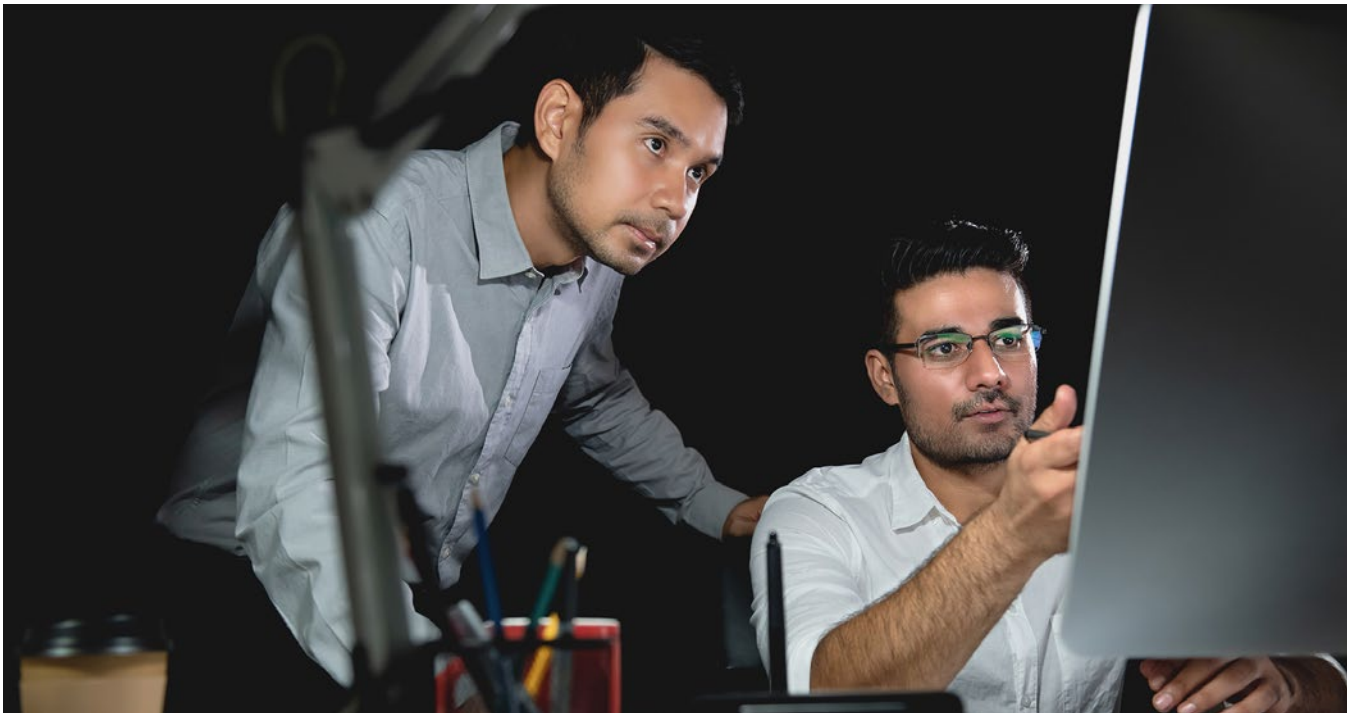

An Optimistic Look at Resource Optimization Into the Future

Feature by Paul Benke and Michaela Brody
ZERO DEFECTS INTERNATIONAL

The current global pandemic situation will not only have long-lasting economic effects but should lead to more fundamental changes. Globalization allowed companies to farm out manufacturing all over the world and deliver their products to markets on a just-in-time basis, bypassing the costs of warehousing. The COVID-19 pandemic has highlighted the value of organizing resources in a way that preserves the continuity of operations when world-changing events threaten the established routines.

The current COVID-19 pandemic has added an impetus to all of the outsourcing dynamics. Employee availability has been impacted. Even though most PCB fab and assembly companies have been deemed as "essential," the logistics alone make it challenging. Employees may be restricted due to social distancing, or they are just unwilling to report to work for even an essential business. In the short term, it is next to impossible, given the skill sets and training required. The CAM service companies whose focus is only PCB engineering have created working structures to guarantee continuity. Fifteen or 20 years ago, it was necessary to build in redundancies and back-up in India to compensate for the underdeveloped infrastructure, power failures, etc., which has given them a unique level of preparation for today's lockdown environment.

Concerns

Any adaption or implementation of a new or different process is rife with objections. The concerns include:

1. **Security and confidentiality:** The security of data is absolutely very strong if you work with a reputable firm with a solid infrastructure. Multinational companies are now outsourcing medical, insurance, financial and technological work to India. Medical records demand especially high security.
2. **ITAR jobs:** These jobs restrict processing by foreign nationals. Most of the PCB fabrication customers process some

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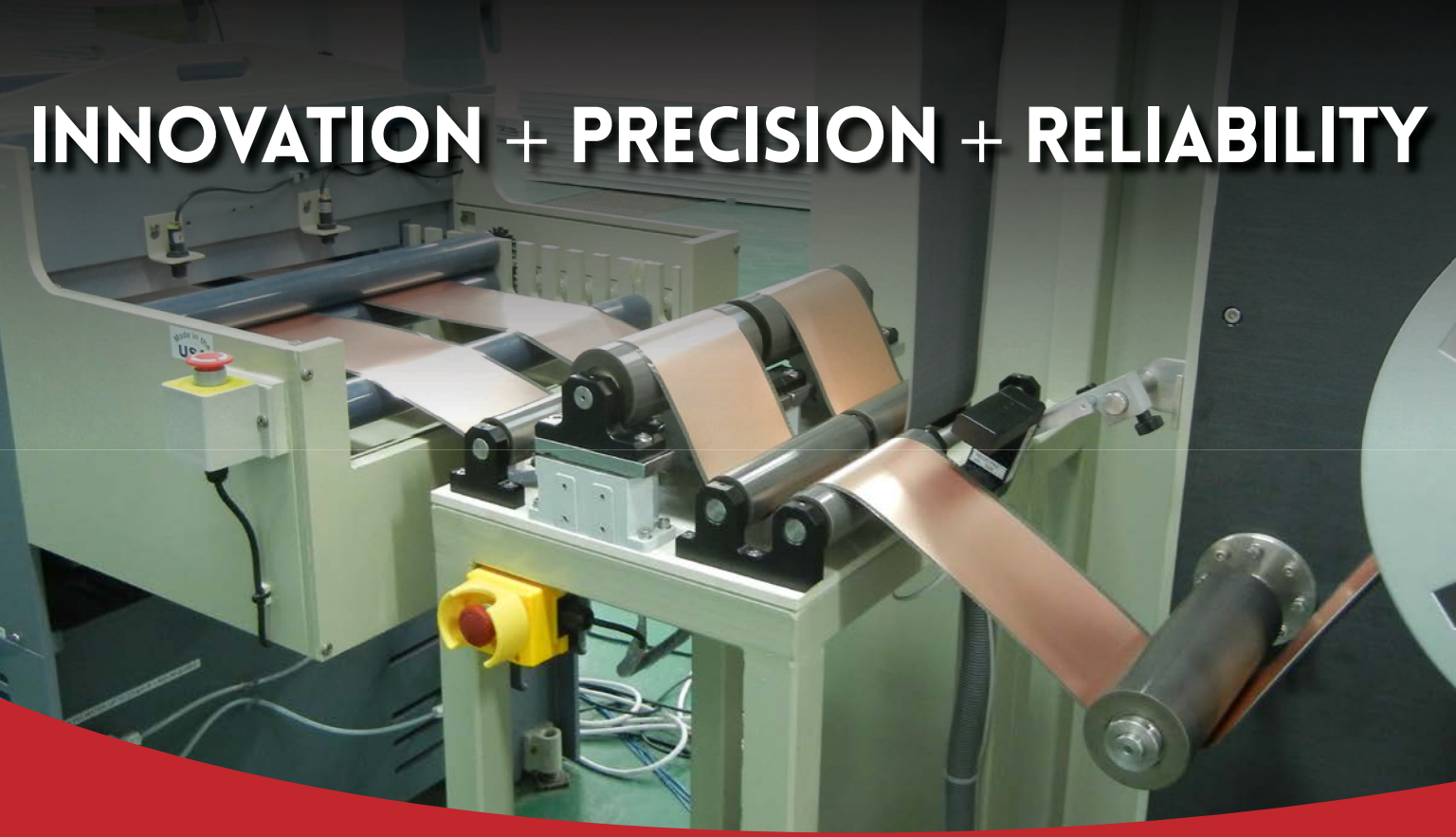

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percentage of jobs with ITAR designation. Multiple customers have been successful in receiving TAA approval from the U.S. Department of State. Engineers in India can legally process ITAR jobs for our North American customers.

3. **USA workers:** The reality is that there are not enough trained persons with the level of education—preferably community college—and experience to provide the scale that is needed for a U.S. manufacturer to grow. Companies cannot recruit, train, and retain workers. This condition has, in recent years, become more important than the potential cost savings.
4. **Resistance to change:** This has been overcome, much like the acceptance of materials and equipment made overseas and the increased prevalence of offshore PCB manufacturing to accommodate larger volumes with lower prices.

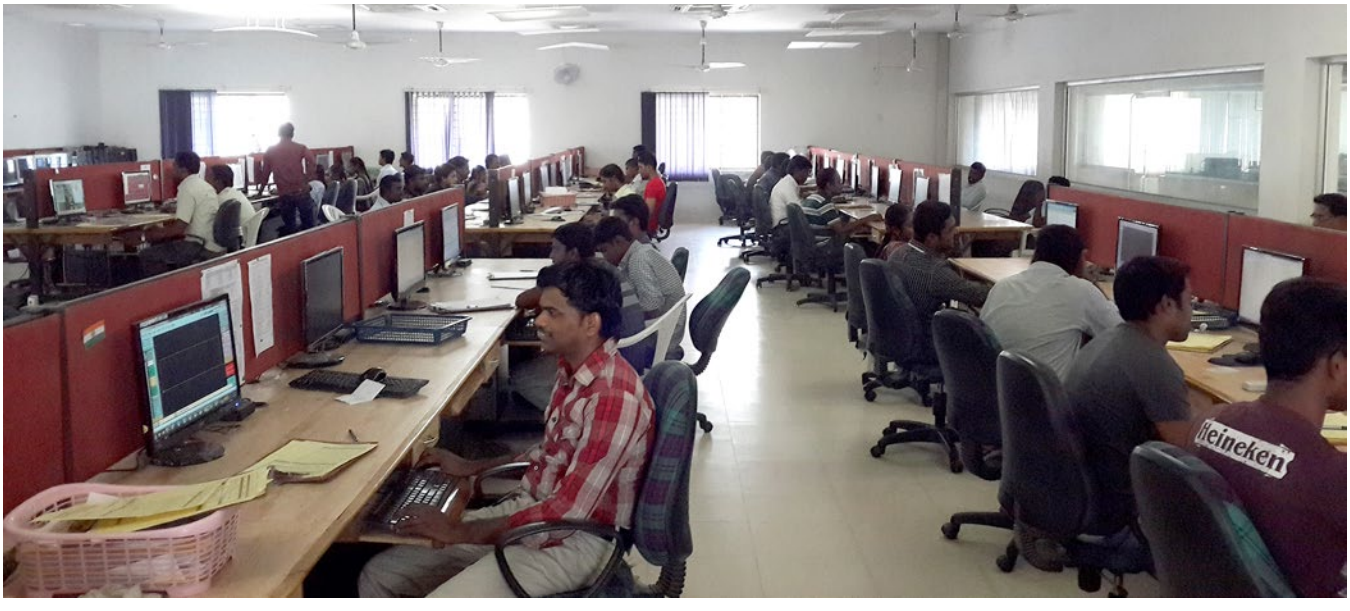
It can be noted that the very largest of the world's multinational PCB manufacturers have front-end engineering work done offshore in their own dedicated "in-house" operations. This includes European, North American, and—of course—Asian PCB companies.

Skyla's Team

When the Prime Minister of India announced a "lockdown" at the end of March, Skyla's team of engineers were relocated to their homes and continued working remotely without any interruption to service. Some smaller CAM entities did not have the immediate capability, or—in some cases—no capability to continue operations. In Southern India, internet connectivity is not much different than what we enjoy in the U.S. Other states and regions in India have minimal capabilities. A lockdown with 24-hour notice shut them down.

The Skyla team has reconfigured working hours to accommodate the many cases of additional demand due to U.S.-based employee unavailability or instability. Fortunately, on the CAM supplier side, the few other major well-established companies have been and are also very likely to have prepared to expand capacity and have engaged in-place safeguards to maintain security.

For the most part, there has not been a perceptible slow-down in business activity. This can change, of course. In the short term, all resources are in play. PCB companies that had outsourced to small, under-resourced India providers need to cover their bases. Companies that have been doing all the work internally are looking to establish engineering resources to augment existing capabilities. In some cases, it may not have been previously known that ITAR work can be outsourced to qualified/registered companies under controlled conditions.



Benefits

Given the scale of financial market losses the world has experienced since February, companies are likely to discard the just-in-time model and favor a supply chain that is closer to home and filled with redundancies to protect against future disruption. The result may be smaller near-term profits but can render the entire system more resilient.

Similar protective redundancies can be realized by utilizing a well-established offshore computer-aided manufacturing (CAM) service. Twenty years ago, CAM services from India were introduced to the PCB industry as a cost-effective supplement to in-house front engineering. Top management embraced this activity as they saw the need to become or remain competitive, especially against offshore manufacturers. The CAM managers within a PCB fabrication company found this to be a way to ensure consistent output or respond to surges, especially as talented CAM labor became scarce.

Additional benefits were also seen, including:

1. Better timing: Sending jobs late afternoon and receiving them back the following morning due to half-day, time zone differentials.
2. Continuity and dependability: There's never a day of sick leave or other unscheduled, missed time.
3. Higher quality and fewer errors: Due to the skill level of the operators (college degrees) and their focus only being on PCB CAM and the quality infrastructure that is built to have a dynamic specification or work instructions.
4. Wage economics: Allowing for quality checkers and additional redundancy.
5. Stability: Operators assigned to one client so that they become familiar as if they were in the factory.
6. Virtual training and web capabilities: Recently, these have been enormously helpful.

Looking Forward

The PCB assembly industry is the next logical segment to embrace offshore engineering for the very same reasons that their PCB counterparts have benefitted. There are many time-consuming and relatively manual operations, including:

- DFM/DFA: Critical to manufacturing and often an afterthought with limited domestic capability
- BOM scrubbing: Renaming and removing parts from the submitted document in preparation for manufacturing
- BOM to CAD comparison: Matching components in the BOM against CAD for parts and quantity
- Polarity auditing
- Fiducial marking
- Pick-and-place machine programming
- Shop floor assembly document

Additional "back office support" activities can be outsourced, including quote preparation, purchase order planning, and placement and logistics support. In fact, the whole supply chain can be streamlined. As with the selection of a basic CAM services provider, the process can be very similar to that of direct employee hiring—reference checking, trial performance, and all appropriate due diligence.

Clearly, this COVID-19 pandemic is the greatest global crisis of this century and perhaps of the lifetime of most of the 7.8 billion people on Earth. The financial and economic crisis will linger long after the immediate health issues have subsided. Accepted "norms" and the rules we have lived by will no longer apply. Some unprecedented actions have taken place between February 2020 and now. For example,

- Some people experiencing homelessness have been moved into housing
- Utilities continue to be supplied when the bills cannot be paid
- Paid sick leave has been extended more broadly
- Student loans have been frozen and may be totally suspended
- Most people are wearing face masks and standing six feet apart
- An unprecedented number of technical workers who—considered "essential"—are successfully working from home

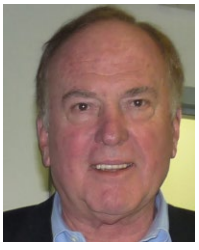
- Meetings are "virtual" using Zoom or other equivalent software
- Drones are being used for pharmaceutical deliveries and other applications

If we carry this forward to the industry in which we operate—PCB fabrication and assembly—just think of the possibilities:

- Onboarding and new customer startup can be done by Team Viewer and Zoom
- Periodic quality meetings can be conducted to ensure that specifications are up to date and dynamic, including root cause analysis and corrective action
- Rules regarding "export" will be revisited
- Management will be able to scale quickly for new customers if more manufacturing returns to the U.S.
- Offshore service providers can be trained remotely without the need for visas and extended travel—in harmony with today's travel and cost limitations
- Drones can deliver quick turn boards or essential component, and supply chain costs will be streamlined
- Augmented reality will eventually take the place of new equipment install and training

Conclusion

When we come out the other side—and we will, at some point—there should be some long-term benefits for all persons including cleaner air, less traffic, stabilized greenhouse gases, better medical care, lower gas prices, and more. **PCB007**



Paul Benke is the CEO of Zero Defects International.

Michaela Brody is the president of Zero Defects International.

New Ultrafast Camera Takes 70 Trillion Pictures Per Second

The new camera developed in the lab of Lihong Wang, Bren Professor of Medical Engineering and Electrical Engineering in the Andrew and Peggy Cherng Department of Medical Engineering at Caltech, is capable of taking as many as 70 trillion frames per second. That is fast enough to see waves of light traveling and the fluorescent decay of molecules.

The camera technology, which Wang calls compressed ultrafast spectral photography (CUSP), is similar in some respects to previous fast cameras he has built, such as his phase-sensitive compressed ultrafast photography (pCUP) device, which can take one trillion frames per second of transparent objects and phenomena.

CUSP combines a laser that emits extremely short pulses of laser light that last only one quadrillionth of a second (one femtosecond) with optics and a specialized type of camera. The optics break up individual femtosecond pulses of laser light into a train of even shorter pulses, with each of those pulses capable of producing an image in the camera.

Wang says the technology could open up new avenues of research in fields that include fundamental physics, next-generation semiconductor miniaturization, and the life sciences.

A paper describing the technology, titled, "Single-shot ultrafast imaging attaining 70 trillion frames per second," appears in the April 29 issue of *Nature Communications*. Wang's co-authors include Peng Wang, postdoctoral scholar in medical engineering, and Jinyang Liang, formerly of Caltech and now at the National Institute of Scientific Research in Quebec. (Source: Caltech)

Plating Simulation Raises Yield and Profitability

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It's All About Being Prepared

The PCB Norsemen
Feature Column by Raymond Goh, ELMATICA

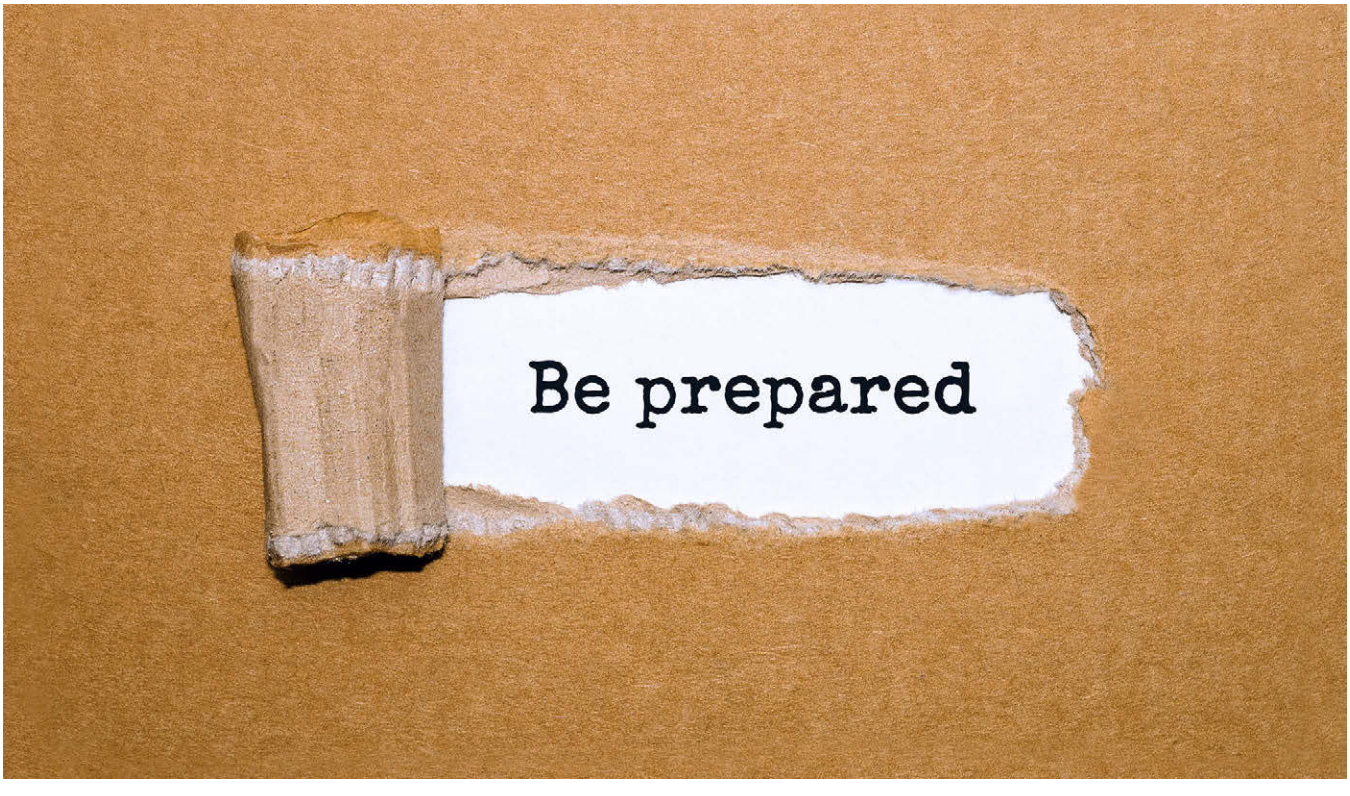
The last five months have been more out of a thriller blockbuster movie than everyday life for all of us. COVID-19, known globally by now, and buzzwords like social distancing, isolation, home office, antibac, and lockdowns, are humming in every ear. The world has changed; that's no secret. The interesting thing is how it will affect us in the future.

