

APRIL 2021

iConnect007
GOOD FOR THE INDUSTRY

PCB007

M A G A Z I N E





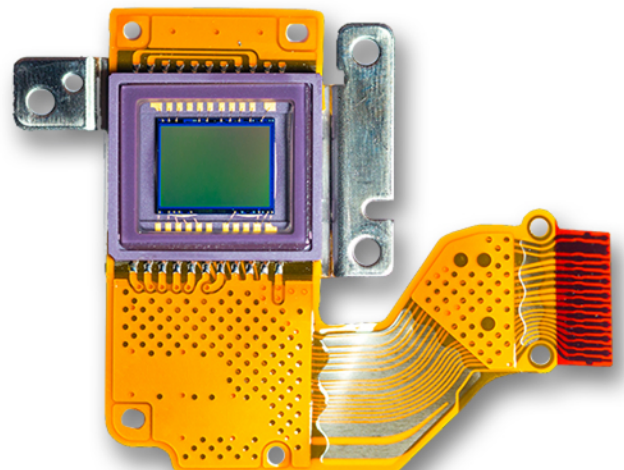
Online Training Workshop Series:

Flexible Circuit Technology

with Joe Fjelstad

This free on-demand workshop series is a comprehensive look into the structures, applications, materials, and manufacturing processes of flexible printed circuits.

START WATCHING



PRESENTED BY

I-Connect007
GOOD FOR THE INDUSTRY

SPONSORED BY



American Standard Circuits
Creative Innovations In Flex, Digital & Microwave Circuits



ROUNDTABLES

Lively and insightful discussions from industry experts. **Watch now!**



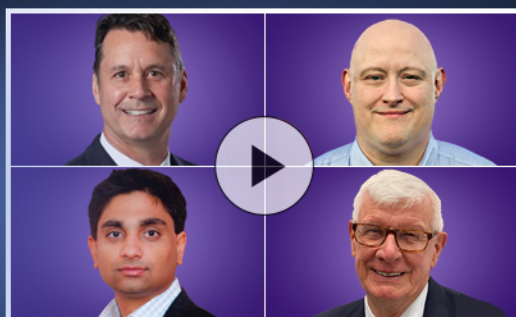
**App Notes
and Fab Notes**



**Process Ionic Contamination
Test (PICT) Standard**



**Achieving Operational Excellence
in Electronics Manufacturing**



**Use of IMS Thermal Materials
in Multilayer Stackups**

PCB007

M A G A Z I N E

Focus on Manufacturing

Here in the U.S., there is a push to reinvigorate our manufacturing infrastructure. In this issue, we investigate critical changes, upgrades, and investments needed to strengthen your business: manufacturing, technical, business, and sales.



10

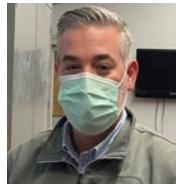
FEATURE ARTICLES

10 Benchmarking Your Process Engineering

Interview with Mark Thompson

24 Driving Down Cost with Process Engineering

Interview with Matt Mack



34 Reinvigorate Your Manufacturing Infrastructure

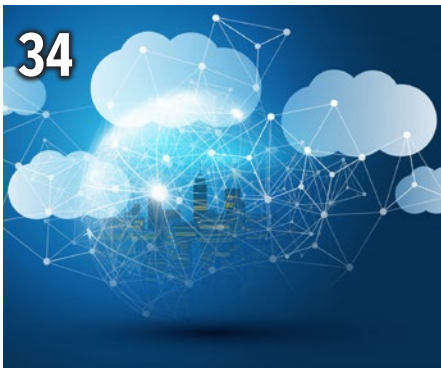
by Mark Goodwin

48 25 Essential Skills for Engineers Excerpt Skill 7: Project and Product Life Cycles

by Martin Tarr

60 Benchmarking for Yield Improvement and Scrap Reduction

Interview with Todd Johnson



34



48



60

FEATURE COLUMN

42 Selling for the Best

by Dan Beaulieu



CAN YOU PLAN FOR THE FUTURE IF YOUR SYSTEMS KEEP YOU IN THE PAST?

See why the top flex PCB fabricators rely on ESI to help them innovate and stay ahead.

Leverage CapStone's unique technologies to deliver breakthrough productivity.

- Cut per-panel processing costs by up to 30%
- Double your flex PCB production throughput
- Lower total cost of ownership

Learn More Here

"Stepping Up To Laser Processing for Flex"



CapStone™



ESI®

www.ESI.com



PCB007

M A G A Z I N E



20

ENVIRONMENT

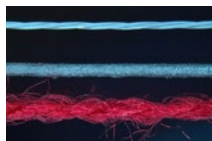
SOCIAL

GOVERNANCE

ESG

SHORTS

- 22** Leveraging the 5G Network to Wirelessly Power IoT Devices
- 63** A Robot That Senses Hidden Objects
- 77** Tactile Textiles Sense Movement Via Touch
- 98** Catching Electrons in Action in an Antiferromagnetic Nanowire



DEPARTMENTS

- 107** Career Opportunities
- 118** Educational Resource Center
- 119** Advertiser Index & Masthead



HIGHLIGHTS

- 37** MilAero007
- 46** EIN007 Industry News
- 73** PCB007 Suppliers
- 104** Top 10 from PCB007



INTERVIEWS / ARTICLES

- 64** Isola Releases IS550H Material
Interview with Michael Gay and Chris Hunrath
- 78** PCB Technologies Expands Capabilities
Interview with Arik Einhorn and Yaad Eliya
- 86** Time, Space, Structures, and Model Analysis of CCL Price Increase
by Hu Yang



COLUMNS

- 8** Manufacturing Excellence
by Nolan Johnson
- 20** Get Familiar With ESG—Environment, Social and Corporate Governance
by John Mitchell
- 38** A Point of Order—Do Not Just Rearrange the Pencils
by Todd Kolmodin
- 56** Leadership 101—The Law of Influence
by Steve Williams
- 74** Plating Anomalies and Defects, Part 2
by Michael Carano
- 94** Don't Forget AABUS
by Jan Pedersen
- 100** 'If I Were 20 Years Younger'
by Tom Kastner



WORLD-CLASS SUPPLIERS

Insulectro, the largest distributor in North America of materials used in the manufacture of printed circuit boards and printed electronics, salutes our premier suppliers.

CALL 949.587.3200 FOR MORE INFORMATION



Because Reliability Matters

THE NEW IS550H

FEATURES


- HIGH OPERATING TEMPERATURE**
Peak Operating Temperature up to 175° C
- HALOGEN FREE**
- CAF RESISTANCE**
≥1000hrs @ 1500V
- HIGH THERMAL RELIABILITY**
Pass -40° C to +175° C, 2000 cycles

MARKETS

- AUTOMOTIVE & TRANSPORTATION**
- AEROSPACE & DEFENSE**

The Material for e-mobility that is suitable to use for those applications requiring high voltage, high power and high thermal stability.

✉ info@isola-group.com ☎ 800-537-7656 🌐 isola-group.com



isola®

EMD PERFORMANCE MATERIALS

Ormet® Sintering Paste: Fewer Multiple Lamination Cycles

Ormet® Transient Liquid Phase Sintering (TLPS) via fill pastes enable anywhere and any-layer vias in high-performance complex printed circuit boards without any need for copper plating. TLPS-filled z-axis interconnect layers can be fabricated in parallel with individual x-y trace layers, or PCB sub-constructions of multiple layers with installed PTH and laminated in a single cycle.



**PASTE
DON'T
PLATE™**

Manufacturing Excellence

Nolan's Notes

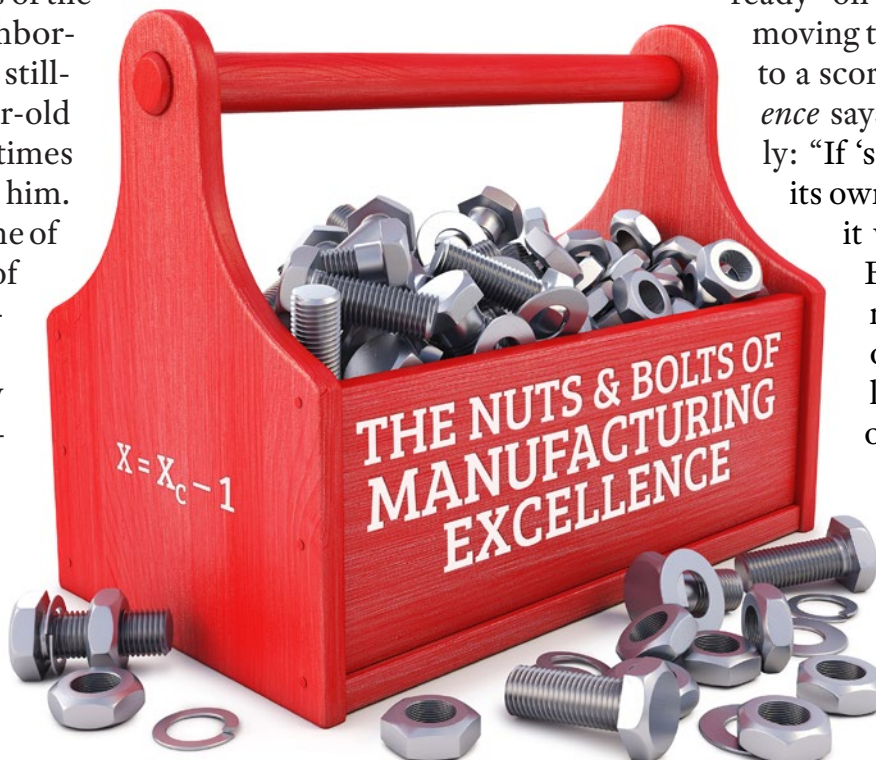
by Nolan Johnson, I-CONNECT007

It's springtime in the United States, and even the late stages of the pandemic can't seem to shut down Major League Baseball. As I write this column, the buzz is about the Texas Rangers hosting the Toronto Blue Jays in a packed, non-distanced stadium full of fans. Baseball has captured my attention since I was very young and growing up on the edge of the Portland, Oregon, metro area. I'd spend significant time at my grandparents' farm and the kid next door—just a few years older than me—was forever packing around his mitt, looking for someone to play a game of catch with. While he preferred catching from the stronger arms of the adults in the neighborhood over my still-developing 8-year-old arm, he'd sometimes let me throw to him. He taught me some of the finer points of throwing a baseball. Later on, that kid—Wally Backman—

ended up in the majors. In 1986, alongside Darryl Strawberry, Dwight Gooden, Lenny Dykstra, Mookie Wilson, and others, Backman helped earn the New York Mets a World Series championship.

In a game built around specialization, Backman's specialty was as a generalist. Baseball calls guys like Wally a "utility player." His value to the team was that you could ask him to do nearly any job on the field and know that he would be an offensive threat as a batter as well. He wasn't a slugger; he didn't hit showy home runs. Instead, he consistently put the ball into play, advancing other teammates already on the bases, and

moving the runners closer to a score. *Baseball Reference* says this about Wally: "If 'scrappy' ever gets its own link in this wiki, it will link to Wally Backman. Backman was the type of player you loved if he was on your team and



hated if he was on the opposition. His uniform was constantly dirty, and he was continuously jockeying the opposition and trying to find ways to get on base.”^[1]

His Major League career can be summed up in his first appearance, “Starting at second base against the Los Angeles Dodgers at Dodger Stadium on September 2, 1980, Backman got a single in his first at-bat, driving in Claudell Washington for his first Major League run batted in.” While he was most dangerous as a defensive infielder, you could ask Wally Backman to do most anything for the team, and he would.”^[2]

Wally Backman is a metaphor for succeeding in our current supply chain. Do something unique very well but be adaptable. His teammate, Dwight Gooden, a pitcher, was extremely valuable as long as he could throw effectively. But did he have value beyond his own specialty? The team wasn’t going to put Gooden in the outfield, for example. Backman? Well, he could be useful almost anywhere.

The supply chain is complex; we all know this to be true. Our global supply chains (all of them) are facing the simultaneous challenges to increase efficiencies (which usually means consolidation tactics) while also increasing resilience (which often requires diversification). Political nationalism aside for the moment, it is true that multiple sources with shorter distribution channels can make for a more reliable supplier network. But doesn’t that also throttle businesses from growing? After all, we’re talking about throttling the market share for any one company in the space by sheer dint of having so many competitors in the space.

Going back to my baseball analogy, in terms of the supply chain, be the supplier who:

- Knows their niche and dominates that specialty
- Is flexible enough to accept a wider range of work than before
- Builds extra capabilities to create new markets for your factory
- Pursues excellence in your manufacturing processes

In other words, you may be the premiere fabricator for, say, high-density circuit fabrication on very thin membrane substrates, but accepting other jobs as the “Plan B” choice for as many OEMs as possible will keep the workflow steady. This is how you become a contributor to the resilience of the supply chain.

It all comes down to excellence. Backman had an overall mastery of his game and craft; yours really isn’t any different. It didn’t matter what the manager asked Wally to do on the field, he’d say yes and then deliver the goods. He earned himself a World Series ring with this skillset, don’t forget. Seems a wise business strategy to me.

In this issue, and as a part of our ongoing series on continuous improvement ($X = X_c - 1$) we look at manufacturing excellence—from process engineering benchmarking and process life cycles, to reinvigorating your manufacturing infrastructure and strategies for selling your manufacturing capabilities. This issue touches on each of these keys to becoming better at all that your firm does well. Not to be left out, of course, are our five expert columnists this month.

Nor do we wish to leave out your stories. We’re always on the lookout for continuous improvement case studies and real-world successes. Contact us and share your continuous improvement tale. **PCB007**

References

1. “Wally Backman,” baseball-reference.com
2. “Wally Backman,” Wikipedia.



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](#).



Benchmarking Your Process Engineering

Feature Interview by the I-Connect007 Editorial Team

Mark Thompson has been in bare board fabrication for over 30 years. He is now laying out printed circuit boards at Monsoon Solutions, a high-tech design bureau near Seattle, Washington. With Mark's extensive hands-on knowledge of PCB manufacturing, he brings a unique perspective to PCB design.

In this discussion with the I-Connect007 editorial team, Mark shares what's important from a process engineer's point of view, and how to stay on top of evaluating and benchmarking your manufacturing process, along with insights from his new role as a designer.

Barry Matties: Mark, now that you're a PCB designer, after decades in fabrication, what is the most surprising thing you've learned?

Mark Thompson: Oh, gosh, there are a number of them. For years I preached things like, "Don't design at minimums due to etch compensations based on copper weights." But now

I find myself living that because I'm running out of space. I'm designing it 4/4 and then thinking, "Well, gosh, if I do that, now I'm going to have to etch compensate it on 1/2 oz copper, and it's going to be 4.5 and 3.5 oz, which means they're going to be relegated to 3/8 oz copper foils." And that might be a problem for power functions. It might be a problem for the part itself, and it may not live with that. So that's one of the things I've learned.

I've also learned a lot about component placement and footprint design. We've talked about footprints before and how critical it is to get your footprints right. And truthfully, the footprints themselves are pretty much the same. What changes is the courtyard, the distance around the component that you're actually putting on the board, and that distance is dictating how much space you have. There could be a tall part, and you might need to actually reach in and hand solder something in on a very tall part. So that becomes an issue, and that's one of the other things that I've learned.

Focused on Solutions

We are setting new standards for PCB manufacturing.

Schmoll Maschinen MDI digital imaging machines provide a high-volume and stable processing solution for manufacturers looking for performance at the highest level. For unbeatable exposure times, look no further.



schmoll  **optronics**

Schmoll MDI Micromirror-Digital-Imaging
Tandem Table Machine

- + Direct imaging of inner layers, outer layers and solder mask
- + High resolution with L/S down to 0.5 mil
- + Tandem table concept (2x 24" x 36") and big panel capability (1x 54" x 36")

For more information call us:
+1 (336) 660-2701

1991
2021  **BURKLE**
NORTH AMERICA, INC.

burkleamerica.com



Mark Thompson

In fact, it's almost like I blanked out my 25 years at Prototron and 30+ years in PCB manufacturing when I started designing. I have to completely rethink the game and deal with a whole lot more variables. Designing is certainly not point-to-point connecting the nets. It is so much more than that. It's understanding those nets; it's understanding power. What's the very first thing I look at when I'm looking at a board? I'm looking at power functions. I ask questions about mechanicals. When we do a kickoff call with a customer, the very first thing I say is, "What sort of mechanical considerations do you have?"

In conjunction with that, there are also power functions. If they have considerations for high-current power, then I've got to make sure that the trace width is going to be large enough. I'll use a site like Saturn and I'll precalculate how wide that trace needs to be, and then I'll be able to preplan things. In fact, that's one of the things that I've learned here recently, very intimately: When I'm placing parts, I allow myself enough space to drop vias to be able to do interconnects. Because if it's a six-layer board and I don't have very much room on the outer layers based on the part geometries and the available space, I'm going to have

to drop down to an internal layer. And by doing that, it means I'm going to have to have a via. I have to account for that via width and that pad size associated with that via all the way down through the stack. I'm also dealing with pouring polygons. That's a big one.

Matties: Right. Is there anything that you used to preach that you would now say, "Hold it, I've rethought this now that I'm on this end, and let's do it this way?"

Thompson: I'll give you an example of that. As a manufacturer, you want things looking nice and clean. If they've got metal at the edge, you're going to try to clip it back. Where do you not clip it back? You don't clip it back on an RF launch, a coplanar waveguide type structure that goes right to the edge of the board and needs to go right to the Z-axis edge of that particular board, and it has to stay that way.

Matties: That's interesting. Thank you for sharing that. With your fabrication background, you're in a really unique position as a PCB designer.

Thompson: I am. I can't tell you how many conversations I've had with the designers here at Monsoon about fabrication-related issues. Frequently they'll ask me what the minimum hole size with a particular pad size is. And they're very simple questions, but they're very helpful if you don't know the answer.

Matties: You're also a PCB fabrication process engineer turned designer. When you look at a shop from a process engineer point of view, how do you go about benchmarking your process?

Thompson: It's all application derived. What's my application? Am I building a cellphone where I'm going to have a very, very thin barrier of copper much like an mSAP process, something like that where it's a very specific process with very rigid constraints on manufacturing,

or am I just going to be building a four- or a six-layer consumable home product and something simple like that? It really depends greatly on what the product is that I would be looking to build. In fact, I've heard the story many times over the years where a designer will literally camp at a fabricator and nurse a job all the way through the process.

And by saying that, what they mean is if there need to be changes—CAD changes, where you have to move a part here or you have to reduce the size here, or you have to move a trace here or there—then they'll do it on the fly at the fabricator. I've heard that many, many times. My brother-in-law did that for many years. He would go to a large company like Compaq and literally camp out for a week in a hotel, just going back and forth through the shop and making sure they were still proceeding forward with the board.

Matties: When we look at fabrication, we're really breaking this down into multiple areas: investment and equipment, and technology. Happy says that there are particular process life cycles. Happy, maybe you want to explain a little bit about what a process life cycle is from your point of view?

Happy Holden: In terms of developing a product, it helps in evaluating or putting in a new process if you actually have a process with milestones from doing beaker level or qualification tests all the way up through a pilot line and then expansion to medium or higher volume production. But there are specific deliverables and specific milestones that are useful to have, including the process of obsolescence. As technology changes, how do we ramp out of this and into the next one? Like you said, Barry, everything should be defined down to a process. New chemical processes and new plating or new materials had a very defined process lifecycle to meet those milestones and deliverables rather than everybody just inventing their own way to do process engineering.

Thompson: Exactly.

Matties: When you were in fabrication, how did you look at process life cycle? Because if you want to change a chemical supplier, that's a large undertaking, a lot of qualifying. It's not an easy or light decision that you would make.

Thompson: Or a material manufacturer. In fact, frequently we would have issues with material manufacturers. Even with the same prepreg ply from the same manufacturer I would have erratic results in signal integrity and controlled impedance. As an example (and this material manufacturer will remain nameless), I went to a trade show and I said, "Look, I'm getting a 1-mil difference in dielectrics of prepregs straight across the board." Styles 106, 1080, 2116, 2113, 7628 all had a linear 1-mil difference.

Even with the same prepreg ply from the same manufacturer I would have erratic results in signal integrity and controlled impedance.

And they said, "Oh, that's because one of our products is made in Guangdong, and the next one is made in Shenzhen. One of them has a dry curing process and the next one has this other kind of a curing process." I said, "That's the problem. You need to give me a sole source. Make your mind up and tell me where you're going to give me the product from and keep it coming from only that particular facility." You can't mix them because I'd never be able to shoot and hit my controlled impedances trying to go with two different materials from two different facilities with two different cure cycles. It never worked.

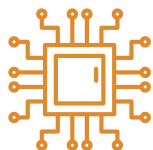


COPPER FOIL

North America's only electrodeposited copper foil manufacturer is celebrating one year as part of the Nippon Denkai, Ltd. family.

DAVID CARY
Technician

DENKAI AMERICA IS THE LEADER in the manufacture of high-quality electrodeposited copper foils for printed circuit board (PCB), industrial, and energy storage applications. With the strength of domestic manufacturing, and backed by a global presence, Denkai America delivers both conventional cladding and application specific copper foils required by technology leading companies. We are committed to:



Continued dedication
to the PCB industry



American made ED
copper foil



Unparalleled
domestic support



New access to
technology and
innovation

803-425-7900

denkaiamerica.com

sales@denkaiamerica.com

Matties: How would you define the role of a supervisor in a PCB facility?

Thompson: That's an interesting question. For years, I was a supervisor at Praegitzer Industries; I ran seven different departments. At one point, I went to my manager and said, "Sir, I do not know everything about all seven of these departments that I am supervising or managing." And he said, "You don't have to. You don't have to know everything about it. What you have to know is how to deal with the people in that department. The people in that department actually manage themselves." And that's actually a very true statement.

Matties: Yes, I think so. For the sales team who's out selling the products, I would think a process engineer is a vital member of that sales team. Explain how that relationship between process engineering and sales works to the customer.

Thompson: Frequently, our outside salespeople would just take me along. They'd start off by going to a customer and saying, "Have you got anything coming up?" And if they had something that was coming up that was a little tricky, they'd say, "I'm not familiar with that, but I'll tell you what, I'm going to grab Mark and I'm going to bring him here and we'll sit down; we'll have lunch, talk about it, and see what we can work through on this." Sometimes it didn't work out at all. Sometimes I'd say, "This isn't a capability that we can support at this time. I understand it; I can tell you about it; I can give you the drawbacks. But I can't necessarily tell you that we support it." Other times I'd say, "That's something we do all the time. That's a daily process for us." So yes, I'd say it's highly effective to have an outside salesperson integrally involved in process engineering and have basically an application engineer.

Matties: Because what could happen in a facility is you could have a process engineer that's so

busy in your sales department that they're not doing process engineering.

Thompson: Happens all the time. Process engineering runs the whole gamut, all the way from ROI of a piece of equipment, what that takes, why I am looking at that particular piece of equipment and what it's going to take to get it into my facility. There's not only how the chemistries play with each other, but there are also environmental considerations. You may have to go through and set up a whole new thing with the county you're in and say, "I'm bringing on this particular chemistry and I'm bringing on this particular process, here's a description of the process." You have to detail the process.

Matties: Right. Waste treatment certainly is a large consideration, because that could create big problems with your effluent if you don't take care of it up front.

Thompson: Absolutely. We used to say at Prototron that the outgoing water is cleaner than the incoming water, and it's a true statement. It absolutely was cleaner than the incoming water with the double pH preadjusts and all the stuff that's on the backend. It was considerably cleaner going out than it was coming in.

I guess the sheer volume of the water that we were going through and the amount of metals-bearing water that was going through the shop at any given time didn't actually warrant a huge tank in the backyard, if you will, to be able to store the outgoing water, to be able to recycle it. Truthfully, in a lot of cases, they actually were recycling the water on the line. But as far as the final outgoing water, no, they just did a pH-free adjust and it went out.

Matties: A lot of what we're talking about is project-based activities. What about the daily process improvement strategy where you're taking your existing process and tightening up the operating parameters?

Thompson: It was continuous, and it should always be continuous at all fabricators, at all times. It should be 100% continuous every day, every hour, every second, and down to the operator and down to everything.

Matties: What was your strategy for implementing continuous improvement? How would you go about that?

Thompson: That really would be more of a quality manager role. But as a process person, I would be looking at the numbers and saying, “We had this problem. What is our strategy to make sure that we don’t have this problem again?” Some things we will do repeatedly, at which point they get higher focus and say, “Look, this has become an epidemic and we need to really focus on this and put this one to bed.”

Matties: The quality manager is really the one who’s saying this process needs to be tighter, then they would come to the process engineer and work with you to tighten up the parameters.

Thompson: Exactly.

Matties: So, it wasn’t necessarily the process engineer who is randomly saying, “I can make this better.” You were really directed by the output and the interpretation of results.

Thompson: In some cases, it was me saying, “We need to do this.” And then I would get with the quality manager. Because it may not manifest itself in a lot of scrap. It may be very low numbers of scrap, but I’d say, “It may be very low numbers of scrap, but it’s continuous year after year, month after month. We’ve got to make sure that we can put this to bed.”

Matties: Right. And what was the other goal?

Yields obviously, as you’re talking about, but time to market is certainly a goal when you’re looking at bottlenecks and that sort of thing. That’s something that the quality manager doesn’t see. Because what you’re looking at as a process engineer is start-to-finish cycle time, I would think.

Thompson: Exactly. We used to time our cycle times on various projects. Did it require blinds? Did it require buries? Did it require alternative surface finishes? Did it require special lamination cycles? Some lamination cycles require a minimum of two-hour extra bake cycles in five places in the process. If you can imagine, that’s 10 additional hours that you may not have planned for as an inside salesperson, saying, “We’ll take that. We can do that.”

Or they’ll get with a production manager and they’ll say, “Sure. We can take that on.” But they’re not necessarily considering, “This is X material, and it’s going to take an additional 10 hours of bake time alone to be able to get this through the shop.”

Matties: We’ve covered a lot in manufacturing, but what do you think it really takes to be a fabricator these days?

Thompson: Honestly, with as many new technologies as are emerging today, I think the key thing is to stay up with technology and to be able to put your money where your mouth is; put your money back into process and be able to purchase the equipment that’s going to be able to support that process.

Matties: Will the goal be to eliminate as much labor as you can in the process?

Thompson: Sure, you certainly can. That was a conundrum when management wanted to



plug in a machine and have somebody press a button, and they don't want them to necessarily know A through Z. They want them to know B to C, or C to D, or D to F, but they don't necessarily want them to know the entire process. Often, it takes somebody that understands the entire process from start to finish to be able to do the job properly. Running an image device where you just press a button, or you run a vacuum and you press a button, that's one thing, but understanding how to use it properly is something else. For instance, let's say you've got a hugely dissimilar dielectric material, and you've got a hugely dissimilar layout structure, where you've got predominant metal on one side and very sparse metal on the opposing side. As we know, that makes for what's called image transfer. And not only image transfer, but it can also end up in misregistration in lamination.

So now I can take it back to my image device. And if I'm smart enough, I can use that image device and table map where it's moving, and I can actually create a new drill program that's going to hit those things right on the mark. And then with the geometries shrinking daily, being able to stay on things and be able to maintain registration and maintain the drill registration throughout the entire process really is a key to the future.

Matties: You're keying in on an area that we don't talk too much about, which is operator training. What sort of training should someone look at if they're really focused on their manufacturing process? And I mean for the existing team that's doing their daily routines, not just processing the big picture stuff.

Thompson: We talked about continuous quality improvement. There's also continuous training. There's a constant training syllabus going on, whether it's coming from somebody like myself as a process person or a controlled impedance person coming in and saying, "This is what we need, and this is how we're going to get there.

We're going to need your help as operators to be able to facilitate this." It's as simple as that.

Matties: When you look at continuous improvement, we're talking about $X = X_c - 1$, taking your current process and improving it by a factor of one, whatever that one happens to be—one day, one minute, one hour, one revolution.

Thompson: One less panel.

Matties: One less panel. Because continuous improvement is an incremental endeavor of small steps throughout. Do you have any examples of where you went in, looked at a process and reduced it, but the results were huge? In many cases, the results can be unexpected or unexpected benefits are found as well.

Thompson: I know there were probably hundreds of them over my career.

Matties: That's the thing, they're small. To draw the baseball analogy, they're just base hits that you do all day long. And that becomes a matter of routine, but the idea is to take that process engineering $X = X_c - 1$ and train your staff to look at what can we have a "minus one" on.

Thompson: To get a better ERA, to use a baseball term.

Matties: Exactly. Mark, we've covered a lot of ground. For some final thoughts, what advice would you give to a PCB manufacturer that really wants to keep focus on their manufacturing?

Thompson: Continuous quality improvement, continuous training. Only buy the equipment that makes sense for your customers and your customers' needs and keep at it.

Matties: Well, Mark, we certainly appreciate you sharing your thoughts today.

Thompson: Of course. Always happy to help. PCB007

Back by popular (on) demand!



Even though this year's show was a little different,
our coverage is still like nothing the industry has ever seen!

DOWNLOAD NOW 

Get Familiar With **ESG**—Environment, Social and Corporate Governance

One World, One Industry

by Dr. John Mitchell, IPC

ESG is the new approach to corporate social responsibility, based on the notion that companies integrating ESG goals into their business decisions and operations are stronger by having accounted for concerns that create liabilities or risk. The financial services community is increasingly relying on ESG ratings and rankings to steer investments.

Today, many IPC members that are public companies have ESG programs and are performing ESG-related data collection and reporting. In many cases, reporting obligations are increasingly flowing down to their suppliers. Our conversations with members indicate they are feeling increasing pressure to achieve ESG standards and reporting requirements, with pressure coming from investors, customers, and the government. Their chief con-

cerns relate to reporting burdens, increased costs, lack of clarity, and regulatory and reputational risk. What is troublesome is that only 25% of the company executives we spoke with felt their company had a strong understanding of ESG.

