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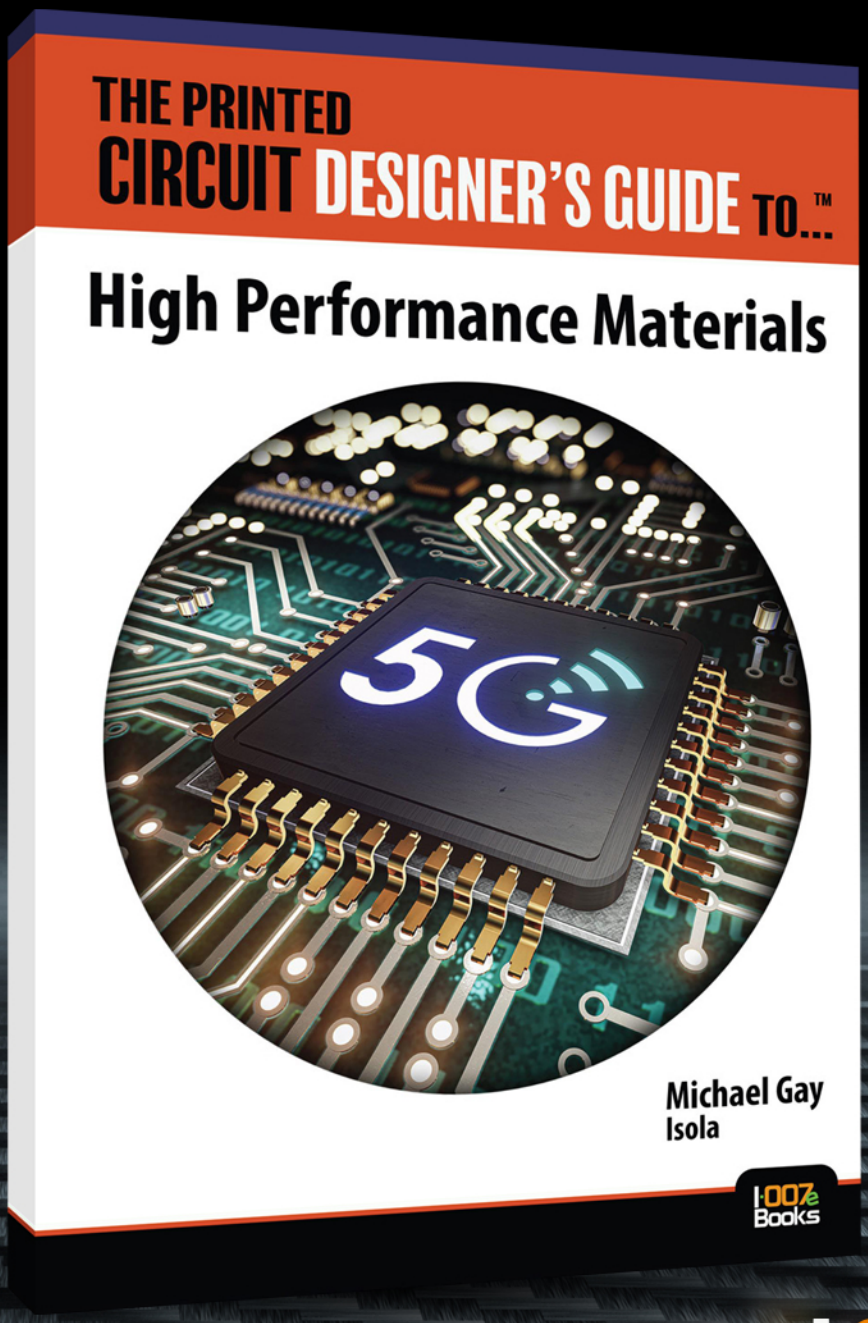

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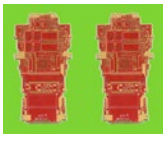
Materials & Technology

In this issue, we dish on the materials research and development efforts to meet the ever-tightening relationship between the product's application and the material selected to serve as the PCB substrate. Now more than ever, material performance, availability and pricing are key factors in the specification of materials in the design phase.

FEATURE ARTICLES & INTERVIEWS

FEATURE ARTICLES & INTERVIEWS

FEATURE COLUMNS



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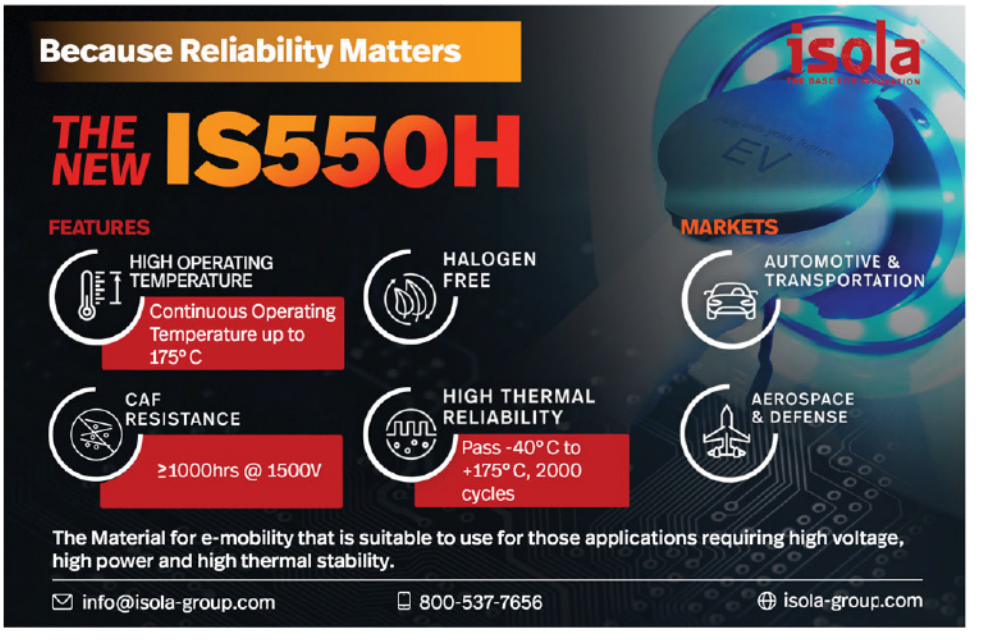

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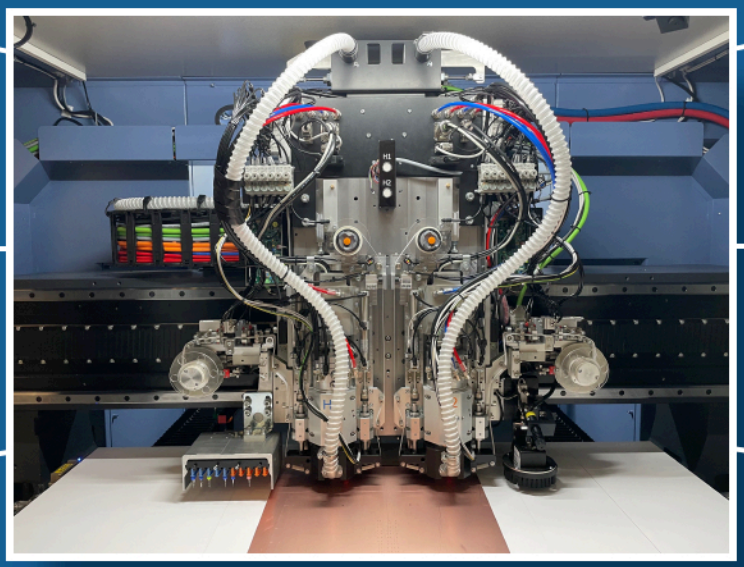

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Materials & Technology

Nolan's Notes

by Nolan Johnson, I-CONNECT007

It didn't start with Forrest Gump—the idea that two things (or people) go together "like peas and carrots"—but that line from the movie certainly has been appropriated by Tom Hank's character in the film adaptation of the Winston Groom novel. As this issue of *PCB007 Magazine* came together, our editorial staff couldn't seem to shake off the image of the vegetable combination when it came to materials and technology.

So, we're picking up on the ongoing development of new base materials for PCB fabrication. We all see and feel the changes in dynamics that are influencing materials; our manufacturing capabilities are being pulled in multiple directions simultaneously. Some characterize it as a fracturing, others see it as an opportunity. I guess it depends on where you stand in the supply chain. We're opening the doors to the materials' research departments to discuss the ever-tightening relationship between the product's application and the material selected to serve as the PCB substrate.

For those who are designing boards for specialized, higher-performance applications, the choice of materials with optimized perfor-

mance is an opportunity. Manufacturers are working on all three key features: performance, manufacturability, and price. This makes the conversation between design team and fabricator a multifaceted affair. As we investigated how materials are changing, we spoke in depth with Eddie Mok at WUS. Eddie is an expert in materials selection and shared some of his market research with us. The more we talked, the more Eddie's comments validated the ideas that there is a symbiosis. Technology is driving materials; materials are driving technology. And fabs find themselves in the middle. In this issue, you'll find one excerpt from that wide-ranging conversation as it relates to the topic at hand.

New designs—and there are a lot of them—have a wide range of choices for materials nowadays. Some materials are optimized for specific applications, such as automotive, high-speed, or RF. While that's been the case for a while now, it's safe to say that materials development to meet application-specific needs has accelerated. And since these materials now play an active role in delivering on performance specifications, the selection becomes a critical engineering function.

Mok makes the point that fabs must validate a material to add it as an offering. That validation process takes time and resources to complete. With so many new materials, the fabs are hard-pressed to validate even a few, let alone all the likely options. And yet, how can a design team get hard data on performance except to build using that material?

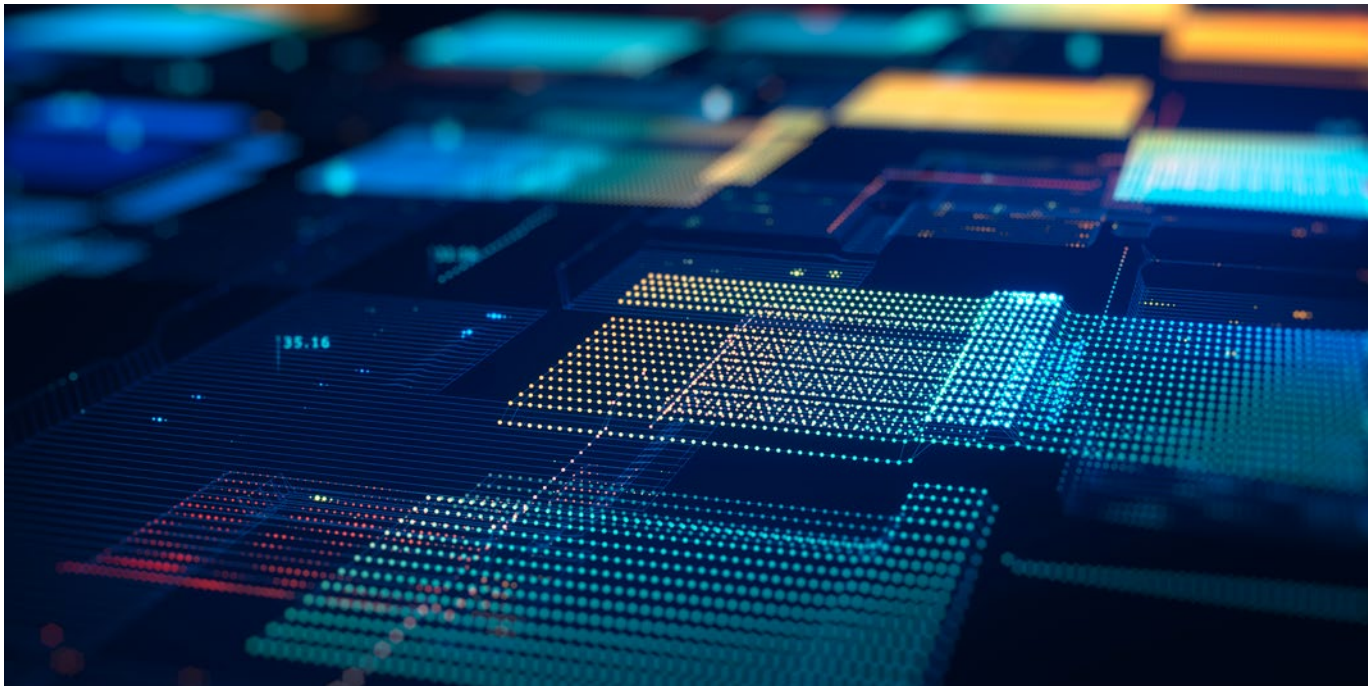
For fabs and designers who aren't on the vanguard of high-performance design, things are a bit more stable—or so people think. But are they, really? And should they be? A PCB assembly's current material may be good enough, as they say, but what if a tweak in material selection reduces overall manufacturing cost? What if that tweak simultaneously improves the performance of the existing design? And is it worthwhile to redesign to take full advantage of a new material? In the spirit of continuous improvement, doesn't it make sense to investigate these new materials? But who to talk to, and which materials manufacturers should you pay attention to?

The answers to these questions vary depending upon whether you're a fabricator or a designer/engineer, of course, and on how you've structured your input materials supply line. To add more detail to the applications table that Mok kindly shared with us, we reached out to all the suppliers on the table, plus a couple others not on Mok's radar (as impressive as Mok's list of suppliers is, it doesn't represent the entire industry). That is a lot to ask of any one source, to share insight on their current development activities. The rest of the features in this issue give those materials manufacturers who submitted some space to share that work. What appears here does indeed provide a peek into the development and innovation underway.

Yes, clearly the technology (both design and fabrication), and the materials themselves, are increasingly interlinked. Materials are increasingly becoming a part of the engineering design work. Back in the 1980s, when electronic design tools were an emerging, disruptive industry, logic simulation was one of the first "killer apps" for electrical engineers. SPICE and sophisticated timing simulation was right there, too. In IC design, electrical field parasitic effects calculation was an early simulation application that helped design teams improve their work.

Doesn't it seem time to bring material performance into the PCB simulation and verification space? Is that our next "killer app" in PCB design? It sure seems like that would be the right bowl in which to put our peas and carrots, don't you think? **PCB007**

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



The Materials Connection

Feature Interview by Nolan Johnson
I-CONNECT007

Recently, Eddie Mok, product innovation development AVP at WUS, spoke with us at length about the state of the materials market from the perspective of a fabricator. In this excerpt from the conversation, Eddie details some example interactions between what materials, design, and manufacturing bring to the ultimate goal of meeting your design specifications and manufacturing costs. It is clear from this conversation that materials and technology are increasingly interconnected.

Nolan Johnson: Eddie, what's your background?

Eddie Mok: I've been with WUS for 16 years, and before that I was at Nelco for 15 years. I'm still working with materials, but I'm applying it now. While materials are changing, there's room for more. And, because of emerging advanced technology, such as VeCS and others in development, that's where we realize that we still need all the material manufacturers to offer our customers innovative PCB solutions, plus we need different versions of the material to support the new fabrication methods. And yet, material alone is not enough.

Johnson: VeCS is a great example of innovative developments in fab. Besides additive technologies, of course. Happy Holden has been saying, "This is the next thing. This is the thing that's going to replace HDI. This gives a lot of capability to designers."

Mok: I've been saying something similar to customers, "Imagine when HDI came along 25 years ago and people said, "What is that? It's too expensive. It doesn't work." Over time and refinement, HDI established itself as a key technology. Now, hopefully, VeCS is another type of interconnect solution that causes the next paradigm shift. We seem to be getting a lot of traction.

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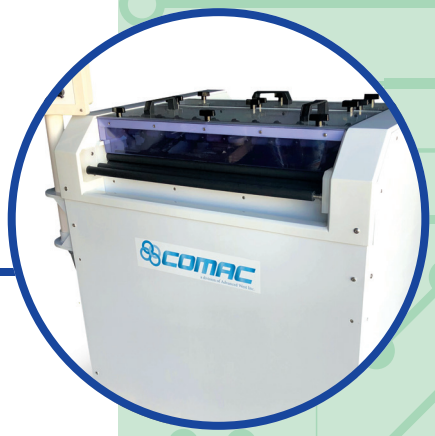

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There's another approach called a 3DMD stackup risk analysis tool, which is also a good example. These are standard/routine solutions at WUS. Signal integrity, rougher or smoother copper, better material— that's pretty routine, as you say, with respect to material selection—but what we want to offer is crosstalk mitigation, improved shielding, and so on by innovative interconnect solutions. The advanced capability, value engineering cost, material performance, and stackup risk—it's all there and of interest to today's designers and fabricators.

Eddie Mok

I get to talk a lot about material, but because of the advanced capabilities requirements, those conversations lead us in many different directions. For example, when you exhaust standard plated through-hole (PTH) back drill technology, you have to go to HDI build-up with multiple lamination designs, or change your design to more costly structures like buried or blind via structures.

Johnson: Eddie, this is a symbiotic situation, isn't it? You have advanced techniques driving materials and materials driving advanced techniques.

Mok: Yes, so many things are happening. These are where most of our activities are. We're constantly looking at different Class 8 material (ultra-super low loss grade), for example.

Johnson: This is for your long-tail legacy work?

Mok: Yes. But that's also where we can't separate material with technology. You can't buy a Ferrari and equip it with budget tires. Customers today will share that they plan to rely on the material to minimize insertion loss. But I make sure to ask them, "What about your shielding? What about your crosstalk? That can't be done by material alone; the interconnect structure needs to help with this."