The world has reacted. Actions have been taken to prevent or slow down the virus from spreading like a pandemic. Will it continue, and for how long? Nobody can tell, until a vaccine is available, or the virus suddenly disappears. I believe we have to live with these uncertainties for some time.

Humans tend to stick to habits. Will the same happen to PCB production? Or will the result of the COVID-19 pandemic be a new, global PCB manufacturing base with a stronger focus on risk management, even better-planned production lines, more automated manufacturing, and humans being replaced by robots in production, which are less vulnerable when a pandemic strikes?

When Times Are Poor, We Find Our Strength and Innovation Happens

At the moment, staying safe and keeping ourselves healthy is the priority. That is the same for an organization. At Elmatica, we



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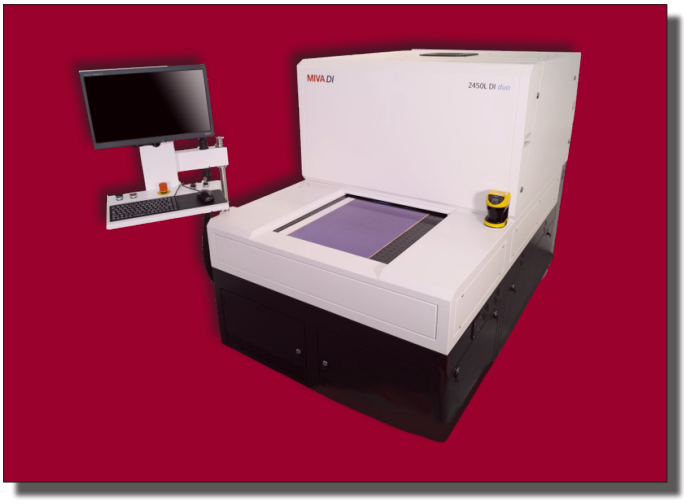

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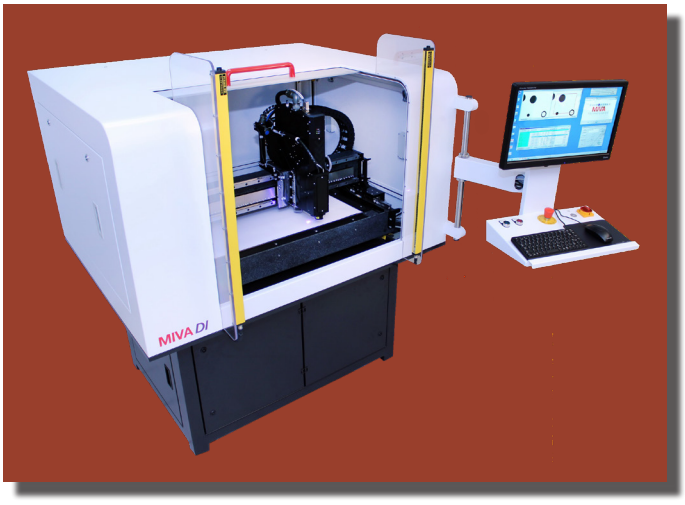

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have taken our precautions to stay afloat, and being able to survive the economic slowdown, brought about by the pandemic, is currently the focus.

Let's fast forward and imagine six months or a year down the road, when this pandemic is over, and a vaccine is found. What will the world look like then? We need to be ready for the future, not simply business as usual. We need to be ready for another crisis. It's when times are poor that we really find our strength, our core business, what we excel at, and what needs improvements.

Unprecedented "pauses" like this also provide an opportunity to look into what the industry should be doing now to prepare for future challenges. There is a Chinese saying that states, "When the situation is poor, change in order to progress (穷则变，变则通)." It is during the most critical moment of challenge that a change or innovation is brought about. That is how we progress and continue to advance and stay relevant.

Unprecedented "pauses" like this also provide an opportunity to look into what the industry should be doing now to prepare for future challenges.

Production Lines Shifting Focus

I came across an article recently about a production line producing respirators that was shut down due to the unavailability of raw material caused by travel bans and flight cancellations all over the world. However, innovative individuals decided to 3D print the parts locally and kept the production line running to support the medical industry fighting the virus.

Over the last few months, we have seen an increase in medical production, not only as a vital and life-saving production in the fight against COVID-19 but also in the innovation of new products. Medical production is naturally and thankfully prioritized by all industry partners, but sometimes, hard times force new and innovative products.

To see good examples of how a crisis makes innovation arise, look at many of our manufacturing partners or customers, shifting their production lines and turning it into a supply chain for what is needed, such as masks or other protective equipment. Even if a crisis is hard to tackle, news like this shows the good in humans and that the industry can work together collaboratively, side by side. Let's hope this is one of the good things we still will prioritize and bring along also when the crisis is over.

Pre- and Post-COVID-19 Changes

What are the changes we might see after the pandemic? Here are some of my thoughts.

For the last decade, China has been the world's manufacturing base. Talking about printed circuits alone, China produces more than 50% of the world's printed circuits output. The heavy reliance on Chinese production will gradually change. Customers will start sourcing for manufacturers outside China, and Southeast Asian manufacturers will benefit from this gradual re-distribution of businesses.

In February, when China was in lockdown, all factories were shut down. Many customers were waiting for orders, and a lot of questions and stressors appeared. When would the orders be received? Can the production be shifted to other manufacturing sites? When the pandemic reached Europe and the U.S., the whole world shut down. Demand reduced, as did the panic of not getting orders out of China.

More Robots Than Humans

At some point, we will see more robots running in the factory than humans. The point here is not about where the pandemic center is; the concern is what if China was not able to contain the pandemic and the lockdown is indefinite? When the COVID-19 situation is over, we should expect people to start reviewing

their supply chain and look for backup sources. This will eventually trigger a re-distribution of supply bases, and China's dominance of the printed circuits supply chain may be challenged sooner than we expect.

Printed circuit manufacturing has been a labor-intensive industry for decades. In recent years, we have seen a slow but steady increase in the use of automation in the factories amid an increasing labor cost. Industry 4.0 has also brought about the implementation of a smart factory. We can expect that factories will hasten the pace to convert and reinvent themselves through the use of AI and algorithms to plan and schedule the production, as well as more sophisticated automation by using robots and unmanned transporters to further reduce the need of manpower. There may also be an increase in the use of automatic optical and visual inspection equipment to improve yield and early detection.

As the factories advance, the requirements for operators will also change, as the factories will require a higher education level of operators to control the systems running the factories, instead of operators physically carrying out manual work. The demographics of recruitment requirements for printed circuits will start to shift.

Risk Management and Procedures for Crisis Handling

All of this will eventually help reduce the intervention of humans directly in the production, improving the factories' yield and predictability, and at the same time, reducing the risk of the factories' operations being jeopardized by the impact of a pandemic. Social distancing or segregation of the workers can easily be implemented in the factories. Operators can remotely control the systems while not on-site. This allows the factory to continue operating during a crisis of such an extent.

Business is expected to slow down during this period. Organizations should take the opportunity to regroup, reorganize, set a new focus, and implement new policies to help them get ready for a new business environment in the future. Most organizations had placed risk management and the work of the safety committee at low priority during good times. After this crisis, organizations will take a more serious approach towards risk management and setting up procedures to handle different scenarios of crisis.

The point here is to always be prepared. Being prepared allows us to handle exceptional situations when it occurs.

The point here is to always be prepared. Being prepared allows us to handle exceptional situations when it occurs.

Do You Have a Duo Source Set Up?

Organizations should align their risk mitigation strategies along with their business strategies, such as having a duo source for their supply chain, having an alternative source of supply in a different geographical region or country, or setting up modular manufacturing operations that can be operated from their own. The key focus is to be prepared for the unexpected. Having an operation ready to scale up or break up into cellular operations to continue business when others cannot makes the organization more resilient to handle major external challenges.

Conclusion

No one knows what the future will look like but being prepared has never been wrong; that is the case in these unprecedented times as well. **PCB007**

Raymond Goh is COO of Elmatica. To read past columns or contact The PCB Norsemen, click here.

The Rush to Remote Work: Amid COVID-19, Businesses Fail to Employ Necessary Safety Nets

Feature by Ken Michael
DOX ELECTRONICS INC.

The COVID-19 pandemic made everyone rush to start working from home. Most of this quick-start remote work was launched without considering the employment of necessary security features, such as multifactor authentication, anti-virus programs, and safety nets for internet of things (IoT) devices. As a result, many businesses are being hacked and paying the consequences for failing to be prepared for employing an instant remote workforce.

Did You Forget the Safety Nets?

With nearly no notice, a multitude of businesses and employers were asked to continue operations with a remote workforce, the likes of which has never before been seen in modern history. Due to the global COVID-19 pandemic, businesses were either deemed "essential" or "non-essential" by our local governments.

Those that were essential were asked to keep working through the crisis despite the health risks. This has included many businesses such as grocers, truck drivers, healthcare professionals, postal workers, fast-food chains, and more. While most of these frontline workers must still attend work in their regular capacity, other businesses that were non-essential were forced to either shut down completely or find an alternative means for their work to continue. The obvious answer was using technology to produce an instant remote workforce.

With access to a computer and the internet, most businesses found their employees could continue working—at least to some degree—from the comfort of their own homes while under shelter-in-place or stay-at-home orders. While this modern technology has allowed many companies and organizations to stay afloat amidst the chaos of such an unprecedented time, many have overlooked the basics of security hygiene in the rush. This means many businesses gave up their proper security safety nets in exchange for a fast fix to keep moving forward.

Where's Your VPN?

Most business leaders now know that when working remotely, all of your devices should employ a virtual private network (VPN) to

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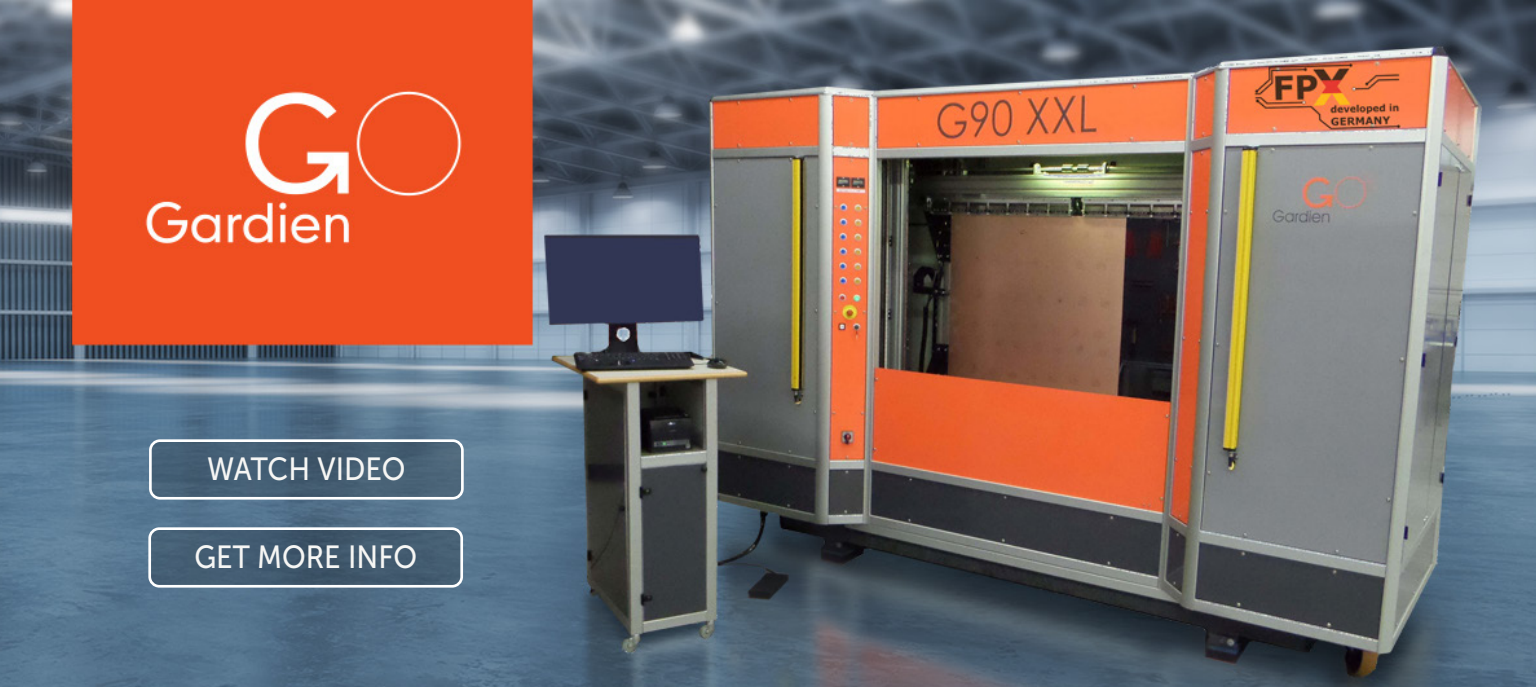

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help keep hackers at bay. It also provides a fast and reliable platform for your remote workforce to plow forward despite their location. Though many businesses may have offered up a VPN for their traveling salespeople, many companies failed to provide them to all of their remote workers when the COVID-19 pandemic began.

This failure can be dangerous, as many unfortunate organizations have already learned. While working from home without the cover of a VPN, people are working on computers with unsecured networks. Cybercriminals can easily take advantage of such unsecured networks to access your company's valuable data from personally identifiable information (PII), such as employee social security numbers to proprietary information and trade secrets that could cost your business millions of dollars or worse.

This is one reason VPNs are so vital to anyone working remotely. A VPN is a private network that can attach to a public network such as the internet to securely connect remote sites and users. The VPN uses a "virtual" connection routed through the internet from a business's private network (or a third-party VPN host) to your remote workforce. This VPN offers additional security for your business data by encrypting it so that it can't be read by a hacker.

Today's VPNs feature lightning-fast speeds, unlimited access for a multitude of remote workers, and advanced security, including military-grade encryption, privacy safeguards, and TrustedServer technology. Modern VPNs allow remote workers access to a business's intranet resources so they can continue to work as if they were at their office desktop. Furthermore, if your business conducts communications and/or online transactions, a VPN really is a must to ensure that your business remains private, and your data is secure even when your employees are working from home.

Once this health crisis subsides, you can continue to utilize your VPN to boost your business. Imagine allowing your employees the ability to flexibly work from home for any reason, such as caring for a sick child, while away on vacation, or while ill themselves. Additionally, you can continue to use it for your traveling salesforce.

Multifactor Authentication

Multifactor authentication is another security feature that should accompany the use of a VPN. This technology ensures that the people logging into your network are who they say they are. It works by requiring additional authentication from anyone attempting to access your company's information.

Computer users (your remote workers) are required to successfully present two or more forms of evidence (factors) to be given access to your business network. The first is something only your employees should know, such as their personal login and password. Now, we all know these can be stolen pretty easily by a seasoned bad actor, but that's where the second factor comes in.

After providing the first key pieces of information, multifactor software will ask for additional authentication, such as a one-time access code that is sent to the employee's mobile device. Once they provide additional information, your employees will be granted access. The odds that a cybercriminal could crack the login and password of your employee while also stealing their mobile device are slim to none.

Authentication factors can be implemented in multifactor software or applications in the four following ways:

1. **Something You Have:** Some physical object the user has in their possession, such as a secret token, bank card, key, etc.
2. **Something You Know:** Some bit of knowledge only the user would know, such as a password, login, personal identification number (PIN), etc.
3. **Something You Are:** A physical characteristic, such as biometrics, including voice patterns, fingerprints, typing speed, etc.
4. **Somewhere You Are:** This is the connection to a specific network or global positioning satellite (GPS) signal to authenticate your location.

Again, this will continue to be a valuable technological asset post-COVID-19. Before the pandemic, it was clear the move to remote work was already underway. According to a blog by HubSpot [1], the number of people who work remotely at least once each week grew by 400% in the last decade, and between 2017 and 2018, telecommuting increased by 22%.

Keeping Anti-virus Software Updated

In addition to employing VPNs and multi-factor authentication, your business will also need to ensure that all of its anti-virus software is updated in the office and for each employee's devices. Anti-virus software is designed to detect, prevent, and disarm (or remove) malicious software, such as viruses, malware, worms, and Trojan horses from your computer(s). Some anti-virus software also removes unwanted spyware and adware in addition to other nasty programs that could create problems for your organization.

Anti-virus software begins by checking all of your computer programs and checking them against known viruses and malware. It will also scan your computer for behavior that's indicative of an infection such as a new, unidentified malware. Anti-virus programs typically scan in three ways:

1. **Specific:** The anti-virus searches for known malware through a set of specific characteristics.
2. **Generic:** The anti-virus looks to detect malware that is variants of know malware with common codebases.
3. **Heuristic:** The anti-virus hunts for previously unidentified viruses and malware by seeking out suspicious activity or files.

Traditional anti-virus software has employed one scanning engine, but the most modern programs employ multiple scanning engines that offer a more robust scan to detect infected files, malicious apps, or security breaches. By running multiple anti-virus and anti-malware scanning engines simultaneously, you improve the odds of preventing attacks while filtering out any threats. This is known as multi-scanning.

In addition to the scanning engines, anti-virus programs contain virus definitions that need to be updated regularly. Every virus or spyware application has a unique code and identification information, which is known as a virus definition. Your security software uses these definitions to seek out, identify, and destroy invasive viruses, malware, and other malicious programs in your network. It's imperative to keep your anti-virus and anti-malware software up to date as new viruses, malware, spyware, and the like are discovered. This allows your security programs to quickly identify new threats.

This is true not just at the office, but for every remote worker as well. Ensure the computers they are working on, from their desktop and laptop to mobile devices, such as smartphones and tablets, have the latest anti-virus software available. A feature of some of the best VPNs available is that they will check the security posture of devices before allowing them to connect. For example, they can be set up to check for adequate anti-virus, firewall, and updates. This will help further protect your company's valuable data. Furthermore, it behooves you to send frequent reminders or auto-updates to these devices to keep your anti-virus updated.

Locking Down IoT Devices

While your employees may have embraced the convenience of smart devices in their homes, they may not realize that their IoT devices may be spying on them and your company as a result. By allowing your employees to work remotely, you're putting your company assets on the same Wi-Fi network as their IoT devices, which are constantly collecting data. This creates a new entry point for malicious individuals to attack your business. The good news is there are ways to reduce the intrusiveness of these devices to protect your employees and your business.

Think about all of the smart devices you or your employees may have in their homes, from smart speakers and TVs to thermostats, Ring doorbells, and video surveillance programs. Even smart pet feeders and litter boxes have the potential to spy on their owners. How?

Most IoT devices have microphones and

cameras that are always online. This is an invitation for hackers who can use them to spy on us. A bad actor can use these smart devices to listen to conversations or even watch us in our own homes. This can create not only a terrible intrusion into one's personal life but can wreak havoc on a company when someone is working remotely from home.

How can you prevent such issues? It begins with set up. Odds are, when you set up these devices, you don't read the entire privacy policy, but it's imperative that you check the default settings when you get started with your IoT devices. This allows you to find out what data is being collected and how it's being used. Take a few minutes while setting up your IOT devices to turn off unnecessary data sharing.

Consider your home router as the front door of your digital world. It is the connection between your smart devices and the internet, so it needs to be secure. Most people use the router provided by their internet service company, but they aren't always very secure. Ask questions about the security of the router they provide. If you're not happy with what they have to offer, many independent companies also sell routers. A move to more secure routers is a great first step in securing your employees from threats of IoT devices.

Next, name your router. Don't stick with the name the manufacturer gave it. Each router comes with an administrator logon for managing the router. Change both the login name and password for yourself. The other name and password you will want to change is the service set identifier (SSID), which is the network name (how it will appear as a Wi-Fi network). Make it an unusual name not associated with your address or street name so that it doesn't give away personal identifiers. In router settings, use a strong encryption method like WPA2 when you set up Wi-Fi network access. This further aids in keeping your network and communications secure. Be sure to set up a guest network for visitors that logs into a separate network that doesn't tie into your IoT devices.

Also, check to see if your router has been infected with malware. In 2018, the VPNFilter malware infected more than 500,000 consumer routers. IoT devices are connected with the internet via routers. Symantec has a free online tool to check if your router is affected by the VPNFilter malware [2]. Use this free tool to check your router from time to time.

Ensure your employees have done their homework about the IoT devices they have purchased or are considering for purchase. Tell them to check the privacy policies for each device and find out if the provider stores the data or sells it to a third party. Also, tell them to find out how updates are enabled on each device.

Other ways to increase the security of your IoT devices are to keep your software updates, conduct and audit of the IoT devices you are already using, and disable any features you may not need. Be sure to change all default usernames and passwords on your IoT products. Also, employ strong, unique passwords for your home Wi-Fi networks and device accounts. Two-factor authentication can also be set up for smart device apps associated with most IoT devices. Encourage your employees to use it for their privacy and the protection of your company data.

Breaches of the COVID-19 Crisis

Several businesses have suffered breaches among the coronavirus pandemic. According to TechCrunch [3], Princess Cruises posted a notification on its website in early March about unauthorized access to a number of email accounts that contained the personal information of employees, crew, and guests, including social security numbers, names, addresses, and information from government identification.

Silicon Angle reported that Samsung also experienced a breach [4]. According to the report, "A technical error resulted in a small number of users being able to access the details of another user." When Samsung became aware of the problem, it reportedly removed the ability for people to log in to the store on the website until the issue was addressed.

Zoom, an industry leader in modern enterprise video communications and digital meeting platform, recently experienced problems when the credentials to more than 500,000

users were stolen and sold on the dark web for less than a penny each. According to a piece by the Daily Mail [5], the credentials included personal meeting URLs, email addresses, and passwords, along with host keys that allow hackers to enter meetings and carry out "Zoombombing" attacks whereby questionable content is shared during Zoom meetings, such as racist or pornographic material.