ESG is likely to impact all companies directly or indirectly, and at the behest of our industry, IPC was asked to help provide much needed navigation on the ESG terrain. At IPC APEX EXPO, we launched an “ESG for Electronics” initiative to develop guidance that advances an industry-specific approach to ESG practices and reporting. A working group of electronics manufacturers is being formed, and the industry can expect to see the product of their work as early as this summer. This initiative will marshal IPC resources and capabilities in





TECHNICA, U.S.A.

Fulfilling Manufacturing Needs Throughout the Electronics Industry



WonderWise



WonderWise is the **Revolutionary** horizontal compact **Atmospheric Plasma equipment** for copper surface preparation before the lamination of photosensitive film on innerlayer process.



Industry4  Ready



Available through Technica, USA in Assigned Territories

1-800-909-8697 • www.technica.com



would like to join IPC's ESG for Electronics steering group. For more information, send an e-mail to ESG@ipc.org or visit www.ipc.org/esg-electronics.

As this area of corporate responsibility becomes more prevalent and relevant, we at IPC will work with you to ensure that we have an industry-specific approach to ESG guidelines and reporting. **PCB007**

standards, workforce, research, and advocacy to achieve industry-backed ESG goals related to environmental stewardship and workforce opportunities.

I look forward to a conversation about this latest issue facing our industry. Please reach out and let me know if your company undertakes ESG reporting, if you're concerned about the effect of ESG on your business, if you believe industry collectively should do more to support ESG goals, if you seek greater industry opportunities to support ESG, or if you



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

Leveraging the 5G Network to Wirelessly Power IoT Devices

Researchers at the Georgia Institute of Technology have uncovered an innovative way to tap into the over-capacity of 5G networks, turning them into "a wireless power grid" for powering Internet of Things (IoT) devices that today need batteries to operate.

The Georgia Tech inventors have developed a flexible Rotman lens-based rectifying antenna (rectenna) system capable, for the first time, of millimeter-wave harvesting in the 28-GHz band. (The Rotman lens is key for beamforming networks and is frequently used in radar surveillance systems to see targets in multiple directions without physically moving the antenna system.)

But to harvest enough power to supply low-power devices at long ranges, large aperture antennas are required. The problem with large antennas is they have a narrowing field of view. This limitation prevents their operation if the antenna is widely dispersed from a 5G base station.

"We've solved the problem of only being able to look from one direction with a system that has a wide angle of coverage," said senior researcher Aline Eid in the ATHENA lab, established in Georgia Tech's School of Electrical and Computer Engineering to advance and develop novel technologies for

electromagnetic, wireless, RF, millimeter-wave, and sub-terahertz applications.

The findings were reported in the Jan.12 issue of the journal Scientific Reports.

The FCC has authorized 5G to focalize power much more densely compared with previous generations of cellular networks. While today's 5G was built for high-bandwidth communication, the high-frequency network holds rich opportunity to "harvest" unused power that would otherwise be wasted.

"With this innovation, we can have a large antenna, which works at higher frequencies and can receive power from any direction. It's direction-agnostic, which makes it a lot more practical," noted Jimmy Hester, senior lab advisor and the CTO and co-founder of Atheraxon, a Georgia Tech spinoff developing 5G radio-frequency identification (RFID) technology.

With the Georgia Tech solution, all the electromagnetic energy collected by the antenna arrays from one direction is combined and fed into a single rectifier, which maximizes its efficiency. (Source: George Tech)



(Photo credit: Christopher Moore, Georgia Tech)



Meetings & Courses

January 22-27

Conference & Exhibition

January 25-27

San Diego Convention Center | CA

Achieve **Digital Transcendence**

Get ready to transcend the norm as you transform through education, innovation and collaboration at North America's largest gathering of electronics industry professionals.

See you in San Diego at IPC APEX EXPO 2022!

IPCAPEXEXPO.ORG | [#IPCAPEXEXPO](https://twitter.com/IPCAPEXEXPO)

Driving Down Cost with Process Engineering

Feature Interview by the
I-Connect007 Editorial Staff

Nolan Johnson and Barry Matties talk with Matt Mack, a process engineer at ICM Controls. Matt shares how he's driving down cost through continuous improvement. He also discusses planning for the future with automation and AI. Matt started with ICM Controls in 2019. Prior, he worked at Whelen Engineering (now GreenSource Fabrication) for about five years. His career in the PCB industry began at Sanmina.

Nolan Johnson: We're interested in learning about your approach to process engineering. What's your thinking for identifying processes that are in need of improvement?

Matt Mack: I start with our price per panels and the costs that are associated with it. I start to think, how can we make the process smoother, more efficient, where I don't need to have as much human interaction with chemicals? That all starts with gathering data with chemical data. I'll do titrations, for example. I'll pick one line at a time that I will not have any dosing on, and I'll calculate the square footage of



Matt Mack, Senior Process Engineer—ICM Controls

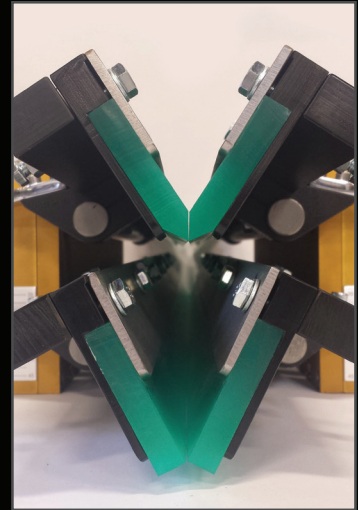
panels through X amount of time, how much it dropped in concentration, and I'll adjust dosing based on panel count. Then you have to optimize speed.

You can also do line speed, increasing or decreasing to optimize quality. I always strive for the 1.33 Cpk for the parts. It's not always possible, but we come pretty close. It took about six months to really get dosing right. Right now, we do chemical analysis about twice a week. That's much lower than recommended, but the data is not driving us to analyze it more. I asked our software guy to develop a chemical database that allows me to input the chemical data and track Cpk, track trends up and down, and in-spec/out-of-spec; if any of those rules are violated, it notifies me through an email.

Some of those are deemed critical, some are not. If any of it is deemed critical, we'll trigger the production's halt. If it's not critical, we might be able to do it on the fly. For instance, let's look at the copper concentration in a microetch. I might empty the line out before its formal dump, but it's not going to impact quality on the product. Those are some of the rules

SOLDER MASK APPLICATION SIMPLIFIED

Introducing the Ultimate Semi-Automatic Double-Sided Screen-Printing Equipment



The DP3500 coating machine is a semi-automatic double-sided screen print equipment. The DP3500 comes with Smart Print System which delivers superb quality with minimum thickness of 1mil. In addition, Differential Print Pressure Control as well as Servo motor-controlled Peel Off features come as standard features. The DP3500 can apply all types of liquid photo-imageable inks including solder mask, primary image, dielectric, and legend.

- Prints +25% greater accuracy
- Smart Peel Off & Save Your Settings Feature
- Greater printing capability
- Prints extremely thin substrates (1mil)
- HMI Touch Screen Controls
- No tooling holes required
- Less ink in holes & fewer bubbles

Precision. Pressure. Performance.



Now located in Carson City, Nevada, (775) 885-9959, www.taiyocircuitautomation.com



Follow us on social media





Matt Mack (right) and Bill Phillips (left) discuss the company's R.O. (reverse osmosis) water treatment processes with Molly Reed and Bruce Graverly of Aries Chemical.

on that piece of production? If you're going to have funnels where, let's say, the score machine is not putting out as many panels as the plating line, I might need to buy either a faster score machine or an additional score machine to maximize output. As we're ramping up here, there is some capex equipment that we're looking to quote in order to increase production on the floor. Generally, speed is what I look at.

The second thing would be chemical usage. If it costs us X to run one panel, what is the impact of that one piece of chemical on the panel? I look at price per panel by operation, as well. Can I get away with dosing less? For instance, for the pre-treat line, they recommended running something like 20 milliliters a panel. I actually optimized it to only run at about 8 milliliters. It saved us \$18,000 over the course of a year. A lot of what drives me to look at process either optimizes panel production or price. Regarding price, for example, every six months I'll review price per panel to determine where we can improve and where we can't.

Matties: You're looking at bottlenecks in your process and the cost of materials. Where does cost of labor come in? Are you looking at automation to reduce labor cost in your process improvement as well?

Mack: Yes. There are some new things out that we've discussed, especially with capex. We are still doing screen solder masking. Scott, who brought me on board, has always looked into inkjet solder mask, which would decrease labor quite a bit. For set-up and tear-down times, it's taking us an hour to two hours a day just to set up and tear down. Inkjet would increase throughput through that process alone. You automate as much as you can, but you still need people.

We might be able to move someone to watch a couple different areas. Right now, we have loaders and unloaders, but even with that, you still need people. We've been doing a lot of cross-training as well, so when some of the

that I observe. Any time you see a trend of five points decreasing, it could be a dosing issue, so I would jump right on the dosing, and verify it's dosing what I've asked it to dose; second, maybe the chemical ran out and there's an airlock. I get a lot of those emails where it will show you process control.

Matties: When you stand back as a process engineer and take that 30,000-foot view of a process, what do you want to improve to optimize it? What's your process for doing that?

Mack: The first thing I monitor is speed. We track panels through and panels out. I would always start with asking: What are some of the slower ones, and how do I increase throughput

older folks retire, we might not need to replace them immediately. That's where we're at with labor. For now, we operate our shop with 13 people, and then two on second shift for secondary drilling.

Matties: Where does the smart factory come in to play for you? Where do you start bringing in AI? You mentioned you came from Whelen... do you continue their thinking with respect to bringing AI and smart factory into your facility?

Mack: In the future, yes. We haven't tapped into too much AI yet because we're still optimizing our panels. We're running about 2,000 a week on one shift, which is pretty good. We're getting about 400 panels a day. The goal, initially, is to ramp up panels per day, because that also decreases panel cost, and price per panel. The more panels I can put out with the people already here brings price per panel down. We're comfortable now where we're at. So, yes, AI will come in the future, but it hasn't started yet.

Johnson: That sounds to me like you're still targeting simpler optimizations in your processes before you start pulling out the big guns of automation.

Mack: We want to do both at the same time. I grew up as a lab tech originally, so I really strive for Cpk and quality control. Right now, we AOI 100% of our panels. We might drive away from that because we're producing, at last count, 99.6% yield through the board shop. That number is really where I start.

Matties: There's a difference, too, between automation and AI. When I think of AI, I think of machines modifying the parameters based on the work the coming through, where you had a barcode, and the machine would adjust to parameters set on that board's barcode. Are you moving in that direction?

Mack: We've talked about laser markings on the panels in order to switch. Right now, our imaging process is still manual. We've talked about buying a flipper and being able to do that. If we do get a little more automation in our imaging department, we'll put down some laser markings beforehand, and then that'll be a whole automated staff and able to swap jobs. We just run double-sided boards right now, single-sided, double-sided. Our rounds are generally pretty big. We don't get a lot of small lots. As we search now, would we want it? Sure. Do we absolutely need it? Not yet.

Matties: When you're looking at the capex, are you looking at equipment that is capable? Is that a consideration for the purchases you're making now?

Mack: Yes. Obviously, I come from a place that was almost fully automated, so I get the idea about what we might use as far as equipment and automation.

**I come from a place
that was almost fully
automated, so I get the
idea about what we might
use as far as equipment
and automation.**

Matties: Whelen went for total factory automation, and what we're recognizing is, in the industry, it's going to be incremental steps. It's what we're calling a smart process strategy rather than a smart factory strategy. What process do you think you would want to prioritize to really make it the smart process?

Mack: We currently have two imagers, and we flip panels manually. I really want to start

there. We might not have to release as much product. That's another thing we've been also looking into. Our lot sizes are very, very big, and now that the board shop is probably the fastest in the plant, the rest of the plant runs three shifts, the board shop and safety stock can come down a little bit. If we can get automation where we can change part numbers on the fly, then that would ease that pain, too. That's where I'd start.

If we can get automation where we can change part numbers on the fly, then that would ease that pain.

In order to change part numbers on the fly, automation needs to be thought about. We panel plate right now, too. So as far as plating, it's one size fits all as we currently have it. I've also thought about different drill machines with a stack system where you can load up the machine and walk away. Right now, we drill about 24—six stacks of four up—in our two machines. Drill is a bottleneck, too, and usually is at most places. But after the DES, you could follow up with inkjet solder mask and then you've got half of your shop fully automated.

Johnson: It sounds to me like you've got an entire roadmap set up for what to work on, what's next and so forth.

Mack: Yes. I'm a data-driven guy, so data will drive those decisions.

Johnson: Given the upgrade plan that you've just laid out for us, how long do you think that will take?

Mack: If it was a full-time thing, if I put all my energy into it, it would probably take a year. Shut-

ting down production is going to be rough. It's pushing me to start bringing in an inkjet solder mask, having to qualify thousands of part numbers. Some of our customers might say, "We trust you, go do it and qualify," while others might not. We could have the capex into the building within a few months, but it's the qualifying that would take probably the longest. If everybody was onboard, I could see it within a year.

Matties: You're going to run parallel processes, obviously, so you have to allow for that.

Mack: When Scott designed the [ICM] factory he had something in mind like inkjet solder mask for upgrading. I know we have some slots in our cleanroom that will allow for conveyORIZED systems. He had that in mind when we designed the factory.

Matties: You're a data guy, so when you look at the effect of the package of automation that you're talking about—imaging, DES, and solder mask inkjet—what's the impact of the savings that you're going to find in your production costs?

Mack: There's quite a bit, actually. I also am a waste treatment guy, so the impact downstream would be much less than what we're producing now. I also look at that. When we start producing more automated equipment, getting more panels out, what is the impact on the waste treatment system? With inkjet solder mask, for instance, we would reduce our waste in that process by 90%. The impact of not having to wash the screens, the debris on the screen, the chemical on the screen having to get waste treated, etc., then it would be just inkjet solder mask and there is no waste coming out of inkjet solder mask.

Matties: My thought is, if the savings are significant enough and the technology is available, why not make this a top priority action in your organization?

INNOVATION + PRECISION + RELIABILITY



IN-HOUSE CUSTOMER LAB

Available to assist every Chemcut customer with:

- R&D process development
- Producing an initial prototype
- Small pilot production runs
- Feasibility studies
- Producing scale-up data
- Operator training and education



Contact Matt



To learn more about our lab, contact Matt Erlichman
at merlichman@chemcut.net

www.chemcut.net

 **CHEMCUT**
BOUNDLESS INNOVATION | UNBEATABLE PRECISION

Mack: I was asked for a detailed list just last week of what impact inkjet solder mask would have, not even as far as ROI, but what would it do for us. I am working on that. The waste treatment thing was the first thing I thought of. I haven't put too much more energy in that yet, at least in the last week.

Johnson: To think about inkjet solder mask having a positive impact on factory effluent is not necessarily the first thing that people think about, at least not with the conversations that I have. That makes for an interesting insight, not just for direct influences from changing out equipment, but also in the rest of your process; it buys you an advantage.

Mack: We talk about, when we increase production and add another shift, how waste treatment has to be one of the biggest priorities because we need to manage the flow, because we have an RO membrane system where we regenerate our wastewater. What is the impact of running 16 hours instead of eight? We also have an evaporator. The environmental impact is a big thing when you start talking about increasing production or perhaps increasing automation.

The environmental impact is a big thing when you start talking about increasing production or perhaps increasing automation.

Matties: When you look at a process, what's your methodology for benchmarking? Do you compare it to other industry standards, or are you just looking at what your needs are?

Mack: We do cross-training. We train people to run to targets. We need to hit this number

for production standard. I also think of ideas, such as how I could speed up the line. How do I get more product out of this line? Sometimes you hit a dead end and you can't, such as with copper plate. We want our plating efficiency to be at or over 100%. The plating recipe we currently have is producing a panel every 54 seconds, and until that becomes a bottleneck, that's pretty good. Again, it always goes back to throughput. How do I increase speed? Can I increase temperature, for instance? Can I increase temperature to increase speed, or concentration? It's ideas of that nature.

Matties: I'm thinking also about upper and lower control limits. How do you tighten that parameter so you can get finer lines (or whatever the requirement may be), or by other opportunities when you tighten your parameters you can then create new market opportunities for your organization?

Mack: Initially, we would increase chemical analysis. I might be calibrating dosing pumps, or at least verifying calibration of dosing pumps a little more often, so that when I do get that data set, I can trust those numbers. That's what will tighten up your process control window. It goes back to being data driven. Part of this system hasn't gotten there yet; I still want to generate Cpk on the fly. It gives me the Cpk, I can drive rules based on the Cpk for process control and know whether I need to tighten up my control or I if can get a little looser on the control.

Matties: What's the most important process inspection tool a process engineer has?

Mack: An eye loupe (laughs). It really is the best tool that I have. I walk the lines multiple times a day with an eye loupe in hand. I do a cross-section once a week. I was doing them every day, but I saw no change in process control, so we're down to validating once a week. We also do a CMI. We'll do a plating thickness on first

panel out, for first article inspection, and then we do random sampling for CMI data for panel thickness, at least with surface thickness.

Happy Holden: What kind of experience from Whelen do you think you can bring forward to ICM?

Mack: I can bring double-sided work, bare board work, and speed wins. For double-sided and bare board, we need to optimize speed and panels out. I know we want to ramp up production; instead of adding another shift, how do we get more throughput with what we have? Throughput comes with automation, process control, speed, and driving those numbers up as high as humanly possible with the current technology.

Matties: What is your thought on continuous flow manufacturing? Are you moving in that direction?

Mack: I don't know if our shop with its current setup would benefit. It's a thought, though.

Matties: You lose a lot of speed in work that sits idle, don't you?

Mack: It might be idle, but with our scheduler, we're about three to four months out of current demand. It's not the greatest to have queues, but with automation will come fewer queues. When we start thinking about automation, starting with the imaging process, there won't be a queue there anymore. We have a pre-clean line. I've thought about putting a U conveyor there: it comes out of the laminator, goes around, then imaging automation takes over, flips it, and it goes down the DES line. That's a thought. We typically have two queue areas, but we'll have zero.

Matties: When work queues up, my understanding is that you have to add additional cleaning processes, which means more bath



Matt Mack (back center) looks on with Molly Reed and Bruce Graverly of Aries Chemical as ICM's Bill Phillips draws a wastewater sample for testing.

maintenance, storage, and purchasing. If you can get rid of those additional steps, you're presumably lowering cost and increasing quality. I think that continuous flow manufacturing makes a lot of sense, but, of course, your shop has to be tuned to that.

Mack: Yes. We can make it that way. It takes some radical thinking and time. Unfortunately, we don't have the luxury of a ton of time, but I know it's thought processes as we continue to grow.

Matties: One of the things that was critical in the continuous flow and smart factory is the front end. You have to have all that data right from your CAD or CAM department as it's coming in.

Mack: Correct.

Matties: How are you connecting the data flow from your front end throughout your factory? What tools are you using there?

Mack: We have a CAM350 system. I don't get involved too much there. There are a lot of hard workers up there. They'll put it into a folder, and I'll upload it onto our CAM350 software and shoot it over to either the Camtek machine or the Miva imaging machine.

Matties: That'll give you the parameters you need for the processes throughout the factory?

Mack: Correct.

Matties: It's those process that, ultimately, you want to be able to feed directly to the equipment, and then have the laser tag adjust the parameters. That's the ultimate goal, right?

Mack: Correct. If you build up more part numbers in a database system like that, especially with Camtek, they've got their new AOI machine, and so every time we start loading a new job onto that machine, it now has it in its directory. Any time an obsolete part number comes out, front end does pull it out, so we're not bogged down with obsolete part numbers. Both of those systems have pretty big databases that work together, but we don't have any barcoding thing yet. We'll get there.

Johnson: Matt, it sounds to me like a key to being a good process engineer is being a good communicator with people, which is not always an obvious skill when we think about process engineers. Will you talk about that?

Mack: I have daily stand-up meetings, and then we have weekly staff meetings. I've always been a person who asks questions. When I do the engineering on the floor, I ask operators specifically, "What do you see? What do you think?" etc. That drives some of my thinking. I might have an idea, but they'll tell me whether it's feasible because they run the machines.

When I start to bring those ideas up, let's say at a quality meeting, we might say, "I have this idea." We have project lists, and usually will follow up on them weekly, if not daily. ICM is really good at having us communicate with each other. In staff meetings, quite a few people attend. All our senior managers are there listening and asking questions. Most of those meetings include questions from senior management: "How are we doing this? How can we make you better? How can we do this? How can we do it faster?" The communication at ICM is amazing.

Matties: In your function, where do the suppliers fit in? How involved are your

suppliers in what you do?

Mack: They're involved as often as I need them to be. With process control, now that we're in a pretty steady state, they call. I contact my chemical rep once a week. We usually have a 10-minute phone call about any issues or concerns. He'll come in if I need help with an issue; that's been few and far between since we've optimized, at least on the chemical end. The only supplier I deal with is the chemical supplier.

Matties: What advice would you give a young process engineer?



Matt Mack inspects a circuit board with an eye loupe in the PCB fabrication shop.

Mack: Talk to the operators. The biggest thing is communication, especially with suppliers and operators. Once you start validating your decisions with data, and then you start communicating with your team, most of the times operators are more than happy to help me with my vision because they feel like they're being part of the task. That's what I would advise young process engineers.

Matties: You've mentioned data repeatedly. It's obviously very important. What training for analytics or statistics do you look for in a process engineer?

Mack: I'll always go back to Cpk. Process engineers need to understand that the 1.33 industry standard can be achieved. That data really needs to drive some of the decisions that you make as a young process engineer.

Matties: They just need to understand what data to collect, how to collect it, how to manage it, how to interpret it, and then how to disseminate it?

Mack: Correct. I've taken Minitab courses a couple of times, and they offer a really good system to start using those tools for analytical and process control.

Matties: Right, because with what you're talking about, there's obviously a math skillset that's required.

Mack: I started as a lab tech. My job was gathering data, and I would report to the process engineers on some of the data that I collected. Once you gain some experience with that data, it will drive you to what comes next.

Matties: What's a typical day look like for you? Give us a rundown, a day in the life of..., if you will.

Mack: After I check my emails, I'll go for a walk



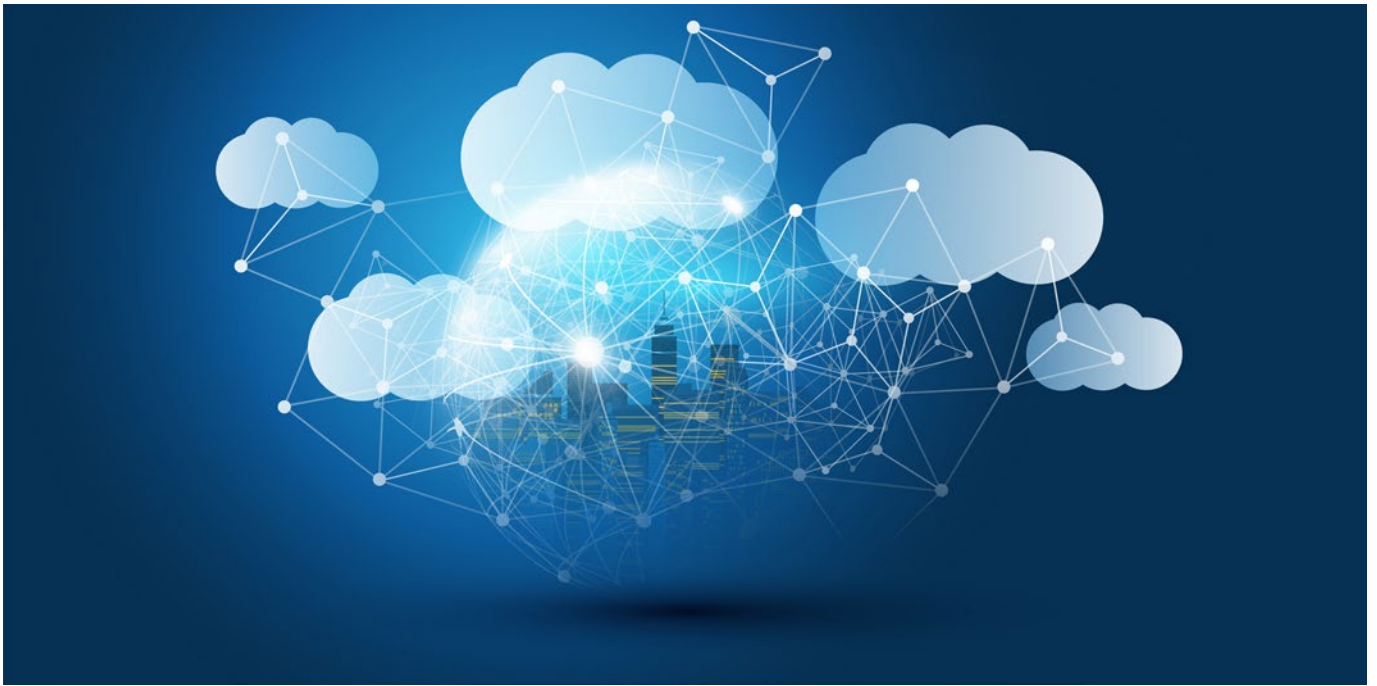
In addition to process controls, Matt Mack also checks inventory on the chemicals used in ICM's board fabrication facility.

through the shop. Then I'll start validating some of the processes that we've set up. I'll go and verify line speed to make sure they're correct. As parts start to come out, so does the eye loupe. I'll usually look at a panel on each process once an hour. I'm walking the floor quite a bit. When I get a few free minutes, I'll start looking at the data. I also do the chemical analytics here, too. I'll pick a project for the day—let's tinker with this and see what happens.

I'm a problem solver, so when we do have an issue, I'm the point of contact to make production downtime minimal. Usually, you get one or two hiccups a week, but they're usually manageable. Typically, I'm just walking the floor looking at panels.

Johnson: Matt, this has been really informative. I think there's a lot of insight here. Thank you.

Mack: You're welcome. PCB007



Reinvigorate Your Manufacturing Infrastructure

Feature Article by Mark Goodwin
VENTEC INTERNATIONAL GROUP

International trade has taken quite a hit due to the global pandemic and it still faces some major uncertainties despite significant advances through joint efforts to open up world trade again as soon as possible. Even before we witnessed the full impact of the COVID-19 virus, there were other challenging events to contend with: Brexit, ongoing tensions between the U.S. and China over tariffs and subsidies, material shortages caused by industrial accidents, and the constant threat of potential disagreements between countries over approaches to trade and development.

The way we do business is constantly shaped by the never-ending stream of events, many of which are potentially disruptive. What is clearer more than ever before is that we need to be aware of what is happening and do what we can to protect ourselves against possible threats.

Ignoring events that are happening far away or just keeping everything close to home are not options for many electronics businesses.

We work in a truly global industry. Taking the printed circuit fabrication business as just one example, some critical materials are produced in one or just a handful of locations worldwide. There are strong economic and technical reasons for this, and new local suppliers are extremely unlikely to spring up; keeping the supply chain domestic is simply not possible for fabricators in most parts of the world, including North America, Europe, and much of Asia.

Instead, our focus must be on ensuring the security and integrity of our supply chains, building in agility both to work around international situations that may arise, and to handle customers' changing demands as efficiently and cost-effectively as possible. The key is to find out as much as we can about our customers' manufacturing plans, recognizing that some confidential information may not be readily shared. It can be less sensitive to use historical data to drive predictive models.

Overall, the more we know the better we can balance supply against demand, prevent delays, and save avoidable logistical expenses.

New Generation Printer Makes Printing Suitable for Today.

Super High Speed Printing Model
CPE6151

8
Print Heads

Print Time
6 sec



Flagship Model Printer

The CPE model is equipped with eight print heads and achieves the fastest print speed in the CraftPix lineup. Its shuttle table is driven by a linear motor combining accuracy and high speed. The CPE can print legend and solder mask for mass production.

High Speed Printing Model
CPQ7861

4
Print Heads

Print Time
11 sec



Standard Model
CPi6151

2
Print Heads

Print Time
17 sec



Budget Model
CPJ6151

1
Print Head

Print Time
32 sec



Various applications –

Solder Mask (Flex/Rigid), Etch Resist, Conductive Inks & Legend

Various print heads supported – 2.4 pl, 3.5 pl, 6 pl, 13 pl

USA MicroCraft, Inc.

U.S.A Headquarters

1247 N Tustin Ave, Anaheim, CA 92807

TEL (714) 482-2550

Email: sales@usamicrocraft.com

NEW - Minnesota Software & Support Center

2405 Annapolis Ln N #220, Plymouth, MN 55441

TEL (714) 482-2550

Email: support@usamicrocraft.com

es, such as emergency or overnight deliveries. For example, look at the order book for companies that routinely place orders for next-day delivery. If it's almost always full for months in a row, then knowing such information makes it possible to set up an efficient schedule that ensures the required components are delivered at the time they are needed, minimizing the potential for mistakes and avoiding expensive express deliveries.

Now, post-COVID, is the perfect time to take a fresh approach to reinvigorate the manufacturing infrastructure!

Now, post-COVID, is the perfect time to take a fresh approach to reinvigorate the manufacturing infrastructure! The ideal situation would be for the planning and purchasing systems on both sides of the customer-supplier relationship to communicate the necessary information automatically on a machine-to-machine basis, by letting the customer's ERP inform the supplier's systems of upcoming orders and activities that will affect volume demand and delivery timing. Alternatively, we can make human communication networks as efficient as possible, beginning by ensuring the right people are talking to each other. On the customer side it may be the planning team, rather than the purchasing department, that has the clearest understanding of forthcoming requirements.

Vendor-managed inventory is an approach that has proved to work well in the automotive industry. Lean practices like this are well suited to automotive, where demand patterns are well communicated and quality requirements and volume demand are high—although others can benefit, especially with a few tweaks to suit their own business model.

The global nature of today's supply chains means they can be somewhat long, so we need to move away from solely efficiency-driven transactional models if we are to make our supply chains agile enough to adapt to events outside our control. Focusing instead on meeting the needs of individual customers is a more effective approach, although discovering exactly those needs may not be easy. Even customers themselves sometimes do not fully understand their own needs.