Generic classification	Class 1	Class 2	Class 2.5	Class 3	Class 4
Consumer / mobile	Primary	Primary	Primary	Primary	
Automotive / Industrial	Primary	Primary	Primary	Next Gen	
Military / Aerospace	Primary	Primary	Primary	Primary	Primary
5G / Telecom.		Primary	Primary	Primary	Primary
Data center				Primary	Primary
Network					
Doosan 斗山 Korea, ChangShu CN	DS-7408	DS-7402H	DS-8502LC	DS-7409 DX DS-7409 DXc DS-7409 DXG	
EMC 台光 TWN, Kunshan CN	EM 825 (I) EM 827 (I) EM 370(5)/Z/Z-15	EM 285 EM 370 (D)	EM 828G EM 355 (D) EM 390	EM 888 (S) EM 526 EM A50 auto	EM 888K
Isola 德联 US, TWN, Suzhou CN	IS 400HR 185HR / 370HR IS 550H auto		IS 415 / HR	FR 408 * FR 408HR * I-Speed	
ITEQ 联茂 TWN, Wuxi CN	IT-158 / IT-180A IT-258GA3 IT-189 / IT-180L	IT-180i IT-150 G / IT-150GTA1 IT-170 GRA / IT-170GL IT-858 G auto	IT-170 GRA-1 IT-150 GS IT-170 GT	IT-150DA IT-170GRA-2 IT-958G	
Nanya 南亚 TWN, Kunshan, CN	NP-155F NP-175FM NP-175FBH	NPG-150N NPG-151 NPG-170N	NPG-171/181 NPGN-150 LKHD NPG-150D	NPG-170D	
Panasonic 松下 JP, TWN, GZ CN	R-1755C R-1755V R-1755M	R-1566W (N)	Megtron 2 Megtron 2E	Megtron 4 / 4S Megtron M	
AGC Nelco Singapore, US	N4000-20			N4000-13 * N4800-20	N4000-13 SI * N4800-20 SI
ShengYi 生益 DG & Suzhou CN	S1000-2/2M/H Autolad-1/3, ST110 SI 643HU	S 7045G Autolad-3G auto	S 7038 S 7040 G	S 7439 / C S 7439G SI 10U (S) auto	
TUC 台耀 TWN, ChangSu CN	TU-668 / TU-768 TU-662 / TU-752	TU-862HF TU-747HF TU-865	TU-862 (S) TU-747 LK	TU-872 LK TU-872 SLK TU-863+ (T1+)	TU-872 SLK SP
Ventec 騰輝 Suzhou CN	VT-481 VT-47, VT-585		VT-464 (TS-2) VT-447	VT-464L (TS-3) VT-461 (TS 2.1)	VT-462L (Tec-speed 4)
Wazam 华正新材 Zhejiang, CN	HA10AH	H 175HF H 175HF(Z)	H 185HF		
NouYa 上海南亚 Shanghai, CN	NY-2170 NY-2150M	NY-6180	NY-3170M NY-6180L		NY-6300SL

This table (right), courtesy of Eddie Mok and WUS, provides a high-level view of how materials and applications match up. This table only captures a subsection of the total market but illustrates that careful selection of material for the correct application is increasingly critical.

Johnson: It's a nice, holistic look; all those are factors in a material selection.

Mok: Different members of the team will have different requirements based on their job. The SI guy wants something specific performance-wise, but the commodity guy is watching the pricing. The program manager is primarily concerned with keeping to the schedule. We get them to just draw a line and start somewhere. It just opens another dialogue because they're just not familiar with all these new materials. We like to offer customers alternative solutions to improve SI performance at the most cost-effective way.

As the materials manufacturers develop iteratively improved materials, they are understandably careful not to violate UL by changing the resin system. To do that, they switch to a better copper foil. That's an easy thing that will drop the insertion loss. In fact, I'm starting to look into the copper foil suppliers to see what they're doing. Recently, I created a copper foil selection guide based on roughness data from suppliers' datasheets to better understand how it impacts the performance and cost of the PCB. When many of the suppliers started showing better SI, that's when we found out the copper changed but not the resin.

Another topic related to material is panel size, which doesn't affect insertion loss or reliability but does influence cost. If an OEM really wants to save even the last penny, we will optimize to a specific panel size. Some laminate suppliers have certain large sheet sizes that are beneficial for material utilization rate.

Johnson: That's where the manufacturing floor comes into play and material utilization and every square centimeter of board that you can use is a benefit to the margin at the bottom line.

Mok: Right. Usually this is the area where our PCB purchasing department really gets involved. We look at utilization to find a panel size that minimizes panel waste to get the lowest per-piece manufacturing cost.

Johnson: Eddie, thanks for the insight. This truly is a two-way conversation nowadays, on performance, availability and cost, isn't it?

Mok: It definitely is. My pleasure. **PCB007**

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Consumer / mobile					
Automotive / Industrial					
Military / Aerospace	Primary	Primary	Primary	Primary	Primary
5G / Telecom.	Primary	Primary	Primary	Primary	Primary
Data center	Primary	Next Gen			
Network	Primary	Primary	Primary	Primary	Next Gen
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EMC 台光 TWN, Kunshan CN	EM 528	EM 891	EM 890 EM 528K	EM 891K EM 890K / (A)	EM 890 K2 EM 892 K/K2
Isola 德联 US, TWN, Suzhou CN		Tera Green I-Tera MT 40	Tera Green 100G Tachyon 100G	Astra MT 77	Tera Green 400G
ITEQ 联茂 TWN, Wuxi CN	IT-968 IT-968G	IT-988G	IT-968 SE IT-968G SE	IT-988G SE	IT-998G
Nanya 南亚 TWN, Kunshan, CN	NPG-188H	NPG-186	NPG-186K NPG-198	NPG-198K	NPG-199 K NPG-199 K2 new
Panasonic 松下 JP, TWN, GZ CN		Megtron 6 Meg 6G/T/E new HF Megtron 6	Megtron 6N HF Meg 6N Megtron 7/7G_E	HF Meg 6N Meg 7N/7GN R5515 auto	Megtron 8N Megtron 8U
AGC Nelco Singapore, US		Meterowave 1000	MWv 2000 MWv 3000	Meteorwave 4000	MWv 8000 MWv 6600
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What Happens in Washington Happens to Us All

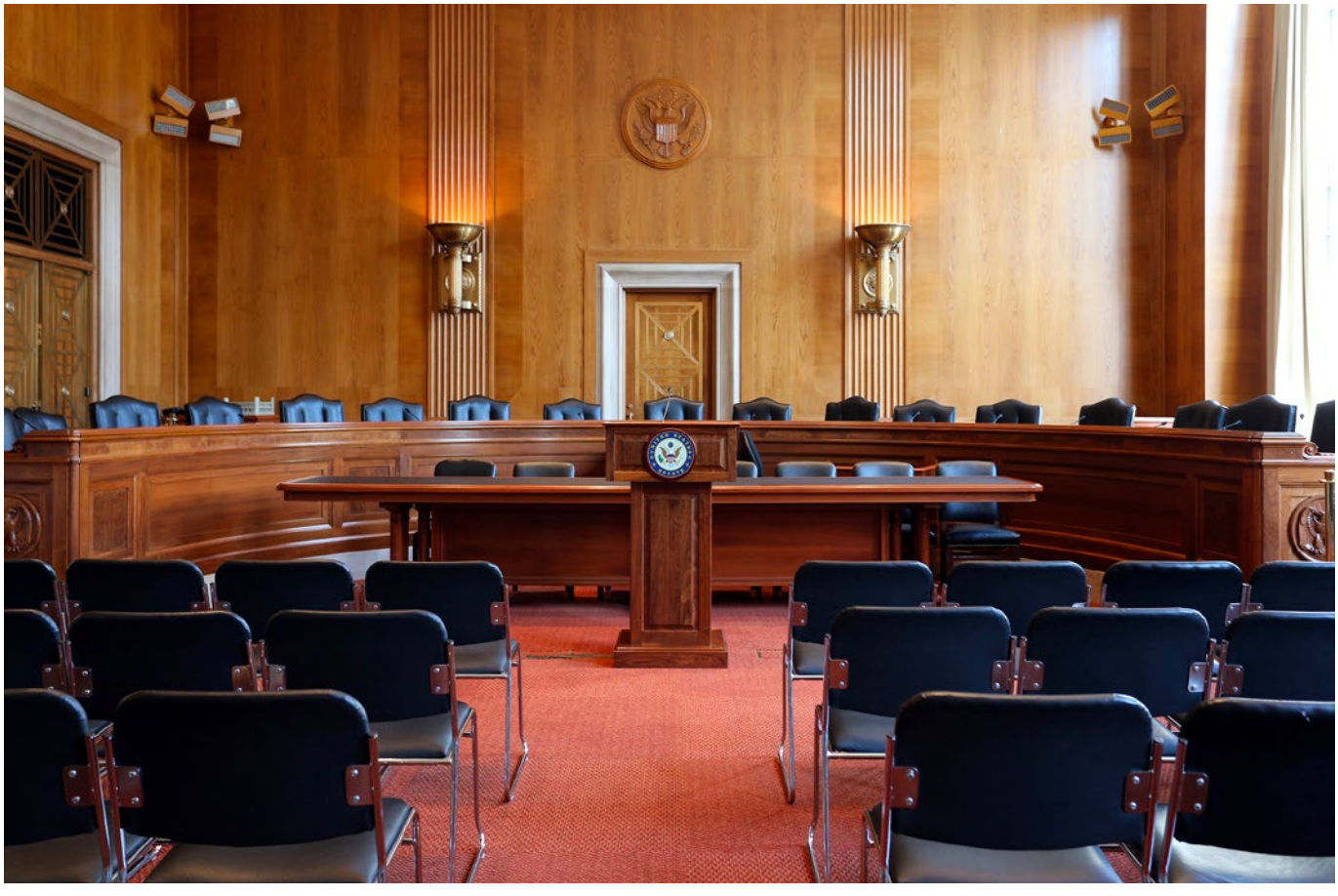
American Made Advocacy

by Travis Kelly, PCBAA

Like many of you, I've spent the last few years grappling with the challenges posed by a global pandemic. Whether it's staffing a production line or obtaining key materials, PCB manufacturers and their suppliers have had to adapt quickly to a radically changed environment.

We're more than 700 days into this new world, but as an industry, we cannot allow our day-to-day focus on operations distract us from what is happening in Washington and what it means to the microelectronics ecosystem.

Independent of the COVID-19 crisis, our industry is experiencing a decades-long shift that needs to be addressed by a strong public/private partnership. Even as more and more technology in our daily lives is dependent on microelectronics, the U.S. has seen its share of the global PCB market shrink from 26% in 2000 to only 4% today. As policymakers



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rightly sound the alarm over a 13% American share of the semiconductor market, we are working to remind them that "chips don't float"—and a truly resilient supply chain must reflect that reality.

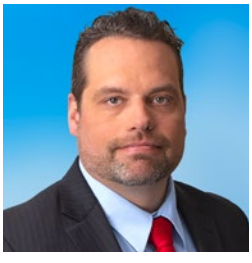
Formed in 2021, the Printed Circuit Board Association of America (PCBAA) is focused on legislative and regulatory initiatives in Washington. Here are examples of the activities we are watching carefully and, in some cases, advocating for passage.

- **The annual federal budgeting process.** Beginning with the release of the President's Budget in the spring and continuing through the fall in most years, Congress works to authorize and appropriate funds for everything from national parks to the post office to the Department of Defense. In the last fiscal year this budget represented nearly $4.8 trillion in federal spending. Not surprisingly, tens of thousands of interest groups are focused on this multi-month process, lobbying for their piece of this enormous pie.
- **Stand-alone economic development bills.** Outside of the annual budget process, Congress often acts to address specific problems, like those currently being felt by American consumers. Shortages of semiconductors have hit American markets hard, and in response, Congress and the administration are pushing for investment in domestic manufacturing through bills like the CHIPS for America Act and the U.S. Innovation and Competitiveness Act (USICA). These bills represent hundreds of billions of additional dollars in spending and incentives.
- **Federal rule-making and regulatory policy.** It's not just Capitol Hill where we need to pay attention. At federal agencies like the Department of Commerce and the Department of Defense, leaders in the executive branch are writing rules and regulations which guide our customers in the national security space and shape the international markets we operate in.

These are just a few examples of the ways that the federal government influences American competitiveness and the health of our industry. They are also potent reminders of why a sustained and focused PCB industry presence in Washington is so important.

We cannot assume policymakers will understand our issues and our technologies. We cannot take for granted that our elected officials will be sympathetic to our arguments. It is incumbent upon us to educate, advocate, and legislate for the outcomes we want. Therefore, the PCBAA was formed.

Our growing association believes in, and continues to fight for, market fairness and a level playing field on which U.S. PCB manufacturers, assemblers and critical material suppliers can compete and win. If you're interested in joining our effort, please visit us online or contact me directly. **PCB007**



Travis Kelly is the CEO of Isola-Group, current chairman of the Printed Circuit Board Association of America, and an I-Connect007 columnist. To read past columns or contact Kelly, click here.

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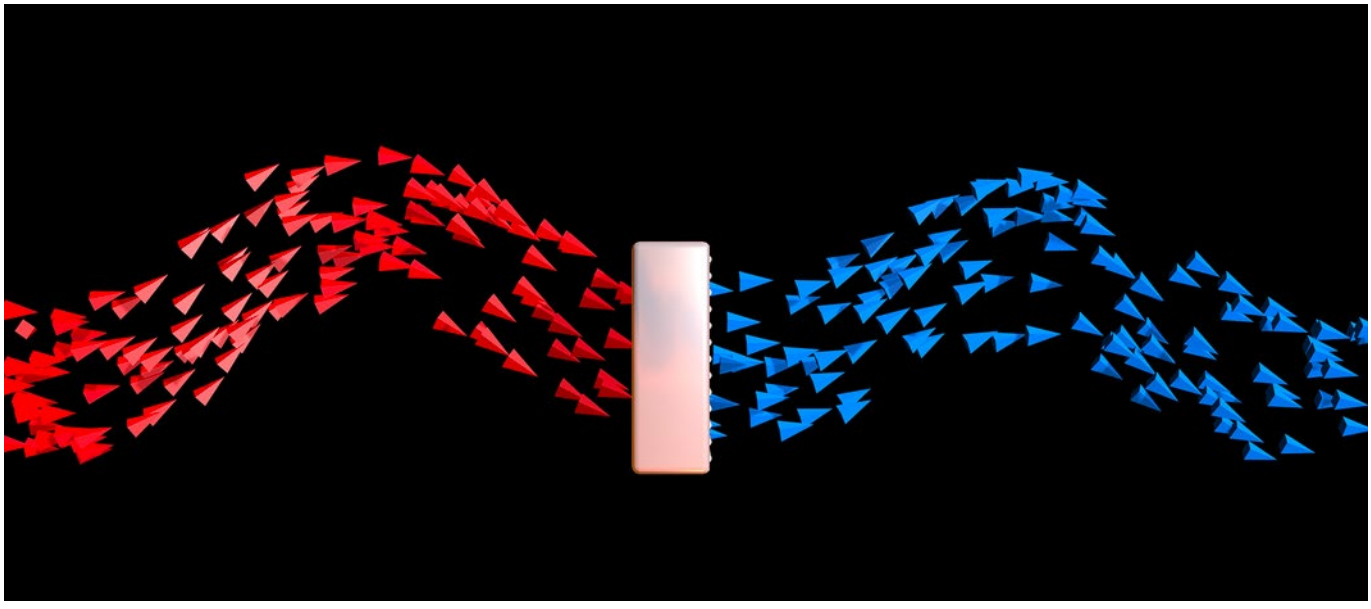

Feature Article by Jeff Brandman
AISMALIBAR NORTH AMERICA

Heat has been a significant concern in electronics since the beginning of the electronics age when hot glowing vacuum tubes were first used to receive and transmit data bits. The transistor and integrated circuit effectively solved that basic problem, but increases in integration resulted in increased concentration of heat, exacerbated by relentless increases in operating frequency. While improvements in electronics technology have been able to mitigate many thermal issues at chip level thanks to improved semiconductor designs devised to operate at lower voltages (thus requiring less energy) the thermal management challenge continues to vex electronic product developers. Moreover, with ever denser heterogeneous integration solutions now being introduced, this is expected to remain a concern to be addressed for the foreseeable future. Thermal engineers have long known that thermal energy must ultimately be "returned to the air" but getting it there in an efficient way is of great importance. They know also that there are but three basic ways of removing heat from a system: conduction, convection, and radiation; of these, conduction is by far the most efficient.

In the manufacture of printed circuits, especially those used in high power applications, the board itself becomes an obvious potential means of helping to remove heat. However, the choice must be made carefully to assure that it fits well into the scheme of traditional manufacturing, as the materials required must not only remove heat but must also maintain the high electrical insulation properties that are vitally important to printed circuit design-

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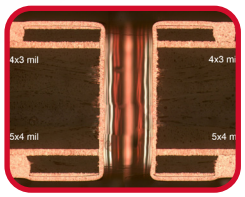

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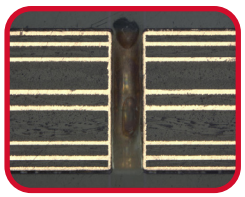

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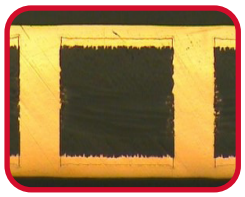

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ers and the products they develop. This has been a primary focus of Aismalibar for some time and the company has accordingly developed a family of new thermal interface material (TIM) technologies designed specifically for printed circuits. The unique materials the company has developed have thermal conductivities up to 3.2 W/mK (tested according to ASTM D5470) and high electrical insulation properties of up to 6 KV AC. (For comparison, nominal laminate materials have thermal conductivities of 0.25 W/mK.)

Concept Model for Thermal Management Chain in Power Electronics

Thermal interface materials are used by design in power electronics modules to facilitate the transfer and dissipation of the heat generated by the active and passive power components on the printed circuit board by enabling efficient transfer of heat through a cooling chain to a downstream cooling element, such as a heat spreader or heat pipe and cooling fan. The ultimate objective is to ensure that the maximum component temperature specified by the manufacturer is not reached.

In addition to providing high thermal conductivity, the TIM must also provide adequate electrical insulation properties; this is especially and increasingly important in high-voltage environments such as those experienced in modern electric vehicles. The better balanced the compromise between thermal conductivity and electrical insulation capability of the TIM, the higher the performance and reliability of the entire power electronics module over its service life (Figure 1).

Thermal Interface Material Solutions

A key recent development, underpinning Aismalibar's new TIM concepts, is a new coating technology referred to by the company as its "air gap filler," which in addition to its excellent thermal and electrical insulation properties, the need to employ an often complex and messy TIM thermal paste application.

A key objective of the air gap filler product is to eliminate voids which otherwise can result in "hot spots" at the interface as illustrated in Figure 2.