The Post-coronavirus World

Once the dust settles post-coronavirus, it's expected many people will continue working at least part-time remotely. A remote workforce forecast by Global Workplace Analytics [6] suggests that the longer people are required to work from home, the greater the adoption we will see when it's all said and done with COVID-19. The employment of all of the above technologies will continue to serve businesses well by protecting their networks and most valuable data as remote work moves full steam ahead into the future. **PCB007**

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5. S. Liberatore, "More than 500,000 Zoom user credentials have been stolen and sold on the dark web for less than a PENNY each," Daily Mail, April 14, 2020.
6. Global Workplace Analytics, "What is your work-from-home forecast for after COVID-19?"

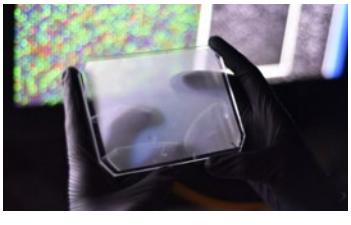
Ken Michael is VP of Dox Electronics Inc.

Crispr-based Diagnostic Chips Perform Thousands of Tests Simultaneously to Detect Viruses

Researchers have developed a new technology that flexibly scales up CRISPR-based molecular diagnostics, using microfluidics chips that can run thousands of tests simultaneously. A single chip's capacity ranges from detecting a single type of virus in more than 1,000 samples at a time to searching a small number of samples for more than 160 different viruses, including the COVID-19 virus.

Called Combinatorial Arrayed Reactions for Multiplexed Evaluation of Nucleic acids (CARMEN), this technology—validated on patient samples—provides same-day results and could someday be harnessed for broad public-health efforts. The work appears in *Nature*.

"The current pandemic has only underscored that rapid and sensitive tools are critical for diagnosing, surveilling, and characterizing an infection within a population," said Pardis Sabeti, co-senior author. "The need for innovative diagnostics that can be applied broadly in communities has never been more urgent."



To showcase the platform's multi-diagnostic capabilities, the team developed a strategy for rapidly testing dozens of samples for the 169 human-associated viruses that have more than 10 published genome sequences. The researchers tested this detection panel against 58 patient samples, using multiple chips. They additionally applied CARMEN on patient samples to differentiate between subtypes of influenza A strains and to detect drug-resistance mutations in HIV.

The team also incorporated detection mixtures for SARS-CoV-2—the virus that causes COVID-19—and other respiratory pathogens to demonstrate, using synthetic viral sequences, how the assay can be rapidly adapted to detect emerging viruses. (Source: MIT News)

MilAero007 Highlights

SMTA Europe's Electronics in Harsh Environments Conference and Exhibition: A Taste of Things to Come ▶

SMTA Europe's Electronics in Harsh Environments Conference has become a must-attend annual event; unfortunately, it also became another casualty of the COVID-19 lockdown. Originally scheduled to take place in Amsterdam in April, it has now been postponed until December 1–3. Pete Starkey reports on a preview seminar presented by SMTA Europe.

Dominate the Electromagnetic Spectrum: Lockheed Martin Cyber/Electronic Warfare System Moves Into Next Phase of Development ▶

The Consortium Management Group (CMG)/ Consortium for Command, Control and Communications in Cyberspace (C5), on behalf of the U.S. Army, awarded Lockheed Martin [NYSE:LMT] a Project Agreement to move into the second phase of development for the "Air Large" component of its Multi-Function Electronic Warfare (MFEW) family of systems program.

Defense Speak Interpreted: Why Is Defense Hyper Over Hypersonics? ▶

Perhaps you have noticed that the term "hypersonics" is now a buzz phrase in a big part of the Department of Defense research effort. What does hypersonic mean, and why is so much work needed in this weapons field? Dennis Fritz explains.

Lone Star Circuits Inc. Recognized by Raytheon With 4-Star Honors ▶

Lone Star Circuits Inc. was one of 86 companies recognized by Raytheon's Integrated Defense Systems business for 4-Star honors.

What It Takes to Be a Milaero Supplier, Part 3 ▶

The decision to pursue military and aerospace certification impacts every facet of the organization, and not every shop is prepared to make this transformation. In Part 3, Anaya Vardya explores what it takes to be a milaero supplier in the areas of purchasing and quality.

ACE Wins JPL's First-Ever Customer Appreciation Plaque ▶

James Hofer, general manager of Accurate Circuit Engineering, recently spoke to I-Connect007 about a customer appreciation plaque the company was awarded from JPL for their work on NASA's Integrated Solar Array and Integrated Solar Array and Reflectarray Antenna (ISARA). James talks about some of the challenges of the project and the role ACE played in developing the ISARA that is now orbiting the Earth.

Murrietta Circuits Appoints Kevin McCartney Business Development Manager ▶

Andrew Murrietta, CEO and co-owner of Murrietta Circuits, announced that his company appointed Kevin McCartney to the position of business development manager.

BAE Systems Wins DARPA Contract to Develop Machine Learning Analytics as a Service for Constant Global Situational Awareness ▶

BAE Systems aims to develop machine learning analytics as a service—a first-of-its-kind, cloud-based model for the government—that can leverage commercial and open-source data to deliver constant worldwide situational awareness for a diverse range of challenges.

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MIL-PRF-31032 Offers a Rewarding Twist

From the Hill

by Mike Hill, MIL-Q-CONSULTING LLC

What Are Your Revenue Priorities Now?

Today's environmental factors have changed business priorities with regard to printed wiring boards (PWBs) requiring military specifications (MIL-PRF-55110, -50884, and -31032). These factors require re-evaluating and re-ranking revenue streams that until recently seemed very stable. On the positive side, military PWB fabrication is now designated as an "essential" business that must stay open as "nonessential" operations close. This bears consideration for the future.

Overview

If you are fabricating PWBs to military specifications, the master drawing will state: "Fabricate to MIL-PRF-55110, MIL-PRF-50884, or MIL-PRF-31032." This sounds very complicated on the surface, but there is a rewarding "twist" if the fabricator is certified to MIL-PRF-31032.

Definitions

1. MIL-PRF-55110

This specification was the first performance military specification for rigid PWBs. The first revision is dated September 1960. It establishes the performance and qualification requirements for rigid single-sided, double-sided, and multilayered PWBs with or without plated through-holes. The standard lists acceptable tests and screening methods for verification. Verification is listed in the associated qualified product list (QPL-55110). MIL-PRF-55110 was superseded by MIL-PRF-31032 as of December 31, 1997; however, legacy fabrication sites not certified to MIL-PRF-31032 can continue to certify to and build MIL-PRF-55110-part numbers.

2. MIL-PRF-50884

This specification was the first performance military specification for flexible PWBs. The first revision was dated October 1971. It establishes the performance and qualification requirements for flexible and rigid-flex PWBs with or without plated through-holes. The standard lists acceptable tests and screening methods for verification. Verification is listed in the associated qualified product list (QPL-50884). MIL-PRF-50884 has been superseded by MIL-PRF-31032 as of December 31, 1997; however, legacy fabrication sites not certified to MIL-PRF-31032 can continue to certify to and build MIL-PRF-50884-part numbers.

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MIL-PRF-31032

This specification covers the generic performance requirements for rigid and flexible PWBs with plated holes, that will use soldering for component/part mounting. Introduced in 1997, it also covers PWBs fabricated to MIL-PRF-55110 and MIL-PRF-50884.

MIL-PRF-31032 is segregated into the following six board types (each covering a major design group):

1. MIL-PRF-31032/1: Multilayer Rigid
2. MIL-PRF-31032/2: Single- and Double-Sided Rigid
3. MIL-PRF-31032/3: Multilayer Flex and Rigid-Flex
4. MIL-PRF-31032/4: Single- and Double-Sided Flex
5. MIL-PRF-31032/5: Multilayer Rigid High Frequency
6. MIL-PRF-31032/6: Single- and Double-Sided Rigid-High Frequency

Key Features of MIL-PRF-31032

Today's military printed board industry has evolved a great deal since the generic qualification concept was first added to MIL-PRF-55110 and MIL-P-50884. In the past, the DoD drove leading-edge technology, and the commercial industry followed. Most printed board manufacturers were captive facilities building products for specific systems. Today, the commercial industry has much to offer the DoD in the way of technology and cost savings. The qualified manufacturers list (QML) concept of MIL-PRF-31032 attempts to capture these best commercial practices and apply them to military products.

The QML concept in MIL-PRF-31032 allows both the printed board manufacturers and the user community to take advantage of best commercial practices while still retaining government oversight to assure printed boards meet the needs of the end-item military user. QML results in quick implementation of new technology into military systems at a higher level of quality and reliability, and at a lower price [1].

Unraveling the 'Twist'

From MIL-PRF-55110 Rev H with Amendment 3:

1. B.1.1 Scope. This appendix contains optional requirements concerning the QML product assurance level (MIL-PRF-31032) for PWBs covered by this specification. This appendix is a mandatory part of the specification when the product assurance level of appendix A is not used.
2. B.3.1 Performance requirements. The performance requirements of the applicable MIL-PRF-31032 specification sheet shall apply to all PWBs procured to the QML product assurance level.
3. B.3.2 Accept/reject criteria. The accept/reject criteria of the applicable MIL-PRF-31032 specification sheet shall apply to all PWBs procured to the QML product assurance level [2].

From MIL-PRF-50884 Rev F with Amendment 3:

1. B.1.1 Scope. This appendix contains optional requirements concerning the QML product assurance level (MIL-PRF-31032) for PWBs covered by this specification. This appendix is a mandatory part of the specification when the product assurance level of appendix A is not used.
2. B.3.1 Performance requirements. The performance requirements of the applicable MIL-PRF-31032 specification sheet shall apply to all PWBs procured to the QML product assurance level.
3. B.3.2 Accept/reject criteria. The accept/reject criteria of the applicable MIL-PRF-31032 specification sheet shall apply to all PWBs procured to the QML product assurance level [3].

To summarize, if the site is certified to MIL-PRF-31032, it can build any parts where the master drawing indicates MIL-PRF-55110 or MIL-PRF-50884.

Two Steps to Implement the 'Twist'

First, do all inspection and tests per MIL-PRF-31032 for parts requiring MIL-PRF-55110 or MIL-PRF-50884. Second, for the finished product certificate of conformance (CoC), use the following statement: "Product was manufactured to meet MIL-PRF-55110H Amendment 3, Appendix B, acceptable requirements." Note: Substitute "MIL-PRF-50884F Amendment 3" for flexible products.

Summary

The twist with MIL-PRF-31032 allows the fabrication of MIL-PRF-55110 and MIL-PRF-50884 part numbers with a simple two-step implementation process and thus "three military specifications with one stone." Furthermore, as the reliability of revenue streams has become more important today, the building and selling of military PCBs has moved up a few steps. **PCB007**

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1. Certification and Qualification Information for Manufacturers MIL-PRF-31032 DLA Land and Maritime: VQE-31032 Revision, August 2013.
2. MIL-PRF-55110H With Amendment 3, March 26, 2018.
3. MIL-PRF-50884F With Amendment 3, March 26, 2018.

Mike Hill is president of MIL-Q-Consulting LLC. He has been in the PWB fabrication industry for over 40 years. During that time, he participated in specification writing for both IPC and the military. Past employers include ViaSystems, Colonial Circuits, and DDi. To read past columns or contact Hill, click here or email Milqconsulting@outlook.com.

Book Review: Change Is Good…You Go First

by Dan Beaulieu
D.B. MANAGEMENT

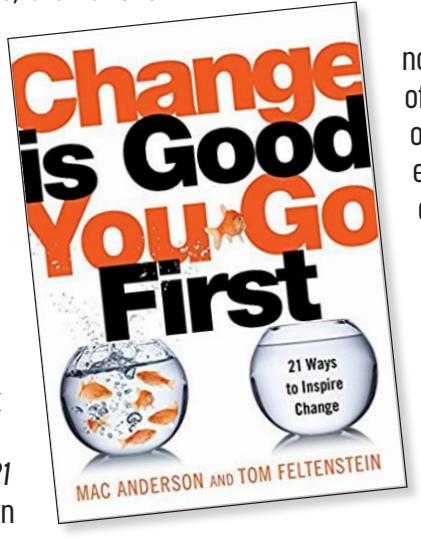
Change Is Good…You Go First: 21 Ways to Inspire Change
Authors: Mac Anderson and Tom Feltenstein
Copyright: 2019
Publisher: Sourcebooks
Pages: 116 with an appendix and notes
Price: $16.99

If you need to change in order to change, then this is the book for you.

"Change" can be a dreaded word. People suffer, and companies fail because they don't want to change. It's natural to despise change because it makes people uncomfortable, and they would rather have things remain the same. Take social media platforms, for instance; some people have made fortunes by taking advantage of changes in that area, while others called Twitter, LinkedIn, and Facebook "passing fads."

From *Change Is Good…You Go First: 21 Ways to Inspire Change* by Mac Anderson and Tom Feltenstein, here are six ways that you can inspire change in your own organization (you can also read more about these steps in one of my past columns here):

1. Change what needs changing—not what's easy
2. Forget in order to succeed
3. Believe
4. Remove barriers
5. Communicate/simplify the message
6. Celebrate your successes



I would urge you to order this book now. It's part of the Ignite Reads series of business books: "Spark impact in just one hour!" These books are written by experts and are designed to be read and remembered in an hour. Talk about an impactful hour!

Dan Beaulieu is president of D.B. Management Group.

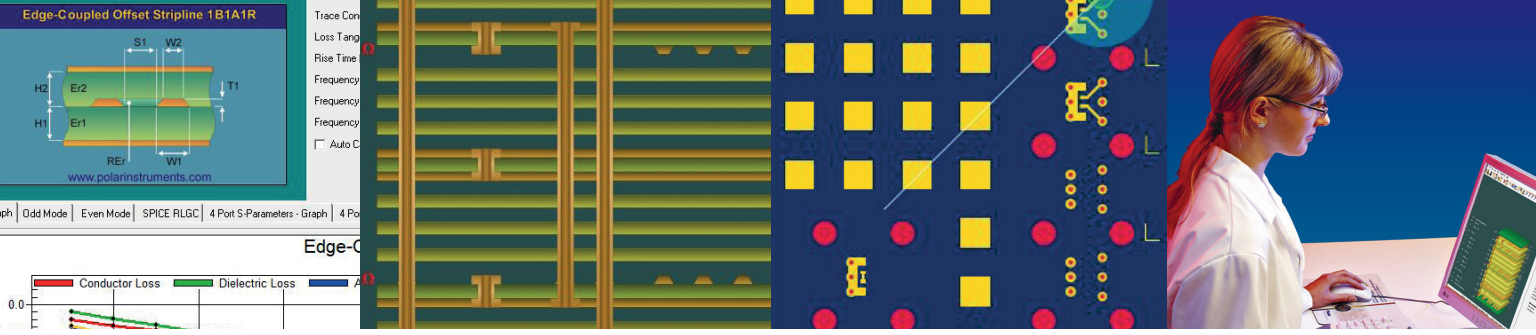
Characterization of Advanced Interconnect Technology

Article by Brandon Sherrieb and Steve Karas
INTEGRATED TEST CORPORATION

Background

Since consumers are driving requirements for smaller handheld devices with all the same functions as previous generation products, PCBs are being driven to smaller feature sizes and decreased pad and drill pitch, all with increased layer counts and decreased plated through-hole to inner layer trace and plane spacing. This is especially true in the automated test equipment PCB market, which builds the PCBs that interface between testers, probers, or sockets and, finally, the device under test. These PCBs ultimately test all the functionality of the chips that go into cellphones, tablets, laptops, smart cars, and many other types of portable electronics. Customers in this market are pushing PTH pitch to less than 0.40 mm, with PTH to inner layer trace and plane spacing of less than 0.0035", all with high layer counts of 40 or more. This is regularly pushing drill aspect ratios to greater than 35:1, which is significantly increasing the difficulty in the drilling and plating departments. As this evidence suggests, this market is starting to demand PCBs with design attributes that far exceed traditional PCB manufacturing process capabilities.

To overcome this at Integrated Test Corporation, we have developed in-house design and manufacturing processes using conductive sintering paste in addition to processes utilizing board-to-board connectors. These processes are designed such that tighter pitch areas are fanned out to areas with a more manageable drill pitch that is then connected through one of the aforementioned methods to another PCB. This allows the more difficult tight pitch areas to be processed multiple up on a smaller PCB where layer counts can be reduced, and items like PTH-to-layer and layer-to-layer registration can be better controlled due to the smaller panel size. Another advantage is that the PCBs can be fully completed through the manufacturing process and tested before attaching to the less complicated PCB that has also been fully tested. In addition to the aforementioned benefits, others include reduced cost and processing time with increased yields. Another significant benefit is that since everything is



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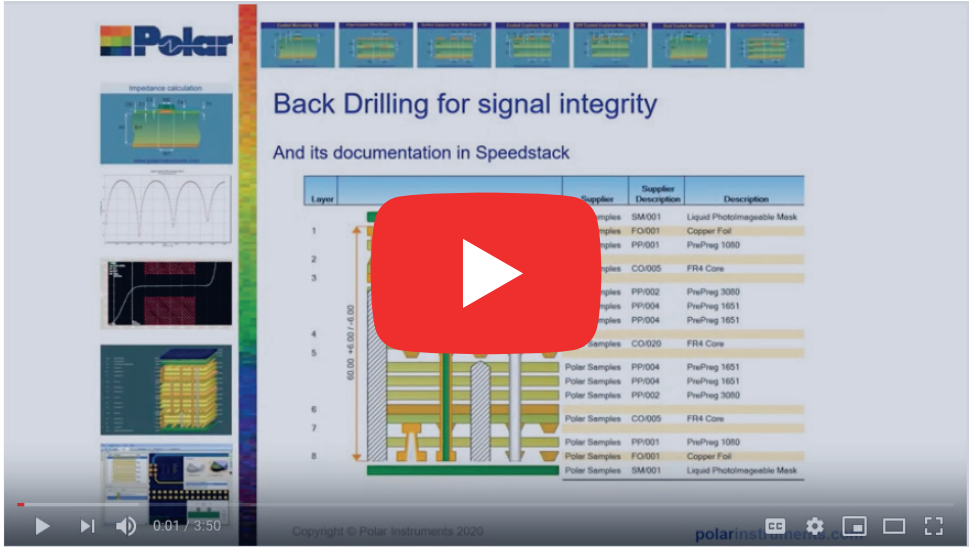

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fully tested, there are also no yield surprises at the end of the manufacturing process, which could cause critical delays to the end customer. Lastly, these methods allow for our customers to have the ability to utilize generic motherboards with specialized daughter cards, which can reduce cost and time to market.

Since we have been using these interconnects, we thought that we needed a better understanding of how they might electrically and mechanically affect our customers' end products. In light of this, we decided to process test vehicles to electrically characterize each of these interconnect types. This would allow us to better suggest which type to utilize based upon our customers' product attributes and expectations. In our testing, we decided to use a high aspect ratio through via as the baseline and compare it to a sintered via, vias connected through a Samtec Z-Ray© connector, Plastronics connector, a reflowed solder ball, and an ISC International elastomer.

Test Vehicle and Via Structure Types

Test vehicle design was completed by Probe Test Solutions. The control in our study was designed at 0.160" thickness PCB with a 0.006" mechanical PTH (27:1 aspect ratio). This via was connected to a 50-ohm impedance controlled outer layer trace on the top and bottom surface. Each of these traces was then connected to an RF connector (Figures 1 and 2). This via structure represents traditional through-hole manufacturing processes and should provide the best electrical performance. It should be noted that our testing simulation of the design (including via impedance) was waived as this test was to be just a comparison of the interconnect methods.

The remaining test vehicles were designed as two independent 0.080" PCBs, each with a 0.006" mechanical PTH. The top PCB would have the 50-ohm impedance controlled trace on the top layer and a pads only layer on the bottom. The bottom PCB would be a mirror image with the pads only layer on the top layer and the 50-ohm impedance controlled trace on the bottom layer. Each of these was then connected to its partner through our various methods (sintering, Samtec Z-Ray© connector, Plastronics connector, solder ball reflowed, and an ISC International elastomer). For some further background on each of the interconnect types included, there are descriptions and some cross-section views in the following paragraphs.

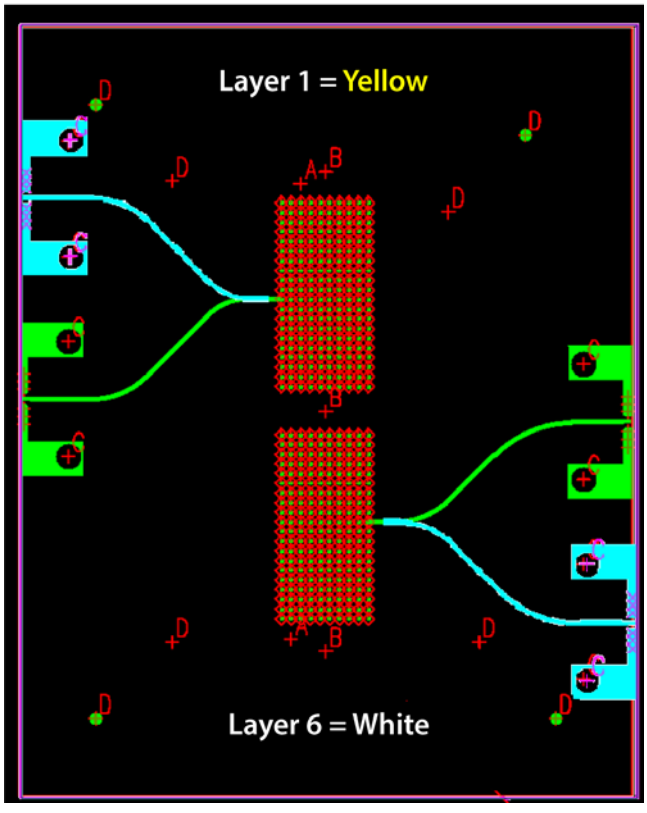

Figure 1: Gerber layout of the top and bottom layer of test vehicle.