It takes trust and close collaboration, involving studying the requirements and capabilities on both sides of the partnership. Success can mean the supplier benefits from long-term revenue, which also should grow with the customer's business, while the customer benefits from being able to trust their supplier to deliver the right materials in the right place at the right time, avoiding mistakes that can lose production. It's harder for either to walk away from such a carefully set up and effective partnership.

At Ventec, we own the complete supply chain of PCB materials including laminates and prepregs from end to end, which enables us to keep lines of communication short and eliminates the clashes that can occur when different businesses have competing interests. It's also possible to maintain carefully managed inventory in various locations worldwide, which gives us the flexibility to very quickly adapt in the event of situations outside normal control, such as global pandemics and natural disasters. By emphasizing a cooperative approach and building trust with a future-oriented, two-way communication strategy, we're on the right path to reinvigorating our manufacturing infrastructure post-COVID. **PCB007**



Mark Goodwin is COO Americas and EMEA, Ventec International Group.



MilAero007 Highlights



Bonding Hybrid Multilayer Constructions at Rogers Corporation ►

John Ekis, Rogers Corporation's market segment director for aerospace and defense, discusses the SpeedWave family of low-dielectric constant, ultra-low-loss prepreg materials with excellent filling and bonding characteristics for hybrid multilayer constructions. SpeedWave prepreg is also compatible with FR-4 fabrication processes and lead-free PCB assembly processing.

New Online Training Programs Enhance Delivery Options ►

Jahr Turchan, Blackfox's Director of Veteran Services & Advanced Manufacturing Programs, discusses how technical training programs pivoted in 2020 and how customers responded to their training needs throughout the year.

Collins Aerospace Wins Contract to Support CH-47F Fleet for Royal Netherlands Air Force ►

Collins Aerospace, a unit of Raytheon Technologies Corp., has been awarded a multi-year performance-based logistics avionics support contract to the Royal Netherlands Air Force's fleet of 15 CH-47F Chinook helicopters.

Eltek Secures Grant from Israel Investment Authority ►

Eltek Ltd. provided an update regarding its award of a grant from the Israeli Investment Authority that will fund 15% of Eltek's expected \$1.5 million investment in Advanced Manufacturing Equipment fit to Industry 4.0

standards, which focuses on interconnectivity, automation, machine learning, and real-time data.

Cobham's Pyrovalves Power Precision Landing of NASA Perseverance Rover on Mars ►

Cobham Mission Systems, the world's leader in critical control solutions, announced that its space pyrotechnic valves on the NASA Perseverance rover mission enabled an historically precise landing on Mars.

Intel to Collaborate with Microsoft on DARPA Program ►

Intel has signed an agreement with Defense Advanced Research Projects Agency (DARPA) to perform in its Data Protection in Virtual Environments (DPRIVE) program.

Nano Dimension's AME Monolithic RF Communications Circuit Has Been Sent to ISS Flight Studies ►

Nano Dimension Ltd. announced that the first ever integrated RF circuit fabricated by Nano Dimension and designed and integrated by L3Harris, has been flown to the International Space Station (ISS).

Korea Aerospace Industries, Elbit Systems to Cooperate on Next-Gen UAS Solution for ISTAR Missions ►

The Korea Aerospace Industries Ltd. (KAI) and Elbit Systems Ltd. signed a Memorandum of Understanding (MOU) to expand cooperation in the field of Unmanned Aircraft Systems (UAS).

A Point of Order—Do Not Just Rearrange the Pencils

Testing Todd

by Todd Kolmodin, GARDIEN SERVICES USA

In our concentration on continuous improvement, we should look at the order of things. Efficiency comes from streamlining processes, effective training, and the ability to monitor success through KPIs and feedback on deliverables.

Most companies are familiar with or have implemented Quality Management Systems (QMS). Continuous improvement is a key factor in all quality programs. You simply cannot improve if you don't know where you are! There are many tools out there to review and monitor efficiency. Honestly, the most effective process is one that provides maximum output with minimal effort or cost, right?

“Lean and mean” is the way to go and to get there we need to get Lean. One of the best tools available to gauge and review processes and work areas is the 5S discipline.

This process, developed in Japan, provides two frameworks: one by Osada, the other by Hiroyuki Hirano. Both follow the steps of the discipline but the compressed “4S” model combines “Set in Order” and “Shine” into one step. I've been involved in many 5S workshops and it can be applied to the simplest of tasks as well as to large multi-faceted departments. Let's get Lean!

Sort (seiri)

This fundamental step begins the process. As I mentioned, we cannot improve unless we know where we are. Take a “bird's eye” view

of the task, workspace, or process. Look at the flow, tools, equipment, tables, chairs, etc. Decide what items are absolutely needed. Remove items that are redundant, unnecessary, or distracting. What we are trying to do here is simplify the task or process utilizing space and increase safety by eliminating distractions and possible hazards.

Set in Order (seiton)

Now that we know all we need for the task or process, we need to review it for efficiency. This can be placement of equipment, desks, tools, and other such items necessary. Look at the flow and optimize as necessary. This should consider distance movements, ergo-

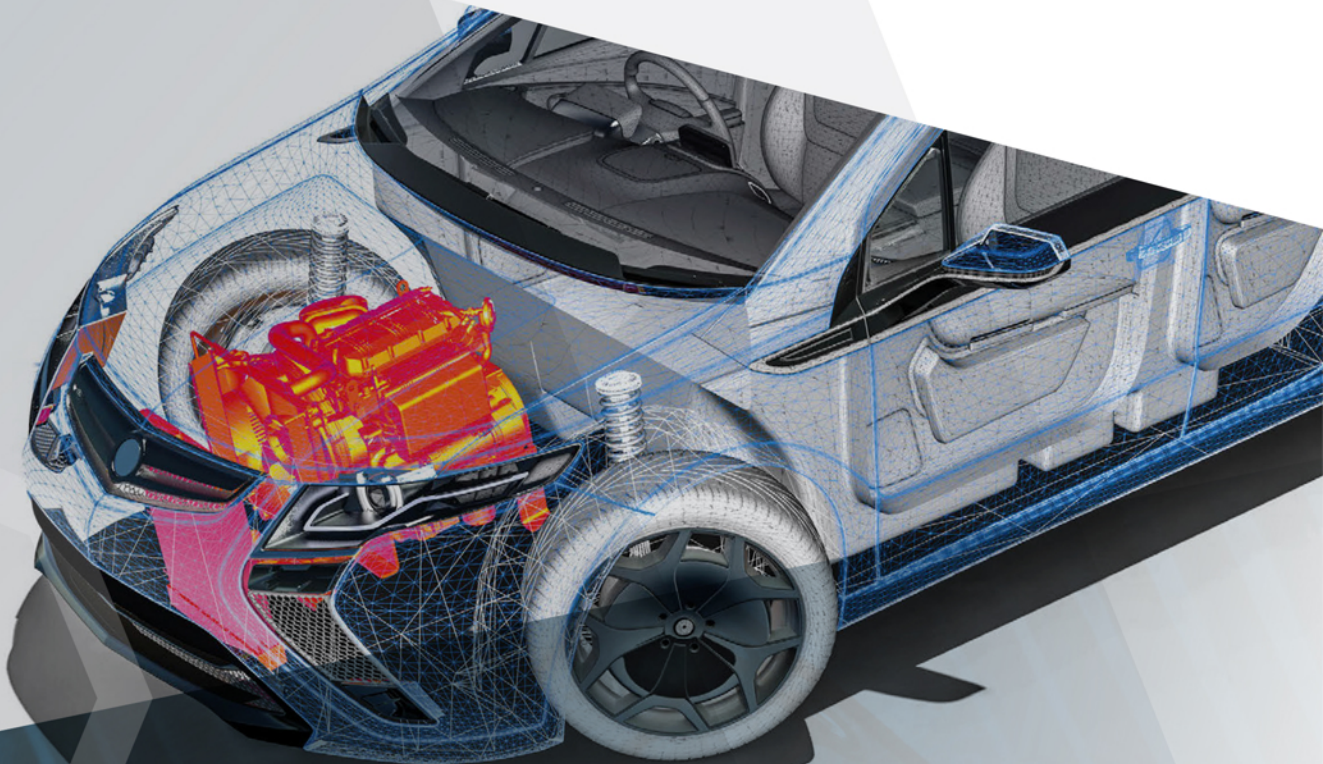


Figure 1: The 5S model.



ventec
INTERNATIONAL GROUP
騰輝電子

autolam: Base-Material Solutions for Automotive Electronics



autolam 

Automotive electronics technologies are evolving at an increasing rate. Paying attention to the properties of materials at the substrate level is the first step towards achieving the most stringent performance targets of today's automotive manufacturers. autolam offers the solutions demanded by the diverse and unique requirements of automotive applications today and in the future.



ventecclaminates.com

nomics, and safety. Remember, a high percentage of down-time or failure in a process is related to the human variable.

Shine (seiso)

With our task or process optimized, we need to keep it that way. We need to keep the area clean and maintained. Depending on the task or process, this may be daily cleaning, sweeping, or inspection. This keeps the area on-point and continuously operating as we designed.

In some operations as noted in the beginning, “set in order” and “shine” are combined, resulting in a 4S plan. Still valid as all steps are considered.

Standardize (seiketsu)

This step is why I like the 5S discipline. Here is where the new process is documented once you have all the steps in place. We have outlined what is necessary, removed clutter, and organized for optimum efficiency. Now we document the process so that the task is repeatable and defined. We now know where we are and can duplicate the results. Well done!

Sustain (shitsuke)

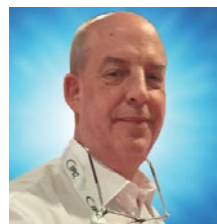
Now that we have a perfect process or workflow, we have come to the last and most difficult step. What happens in many instances is that we develop the great process and workspace only to review it in a month’s time and it has fallen into utter chaos. Am I right? You are nodding your head. This is the step that

gets forgotten. We need to police the area regularly to validate the success. Optimally this can be done by a performance indicator (KPI) or maintenance interval where the area is reviewed, equipment and tools inspected, and, importantly, debrief of operators involved for feedback. Adjustments can then be made with emphasis on reviewing the first four steps to see if there is an impact.

I know I am not bringing up anything new and I am sure many of you have already lived through the 5S discipline workshop. However, as 2021 is focused on continuous improvement it is appropriate to revisit some of the tools that can positively impact manufacturing and general workflow.

Within our group we always strive to find 5S projects as part of continuous improvement. However, when identifying these project areas, we must not “just 5S” because I must find one. 5S is a discipline and not just a project. Rearranging pencils or cleaning one’s desk does not really cut it as a 5S unless one embraces the five (or four) steps needed with the discipline. Countless times I have seen an office 5S where, of course, it is neat and tidy initially only to be a train wreck three weeks later. 5S = Fail!

Stay Lean, my friends! 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](#).



American Standard
Circuits



On Demand: Free Training Video Series

FLEXIBLE CIRCUIT TECHNOLOGY

with Expert Joe Fjelstad

[WATCH NOW](#)

Need help finding the right people for your team?

DB Management knows that finding the right people can be like looking for a needle in a haystack. We can streamline your hiring process with pre-qualified candidates.

Engineering • Management • Sales & Marketing



[Click here to get started](#)

☎ 207-649-0879 ✉ danbbeaulieu@aol.com

Selling for the Best

It's Only Common Sense

Feature Column by Dan Beaulieu, DB MANAGEMENT

So, your company got its act together. They bought the right equipment, increased their technology to the highest level—the cutting, nay, the bleeding-edge level. All the right players are in place. You are now poised to be among the best, most elite of the PCB companies in the world. Now what do you do? How do you market a company like yours? How do you sell the best?

First, don't waste your time telling people you are the best. You cannot run around bragging that your company is the best; do that and you'll just be one of the crowd. Every company says they are the best, whether they are or not. Nobody brags about being "pretty good" or "no worse than anyone else." In the words of the inimitable Dr. House (from the Fox television show *House*), "Everybody lies." And when

you are dealing with purchasing people who are incentivized by how much money they can save their company, their justification for buying from the lowest-priced company is to hide behind the age-weary comment, "All of you are exactly alike, so I just chose the one who had the cheapest price." An absurd statement, and a true testament to sheer laziness on their part.

How many people do you know who walk around bragging about living in the cheapest house, driving the cheapest car, buying the cheapest food, dressing in the cheapest clothes, and going to the cheapest doctors, ending up in the cheapest casket, at the cheapest funeral home, buried in the cheapest part of the cheapest cemetery?

So, don't play that game when you are marketing and selling for the best you have to



**We offer a wide range of process equipment,
service, spare parts and specialty consumables**

all4-PCB®

WORLDWIDE

**Via Fill
Process**

Via fill equipment
Planarization
Ovens and vacuum chambers
Conductive and non-conductive pastes



Imaging

Direct image, photoplotter, inkjet printing
Contact exposure
Dryfilm lamination
Line & space measurement



**Lamination
Area**

Vacuum presses with and without automation
Lay-up & breakdown, press plate cleaner
Press pads for high and regular temperature
Release films and other lamination aids



MSC POLYMER



Fabrication

Flash cutting, v-score
Drilling & routing, laser processing
Deburring, plasma, hole-checking
Cross section equipment



MSC POLYMER



Automation

Loaders & unloaders, robot solutions
Accumulators, buffers



Wet Process

Etchers, strippers & developers (DES & SES)
Chemical pre-clean, pumice and alum oxide jet spray
Direct metallization, horizontal and vertical de-smear
Electroless & Electrolytic plating



**Final
Processes**

Solder mask coaters spray and screen print
Developers, ovens
Final finish: HASL, ENIG, immersion silver, OSP,
electrolytic Au
Electrical test flying probe and grid



www.all4-PCB.us

Ralph Jacobo
ralph.jacobo@all4-PCB.com
+1 818.531.2687

Conrad Micale
conrad.micale@all4-PCB.com
+1 747.238.0010

show. Better yet, you have to demonstrate that you are the best and then show how you are the best.

This means appealing to your customers' process engineers, quality managers, program managers, and other lead people: the people who will actually use and value your products. Those people will see value in doing business with you and will put that value ahead of anything else—including price.

When you are selling for the best, demonstrate it by focusing on your:

- Value
- Knowledge
- Technology
- Quality
- Reliability
- Consistency
- Superiority

But you can't just talk the talk, you have to walk it as well. As I mentioned earlier, you can't just sell through buyers. It isn't enough to be waiting around in a lobby for the chance to go into that little room and spend 10 minutes with that harried buyer who looks nervously at his watch making sure he blocks out everything you're saying. To him, your words—no matter what you say—sound like the parents' mumbled words in the Peanuts comic strip. Instead, you must get beyond that guy. You must get to the people who cherish and value using the best products and services available today.

All your marketing and sales tactics must be focused on demonstrating how good you are, how you are truly the best. Here is how this is done:

- **White papers:** This shows that you are on the forefront of technology. Publish them and present them at trade shows and conferences.
- **Webinars and seminars:** Now that everyone is acclimated to using Zoom, it's easy to set up, publicize, and present webinars.

You can give a very technical presentation to an unlimited number of very interested potential customers—people who have signed up and divulged their contact information to hear what you have to say. How much time, effort and money would that take normally?

- **Technical columns:** Writing regular technical columns which are published in magazines such as this one is the surest way to get your name and your capabilities out to the market. A monthly column will get to people who don't know your company or what you do. You can establish your reputation as the best by writing a column.
- **Technical bulletins:** Reach out and touch people. Accumulate lists of qualified potential customers and send them bulletins filled with technical advice about the exact subject you know they care about, based of course, on the lists you have accumulated.
- **Website:** Your website should be a place that the right potential customers want to visit repeatedly. This means filling your site with valuable information, as well as tips and tools that will help them with what they are working on. Everything you do, all the marketing you do, is designed to get people to your website; don't let them be disappointed when they get there.
- **Research and development:** Years ago, your customers—those large OEMs—had their own board shops and their own experts doing their R&D. They don't any longer and they have to rely on us to provide it for them. They need to turn to their PCB vendors for not only the high-tech products they need today but, more importantly, to help them get where they need to be tomorrow. Get them to rely on you.

- **Trade shows:** Shows are where you demonstrate how good you are. This is when you get to talk to people who are seeking help with their own products. Develop a good trade show strategy including a well-thought-out plan to get the right people to your booth. Go to the right trade shows, the ones where the right people will be looking for your expertise in the technology they need. Remember, do not go to a trade show without taking the opportunity to present a white paper.
- **Technical micro-ebooks:** Imagine being the company that wrote the book on that technology, the one that your potential customers are reading and which they downloaded for free in exchange for their contact information—and that they refer to time and again when they need to check on something. I-Connect007 has gained a reputation for producing high-quality, educational books for their customers. They handle everything from editing and layout to strategic marketing. An I-007eBook will position your company as the true industry leader, the true experts in your field and in your market.

In the end, the goal is to get potential and current customers' technical people on your

side: operators, quality, and program managers. These strategies will get them to want to work with your company so they will overrule that buyer who only wants to go with the lowest price.

Selling the best means being so valuable that, when one of your customers hires a new accountant/controller and that person wants to know why they are paying a 20% premium on your products (while bragging about saving them money by using the mediocre supplier they used at the last company), everyone will tell that person to shut up and mind their own business. They will go on to talk about the extra value that they get from working with your company. They will talk about the value your company brings that far exceeds any amount of savings they can bring with their mediocre supplier. Then they will say to be quiet and never mention that cheap and mediocre supplier to them again. That's how much they will value buying from the best.

It's only common sense. **PCB007**



Dan Beaulieu is president of D.B. Management Group. To contact Beaulieu, or read past columns [click here](#).

jobCONNECT007

Companies seeking talent with circuit board industry experience post their jobs with us.



jobconnect007.com

ein Electronics Industry News and Market Highlights



Global Semiconductor Materials Market Sets New High of \$55.3 Billion ▶

The global semiconductor materials market grew 4.9% in 2020 to \$55.3 billion in revenue, surpassing the previous market high of \$52.9 billion set in 2018, according to SEMI, the global industry association representing the electronics manufacturing and design supply chain, as reported in its Materials Market Data Subscription.

LG Innotek Joins Hands with Microsoft to Proliferate Cloud-Connected 3D Sensing Camera ▶

LG Innotek announced that it has collaborated with Microsoft to unblock access to 3D vision technology and unleash innovation across multiple industry verticals such as: fitness, healthcare, logistics and retail with LG Innotek's ToF (Time of Flight) technology-based 3D camera modules and Microsoft's Azure Depth Platform.

Nokia, Orange Strike Global 5G Network Optimization Deal ▶

Nokia has announced that it will expand its Self-Organizing Networks (SON) technology across 5G networks operated by one of the world's leading telecommunications carriers, Orange.

Smart Eye Launches a Complete Driver Monitoring System for Automotive Aftermarket ▶

Smart Eye, leading developer of AI-based eye tracking technology, breaks new ground with the launch of the AIS. After more than two decades delivering eye tracking software to the

automotive industry, the company is launching a complete driver monitoring system to raise safety standards for public transport and commercial vehicles.

Artificial Intelligence Technology Solutions Subsidiary to Integrate EAGL Gunshot Detection Technology ▶

Artificial Intelligence Technology Solutions, Inc. has announced that its wholly owned subsidiary has entered into an agreement with EAGL Technology, Inc. to offer EAGL's Gunshot Detection System in all present and foreseeable future RAD devices.

Fujitsu, Kyoto University Develop Explainable AI Verification System ▶

Fujitsu Limited and a Kyoto University research group led by Professor Yasushi Okuno of the Kyoto University Graduate School of Medicine have developed an AI verification system called "MGeND Intelligence."

DeepSig 5G Wireless AI Lab Enables Advanced Research and Development ▶

DeepSig's new 5G Wireless AI Lab has officially opened. The lab includes an end-to-end 5G network using state-of-art, commercial grade, multi-vendor products and tools.

Researchers Realize Quantum Communications Milestone Using Light ▶

Technologies based on the notoriously tricky laws of quantum mechanics promise to enable computers more powerful than today's fastest supercomputers unhackable secure communications and unprecedented sensing capabilities necessary for further scientific discovery.

A bond that lasts a lifetime – and beyond



We are constantly striving to disrupt the industry by developing cutting-edge technology. With **BondFilm® EX**, we have achieved this goal. The **bonding enhancement solution** for advanced HDI PCB (printed circuit board) high-frequency applications assures superior, long-lasting bonding while providing excellent thermal reliability and advanced performance in terms of reduced signal loss. It also ensures minimal copper removal, thus providing a smooth copper interface as desired for high-frequency applications.

Interested? Find more information in our on-demand webinar for 5G bonding applications using the QR-Code to the right.



25 Essential Skills for Engineers Excerpt

Skill Number 7: Project and Product Life Cycles

Feature Article by Martin Tarr
with an introduction by Happy Holden

Editor's note: this article is excerpted from 25 Essential Skills for Engineers: Skill 7—Project and Product Life Cycles, authored by Martin Tarr with an introduction from Happy Holden. For magazine purposes, the chapter has been condensed.

Introduction

It is particularly useful to consider the electronics industry because it has been under considerable pressure recently. The sales life of electronic products has decreased. Prices have fallen and expectations of quality and functionality have risen. Since the 1970s, Western manufacturing in general has seen aggressive competition from traditionally subdued Far Eastern-based companies—first Japan, then Taiwan and Korea, and now China. Communication technology has improved, with email and the internet, to the point that competition that was once local is now global. Here, these pressures on the electronics industry and the effect on profits will be explored. Once the reasons are understood, they can be addressed.

Most companies realize the importance of an efficient PLC process to develop products and get those products to the customer as quickly as possible. In the electronics industry, it can mean the differ-

ence between success and failure or in extreme circumstances survival and closure. From a list of PLC efficiencies, one can determine a requirements list for a PLC process to maximize profits.

Pressure on the Electronics Industry

Figure 1 shows the change in profit making period for various industries during the 1990s and the pressure on the electronics industry.

The product life cycle span (PLS) is the upper line and is the length of time the product will remain on the market. The pay-off period is the lower line and is the time for the product profits to pay-off the development costs. The grey area represents clear profit. For the electronics industry, the pay-off period has risen

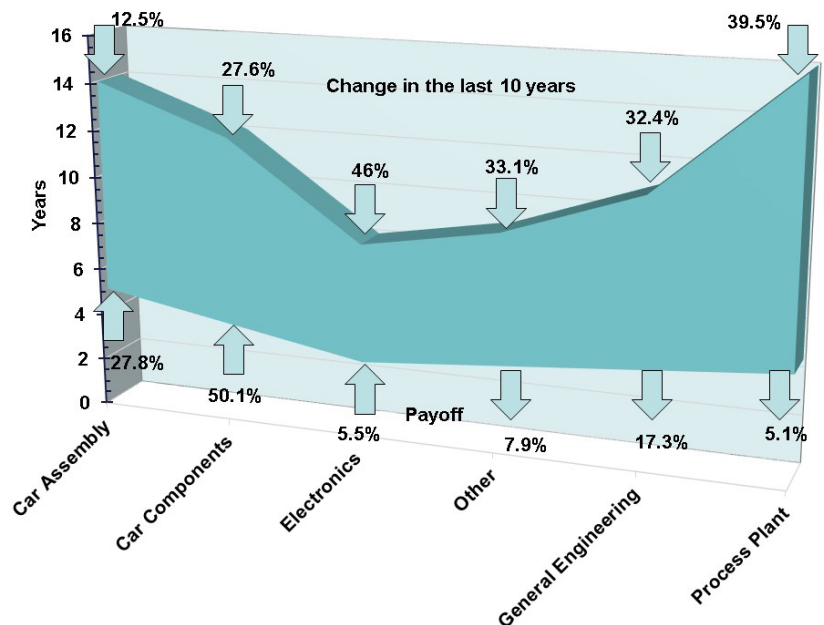
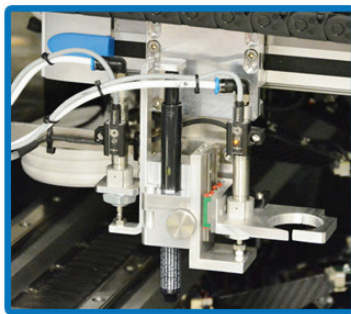


Figure 1: The change in pay-off and product life span over the 1990s. (Source: Martin Tarr lecture)

Unrivalled Test Speed with Full Automation



Introducing the newly designed atg A8a with 8 test probes and a new high speed “lights out” automation for unrivalled throughput.



Highlights:

- Small footprint (6 square meters)
- Dual shuttle pick & place automation
- High accuracy combined with high test speed
- Pen or label marking option

Watch video

Get more info

atg Luther & Maelzer GmbH

Zum Schlag 3 • 97877 Wertheim • Germany
Phone +49-9342-291-0 • Fax +49-9342-395 10
klaus.koziol@cohu.com • www.atg-lm.com



by on average 5.5% but the PLS has fallen by 46%. This has the effect of squeezing the time the products should make profits. The time it takes profits to pay for all the development costs is an important metric called the break-even time (BET). Also, notice that the electronics industries represent the narrowest part of the graph. This means that, although other industries' profits are being squeezed as well, there is pressure on the electronics industry.

The product, and or project (process) life cycle (PLC), is fundamental to a corporation intent on developing new products or processes. It is sometimes called the new product introduction (NPI) process, but that is only half of the life cycle. There is product support, enhancement, and eventually, obsolescence. I was introduced early to the phases of the PLC process because our group supplied all the prototype printed circuits to HP Product Divisions. My first large PLC was the HP-35 hand-held scientific calculator in 1971. I practiced the PLC on this, and subsequent calculators, for the next 20 years. Many considered this battery-powered marvel to be the beginning of the portable appliance age. Until then, the only portable computing devices were the slide ruler and the abacus (not too many people had the mechanical Curta).



Figure 2: The Curta is a handheld mechanical calculator developed by Curt Herzstark.
(Source: Rama, Wikimedia Commons)

The PLC process consists of all the work involved in developing, prototyping, manufacturing, enhancing, supporting, and obsoleting a product as an organization's new product for a marketplace. There are generally four to six phases: concept design, physical design, prototype manufacture, pre-production, and volume ramp. After this, the product is handed over to full production. The organization may also have some involvement in after-sales.

The PLC was one of the most important of procedures used in Hewlett-Packard. HP derived their high-profit and stellar reputation because of the innovations in their measurement instruments. HP prided itself on being able to measure anything physical. Later in the '70s and '80s, they expanded their product lines to include chemical, medical, nuclear, and genetics in the '90s. As the company grew and diversified, so did the number of products, reaching a peak in 1985 of 27,000 separate products having 35,000 options.

Because of the state-of-the-art nature of most of these products, their life was only about three years before a better version was created. Many of the first generations came from HP Laboratories and their investment in groundbreaking concepts. The majority of new products were the result of customer feedback, based upon their needs. This PLC is the life cycle for those customer-needed products and not the revolutionary products coming out of HP Labs.

The Phase Review Process

The phase review process (PRP) is another version of the product life cycle or product definition process. It is used to manage the interrelationship among various entities within an organization or business, and its related technologies in the development of products. The need for new products is a continuous process of innovations (revolutionary) and refinements (evolutionary) conducted over time (Figure 3).

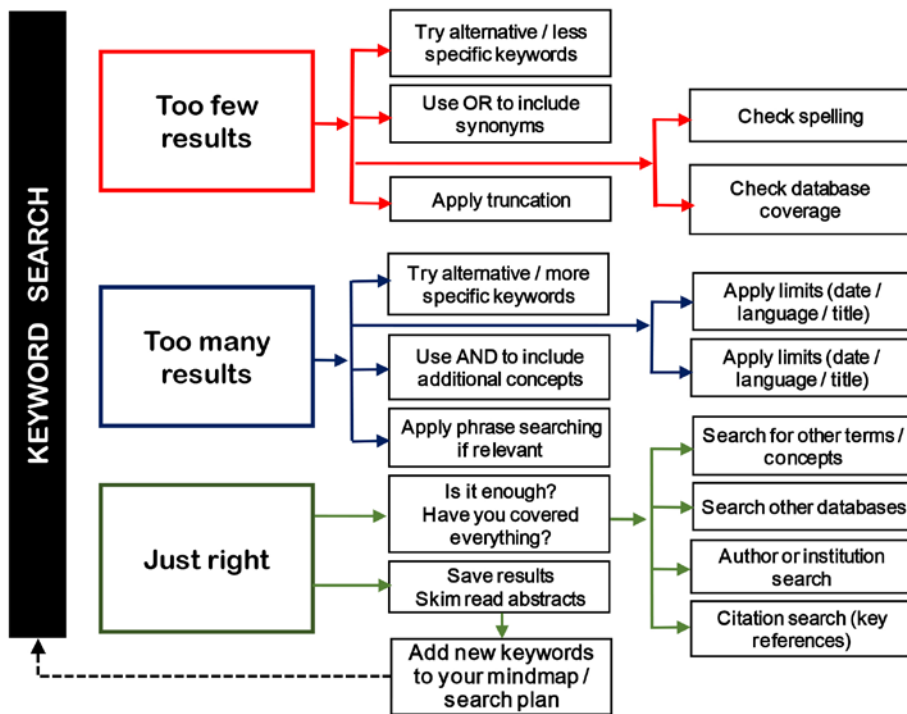


Figure 3: The phase review process and the product development process follow the well-known S-shaped curve of development.
(Source: HP Product Guide)

The phase review process consists of seven phases (0–6). Each phase represents one aspect of the system development effort and is well defined, including the following:

- Explicit exit objective that must be met before the product can be advanced to the next phase.
- A detailed set of activities and deliverables which, when completed, will fulfill the phase exit objectives.
- Identification of management commitments to the product in terms of continued funding and other resources.

Phase 0: Concept and Integrated Planning

The product requirements plan is a description of the features, forms, and functions of a product and is usually accompanied by a set of requirements, analysis of competitive products, and economic justification of the project.

Assemble requirement planning: The product team convenes with representatives from

each of the functional areas that will participate in the product development. The product team works closely with its marketing representative to develop product-specific requirements.