The novel air gap filler material solution being offered is non-adhesive at room temperature for ease of handling and advantageously begins to polymerize at low temperature (~40°C). The material is tack free and thus requires no peelable liner, avoiding waste and streamlining the

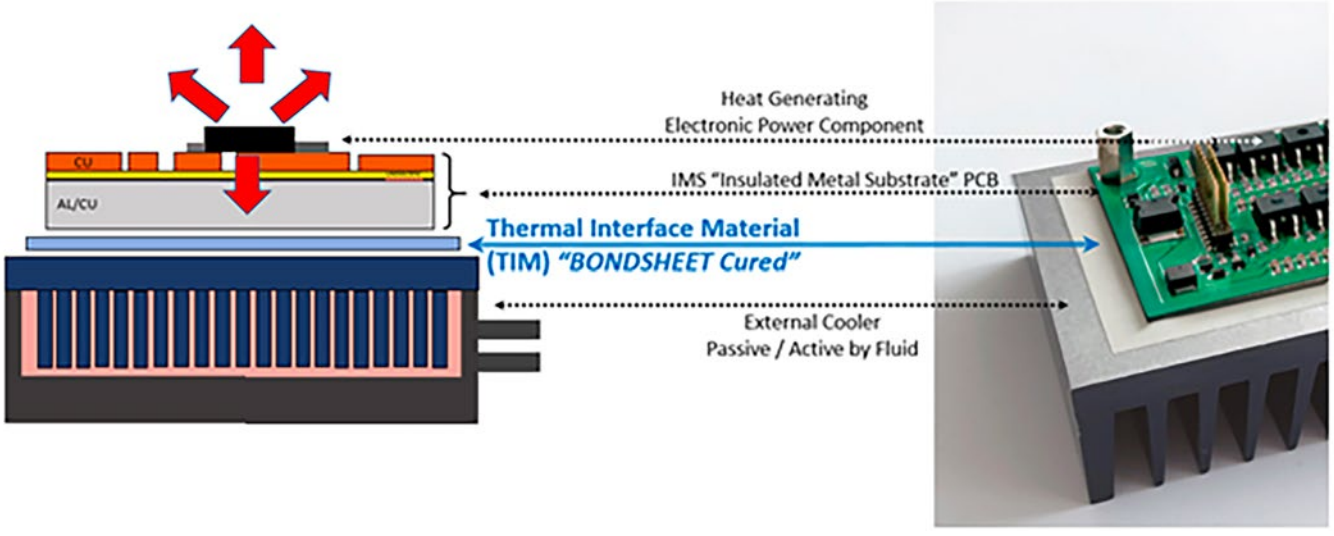

Figure 1: Thermal management is commonly achieved by means of a chain of materials beginning at the integrated circuit chip or heat-generating electronic power component or element. Thermal interface materials serve a vital role in facilitating such heat exchange.

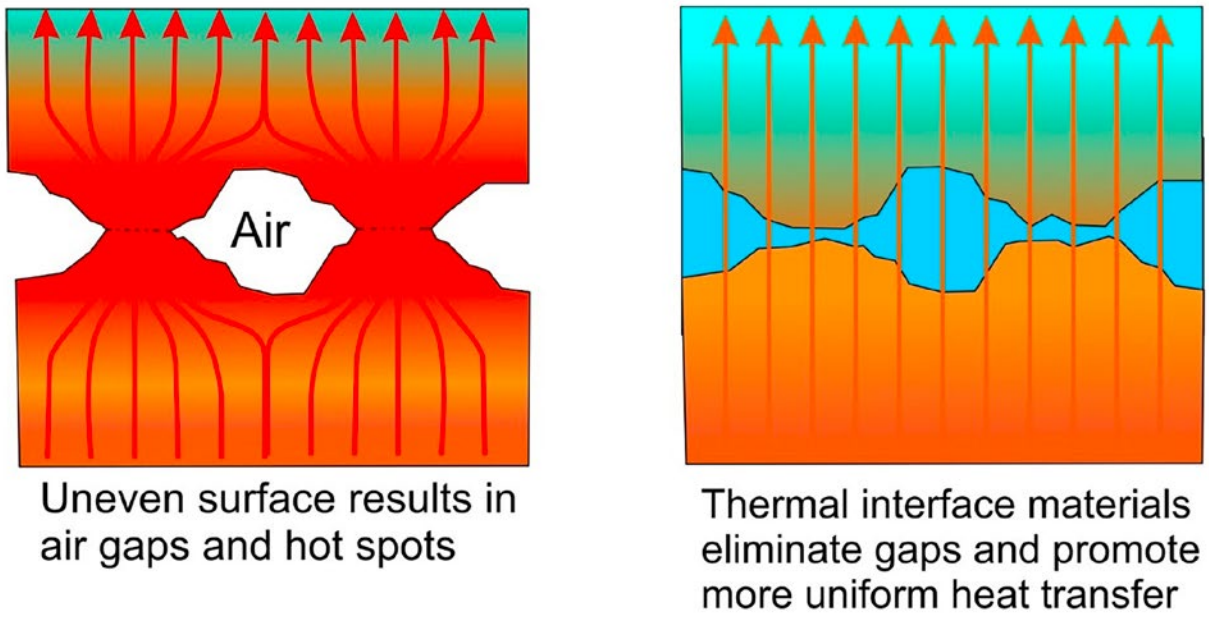

Figure 2: The novel "air gap filler" mitigates small voids or micro air pockets which are found at the interface between electronic components and the thermal spreading element dedicated to heat removal, especially when using thermal pastes which are difficult to spread evenly. Because air is a poor conductor of heat, void elimination is necessary to prevent hot spots which can result in thermal damage to components and system failures.

product's use. The air gap filler has no woven glass reinforcement allowing it to more effectively fill completely the space between mating surfaces and it bonds effectively and securely with only slight mechanical contact pressure, adding to its ease of use. The low temperature bond creates a solid, long-lasting thermomechanical connection between constituent elements of the cooling chain for the power module during the assembly process. In addition, Aismalibar has developed other cost effective, self-adhering TIM variations comprised of the novel adhesive in combination with highly conductive copper foils coated with a thin electrically isolating layer (Isolcopper). These inexpensive self-adhesive, thermally conductive foils are available as cost-effective coating options in the new TIM family of solutions which help simplify the thermal management.

The current roster of thermal solutions is based on reinforced dielectric polymerized interface material designed for high dielectric isolation and low thermal resistance both in normal and a high Tg (180°C with reduced CTE) formulations. The products are fundamentally a thin dielectric layer, high dielectric strength, high thermal conductivity, and low thermal resistance comprised of a glass fabric base, enriched with mineral fillers. The product has a thermal conductivity of 2.2 W/mK with dielectric strengths greater than 4 KV (70 mm dielectric) or 6 KV (100 mm dielectric thickness) and a low thermal resistance R_{th} of 0.315 (70 mm), or 0.45 Kcm^2/W (100 mm), to efficiently dissipate the heat generated by the power components to the cooling elements. Importantly for many applications, the product is silicone free and can be easily adapted to pick and place automation.

Again, a very important solution in the Aismalibar stable of products is Isolcopper—a thin copper (35-80 micron) clad with an ultrathin dielectric layer filled with high end mineral content. The product combines the benefits of the excellent thermal conductivity of copper with a specially developed dielectric

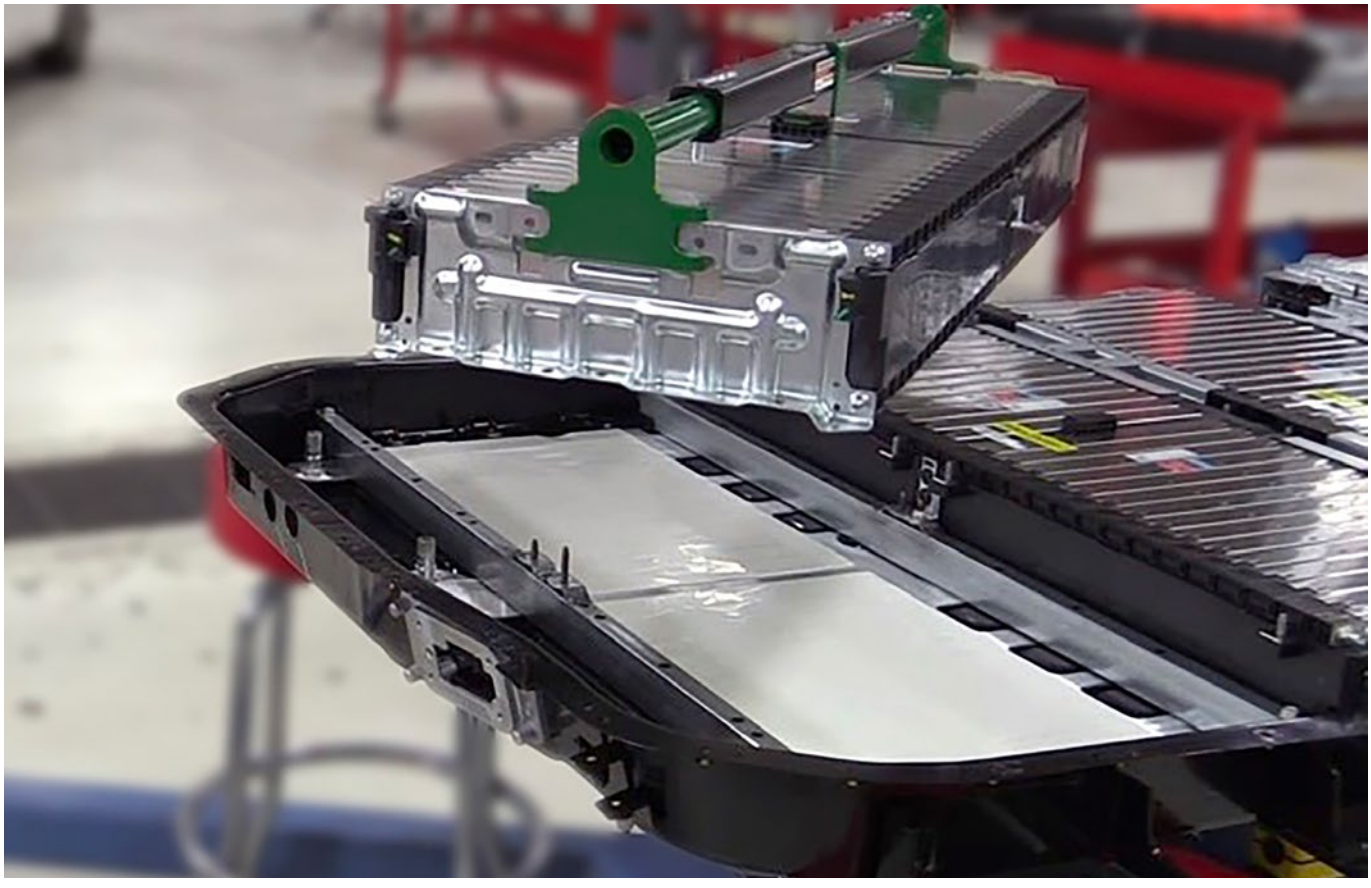

Figure 3: Today's wide-ranging thermal problems require a wide range of thermal interface material solutions.

coating to provide the benefits of copper conductivity with electrical isolation when and where it is desired or beneficial.

All materials can be procured with the air gap filler applied to one or both sides, which is very important for the elimination of air gaps and voids. The company offers a thermal tape, up to 100 mm thickness, which provides versatility and ease of use in special applications or for repairs or modifications. All products are UL V0 rated and all products can be easily cut or punched to a desired shape and size.

Solution Selection Considerations

Given the relentless trend in electronics toward ever-higher power in an ever-wider array of electronic products, from power modules in PV inverters and wind power controls, to electronic-governed mechanical transmissions, AC/DC converters, and high-power LED-based industrial lighting systems, each application may require a different solution to assure that the heat generated by the electronics is dissipated as quickly, effectively, and cost-efficiently as possible. A well-balanced thermal management concept will promote and enable a longer service life for the electronic components and thus higher performance and quality of the electronic end-product.

Key factors when selecting the most suitable TIM for a particular application are most fundamentally the thermal conductivity or thermal resistance, the electrical insulation properties of the material used, while taking into account the different material expansion coefficients to assure that thermal conductivity is maintained, in the X-Y plane and vertically in the Z-axis, when in use to control and mitigate thermally induced forces which might cause undesirable mechanical stresses. Figure 3 provides cross-sectional representations of the structures of Aismalibar's family of TIM products.

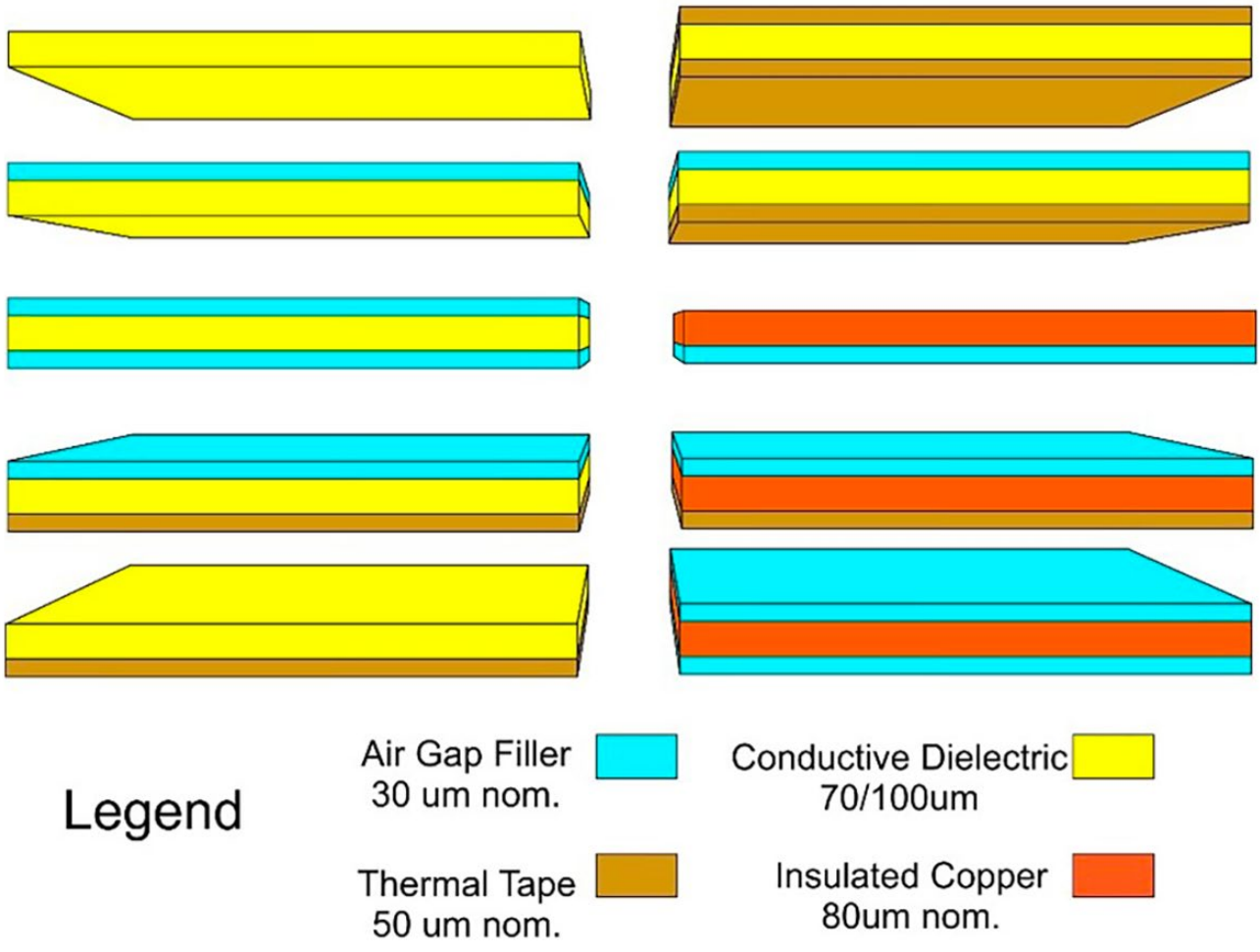

Figure 4: Aismalibar TIM construction offerings.

Summary

Electronics have continued to find their way into the products we use in our daily lives and it is unlikely this will abate any time in the foreseeable future. Management of the heat generated by those products to preempt early heat-related failure will likely grow in importance. Today, many users around the world rely on this proven TIM technology for power modules in PV inverters, wind power controls, electronic gears, AC/DC converters, and high-power LED-based industrial lighting systems. Many applications can also be currently found in electric vehicles (EV) for including areas of the drive train, charging devices used in the vehicle (on-board charger), and for the rapidly growing external rapid-charging infrastructure.

The solutions described in this article are proven, available, and ready to address the important thermal challenges including those where high dielectric strength is desirable. Aismalibar products are well suited to meet the growing need for such thermal management solutions to help mitigate and/or eliminate thermal challenges facing the electronics industry as power densities continue to climb. **PCB007**

Jeff Brandman is president of Aismalibar North America.

Etch Uniformity and the Puddle Problem

The Chemical Connection

NEW COLUMN **by Christopher Bonsell,** CHEMCUT

Christopher Bonsell, a chemical process engineer at Chemcut, is a new columnist for I-Connect007. His columns will appear monthly in PCB007 Magazine and will focus on topics concerning wet processes, wet processing equipment, and how changes in these areas can improve PCB manufacturing.

Printed circuit board manufacturers who utilize wet processes have always strived to obtain a uniform etch across their panels. Although it is one of the most common matters these manufacturers tackle, it is perhaps the least understood. There are a few reasons for this, one of them being that there doesn't seem to be an agreed-upon terminology within PCB manufacturing.

The term that I have been using to describe the consistency of etch across a single panel is "etch uniformity." Sometimes this term can be equated to the consistency of etch across several panels, but perhaps a more suitable term is batch uniformity, which is directly related to how you maintain the chemical properties of your etchant. When it comes to etch uniformity, however, the factors that affect it can become complicated.

What are the obstacles to etch uniformity? There are two primary things that limit your ability to get a uniform etch: conveyor density and the "puddle effect." Overall, the issues of etch uniformity stem from the idea that the etching reaction is drastically affected by diffusion and how quickly fresh etchant can contact the surface.

Conveyor Density

Conveyor density, in relation to wet processing equipment, can refer to how much space the wheels inside the processing chambers

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take up. To perform a conveyorized wet process, there needs to be enough open space to spray your panels. If you have too many conveyor wheels to move your panel, you are going to have a tougher time getting the etch rate you want. When it comes to etch uniformity on a single side of a panel, it is less about general conveyor density and more about the consistency of the wheel pattern. If you are trying to improve etch uniformity, this is not likely to be a concern unless someone running your machine decides to mess with the wheel placement, or if your wheels begin to deteriorate or warp from prolonged exposure to harsh chemicals. No matter what material your conveyor wheels are made of, they will eventually need to be replaced; how soon will depend on the material, the etchant used, and how often the machine is used.

If you are performing an etching process on both the top and bottom sides of a panel, conveyor density can also affect the overall uniformity. Since the bottom side of the conveyor will have more wheels than the topside, you will get different etch rates on both sides. This is because of the differing exposure and the pressure reduction caused by the wheels getting in the way.