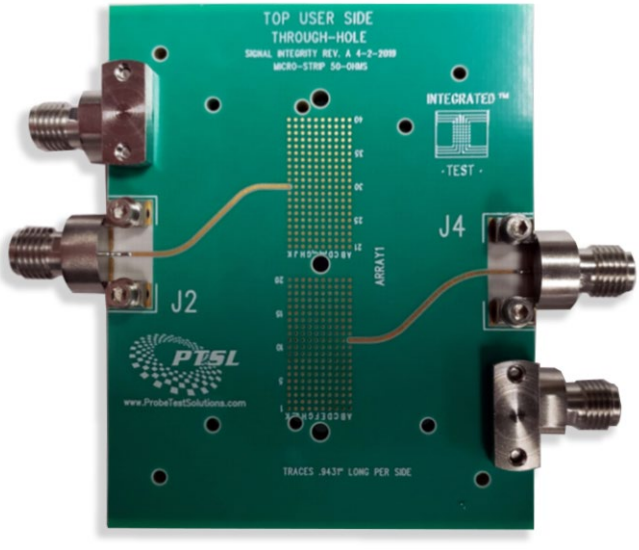

Figure 2: Actual through-hole test vehicle.

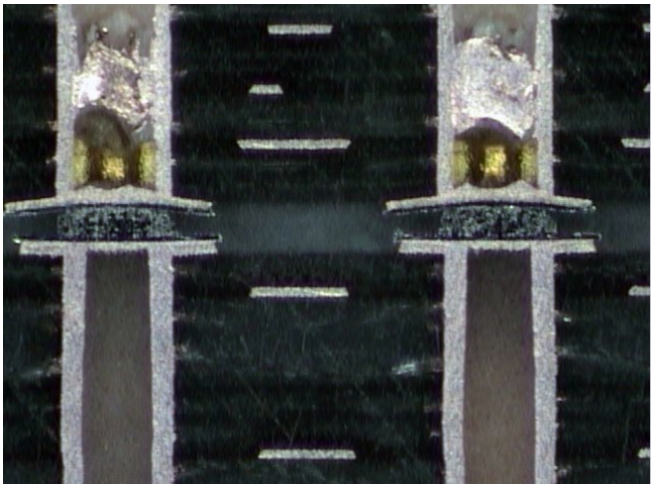

Figure 3: Sinter bond cross-section.

Figure 5: Z-axis view of Samtec Z-Ray© connector.

The sintered connection adds b-stage dielectric and sintering paste between two completed PTHs. The sinter paste is cured during a lamination cycle, as is the surrounding B-stage dielectric. This results in a permanent bond between the PCBs. Since this bond is completed with a similar B-stage dielectric as to what is included in each of the completed PCBs, it typically will result in a thermally robust bond. A cross-section example of this via connection is shown in Figure 3. Figure 4 shows a PCB completed in this process.

The Samtec Z-Ray© connector that was used is composed of beryllium copper contacts assembled into a 0.040" FR-4 substrate. These contacts are designed at the same pitch as the top and bottom of our test vehicle, and when compressed, make the electrical connection. Since this is a connector, this solution does not form a permanent bond; therefore, it is removable. A Z-axis view and cross-section depiction are shown in Figures 5 and 6, respectively.

The Plastronics connector utilizes their HPin technology, which is composed of BeCu and then Au-plated with a stainless steel spring for compression. These are assembled into an 0.040" substrate with 0.10 to 0.15 mm pin length above the surface on either side. This solution also does not form a permanent bond. The top and bottom views are shown in Figures 7 and 8.

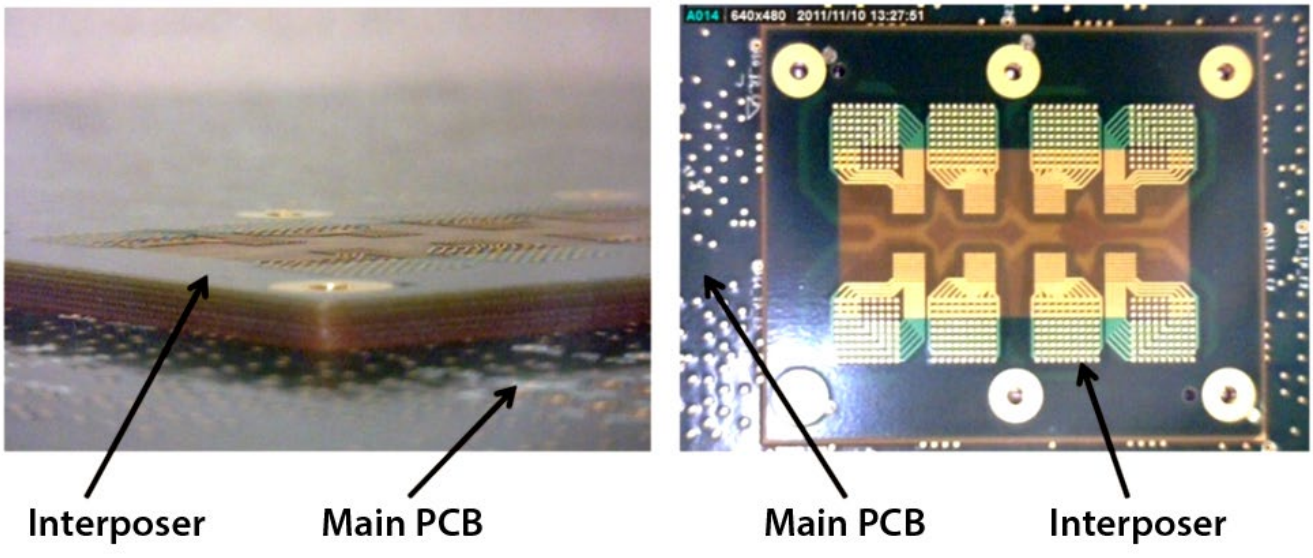

Figure 4: Sintered PCB.

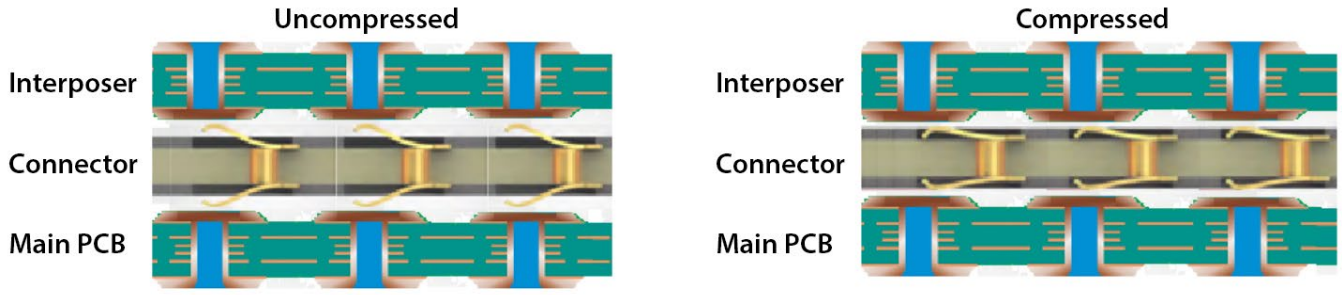

Figure 6: Samtec Z-Ray© cross-section depiction.

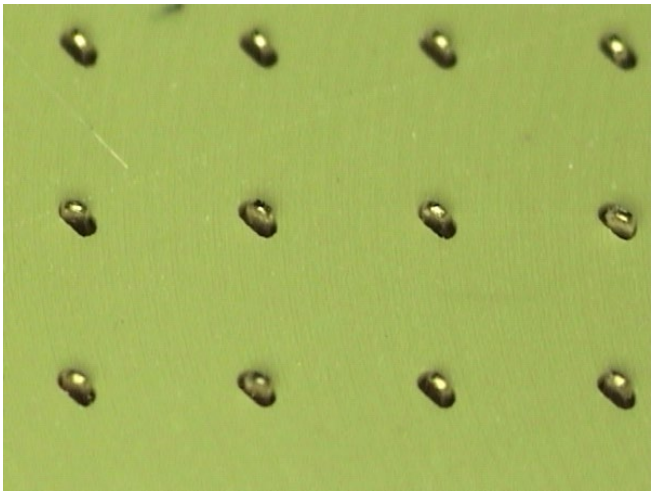

Figure 7: Plastronics 400 T033 HPin connector, side 1.

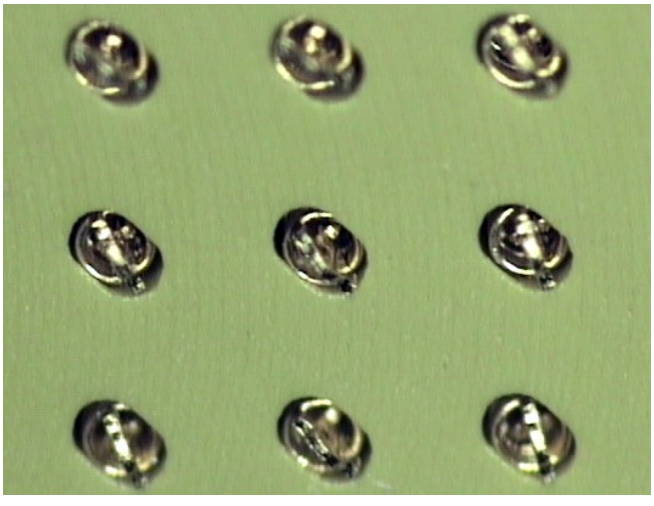

Figure 8: Plastronics 400 T033 HPin connector, side 2.

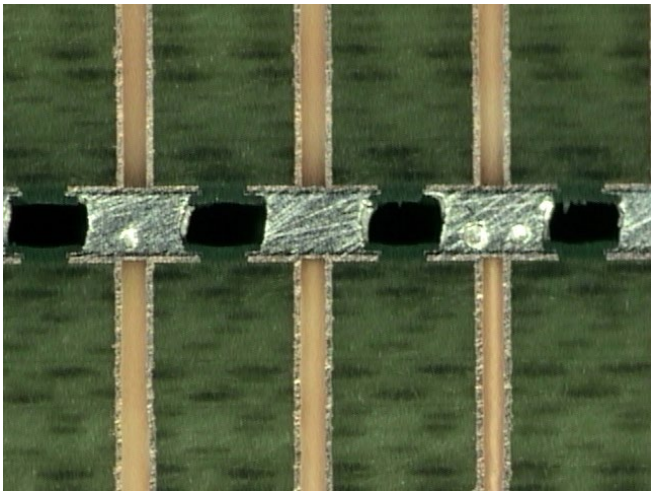

Figure 9: Solder ball reflowed cross-section.

For the solder ball reflowed test vehicle, a solder ball kit at the same pitch as our test vehicles was procured, and then the two test vehicles were reflowed together. A cross-section of this configuration is shown in Figure 9. Surprisingly, this happened to be one of the more costly solutions in our testing.

The ISC International elastomer that was used is composed of a specialized silicon rubber. This specialized silicon rubber is formed into the contact locations and filled with a conductive material. When compressed, these contact locations, which are designed at the same pitch as our test vehicle, make the electrical connection between the top and bottom of it. A Z-axis view and two cross-section views are shown in Figures 10, 11, and 12, respectively. A benefit to both the elastomer solution and the connector solutions is that since they do not form a permanent bond, the main PCB can be generic and designed to connect and attach to numerous other PCBs, each of different designs and functions.

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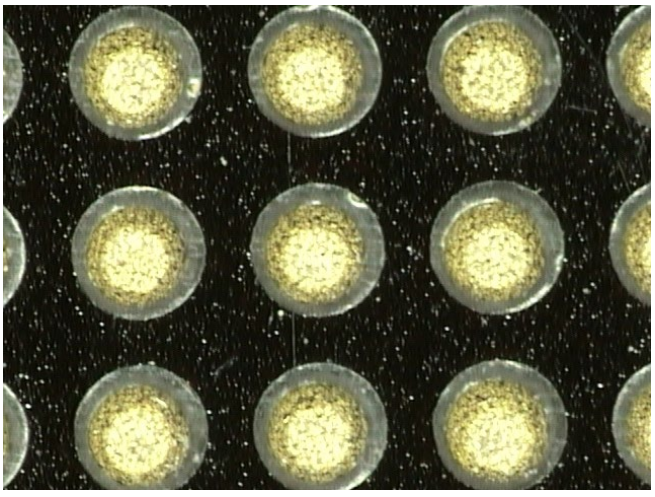

Figure 10: Z-axis view of the ISC International elastomer.

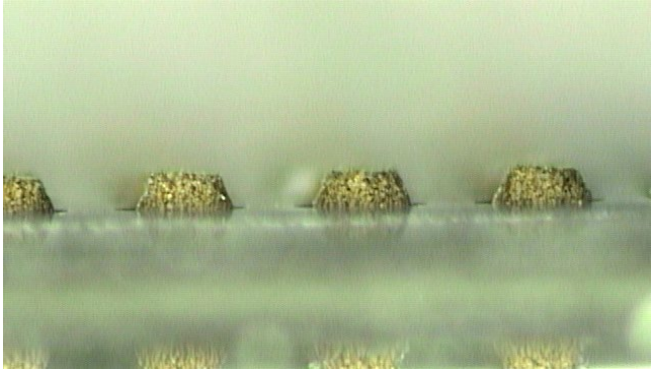

Figure 11: Cross-section view 1 of the ISC International elastomer.

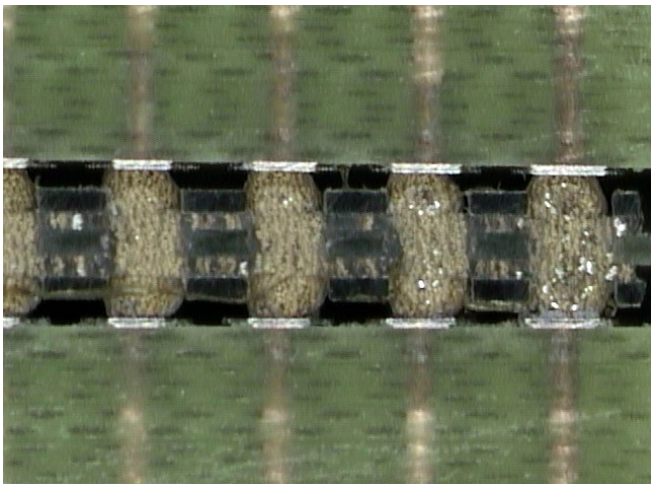

Figure 12: Cross-section view 2 of the ISC International elastomer.

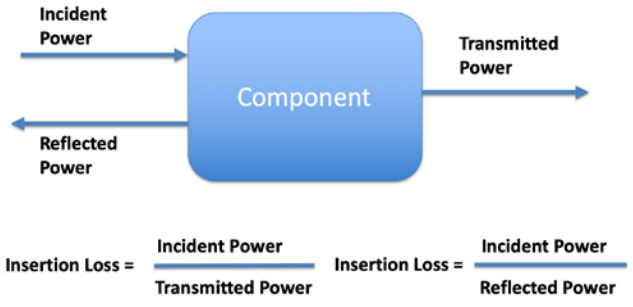

Figure 13: Insertion loss vs. return loss [2].

Electrical Testing and Properties Analyzed

A vector network analyzer utilizes a receiver to measure both the reflected input signal and the signal that passes through to the output of the device under test. It is then able to compare them to the known stimulus signal [1]. In our test case, the device under test would be our 50-ohm controlled impedance trace on the top layer, our via structure, including connection method, and the 50-ohm controlled impedance trace on the bottom layer. In our testing, the following electrical properties of the interconnects were compared: return loss, insertion loss, impedance, and rise time degradation, each of which is described briefly in the following paragraphs. The electrical testing was completed by GateWave Northern Inc.

Return loss and insertion loss typically correlate with one another in that if there is a high return loss, it will typically correlate to a low insertion loss. This is due to the fact that return loss is the loss of signal power due to signal reflection or return by discontinuity in the transmission line, while insertion loss is the loss of signal power along the transmission line [2] (Figure 13). With all things being similar in our test vehicle (excluding the interconnect type), any difference in the insertion loss would be directly related to that interconnect type.

The impedance measurement is the amount of opposition faced by the direct or alternating current when it passes through a circuit. Typically, in PCB applications, impedance is mea-

sured on traces. In our testing, since everything is equal (outer layer trace length and width, via length, dielectric material, and spacing, etc.), differences in our impedance measurements will be the direct result of our interconnect type.

Finally, rise time degradation is the increase in the rise time of a pulse as it travels through a circuit and the slowing down of the wave. This occurs due to the resistive, inductive, and capacitive effects of circuits [3].

Since flatness is a critical criterion for our customers, we also measured and compared the flatness of each of our test vehicles using our RAM/QVI CMM.

Results

To analyze return loss, S-parameter results were reviewed for all test samples. Since S11 and S22 results were compared and were similar, we chose to focus on S11 parameters in our testing.

Figure 14 shows the S11 overlay of all test samples, which were tested under standard conditions by GateWave Northern Inc.

In the lower frequency range (less than 10 Ghz) the Samtec Z-Ray connector showed the most promising results of all the interconnect methods. However at frequencies higher than 10 Ghz the benefit of this connector suffered, resulting in lower return loss values when compared to the other interconnect methods. In Figure 15, the return loss of both of our test connectors is shown.

This again shows that at lower frequencies, the Samtec Z-Ray connector shows better results than the Plastronics HPin connector. However, the Plastronics HPin connector did show better results at higher frequencies. This is an indication that highlights the fact that the proper interconnect must be chosen based upon end-user application.

Figure 16 shows the return loss comparison between the sintered via connection and the PTH via. Surprisingly, the sintered via connection shows similar return loss results to the PTH via. In fact, through most test frequencies, the sintered interconnect actually shows

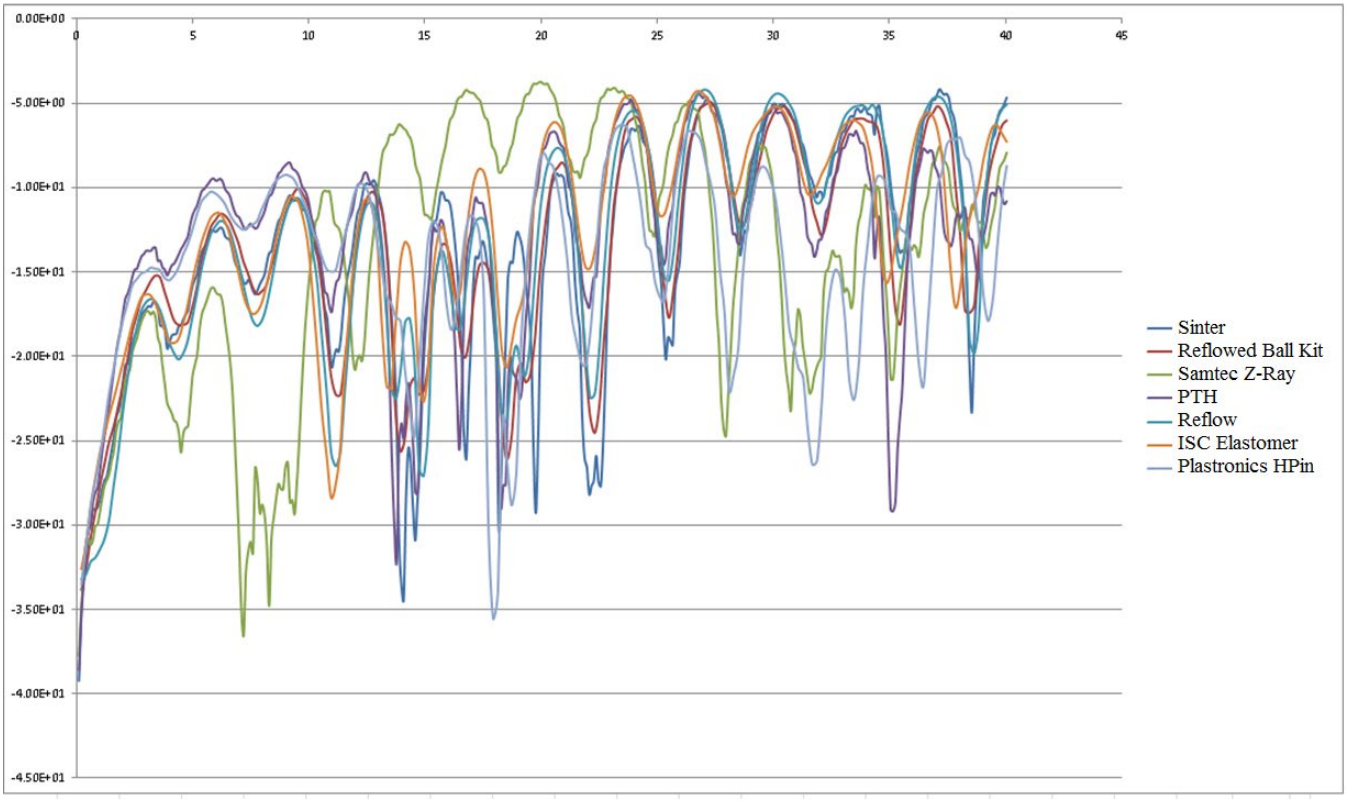

Figure 14: All test samples, return loss.