Review of customer requirements: This will be interlaced with the marketing functions that will establish whether the market exists, collect customer needs, and identify lead users. Working with R&D, the project team develops a product-specific set of requirements.

The product team develops the following:

- A clear definition of the target market segment and market requirements
- An understanding of competitors' activities and their potential effect on the proposed product
- Assesses leverage opportunities that will enhance the development effort
- Identifies preliminary resources and investment needs
- Determines potential development interdependencies
- Defines a phase 1 study plan and a product requirement document (PRD)

Phase 1: Study and Define Objectives

The functional areas respond to the PRD with a proposed product definition that satisfies customer/user needs and time-to-market constraints. The product team will develop initial product functional specifications including resources, schedules, testing strategies, and external dependencies.

Product design specification: The development team will identify and benchmark competitive products and provide functional

requirements and technical specifications. Plans for product options and extended product families will be developed. The product manager identifies and resolves differences between the product specification and the requirements stated in the PRC. The development team does the following:

- Develops the initial product functional specifications
- Develops release specifications
- Develops implementation plans with resource and schedule projections
- Defines testing strategies
- Identifies and resolves compatibility issues and external dependencies

Design analysis: Initially, concept development and technology assessment will take place considering product platform and architecture. Alternative concepts will be investigated, and experimental prototypes built and tested. The best will be selected.

Phase 2: Specifications and Physical Design

Each functional entity creates a design to meet the phase 1 functional specifications. The design is complete and detailed enough that the developing entities can make a relatively accurate assessment of and commitment to FURPS+ (functionality, usability, reliability, performance, supportability, and other factors), cost, schedule, function, and performance. In general, the deliverables for this phase include:

- Design specifications
- Marketing implementation plan
- R&D plan
- Quality plan
- Manufacturing plan
- Support plan
- Financial plan

Design realization: Schematics and product layout drawings will be generated, and simula-

tions of the design will be carried out for product function, cost, schedule, environment, and any qualification to recommended regional or global safety or design standards.

Component procurement and supplier negotiations: Marketing commits to a revenue and unit forecast. Unit quantities would be known for bargaining power with component suppliers, and designs would have to be assessed with contractors' process capabilities.

Test strategy and process development: Manufacturing simulations would ensure the process compatibility of the manufacturing functions, both in-house and contract. Test engineers would ensure testability of the design during production.

Phase 3: Develop, Prototype, and Test

Verification of design and process information: Prototypes should be built as close as possible to the full-scale assembly using the intended components and processes and to the product specification. Tooling and specialized process equipment would be designed and tested. All other functional entities (marketing, quality, manufacturing, and support) begin implementing their respective plans.

Conformance test and customer acceptance/demonstration products: Beta prototypes would be internally tested and used for demonstration purposes. They would also be used for customer conformance and documentation, support services, marketing literature preparation, localization, and legal requirements. Tests verify the completeness of the total solution and ensure that what has been developed matches FURPS+ objectives and adheres to product specification. Specific deliverables include:

- Functioning and tested product components
- Updates to plan, specifications, and outstanding issues

Excellon

*Manufacturers of precision Micro-Machining
Solutions for over 50 Years*



COBRA II Hybrid Laser

*UV and CO2 lasers
Blind via, flex cutting, cavities*



HS-4L

*Low-cost, 4-station precision drilling
or routing system with large panel option*



HS-1L DS

*Single-station, dual spindle high-speed
drilling/routing with Intelli-Drill Vision*



136L

*High-Speed, precise accuracy
drilling/routing with Intelli-Drill Vision*



154L

*Large panel size precision drilling/routing
Single station with vision options*



HS-2L

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

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

	Business Planning Process	Product Phase Review
Overall Business Objectives	Enterprise Management	Product management/product team implements product phase review
	<ul style="list-style-type: none"> Set business objectives Create enterprise marketing and support plans Create enterprise technology plans Update program plans Place programs into phase 0 Manage product phase review implementation 	Approvers/reviewers evaluate implementation effort Product phase review approvers' meeting reach agreement on product advancement to the next phase

Linkage	System Phase Review		Phase 0 Req/Plan	Phase 1 Study/Define	Phase 2 Specify/Design	Phase 3 Develop/Test	Phase 4 User Test/Ramp Up	Phase 5 Enhance/Support	Phase 6 Maturity					
	Major Activities	Life Cycle Management		Integrated Planning		Objectives	Definition	Design	Verification	Functional Builds	Certification	Process Verification	Ramp Up	Volume Shipments
System Team		HW Release Team	SPU Team	Develop technology alternatives; identify leverage opportunities; develop dependencies; estimate cost of resources; schedule, and interdependencies; develop functional plan and justify investments.	Respond to System Requirements Document. Define objectives, identify functionality, resource, schedule, and interdependencies; develop functional plan and justify investments.	Fully specify the Product	Design the product	Verify the product design. Software true simulation and/or breadboarding.	Build, debug, and qualify functional prototypes.	Build prototype that meets all specifications and Design Objectives.	Build to specification using all manufacturing process; verify initial documentation is correct and supportiveness; work. Ensure that the production be manufactured in volume.	All company functional areas prepared to deliver and support system. Production company ready; for unanticipated customer support.	Establish the new products as a profitable business; do Post Shipment Review; Enhance product improve to stand quality.	Continuously optimize the profitability of mature product.
*		✓		How System Management										
✓		○		How Marketing										
○		○	○	Finance										
✓		*	✓	HW Program Management										
		✓	✓	Support Engineering										
		✓	○	Field Support Documentation										
		○	○	Architecture										
✓		✓	✓	Performance										
✓	✓	○	System Test											
	✓	✓	Reliability / Supportability											
	✓	*	Hardware R&D											
○	✓	✓	Manufacturing											
○	✓	✓	Hardware Quality											
	○	○	Hardware Subsystem											
Checkpoints	✓ Team Member													
	* Team Leader													
	○ As Required													
	— Key Check-Points													
	*** System Level Only													
			SRD System Requirements Defined	DOSO Design Objectives Sign-Off	EDF External Design Freeze	IDF Internal Design Freeze	DR Design Release	FPSO Functional Prototype Sign-Off	PSO Prototype Sign-Off	MR Manufacturing Release	SR Shipment Release	RDC R&D Enhancement Complete	DPC Discontinuation Plan Complete	
			Requirements specified by SPC is met by BPC is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met by HPO is met by IPO is met by JPO is met by KPO is met by LPO is met by MPO is met by NPO is met by OPO is met by PPO is met by QPO is met by RPO is met by SPO is met by TPO is met by UPO is met by VPO is met by WPO is met by XPO is met by YPO is met by ZPO is met by APO is met by BPO is met by CPO is met by DPO is met by EPO is met by FPO is met by GPO is met											

54 PCB007 MAGAZINE | APRIL 2021

Phase 4: Process Verification and Volume Ramp

Volume manufacturing qualification: The focus is on testing the product and all supporting materials in a customer environment and demonstrating that the product can be supported in the field. This is important for product quality and process refinement. Any final engineering changes should be actioned before large-scale manufacture and manufacturing should demonstrate the ability to build and ship in volume. Also, the work force can be trained to use any new production processes, machines, or tooling. Customer support can sign off on the field's ability to support the product.

Evolution of manufacturing efficiencies and yields: The first process results are gathered for yield improvement studies, etc.

Market and supply chain development: Market push can continue with products visible at trade fairs, customer visits, etc. Regular order quantities can be placed, and suppliers tested for delivery times and quantities. Specific deliverables include:

- Functional release sign-off
- Shipment release sign-off

Phase 5: Volume Shipment, Enhancement, and Support

Product is supported by manufacturing and field sales: Phase 5 enhancement is a feature or function that significantly enhances an existing product and requires tracking through an abbreviated product phase review. It is a major product addition, but not a new product requiring a new part/product number. Finance measures and reviews the actual return on investment in the product and compares the measurement to original product goals. Maturity requirements are developed, and discontinuance process is initiated at the exit of phase 5.

Issues to consider include:

- Periodic ROI calculation
- Distribution and field service

TQC and USE OF THE 7 PRODUCT DEFINITION PHASES

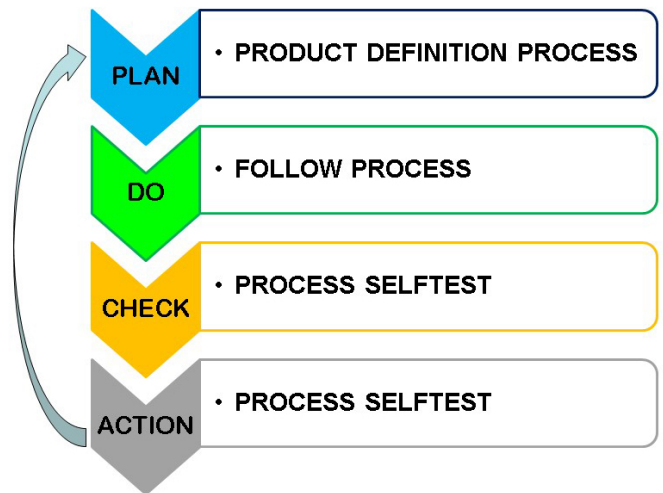


Figure 5: The PLC with linkages, major activities, and checkpoints/milestones.
(Source: HP Planning Guide)

- Spares and repair
- Take-back, disassembly, recovery, re-use, refurbishment, and disposal

Phase 6: Maturity

Responsible organizations plan for discontinuance: Discontinuance planning takes into consideration customer satisfaction, the migration of customer applications, and parroting of third-party products. These issues require critical consideration in future product planning.

Issues to consider include:

- Product demise
- Disassembly and disposal
- Migration or discontinuance plans

This entire PLC and the PRP are linked (Figure 4). The PRP process is part of the larger enterprise-wide business planning process (Table 1). The PLC and PRP are also tied to the TQC process (Figure 5). **PCB007**



Martin Tarr is a retired PCB technologist, and lecturer in the MS engineering degree program at Bolton University.

Leadership 101— The Law of Influence

The Right Approach

by **Steve Williams**, THE RIGHT APPROACH CONSULTING

Introduction

Good leadership always makes a difference; unfortunately, so does bad leadership.

This leadership truth continues as we will be talking about the second of the 21 Irrefutable Laws of Leadership^[1]: the law of influence.

Influence

The true measure of leadership is influence, nothing more, nothing less.

This simple truth is the most powerful trait a great leader can have: the ability to influence others. People often equate education to leadership, and that you need to be really book-smart to become a great leader. Nothing could be further from the truth, as these facts indicate:

- More than 50% of all CEOs of Fortune 500 companies had C or C- averages in college
- 65% of all U.S. senators came from the bottom half of their school classes
- 75% of U.S. presidents were in the lower-half club in school
- More than 50% of millionaire entrepreneurs never finished college

Now this is not to diminish the value of higher education or say that great leaders are not smart; quite the opposite. But great leaders and entrepreneurs tend to fall on the creative side and become bored easily with the mundane, such as sitting in classrooms, and spending hours upon hours doing homework. They feel their time is better spent on higher-level thinking and doing, and in some cases feel that



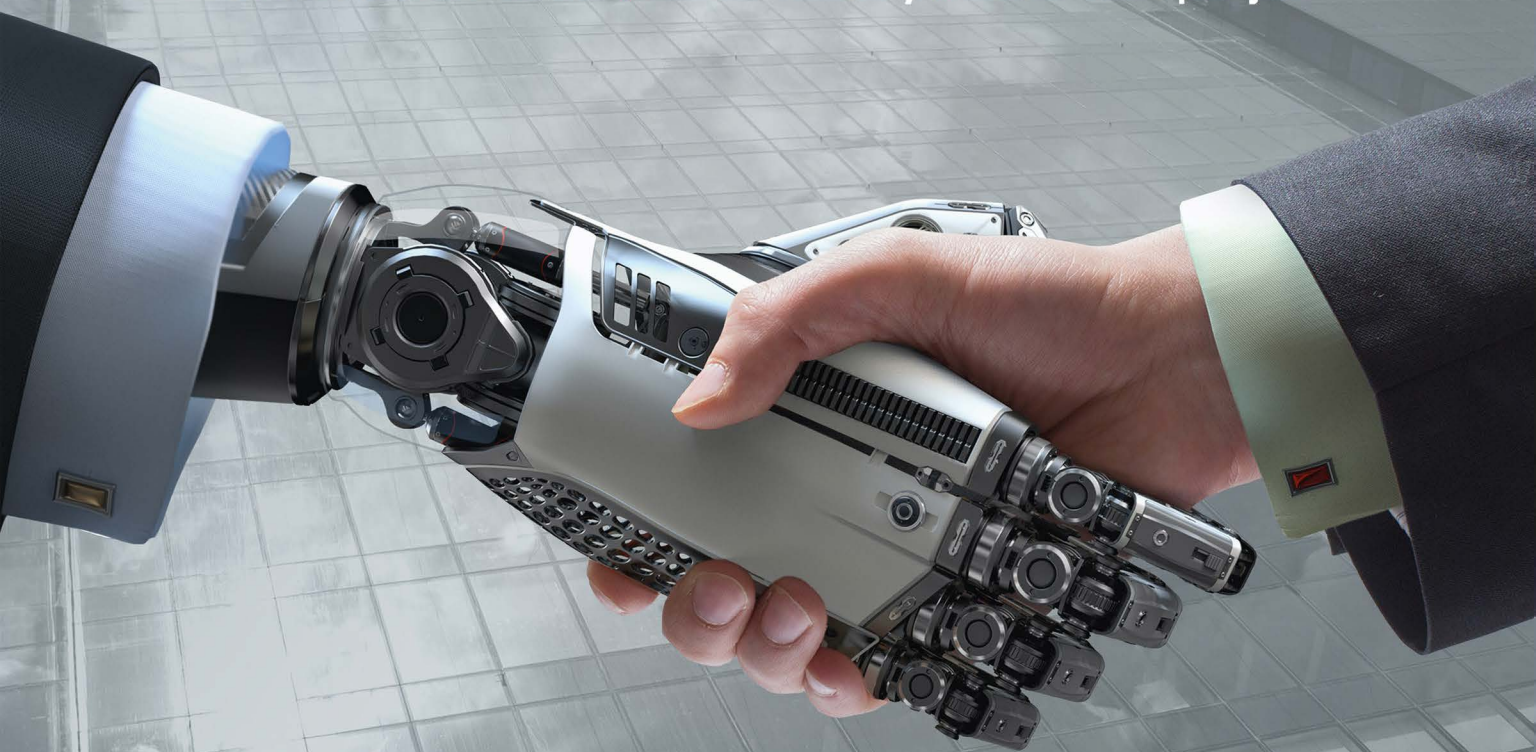


Market leader in
PCB CAM and Pre-CAM Software
Laser Photoplotters
Direct Imaging Systems
www.ucamco.com

iamcam

Intelligence Aided Manufacturing

Artificial intelligence | Next level of automation | Global web access
Fewer human errors | Faster delivery | Lower cost per job



AI automation shortens
delivery times

Free your brain resources
for complex jobs

iamcam.ucamco.com

they know more than the professors (which they normally do!).

Servant Leadership

A continuing theme in this series, and the 21 Irrefutable Laws of Leadership, is that leadership is not title or position—it's influence. Early in my leadership journey I believed leadership was all about me; then I shifted and pretended it was all about them, but I still secretly still thought it was all about me. Many years later I realized it was all about them; it's influence, and that comes from adding value to others. Servant leadership is all about adding value to others, where the leader's goal is to serve. While the organizational chart may show all the folks who work for you, servant leadership means that you actually work for them. My good friend, motivational speaker Zig Ziglar, summed it up nicely:

"You can have what you want...if you will help enough other people get what they want."

Poor leaders always have a difficult time understanding this, which is probably why they are poor leaders. Learning to ask, "How can I help you?" instead of "What can you do for me?" is the first step to becoming a great leader. I firmly believe that one of the problems with leadership is there are so many myths, particularly when it comes to influence. Here are the "Five Myths of Influence."

1. The Management Myth

As discussed in prior installments, people often get management and leadership mixed up. Management can be a part of leadership, but just because you can manage something efficiently doesn't mean you can lead. Management is doing things right; leadership is doing the right things. Management is efficiency, control, and managed risks; leadership is direction, enthusiasm, inspiration, and influence. People often think they're the same thing but they're really not; monitoring what time people come into work, how long they have for



lunch, that sort of thing is not the same thing as leading an inspired team united in pursuit of a challenging goal—is it?

2. The Entrepreneur Myth

The prevailing thought is that entrepreneurs make great leaders, right? But if you stop and think about it, that makes no logical sense whatsoever. Just because someone identified a market need and moved quickly to exploit an opportunity doesn't make them a leader. That's a totally different skillset than leadership. An entrepreneur may be brilliant and a visionary, but that's not leadership; what's missing is care for others.

3. The Knowledge Myth

This is a classic myth: information is power and therefore whoever has the power is a great leader because leadership equals power, right? Wrong. Leadership equals influence: you can't force people to follow you, they have to want to.

4. The Pioneer Myth

This again is a popular fallacy. Just because someone got there first or is out in front means they are a leader; wrong again. Once you can appreciate that leadership is a separate, distinct skillset this becomes crystal clear.

5. The Position Myth

I think this is the biggest misconception of all, and the most dangerous because it is so common. So many people think that it's position that makes you a leader: give me the position, the title, and the corner office, and then people will listen to me! It's not position that makes the leader, it's the leader that makes the position.

I will close with a timeless quote from a leader that truly gets it:

"Being in power is like being a lady, if you have to tell people you are, you aren't."

—Margaret Thatcher PCB007

References

1. *The 21 Irrefutable Laws of Leadership: Follow Them and People Will Follow You*, by John C. Maxwell, published by HarperCollins Leadership, 2007.



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



Get smarter here.



Benchmarking for Yield Improvement and Scrap Reduction

Feature Interview by the I-Connect007 Editorial Team

The I-Connect007 editorial team submitted a series of questions to Todd Johnson, quality control director for Wus Printed Circuits, KEPZ China. Wus elaborates on the importance of benchmarking in his organization, particularly for yield improvement and scrap reduction.

Q: How do you see benchmarking used within the Wus organization?

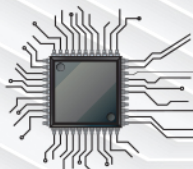
A: I will try to give you a comprehensive view of benchmarking use throughout the organization. There are aspects of benchmarking implemented from individual operator performance to internal plant KPIs, and cross-BU (business unit) optimization through to supplier, cooperative competitors, and customer intelligence.

To start at the lowest level, within operation areas individual training programs include ongoing weekly and/or monthly monitoring to push all employees to achieve the efficiency,

quality, and performance of the best employees within that area. This benchmark activity is captured within KPI targets for both individuals and the process areas.

At the next level, there is cooperative competition between process areas of the same plant, also captured through KPIs. Common process types—such as cleanroom/imaging, IL, OL, and SM—have common outputs and imaged structures utilizing similar systems and tools. Disciplines that affect output are benchmarked and optimizations shared between these common processes, for example: cleanliness techniques, preventative maintenance frequencies, controls, automation, etc.

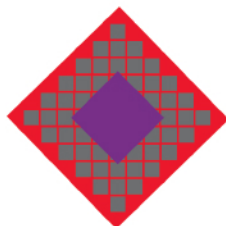
There is plant/business unit benchmarking where we have antenna/PA, telecom/infrastructure, automotive/industrial, and HDI/anylayer. While all have their key focus—quality and reliability for automotive, high layer count and hybrids for telecom/infrastructure, PTFE-related materials for A/PA, special processing and lamination for HDI/anylayer—there is substantial overlap. Automotive quality disciplines on cleanliness and controls help HDI; PTFE-related materials and HDI are



MivaTek

Global

Major New Technology Release



NextGen LE

New Light Engine Technology

Miva Technologies NextGen Light Engine is loaded with new features in support of its technical road-map. The NextGen is now available in all models.

- **Quad-wave Technology:** Images everything - in a single machine.
- **DART™ Compliant:** Scaling and line-width control tools that operate at 10X resolution for the most precise and repeatable total process.
- **New Vision System:** Miva's new vision system sets the stage for its line-width measurement and Gerber driven metrology.
- **Increased camera FOV:** Expanded FOV improves automation operation as well as eases panel alignment.
- **Resolutions:** NextGen 15/30-micron available allows for high speeds and resolutions.

High Power LED for 2x+ throughput:

Light Engines	1	2	3	4
30Mj Resist	46	83	100	124
50Mj Resist	33	62	75	95
DI SM	25	47	57	73

**18x24 panels per hour, both sides, 2400DT



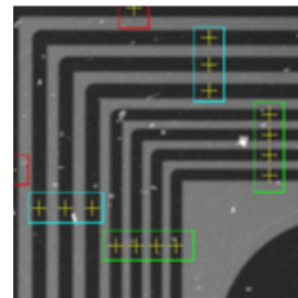
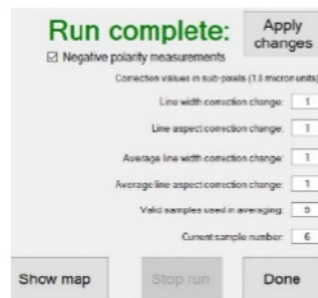
Digitally Adaptive Rasterization Technology

DART™ changes everything. Rasterization at 10X imaging resolution permits on the fly digital adjustments to line-width and scaling at 10X system resolution for hyper-precise feature/scale control.

- **TRUE Zone:** Pre-rip scaling capabilities allow for true zone scaling in linear or non-linear algorithms at 10X system resolution.
- **Feature Tuning:** Globally adjust feature sizes to include changes in develop or etch conditions in sub-pixel increments.

DART Optimization Suite

- **FA Tool:** Closed loop digital line-width compensation to include develop and etch process variation for first article or continuous.
- **Process Control Tools:** Topographical mapping of develop and etch process variations for improved process control and AB etch uniformity.
- **Coming Soon:** Integrated AB Registration Confirmation



**Worldwide patents pending



Todd Johnson

naires, spec changes, complaints, and audits. And sometimes quality alerts are sent out by customers to avoid having similar problems at our plants. This intelligence is fed through our engineering, manufacturing, maintenance and quality teams to upgrade and improve as problem avoidance and prepares higher level capabilities years before customers actually demand them.

Q: Where specifically have you gained yield improvement from these many benchmarking activities?

A: Supplier management is one successful program. For key suppliers, we provide monthly scorecards and along with supplier specific improvement programs leverage the cross-supply chain information to drive defects out of the supply chain. This isn't a one-way street. For example, Wus has ongoing drives for improved cleanliness and yields related to lamination processes. The improvement methodology is shared with laminate suppliers to assist in their improvement efforts (as well as used internally across BUs).

The combined laminate supplier and Wus internal benchmarking cleanliness/lamination improvement efforts have been key elements of a five-year effort in our automotive BU to reduce incidents by nearly 80% and has led to internal electrical test foreign material shorts cut by about 50%.

Q: What about scrap reduction?

A: Wus has a couple of cooperative partnerships which highlight this well. One is the Schweizer-Wus HF technology/sales partnership. Schweizer is a high-quality German PCB manufacturer key to developing the automotive radar market. We have been working together for about seven years and have performed numerous benchmarking efforts aligning equipment capability, test methodology, engineering disciplines, and pre-production engineer-

growing in automotive electronics; high layer count and anylayer are moving beyond the high end with progress in AI; and size/weight compression throughout electronics supply chains. Wus has performed several plant collaboration benchmarking exercises to prepare each plant to upgrade its proficiency and capabilities. These are needs-dependent as they tend to take a lot of engineering, manufacturing, and quality resources over several months' time.

In addition, Wus has a Corporate Reliability Team that benchmarks key processes, test technologies, Finite Elemental Analysis techniques, and material/product modeling across the business units, suppliers, and industry to prepare Wus for next generation developments.

Customers also provide interesting benchmarking opportunities. Some customers directly show us how we compare to our competitors for quality, cost, delivery, responsiveness, and of course, this is quite valuable. What is more interesting and deeper is the information that is gleaned from customer question-

ing optimization to capture increasing market shares. As an example of how this benchmarking allowed scrap reduction, when faced with concerns regarding relatively low yields on initial mass production radar products at our Kunshan plant, the team was able to confidently state we would solve this within the coming months before full mass production scale-up occurred. We not only hit our yield targets, we continued to progress to far better yields than was originally thought possible.

Another cooperative relationship is with Rayben, a Zhuhai-based technology partner that has specialization in thermal management technologies. Wus purchased a license to their ceramic inlay technology and we have ongoing benchmarking activities aligning processes, inspection, and test (key to Rayben's technology), including participating together with key customer audits at both our plants. This has allowed both manufacturing locations to dramatically reduce scrap related to suppliers, processes, and handling while ensuring quality and reliability to customers.

Q: Do you have any final thoughts about benchmarking?

A: Often, benchmarking is defined as comparing yourself to your competitors and industry standards. I'd say that is a narrow view. When considered as a tool and applied intelligently as part of a holistic approach to the management and development of your organization, it can help your company from individual effectiveness to integrated supply chain management to improve customer satisfaction and profitability.

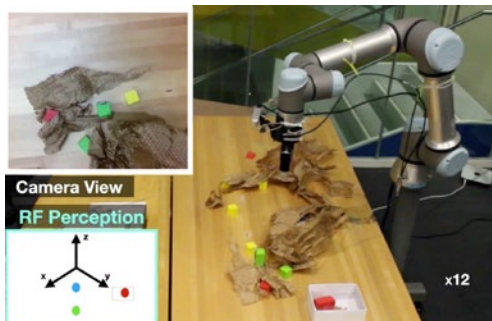
Wus has great strategic vision. Each plant focuses on core products to manage customers and technology requirements while the organization consciously leverages the strengths of each and the entire supply chain for achieving technology, quality and yield advances. **PCB007**

Todd Johnson has over 20 years of experience in PCB quality, engineering, reliability, chemistry, and R&D.

A Robot That Senses Hidden Objects

In recent years, robots have gained artificial vision, touch, and even smell. "Researchers have been giving robots human-like perception," says MIT Associate Professor Fadel Adib. In a new paper, Adib's team is pushing the technology a step further. "We're trying to give robots superhuman perception," he says.

The researchers have developed a robot that uses radio waves, which can pass through walls, to sense occluded objects. The robot, called RF-Grasp, combines this powerful sensing with more traditional computer vision to locate and grasp items that might otherwise be blocked from view. The advance could one day streamline e-commerce fulfillment in warehouses or help a machine pluck a screwdriver from a jumbled toolkit.



As e-commerce continues to grow, warehouse work is still usually the domain of humans, not robots, despite sometimes-dangerous working conditions. That's in part because robots struggle to locate and grasp objects in such a crowded environment. "Perception and picking are two roadblocks in the industry today," says Rodriguez. Using optical vision alone, robots can't perceive the presence of an item packed away in a box or hidden behind another object on the shelf—visible light waves, of course, don't pass through walls.

But radio waves can.

"RF is such a different sensing modality than vision," says Rodriguez. "It would be a mistake not to explore what RF can do."

(Source: MIT News)



Isola Releases **IS550H** Material

Interview by Nolan Johnson
I-CONNECT007

Nolan Johnson speaks with Michael Gay of Isola and Chris Hunrath of Insulectro about the release of their new halogen-free, high-thermal reliability material, which they hope fills the gap in the market between epoxies and polyimides.

Nolan Johnson: I understand there's something new on the market for us to talk about. Why don't you tell us what it is and what the application is?

Michael Gay: Quite a few years ago, the automotive industry OEMs were looking for an alternative to ceramic-based materials for high temperature applications. They wanted something that was less costly. They wanted something that would fill in the gap between typical FR-4 applications and ceramics. A consortium called The Help Project was developed with several large OEMs and other industry participants in the automotive sector who wanted to work together and develop this materi-

al. We started with about a half-dozen different candidates and then whittled it down, making comparison to products like 370HR, which is a typical FR-4 lead-free compatible material. We started doing evaluations and we came up with the product we now call IS550H.

Johnson: And this is a new product?

Gay: Yes, it's brand new. We launched this product about four or five weeks ago. The product is manufactured in Asia. It's really directed toward the automotive industry, but because of the properties of the material, it can actually be applied to other industries where high temperatures and high voltage CAF performance are required.

Johnson: From the automotive application perspective, how is this a response to the demands of OEMs?

Chris Hunrath: High-speed charging is an obvious area of concern, and one of the ways you accomplish that is using higher voltage. You need something with very good dielec-



Profit. On Demand.

Gardien has two test and inspection solutions that will improve your bottom line.



On Demand

Global test and inspection service where and when you need it.

[SEE NOW →](#)



Integrate

We manage and improve your QA department

[HERE'S HOW →](#)

tric properties. Epoxy is good, but this material is better. Rapid charging drives this heavy copper requirement as well as the ability to make circuits and embed them in the dielectric material. With thermal performance, in the organic substrates, it has always been the domain of polyimide, with epoxies, multifunctional epoxies, and some materials in between. But there was a space between polyimide and epoxy, and we knew that polyimide doesn't do certain things very well. It absorbs moisture, but it gets brittle as it cures. It is very decomposition resistant, but it does have some other drawbacks.

As Michael mentioned, ceramics are very good in certain applications for high temperature, but you can't do everything you want to do in circuitry in ceramics that you can easily do with a PCB material or organic PCB material. This just gives the engineers and designers a whole lot of options when they're designing circuits. The base resin chemistry (I don't believe it's proprietary) is something called benzoxazine, and it's a newer resin system. It's been around for a long time, but it's newer than epoxy. The way it cross-links and the way it behaves in high temperature applications is different. It has actually been used in aircraft bodies. You've heard the airline industry is moving away from aluminum parts to composite parts. Well, this is the resin that is being used. Resin has to be able to flow and fill large features very well, but it also has to withstand temperature variations. Think of an aircraft on the runway vs. an aircraft in the upper atmosphere—we see some pretty wide temperature changes. This resin chemistry does all those things very well.

Johnson: If it's being used for exterior aircraft parts, that indicates it is resistant to UV.