Conveyor density is the primary limiting factor to etch uniformity and etch rate on the bottom side. The top side's primary limiting factor is a completely different challenge of its own.

The Puddle Effect

The puddle effect is a phenomenon that occurs on the top side of a PCB during the etch process. This effect is caused by the accumulation of etchant on top of a panel while it is being sprayed in the etch chamber. This puddle becomes an obstacle to etch uniformity because it makes the center of the panel harder to etch than the sides. As you spray a panel, the moment the etchant contacts the copper, it becomes less effective since it has already reacted. In the middle of the panel, this accumulation can happen quickly because it is hard for the etchant to run off the sides (Figure 1). Even with oscillation sprays, it takes a lot of work to push etchant in the middle of the panel out to the sides where it can flow off. Thus, if you ever just etch a panel without anything to assist the etch uniformity, you will see the middle of the panel obtaining less etching compared to the edges. If you are trying to process large panels, this variation can become quite noticeable. This has become such an obstacle that often in discussions about etch uniformity, the focus is on ways to get around this puddle.

What makes this puddle challenging to get around is that this would be like trying to solve a complex fluid boundary layer problem. When you are spraying into a puddle, it may take a lot of pressure to break through and give enough push and turbulence to the surrounding fluid. What happens at this fluid-surface interface is what makes etch uniformity the least understood topic. Developing a mental model of this can get very complicated because of a variety of factors such as the nozzles used, oscillation

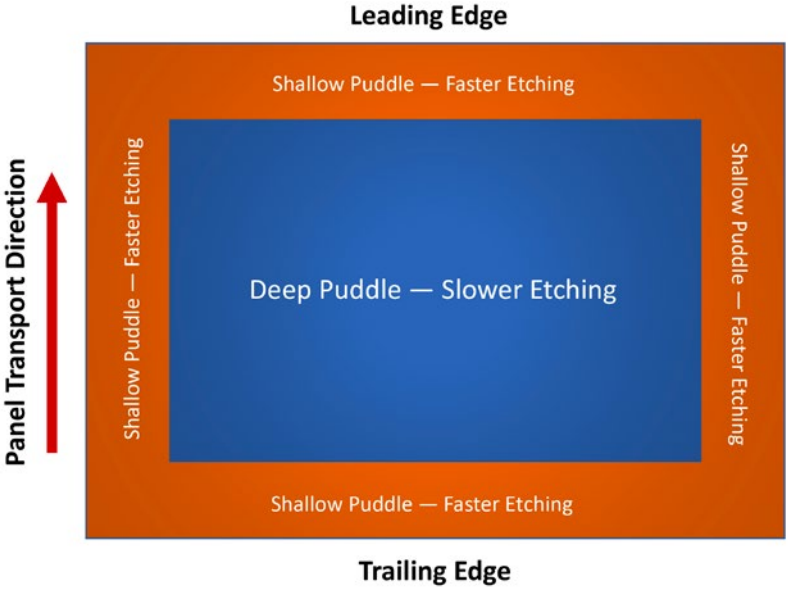

Figure 1: The puddle effect observed on the topside of a circuit board panel.

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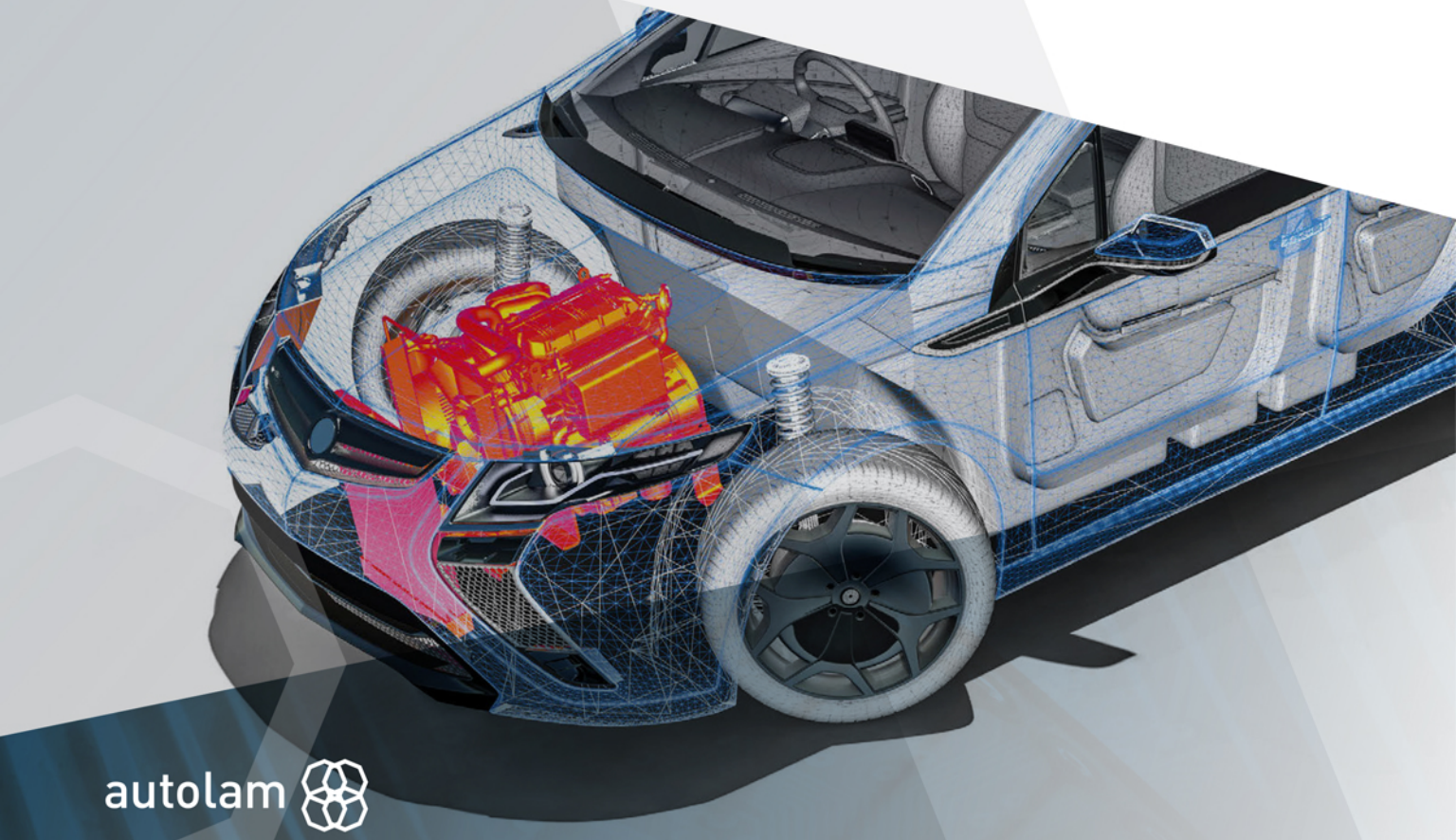

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rate, changing surface structure, spray tube flow rates, and many more. Often, changes in what seems to be the most intuitive solution do not provide much different results.

Although this puddle can be a significant obstacle, there is technology available for getting around it. In a future column, we will discuss the different technologies available, how they compare, and in what direction these etch uniformity solutions are heading.

How Can Changes in Etch Uniformity Affect PCB Manufacturing?

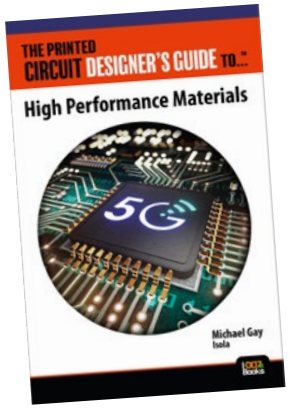
Improvements in etch uniformity technology could be a great boost to the PCB industry by allowing greater output from conveyorized systems and reduced error in manufacturing. If matters like the puddle effect could be negated, producers of printed circuit boards could make panels as large as they wish. Since it is a common practice to produce multiple smaller circuits from one panel, this change would greatly boost production and effectively make producing circuit boards at lesser cost.

Right now, the main hurdle to overcome is the puddle effect, but in the future, I foresee that the puddle effect will become less significant. With constant efforts to get around the puddle effect and improve the topside etch uniformity, we may get to a point where the topside uniformity becomes better than that on the bottom side. That is when new questions will arise. If top side etch uniformity becomes the new standard, how can we improve bottom side etch uniformity? Will changes in conveyor density be enough? If it is not, what will be the new limiting factors and how can we get overcome them? **PCB007**

Christopher Bonsell is a chemical process engineer at Chemcut. To contact Bonsell, click here.

BOOK EXCERPT

Introduction to *The Printed Circuit Designer's Guide to... High Performance Materials*



Choosing the right material for your application can be a major challenge. There are "cost to performance" decisions that need to be made in order to select material that will meet the expected performance requirements and the desired cost targets. Selecting a material that meets cost targets, but fails to perform in prototype development testing, results in costly revision spins, increases cost, and results in delays to market.

From the resin type, the styles and types of glass fabrics, and various types of copper foils, the reader can have a clearer picture of what to know when selecting which material is most desirable for their upcoming products. This book does not provide answers to all things laminate, but the hope is to provide a solid base for making material selection decisions and, along the way, answer some key questions.

When designs require high voltage CAF performance, thermal robustness, or high-speed massive data transmission rates, laminate materials must be selected to suit your requirements for printed circuit boards. The components used to make the laminates must be studied to know the influence on these kinds of applications.

This book was generated by key technical resources at Isola Group. Each of the contributing technical experts have 25–35 years of industry experience in laminate raw materials, laminate and prepreg manufacturing, laminate material development, new product introduction, PCB fabrication, and OEM applications. These individuals have contributed many years of tacit knowledge and experience, which are the basis for this book.

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How the Pandemic Impacted PCB Manufacturing

The Plating Forum

Feature Column by George Milad, UYEMURA

The coronavirus pandemic has had a major impact on PCB manufacturing and assembly. Thanks to its classification as an essential business associated with national security, PCB manufacturing in the U.S. was exempt from shutdowns; it was not, however, immune from supply chain disruption. Raw materials shortages set the stage for higher prices. Companies that relied on just in time (Kanban) inventory management held back product, further burdening the supply chain.

Conversely, the pandemic also had a positive impact on manufacturing in the United States. Domestic companies increased their output and new opportunities were created. In addition, the pandemic itself created demands on the electronics industry, particularly in the field of testing, where millions of single-use circuits had to be manufactured locally.

The prolonged pandemic also forced companies to set up remote work. It quickly became apparent that high-speed internet allowed even complex tasks to be completed off-site. Today it is common for managers and technicians at all levels to work remotely. As the pandemic evolves into endemicity, working remotely is widely expected to remain an option for many.

In the electronics industry, opportunities for remote work are limited; companies must compete with the appeal and convenience of remote work, making employee retention more challenging than ever. Companies that meet this challenge do so by demonstrating a career path for those who meet expectations; they also invest in continuous training so that employees believe that management is invested in their progress. An employee who

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receives pay increases, learns new skills, and is given more responsibility is less likely to seek employment elsewhere.

Of course, the biggest incentive to stay with a company is the belief by the worker that he is a member of a winning team, trusted by management to make decisions that will keep the company moving forward.

For the industry to thrive, it must be able to contend with global competition. To support the electronics industry and level the playing field against foreign competitors, the Senate passed The United States Innovation and Competition Act (USICA) in June 2021. The bill provides billions of dollars to improve the domestic capacity to produce semiconductors. This bill is welcome by the electronics industry as an incentive to produce semiconductors. However, the bill limits funding to a small sector of the industry and fails to address other related links in the supply chain that are critical to America's competitiveness.

For the industry to thrive, it must be able to contend with global competition.

According to Meredith Labeau, chief technology officer at Calumet Electronics, "Semiconductors don't work alone; they are only one piece of the electronics DNA. The electronics value chain is complicated. To build advancing technologies, the system requires a wide array of moving parts: semiconductors, yes, but also organic/ceramic interposers, assembled printed circuit board and more. All these different components are critical for chips to actually do anything. And America is woefully trailing in the global competition to produce these critical products. The domestic supply chain has 1-2% of the advanced packaging economy needed to put these products together to power our technology. And these supply chains are often the most vulnerable to global shocks and disruption."[1]

PCB manufacturing and assembly was not included in USICA. To bring government attention to this omission, the Printed Circuit Board Association of America (PCBAA) was established in 2021 by a consortium of major PCB manufacturers and their suppliers, who understood the need for greater support from their government to protect against unfair foreign competition.

PCBAA's goal is to level the playing field with overseas suppliers that are frequently subsidized by their governments, and often do not have to comply with the environmental constraints that are imposed on U.S. manufacturers. For the sake of national security and stability, the domestic PCB industry needs the support required to expand its share of the world PCB market far beyond the current 4% of the total production.

The author supports this effort. PCB manufacturing and assembly in the U.S. needs a concerted effort to propel the industry forward and regain market share. Government agencies must also support the industry by funding innovative research that will incentivize domestic suppliers and attract OEMs back to the local market. **PCB007**

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1. "Meredith LaBeau: How Congress Can Support American Electronics Manufacturing," Calumet Electronics Corporation, Oct. 15, 2021.

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

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Engineering RF Dielectric Material to Enable 5G/6G Antenna Devices

Feature Article by Chudy Roosevelt Nwachukwu
ITEQ CORPORATION

Introduction

Accurate characterization of frequency-dependent inhomogeneous dielectric material properties is key to the optimal design of high performance and cost-effective PCB antennas. These antennas will be required to enable the plethora of devices forecasted for 5G/6G communication. Therefore IT-88GMW, an advanced resin system reinforced with tightly woven thin glass fibers has been formulated to improve the Q-factor of interconnects and passive components fabricated on PCB laminates.

The electrical and thermomechanical properties of dielectric materials primarily determine the performance of high-speed circuitry fabricated on PCB laminate technology. Therefore, a recommended practice for PCB fabrication is to implement characterization methodologies that provide relevant information about the material's performance in realistic scenarios. Hence, rather than limit characterization to solely obtaining nominal data at particular frequencies by assuming signal propagation in a direction of best performance, the material characteristics should be analyzed in different directions and positions. This gives the designer a clearer idea of how much variation to expect in an actual implementation, in contrast to ideal conditions that are typically assumed to simplify the design cycle.

In selecting a laminate material for a high speed/frequency antenna design, the composite material properties are critical parameters that will determine if the antenna patches and network of interconnects to be fabricated can

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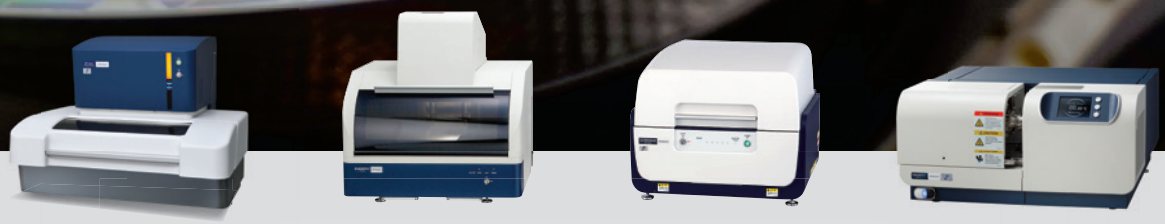

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meet the loss, timing delay, and impedance match requirements of the application. PCB laminates are typically manufactured in two ways:

1. By impregnating and strengthening a woven fiberglass fabric with resin.
2. Reinforcing the resin system with non-woven fibers or alternative fillers to control the coefficient of thermal expansion.

In addition to optimal electrical properties, dielectric materials for high speed/frequency applications are engineered to exhibit improved thermal reliability, dimensional stability, and low moisture absorption. The resin matrix at the core of these systems has greatly evolved from standard epoxy to olefin chemistries which exhibit the desired electrical properties of PTFE-like substrates, but also offer ease of processing and low reliability risk. Figure 1 offers a simplified illustration of these resin chemistry performance targets.

In addition to dielectric properties, conductor losses (due to resistivity and skin depth) are important criteria for laminate selection. The surface roughness of copper plays an important role in increased attenuation observed at the millimeter wave frequencies required for 5G/6G communication. In this regard, cop-

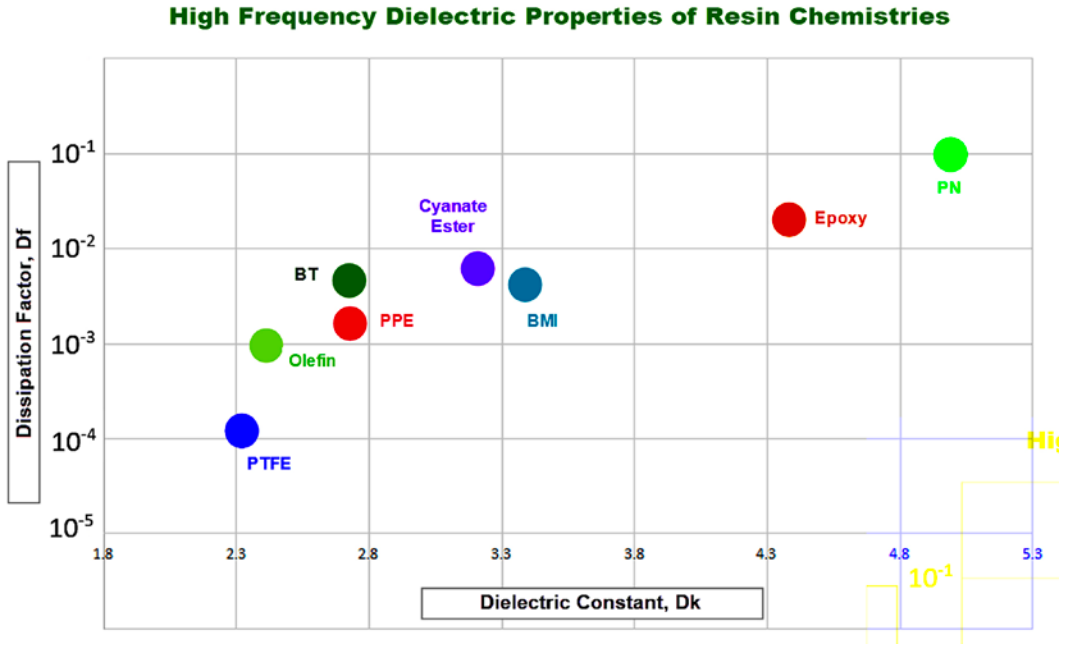


Figure 1: Evolution of resin chemistry dielectric properties.