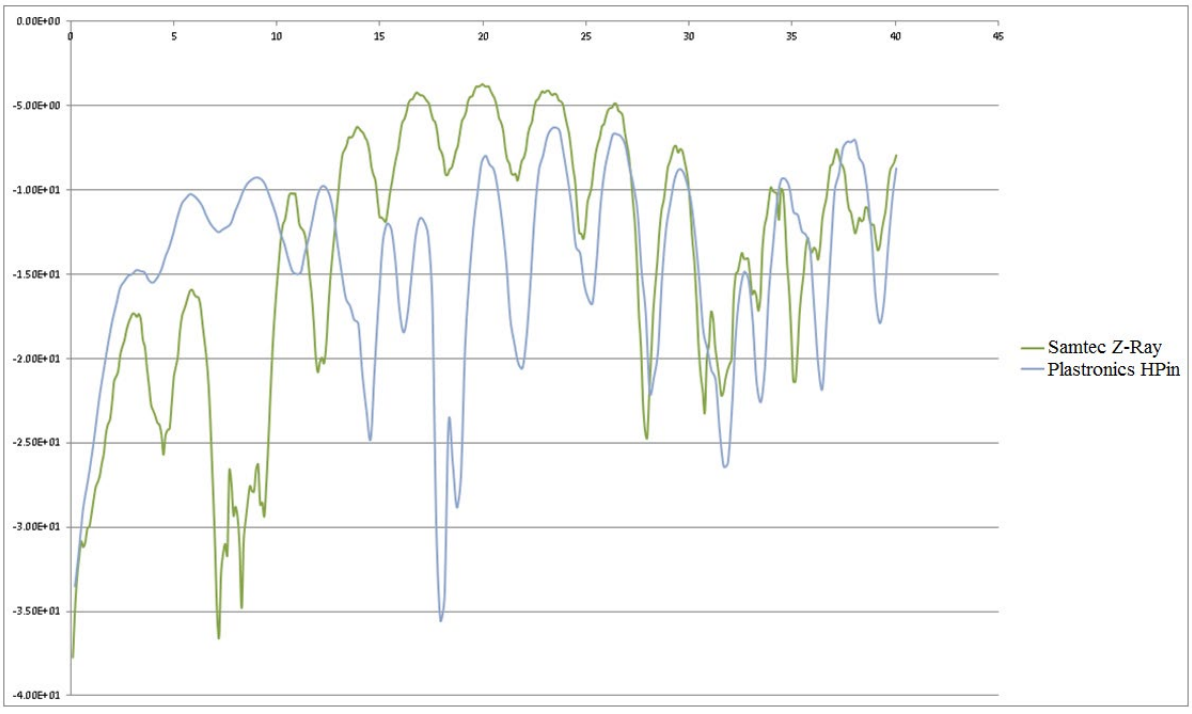

Figure 15: Samtec Z-Ray and Plastronics HPin connector return loss.

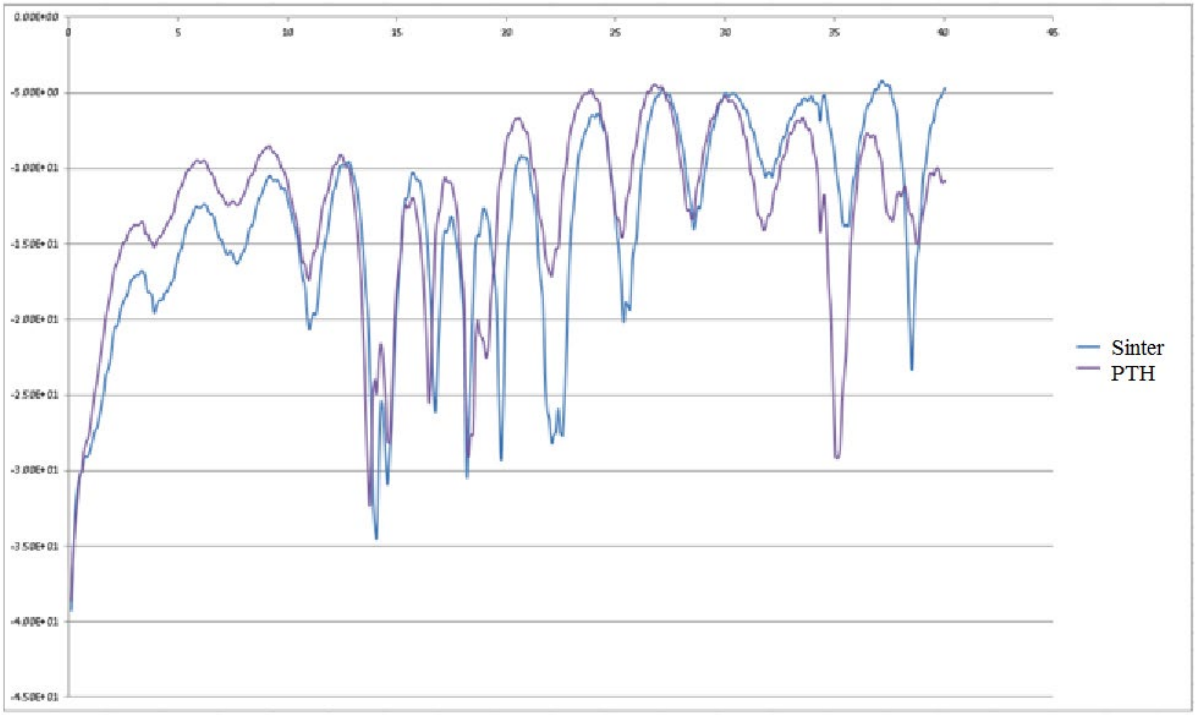

Figure 16: Sintered via and PTH via return loss.

a slight improvement in return loss when compared to the PTH test sample.

Lastly, Figure 17 shows the return loss comparison between the sintered via, reflowed ball kit, and the ISC elastomer. Regarding the elastomer, this method performed similarly to the PTH or sintered via at low frequencies (less than 10 Ghz). After this threshold, the PTH

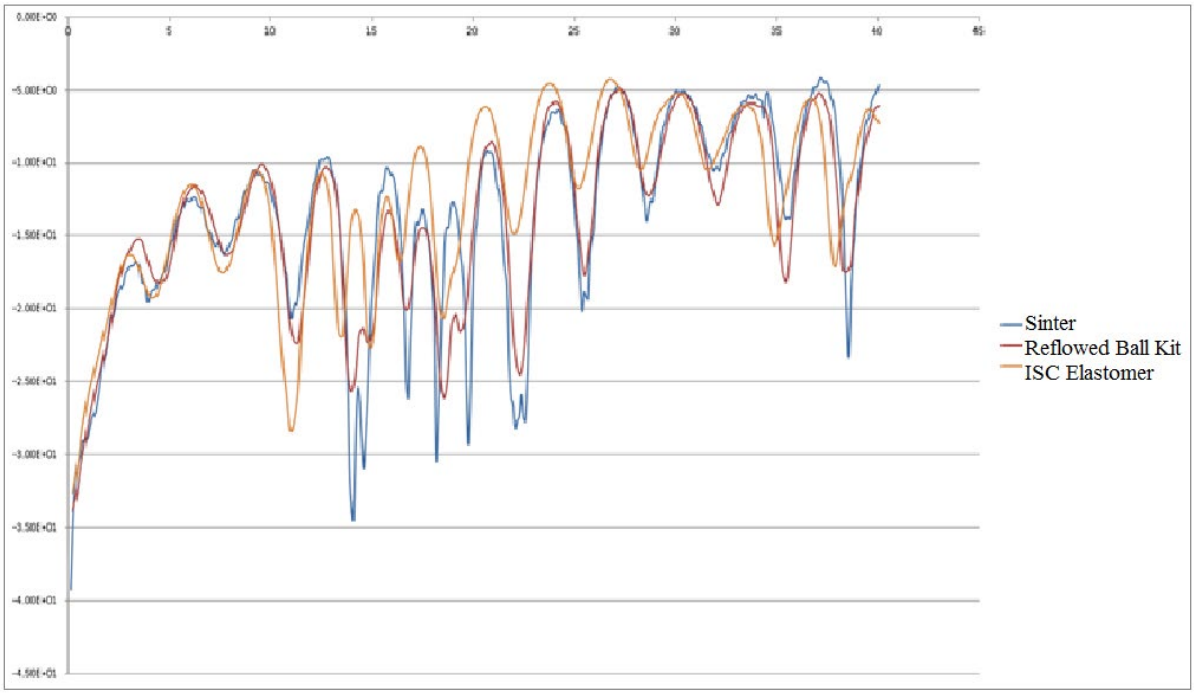

Figure 17: Sinter via, reflowed ball kit, and ISC elastomer return loss.

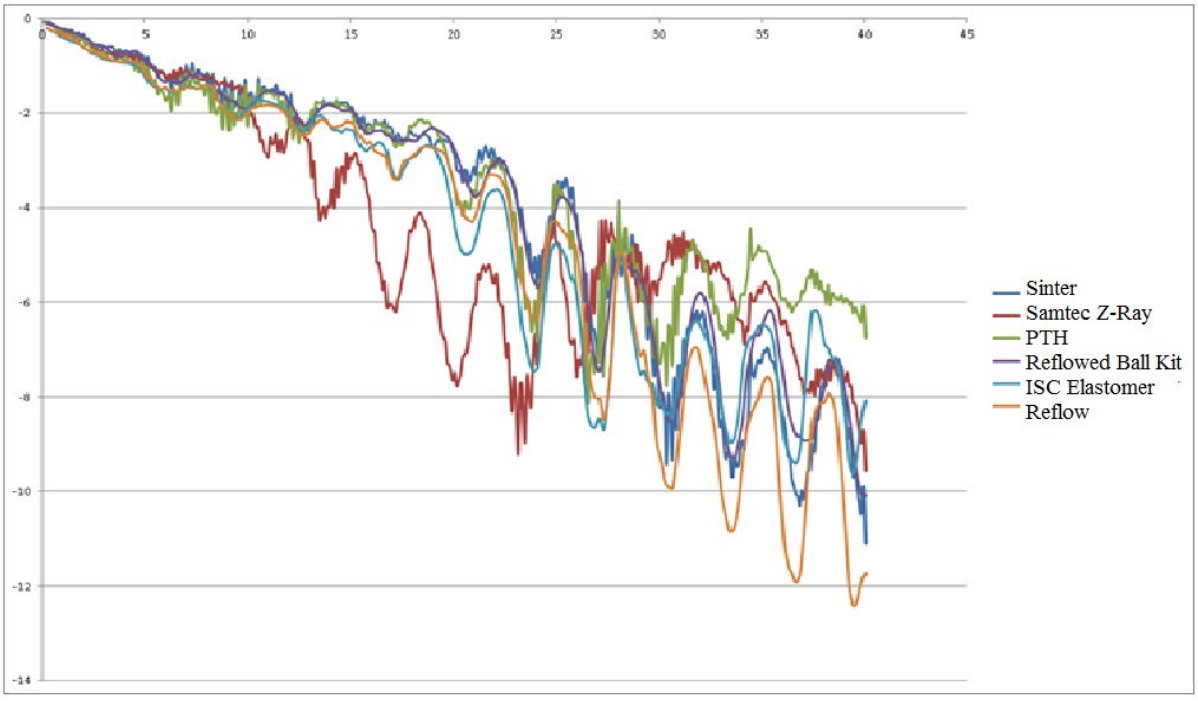

Figure 18: All test samples, insertion loss.

baseline performed better, showing higher return loss values through 35 Ghz. The reflowed ball kit performed in a similar fashion, and it was improved over the elastomer (Figure 17).

To evaluate insertion loss, S21 tests were reviewed for each of the test samples. Figure 18 shows an overlay of all tests.

The graph shows that most of the intercon-

nects performed similarly through 10 Ghz. At higher frequencies in the range of 10–30 GHz, the Samtec Z-Ray connector showed the highest levels of insertion loss compared with the other interconnects. In this range, the elastomer showed higher insertion rate values when compared with the PTH via which performed similarly to the sintered via and the reflowed ball kit. In fact, the sintered via and PTH via again performed similarly through all frequencies up to 30 Ghz. At the highest test frequency range (greater than 30 GHz), the PTH via showed the lowest levels of return loss while the reflowed ball kit experienced the highest levels.

As previously noted, interconnects were not optimized to a 50-ohm impedance environment, which leaves room for optimization of the structure as a whole. Since the focus of this testing was on the comparison of the interconnect structures and not the vias themselves, we were not concerned with meeting the 50-ohm model as much as differences between each sample.

The sintered via had similar impedance to the PTH via, but the sintered via did show the highest impedance value at the interconnect when compared to the other methods. The reflowed ball kit and ISC also showed similar results to the PTH via. The Samtec Z-Ray connector showed a double peak in impedance, which would have adverse effects at higher frequencies. This double peak is a direct result of the composition of the connector (pin + FR-4 + pin); this is shown in Figure 19. The reflowed ball kit and ISC elastomer results were left off of this chart for clarity as results were similar to the PTH via.

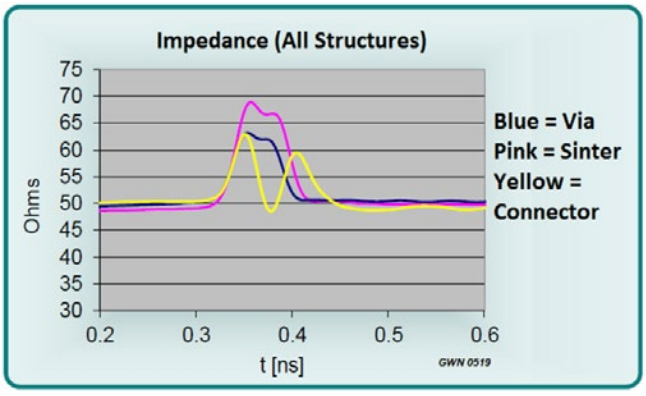

Figure 19: PTH via, sintered via, and Samtec Z-Ray connector impedance.

Rise time degradation was evaluated for each of the interconnect types. The evaluation showed that all structures showed similar and acceptable values in the 20–80% range. The sintered via had the lowest delay (AVG = 335.7 ps), while the ISC Elastomer had the highest delay (AVG = 385.1 ps). For reference, the PTH via was AVG = 339.4 ps. The Samtec Z-Ray connector showed some variation due to the impedance mismatch in the connector. Figure 20 shows the rise time degradation for the PTH via and the Samtec Z-Ray connector.

Finally, another key element to picking the proper solution is flatness across the contact pad array. Flatness was evaluated using a laser

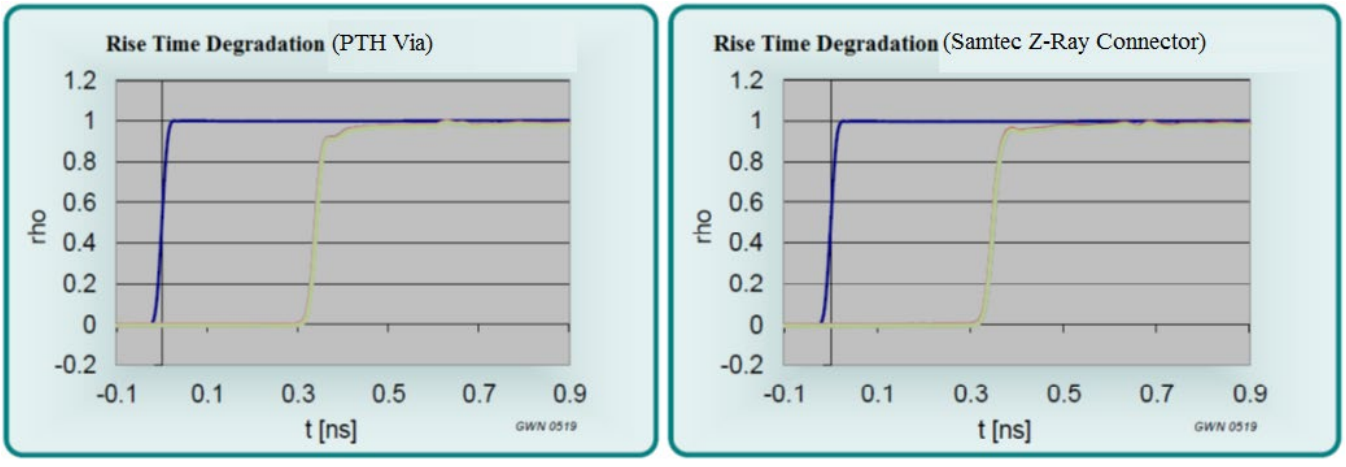

Figure 20: PTH via and Samtec Z-Ray connector rise time degradation.

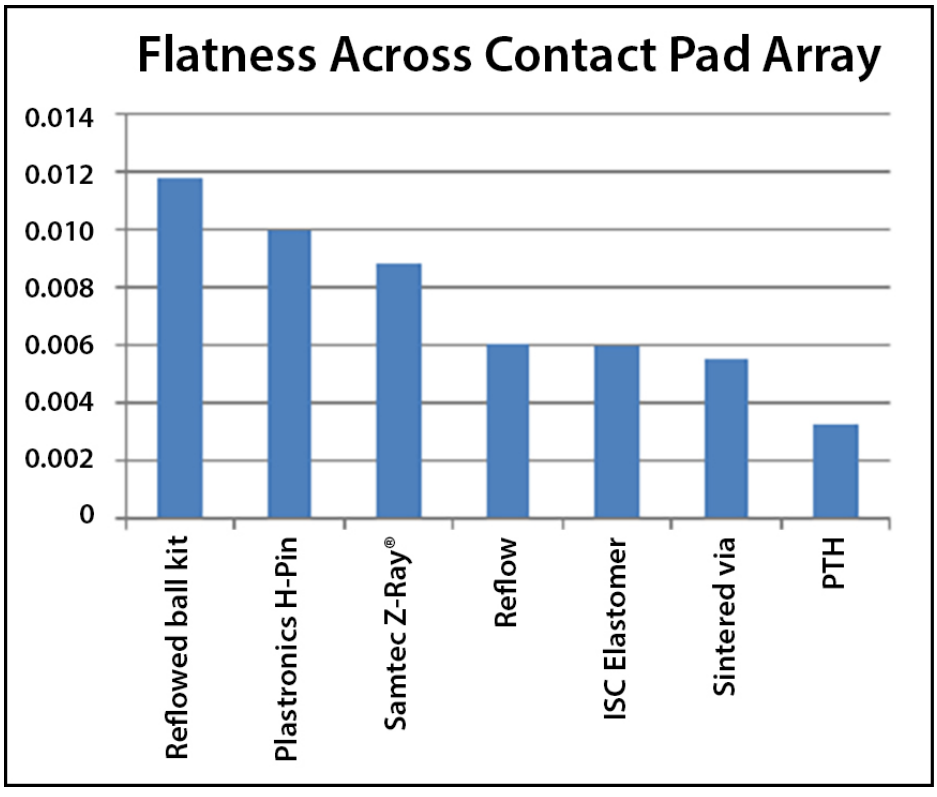

Figure 21: All test samples, flatness.

measurement technique on a RAM/QVI CMM unit. Figure 21 shows the measurement results. The data showed that the reflowed ball kit had the worst flatness rating, and the PTH via was, as expected, the "flattest" sample. The sintered via and elastomer showed similar flatness results. Both connector samples that were evaluated showed more flatness variation.

It is important to note that we attempted to minimize deflection for the temporary interconnects (Samtec Z-Ray and Plastronics connectors and ISC elastomer) by building a shim slightly lower in thickness than the thickness of the FR-4 in the connectors or elastomer. This was done to minimize any deflection that may occur when press-fitting these samples. Even with these precautions, the data showed a larger variation that is present with these types of interconnects.

Conclusion

While this exercise provided a lot of useful electrical characterization data for each of the different interconnect types that we offer to our customers, it did show that the interconnect method chosen needs to be selected carefully based upon the application. A combination of flatness and electrical performance requirements must be considered when selecting an option.

With that being said, in our study, it was observed that the sintered via compared most favorably to the PTH via over most frequency ranges when comparing insertion and return loss. It had the lowest delay and similar impedance to the PTH via, which would indicate acceptance for high-frequency applications. It also showed flatness results that were second only to the PTH via test sample, making it a good alternative where flatness is a critical requirement.

In the two connectors that were evaluated based upon insertion and return loss, the Samtec Z-Ray connector would be a viable option for low-frequency applications (less than 10 GHz). However, due to an impedance mismatch in the connector related to its construction, its use would be prohibited at higher frequencies. Conversely, the Plastronics HPin connector would be an option at higher frequencies but not at lower frequencies where it performed worse than the Samtec Z-Ray connector. Neither of these connectors had favorable planarity results and, therefore, could not be recommended where flatness was a critical requirement.

Lastly, the ISC elastomer and reflowed ball kit solutions showed worse return and insertion loss compared to the alternative methods, which would indicate that without further testing, these interconnect methods should be avoided in high-speed applications. In addition, the planarity results showed more varia-

tion than the PTH via test sample; like the connector solutions, these solutions should not be recommended in planarity critical designs.

In conclusion, as PCB technologies become denser with smaller feature sizes and increased speed requirements, it will become necessary to use non-standard via structures in your manufacturing processes. As we have pointed out, the interconnect method should be carefully selected based upon the customers' electrical and mechanical requirements. If the interconnect is properly selected, not only will it perform as expected in your customers' end product, but it could also improve your manufacturing yields. Hopefully, this will provide you something to consider when thinking about advanced interconnect methods. **PCB007**

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1. Tektronix, "Introduction to VNA Basics," 2017.
2. Cadence PCB Solutions, "Insertion Loss vs. Return Loss: Signal Transmission and Reflection," January 15, 2020.
3. R.C. Dorf, *The Electrical Engineering Handbook: Second Edition,* CRC Press, 1997.

Brandon Sherrieb is currently the process engineering manager at Integrated Test Corporation in Dallas, Texas. He has a degree in mechanical engineering and 15 years of process engineering experience in the industry with a focus on mechanical and thermal processes.

Steve Karas has over 10 years in PCB manufacturing experience working across a number of market segments. He had been a process engineer for many PCB processes, as well as a product engineer for new product releases. Steve is currently an engineering manager responsible for product development, which includes planning, technical customer engagement, NPI, NTI, and roadmap development. Steve attended the University at Buffalo with a chemistry degree and has received advanced training in various manufacturing methods, such as Lean Six Sigma techniques.

Electronics Manufacturing Supports More Than 5.3 Million U.S. Jobs and Almost 4% of U.S. GDP, Says IPC

Electronics manufacturing contributes powerfully to the U.S. economy, according to a new report released by IPC. The electronics manufacturing sector directly supports more than 1.3 million U.S. jobs. For every U.S. electronics manufacturing job, three other jobs are supported in the U.S. economy, contributing to a total of 5.3 million American jobs. Also, the industry indirectly and directly contributes $714 billion (3.7%) to U.S. GDP.