Chris Hunrath

Plus, it's good with rapid temperature variations. It's good with humidity issues.

Hunrath: It's good with fracture toughness.

Gay: Yes, fracture toughness is a big deal.

Johnson: Right. And that fits with what the automotive industry has been asking for. You can't necessarily put standard FR-4 into a vehicle that might go to either an Arctic region

or a tropical region.

Hunrath: Yes, and this is intended for the electronics, the battery structure, the charging systems, and those types of things.

Johnson: How appropriate is benzoxazine for miniaturization? Does it play well on the sensor side, or is this primarily the powertrain?

Gay: It's primarily designed for power distribution and the systems that connect the automobile to the charging stations, and then distribution within the automobile. In the charging arena, we're going from lower voltages to much higher voltages. The material has to be able to withstand those voltages across tight spacing. You have the hole wall-to-hole wall spacing, and it needs to be able to manage both that and Z-axis spacing. You can't build a board that's two inches thick; you have to build a thin board, so Z-axis capability on thin dielectric is really important. This is where this particular material excels.

Johnson: Do you see IS550H having application in the infrastructure and charging distribution portion of the network?

Gay: Yes, there are definitely opportunities in the distribution network. We've seen applica-

tions that are ripe for this type of material where voltages are up in the 20K to 160K range. There are many applications where very high voltage is applied. We see that as an adjacent market we need to look at as well and see how that works. As for automotive—for example, the wall charging systems, the trailered battery systems—those types of systems all need to be managed. Distributing that energy, and the heat generated as well, must be managed through that material. An advantage of this material is that it has a much higher thermal conductivity than a typical FR-4. Typical FR-4 will be about 0.35 to 0.4, whereas this material is 0.7 W/mK. This gives it a much better current-carrying capacity and heat dissipation capability, so that when you do have those high voltages and high currents, you're not damaging the material and causing premature failure.

Johnson: You mentioned that there were some other applications outside of automotive that seemed to be well suited for this material.

Hunrath: The material comes in the regular building blocks that people are familiar with for multilayers. There are many other applications, everything from the ATE and burn-in boards to even some down-hole applications. There are plenty of applications where you need higher thermal performance, but you don't want to do something with a more exotic material.

Gay: Adding to that, for example, polyimides have always been used as the primary high temperature material. The polyimides are fairly brittle and this material is just the opposite. It has the high temperature capability, but it's not brittle. It has a very high Tg because



Michael Gay

it's halogen-free, and it delivers good temperature management while maintaining its structural integrity when vibration is applied. It also had good temperature management when various structures within the material—copper for heat dissipation such as embedded heat sinks or coins, for example—are applied. With polyimide, you may have a hard time doing that because it creates stress risers and those stress risers crack during thermal cycling; this ma-

terial is a solid material for those types of applications.

Johnson: So how does this material behave during fabrication?

Hunrath: We have some experience with BT-based (bismaleimide triazine) materials; they drill and they smear and plate pretty conventionally. That's another nice thing about this material—when you try to form circuits on ceramics, it's a whole different, more complicated and specialized technology. There will be applications where there are certain sensors in the exhaust system that must be ceramic based. Of course, that's not an electric vehicle; that's a combustion engine. But this material can be dropped into a PCB fabricator. And that's really the point—you can use conventional building blocks in terms of the prepregs and cores. It also goes through the shop, drills normally, plates, and all that.

Johnson: Fabricators can anticipate it behaving a lot like FR-4?

Gay: Yes, FR-4 processing ease.

Johnson: That certainly plugs a hole in the spectrum of materials, doesn't it?

Hunrath: There has been a need for something that has the performance advantages of polyimide without some of the drawbacks. When I saw the data from Isola on this material, I was really impressed with its CAF performance.

Gay: We've actually had four different OEM tests that have been run all the way up into the 1500-volt DC range. You're looking at both hole wall-to-hole wall at various spacings and then also Z-axis spacing. We've seen that at 1,500 volts, you can run the material up to 2,000 to 3,000 hours in an accelerated life test. Now with the voltages increasing, we will have to go higher than that, maybe up to 3,000 volts or possibly higher, but when you do an accelerated life test, you're trying to test multiples of the actual operating voltage. For example, 460 VDC might be a pretty common voltage for some of these supercharging stations to operate. Those inverters that are in the car get very hot, very easily. This type of material is going to be a solution for those specific boards within the interconnection of the car and the charging station.

Hunrath: If you put that into perspective, passing a 100-volt CAF test at 1,000 hours is considered very good. To do 1,500 volts for 3,000 hours is off the chart.

Johnson: It would seem this is a good response to some of the automotive industry requirements regarding charging and battery management.

Gay: What's interesting is that the construction set in those tests has included 7628 glass and

automotive folks want the least cost option to build the boards out of it. Just a couple of these tests are using 7628 and the hole wall-to-hole wall performance is great at these very high voltages at tight spacing. It's pretty interesting chemistry that allows you to do that with 7628 glass.

Hunrath: I would think that probably comes from a combination of the fracture toughness and the resin's ability to bond to the glass fabric.

Gay: Yes, definitely.

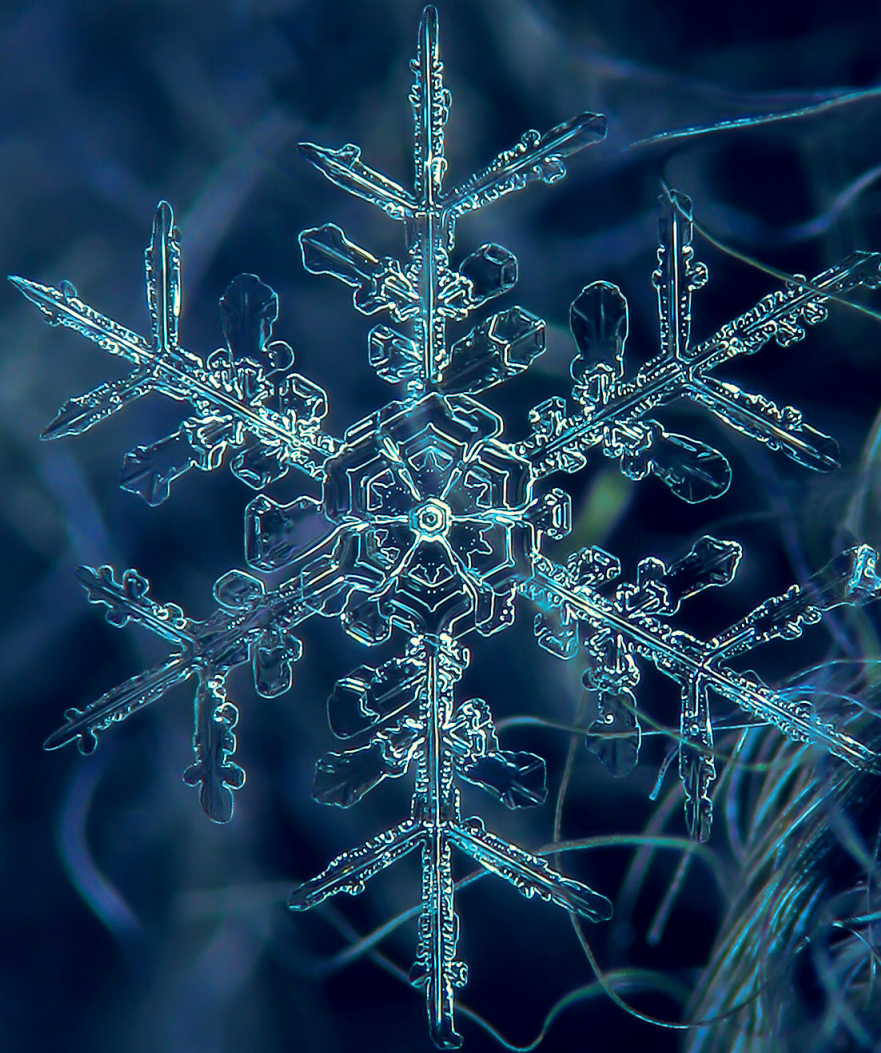
Johnson: Did you say that you've had three or four OEMs working with you or working with this material?



Gay: Yes, several automotive OEMs have done tests, but we're also looking at applications outside the automotive segment. They are looking for the attributes like burn-in board or ATE type applications where you're seeing repeated thermal cycling. That repeated thermal cycling in a typical burn-in board has numerous slots on a

given board and that's going through four or five cycles for that chip set so that they can test it. It's loaded again, put back in the oven and thermal cycled again, then they take it out and load more chips. This happens repeatedly. As the number of sockets is reduced on that test board, it reduces the amount of throughput. When you get to a certain number of sockets that are defective or not functioning, then you have to pull that board out and replace it with another board. This type of material would give the test equipment the ability to run more cycles and last longer in their test system, thus reducing the overall cost.

Uniquely suited solutions for an increasingly demanding world.



Outsourcing can help you remove your CAM bottleneck. We deliver the highest quality PCB CAM engineering services to customers around the world.

Find out how we can help you >



www.entelechyglobal.com

Hunrath: There are probably applications for this material in aerospace, outer space, where we need that extra reliability combined with fracture toughness—extra thermal reliability combined with fracture toughness. There are probably a lot more applications for this material.

Gay: Yes, exactly.

Johnson: You're manufacturing it in one facility right now?

Gay: We developed the material in Düren, Germany, and that facility can run the material, but because most of the automotive work is done in Asia, we've set up our facility there for building this material. It is where most of the material will be manufactured. We have inventory in place, so the necessary materials will be readily available for customers that want to do testing, UL qualifications, process evaluations, and so forth.

Johnson: Finally, let's talk about pricing for this new material.

Hunrath: From a material cost standpoint, this will be a premium over epoxy, but less than polyimide. It fits that in-between space. As Michael pointed out, automotive applications are very cost sensitive. Both the material costs and some of the building blocks are such that you should be able to make a whole lot of those applications, and that's another good thing about this. I think there are some aerospace applications that have historically been polyimide. I think that this material in some of those applications could outperform polyimide. Polyimide is still very decomposition resistant, but it does get brittle when exposed to heat.

Johnson: Which limits its lifetime.

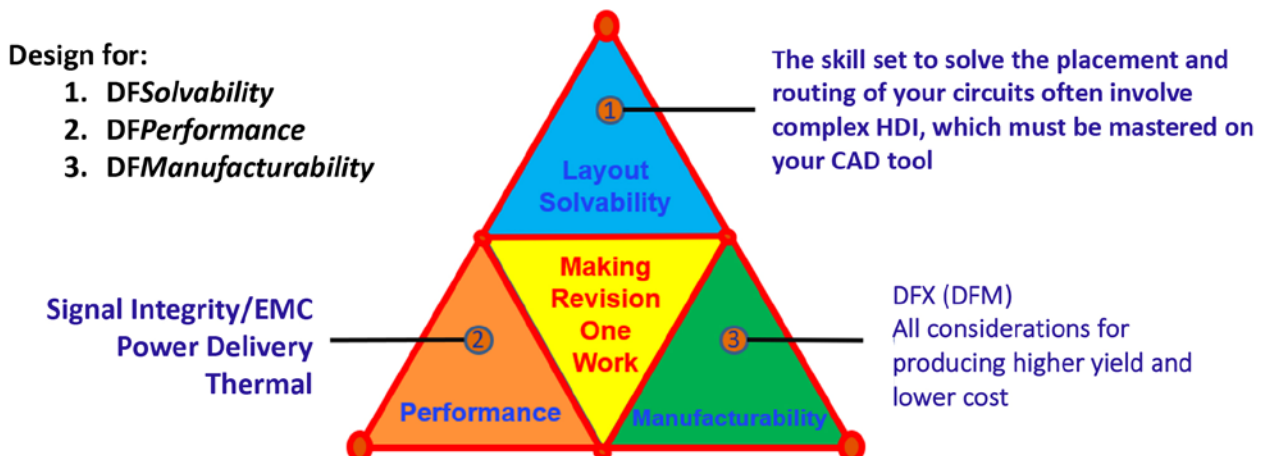
Gay: Exactly.

Hunrath: That is a drawback. Anything that sees break shock and vibration in copper structures, this material could be a good fit.

Gay: Thinking about that from an automotive perspective, your automobile is going to see a lot of vibration over the lifetime of the car. It's

Make Revision One Work With High Yield Never Lose Focus on This Imperative

Today's Circuit Engineers Must Meet 3 Competing Perspectives for Success



also going to see thermal cycling. You've got cars that are up north, you've got cars that are down south. You've got cars that are operating in dry desert environments like Arizona, and ones that are operating in wet environments like Seattle, Washington. You need a material that withstands those environments very solidly and performs well for a long lifetime. You don't want to have to be replacing circuit boards in these electric vehicles every few years.

Hunrath: I think its price point puts it in a place where it is actually more economical than the alternatives, and that's an important attribute. We're talking about a new resin technology that allows you to do more with organic PCB materials rather than using something like ceramic. This extends the range of what organic can do. Michael, do you know why you couldn't use this in some of the BT applications?

Gay: Oh, I think it might fit in that category just fine.

Hunrath: BT resins were a popular choice for organic chip substrates, and it's been hard to get for a long time. The supply chain is not great on that material. So, if I look at the numbers, this material outperforms BT.

Gay: And it's also a very moisture-resistant type of material as well, which is one of the things the BT is tested to using JEDEC standards.

Johnson: I think you're onto that. This is one of those situations where the overall cost is lower for the OEM than the price of the material because of the durability, reliability, and manufacturability they're going to get out of this material. It may be at a premium for price, but all in it's going to be cheaper in the long haul.

Hunrath: And it's not that much of a premium; it's not like some of the more exotic materials out there, but because of its standard building

blocks, you can also broaden its applications, especially if you need high reliability. I mean, it doesn't have to be just the power network in a vehicle, it could be the motherboard in an electric vehicle where you want that extra reliability.

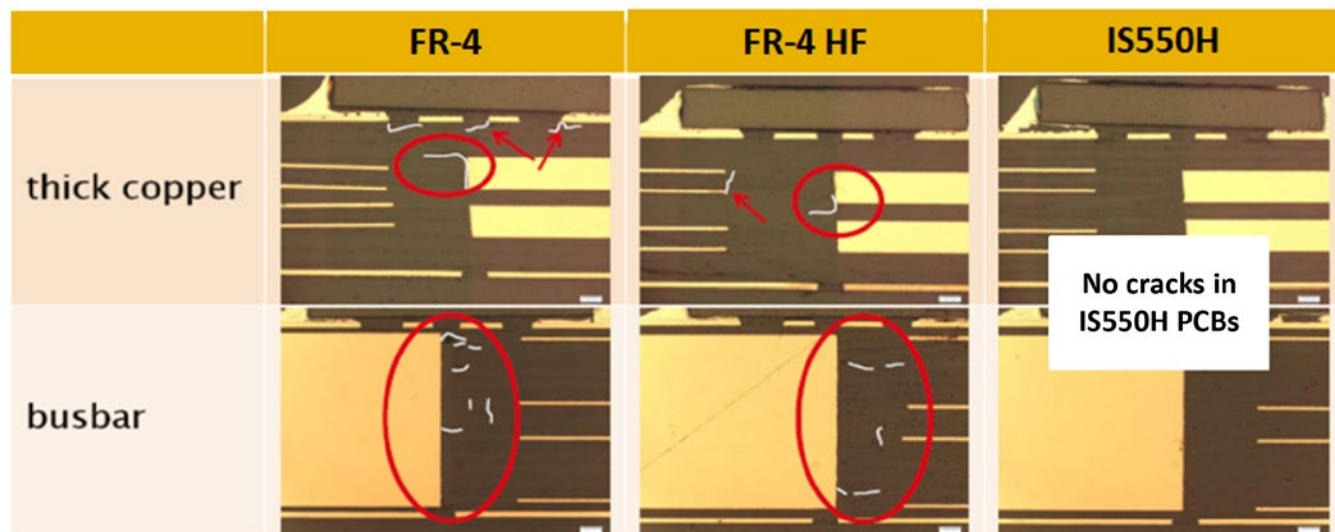
Johnson: Where you're seeing the heat and the humidity, nonetheless.

Hunrath: Right. You may not have some of the other challenges, but you want to get some more reliability without going to a polyimide or ceramic. This is an option.

Johnson: That's part of the challenge for the automotive industry in that you need to be able to handle all conditions. In automotive, reliability is so important. I know this product is relatively new, but do you have any hints or indication on how it's doing for overall reliability?

Gay: As far as reliability is concerned, we've done a lot of accelerated life testing, but as far as applications are concerned, since we just launched the product, there's not a lot of in-the-field type of reliability data that we can cite at this point in time. We've done some cycling tests from -40°C all the way up to 175°C, and that cycling, I think, was in the neighborhood of 2,000 or 3,000 cycles. There was some additional testing where we heated up the material from room temperature to 200°C, then 225 and 250 degrees; we did this in 500-hour increments. This material just does not degrade over time. It maintains its integrity, even though it's been through a lot of environmental conditions. We see this as the type of material that can really prove itself in the field. With the data that's used in the industry to understand material performance, the indicators are that this material will perform very well in the field.

Hunrath: It should outperform phenol-cured epoxies.



IS550H PCBs show good reliability after 1500 cycles – thermal shock (TS) –40/175 °C

Figure 1: Temperature cycling test (TCT) results are shown in this cross-section. Note the highlighted areas where cracks appear white in the FR-4 materials.

Gay: Most definitely.

Hunrath: It is also halogen-free and has a V0 UL fire retardant rating. It's got those boxes checked off as well. But based on the nature of the resin chemistry and its history in aerospace composites, it should outperform epoxy in every attribute.

Gay: Yes. In this image (Figure 1), you can see the white lines are where the cracks are located. It's obviously drawn over the top of the cracks vs. actually showing the cracks because they're hard to see in the materials.

Hunrath: Right. You'd see in the microscope the cracks would be a dark line or you'd see the fracture on the resin.

Gay: Probably one of the standout features of the material is the fracture toughness. When you look at it from that perspective and the vibration that the product is going to see in during its life cycle, I think that's pretty important. But you know, maybe even under-the-hood applications on fuel powered cars as well.

Hunrath: This just shows the thermal conductivity. Resins are not only electrical insulators, they're also thermal insulators. But this resin chemistry has a better ability to dissipate heat.

Gay: Yes. It certainly increases the current carrying capacity of the circuitry. And that means you're going to be able to increase how much power you've pushed through the system into the vehicle's battery. This kind of attribute is one of the things they were looking for during the development process.

Johnson: Gentlemen, thank you for such a detailed discussion today.

Gay: I appreciate the opportunity to talk with you. It's really great to do that. And having Chris on this call makes me feel a lot more comfortable because he's a very knowledgeable applications expert.

Hunrath: Thanks. PCB007



Supplier Highlights



Insulectro Picks Paul Welter for Director of Sales for Dupont Chemistry Line ►

Insulectro, the largest distributor of materials for use in manufacture of printed circuit board and printed electronics, has announced it has promoted industry veteran Paul Welter as director of sales for DuPont Chemistry.

Ventec Intensifies Direct Sales, Service Support in Israel Market ►

Ventec International will intensify its direct sales and service support to PCB fabricators, OEMs, ODM's, contract manufacturers and EMS companies in Israel with immediate effect. This follows the termination of its sales representation agreement with A.J. Englander (1980) Ltd.

Achieving Growth in a Difficult Year: The Benefits of Global Supply Chain Management ►

Jack Pattie, president of Ventec USA, discusses the growth of the business, the strengthening of the operation, quality system accreditations, the advantages of building close working relationships with OEMs, and how a well-managed global supply chain has overcome some of the challenges and frustrations encountered during the past year.

Arlon EMD Completes IPC Validation Recertification Audit ►

Arlon Electronic Materials has successfully completed an intensive two-day recertification audit by IPC Validation Services. This audit was focused on validating Arlon's manufacturing processes and testing procedures.

Taiflex February 2021 Revenues Up 54% ►

Taiflex Scientific Co. Ltd, a Taiwan-based manufacturer of flexible PCB materials such as flexible copper clad laminates, coverlay, and bonding sheets, has announced that consolidated revenue for February 2021 totaled NT\$680 million (\$24.34 million at \$1:NT\$27.93), down by 9.3% from the previous month, but up by 54% year-on-year.

Accurate Circuit Engineering Inc. Chooses atg Flying Probe Technology ►

atg Luther & Maelzer GmbH, confirms the order for high-speed bare board testing technology. The atg A5EO 8 head, double-sided, high-speed, flying probe test system has been ordered and installed at Accurate Circuit Engineering Inc., in Santa Ana, CA.

TECHNOSYSTEM Supplies High-End Automation Systems to Schweizer Electronic AG ►

As a leading manufacturer of automation systems, TECHNOSYSTEM, part of the Benmayor Group and sister company to Aismalibar, has been developing innovative customer-specific automation solutions for circuit board manufacturers worldwide for years.

Taiyo Does It Right ►

In this video interview, Editor Dan Feinberg and Taiyo America's Zach Maekawa discuss the ways that Taiyo adds value to the supply chain while driving innovation in solder mask technology. As Zach explains, Taiyo works with customers and OEMs, measuring all of the "nitty gritty stuff."

Plating Anomalies and Defects, Part 2

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

Introduction

One of the most difficult things about troubleshooting PCB defects is getting to and understanding the root cause of defects. Many of these defects can have multiple origins. And many may not manifest themselves in the process where the defect actually occurred. Thus are the perils of jumping to conclusion about the defect. Not understanding the true genesis of the defect will lead to incorrect remedies to these issues. I will now present some of these defects and the possible remedies.

Blisters (Hole Wall Pull-away)

The common complaint one hears is that “the copper plating is peeling.” Okay, but where? From the surface or from within the via? What about the interconnect? And is the peeling layer the electroless copper deposit or the

electrolytic copper? These are the questions one must answer to properly troubleshoot the defect. Figure 1 shows a real-life example of a blistered or peeling deposit. In Figure 1, the copper deposit has actually flaked off or blistered from the hole. In some cases, the deposit did not completely flake off the surface, but indeed did pull away from the hole wall. This condition is referred to as hole wall pull-away (HWPB).

Now the question is, where is the origin of the blister? The good news in this case is that we are only looking at the electroless copper. There has yet to be an electrolytic copper deposit applied to the circuit board. But that is all one can tell at this point. Figure 2 shows an actual cross-section of a circuit board that was part of the production lot related to the photo in Figure 1.

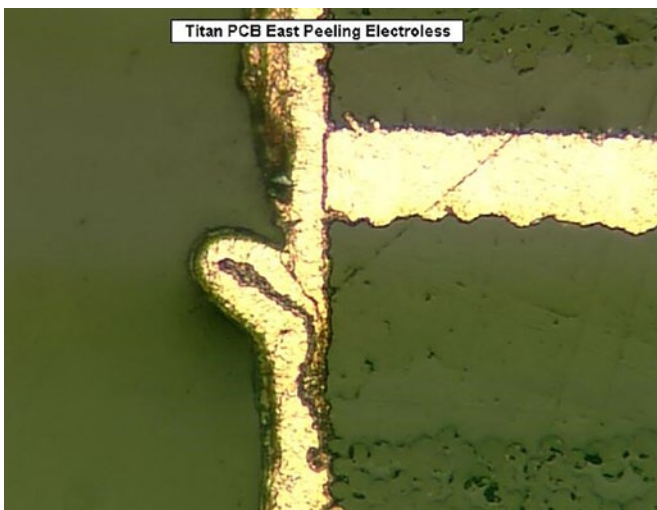


Figure 1: Arrow points to blisters in the via.



Figure 2: Electrolytic copper applied to board. Arrow points to a blister (HWPB) that originated in the electroless copper.



pluritec



Surface Preparation Machines for Printed Circuit Boards

PUMEX/PUMIFLEX

Mechanical cleaning (Brush - Pumice or Aluminum Oxide)



MECETCHBOND

Chemical cleaning, supports all industry supplied or in-house created blends.



Don't settle for less – make IS your trusted partner. 40 years of experience with mechanical and chemical surface preparation ...and counting!



www.pluritec.com | info@pluritec.com

There are several possible causes for the condition shown in Figure 1:

- Inadequate desmear
- Overactive electroless copper process
- Drill debris
- Excess catalyst
- Insufficient filtering of electroless copper solution
- Instability (“dusting” in the bath)
- Excessive solvent penetration
- Poor rinsing or rinse water quality

A more typical example of HWPB is depicted in Figure 3. The deposit pulled away from the hole wall but did not fracture or flake off. Nonetheless, this is a defect and must be remedied. The root cause of HWPB is very similar to those that lead to flaking and blistering. I consider this at the very least a “process indicator.” This means that the desmear and metallization processes need attention. Of course, if the hole wall pull-away causes a violation of hole wall minimum diameter or leads to other violations in hole diameter dimensional requirements, then this is, of course, a cause of concern and will result in non-conformance.

So, one is dealing with the origin of the blister or peeling deposit prior to electrolytic copper plating. Table 1 lists the most common causes for this type of defect.

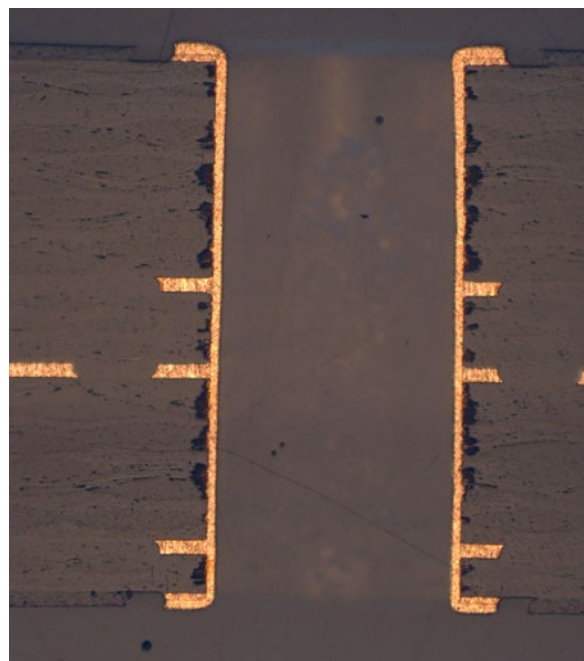


Figure 3: Example of resin recession.

A precautionary note: Don’t confuse HWPB with resin recession (Figure 3). Resin recession is a material-related issue where the resin has recessed or shrunk back away from the plating. This is evident generally after thermal stress. According to the IPC-A600K, resin recession is permissible. Resin systems, for lack of a better term, will “shrink.”

Keep in mind that there is no substitute for process control. The operators should have a basic understanding of why certain process-

Cause	Look at	Remedy
Excessive catalyzation	Dwell time and temperature	Reduce time and temperature in catalyst
Smooth topography on resin	<ul style="list-style-type: none"> • Desmear process not able to produce topography • Excessive solvent penetration • Insufficient rinsing after cleaner / conditioner step • Inadequate etching of the resin (poor topography) 	<ul style="list-style-type: none"> • Review resin type—higher Tg resins are more difficult to desmear, excessive lamination temperature and cure time over cross link material • Make sure cleaner conditioner is free-rinsing—consider reducing concentration and dwell time • Measure weight loss of the test coupons after desmear
Electroless copper deposition rate too high	<ul style="list-style-type: none"> • Check rate coupons: Is deposition rate higher than normal? • Check operating temperature of electroless copper solution • Check concentrations of the key additives: copper, sodium, hydroxide, HCHO, stabilizer concentration 	<ul style="list-style-type: none"> • Check specific gravity of electroless copper bath: Solution bailout as needed to bring specific gravity into range • Reduce operating temperature • Analyze and adjust concentrations to recommended levels

Table 1: The most common causes for this type of defect.

es must be controlled within the stated limits. This will go a long way in preventing costly rejects.

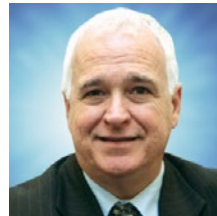
I am a true believer in the inter-relatedness of processes and the origin of process-related defects. It is helpful to keep a few things in mind when troubleshooting a process issue.

To be successful at troubleshooting a problem, common sense usually applies. Basically, one must first:

- Identify the problem or problems (be as specific as possible)
- Determine possible causes (looks for links to those other less obvious processes)
- Methods and procedures to test to see which causes are most likely
- Test the assumptions
- Implement corrective action

While this sounds like an oversimplification, this approach is required to properly identify and attack the problem at hand. A structured routine is really what is required. Remember the most critical success factor is being able to get to the root cause of the problem. Stop the finger pointing and get the different process teams to work together.

In these columns we will attempt to provide some insight as to the cause or causes of these non-conforming defects and the potential solutions. We will discuss process parameters and the importance of control of the processes. **PCB007**



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

Tactile Textiles Sense Movement Via Touch

In recent years there have been exciting breakthroughs in wearable technologies, like smartwatches that can monitor your breathing and blood oxygen levels.

But what about a wearable that can detect how you move as you do a physical activity or play a sport, and could potentially even offer feedback on how to improve your technique? What if the wearable were something you'd actually already be wearing, like a shirt or a pair of socks?

That's the idea behind a new set of MIT-designed clothing that use special fibers to sense a person's movement via touch. Among other things, the researchers showed that their clothes can actually determine if someone is sitting, walking, or doing particular poses.

The group from MIT's Computer Science and Artificial Intelligence Lab (CSAIL) says that their clothes could be used for athletic training and rehabilitation.

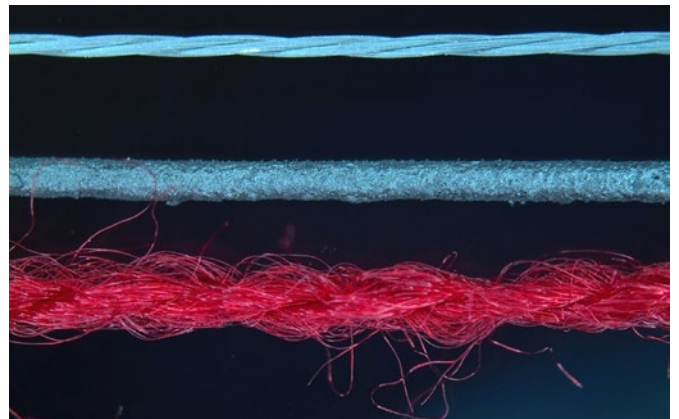
The team's "tactile electronics" use a mix of more typical textile fibers alongside a small amount of custom-made functional fibers that sense pressure from the person wearing the garment.