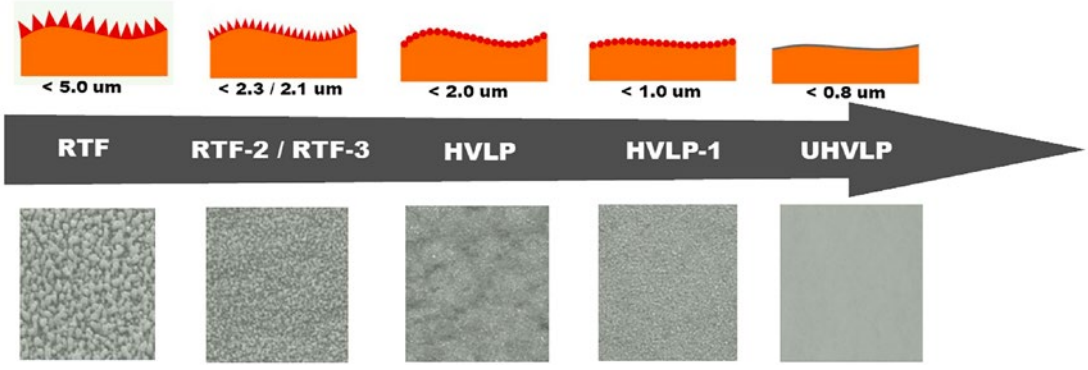


Figure 2: Rz measurements showing copper roughness improvements.

Material selection	Laminate thickness	Copper Type #1	Laminated side (Rz)	Photoresist side (Ra)	Copper thickness	Dk @ 40 GHz	Df @ 40 GHz	Antenna Freq Target
IT-88GMW	5 mil	HVLP1	0.88 µm	0.18 µm	0.625 mil	3.00	0.0012	72–81 GHz

Table 1: Attributes of the RF material chosen for antenna.

per vendors have responded to the industry's needs and greatly improved surface roughness to minimize skin effect and improve peel strengths to promote optimal adhesion of the dielectric material to the treated foil. Figure 2 shows the recent improvement in copper surface topography.

Description of PCB Prototypes

ITEQ Corporation and INAOE collaborated to design two test vehicles to investigate the sensitivity of patch antenna structures to Dk and Df variability over spatial material inhomogeneity and across millimeter wave frequencies. The four-layer hybrid material stackup shown in Table 1 was designed with ITEQ's IT-88GMW high performance RF material; 5 mil cores, constructed with 1/2 oz ultra-low roughness copper.

This critical layer was supported with a nonfunctional 50-mil standard IT-180 high Tg material core and prepreg, to improve rigidity and minimize measurement-induced errors due to warpage or flexure of the thinner radio frequency-grade performance dielectric core. The stackup details, microstrip impedance target, surface finish and layer dimensions are shown in Figure 3.

Pressed Thickness (mil)	IT-88GMW RF Stackup	DESIGN TARGET Z SE (ohm)	Line W (mil)
58			
	ImAg surface finish		
1.2	1 0.5 oz U-HVLP	50	12.6
5	RF core		
0.6	2 0.5 oz U-HVLP	REF	
50	IT-180 prepreg & core		
1.2	4 0.5 oz STD	-	-

Figure 3: Stackup construction for the prototype.

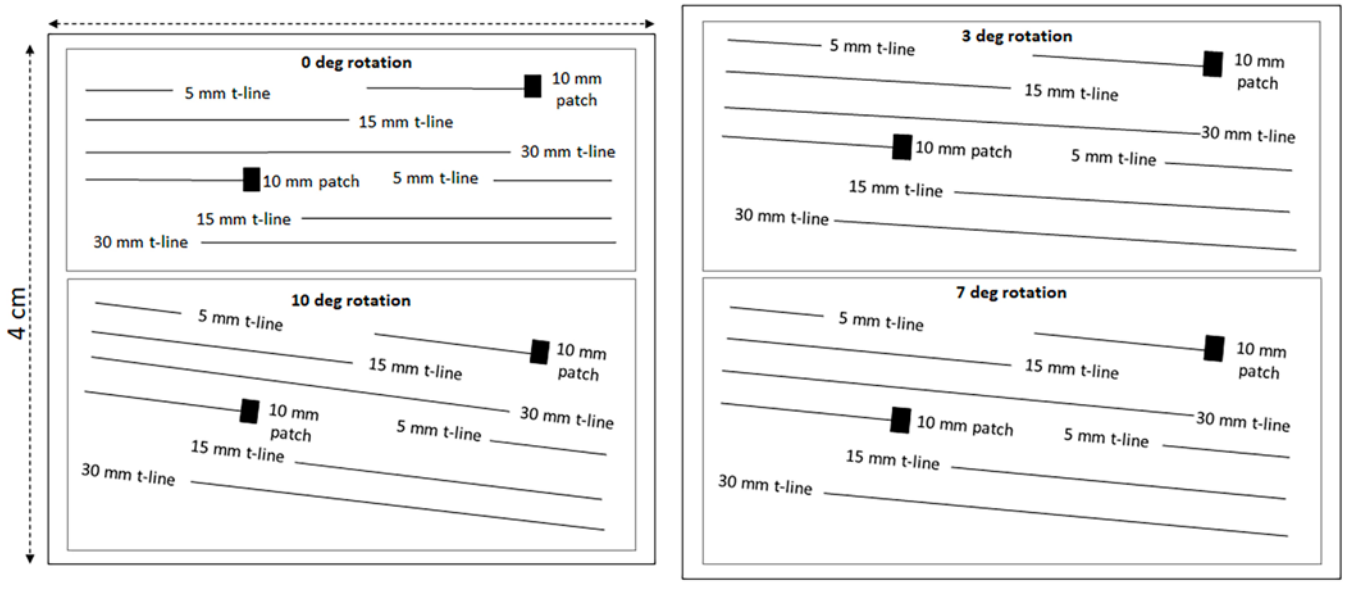
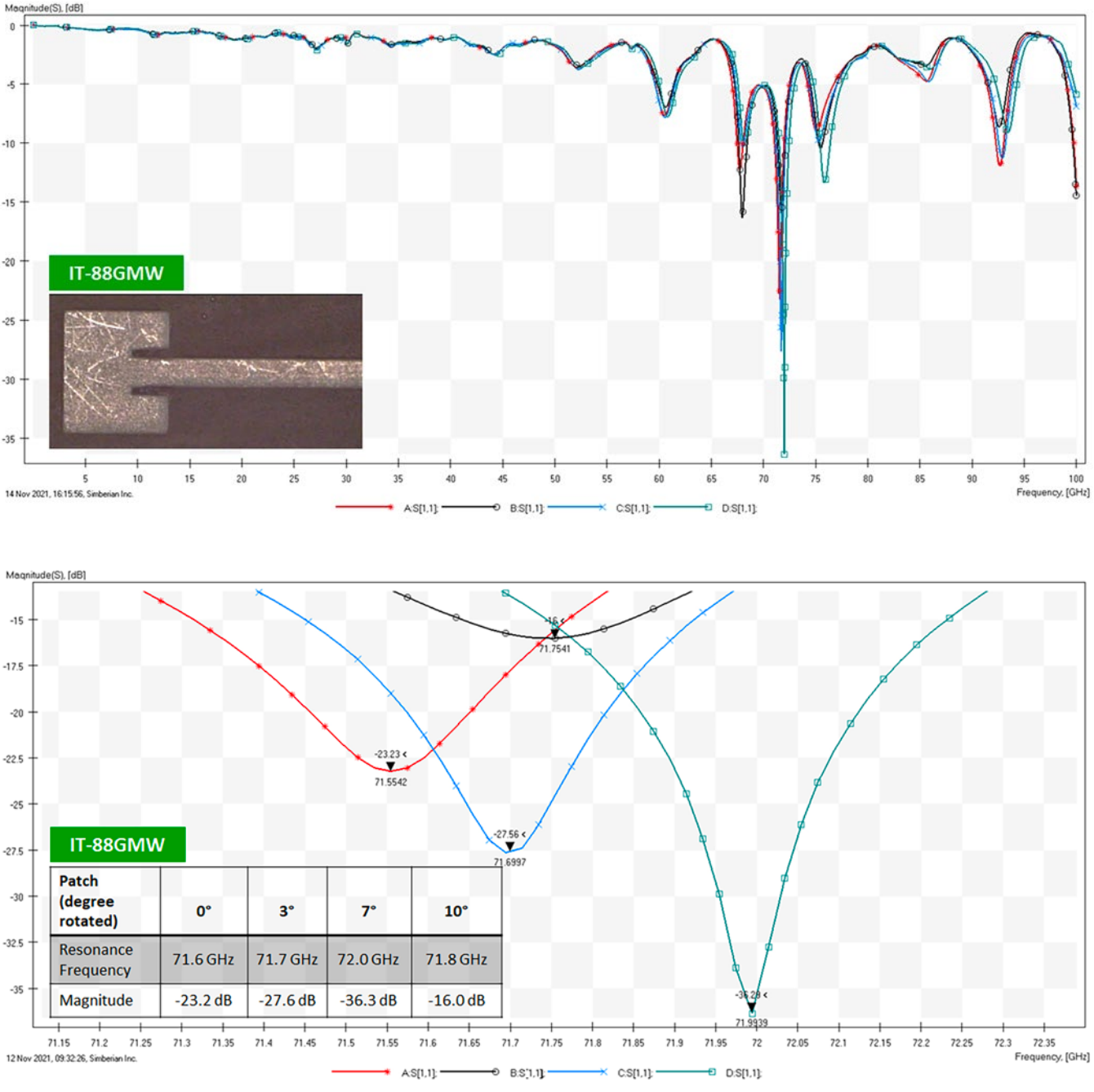


Figure 4: PCB serialized layout for test vehicle fabrication.

The inhomogeneous composition of most PCB laminates introduces local variations in the material's complex permittivity, which in turn can affect the performance of interconnects operating at high frequencies. These local variations in the horizontal plane are primarily caused by the fiber weave and have been shown to result in a periodic loading effect exhibited by the transmission line interconnects. The comprehensive study[1] predicted the frequency at which these resonances occur with rigorous numerical and graphical methods, which considered the pitch between the fiber woven bundles and trace angle (with respect to the bundles).

To investigate the effect of this periodic loading phenomenon on our patch antennas, the following routing Φ angles (0°, 3°, 7°, 10°) were used to orient the microstrip structures with respect to weft of the weave. Figure 2



Patch (degree rotated)	0°	3°	7°	10°
Resonance Frequency	71.6 GHz	71.7 GHz	72.0 GHz	71.8 GHz
Magnitude	-23.2 dB	-27.6 dB	-36.3 dB	-16.0 dB

Figure 5: Patch antenna measurements.

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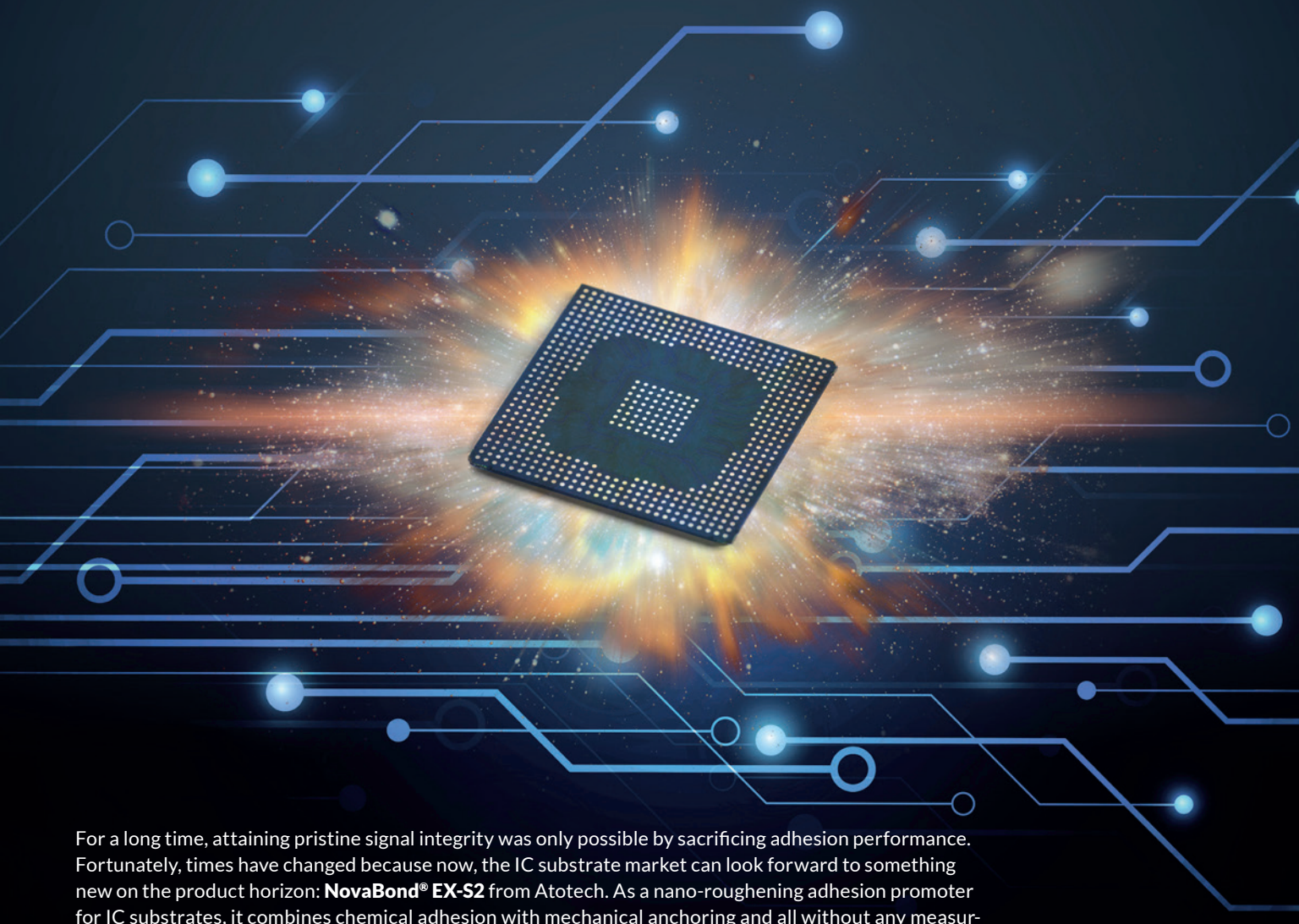

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depicts the serialized layout of the fabricated PCB structures.

Each serialized coupon featured transmission line segments terminated on one end (for the RF patches) and both ends (for single-ended microstrips) with ground-signal-ground (GSG) pads so that coplanar RF-probes with a 200 µm pitch could be used to perform high frequency S-parameter measurements up to 103 GHz. The test structures are as follows:

Four sets of 5 mm, 15 mm and 30 mm long microstrips oriented at 0°, 3°, 7°, and 10°

Two sets each of antenna patches oriented at 0°, 3°, 7°, and 10° fed by 5 mm and 10 mm microstrip lines

Measurement Results and Summary

Antennas routed on the IT-88GMW material showed ~0.17 standard deviation from target resonance frequency. The magnitude of the resonance showed optimal reflection coefficient (max -36.3 dB) in all rotated positions (note: minimum required gain is -10 dB for an efficient patch antenna). Compared to datasheet values (~3.0 Dk), IT-88GMW showed 1.34% change in Dk reflecting the degree rotations across the panel.

The data obtained from this investigation shows that this is an optimal copper-clad laminate material engineered for W-band frequency antenna designs. **PCB007**

Acknowledgements

- INAOE (National Institute of Astrophysics, Optics and Electronics)
- E/E Department - Reydezel Torres-Torres, INAOE
- Edgar Colín-Beltrán, Conacyt-INAOE
- Maria Serrano-Serrano, INAOE

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Chudy Nwachukwu is technical director, OEM marketing and design for SI, ITEQ.

IPC APEX EXPO: Conference Speakers Speak Out

Qualification Protocols for a Sustainable and Innovative Release Aid Within the PCB and CCL Laminating Press Process

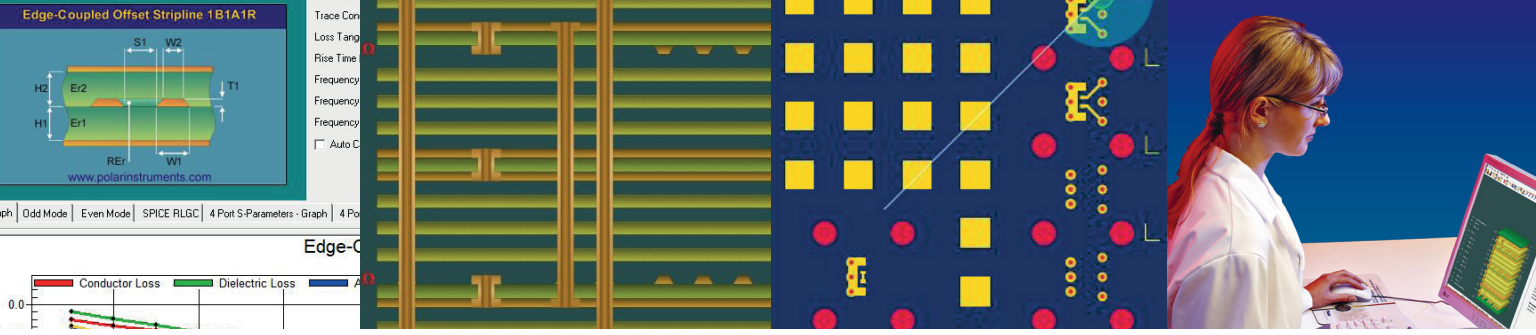
Presenters: Clothilde Manzano, Ph.D.,
Marketing Development Manager

Ahlstrom-Munksjö Sébastien Esnault,
Product Engineer, Atlantec, Group ACB

What is the most interesting question that your IPC APEX EXPO presentation answers? How can we improve the environmental footprint of PCB producers when considering only consumables? In this way, could we replace the standard plastic film used as release sheet during PCB lamination by a more sustainable and cost-effective release sheet?

What is your answer to that question, and why? Replace the traditional plastic release films by a new generation of release sheets: the release parchments. The release parchment, OptiLayup, is made of 100% cellulose, is biodegradable and compostable. Last but not least, it is cost efficient and has shown very good performance for IPC Class 3 PCB production.

What is the most important piece of advice that you have for your audience? See beyond and do not be stuck to your first impression. Innovation is a journey and even a tiny step is useful for every stakeholder!