John Mitchell, president and CEO of IPC, stated, "More than most industries, we are vertically and horizontally integrated across many markets, and the health of our industry is key to the overall success of the U.S. economy."

Sixteen states, led by California and Texas, account for about 75% of direct electronics manufacturing jobs in the United States. California alone has nearly 275,000 direct electronics manufacturing jobs and almost $197 billion in direct output, accounting for 3.4% of California's GDP.

The coronavirus epidemic is being felt by the U.S. electronics manufacturing industry.

While manufacturers and suppliers report several concerns, they appear most concerned about weaker demand. Some 44% reported they are most concerned about supply shortages, while just over one-third said they are worried about worker shortages.

Many manufacturers issued temporary layoffs in March and April, and now a majority of respondents report they expect to bring furloughed workers back to factories by the end of June 2020. However, one in five said furloughed workers would not return. (Source: IPC)

Electronics Industry News and Market Highlights

GTX CEO Chairs So. California COVID-19 Supplies Taskforce ▸

GTX Corp., a pioneer in the field of health and safety wearable technology, announced, in an effort to support the community at large from the coronavirus pandemic, that CEO Patrick Bertagna now chairs the Southern California Biomedical Counsel COVID-19 Supplies Taskforce.

SAMWHA ELECTRIC Receives Attention in Electronics for the Smart City Industry ▸

SAMWHA ELECTRIC, a manufacturer specialized in electrolytic capacitors in Korea, launched a conductive polymer hybrid electrolytic capacitor leveraging advanced technology to cope with increasing demand for electronic components used for the smart city industry—a future strategic market.

Everflow JV to Manufacture Vanadium Redox Flow Batteries in KSA ▸

Nusaned Investment and SCHMID Group have closed the JV transaction in Saudi Arabia, focusing on manufacturing and technology development in the field of vanadium redox flow batteries.

NVIDIA Chief Scientist Releases Low-Cost, Open-Source Ventilator Design ▸

NVIDIA Chief Scientist Bill Dally released an open-source design for a low-cost, easy-to-assemble mechanical ventilator.

Intel Joins GA Tech in DARPA Program to Mitigate Machine Learning Attacks ▸

Intel and the Georgia Institute of Technology (Georgia Tech) announced that they had been selected to lead a Guaranteeing Artificial Intelligence (AI) Robustness against Deception (GARD) program team for the Defense Advanced Research Projects Agency (DARPA). Intel is the prime contractor in this four-year, multimillion-dollar joint effort to improve cybersecurity defenses against deception attacks on machine learning models.

Universal Robots Launches the World's First Autonomous Bin Picking Kit for Machine Tending Applications ▸

The complexity of automated bin picking is well-known throughout the industry, requiring huge efforts in both integration and programming. Today, most bin picking products are solely focused on the vision aspect of bin picking and often require hundreds of lines of additional programming to bridge the gap from "pick" to "place" —especially if the "place" is not just dropping into a box or tote but accurately inserting the part into a fixture for further processing.

Cadillac Products Manufacturing Medical PPE to Help Healthcare Workers Fight COVID-19 in Michigan ▸

Cadillac Products Automotive Company and Cadillac Products Packaging Company have launched an effort to fight COVID-19 by combining workforces, capabilities, and factories to manufacture medical personal protective equipment (PPE) for frontline doctors and nurses.

Robotics Duo Digs Into the Weeds With Winning AI Project at Hacketer.io ▸

Kevin Patel and Nihar Chaniyara grew up among rural India's herbicide-treated crops of corn, sugarcane, and mangos. Today, they cultivate organics with data, vision models, and GPUs.

SEMI Update on COVID-19 Resources ▸

SEMI gives an update on the resources they have available to members regarding COVID-19.

Can 'Nickel Corrosion' Occur in ENEPIG?

The Plating Forum
by George Milad, UYEMURA

Nickel palladium gold (ENEPIG) surface finish is being referred to as the "universal finish." The finish is an excellent soldering surface, forming a Ni/Sn intermetallic (IMC). It is a wire-bondable surface for both gold and aluminum wire. It also serves as a good contacting surface. ENEPIG was also the answer to the nickel corrosion "black pad" occasionally encountered with electroless nickel/immersion gold (ENIG) deposits.

As the finish gained more market share due to its flexibility—particularly as a gold wire bonding surface—occasional bond failure was observed in cases where the dwell time in the immersion gold was extended in an attempt to meet design requirements of > 3.0 µins (0.075 µm) of gold. The failure was manifested as wire bond lifts. Failure analysis of the failed bonds showed a separation at the Ni/Pd interface. The nickel surface was black, and was clearly corroded "black pad." Nickel corrosion in ENIG occurs in the immersion gold deposition step and is usually the result of a compromised nickel surface (uneven), in combination with an aggressive immersion gold bath (low gold concentration, low pH) and an extended dwell time in the gold bath. The extended dwell time is used in instances where the design requirements demand a thicker immersion gold. How can the nickel capped with an electroless palladium layer corrode when it is theoretically not available to the immersion gold step?

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Immersion gold deposition is a displacement reaction where one atom of nickel metal is oxidized to the nickel ion giving up two electrons. The two electrons are picked up by two positively charged gold ions in solution and, in turn, are reduced to the metal and deposited on the surface of the nickel substrate.

The driving force of the oxidation-reduction displacement reactions can be derived from the electromotive series. The electromotive series is a listing of chemical species (atoms, molecules, and ions) in the order of their tendency to gain or lose electrons (be reduced or oxidized, respectively), expressed in volts and measured with reference to the hydrogen electrode—which is taken as a standard and arbitrarily assigned the voltage of 1.0 v.

Immersion gold on nickel:

$$Ni \rightarrow Ni^{+2} + 2e \quad -0.250\ v$$
$$Au^{+2} + 2e \rightarrow Au \quad +1.498v$$

$$\text{Driving force} = +1.498\ v - (-0.250\ v) = +1.740\ v$$

Immersion gold on palladium:

$$Pd \rightarrow Pd^{+2} + 2e \quad +0.987v$$
$$Au^{+2} + 2e \rightarrow Au \quad +1.498v$$

$$\text{Driving force} = +1.498\ v - (+0.987\ v) = +.511\ v$$

The driving force for the Ni/Au exchange is 3.4 times greater than that of the Pd/Au exchange. If the immersion gold ion has access to the underlying nickel, this would be the path of least resistance for the reduction of the gold. The gold will be reduced at the expense of the nickel, allowing nickel to be oxidized or corroded and gold to be deposited on the top palladium layer. Investigation and failure mechanism analysis showed that the immersion gold, under certain conditions (compromised nickel deposit coupled with extended dwell time in an aggressive immersion gold bath), could get access to the underlying nickel.

The IPC Amended ENEPIG Specification 4556-A specifies the immersion gold thickness at 1.2–2.8 µins (0.03–0.07 µm). Although data shows that this thickness of gold is adequate for gold wire bonding, thicker gold (> 3.0 µins, 0.075 µm) is often spelled out in the board design for the purpose of opening the wire bonding window.

There are three approaches to mitigate nickel corrosion in ENEPIG deposits. The first approach is to control the electroless nickel deposition process in order to produce an even deposit with minimum crevices, to increase the phosphorous content of the deposit by one or two percentage points, and not to attempt to deposit thicker gold in an immersion gold bath.

The second approach is to deposit a thicker (6–8 µins, 0.15–0.20 µm) electroless palladium layer that could cover any imperfections in the nickel deposit and act as a barrier between the immersion gold and the underlying nickel. This is a relatively costly proposition as the price of an ounce of palladium now exceeds the price of an ounce of gold.

The third approach is to replace the immersion gold (IG) with reduction-assisted immersion gold (RAIG). RAIG is a mixed reaction bath. Both immersion and autocatalytic reactions start simultaneously. As the substrate becomes less accessible, the immersion reaction will diminish, and the autocatalytic reaction will dominate. RAIG is non-aggressive and will not produce substrate corrosion and is capable of depositing 4–6 µins, (0.10–0.15 µm) of gold in a single step.

The choice of which mitigation approach is best is left to the manufacturer and their supplier to determine availability and that the process choice fits in the production floor and is within the manufacturer's budgetary constraints. It is worth mentioning here that the RAIG solution is gaining popularity and is becoming the choice for ENEPIG, particularly if thicker gold is specified in the design of the board. **PCB007**

George Milad is the national accounts manager for technology at Uyemura. To read past columns or contact Milad, click here.

Supplier Highlights

MKS Instruments Sells 1,000th ESI 5335 System ▸

The popular flexible circuit UV laser drilling system reaches an industry-first production milestone.

Ucamco Releases Latest Version of UcamX ▸

Amid the current worldwide situation, Ucamco is proud to bring positive news and announce the v2020.03 release of UcamX.

Averatek and RBP Chemical Technology Announce New Distribution Agreement ▸

Averatek Corporation has announced that RBP Chemical Technology will become a new distribution partner. RBP will be supplying supporting chemistries that are needed by licensees of Averatek's A-SAPTM process.

Nano Dimension Launches NaNoS Digital Fabrication for Prototyping of 3D-Printed Electronics ▸

Shortening supply chains trend lead to a successfully printed first order of PCBs for prototyping breathing-support-ventilators.

Taiyo America Mourns Loss of Chris Liu, Pentalements Inc. Founder ▸

The Taiyo family is saddened by the loss of a very special man and colleague, Christopher (Chris) Liu. After over 25 years of mutual respect in business and friendship, Chris will be sorely missed and never forgotten.

DIS: It's All About Alignment ▸

Jesse Ziomek, VP of sales for DIS, updates Pete Starkey on the capability of the company to achieve ultimate accuracy in layer-to-layer registration, not just in rigid multilayers, but also in flex and rigid-flex builds. Jesse also comments on keeping technology exciting enough to attract young engineers into the industry.

Ventec High-Performance IMS Dielectric Material VT-4B5H Receives UL-Authorization ▸

Ventec International Group Co. Ltd. is pleased to announce that UL's evaluation of Ventec's high-performance ceramic-filled, non-reinforced IMS dielectric material has received authorization to apply the UL mark and has thus been recognized for achieving 155°C maximum operating temperature (MOT) for electric and mechanical relative temperature index (RTI).

Technica USA Announces Cooperation With TCT Circuit Supply on EMC Products ▸

Technica USA, located in San Jose, California, announced they reached an agreement with TCT Circuit Supply to act as a sales representative of EMC products in defined territories and accounts. Additionally, the two companies established a Master Service Agreement, whereas TCT Circuit Supply (TCS) will be providing fabrication and logistics support for Technica from their Plymouth, Minnesota, location.

Language of Electronics: Tips to Maximize the Value of Digital Inkjet ▸

In this latest commentary, Rick Herrmann, Orbotech West's inkjet expert, provides tips on how to take full advantage of your digital inkjet printers in PCB manufacturing, explaining how to maximize their performance, increase uptime while saving time and money, and provide high-quality boards.

Plasma Applications in the PCB Industry

Article by Nikolaus Schubkegel

Plasma, which consists of ionized gas atoms, is the fourth state of matter. On Earth, plasma does not occur naturally, but it is sometimes visible at high altitudes as auroras. But off-planet, elsewhere in the universe, almost all visible matter is plasma. Plasma is a mixture of positively charged atomic hulls, free electrons, free radicals, and neutral particles; the total electrical charge is neutral, conductive, and highly reactive.

Due to permanent recombination, plasma lights can come in different colors. The colors depend on the nature of the gas [1]:

- CF_4: Blue
- SF_6: Pale blue
- SiF_4: Light blue
- $SiCl_4$: Light blue
- Cl_2: Light green
- CCl_4: Light green
- H_2: Pink
- O_2: Pale yellow
- N_2: Red to yellow
- Br_2: Reddish
- He: Red to purple
- Ne: Brick red
- Ar: Dark red

The plasma particles have great speed, and thus, high energy content. Irving Langmuir was the first who called ionized gas "plasma" [2].

Although there are several methods known to produce plasma, only one method is widely used in manufacturing PCBs: RF discharge at 40 kHz or 13.56 MHz or microwave discharge at 2.45 GHz at low pressure 0.1–1.0 mbar. This method produces what is commonly known as "cold plasma." There is also plasma at atmospheric pressure, with technical applications. This article deals only with low-pressure plasma.

Equipment Available to Produce Plasma

Most plasma equipment is comprised of discontinuous (batch) systems, although there are also continuous systems available. The batch systems have some volume of l.0 to 10 m³ and more. The common units in the PCB industry have volumes of approximately 0.2 to 3 m³. Continuous systems are available for flexible circuits, reel to reel, and rigid products as well.

All systems have one or more vacuum pumps, a gas supply with a plurality of gases (oxygen, argon/nitrogen, tetrafluoromethane, ammonia, hydrogen and nitrogen, and sometimes helium), a control unit with timer, and

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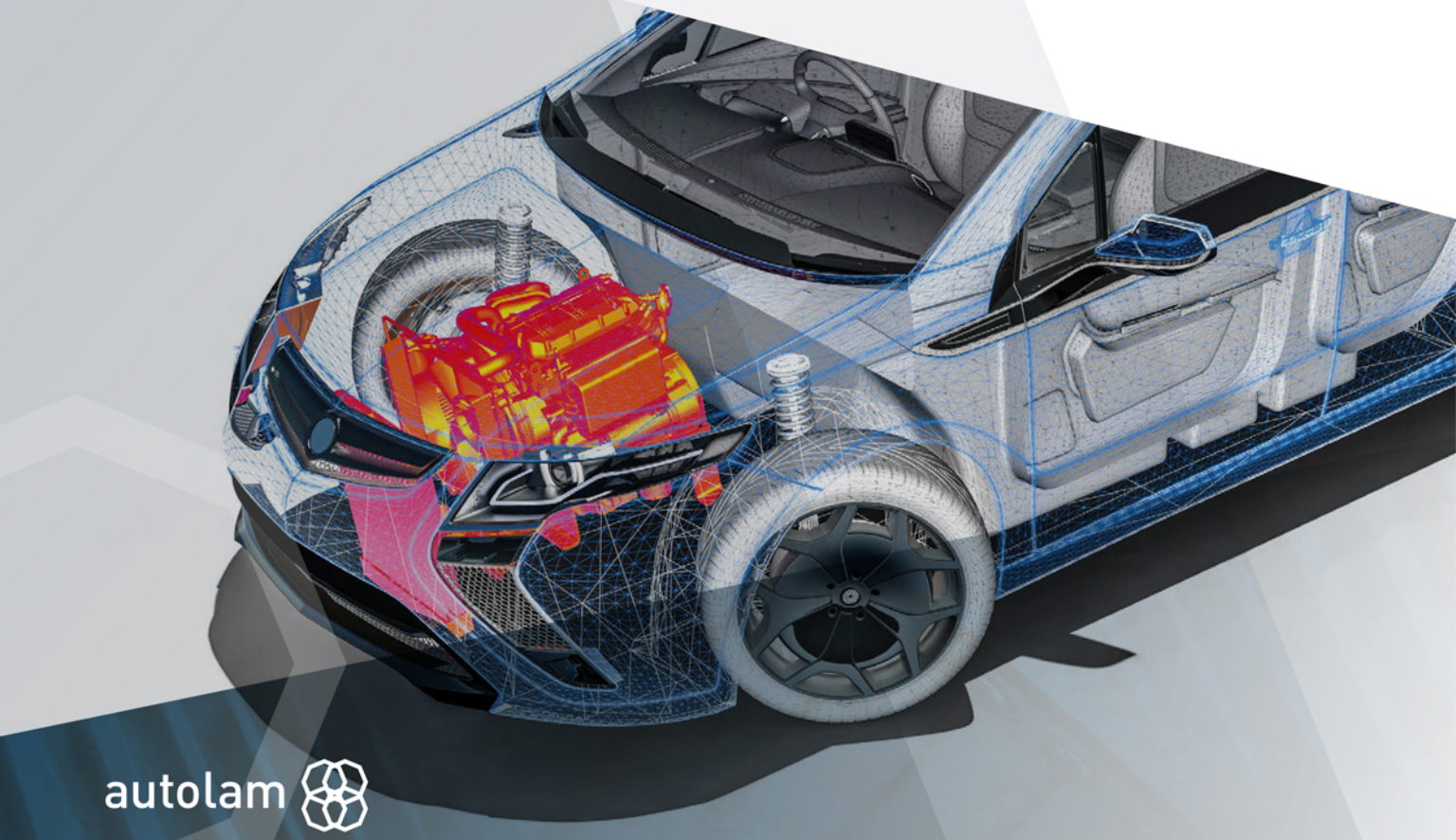

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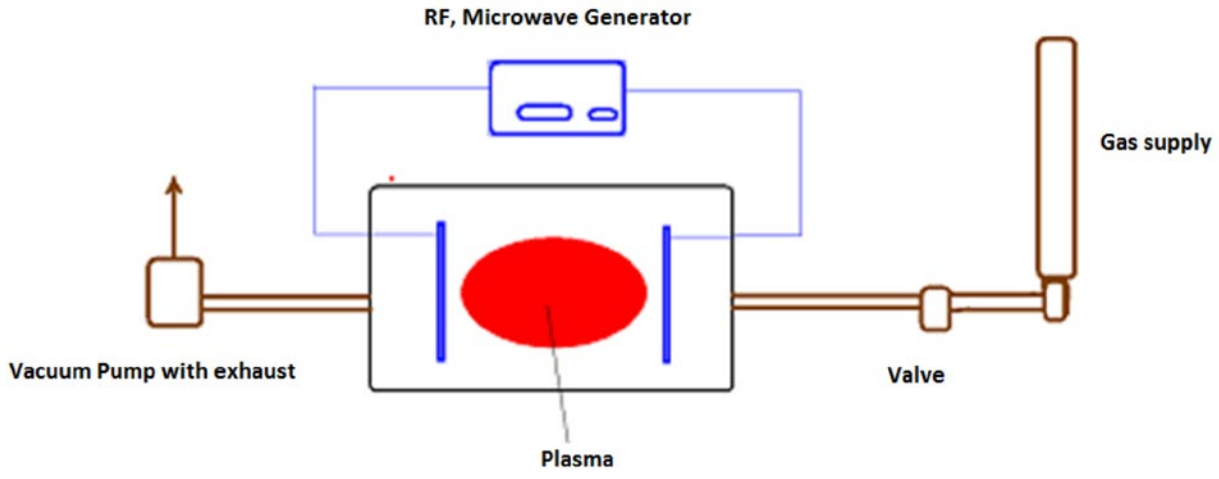

Figure 1: A simple schematic diagram for generating plasma.

an RF or microwave generator (Figure 1). In the chamber, there are several antennas between which the radio frequency travels. The antennas can be cooled or heated. The boards for plasma treatment are stacked with gaps in the chamber. The pressure in the chamber (vessel) is reduced to 10^{-2} to 10^{-3} mbar. The gas that is introduced in the chamber is ionized by the high-frequency generator, creating the plasma.

A specific characteristic of the plasma is the visible glow discharge in different colors, depending on the type of gas. At the same time, invisible UV radiation is generated. The color can be used as an indicator of whether the gas is contaminated. The highly reactive particles react with the surface of the boards with chemical and physical modifications of the surface.

The Effect of Plasma

With low-pressure plasma technology, gas is excited in a vacuum by energy supply. It generates energetic ions and electrons, as well as other reactive particles constituting the plasma. These produce effective surface changes. There are three plasma effects:

1. Micro-sandblasting (the surface is removed by ion bombardment).
2. Chemical reaction (the ionized gas chemically reacts with the surface).
3. UV radiation (breaks long-chain carbon compounds).

Varying the process parameters—such as gas composition, pressure, power, process time, gas flow, and exhaust—changes the effect of the plasma.

The General Use of Plasma

In general-purpose industrial applications, plasma is used for:

- Cleaning of metal parts before printing, coating, and bonding
- Activation of plastics, elastomers, and foils before gluing, printing, casting, painting, and coating
- Etching of components, milling
- Reducing of metals and chemicals
- Polymerization of coatings, protective coatings, hydrophobic coatings, insulating layers
- Soldering pretreatment, soldering without flux
- Artificial aging of components
- Epilamisation, deposition of a PTFE-like layer to prevent creeping away of lubricating oil
- Pretreatment before bonding (e.g., gold wire, copper wire, or aluminum wire)
- Sterilization
- Cleaning, drying, and preserving of archaeological objects
- Hydrophilize, hydrophobize, and change of the surface tension
- Cleaning of metal powders

- Activation of plastic powders
- The final surface finish

Plasma processes performed in the PCB industry include:

- Desmear of drilled holes and laser-drilled holes, carbon removal
- Surface activation of PTFE (surface and drilled holes, laser-drilled holes)
- Surface cleaning before solder mask
- Surface treatment of PCBs after thermal cure of solder mask (increasing surface tension, improving adhesion of legend ink, conformal coating, and other coatings)
- Cleaning/activation of prepregs before bonding
- Desmear of hole fill paste before plating
- Cleaning of a gold surface before soldering or bonding
- Cleaning of surface, deoxidation before soldering, fluxless soldering
- Drilling and milling of polyimide, flexible circuits
- Surface activation of PI for fully additive copper plating
- Panel/layer descumming
- The final surface finish of a PCB, copper preservation (Semblant)
- Conformal coating

In this article, I will concisely summarize all of these processes, identify where this step is located in the manufacturing chain of events, and outline the specific plasmas and methods used in each step; some steps have more than one plasma option. Some processes were, or are still, patented. The feasibility must also be checked under the local conditions. Before using such a procedure, check to confirm that no patent is infringed. The list of applications is open; some of the applications are carried out very rarely, and there are always new applications.

Desmear of Drilled Holes and Desmear of Laser-drilled Holes/Carbon Removal [3]

The removal of resin smear from drilling (desmear) is a process step after drilling, but before copper plating required to ensure electrical contact. It is usually done with potassium permanganate in a warm, aqueous solution. Instead of permanganate, a plasma process can be used with similar results on copper adhesion. Plasma processing removes epoxies, polyimides, cyanate ester, and blends of different resins (bismaleimide triazine). The plasma process is generally carried out in three steps, although it is possible to perform the process in one step.