According to CSAIL graduate student Yiyue Luo, unlike many existing wearable electronics, theirs

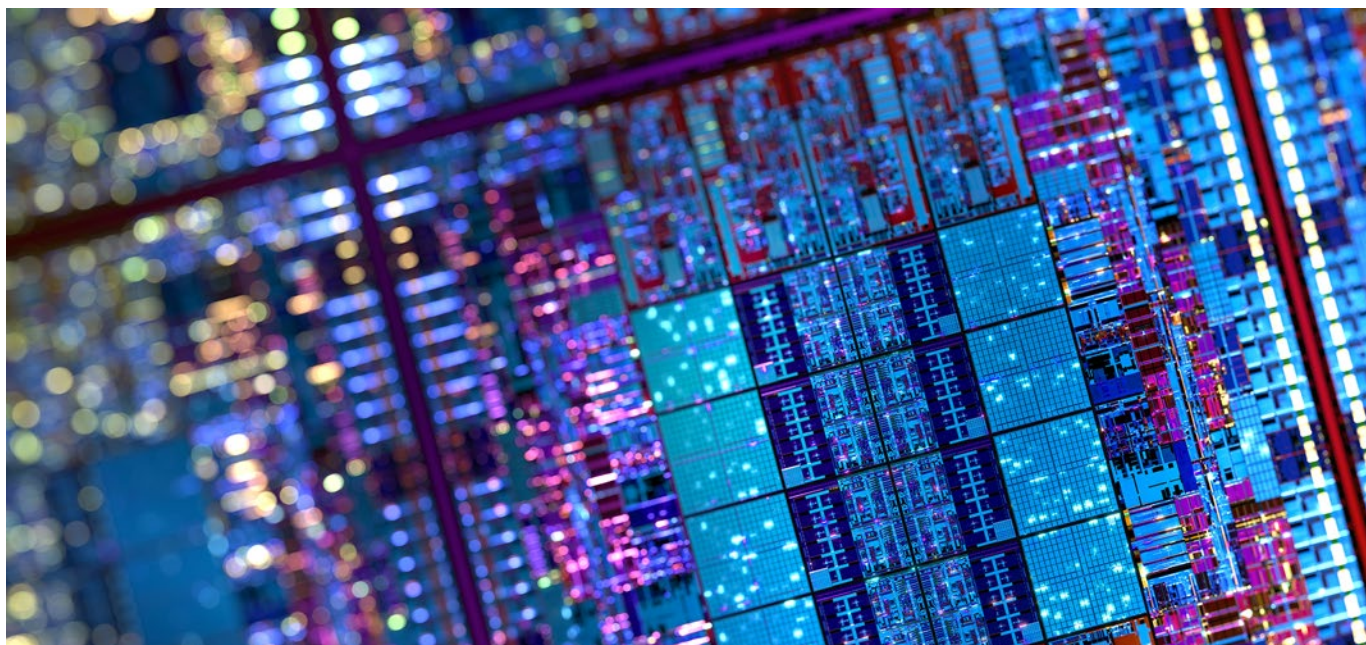
can be incorporated into traditional large-scale clothing production.

"Traditionally it's been hard to develop a mass-production wearable that provides high-accuracy data across a large number of sensors," says Luo. "When you manufacture lots of sensor arrays, some of them will not work and some of them will work worse than others, so we developed a self-correcting mechanism that uses a self-supervised machine learning algorithm to recognize and adjust when certain sensors in the design are off-base."

(Source: MIT News)



(Image courtesy of Nature Electronics)



PCB Technologies Expands Capabilities

Interview by Nolan Johnson

I-CONNECT007

Nolan Johnson speaks with Arik Einhorn and Yaad Eliya of Israel-based PCB Technologies about how they've increased their capabilities down to 1 mil line and space to better support their customers from the military, aerospace, and medical markets.

Nolan Johnson: Arik, let's start by talking about the new 1-mil capabilities and how you got there. What was the trigger for PCB Technologies to decide to go to 1 mil? And what sort of resources did you have to invest?

Arik Einhorn: PCB Technologies' goal is to be in front of the technology. Two years ago, we started to build our five-year technological roadmap and for that purpose, we put together a committee of market representatives, assembled from several of our high-end customers' R&D and innovation executives. We had representation for military, medical, communication and other markets and for different

applications within these markets. We asked them: "What do you need that you currently don't get?" And "what will you need down the road?" Our CTO, Yaad, was head of this discussion.

We have mapped the trends, the applications, where they want to be, what will help them better the performance of their products. From this, we got a wish list. The next thing was for Yaad and his team to translate the wish list into a roadmap and a good solid plan of how to get there—machinery, people, chemistries and processes, materials, functions, training. This 1-mil line/space, was one part of the complete roadmap, as we saw it popped up over and over again in many of the line items in the wish list.

Yaad Eliya: Across the roadmap, we saw a few motivations for miniaturization. When it comes to making things smaller, we always start with shrinking the line and space resolution. Then we deal with the diameter or the geometries of the via, lowering the dielectric thickness, lowering the copper thickness, etc.; that is our process for miniaturization. Generally speaking,

Electronics Coatings for the Digital Era



ELECTRA

ELECTRAJET® EMJ110 **Inkjet Soldermask**

- SM840 and UL V-0 approved
- High resistance to ENIG, Tin and lead-free processes
- Suitable for rigid & flexible substrates
- Optimised ink characteristics for sharp printing and excellent cosmetics
- Wide jetting window to maximise print strategy options
- Universal product suitable for a range of print heads including Konica Minolta 1024i Series and Dimatix Samba™
- Fully additive process with substantial environmental improvements in energy usage and VOC emissions

EMJ110 is a high performance, high reliability soldermask specifically designed for application by inkjet. Using over 35 years' experience in developing and supporting soldermask products, Electra has rigorously formulated EMJ110 to meet or exceed industrial standards and PCB manufacturing process demands.



T +44 (0)1732 811118
info@electrapolymers.com
www.electrapolymers.com

more and more customers need to miniaturize their products and one of their constraints is the size of the electronics. A number of technologies and industries were developed in the last 10 to 15 years to “bridge the gaps” between the die, the chip, and the semiconductor and



Yaad Eliya

the PCB itself. When you think about it, the semiconductor industry follows Moore’s law, making things smaller at an exponential pace whilst leaving the PCB behind. The first solution for this gap was the creation of the IC/substrates industry that took some processes

combined with processes and materials from the PCB production.

What we figured out is that we can save many headaches for our customers by creating 1-mil line and space, and by that, simplify the design of the system along with promoting its miniaturization. For example, smaller sensors can help medical companies that work with us—especially ones that produce systems for surgery and other invasive devices; most of them are using FPC (ultra-flex PCB) which they design with us and buy from us. We also found out that the aerospace industry wants miniaturization to reduce the loss of signals in dB per mil. As long as the line and space is smaller and fine-shaped, then the loss will be lower. We understood that this 1-mil line/space capability will allow us not only to support customers who want to minimize their product, whether it’s in aerospace, medical, or military, but also improve the performance of their systems.

Johnson: As you made your roadmap, undoubtedly you found gaps between what you can do now and what you needed to achieve to be able to fulfill your customers’ requests. How did you invest? Was it equipment, staffing, facilities?

Eliya: Yes. First, it’s very easy to buy an off-the-shelf machine that was designed to make a particular product. It is more complicated when you need the machinery and processes that match the full range of your products, your R&D activity, plus future products. We already invested two, three years ago in a very special etching and developer system to create the dense and fine line. Our next gap was the lithography process, and without getting into everything we did to close this gap, I will say that we purchased an LDI with the wavelength to create 18 microns line and space. And when, in the future, customers will want a 20-micron line and space, it’s achievable. In fact, we are already running a product with 20-micron lines with this machinery.

The most challenging and expensive part was the wet processes. It’s a 22-meter-long automatic machine for etching the copper and developing and stripping the photoresist. Alongside the machine and the process, we had to replace our regular photoresist and upgrade to a photoresist that can support a 1-mil line and space or 20-micron line and space, and that can be sensitive enough for the wavelength that the LDI creates. This also changed our vendors’ base.

When we went to the market with this process and took it to a medical customer, they designed a flex board that had those fine lines, 20- or 25-micron lines and space. Now we will have not only the production but the OEM feedback.

Johnson: It sounds to me like your customers were quite involved in defining your process?

Eliya: Of course. Our customers see us as an integral part of the design and production for their products, so when they want to have a better and smaller system they need us to have better capabilities. This is the relationship we hold with our long-term customers. We have customers from aerospace in the U.S. who have been working with us for 25-30 years. We have

customers in Israel from the medical and military industries who have been working with us since day one. It's a vested interest. They want us to be better, and they want us to be up to date in terms of technology because they are getting better. As their competition is getting tougher and their market demands get higher, it only makes sense that we combine forces as early as we can in the design phase. We do not take these relationships for granted.

Einhorn: We're a company that really likes the challenges. This means that, often, a lot of our competitors won't take on projects that are too complicated, but we believe that these challenges make us much better and expand our capabilities. This is one of the reasons why customers are staying with us for so many years and why new, high-end customers are approaching us.

Johnson: Speaking of the U.S. market, as an Israel-based company, what's your competitive advantage? Why do the U.S. companies work with you over other options?

Eliya: In terms of production and technology, we are serving the high-mix, low volume, high-performance markets. We are producing rigid-flex, rigid, ceramic, high power and high-frequency boards up to 120 gigahertz. That means that we are working with a variety of resin systems and materials from all over the world—from Korea, Japan, the U.S., and Germany; from the IC substrate industry, the PCB industry, the flex industry, and from the hybrid PTFE base vendors. Just to emphasize this complexity, if you take a rigid-flex board made of polyimide, and you press laminate with an external layer of PTFE, it's very difficult to have a process window that supports such a stackup because PTFE and other kinds of a Teflon® are very soft material, and polyimide is a very rigid material. You need to drill and rout it, you need to plate it, you need to learn the behavior of the material (CTE impacts dimensional stabil-

ity, etc.) before and after lamination. It's a full process learning, all the way to the PCBA (assembly step) and, sometimes, even field environment impacts. All the above should match the reliability required by our customers.

Remember, the variety of applications we offer to our customers is almost unlimited. We are talking about coin, cavity, air cavity, heat sink, and high power solutions and more, all in rigid and flex-rigid stackups. When you are combining our variety of high-end technologies with our knowledge base of many different raw materials and the ability to integrate all in the same stackup, you see what makes us very special. Before getting into the 1-mil line/space we saw the benefit of buried passive, space-wise, for our customers. So, we went and implemented several technologies for that purpose. For several years now we have been doing buried capacitors, buried resistors, buried heaters, and buried thermocouples inside the PCB. It's easy to see how you can minimize things with buried passives and 1-mil line/space. And we have more plans on our roadmap for miniaturization that we will reveal a few months from now.

Einhorn: Our roadmap is very ambitious and has some game-changing milestones. It is important to say that we are constantly "checking the pulse" either with our customers' needs, new material, or new capabilities. It is safe to say that today we are ahead of the curve.



Arik Einhorn

Johnson: You've wrapped some services and customer programs around that technical capability; tell me about that.

Einhorn: In that manner, we are doing "vertical integration." We recently added a design

service. Yaad's group and our design team are working shoulder-to-shoulder to better define the rules of the design, taking into consideration market needs, new practices, and production guidelines. Now we are in the midst of training the designers to do design for miniaturization and 1-mil line and space. It's not the same as regular design; it also requires knowledge of what happens after fabrication, like the coating. Most of the time, a typical conformal coating won't be enough. We need to use some other technology, CVD for example, that gives us the ability to make things smaller. Between the coating and the PCB manufacturing, of course, is SMT. We also trained our assembly staff, so they would know how to handle smaller assemblies, so to speak. Maybe next time we can elaborate because some new capabilities are still in progress.

Most of the time, a typical conformal coating won't be enough. We need to use some other technology, CVD for example, that gives us the ability to make things smaller.

Johnson: And you have gone so far as to actually put together a program, the All-in-One program.

Einhorn: Yes, our concept is All-in-One. Not just referring to all the key aspects of the supply chain—purchasing, logistics, etc.—that are under one roof. We are also practicing All-in-One technology or integrative engineering, meaning that the engineers are working together to provide our customers with the best

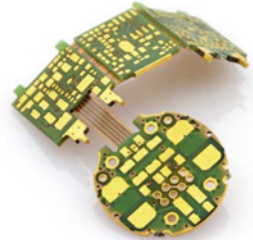
solution. From a supply chain standpoint and operations standpoint, of course, it's going to be faster. But it's also going to be more reliable because the different technologies are integrated, and there are no interfacing mistakes between assembly, PCB manufacturing and the design.

Johnson: In other words, when they come to you, they're going to be able to talk with you about the design, the design rules, manufacturing constraints, very competitive manufacturing tolerances, and capabilities down to 1 mil and so forth, all the way through to the end. They're going to get a finished, complete board assembly back from you that's ready to put on the bench and functional test.

Einhorn: Exactly. We are also doing the functional test and, in some cases, box build. This is another service that we've added. We are getting away from high volume consumer goods and focusing on very unique systems, from surgery systems through drones to foreign object detection systems for runways in airports. You can understand the complexity of this latter system. It combines optics and lasers and other stuff. And everything is being done here. This system comprises 15 types of PCBAs, to be more exact. And for all of these, we've done everything together, in-house, for our customers. And, by the way, time to market was very crucial, and within less than half a year we finished design, procurement, production, and delivery of 300 systems. It was quite a challenge, and we're proud to say that we've met it.

Johnson: Given the fact that this is a U.S.-Israeli transfer of technology, international trade becomes a factor. How does ITAR affect working with PCB Technologies? Are there any particular complications that a U.S. company would need to be aware of or plan for in having their subsystems manufactured in Israel?

Focused on Flex

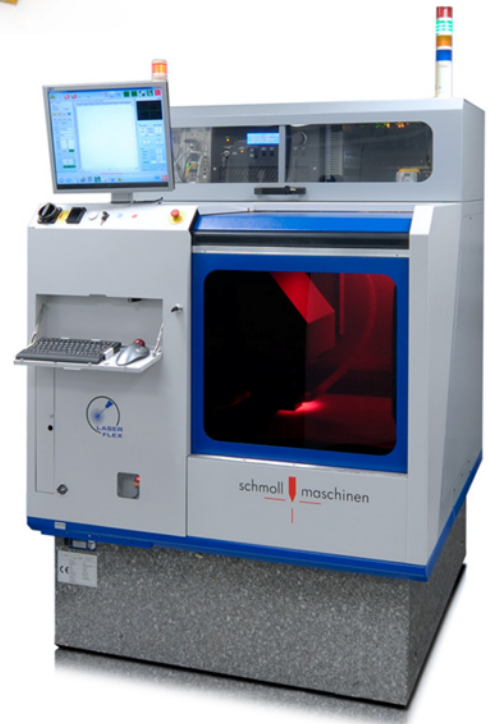


Laser μ Flex series

The versatility and precision of laser processing makes it the ideal tool for machining a wide range of materials.

Typical applications:

- Polymer cover foil
- Covered polymer laminates
- Thin, rigid-flex materials
- Inner layers and prepregs
- Separation or decap from tracks
- Structuring cavities
- Micro-via and through-hole drilling



For more information call us: +1 (336) 660-2701

burkleamerica.com

Einhorn: We have a subsidiary in New Jersey that has the appropriate certifications and approvals from the Department of State, who is controlling the ITAR, to provide us with access to U.S. customers' data that is being supervised and legalized by ITAR. We believe in All in One. We learned about ITAR years ago, and we are fully covered from this aspect.

Johnson: Let's consider some results, then. Let's talk reliability.

Eliya: We have a fully certified and operative HATS lab from Microtek Laboratories in the U.S. This lab is like those labs that NASA, Lockheed, Raytheon, and all the military and aerospace companies are using for testing their products for reliability. Besides using this HATS lab for products, we are using it also for testing all our raw materials, new or old, that are coming into our shop. We translate their

We translate their performance not only for yield but also for reliability and keep a very comprehensive log of all tests done thus far.

performance not only for yield but also for reliability and keep a very comprehensive log of all tests done thus far. Since we serve also aerospace and military customers this has become a standard practice for us. This log that I am talking about allows us to provide quick answers (sometimes without the need of performing the test) to our customers and by that helping them shorten the design phase and be the first to market.

We have good relations with IRTS experts and have several engagements with them around reliability and its tight connection with design, manufacturing process and technology, and good practices. We can measure reliability in terms of competitive raw materials. We can compare flex vendors. We can compare the impact of a number of sequential laminations or a combination of buried versus blind vs. stacked microvias vs. back drill. We can translate all kinds of technologies to reliability. And if a customer in the future is running a specific stackup with limited reliability, we raise a flag saying, "Watch out! You have a problem. You have chosen problematic material for sequential lamination for example, or the density is risky when plating according to Class 2. You can choose the alternative if you care about reliability." Sometimes the customer doesn't care about reliability. Sometimes if it's a missile, it's a one-way ticket. But if it's a radar that is working in the hot desert, in the sea or an airplane, reliability is critical. Bottom line, we have the ability to measure everything, from design throughout manufacturing and translate it to reliability.

Einhorn: One last thing that we should say, in order to complete the story of the roadmap started two years ago, is that we only invested \$10 million in 2019 and 2020 to buy the equipment needed; most of it customized, in order to fulfill this roadmap. Of course, some of it was for the 1-mil line and space, but not all of it. Some other machines that we've bought are also for the area of reliability. We bought another vapor phase reflow unit, for example, for assembly. We've upgraded our AOIs to be 3D and bought the most advanced X-ray. Our product was good before, but now it's excellent!

Johnson: Arik, Yaad, thanks for sharing this information! **PCB007**

Why Choose Fein-Line?

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

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

Fein-Line Associates specializes in:

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

Fein-Line Associates

P.O. Box 73355

San Clemente, CA 92673

Telephone: (949) 498-7866

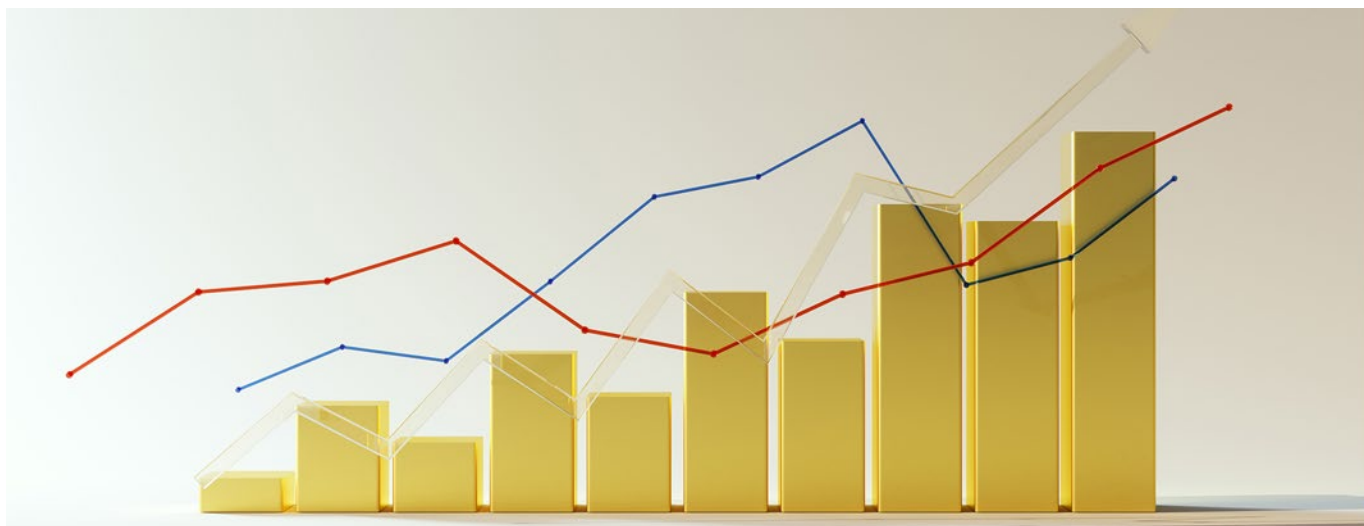
Email: baer@feinonline.com



Dan (Baer) Feinberg



www.feinonline.com



Time, Space, Structure, and Model Analysis of CCL Price Increase

Article by Hu Yang

ZHONGTAI SECURITIES RESEARCH CENTER

Editor's note: The price of copper clad laminate (CCL) affects the whole electronics industry. Here, we invited analysts from Zhongtai Securities to analyze and forecast the current situation. The content of this article is also based on field research data of Zhongtai Securities and its researchers. This article was written in January 2021, originally appearing in the March 2021 PCB007 China Magazine, it has been translated from the original Mandarin.

Material prices remain firm, and the supply-demand structure has improved. These are the core driving forces of the current round of price increases.

Raw materials account for more than 80% of the cost, and the profit is greatly affected by the material cost.

According to the CCL Association, copper foil accounts for the largest proportion of raw materials (traditional CCL uses ep-

oxy resin, glass fiber cloth and copper as raw materials). Copper foil in thin plate accounts for about 30% of the overall cost; in thick plate copper accounts for 50%. In CCL production, using Shengyi Technology and Chaohua Technology as examples, the cost of raw materials accounts for about 88% of the total cost, with labor accounting for about 4%. Other costs such as equipment depreciation account for about 8%.

The industry chain has strong bargaining power.

The CCL industry has a high entry threshold. Because of the various raw materials, precision, structure, and different production processes, suppliers need to have a higher level of technology to meet the high level of product requirements. In addition, copper clad laminate production requires higher capital expenditure, which also brings significant capital barriers. But this combination strengthens the industry as a whole. According to a Prismark ranking of global rigid copper clad laminate companies, the ranking and market share changed little in recent years, with CR10 ac-

THE INDUSTRY LEADER IN SOLDER MASK PRODUCTION

THERMO COOL

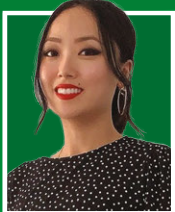
BY TAIYO

The electronics industry continues to innovate. Innovation means more functionality to the consumer in smaller packages. Because the PCB industry is evolving, PCBs are getting smaller, more functional, and in some cases, thicker with copper.

To combat this added heat, Taiyo America has introduced Thermo Cool (Patent Pending). Thermo Cool is a revolutionary product that can dissipate heat at over 10 W/m K. If you need thermal management for your PCB designs, you need to add Thermo Cool.

Thermal Conductive/Heat Dissipating Product Features:

- ⊕ High Tg (169°C)
- ⊕ Extremely Low CTE
 $\alpha 1-14$ ppm / $\alpha 2-45$ ppm
- ⊕ Thermally Cured
- ⊕ Application for Gap Filling, Via Filling and as an Adhesive
- ⊕ Thermal Conductivity - 10 W/mK
- ⊕ Screen Print or Via Fill



Kate Han

Western Technical
Sales Engineer

(949) 910-2028 (cell)
KateH@taiyo-america.com



Don Monn

Midwestern Regional
Sales Manager

(651) 491-4199 (cell)
DonM@taiyo-america.com



Bob MacRae

Eastern Regional
Sales Manager

(508) 380-5475 (cell)
BobM@taiyo-america.com



Follow us on social media

Contact your local Taiyo Sales Representative
for your FREE SAMPLE (1KG) ▶

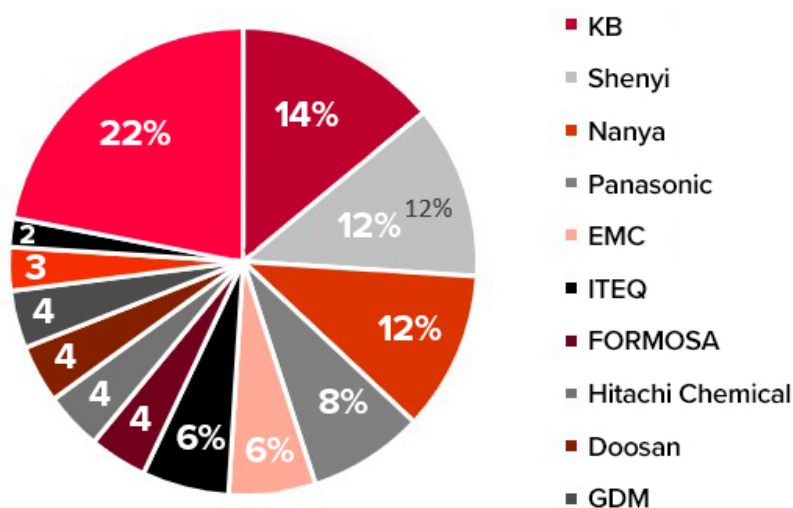


Figure 1: Market share of the main rigid copper clad laminate companies in 2019. (Source: Prismark, compiled by Zhongtai Securities Research Institute)

counting for about 70% of total market share in 2019. This gives them strong bargaining power in the industrial chain.

PCB manufacturers are not overly sensitive to price, and customers generally pay more attention to product quality, technical content, and supply stability than pricing. As a result, the PCB customers are more stable in the eyes of the suppliers, owing to the constant strength of the leading companies.

The price of raw materials remains firm; the Q3 profit margin of CCL manufacturers was under pressure last year.

Since the second quarter of 2020, the price of raw materials has been increasing. For copper

foil, the price of non-ferrous metals (one of the basic raw materials) began to rise as companies recovered from the pandemic. In addition, the Chinese government began to increase its spending on infrastructure, thus this “new urbanization” boosted the demand for industrial metals. The spot price of copper at the London Metal Exchange (LME) has increased from US \$4,617/ton in March last year to US \$7,100/ton. Based on the price at the beginning of the year, the cumulative increase rate is more than 55%.

Looking at epoxy resin, after two rounds of callback in 2020, the price returned to the level of 20,000 yuan/ton, and the short-term price is still rising steadily. According to recent data, the high price of raw materials (epoxy chloropropane and bisphenol A) is the reason for higher epoxy resin prices. On the other hand, since September 2020, the domestic demand and supply of epoxy resin has been generally steady even with the increasing demand from PCB manufacturers. Epoxy resin production capacity is relatively limited, and the supply is somewhat tight. It is expected that product prices will remain firm.

Glass fiber demand has been growing steadily, especially as the economy recovered in the second half of 2020. However, supply has been limited since 2019, making for a tight supply-

Table 1: Calculation of the impact of CCL price increase on corporate gross profit margin.

CCL price increase	Average gross profit margin of enterprises in Q3 2020	Gross profit margin level after price adjustment
3%~5%	21%	23.3%~24.76%
10%		28.18%
15%		31.30%

(Source: Choice, Zhongtai Securities Research Institute)

demand structure. The glass fiber industry has remained strong specifically because of the demand from wind power and its infrastructure. According to Tonghuashun, since September last year, three domestic glass fiber leaders have raised prices, which may indicate a rise in materials is forthcoming.

Rising raw material prices put pressure on CCL enterprises in the third quarter of 2020, so price adjustments were necessary. According to our research, gross profits of major CCL companies declined month-on-month in the third quarter of 2020. Among them, Chaohua Technology declined by more than 5%. Even without the impact of the epidemic, this is the lowest gross profit rate in a single quarter since 2019. Other enterprises have also declined by 2–5% in varying degrees.

As of the fourth quarter of 2020, major manufacturers in the industry have started to raise prices.

According to our research, the main manufacturers in the industry have steadily raised prices. Shengyi Technology raised prices in both October and November 2020, with a cumulative rate of more than 10%. Kingboard has issued two consecutive rounds of price adjustment notices since November 2020, and when compared with the first price increase on July 1, 2020, the cumulative price adjustment rate for ordinary FR-4 products has increased by more than 30%. In addition, WAZAM, NOUYA and other manufacturers have made price adjustments ranging from 5–10%. At present, Taiwan's major manufacturers such as ITEQ and EMC have increased their prices by 5–10%.

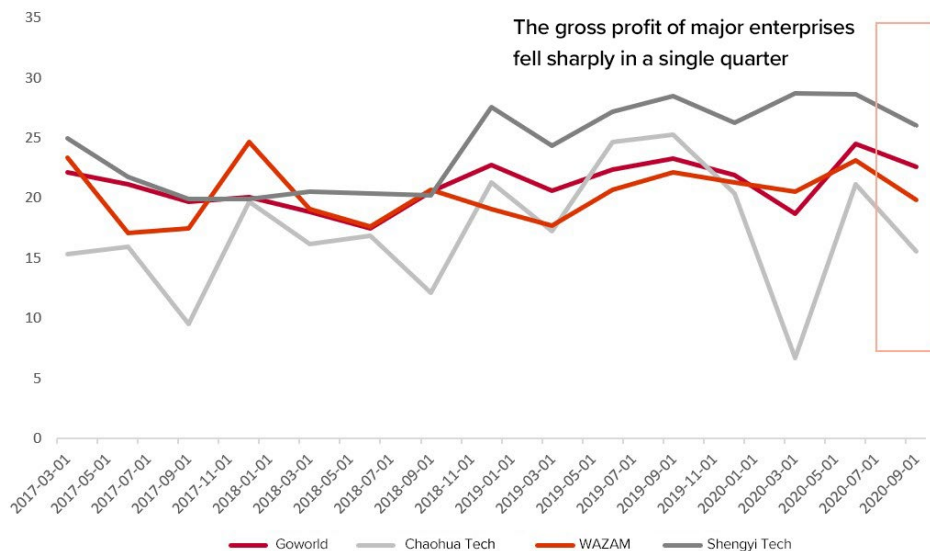


Figure 2: The gross profit margin of major companies in the industry generally declined in Q3 2020. (Source: Choice, compiled by Zhongtai Securities Research Institute)

Improving supply-demand structure builds the core support of the price increase.