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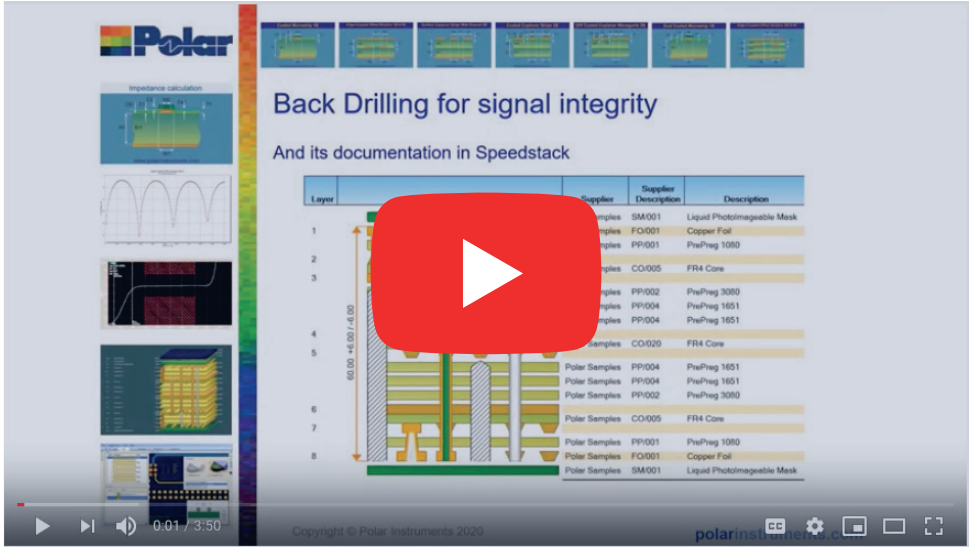

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Looking at the Process of Repanelization

Happy's Tech Talk #6

Feature Column by Happy Holden, I-CONNECT007

I have spent many years in printed circuit fabrication, including nearly 20% of my career in Asia. One problem that concerns all fabricators is the issue of how many "X-outs" are allowed per assembly sub-panel array. Here are a couple of solutions I have used and encountered in my travels.

X-Outs

Many of you may follow the good advice of Greg Papandrew, who writes about PCB issues. He says, "X-outs are allowed. However, not more than 20% of the PCBs in an array can be X'd-out, and no more than 10% of the arrays to be shipped may contain an X-out. X'd-out arrays are to be segregated and identified accordingly at time of shipment."[1]

X-out Repanelization Replacement Technology

The process that my engineering group developed was a "replacement" technology. This process was developed as part of enhancing the number of good arrays that we were shipping, thus eliminating waste.

Perfect yields are always the goal, but when faced with the production obstacle that has more than 20% X-outs on an array, the ability to "repanelize" with good boards creates an "all good array" when the alternative was to scrap good boards. This process is shown in Figures 1 and 2.

The process of repanelization consists of seven steps:

1. By lot acceptability. Does the customer and board costs indicate this is a good business move?
2. Rout the good boards out of their array. Then rout the opening for the board in the new array.
3. Do the array dimensions permit the substitution?

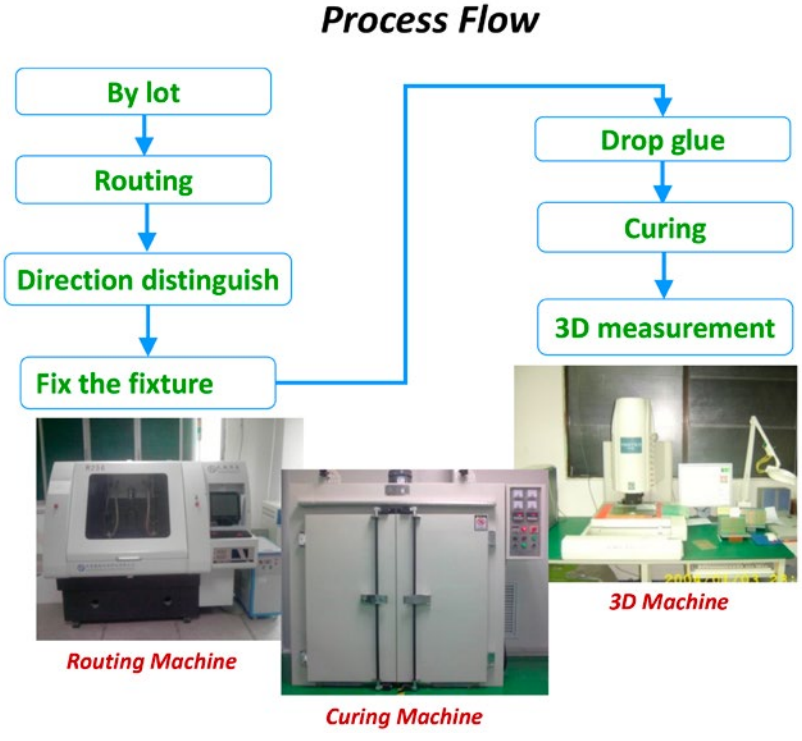

Figure 1: Repanelization replacement process and key equipment.

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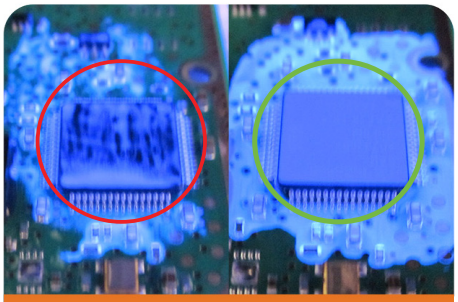

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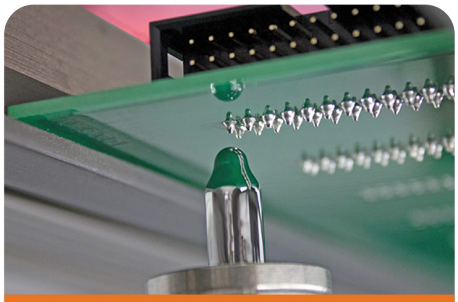

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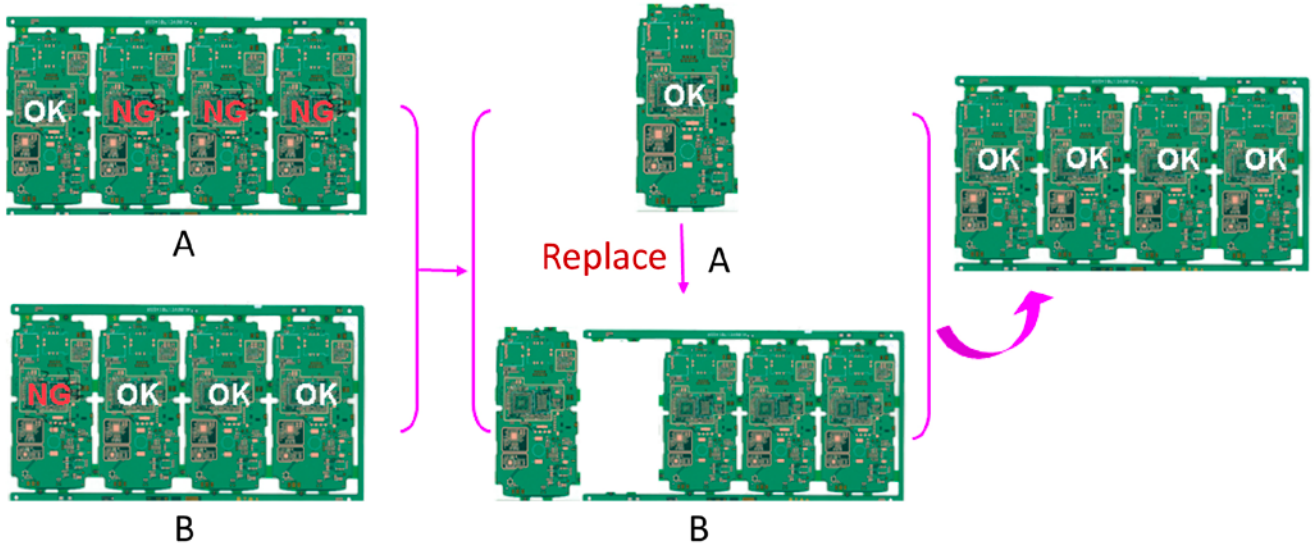
4. Affix the array and added boards in a fixture that will hold the individual pieces.
5. Apply the glue that will hold the board in the array.
6. Cure the glue either by heat or UV light.
7. Measure the placement to match any specifications (Figure 2).

Optimized Repanelization

Customers are not always aware of the added costs subpanel-arrays may create. Tightly packed arrays are not a cost problem, but if the customer or EMS has spaced the boards apart and the materials are expensive, this wasted material will increase the cost of the board or array. With the costs of high-layer count mul-



No	Item	Specifications	Frequency
1	Plane-height-tolerance measurement	± 50um (or follow customer requirements)	5 Strips/Lot
2	Pad-to-pad registration tolerance	± 75 um (or follow customer requirements)	ALL
3	Reflow verification	Reflow for 5 cycles. No blister, delamination at the connector of XOR board.	3 Strips/Lot
4	Thermal stress test	288 ± 5°C, 3 cycles. 10~11 seconds per cycle. No blister, de-lamination at the connector of XOR board.	5 Strips/Week
5	Tensile strength test	Board thickness 0.4mm >1.5 kgf Board thickness 0.6mm >3 kgf Board thickness 0.8~1.05mm >5 kgf Board thickness 1.6mm UP >8 kgf	3 Strips/Lot
6	Tape-peeling test	No copper exposure after peeling with 3M	3 Strips/Lot
8	Bow & twist test	≦ 0.5% (or follow customer requirements)	3 Strips/Lot
9	Soldering test	Observe the soldering status whether reach 95% (qualified standard); crack, bubble and discolor at replacement area are not allowed. (or follow customer requirements)	By P/N

Figure 2: Repanelization process and quality control items for the process.

tilayer and HDI going up, we modified the replacement process to create a new paradigm in array design. When the costs indicate that the array layout creates a lot of wasted material, we have the CAM department lay out a multi-image panel for production. After test and inspection, the good boards are placed in an array made to the array specifications from a routed bare FR-4 material.

The advantages of this process are:

1. Single module and break-aways can be individually produced.
2. Increases the production panel material utilization or plating distribution.
3. Improves the dimensional stability.
4. Reduces environmental pollution and scrap caused by discarded boards.

The process is seen in Figures 3 and 4. Interestingly, some customers now prefer

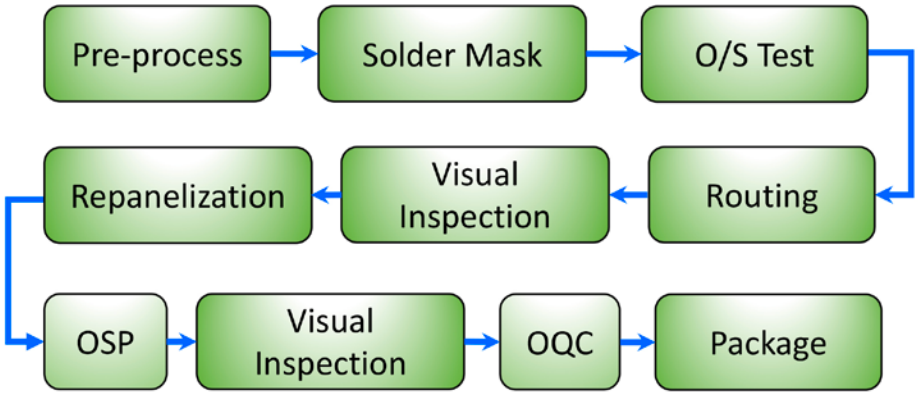


Figure 3: Process flow for array repanelization.

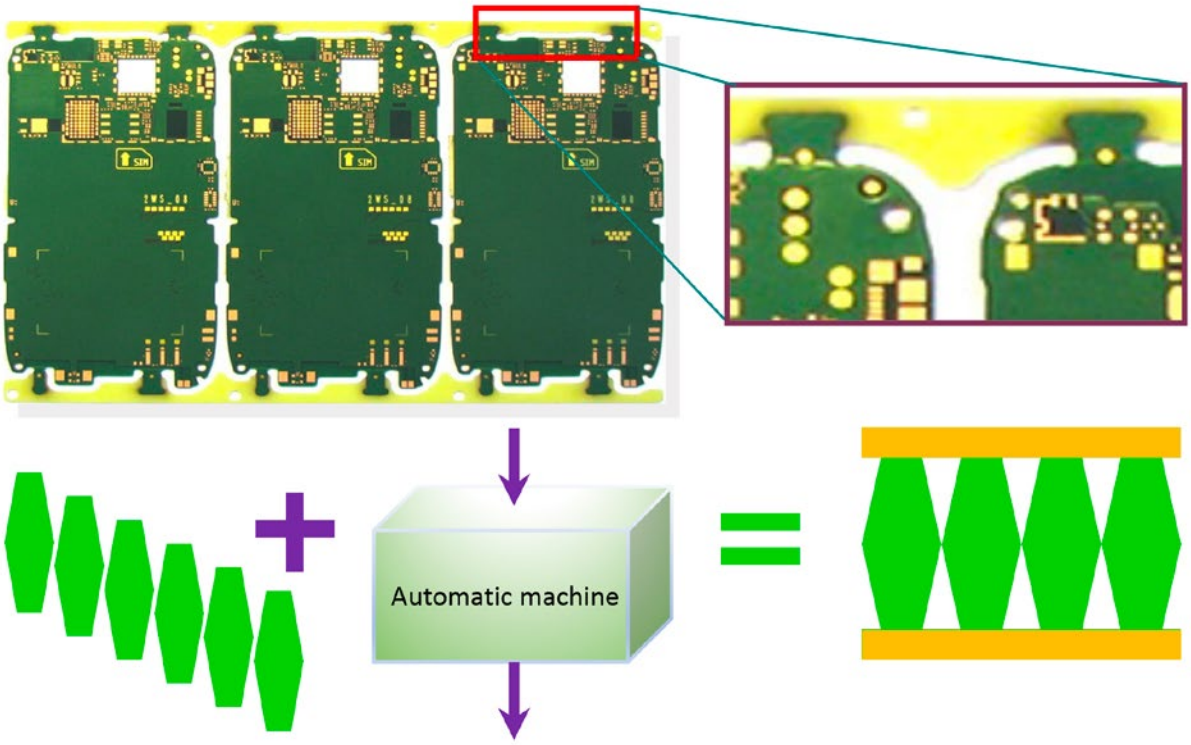


Figure 4: Individual finished board repanelization in a simple piece of laminate.

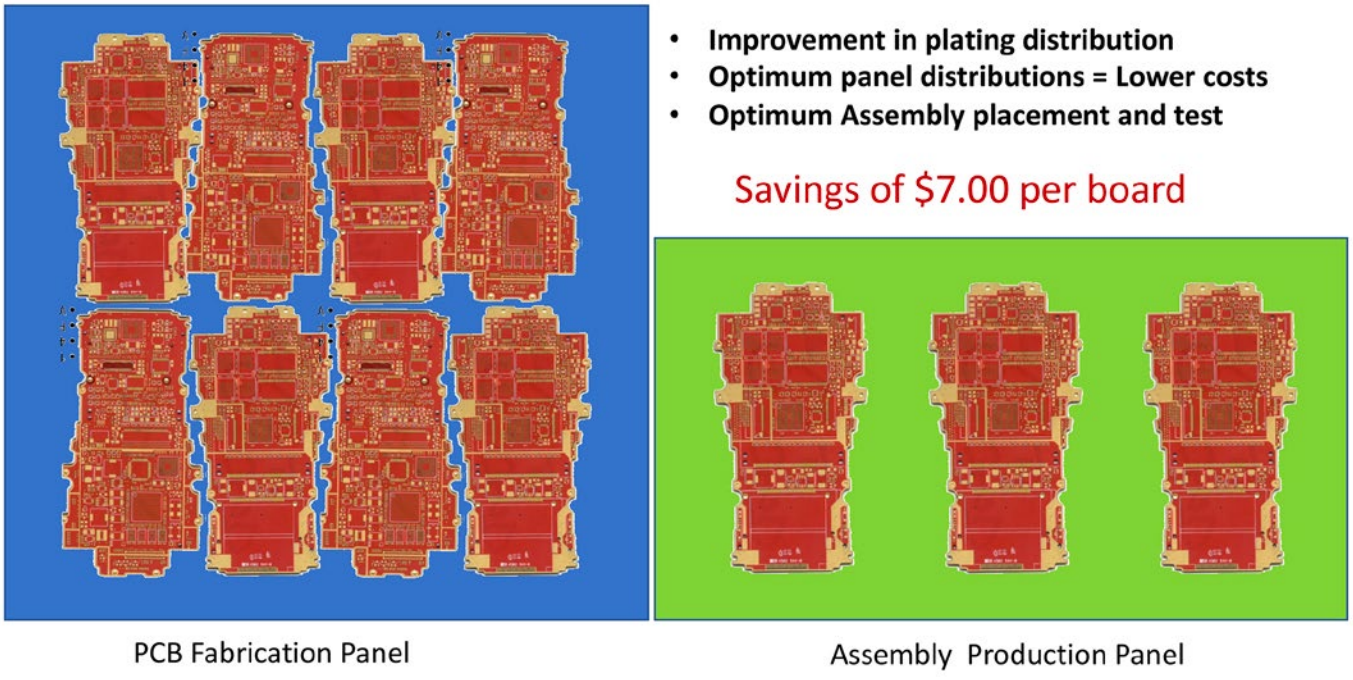
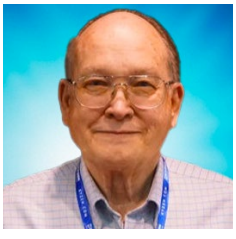


Figure 5: Example of an HDI 12-layer (3+6+3) placed in a simple FR-4 carrier to save wasted material on the production panel.

this standardized-optimized array procedure to the old array method.

A good example of this is shown in Figure 5. The 12-layer HDI board (3+6+3) was ordered by the customer in the array of 3-up. By using a production panel of 8-up or 12-up, even with the additional material of the carrier and labor, the cost of this HDI board was reduced by $7 per board. **PCB007**



Happy Holden has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa Westwood, Merix, Foxconn, and Gentex. He is currently a contributing technical editor with I-Connect007, and the author of *Automation and Advanced Procedures in PCB Fabrication,* and *24 Essential Skills for Engineers.* To contact Holden or read past columns, click here.

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Fundamentals of Acid Copper Electroplating

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

Introduction

Electroplating a printed circuit board is by no means a trivial task. Higher layer counts, smaller diameter vias (through-hole and blind), as well as higher performance material sets contribute to the greater degree of difficulty with today's technology. So, process engineers pay close attention to the "softer" issues such as cathode current density, solution chemistry (copper sulfate and sulfuric acid concentration), and—sometimes—addition agent control.