This process is also suitable to remove carbon, which is a byproduct left after laser drilling. After laser drilling, a mixture of different resins and carbon remains. The resin is destroyed by CF_4 and oxygen. The carbon is burned and removed by oxygen/argon.

This process in three steps is as follows:

1. Oxygen until 80–100°C is reached on the board surface (oxygen and 10% inert gas, nitrogen/argon).
2. Mixture of CF_4 and oxygen with 10% inert gas (15 minutes).
3. Oxygen with 10% inert gas to burn the residues. This step removes any ash, carbon, and fluorine left from step one or two. Time is adjusted to meet desmear or etch-back requirements. When etch-back is required, glass fiber removal is done before plating. The inert gas is very important; it makes the chemical attack more uniform, and for an inert gas, nitrogen or argon can be used. Helium is fine too but is not usual in Europe.

This process in one step is as follows:

1. Mixture of CF_4 and O_2 with 10% inert gas, nitrogen or argon (5–30 minutes, depending on the energy of the RF generator).

Surface Activation of PTFE (Surface and Holes) [3-5]

Although PTFE does not smear during drilling, it must be activated in the hole wall to increase the wettability, and plasma treatment is a very good method for surface activation of PTFE. The process is carried out in one step. If other materials besides PTFE are involved, then the process

is carried out in four steps. PTFE means polytetrafluoroethylene (a common trade name is Teflon®; it belongs together with perfluorethylenpropylene (FEP), perfluoralcoxipolymers (PFA), and ethylene-tetrafluroethylene-copolymer (ETFE) to the fluoropolymers.

All fluoropolymers can be pretreated with plasma in a similar way. These products are available as pure blends or with fillers. The fillers generally improve the properties of the laminate, thermal conductivity, coefficient of thermal expansion, electrical properties, and mechanical properties. They can make processing easier. The types of fillers are generally not public; they can be talc, silica, hollow glass spheres, or ceramics. Even PTFE can be used as filler. Plasma activation of PTFE and pure blends can be done in one step with ammonia (NH_3) or with a mixture of hydrogen and nitrogen. It is possible to perform the process in three steps.

When PTFE with fillers (ceramic, glass) are used, two segments are required. The filler material has to be pre-etched before the PTFE is activated. To do this, CF_4/O_2 is introduced in the first segment, followed by the second segment of H_2/N_2 to activate the PTFE.

The process in one step is as follows:

1. Ammonia or hydrogen and nitrogen (70% H_2/30% N_2, 10–30 minutes).

This process in three steps is as follows:

1. Heat up oxygen with 10–20% of nitrogen to reach 70–90°C.
2. Surface etch 80% hydrogen with 20% nitrogen (30 minutes).
3. O_2 burn, 100% O_2, to remove residues (5 minutes).

PTFE Together With Other Types of Laminate [3]

Multilayer PCBs consist of several different materials to reach thermal and signal requirements. Different types of prepregs are laminated together and give a multilayer. There are many possible combinations of different types of epoxy, polyimide, and fluoropolymers. Desmearing panels with mixed material can also be done through plasma. Laminated combinations, such as epoxy and PTFE, require desmearing and PTFE activation. Because hybrid panels are partially made up of the same resins as standard rigid panels, the drill smear must still be removed. PTFE does not smear. However, it must be activated in the hole wall to increase wettability. Desmearing and PTFE activation in the same process uses four gases and four steps. This allows hybrid panels to be processed for electroless plating in one step. No glass fiber removal is required for this process.

This process in four steps is as follows:

1. Oxygen until 80–90°C is reached on the board surface (oxygen and 10% inert gas, nitrogen/argon).
2. Mixture of CF_4 and oxygen with 10% inert gas (10–30 minutes).
3. Oxygen with 10% inert gas to burn the residues (5–10 minutes).
4. Mixture of hydrogen and nitrogen (3:1) or ammonia (5–20 minutes).

This process in two steps is as follows:

1. Mixture of CF_4 and O_2 with 10% of inert gas, nitrogen or argon (5–30 minutes, depending on the energy of the RF generator).
2. Mixture of H_2 and N_2 (3:1) or ammonia (5–20 minutes).

Surface Cleaning Before Solder Mask [3]

Cleaning the surface before solder mask makes sense if copper deoxidation of the surface is needed to prepare the laminate before solder mask. The first step is chemical preclean and microetch. Next, follows plasma cleaning in one step with an inert gas like argon. It is possible to perform this plasma step with other gases, too, such as hydrogen or helium. Note, however, that if the outer layer is made of PTFE, you will want to proceed as described in the section on PTFE.

Surface Treatment of PCBs: Increasing Surface Tension [3]

Plasma treatment can also be used to improve solder mask surface adhesion for leg-

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end ink, as well as the adhesion of conformal coating and other coatings. Plasma creates a wettable surface without discoloring the solder mask. As a result, the surface tension is strongly increased (plasma treatment with O_2 at low pressure, one step, 10% inert gas).

Desmear of Hole Fill Paste Before Plating [3]

Plasma treatment is a good alternative to a wet process with permanganate.

This process in one step is as follows:

1. Mixture of CF_4 and O_2 with 10% of an inert gas, nitrogen, argon, or helium (5–30 minutes, depending on the energy of the RF generator).

This process in three steps is as follows:

1. Oxygen until 90°C is reached on the board surface.
2. Mixture of CF_4, O_2, and 10% of an inert gas (10–30 minutes).
3. Oxygen to burn the residues (5–10 minutes).

Cleaning of a Gold Surface Before Soldering and Bonding

Plasma cleaning of a gold surface (ENIG, electroless, electroplated, soft gold, hard gold), full body or selective, significantly improves the solderability and wire bonding, as the dispersion will be smaller, and the pull-off values for the wires and solder joints are much more consistent. There are several gas mixtures to perform this cleaning process; very good results are obtained with argon plasma in one step.

Cleaning of Surface: Deoxidation Before Soldering

Plasma cleaning of PCBs before soldering is a viable alternative to wet cleaning processes and is done in one step. Hydrogen, or a mixture of hydrogen with argon, is used to make up the plasma (10 minutes, give-or-take).

Drilling of Polyimide and Flexible Circuits

Plasma treatment is an elegant alternative for polyimide machining (drilling) or laser machining. With plasma, holes, via holes, and blind vias up to a diameter of 50 µm can be generated. The plasma drilling process is completed in one step, with a mixture of oxygen and tetrafluorocarbon with 10% argon (nitrogen). Milling and the creation of irregular contours are also possible with this technology.

Surface Activation of Polyimide for Fully-additive Copper Plating

For flexible circuits, a flexible polyimide copper clad is generally used. Surface patterning is done with photolithographic wet subtractive techniques. For the highest pattern resolutions, it is possible to use additive patterning. Then, plasma can be used to achieve the best surface activation for palladium adhesion. Plasma-based surface activation is performed with a mixture of hydrogen with nitrogen in one step at low pressure. With this treatment, the amine groups are created on the polyimide surface, which ensures a good palladium adhesion.

Panel/Layer Descumming [3]

Descumming is the removal of resist residue left over from the circuit image developing process.

Developing the resist on panels and layers with fine pitch design features will sometimes leave a developer scum between the circuits. If this residue is left on through plating or etching, the residue will cause an electrical short. Plasma can be used to remove scum between the fine pitch features.

The process can be performed in one step with oxygen. The duration of plasma treatment depends on the power of RF/microwave generator, and the scum thickness that needs removal (15–30 minutes is usually sufficient to remove the variable thickness of resist sum).

The Final Surface Finish of a PCB for Copper Preservation (Semblant)

The Semblant plasma finish (SPF™) is deposited using a plasma polymerization process in a vacuum chamber. The process creates a dense, highly crosslinked, ultrathin fluoropolymer coating on the surface of the

PCB by ionizing a precursor gas in a low-pressure plasma.

Because the coating is deposited uniformly wherever the process gas contacts the substrate, the process can deposit a completely continuous film at coating thicknesses as low as 15 nm, including inside high aspect ratio vias. In the plasma polymerization process, a mixture of gases (precursor gas) is introduced in the vacuum chamber containing the PCBs.

A microwave/RF generator sparks the plasma which ionizes and fragments the gas molecules in a glow discharge. These active molecular fragments recombine on the surface of the circuit board to create a thin film with good adhesion to the substrate. This resultant fluoropolymer has remarkable chemical properties, which extend the shelf life of the PCB. The surface is solderable.

Conclusion

Gas plasma is a well-established and reliable technology, which has been used for decades. The plasma process is an environmentally friendly, efficient, and reproducible cleaning method. Plasma treatment is a green technology. There is no waste or wastewater. There are small amounts of gases that can be easily released into the atmosphere. The gases used can be environmentally relevant, even in the manufacturing process of these gases. **PCB007**

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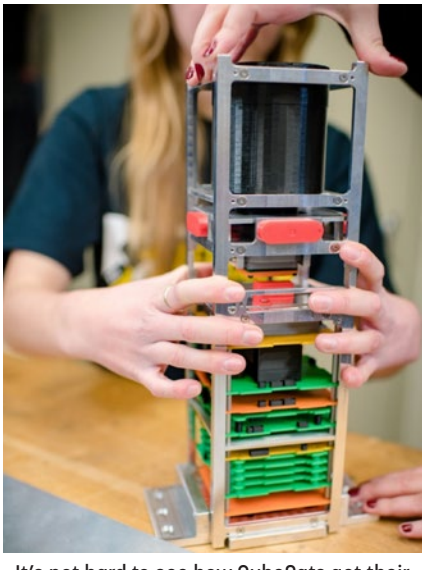
Nikolaus Schubkegel retired in February 2019. For the past 12 years, Schubkegel worked at Umicore Galvanotechnik GmbH in Germany as a technical service engineer for Taiyo products. Before that, he worked as a process engineer in the solder mask department at the former IBM-PCB plant (later STP) in Albstadt, Germany. Schubkegel obtained an M.Sc. degree in chemical engineering from the Polytechnic Institute in Timisoara.

MTU's Next Student-built Satellite Set to Launch in 2021

NASA has slated Michigan Technological University's second student-built satellite for a March 2021 deployment from the International Space Station (ISS). Stratus, named for its cloud-imaging mission, will be carried to the space station, 200 miles above Earth, in a SpaceX Dragon cargo capsule on a Falcon 9 rocket. The Dragon will dock to the ISS. Once successfully deployed, Stratus will be the University's second orbiting nanosatellite. (Source: MTU)

Michigan Tech's Aerospace Enterprise empowers undergraduate students to design, build, and fly spacecraft.



It's not hard to see how CubeSats get their name. Stratus is a 3U spacecraft, which means it's composed of three units. This photo was taken in fall 2019.

Guerilla Tactics to Pass Any QMS Audit, Part 2

The Right Approach

by Steve Williams, THE RIGHT APPROACH CONSULTING

Introduction

Continuing March's Part 1 column on "Guerilla Tactics to Pass Any QMS Audit," I will cover tactics 5–8. Hopefully, you are finding a number of solid strategies you can apply immediately to improve your audit success.

Guerrilla Tactic 5: QMS Audit Tactical Strategies

> ***Williams' Law 5***
> *Every time you volunteer something not asked for, you will end up sharing something you don't want shared.*

Don't Volunteer Anything

Teach all employees to listen to the question and be polite, courteous, and helpful. However, answer the question and only the question. Teach it, preach it, and audit to it!

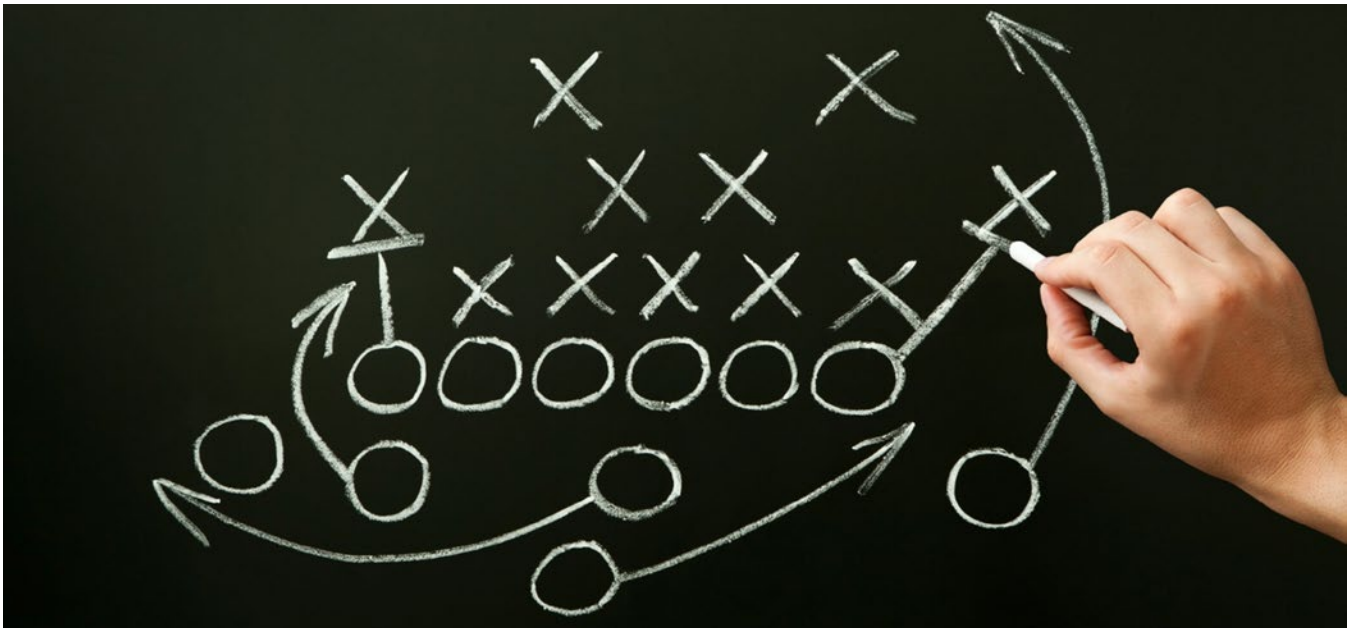
Develop an Audit Vacation Policy

Consider having no vacations for "key" positions, such as procedure approval signatories and department supervisors/leads, and mandatory vacation for "suspect" employees during an audit.

Get In and Get Out

Job one is to get the auditor out of each department as quickly as possible. Every manager, supervisor, and operator must be proficient at this; be efficient, informative, polite, and professional. Further, employees must be comfortable dealing with auditors.

Also, practice the "15-second time-to-retrieval" rule. Within 15 seconds, any operator should be able to physically secure the procedure, find the answer in the procedure, and provide proof of operation (completed form, history, log, etc.).



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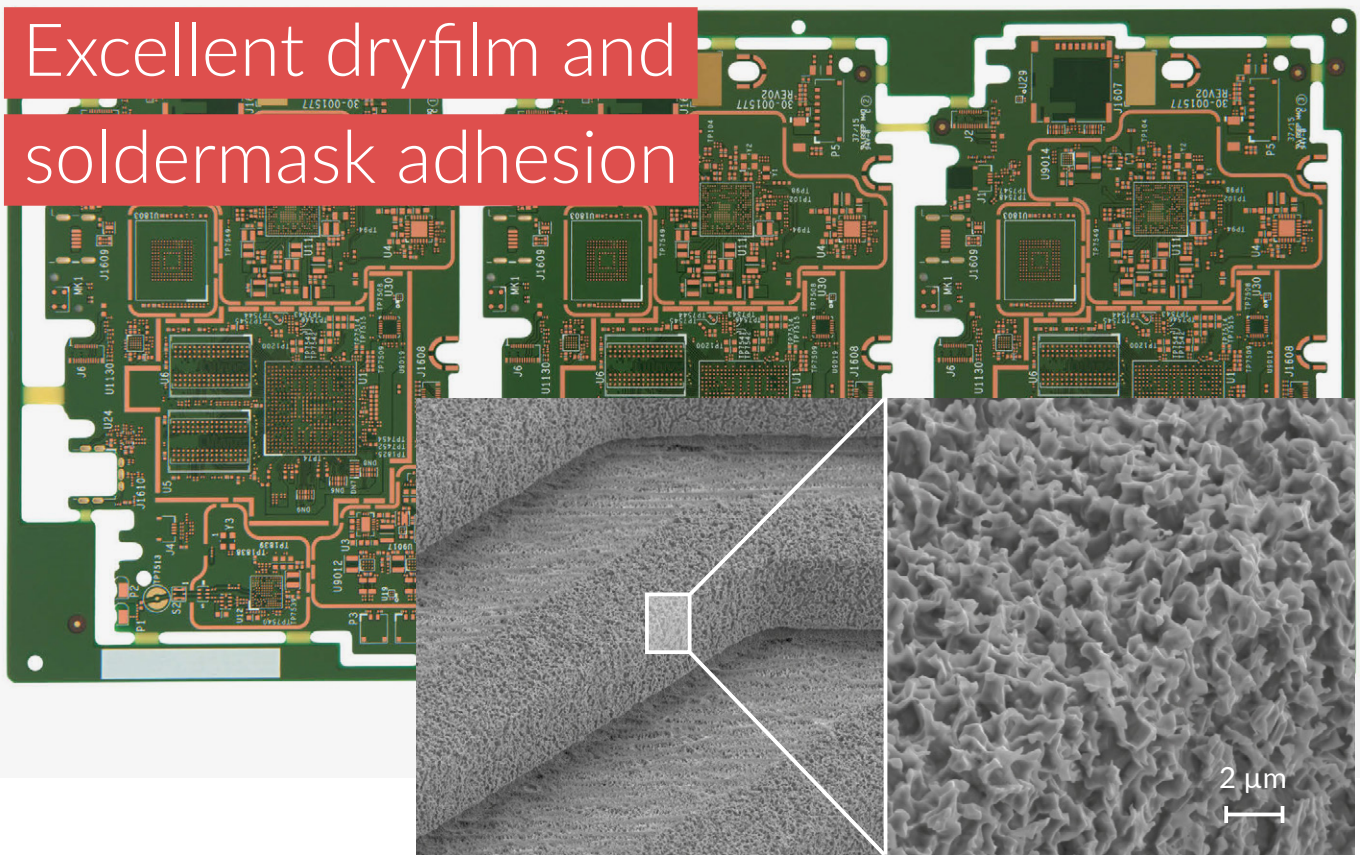
Dryfilm and soldermask pretreatment with advanced adhesion performance

ATOTECH

Excellent dryfilm and soldermask adhesion



Pic. 1: CupraEtch® SR8000 etched Cu

Metal complex free solution

CupraEtch® SR8000 is a cupric chloride based microetching system with unique additives. The simple three step process creates uniform roughening of surface at low temperatures. Atotech's cost-effective pretreatment easily drops into existing lines and reliably improves the adhesion of all copper types to industry standard dryfilm and soldermask types. Metal complex free solution benefits in cost-effective waste water treatment.

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Guerrilla Tactic 6:
Train, Train, and Train Some More

> ***Williams' Law 6***
> *If an auditor waits longer than 15 seconds for a response, they will wander around and invariably find something you don't want found.*

Don't focus on procedural memorization; the key is an ability to quickly retrieve information from the procedure. Utilize a Certified Operator Program, have simple training records, and use written tests that demonstrate understanding and competence and require annual recertification.

Make training status visible. It should be easy to verify that an auditee is trained and certified to a task being performed (badge, color coding, training matrix card, etc.). Clearly identify temps and trainees; auditors will typically not question these employees.

Create Improvement Teams

Primary responsibilities of these teams would include:

- Pursuing continuous improvement
- Being a procedure and process owner
- Being departmental ISO champions and watchdogs
- Being a powerful ISO support system
- Being quality system "buy-in" facilitators
- Fostering a "sense of ownership"
- Enforcing and complying with the system

Be creative in naming your team. For example:

- PIT Crew (Product Improvement Team)
- CIT (Continuous Improvement Team)
- Bulldog Brigade
- Tiger Team

Common Sense Process Control

Only control "critical" processes, and be operator-centric—not engineering-centric. There should be operator-level responsibility; train those who actually do the work.

Guerrilla Tactic 7:
MBWA

> ***Williams' Law 7***
> *You can't manage from your office, and if you don't constantly monitor the pulse on the shop floor, it is easy to lose control.*

Tom Peters, the author of the "Excellence" series of books and one of my favorite management consultants, coined the phrase "management by walking around," or MBWA. This is another of those concepts that seem so obvious, but how many of us actually do this? This is a rhetorical question, but really, how often do you go out on the shop floor and just observe what is going on? I don't mean tracking down orders and making sure people are working, but how does the facility look? Do the workers look happy? What are they saying? Are we working smart or overcompensating by working hard? What would I think if I were the customer? You can't answer these questions by sitting in your office.

Guerrilla Tactic 8:
Learned Behaviors

> ***Williams' Law 8***
> *You CAN teach an old dog new tricks.*

Many of the concepts discussed in this series may seem unconventional and may not come naturally. That is to be expected, but the good news is that they are easily learned with practice, diligence, and continuous positive reinforcement. A learned behav-

ior is a behavior observed by someone that they find beneficial to them in some way. There's a motivating factor behind it. Unlike innate behavior, a learned behavior is one that you make a conscious decision to learn; in other words, nurture rather than nature.

Think about writing. When you first began to learn to write, it required constant thought and attention. Now, when you jot down a note, it is automatic or second nature. That is how all learned behaviors are developed. The following list is a way to initiate and reinforce the learned behaviors that will be required to foster the culture needed to get the full benefits out of all the concepts, techniques, and methodologies discussed throughout this series.