The recovery of communications, automobile, consumer electronics and other related industries is positive. Specifically, with the planned construction of 5G base stations this year, communications orders will be restarted soon. According to data released by China Automobile Association, automobile industry sales volume in November 2020 was estimated to be 2.733 million units, with a month-on-month growth of 6.2% and a year-on-year growth of 11.1%. The market trend shows a continuous recovery.

Consumer electronics demand is recovering. IDC data shows that since the third quarter of 2020, global sales of smartphones has continued to pick up, with the total sales of about 354 million units in the third quarter, basically returning to the same period as previous years. These strong sales result in a higher demand for CCL materials. According to our industrial chain research results, the main manufacturers in the industry are at full production and the supply-demand structure continues to improve.

The Price Boom is Expected to Continue

Strategy choice among manufacturers: Joint price increase.

According to the CCL industry structure, in recent years, the global CCL production capacity is mainly concentrated in the mainland and Taiwan. According to statistical data from Prismark, more than 90% of the global output value of rigid copper clad laminate in 2019 comes from the mainland and Taiwan.

Therefore, whether the price increases continue depends mainly on the interactions between mainland manufacturers and Taiwan manufacturers.

If you review price adjustments since the fourth quarter of last year then, on the whole, mainland manufacturers are better than Taiwanese manufacturers. The main reason is that under diversified competition, there are differences in overall productivity growth rates. Specifically, in early November 2020, major

Table 2: Strategic choices in different regions—manufacturers.			
Inter-regional competition between companies		Taiwanese manufacturer (Company B)	
		Price Increase	No price increase
Mainland China manufacturers (Company A)	Price Increase	<ul style="list-style-type: none"> • Hedging cost pressure • Win-win 	Potential order transfer Mainland China→Taiwan (A→B)
	No price increase	Potential order transfer Taiwan→Mainland China (B→A)	<ul style="list-style-type: none"> • Bear cost pressure • Lose-lose

(Source: Choice, Zhongtai Securities Research Institute)

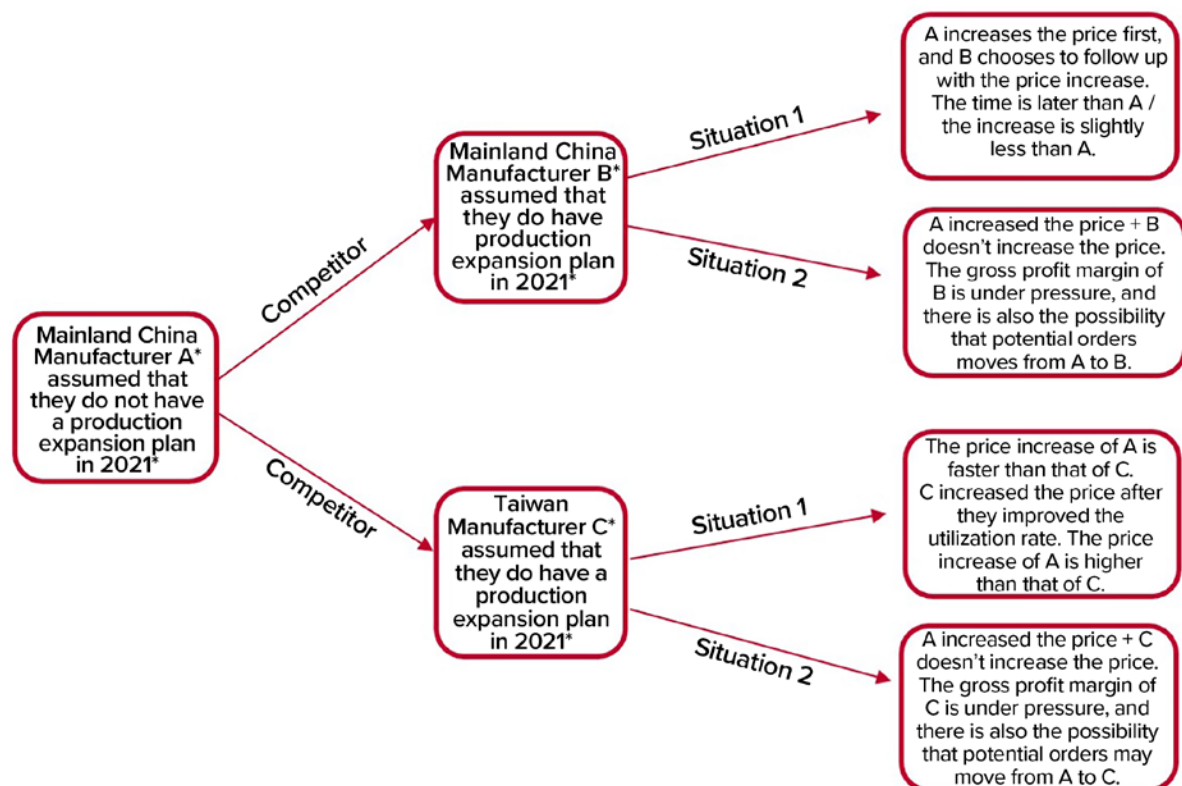


Figure 3: Models on the Game of Oligarch Manufacturers: “plan to expand production” vs. “no plan to expand production”. (Source: Zhongtai Securities Research Institute)

mainland manufacturers, such as Shengyi and KingBoard, took the lead in raising prices, which drove other manufacturers on the mainland to follow suit. As the production capacity of Taiwan manufacturers has not yet reached its full capacity, Taiwan initially took a wait-and-see attitude. The Taiwan manufacturers did not start to raise prices until late November when the main manufacturers were back in full production.

On the whole, the main manufacturers in the industry are in full production and focused on on-time delivery. Some manufacturers in different regions have increased prices to hedge against their own cost pressures. In addition, manufacturers with plans to expand are still looking to take orders but have increased prices to brace for any shortfall, while manufacturers without expansion plans will be more active. We see that Shengyi Technology and other manufacturers, who have no significant production expansion plans in 2021, will still look to increase prices, while other manufacturers will follow up at the right time according to their own situation. Overall, the trend of the industry will still be to increase prices.

Prices will continue to increase in the first quarter of 2021.

According to our research, since the end of November 2020, the mainstream manufacturers have basically achieved full production and full sales. Thus, short-term demand from PCB manufacturers remains strong in Q1 2021. How long these prices continue to increase depends on whether PCB shops maintain demand. Based on the current orders, we believe it may reach a short-term peak around the lunar new year [Editor's note: lunar new year for 2021 occurred on February 12.]

The highest price increase rate may exceed 20%.

The key to judging the price increases is choosing when to look at them. Due to the pressure on the performance of CCL enterprises in Q3, we chose July 2020 as the base period to observe the trend of raw materials. Up until now, LME copper has increased by more than 19%; epoxy resin has increased by more than 50%; and glass fiber cloth has increased by more than 15%. Taking the median increase as the average cost increase in that time period, the average cost increase of thick copper

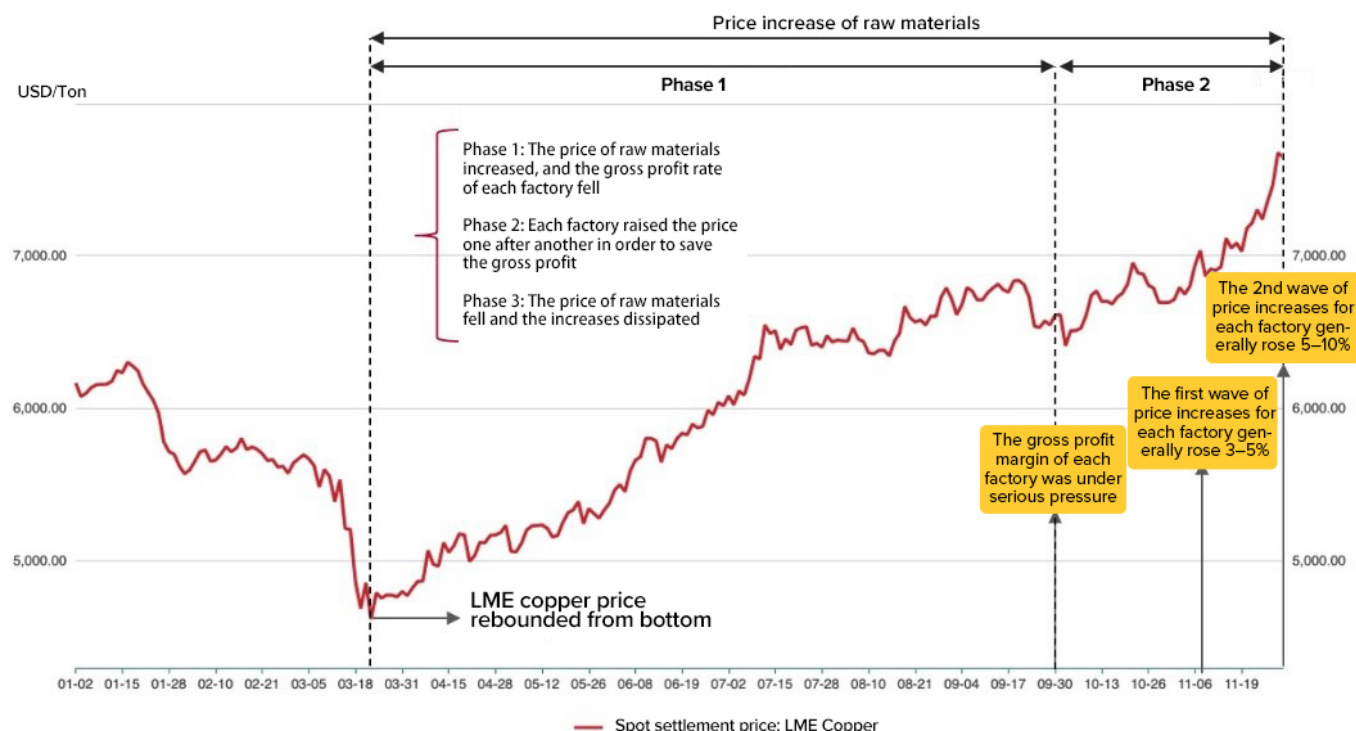


Figure 4: Sorting out the stages of price hikes. (Source: Wind, Zhongtai Securities Research Institute)



Figure 5: The last round of CCL price increase cycle.
(Source: Wind, Zhongtai Securities Research Institute)

products in the past six months since July is about 11.22%, and that of thin copper is about 10.64%.

According to the survey data, the highest price increases of CCL enterprises mainly occurred after October last year, with PCB enterprises increasing the price by 5–10%. According to our calculations, the price increase rate could not cover the cost increase. One month later, some enterprises conducted a second round of price increases, with a range of 5–8%. After that round of price adjustment, some

enterprises have been able to cover costs, and the gross profit rate has gradually risen.

Over time, the cost of raw materials will gradually approach a price peak. According to the latest quotation of raw materials, the cost of thick plate has increased by about 22%, and the cost of thin plate has increased by about 20%. Assuming that the price of raw materials can remain stable or increase, product costs will still rise in the short term, and over time, the average increase will grow

from 10% to more than 20%. Therefore, on the basis of the current price increase of various manufacturers' products and the price trend of raw materials, we believe costs will continue to increase as much as 20% to ease some of the pressures on both sides.

The price increase of thick plate is the highest; high-frequency high-speed plate is lower.

Different products have different growth rates. According to the survey results, for the mainstream mainland manufacturers and

Table 3: Comparison table of sensitivity coefficients of raw materials.

Raw materials	Sensitivity factor (1% increase in raw materials, the impact on the total cost of CCL)		Increase since July 2020 (Based on early July)	Q4 cumulative increase (Based on October 1, 2020)
LME copper	Thick plate	0.32%	19.31%	12%
	Thin plate	0.4%		
Epoxy resin	Thick plate	0.24%	52.78%	25%
	Thin plate	0.2%		
Fiberglass Fabric	Thick plate	0.24%	15%	10%
	Thin plate	0.2%		

(Source: Choice, Zhongtai Securities Research Institute)

Taiwan manufacturers, the price increase of thick plate is the highest. As of November 30, 2020, the price increase of thick plate manufactured by mainstream manufacturers is about 30–40%, followed by the medium and high level Tg FR-4 series for automobile, with a price increase of more than 20%. The third one is the lead-free and halogen-free FR-4 series products, with a price increase of about 10–20%. Due to the relatively small shipments of high-frequency and high-speed plates, and

the competition for potential orders, the price increase is the lowest, less than 5%. In terms of Kingboard, as the products are concentrated in the low and medium-end fields, and are relatively in single structure, the price adjustment is stable. With the mainstream FR-4 series increase more than 30%. We believe that the current price increases are in line with the logic of market supply and demand, and the competition among enterprises. We see this will continue.

Looking back, copper clad laminate raw materials also experienced a wave of price increases from mid-2016 to the end of 2017, and major manufacturers also conducted several rounds of price adjustments, with the price adjustment range of 8–10%.

After that last round of price increases, the profitability of major manufacturers including Shengyi Technology, Wazam, GDM and GOWORLD has improved significantly. In the first quarter of 2017, the revenue growth rates of Shengyi Technology, Wazam, GDM and

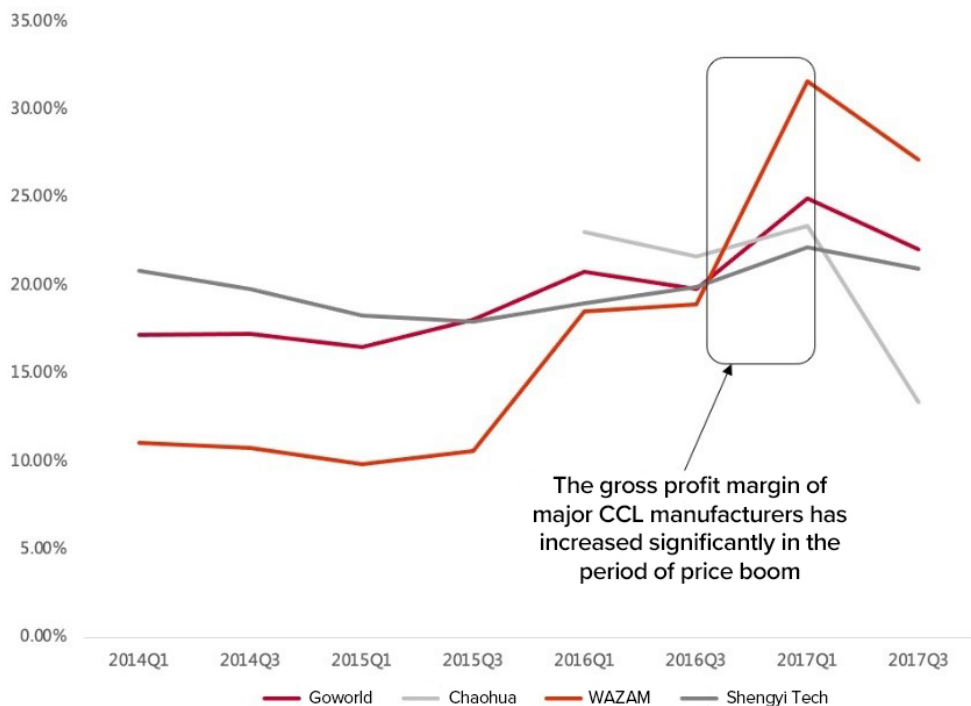


Figure 6: The gross profit margin of major CCL manufacturers increased significantly during the price boom.
(Source: Wind, Zhongtai Securities Research Institute)

GOWORLD were 25.60%, 47.61%, 35.57%, and 15.39%, respectively, while the corresponding operating profit growth rates were 86.45%, 56.39%, 307.30%, and 215.51%. The profit growth rates of CCL manufacturers were much higher than the revenue growth rates, and the performance elasticity increased significantly.

Hu Yang is an analyst for the electronics industry, Zhongtai Securities Research Center, Yang holds a Master of Microelectronics, Peking University, with a focus on PCB, LED, semiconductor and other research directions. **PCB007**



Hu Yang is an electronic analyst at Zhongtai Securities and has a master's degree in microelectronics from Peking University. He currently focuses on PCB, LED, and semiconductor research.

Don't Forget AABUS

The PCB Norsemen

by Jan Pedersen, ELMATICA

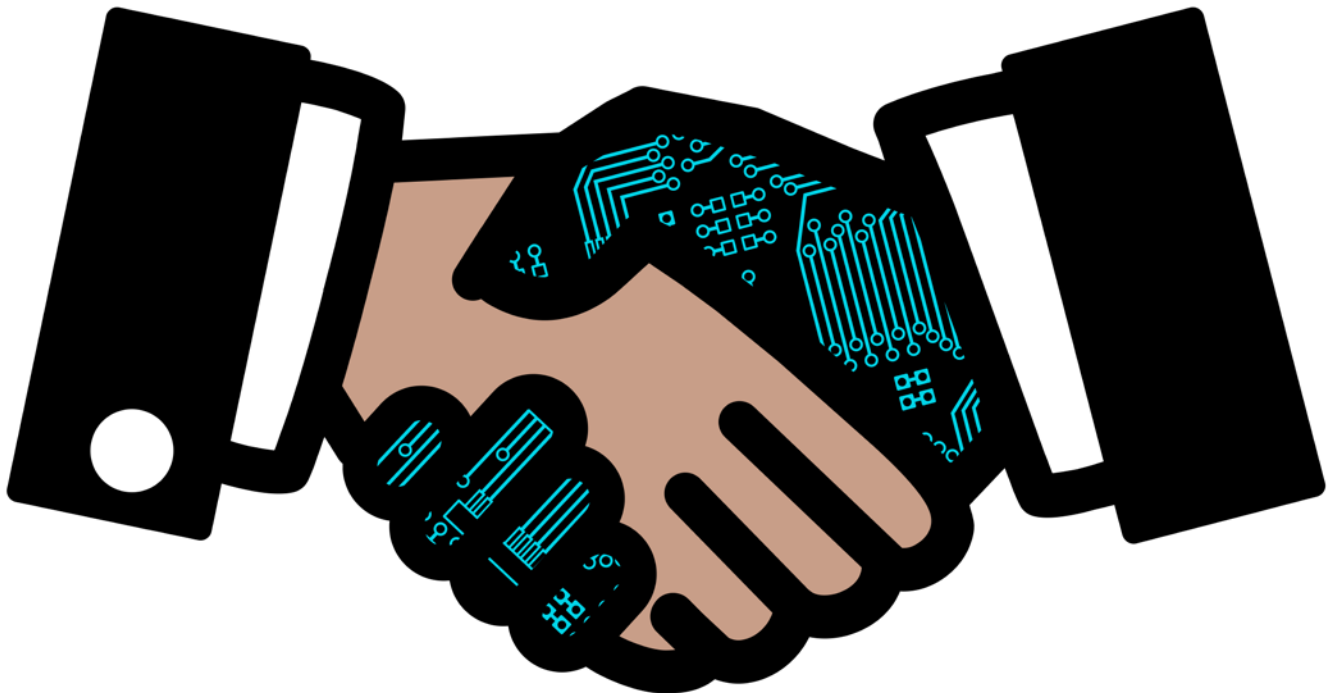
Last spring, I wrote a [column focusing on cosmetic issues](#) and I asked, “Why does the electronics industry reject good products when it’s not always needed?” In my [next column](#), I turned the coin around and asked if we have understood the workmanship rule correctly: “Printed boards shall be free of non-conformances in excess of those allowed in this specification.” I ended the column by asking, “So, what can we learn from this?”

The most important thing is to know the standard and how to use it. Most people read the measurable requirements, while a requirement like the workmanship rule is left out. Leaving out the workmanship can make it hard to agree, because it requires at least two parties to find a solution that works for both.

This, however, leads us here, where we shall discuss AABUS, what it means, how to handle it, and basically a list of issues that need AABUS.

Why Do We Even Need an Agreement?

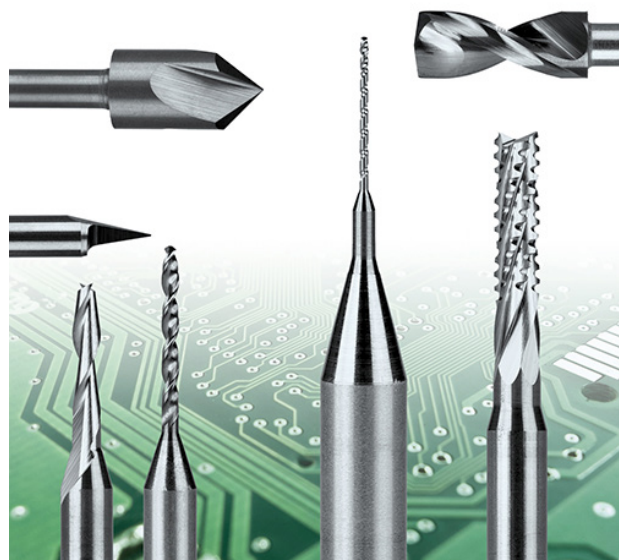
First, AABUS means “As Agreed Between User and Supplier.” As already mentioned, an agreement needs two parties, and those two need to find a common solution. The problem with such cases is why we need that agreement. It can obviously be something that can be seen from two sides and end up with a very different understanding if you don’t talk together. However, in the IPC standard it could even be a measurable parameter, but the standard has left the solution to be agreed upon.



WORLD-CLASS SUPPLIERS

Insulectro, the largest distributor in North America of materials used in the manufacture of printed circuit boards and printed electronics, salutes our premier suppliers.

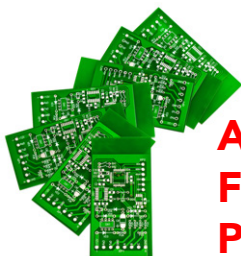
CALL 949.587.3200 FOR MORE INFORMATION



KEMMER PRÄZISION

The Wait is Almost Over! Drill Line Coming Early 2021

The Insulectro team is pleased to have received outstanding performance feedback on both quality and tool life with the solid carbide Kemmer router and endmill lines. Our router inventory consists of both Chipbreaker and Diamond cut tools with both Fishtail and Drill Point end styles. Our Endmill offerings will be in single and two flute. The rollout of the Kemmer drill line will be in early 2021.



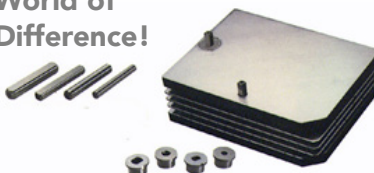
Lamination Assist For Flex & Rigid PCBs



Providing innovative lamination processing solutions including TRIPAK (PACOTHERM™), a releasable Press Pad that is specifically engineered to control the variables associated with the lamination processes.



Let us Make a
World of
Difference!



TADCO PRODUCTS: the most precise Lamination Tooling in the industry.

- Lamination Plates,
- Precision Pins & Bushings
- Release Agents
- Pin Cleaners
- Brushes

Precision is our specialty!



Denkai America is a leader in the manufacture of high-quality electrodeposited copper foils for printed circuit board (PCB), industrial, and energy storage applications. With the strength of domestic manufacturing, and backed by a global presence, Denkai America delivers both conventional cladding and application specific copper foils.



So, let's go to the source. We look into IPC-6012E, the performance specification for rigid PCBs and supported by the acceptability standard IPC-A-600K. Reading the first pages of IPC-6012E, the document scope, we find the first reference:

1.3.1.1: Requirement Deviations: Requirements deviation from "these heritage classifications" SHALL be as agreed between user and supplier.

This means, anything you want that is different from IPC Class 1, 2, or 3 shall be specified. Then in 1.3.3.1 we read:

"The procurement documentation SHALL specify those requirements that are a result of the selection process within this specification. This includes ALL references to AABUS. If the requirement selection is not made in the procurement documentation including all related documents, then the default requirements in IPC-6012E Table 1-2 SHALL apply.

Then the standard gives us a selection system, and the default requirements. But frankly speaking, a lot of the requirements are not what you expect or are at least still open for discussion. As an example, the IPC-6012E still specifies solder coating as Sn63/Pb37.

A Burden for the Buyer's Knowledge

If we now jump to A-600K, the acceptability of the boards you receive, the "approach of this document" says, *"This document cannot cover all of the reliability concerns encountered in the Printed Board Industry, therefore attributes not addressed in this issue SHALL be AABUS."* So, using IPC standards for PCBs leaves a substantial burden on the buyer to know the standard and to specify requirements not clearly written in the standard.

Quite a few attributes need to be discussed, unless you simply trust that your chosen supplier will be kind and accept a remake if the boards cannot be used as a result of wrong

hole tolerances, or surface finish solderability—just because you did not mention the usage of those boards.

Back to the Workmanship requirement. We find this both in IPC-6012E and A-600K. Where IPC-6012 says, *"Printed boards shall be free of non-conformances in excess of those allowed in this specification,"* A-600K takes it to the next level stating, *"Acceptance of imperfections not specifically covered by this document SHALL be AABUS."*

For the discussion of those imperfections typically referred to by the PCB supplier as "cosmetic issues," please read my last column, [**"Attacking the Loophole That Does Not Exist."**](#)

In IPC-6012E you find the term AABUS around 50 times (some are repeated in tables, etc.). In IPC-A-600K, it is mentioned 22 times. What does this tell us? It tells us that we have to be aware. Some of the attributes are not that important for all of us, but you can be sure that you will find some attributes impacting almost every printed board design.

So, What Are the AABUS?

The General One

We already mentioned the selection process within IPC-6012E, paragraph 1.3.3.1, that includes all references to AABUS and any requirement deviation—anything you need that is not mentioned in the standard. Or, if you want to combine IPC classes such as general requirements to Class 2, but copper plating to Class 3.

The Most Important Ones

3.3.1: *"When edge spacing is not designed in accordance with IPC-2222, nicks, crazing, delamination and haloing SHALL be AABUS."* If you overlook this rule, you could easily be forced to pay for boards that basically don't meet your reliability requirements. Many designers are forced to utilise the space to the limit, placing traces closer to the outline that brings the design and the final PCB into this

situation. The supplier should warn you, but not if the design meets their capabilities.

3.4: *“Printed Board Dimensional Requirements SHALL be defined as per IPC-6012E 3.4 unless otherwise AABUS.”* You cannot come after delivery and call for tighter tolerances, or you may end up with a higher unit price based on requirements revealed in the EQ process.

3.4.2: *“Annular Ring and Breakout external: The use of teardrop designed pads for class 3 SHALL be AABUS. The same is 3.6.2.9 for inner layer pads.”* If you fail to add teardrops, you could end up with inner layer trace-to-pad junction breakout. This could be a true reliability issue causing field error.

3.4.3: *“Bow and twist requirements for the array SHALL be AABUS.”* This is probably the most overlooked rule in IPC-6012. Most of us believe the bow and twist rule is for the customer panel but it is not, unless this is part of your requirement specification. This also means panel frame design is critical to secure a flat panel even after the first soldering process. And, if you shall be 100% sure, you should specify that bow and twist assessment shall be done after one thermal process. This is even more important if the construction is unbalanced, as mentioned in paragraph 2.3.4, and such requirements will lead your supplier to check the construction.

3.6: *“Structural Integrity: A/B coupons shall be used unless AABUS.”* This paragraph also leads us to the evaluation of Table 4-2 sampling plan and Table 4-3 acceptance testing and frequency. The supplier will probably not use A/B coupons unless you specify it, or if the supplier has a focus on defense and other industries where customers typically have a focus on these coupons. Coupons are widely used in the U.S., less in Europe, and very seldom in Asia. That means you need to specify if you want the IPC A/B coupons to be used. I would argue for using the PCB itself for lot qualification micro-sections.

3.6.2.11: *“Plating thickness. Deviations to Tables 3-3 through 3-6 of IPC-6012E SHALL be AABUS.”* This may very well happen in tight HDI designs! In such cases it is important that your design calculates for thinner copper, and that this is agreed upon with your supplier.

3.6.2.11.3: *“Requirements to bumps and dimples in copper filled microvias SHALL be AABUS.”* It is quite strange that IPC has chosen not to specify the requirements to a flat surface of copper-filled blind vias. The requirement is there for resin-filled vias, so why not for copper-filled? If your assembly requires a flat surface, you should specify the requirement, or you can refer to IPC-6012EM, the Medical Addendum to IPC-6012, where this is specified.

3.7.1 f: *“Solder mask encroachment on rectangular SMT pads with pitch less than 0.65 mm SHALL be AABUS.”* Be aware of the challenge to avoid encroachment on rectangular SMT pads, especially when pitch is less than 0.65 mm. Many customers are not aware of this limit in the standard.

3.7.3: *“Solder mask thickness requirements SHALL be AABUS.”* This is the AABUS most used in PCB specifications and corporate requirements. It is damaging for solder paste printing when solder mask gets too thick, and of course we fear exposed copper if it gets too thin.

3.9.2: *“Cleanliness testing after solder mask only when specified.”* The standard asks the designer and buyer to specify if such a test is required. The challenge is, the test method specified in IPC-6012E, IPC-TM-650-2.3.25 was designed for process control, and not a proof test of cleanliness on the finished board. I suggest using the specification in IPC-6012DA (revision E comes in 2021).

3.11: *“Repair—the allowance and requirements for repair of bare printed board SHALL*

be AABUS.” Many people, including PCB suppliers, claim that IPC-6012 accepts track welding. This is not correct. It has been the rule for many years that any repair shall be AABUS.

4.3: “*Deviation from IPC-6012E Quality Conformance testing SHALL be AABUS.*” Very few suppliers follow strictly the quality conformance test requirements as mentioned in IPC-6012E Table 4-4. I recommend checking with your factory to see whether they follow this requirement; if not, find out why. From my experience, some of these tests such as Dielectric Withstanding Voltage, and Moisture and Insulation Resistance, are done once only.

Some of the Rare Ones

Some of the AABUS requirements are very special and rarely used, such as: nickel barrier and electroless gold, electrodeposited tin, lead-free solder coating, and heat sink material. “Deviations to 6012E SHALL be AABUS,” which tells us there are many variations in the market and we cannot have all such variations into a general standard.