The concern here is that acid copper pattern plating of a printed circuit board has many critical aspects that must be diligently controlled for optimum performance. These include solution agitation and filtration, anode length and placement, current distribution effects, reducing electrical resistance in the plating cell, photoresist development, and controlled organic contamination in the plating solutions. More on these issues in a future column.

Yes, electroplating or electrodeposition, as some prefer, is a complex process. A review of the fundamentals is warranted.

In this month's column, the intricacies of electrodeposition technology and its function of building up the thickness of copper in the holes and on the surface will be presented in detail. In this next series of columns, the function of the active ingredients in the copper plating solutions will be presented. Process control limits for the various plating solution components and the effects on deposit integrity will be discussed.

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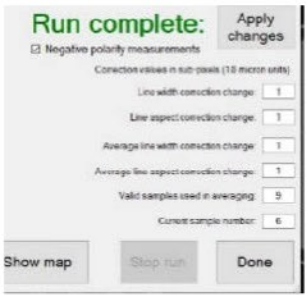

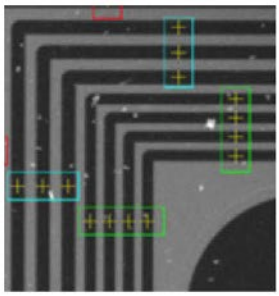

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Understanding Plating Cell Resistances

While most engineers work diligently to control the chemical aspects of the electroplating process to ensure optimum throwing power (surface-to-hole ratio), they often overlook other critical parameters of the process. These include resistance through the cabling leading from the power supply to the plating cell, plating rack current-carrying capacity, and additional resistances within the cell. As it stands, electroplating is governed by Ohm's Law: The greater the resistances within the plating cell, the more difficult it will be to achieve uniform plating thickness distribution. I like this analogy:

- Current flow (analogy) is likened to a flow of water through a hose
- Flow of water:
  GPM = pressure divided by resistance
- In other words, the longer the hose or the smaller the diameter of the hose opening, the less water you will get

The same then can be said about current flow to the plating cell. Current is dependent on resistance and voltage. If resistances increase, the flow of current to the plating cell is reduced.

Thus, based on this analogy, I prefer to design the cell with minimal distance of the cables from the power to supply to the plating cell. In addition, the current carrying capacity of the cables is critical to achieve uniform current flow and to minimize current loss. If the cabling from the power supply (rectifier) to the cell feels "hot" to the touch, this is an indication that there is a loss of current reaching the cathode (circuit board). Figure 1 depicts the connections and solution resistances in the electroplating cell.

Understanding where these resistances are and finding opportunities to mitigate them will help improve plating distribution and throwing power especially in high aspect ratio through-holes.

The key takeaway from Figure 1 is that in addition to these various resistances in the cell, there is a voltage drop (IR drop) down the through-hole. The greater the resistance through the via, the less uniform the plating in the through-hole will be. Copper plating

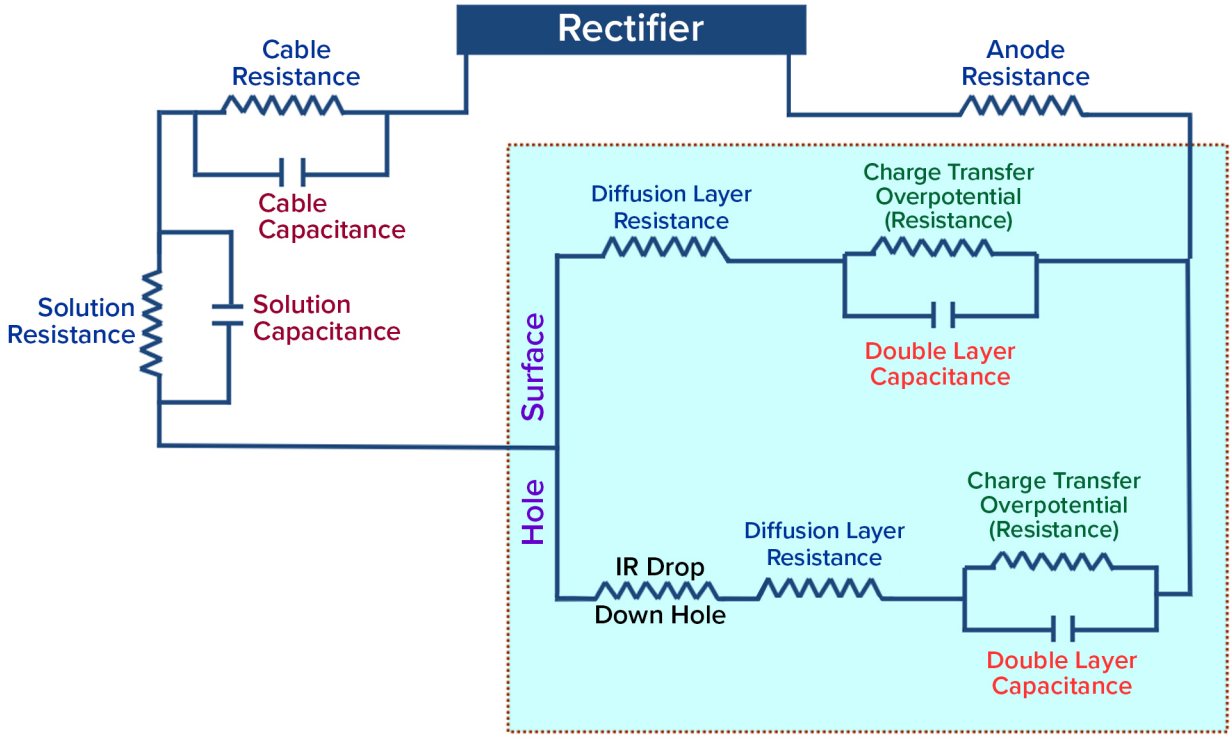

Figure 1: Schematic of an electroplating cell.

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thickness does matter in terms of long-term reliability.

- IPC-6012 specification requires a minimum of 0.8 mils of plating in holes for Class 3 products. On thicker PCBs, this plating thickness may produce occasional problems with plated through-hole reliability.
- If the thickness is insufficient (especially in the center of the barrel of the through-hole), long term reliability with respect to lead-free assembly and harsh use environment (HUE) is compromised.

An example of lower copper thickness is shown in Figure 2.

The depiction in Figure 2 is somewhat common, particularly as boards become thicker and via diameters become smaller. However, that is no reason to throw up one's hands and accept such a condition. There are ways to mitigate this issue and improve the throwing power even in complex high aspect ratio board designs. Ensuring sufficient copper plating thickness is critical to meet and exceed long-term reliability requirements.

More on this subject in my next column. **PCB007**

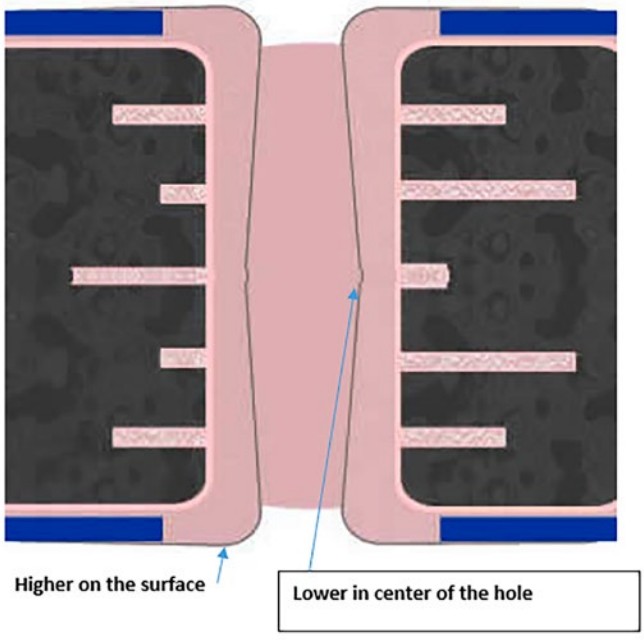
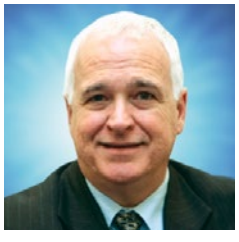


Figure 2: Poor throwing power results in lower copper thickness in the center of the via as compared to the surface.



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

Automotive Initiatives at IPC APEX EXPO 2022

By Tracy Riggan
IPC SENIOR DIRECTOR, SOLUTIONS

A significant number of automotive activities made notable strides at this year's IPC APEX EXPO. Several committees dedicated to creating and updating automotive addenda for existing IPC standards, like assembly processes, PCB fabrication, and high-voltage cable, met and were led by companies like Toyota, Bosch, Continental, and Elmatica. Automotive dedicated groups, like the Cold Joining/Press-fit Task Group, also met and discussed inclusions in its next planned revision. As part of the IPC-6012 Automotive Addendum Task Group meeting, the group brainstormed high voltage considerations in the next revision or as separate standards, building on discussions that took place during task group meetings in conjunction with productronica 2021.

Additionally, automotive was a component of educational programming, with several courses and technical papers presented throughout the week. The Press-fit Technology Deep Dive course outlined key design processes and how to use the standard for process, quality, and design/development engineers for manufacturers and OEMs who use electronic components. Vern Solberg, Solberg Technical Consulting, conducted a course on PCB design which addressed flexible and rigid-flex applications and design principles for automotive use environments.

To learn more about or become involved in IPC automotive initiatives, contact: TracyRiggan@ipc.org.

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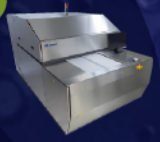

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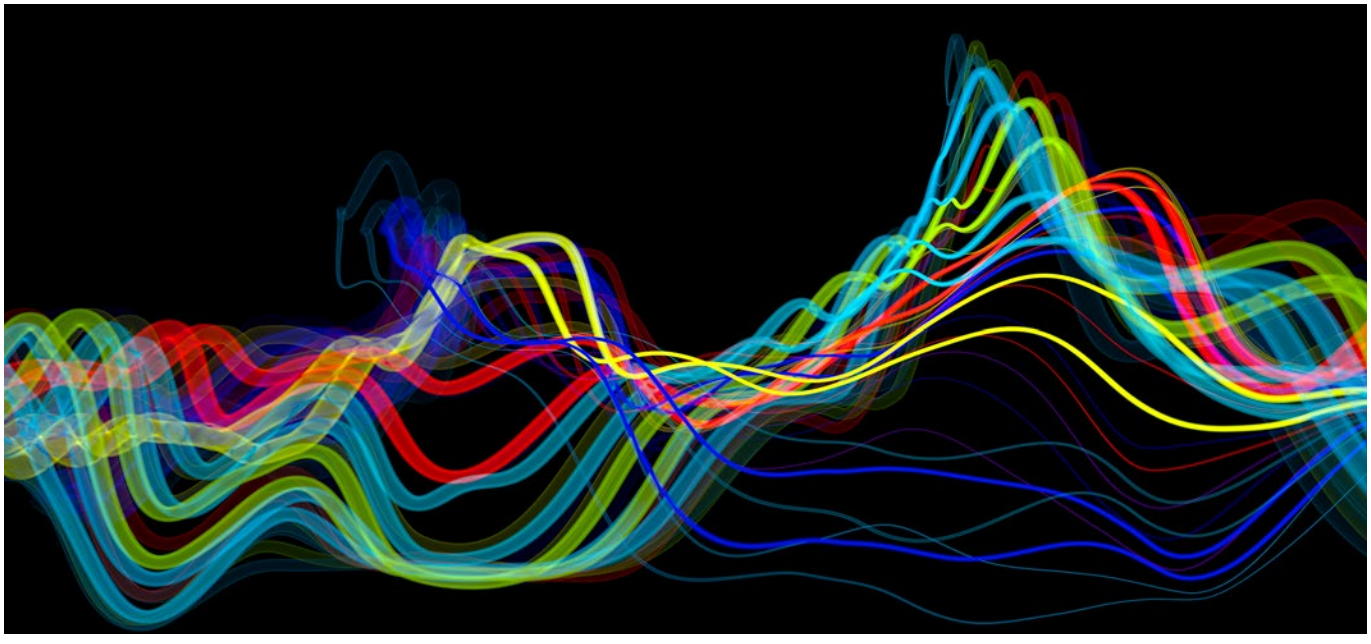
Measuring Multiple Lamination Reliability for Low-loss Materials



Feature Article by John Strubbe
TAIWAN UNION TECHNOLOGY CORPORATION

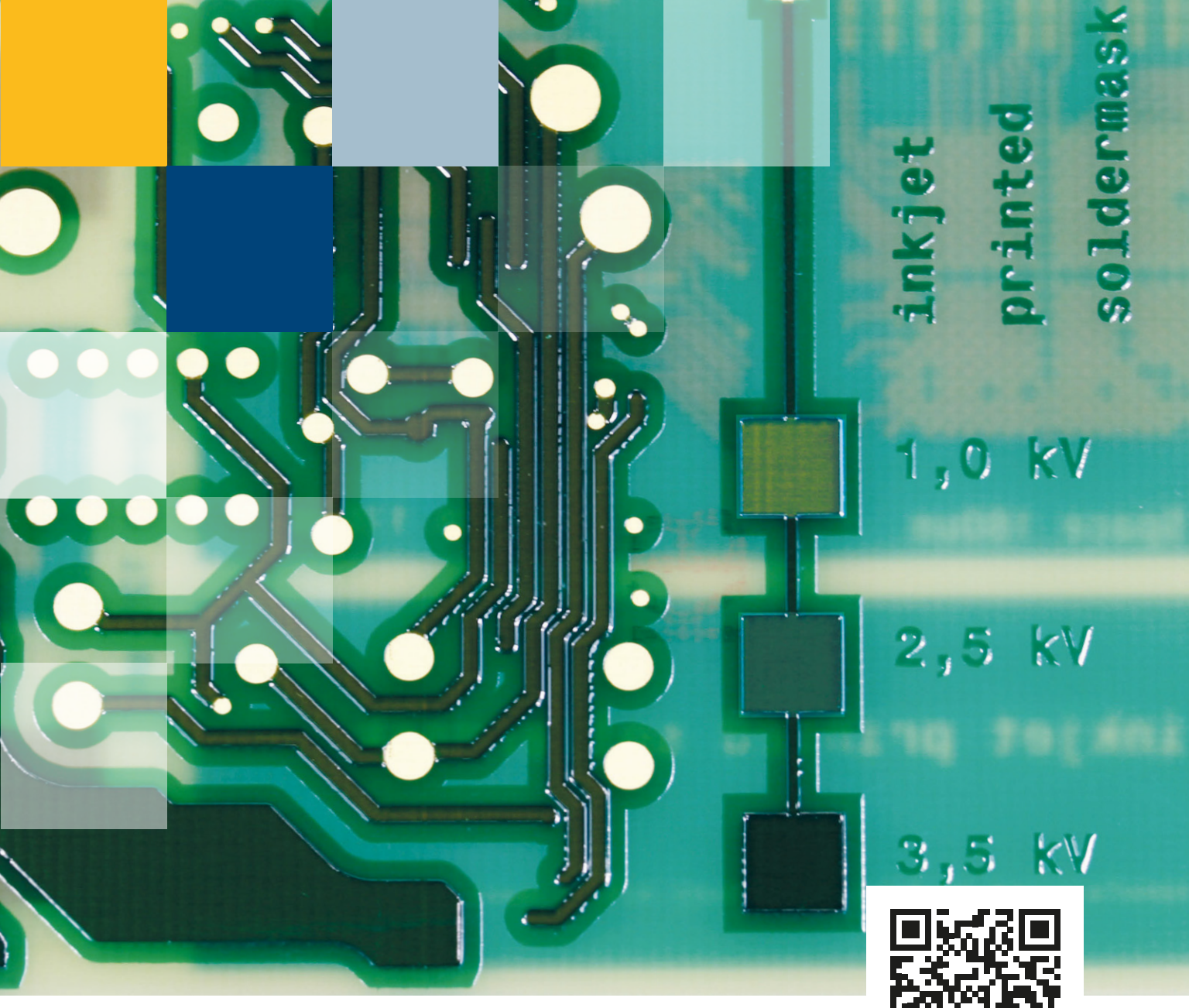
Taiwan Union Technology Corporation (TUC) provides copper-clad laminates and dielectric resin composites used to manufacture printed circuit boards. The enthalpy of these resin composites meets and exceeds customers' objectives and shows the deterioration of the resin's physical properties as a result of multiple lamination cycles (up to 10X). This article describes how TUC evaluates the possible change in resin structure due to multi-thermal laminations.

Polymer Degradation Based on Stress-Strain Curve

The curve describes the method of measuring polymer degradation using tan δ (tan delta)—ratio of G″ to G′. With regard to material compounds of synthetic macromolecules, the degradation is evaluated by measuring the resin composite interfaces and adhesion, and how they collectively play a role in determining the properties of the polymers during processing. The strength of polymer-polymer interface between polymers depends on the structure that develops during its formation.

The accumulating cycles on these resin composites can be analyzed by applying the principles of the stress-strain curve, a graphical representation of the relationship between stress (derived from measuring the load applied on the sample), and strain (derived from measuring the deformation of the sample).

The stress-strain curve provides design engineers with a long list of important parameters needed for application design. It is obtained by gradually applying load to the sample and measuring the deformation. These curves reveal many properties of a material, such as the Young's



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modulus, the yield strength, and the ultimate tensile strength. Laboratory instruments are used to assess these responses, otherwise known as viscoelastic properties, under conditions of low mechanical force. Controlled heating and cooling are incorporated to study temperature effects on polymer stiffness and resiliency.

Method of Assessment

In this evaluation, we used dynamic mechanical analysis (DMA) to study and characterize storage modulus (E′), loss modulus (E″), and loss factor tan (delta) as a function of temperature. This is all captured by applying the glass transition temperature of resin composites.

From the elastic and storage modulus, we can calculate tan delta—ratio of G″ to G′—showing the relative degree of damping of the material. This is an indicator of the material's efficiency in preventing energy loss from molecular rearrangements and internal friction. Tangent of delta, or tan delta, quantifies the way in which a material absorbs and disperses energy. It expresses the out-of-phase time relationship between an impact force and the resultant force transmitted to the supporting body, whereas loss modulus and storage modulus are attributes to the given tan delta.

We selected and evaluated three known TUC resin composites that are predominantly in HSD designs and applications.