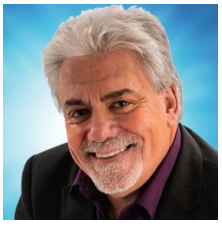
Prepare all employees much as a trial lawyer would prepare a witness, including:

- Coaching responses
  - Not just answer, but the tone, eye contact, politeness, etc.
  - Confidence (a learned behavior)
- Scripting for common questions
  - Where is your procedure?
  - How do I know you are trained to do this operation?
  - Where are your training records located?
- Memorizing the quality policy and battle cry
  - Teach and practice with internal audits and rallies
  - Query employees with every interaction
- Helping operators to understand procedures (this is a MUST)
  - Don't teach memorization
  - Teach content and structure
    - Know the importance of standardized sections
    - Know where to find answers
  - Operator certification: open-book test
- Training operators not to guess at auditor questions
  - Teach "Please let me refer to my procedure"
  - Supervisor or ISO rep can assist in guiding employee to correct answer
- Practicing response time to the 15-second rule

You must be comfortable with 100% of employees' abilities to deal with auditors/customers. Condition employees through internal audits, and practice, practice, practice. Cheating is not acceptable; facilitate applied learning because character and integrity are everything.

Conclusion

It is my desire that as we work through the various strategies, techniques, and tactics presented throughout this series, you will appreciate that these are tried-and-true, practical applications and lessons learned over the course of my career that I hope you will find some value in. **PCB007**



Steve Williams is the president of The Right Approach Consulting. To read past columns or contact Williams, click here.

Lamination and Delamination

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

Introduction

There are many reasons to get incredibly frustrated and confused when presented with complex issues related to the PCB fabrication process. There is much room for error, and often, the simplest little detail overlooked leads to significant product quality loss. Consider the design requirements, along with more stringent reliability performance, and there is a recipe for defects, such as delamination. Let's review the concerns with the possibility of multilayer board delamination and the root cause or causes of the defect.

Delamination Versus Laminate Voids

When reviewing the potential root cause of delamination, the first thing the troubleshooter must do is determine if the anomaly is delamination or a lamination void. They are different as to the root causes of each. And once this is recognized, the protocol—along with fishbone diagrams and brainstorming—can begin. Voids are not a separation of the resin from the copper. Rather voids are basically air pockets formed within the multilayer package. An example of laminate voids is shown in Figure 1.

IPC-T-50 defines a void in laminate as a circular pocket within resinous area of laminate, usually formed by entrapped air or volatile materials and at or near the surface of the laminate.

The prepreg or prepreg/laminate surface may show small voids. These may expand when subjected to soldering or reflow. Small voids in the board may bridge conductors, pick up moisture, and cause electrical shorts.

Delamination is a horse of a different color. Delamination is defined by IPC T-50 as "a separation between plies within a base material, between a base material and a conductive foil, or any other planar separation within a printed board"—the key concept being separation.

Blisters, even on inner layers, affect the surface of the printed board. A bubble will be able to be felt when touched. Understanding the root cause, however, is most critical at this juncture. A blister doesn't necessarily equate to classic delamination. Nonetheless, the blister is a separation and most likely caused by moisture within the laminate package. What

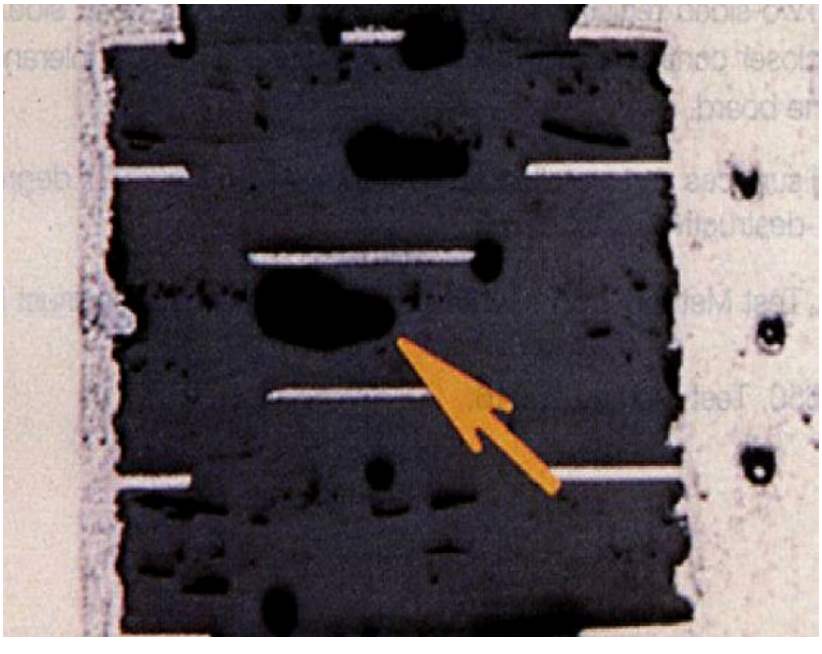


Figure 1: Laminate voids.

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Ultra-low Transmission Loss Multi-layer Circuit Board Materials for ICT Infrastructure Equipment

MEGTRON7 (G)type NEW

Laminate **R-5785(GN), R-5785(GE)**
Prepreg **R-5680(GN), R-5680(GE)**

(GN):Low Dk Glass cloth type (GE):Normal Glass cloth type

Features

- Improved lamination processability compare to MEGTRON7 R-5785(N)
- Glass transition temperature (Tg): 200˚C (DSC)
- Multi-site production in Japan/China

	Dk	Df
R-5785(GN)	3.4	0.002 @ 12GHz
R-5785(GE)	3.6	0.003 @ 12GHz

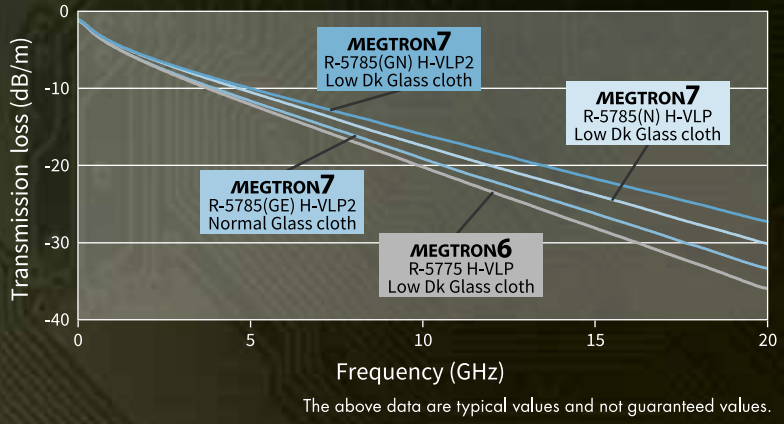
Applications

- High-end servers, High-end routers, Supercomputers, and other ICT infrastructure equipment, Antenna (Base station, Automotive millimeter-wave radar), etc.

Transmission Loss

- Construction

Trace thickness(t)	18μm
Dielectric thickness(h)	300μm
Copper thickness	18μm
Inner treatment	No-surface treatment
Core	0.15mm (#1078 x 2ply)
Prepreg	0.15mm (#1078 x 2ply)
Line length	1000mm
Impedance	50Ω



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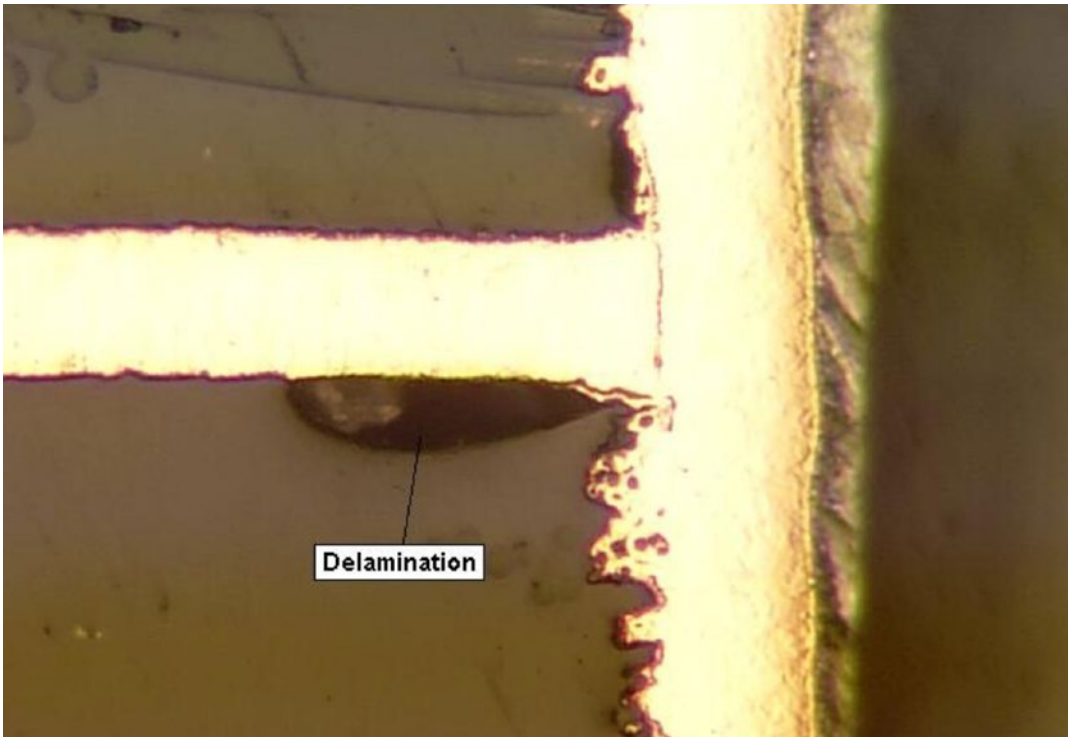


Figure 2: Delamination with resin separation from the copper.

is critical to understand is whether there is a separation from the copper surfaces where the resin is separated (Figure 2).

The microsection in Figure 2 is a good depiction of classic delamination. There are a number of factors that can contribute to the delamination shown in Figure 2. Table 1 provides a good overview of the causes of delamination.

As the reader can surmise, there are many variables to monitor and check if the process is not in proper control. However, delamination also occurs within the resin itself for a number of reasons (Figure 3).

Since this is not classic delamination, what is the probable cause here? One probable cause is moisture remaining in the laminate material. One cannot assign the cause of this defect to the inner layer preparation process as there is no separation of the resin from the copper surface, as shown in Figure 2. For the issue noted

Cause	Action
Moisture in prepreg or copper layer	Bake layers before lay-up
Resin not able to bond to the copper surface	Investigate surface prep/oxide bonding chemistry to ensure an effective surface area for prepreg to bond
Insufficient resin content	Increased prepreg with higher resin content material or add an additional sheet of prepreg
Excessive resin flow	Adjust lamination pressure and heat rise to improve resin flow and encapsulation
Incomplete cure of the resin	Review press cycle, check thermal couples, press cycle too short, cure temperature too low
Inner layer treatment is non-uniform or has incomplete coverage over the copper	Analyze the process and adjust key parameters to ensure uniform coating to enhance bonding

Table 1: Delamination overview.

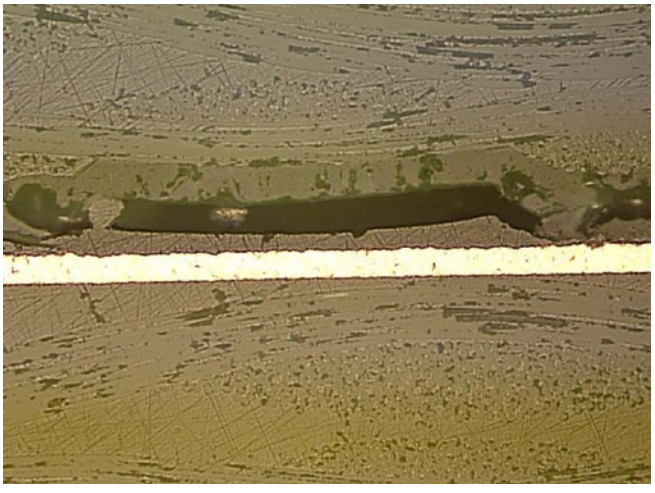


Figure 3: Delamination within the resin itself.

in Figure 3, a thorough review of the prepreg storage conditions—as well as the lamination cycle—is in order. If a single-stage press cycle was used in this case, one should switch to a dual-stage lamination cycle. While up to 10–12-layer multilayer boards are amenable in a single stage, in most board stackups, the dual-stage or kiss cycle has advantages for higher layer counts as well. The release of volatiles is optimized during the low-pressure portion of the kiss cycle.

Another probable cause of delamination within the resin itself is defective incoming material from the supplier. If the fabricator has taken all necessary precautions to ensure proper storage of the prepreg, including storage at low humidity and low temperature, this issue requires a new lot of prepreg material.

Remember, the printed wiring board fabrication process is made of chemical and mechanical processes. Understand how these work together to ensure the fabrication of a high-quality product. **PCB007**

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

Recognizing the Passing of Industry Veteran Brian Keith Fisher

The PCB industry recognizes the passing of Brian Keith Fisher of Port Orchard, Washington, on Sunday, May 3, 2020. His network of friends and acquaintances was vast as he had worked in many areas of the industry including as a plater, a laminator, in distribution as a manufacturer's representative, a copper foil supplier, and ultimately for a copper foil manufacturer. Brian might also be considered one of the fathers of using foil cap lamination, instead of the more common core cap, used in the early stages of multilayer construction. In the early '80s, there were only a few fabricators that were interested in this approach which, has become commonplace today.

Brian's PCB career began in Palo Alto, California, with a company affiliated with Hewlett Packard. Later on, he moved to Everett, Washington, to join John Fluke Manufacturing. His next stop was Mica Laminates in Culver City, California, working in the technical marketing department supplying copper-clad laminates to the electronics industry. He later returned to Washington state, and in 1979, started American Pacific Marketing to provide Northwest fabricators with many of the consumables used in plating and drilling, progressing from his house to a warehouse in Redmond. In 1997, this business was sold to Electrical Insulation Suppliers, and Brian joined forces with them to coordinate sales of APM's broad product line. Brian left EIS to begin working at Circuit Foil, providing sales and technical support for their products in the U.S.

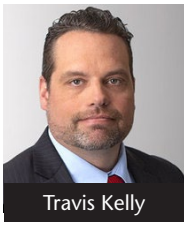
Brian Keith Fisher

Later on, he would leave Circuit Foil to begin a new adventure in the agricultural industry, specifically harvesting, storing, and reselling bee pollen to improve crop yields for farmers for a large part of the West Coast. He performed that duty until mid-2019, at which time he fully retired and pursued his real passion for woodworking from his home with some limited commercial applications.

In the 35 years that Brian was in the industry, competitors would tell you he was a tough guy to get out of an account. He was an innovator and was not afraid to try things even though they had never been done before. He was a leader, a mentor, and a friend to many. He will be missed.

Editor Picks from PCB007

1 Isola's Travis Kelly: Maintaining Continuity of Supply ▶


Travis Kelly

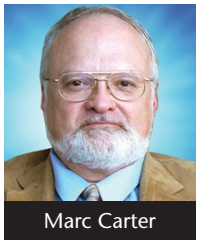
Publisher Barry Matties recently spoke with Travis Kelly, Isola president and CEO, who gave an update on Isola's responses to the COVID-19 challenges in materials manufacturing. Travis pointed out that Isola's products fill a critical need in the switch to medical equipment manufacturing for ventilators and related products.

2 Dr. John Mitchell: IPC's Ongoing Efforts Related to COVID-19 ▶


John Mitchell

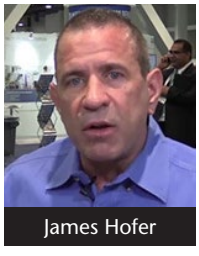
On April 14, IPC president and CEO, Dr. John Mitchell, described IPC's ongoing efforts related to COVID-19 with I-Connect007 Publisher Barry Matties. From a standpoint approximately 30 days into the U.S. shutdown, Mitchell reported that 94% of the executives attending the executive forum are expressing concern.

3 Better to Light a Candle: Chapter Seven—Coping With COVID-19 ▶


Marc Carter

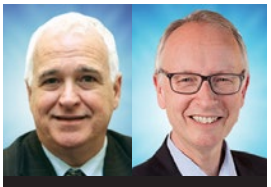
The cascading effects of the exploding COVID-19 pandemic have, as you'd expect, forced major changes in the educational experience at MTU (and generally at universities across the country), and put plans elsewhere on hold. Marc Carter outlines the ways MTU students, educators, and guest lecturers are coping with the unexpected "remote learning" as the new reality.

4 Accurate Circuit Engineering Staying Ahead of the COVID-19 Curve ▶


James Hofer

On April 16, Andy Shaughnessy spoke with Accurate Circuit Engineering's James Hofer, who provided an update on the company's responses to the challenges of fabricating PCBs while much of the country is under COVID-19 quarantine.

5 IPC Europe Shares Technical Education and Standards Awareness ▶


Carano and Pedersen

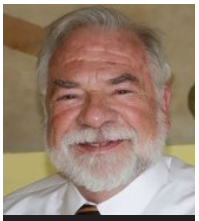
Against a background of COVID-19 uncertainty and unprecedented challenges, but recognizing the vital importance of continuing to educate engineers and share the knowledge and skills required to manufacture boards and assemblies of the highest yields and reliability, the IPC Europe team hosted a technical webinar for the European electronics industry, featuring the expertise of two of I-Connect007's regular columnists: Mike Carano and Jan Pedersen.

6 Photography Slideshow by Columnist Mehul Davé ▶


Mehul J. Davé

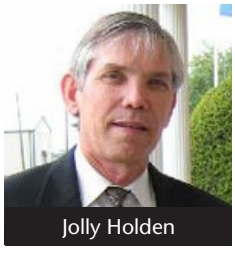
At I-Connect007, we like to work hard, play hard, and highlight our contributors. Mehul J. Davé is a great example of someone who is passionate about the industry as well as his other interests outside of work—especially photography. Here, we feature some of his work.

8 Aurora Circuits Offers PCBs for Ventilators at No Cost ▶


Christopher Kalmus

Dr. Christopher Kalmus, president of Aurora Circuits, announced that Aurora Circuits would produce PCBs for ventilator manufacturers at no cost.

7 Jolly Holden: Expert Insights Into Distance Learning and Webinars ▶

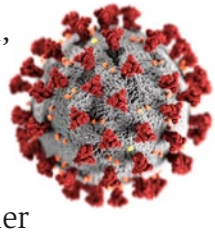

Jolly Holden

With COVID-19 leading to increased distance learning throughout the U.S. and world, the I-Connect007 editorial team spoke with Jolly Holden, Ed.D., who is an expert on distance learning (and also Happy Holden's brother). In this wide-ranging interview, they discuss what distant learning is, how to do it well, what not to do.

9 NCAB Group Acquires Bare Board Group in the USA ▶

NCAB Group—one of the world's largest suppliers of PCBs, with headquarters in Sweden—signed an agreement on April 24 to acquire 100% of the shares in Bare Board Group Inc. (BBG). BBG—based in Largo, Florida—had revenues of approximately US$30 million in 2019.

10 The Big Picture: Globalization—COVID-19 ▶



In Mehul Davé's last column, he spoke to the challenges of tariffs and alternate sources for PCBs and the larger divide between the U.S. and China, potentially leading to far broader implications for U.S.-led vs. China-led technologies. The world has changed dramatically since then.

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Send CVs to: Corinne Tuthill,
ctuthill@greensourcefab.com
or GreenSource Fabrication, LLC,
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- Experience using SKILL script automation such as dalTools
- Excellent team player that can lead projects and mentor others
- Self-motivated, with ability to work from home with minimal supervision
- Strong communication, interpersonal, analytical, and problem solving skills
- Other design tool knowledge is considered a plus (Altium, PADS, Xpedition)

Primary Responsibilities

- Design project leader
- Lead highly complex layouts while ensuring quality, efficiency and manufacturability
- Handle multiple tasks and provide work leadership to other designers through the distribution, coordination, and management of the assigned work load
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Thank you, and we look forward to hearing from you soon.

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- Compile feasibility studies for bringing new products and emerging technologies through manufacturing to the marketplace
- Provide product and manufacturing support
- Provide product quality control and support
- Must comply with all OSHA and company workplace safety requirements at all times
- Participate in multifunctional teams

Required Education/Experience:

- Minimum 4-year college degree in engineering or chemistry
- Preferred: 5-10 years of work experience in designing 3D and inkjet materials, radiation cured chemical technologies, and polymer science
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Working Conditions:

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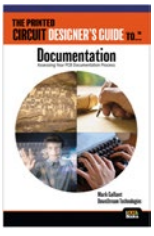
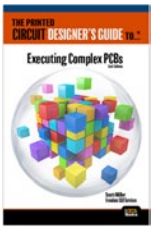
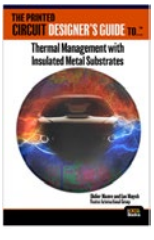


Documentation, by Mark Gallant, Downstream Technologies
When the PCB layout is finished, the designer is still not quite done. The designer's intent must still be communicated to the fabricator through accurate PCB documentation.



Executing Complex PCBs, by Scott Miller, Freedom CAD Services
Designing a complex circuit board today can be a daunting task. Never before have PCB designers on the cutting edge faced more formidable challenges, both electrical and mechanical.

Producing the Perfect Data Package, by Mark Thompson, Prototron Circuits
For PCB designers, producing a comprehensive data package is crucial. If even one important file is missing or output incorrectly, it can cause major delays and potentially ruin the experience for every stakeholder.



Thermal Management with Insulated Metal Substrates, by Didier Mauve and Ian Mayoh, Ventec International Group
Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.

Fundamentals of RF/Microwave PCBs, by John Bushie and Anaya Vardya, American Standard Circuits
Today's designers are challenged more than ever with the task of finding the optimal balance between cost and performance when designing radio frequency/microwave PCBs.

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

CREATIVE TECHNOLOGIST: **BRYSON MATTIES**

COVER: **SHELLY STEIN**

COVER IMAGE: **ADOBE STOCK © ALPHASPIRIT**

PCB007 MAGAZINE

PCB007 MAGAZINE®
is published by BR Publishing, Inc.,
942 Windemere Dr. NW, Salem, OR 97304

May 2020, Volume 10, Number 5
PCB007 MAGAZINE is published monthly,
by BR Publishing, Inc.

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