Lessons Learned—Good Product Specification

The lesson learned from reading all the AABUS references in IPC-6012E and A-600K tells me that the burden to secure a product in compliance with your requirements and expectations lies in a good product specification, where you have answered most of the AABUS references in the standard.

By doing this, you ensure that the quotation you receive is in compliance with your design and product requirements, and that you avoid unwanted surprises when you receive the first boards. **PCB007**



Jan Pedersen is a senior technical advisor at Elmatica. To read past columns or contact The PCB Norsemen, [click here](#).

Catching Electrons in Action in an Antiferromagnetic Nanowire

The electron is one of the fundamental particles in nature we read about in school. Its behavior holds clues to new ways to store digital data.

In a study published in Nano Letters, physicists from Michigan Technological University explore alternative materials to improve capacity and shrink the size of digital data storage technologies. Ranjit

Pati, professor of physics at Michigan Tech, led the study and explains the physics behind his team's new nanowire design.

“Thanks to a property called spin, electrons behave like tiny magnets,” Pati said. “Similar to how a bar magnet’s magnetization is dipolar, pointing from south to north, the electrons in a material have mag-

netic dipole moment vectors that describe the material’s magnetization.”

(Source: Michigan Tech University)

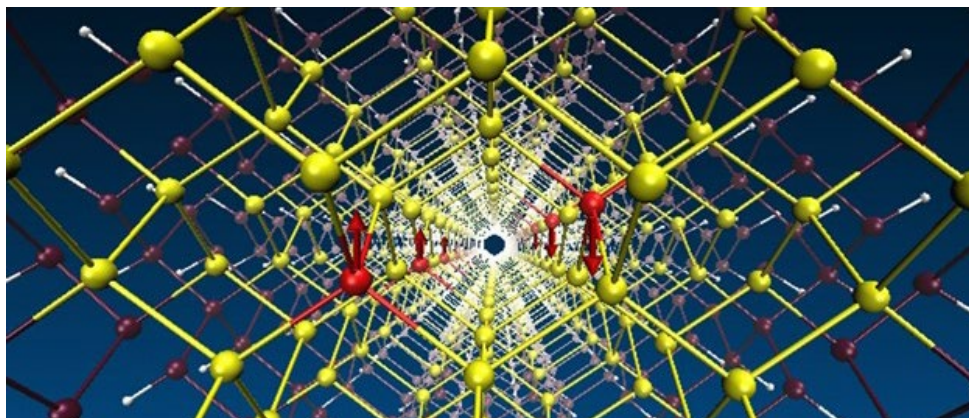


Photo left: Chromium-doped nanowires with a germanium core and silicon shell can be an antiferromagnetic semiconductor.



PCB DESIGN COURSES

DRIVE QUALITY AND INNOVATION

Introduction to PCB Design I

Upcoming class:

7/6 to 8/12

Introduction to PCB Design II

Upcoming classes:

3/30 to 5/20

8/31 to 10/21

Advanced Packaging

Upcoming classes:

3/22 to 4/28

11/8 to 12/15

Military & Aerospace Applications

Upcoming class:

8/30 to 10/6

Rigid-Flex Boards

Upcoming classes:

5/25 to 7/1

8/30 to 10/6

Extreme Environments

Upcoming class:

7/5 to 8/11

Look for these new courses soon!

- Introduction to PCB Design for Manufacturability
- PCB Design for Manufacturability
- PCB Design Embedded Components
- PCB Design RF Boards
- PCB Design for Printed & Wearable Devices

Learn more about our [PCB Design Courses](#).

‘If I Were 20 Years Younger’

Punching Out!

by Tom Kastner, GP VENTURES

We hear a lot of owners say, “If I were 20 years younger, I would...,” meaning they would make major investments or strategic changes if they had the time to realize the return on investment. Other reasons for not making investments are the lack of funds, lack of energy, etc. However, we feel that the return on investments does not always take as much time, money, or energy as owners think.

Some of the investments that owners can make are the following:

Equipment: Some companies in the PCB and PCBA sectors have a CapEx deficit in terms of equipment and facilities. It is easy to fall into the trap of stopping CapEx in lean years, then not making up for it when markets recover. Once a company falls behind, it becomes even

more expensive to catch up. One way to make up for it is to buy used or new-ish used equipment. Any new equipment should more than pay for itself within a few years in terms of efficiency or new customers. Companies should promote any new CapEx to customers and media, which can attract new customers and projects. Check with local municipalities for tax credits for investments.

Training: People fear change, but they crave progress. Similar to new equipment that brings efficiencies and capabilities, a well-trained work force is more productive, efficient, and loyal.

Certifications: Many small companies let their certifications lapse or stop working toward new goals. All electronics companies should



Your circuit boards delivered...

**1
DAY
LATE**

**2
DAYS
LATE**

**3
DAYS
LATE**

WHAT'S THE COST TO YOU WHEN YOUR BOARDS ARE DELIVERED LATE?

With Prototron, you don't have to ask that question. Serving customers for over three decades with a 98% on-time delivery record, we understand that providing you with high-quality PCBs on time, and right the first time, is critical.



Prototron Circuits
America's Board Source

www.prototron.com

continue to push the envelope in terms of technology, quality, and capabilities.

Enterprise Systems: ERP, CRM, and design software upgrades—these investments all cost time and money, but it is more expensive to not invest and eventually find yourself behind the times. Many of these systems have moved to a SaaS model and are becoming easier to implement, which makes it less costly. Also, due to cybersecurity requirements, companies must have more secure, compliant systems or customers will be forced to send their jobs somewhere else.

Sales/Marketing/PR: Many small companies have almost no sales, marketing, and PR efforts. That is a guaranteed way to stay small. Staring at the phone or email inbox does not make new customers contact you. It costs nothing to manage and encourage salespeople. Marketing can be done efficiently, such as sending out monthly newsletters and articles. Everyone has a story that they can promote.

Management Team/Delegation: Owners should develop their management team by delegating tasks, coaching, paying for training, and encouraging their team to develop new skills. It is hard to sell a company that is over-dependent on the owner.

Financials: Still using spreadsheets or Quickbooks? It may be time for an upgrade. Before launching into a major investment, challenge your CPA/tax advisor to find improvements. Every \$1 in increased efficiency goes into the owner's pocket, and results in a 4, 6, 8X increase in value at the time of sale.

Facility, parking lot: We understand that owners do not want to build a new facility a year before selling, but it does not cost a fortune to put in new lights, paint here and there, fix the parking lot, etc. Perhaps the landlord will give some credits for facilities improvements. Some cities or other government entities give credits for LED lighting or solar panels. If the employees see that the owner is not putting any money into the facility it hurts morale.

Customer projects, designs: Business owners may not want to change their company into a science project, but it pays to take on selective projects that increase the connection to the customer as well as improve the company's capabilities. Working with local universities and community colleges is an inexpensive way to promote technology as well as find new employees.

Partnerships: Many businesses supplement their capabilities by forming partnerships with companies that have different strengths. For example, a rigid PCB shop working with a flex shop on marketing leads, or with an assembly shop for special PCBA jobs.

Owner education: Many owners seem to reach a plateau and stop trying to learn new tricks. Meanwhile, the world is changing. Believe me, I know it gets harder to learn as one gets older, but it is good for the brain and the company to keep learning. Find out what your weak points are and take some steps to learn what you can. The last time I looked, the internet and YouTube are free and have tons of interesting/educational information.

Why do owners put off or stop investments? Some of the reasons are milking, cruising, lack of energy, life-style decisions, etc. Owners always must decide whether they want to grow, sell, milk, or close. We often see that companies do not have an estimated valuation that would be high enough to compel an owner to sell. By continuing to invest in the company, employees, and capabilities, owners can help ensure a great payday and smoother process at the time of sale. **PCB007**



Tom Kastner is the president of GP Ventures, an investment banking firm focused on sell-side and buy-side transactions in the tech and electronics industries. GP Ventures has offices in Chicago and Tokyo, with five

people in total. To read past columns or contact Kastner, [click here](#).



ROUNDTABLES

Lively and insightful discussions from industry experts. **Watch now!**



**App Notes
and Fab Notes**



**Process Ionic Contamination
Test (PICT) Standard**



**Achieving Operational Excellence
in Electronics Manufacturing**



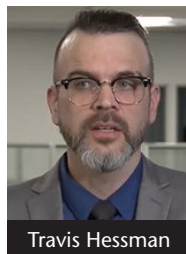
**Use of IMS Thermal Materials
in Multilayer Stackups**



Editor Picks from PCB007

1 IPC APEX EXPO 2021 Keynote: Travis Hessman on 'The Great Digital Transformation' ▶

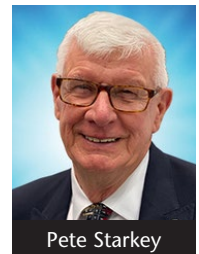
The March 10 keynote at IPC APEX EXPO 2021 came from Travis Hessman, editor-in-chief of *IndustryWeek*. Hessman made it clear that his goal was not to hype an already over-hyped industry, nor to focus on the technologies themselves, but to walk-through the process of transformation.



Travis Hessman

3 EIPC Technical Snapshot: 5G and Loss Minimisation ▶

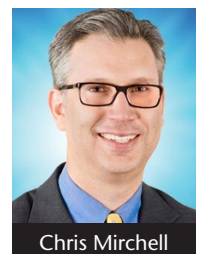
Bringing a specialised technical area into sharp focus, this month's topic was "5G and the understanding of loss minimisation at the PCB level," with papers on dielectric material, copper foil, and modelling solutions.



Pete Starkey

4 The Government Circuit: Making Connections Between 'Build Electronics Better,' 'Build Back Better' ▶

The new year has already spawned several positive government policy actions for the electronics industry, leaving us intrigued about the year to come. We're seeing an increase in policy debates that affect our industry, making IPC's government relations work more critical than ever.



Chris Mirchell

2 IPC APEX EXPO Keynote: John Mitchell on the State of the Industry ▶

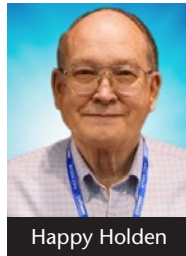
Delivered via video conference on March 8 as part of this year's virtual format, Mitchell made good use of a panel approach. After opening remarks, Mitchell anchored an around-the-horn series of reports from IPC experts.



John Mitchell

5 Happy's Play-by-Play of IPC APEX EXPO ►

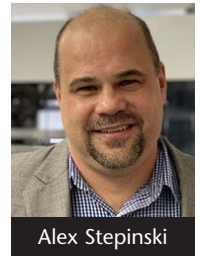
This was the first time IPC had a virtual APEX EXPO. It went well, but I missed seeing everyone. On the other hand, all this material being available for 90 days certainly allows it to fit anyone's schedule. I spent all week intently listening to the presentations.



Happy Holden

8 Vertical Integration on the Rise ►

Alex Stepinski, founder and vice president of GreenSource, shares his thoughts after his presentation in the managers' forum at IPC APEX EXPO. His presentation focused on the vertical integration trend and zero waste.



Alex Stepinski

6 IPC Managers Forum: Packed With Useful Information ►

Gene Weiner of Weiner International Associates discusses the highlights of the IPC Managers Forum which took place on the first day of IPC APEX EXPO. The forum was filled with a variety of speakers covering a range of industry topics.



Gene Weiner

9 Cicor Closes Challenging 2020 with Solid Result ►

Cicor reported a sales decrease of 15.4 percent year-on-year to CHF 214.9 million in 2020 (2019: CHF 253.9 million), due to the ordering behavior of selected major customers during the COVID 19 pandemic, which is at the upper end of guidance due to a pick-up in business toward the end of the year.



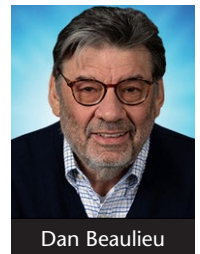
7 I-Connect007 Releases Special Annual 'Show & Tell Magazine' ►

I-Connect007 is proud to announce the release of our special 2021 edition of *Real Time with... IPC APEX EXPO 2021 Show & Tell Magazine*. This unique publication provides you with in-depth coverage of this year's virtual IPC APEX EXPO 2021.



10 Rooting Out an 'Us vs. Them' Mentality: An Interview with Laura Kriska ►

Earlier this year, I-Connect007 columnist Dan Beaulieu submitted a book review on "The Business of WE: The Proven Three-Step Process for Closing the Gap Between Us and Them in Your Workplace." As a follow up to that review, Dan has interviewed the book's author, Laura Kriska.



Dan Beaulieu

For the Latest PCB News and Information, Visit: [PCB007.com](https://www.pcb007.com)

Career Opportunities



How Do Your Team Members Stack Up?

Find industry-experienced candidates at I-Connect007.

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

In addition, your ad will be featured in at least one of our newsletters, and your posting will appear on our jobConnect007.com board, which is also promoted in every newsletter.

Potential candidates can click on your ad and submit a resume directly to the email address you provide or be directed to the URL of your choice. If you wish to continue beyond the first month, the price is the same per month.

No contract required. We even include your logo in the ad, which is great branding!

To get your ad into the next issue, contact:

Barb Hockaday at barb@iconnect007.com or +1 916.365.1727 (-8 GMT PST)

I-Connect007
GOOD FOR THE INDUSTRY



Career Opportunities



JOHNS HOPKINS

CAM / Process Engineer

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

Responsibilities:

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

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

apply now



ventec
INTERNATIONAL GROUP
騰輝電子

Customer Service Representative, UK

We are looking to expand our UK Customer Service/Internal Sales team. As Customer Service Representative you will provide great sales and customer service support and respond to the needs of clients from industries including Aerospace, Defence, Automotive and Pharmaceutical. Duties include:

- Maintain & develop relationships with new and existing customers
- Make rapid, accurate cost calculations and provide quotations
- Accurately input customer orders through bespoke MRP System
- Liaise with colleagues at Chinese HQ and other Overseas Business Units to manage domestic and international requirements
- Assist sales team with reporting, sales analysis and other items at their request

Skills and abilities required for the role:

The ideal candidate is a proactive self-starter with a strong customer service background. Friendly, approachable, and confident, you should have a good phone mannerism and be computer literate.

- Previous experience in a Customer Service background, ideally management or supervisor role
- Experience with MRP Systems
- Good working knowledge of Microsoft Office Tools such as Outlook, Excel etc.

What's on Offer:

- Excellent salary & benefits commensurate with experience

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

Please forward your resume to HR@ventec-europe.com

apply now

Career Opportunities



Micropack Private Limited Sales Representatives

Micropack is a leading Indian PCB manufacturer with a state-of-the-art facility in Bangalore. Our focus on quality and reliability is demonstrated by the fact that we are certified to Nadcap, MIL 31032 & AS9100, apart from many customer approvals.

Catering to both quick-turn and medium volume requirements, our product range covers:

- Double-sided & multilayer PCBs, up to 30 layers
- Rigid-flex PCBs
- High-copper PCBs
- Hybrid PCBs with FR4+ Hydrocarbon Ceramic Substrates
- Heatsink Multilayer PCBs—Metal core and thermal plate PCBs

We are looking beyond our borders for sales representatives to expand our customer reach in the United States, Europe & South America.

Candidates must have previous PCB sales experience and should understand the technical aspects of printed circuit board manufacturability.

Contact us for more information.
mp3@micropack.in

[apply now](#)



We're Hiring! Atlanta Georgia Facility

ADVANCED CIRCUITRY INTERNATIONAL is a world class supplier of RF/microwave and antenna PCBs. We have four state-of-the-art facilities on three continents to serve our customers. From rapid prototype development to large scale production ramp-ups, we supply many notable OEMs and EMS companies around the world.

As we are anticipating rapid growth for 2021 and beyond, we are recruiting for the following positions:

- Manufacturing manager
- Process engineering
- Sales and business development
- Maintenance management

Qualifications:

- 5-10 years' experience working in the PCB industry
- The ability and drive to learn about our unique product offering
- Excellent written and oral communication skills
- Strong, honest work ethic
- Degree in engineering, operations management, or related field preferred but not required

What We Offer:

- Excellent salary and benefits commensurate with experience

If you want to be part of the upcoming **5G** revolution and the growth in RF/microwave and antenna PCB manufacturing, consider a career at **ACI**. We're located in the Northern Atlanta suburbs, where you will enjoy a moderate climate, affordable housing, low taxes, quality school systems and numerous recreational opportunities. Please send your resume in confidence to: Career@aciatlanta.com

[apply now](#)

Career Opportunities



Indium Corporation: Field Sales Representative

Field Sales Representative serves as lead sales contact and customer advocate to maintain existing sales and to drive new qualifications and sales of products and services through effective account management and coordination of efforts throughout Indium Corporation's Metals, Compounds, Solar and Reclaim (MCSR) organization. This position is ideal for a sales- and customer-focused individual with an engineering degree.

- Develop, cultivate, and follow-up with prospective and existing customers to generate orders
- Develop an in-depth expertise of product offerings
- Work to gain insight into customer activities for future R&D developments
- Respond to customer requests for product data, specifications, and service information
- Identify customer requirements, priorities, and opportunities
- Build strong, trusting relationships with key decision-makers and influencers at target accounts
- Gather competitive insight, including pricing, delivery, and performance information
- Visit customer facilities to observe manufacturing processes and exchange information
- Promote industry recognition of Indium Corporation, its products, and its services
- Be a key member of overall team, including worldwide sales organization, product management, operations, engineering, R&D, etc.
- Submit required paperwork in timely manner
- Work within established budget, while increasing market share
- Perform other duties and projects as assigned

Click below for more details on job responsibilities and requirements.

[apply now](#)



Circuit Engineering Planning Engineer

Experience

- Minimum of 5 years working within printed circuit board manufacturing industry

Responsibilities

- Review Gerber data and talk with the customer when necessary
- Create production traveler based on Gerber data to release the order
- Improve process capability, yields and cost while maintaining safety and improving quality standards
- Work with customers in developing cost-effective production processes

Quality Engineer/Manager

Experience

- Minimum of 2 years working within printed circuit board industry
- Possess working knowledge of the IPC requirements and submitting PPAP reports
- Should have knowledge of working with the A16949 certification

Responsibilities

- Perform defect reduction analysis and activities
- Participate in the evaluation of processes, new equipment, facility improvements and procedures

Sales Associate/Customer Service

- Should have a minimum of 2 years' experience
- Salary plus commission

All positions will be on location at Circuit Engineering, 1390 Lunt Ave., Elk Grove Village, Illinois, not remote!

Contact: Felix Simon: +1 847 806-7777, ext. 109

[apply now](#)

Career Opportunities



MANUFACTURERS OF QUALITY PRINTED CIRCUIT BOARDS

Pre-CAM Engineer

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

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

[apply now](#)

Process Engineer

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

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

[apply now](#)



American Standard Circuits

Creative Innovations In Flex, Digital & Microwave Circuits

CAD/CAM Engineer

Summary of Functions

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

Essential Duties and Responsibilities

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

Organizational Relationship

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

Qualifications

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

Physical Demands

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

[apply now](#)

Career Opportunities



Senior Account Manager Midwest Region

Summit Interconnect, a leading North American manufacturer of advanced technology printed circuit boards across all end-user markets, is seeking an experienced, dynamic leader to drive new business in the Midwest Region of the U.S.

Headquartered in Anaheim, Calif., with additional locations in California and Toronto, Can., Summit's manufacturing features facility-specific expertise in rigid, flex, rigid-flex, RF/MW, and HDI PCBs.

The ideal candidate is highly motivated and should possess in-depth market knowledge, deep contacts across multiple markets and extensive experience in PCB sales with a demonstrated aptitude in proposing engineered solutions to complex requirements.

Reporting to the VP of Sales, the Midwest Senior Account Manager will be the primary hunter in the region and responsible for monitoring customer, market and competitor activity to build appropriate sales strategies for the region, create a strategic plan to grow existing and new business in the region, and be responsible for interfacing across all levels of the organization.

Preference is for the applicant to reside in region and be located within one-day travel to key accounts in the metropolitan business areas. However, the proven professional able to demonstrate reach into the region will be considered regardless of physical location.

Compensation will be a combination of salary and commission, with a comprehensive, competitive benefits package.

[apply now](#)



Our Summit Anaheim, CA, division currently has multiple open positions for planning engineers.

The planner is responsible for creating and verifying manufacturing documentation, including work instructions and shop floor travelers. Review lay-ups, details, and designs according to engineering and customer specifications through the use of computer and applications software. May specify required manufacturing machinery and test equipment based on manufacturing and/or customer requirements. Guides manufacturing process development for all products.

Responsibilities:

1. Accurately plan jobs and create shop floor travelers.
2. Create documentation packages.
3. Use company software for planning and issuing jobs.
4. Contact customers to resolve open issues.
5. Create TDR calculations.
6. Assist in the training of new planning engineers.
7. Review prints and purchase orders.
8. Create stackups and order materials per print/spec.
9. Plan jobs manufacturing process.
10. Institute new manufacturing processes and or changes.

Education/Experience:

1. High school diploma or equivalent
2. Minimum five (5) years' experience in the printed circuit board industry with three (3) years as a planning engineer.
3. Must be able to cooperate and communicate effectively with customers, management, and supervisory staff.
4. Must be proficient in rigid, flex, rigid/flex, and sequential lam designs.

[apply now](#)

Career Opportunities

Now Hiring

Director of Process Engineering

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

Job Summary:

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

Duties and Responsibilities:

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

Education and Experience:

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

[apply now](#)

Now Hiring

Process Engineering Manager

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

Job Summary:

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

Duties and Responsibilities:

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

Education and Experience:

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

[apply now](#)

Career Opportunities



Sales Account Manager

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

Responsibilities

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

Qualifications

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

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

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

Contact Oscar Akbar at: hr@lenthor.com

[apply now](#)



Senior Process Engineer

Job Description

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

Position Duties

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

Qualifications

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

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

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

Contact Oscar Akbar at: hr@lenthor.com

[apply now](#)

Career Opportunities



SMT Operator Hatboro, PA

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

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

Duties and Responsibilities:

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

Requirements and Qualifications:

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

We Offer:

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

[apply now](#)



SMT Field Technician Hatboro, PA

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

Duties and Responsibilities:

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

Requirements and Qualifications:

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

We Offer:

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

[apply now](#)

Career Opportunities



IPC Instructor

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

*Independent contractor,
possible full-time employment*

Job Description

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

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

Qualifications

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

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

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

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

apply now



eptac
TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

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

Qualifications and skills

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

Benefits

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

apply now

Career Opportunities



APCT, Printed Circuit Board Solutions: Opportunities Await

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

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

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

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

[apply now](#)



MivaTek Global: We Are Growing!

MivaTek Global is adding sales, technical support and application engineers.

Join a team that brings new imaging technologies to circuit fabrication and microelectronics. Applicants should have direct experience in direct imaging applications, complex machine repair and/or customer support for the printed circuit board or microelectronic markets.

Positions typically require regional and/or air travel. Full time and/or contractor positions are available.

Contact HR@MivaTek.Global for additional information.

[apply now](#)

Career Opportunities



U.S. CIRCUIT

Sales Representatives (Specific Territories)

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

- Florida
- Denver
- Washington
- Los Angeles

Experience:

- Candidates must have previous PCB sales experience.

Compensation:

- 7% commission

Contact Mike Fariba for
more information.

mfariba@uscircuit.com

[apply now](#)



YOUR
JOB
AD
HERE

For information, please contact:
BARB HOCKADAY
barb@iconnect007.com
+1 916.365.1727 (PACIFIC)

I-Connect007
GOOD FOR THE INDUSTRY



Webinar: For more information about the iamcam concept, please request the iamcam webinar video via presales@ucamco.com.

REALTIMEwith... I-Connect007

ROUNDTABLE DISCUSSION FEATURING:



Chris Hanson
Ventec International Group



Rax Ribadia
Excello Circuits



Denis McCarthy
Ventec International Group

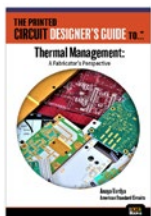


Pete Starkey
I-Connect007

Video An IMS Thermal Materials Discussion

Roundtable: "Use of IMS Thermal Materials in Multilayer Stackups for Power Applications" with Ventec International Group and Excello Circuits.

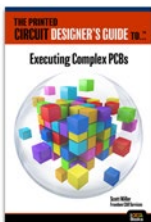
I-007eBooks The Printed Circuit Designer's Guide to...



Thermal Management: A Fabricator's Perspective

by Anaya Vardya, American Standard Circuits

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



Executing Complex PCBs

by Scott Miller, Freedom CAD Services

Readers will learn how to design complex boards correctly the first time, on time. This book is a must-read for anyone designing high-speed, sophisticated printed circuit boards.



Thermal Management with Insulated Metal Substrates

by Didier Mauve and Ian Mayoh, Ventec International Group

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



Fundamentals of RF/Microwave PCBs

by John Bushie and Anaya Vardya, American Standard Circuits

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



Flex and Rigid-Flex Fundamentals

by Anaya Vardya and David Lackey, American Standard Circuits

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

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

PUBLISHER: **BARRY MATTIES**
barry@iconnect007.com

MANAGING EDITOR: **NOLAN JOHNSON**
(503) 597-8037; nolan@iconnect007.com

EDITOR | COLUMNIST COORDINATOR: **MICHELLE TE**
michelle@iconnect007.com

CONTRIBUTING EDITOR: **PATRICIA GOLDMAN**
(724) 299-8633; patty@iconnect007.com

TECHNICAL EDITOR: **PETE STARKEY**
+44 (0) 1455 293333; pete@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **DAN FEINBERG**
baer@iconnect007.com

CONTRIBUTING TECHNICAL EDITOR: **HAPPY HOLDEN**
(616) 741-9213; happy@iconnect007.com

SALES MANAGER: **BARB HOCKADAY**
(916) 608-0660; barb@iconnect007.com

SALES: **ANGELA ALEXANDER**
(408) 489-8389; angela@iconnect007.com

MARKETING SERVICES: **TOBEY MARSICOVETERE**
(916) 266-9160; tobey@iconnect007.com

PRODUCTION MANAGER: **SHELLY STEIN**
shelly@iconnect007.com

MAGAZINE LAYOUT: **RON MEOGROSSI**

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

CREATIVE TECHNOLOGIST: **BRYSON MATTIES**

COVER: **SHELLY STEIN**

COVER IMAGE: **ADOBE STOCK © DIMDIMICH**

PCB007
MAGAZINE

PCB007 MAGAZINE®

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

© 2021 BR Publishing, Inc. does not assume and hereby disclaims any liability to any person for loss or damage caused by errors or omissions in the material contained within this publication, regardless of whether such errors or omissions are caused accidentally, from negligence or any other cause.

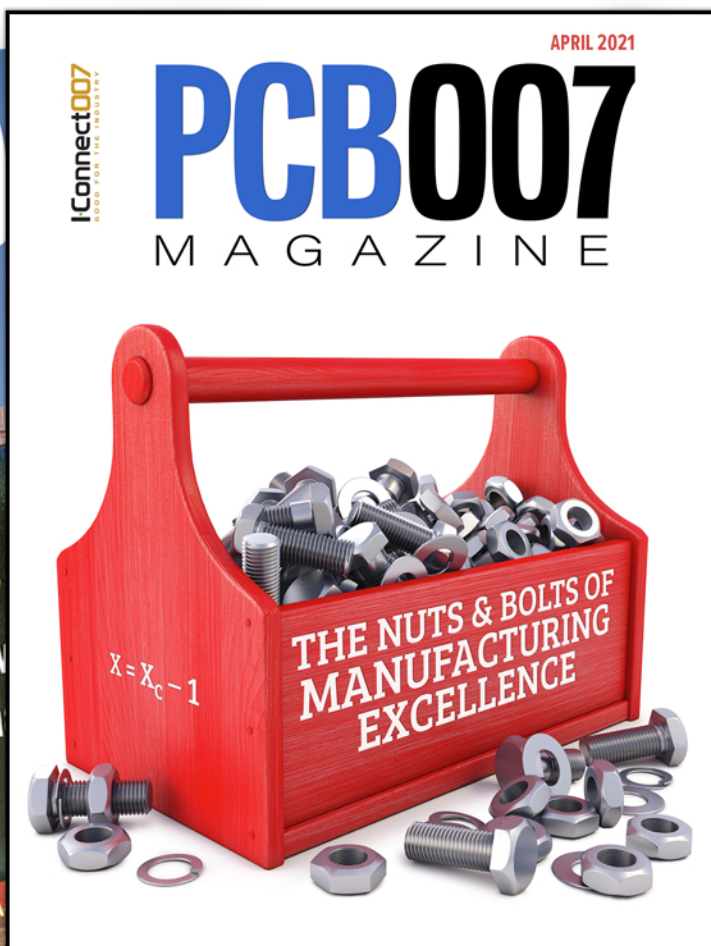
April 2021, Volume 11, Number 4
PCB007 MAGAZINE is published monthly,
by BR Publishing, Inc.

ADVERTISER INDEX

all4-PCB.....	43
atg Luther & Maelzer GmbH.....	49
Atotech.....	47
Burkle North America.....	11, 83
Chemcut.....	29
DB Management.....	41
Denkai America.....	15
Electra Polymers.....	79
Entelechy Global.....	69
Excellon.....	53
Fein-line Associates.....	85
Gardien.....	65
I-007 eBooks.....	3
I-007e.....	2, 103
IPC.....	23, 99
Insulectro.....	7, 95
MicroCraft.....	35
MivaTek Global.....	61
MKS ESI.....	5
Pluritec.....	75
Prototron Circuits.....	101
Show and Tell Magazine.....	19
Taiyo America.....	25, 87
Technica USA.....	21
Ucamco.....	57
Ventec International Group.....	39

I-Connect007

GOOD FOR THE INDUSTRY



FREE SUBSCRIPTION



myconnect007.com

EDITORIAL CONTACT

Nolan Johnson

nolan@iconnect007.com

+1 503.597-8037 GMT-7



mediakit.iconnect007.com

SALES CONTACT

Barb Hockaday

barb@iconnect007.com

+1 916 365-1727 GMT-7



www.iconnect007.com