Observation

Due to customer requests, we did numerous sequential laminations and measured tan delta after each thermal lamination exposure. The data indicates that all three resin composites meet their design requirements. We did observe an initial drop in tan delta during the second lamination cycle on T2Sp, but the T2Sp did not reach a fatigue outcome overall, thus avoiding premature fatigue. Even after doing up to 10 sequential thermal laminations, the data showed no significant spread between the sixth and 10th cycles in terms of tan delta, indicating that all three resin composites can endure multi-lamination cycles, as shown in Figures 1 and 2 with eight and 10 sequential cycles.

The data for all three resin composites was compiled using DMA shift and tan delta drop. Tg is a function of heating/cooling rate. We measured energy dissipation through loss modulus to determine the hardness and stiffness of the composites during sequential lamination cycles. The data suggest that there is a

Table 1: TUC resins material properties.

Type	T2Sp TU-883Sp	T2ASp TU-885	T4N TU-943N
Tg, (DMA), °C Tg, (TMA), °C Td, (TGA, 5% weight loss) °C	220 170 420	240 170 420	230 190 400
Z-axis expansion, (25-260 °C), %	2.0	2.0	2.2
Dk @ 10GHz (3 mil, SPC method) Df @ 10GHz (3 mil, SPC method)	3.22 0.0029	3.25 0.0019	3.22 0.0017
Flammability, UL94	V-0	V-0	V-0
Peel strength (HTE 1oz), lb/in	> 4	> 4	> 4
T-260, min T-288, min T-300, min	> 60 > 60 > 60	> 60 > 60 > 60	> 60 > 60 > 60
PCT/1hr/Dip (288°C), sec	> 180	> 180	> 180

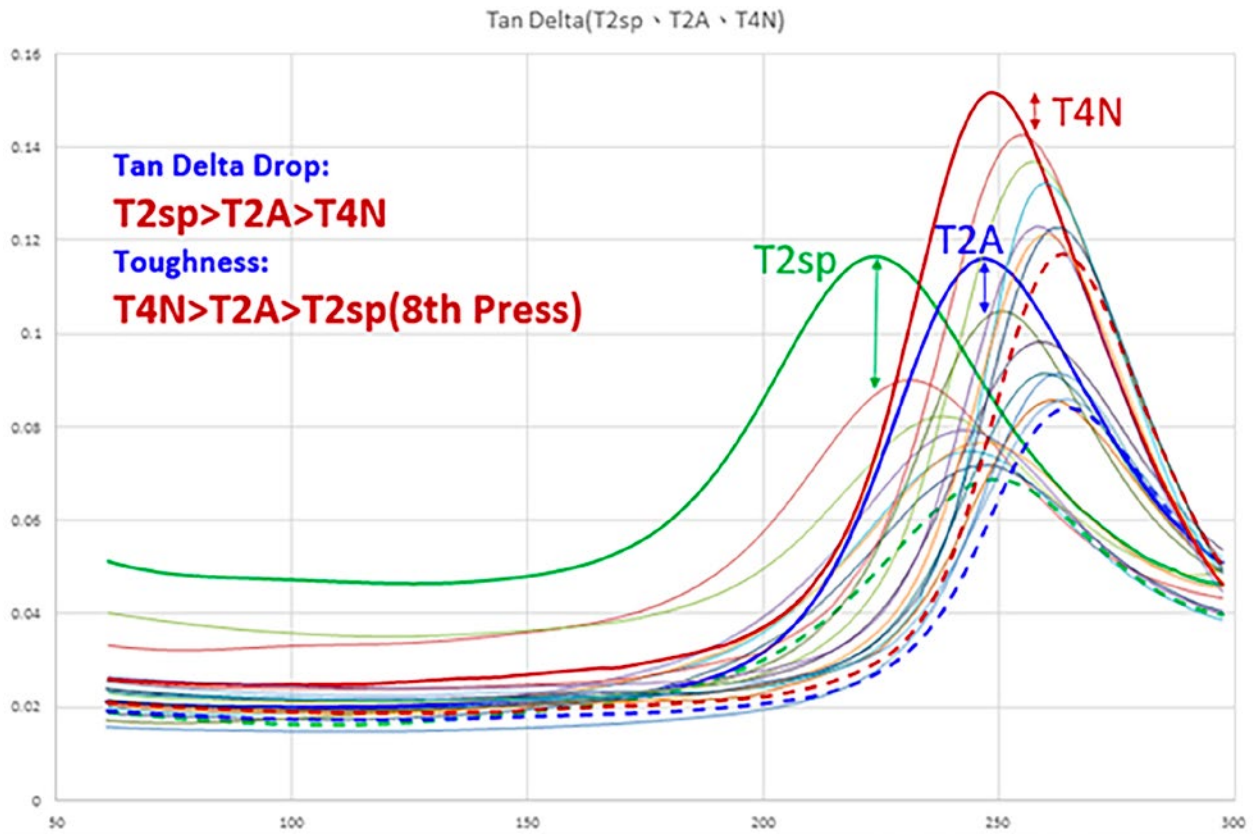

Figure 1: The energy dissipation potential of the material after eight lamination press cycles.

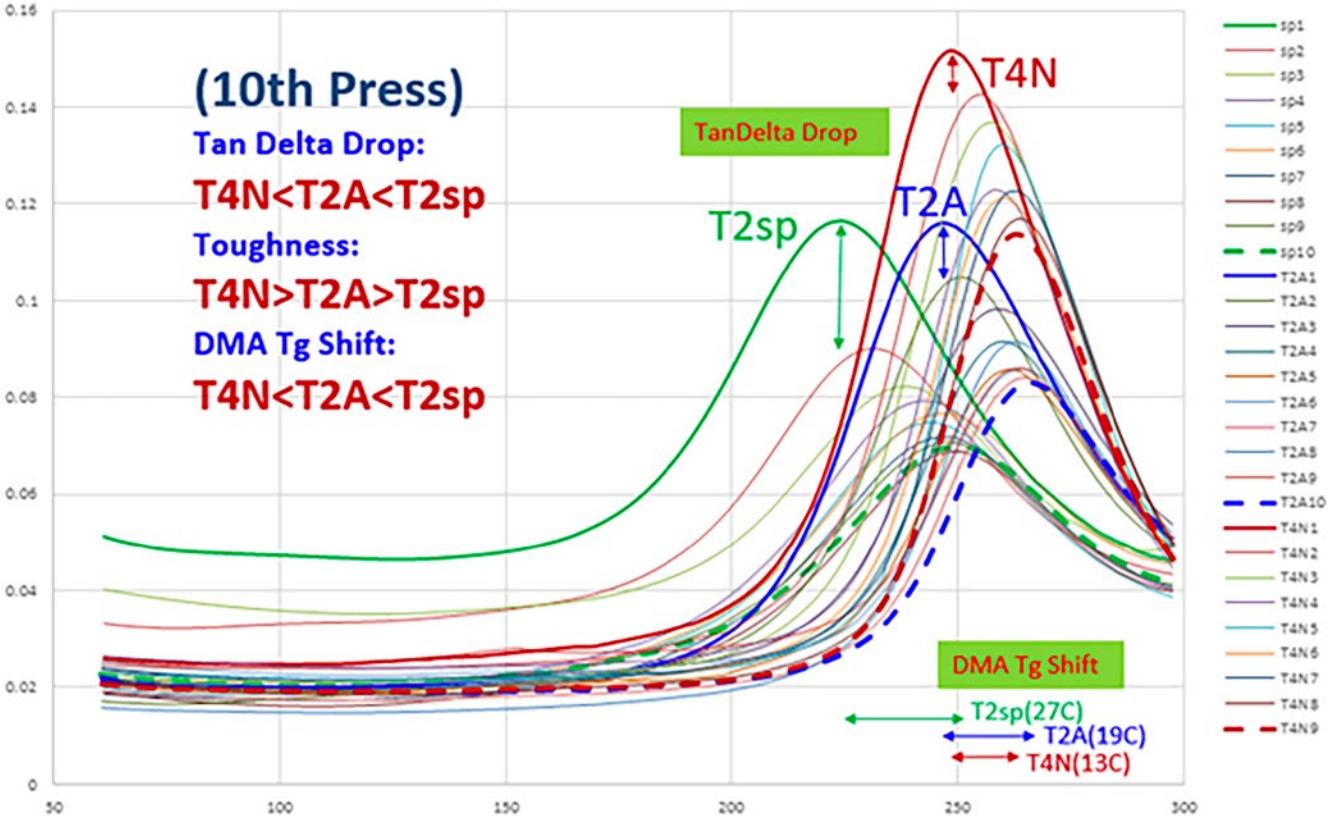

Figure 2: The energy dissipation potential of the material after ten lamination press cycles.

DMA Tg Shift

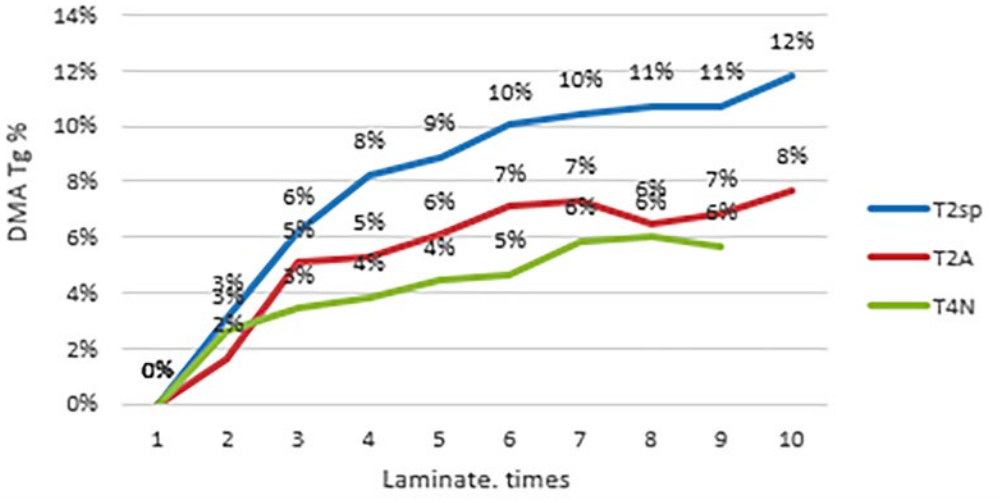

Figure 3: The glass transition shift from the storage modulus onset.

Tan Delta Drop

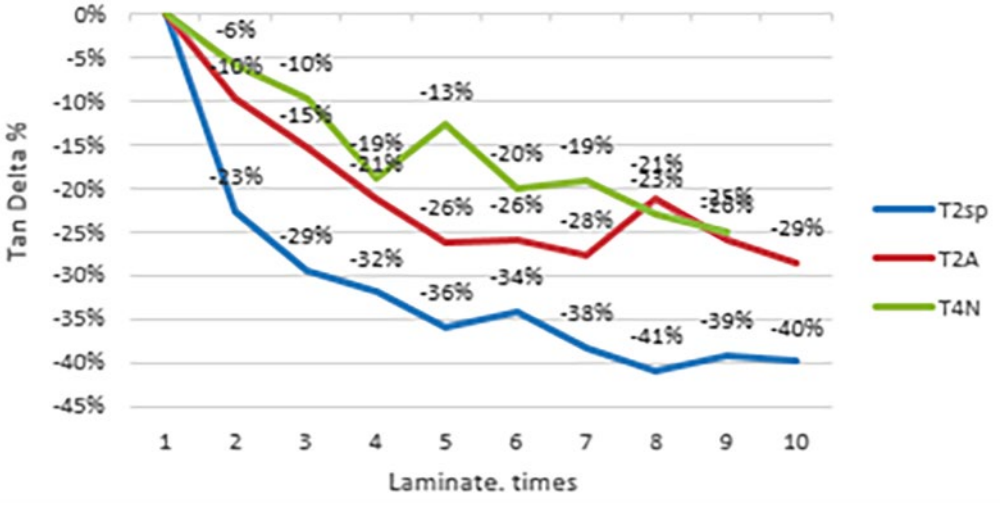

Figure 4: The dielectric loss tangent (tan δ) after each lamination press cycles.

difference in enthalpy behavior between these resin composites (Figures 3 and 4).

Conclusion

The data indicates that these resin structures can sustain up to ten (10) sequential lamination cycles with no significant tan delta drop. DMA shift data had no significant changes after two sequential lamination cycles. However, T2Sp gradually formed a two-digit shift after six lamination cycles, whereas T2A and T4N maintained single-digit shifts all the way up to 10 lamination cycles. T2Sp and T2A are both high Tg, halogen-free resin composite systems, while T4N is a brominated resin composite system.

By knowing the surface and interface phenomenon in polymer interface/interphase multiphase systems, the tan delta quantifies the way in which a material absorbs and disperses energy. Thus, the tan delta is ultimately an indicator of a material's capabilities and effectiveness. **PCB007**

John Strubbe is vice president of technology at Taiwan Union Technology Corporation.

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Electronics Industry News and Market Highlights

ELISE Low-code Engineering Platform Joins the Altair Partner Alliance ▸

Altair, a global leader in computational engineering and intelligence, announced that ELISE GmbH has joined the Altair Partner Alliance. This agreement makes ELISE's low-code engineering platform available via the APA and accessible via Altair's patented licensing system.

European Semiconductor Market Hits Record High in 2021 ▸

The European Semiconductor Industry Association reported that yearly semiconductor sales in the European market reached US$ 47.757 billion in 2021, a 27.3% increase versus 2020 and a 27% increase versus the same month in 2020.

Keysight Unveils Self-Service Enterprise Agreement Licensing Portal ▸

Keysight Technologies, Inc., a leading technology company that delivers advanced design and validation solutions to help accelerate innovation to connect and secure the world, unveiled a new self-service Enterprise Agreement Licensing portal.

SEMI: Worldwide Silicon Wafer Shipments, Revenue Set New Records in 2021 ▸

Worldwide silicon wafer area shipments in 2021 increased 14% while wafer revenue rose 13% compared to 2020, topping $12 billion, to reach new all-time highs, the SEMI Silicon Manufacturers Group reported in its year-end analysis of the silicon wafer industry.

Intel, Partners Open Applications for New AI Labs at Community Colleges ▸

Intel, Dell Technologies, and the American Association of Community Colleges (AACC) are announcing the AI Incubator Network, a new initiative from Intel's AI for Workforce program that will design and build artificial intelligence (AI) labs across the country by utilizing the expertise and industry connections of America's community college system.

Smart Manufacturing Spend Climbs Over $950B in 2030 ▸

The COVID-19 pandemic quickened the pace of digital transformation, placing technologies at the very center of how people live and work—and that pace shows no signs of slowing down.

Cadence EDA Solutions, IP Optimized for Intel Process and Packaging Technologies ▸

Cadence Design Systems, Inc. announced it has joined the new Intel Foundry Services (IFS) Ecosystem Alliance to support mutual customers with the development and delivery of innovative system-on-chip (SoC) designs.

Dark Fiber Gift Enables a Major Expansion of the COSMOS Beyond-5G Testbed ▸

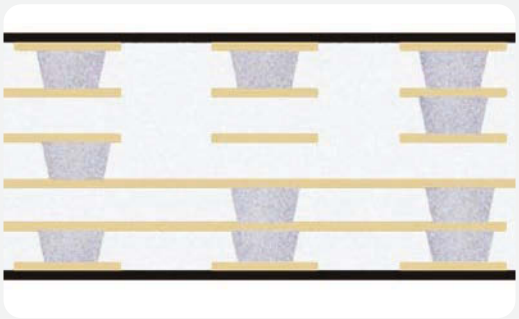
The COSMOS beyond-5G testbed now being deployed in West Harlem is one of four wireless networks recently created across the country for U.S. researchers to test new ways of boosting wireless internet speeds to support data-intensive applications in robotics, immersive virtual reality, and traffic safety.

Metallizing Paste

High reliability high layer count semiconductor package board application

Applications

Inter-layer connections



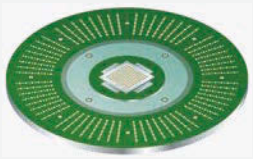
High layer count high-speed data transmission boards

Consumer electronics

e.g. : High-speed data transmission substrates for smartphones

Automated test equipment (ATE) boards

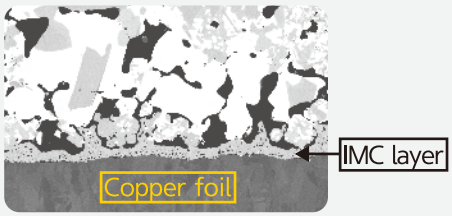
e.g. : Probe cards



Features

What is "Metallizing paste"?

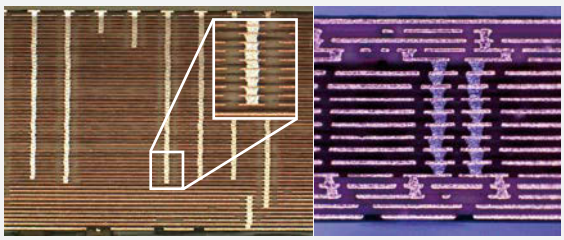
High and low melting point metal particles formulated, transient liquid phase sintering paste.
High and low melting point metal particles formulate intermetallic compound(IMC) layers.
IMC layers achieve high reliability connection on copper foil.



- IMC layer formation with copper foil
  Stable circuit connection reliability with various base materials
- High heat resistance and high thermal conductivity
- No through-hole plating required, enabling fine pitch routing

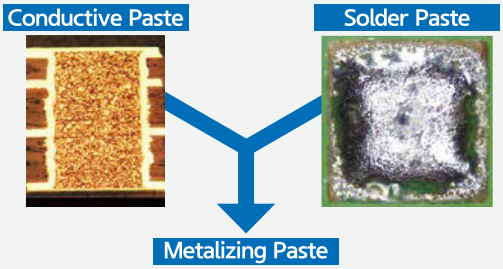
Product line-up & properties

Product			MP8300	MPA500	MPA510	MPA550 NEW
Filler	Conductive particles		Silver, Copper, Solder	Silver, Copper alloy, Solder		Silver coated copper, Solder
	Average particle size	μm	4 - 6		2 - 4	4 - 6
Binder	Resin		Epoxy			



Actual products of FICT LIMITED
Cross section image of F-ALCS® PCB

Conductive Paste x Solder Paste = Metalizing Paste



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Developments in Low-Loss Substrates for High-Frequency Applications

Feature Article by Alun Morgan
VENTEC INTERNATIONAL GROUP

The electronics industry as we know it today can trace its birth to the creation of the first integrated circuit in 1958, although conception occurred 10 years earlier with the invention of the transistor. That first IC contained a single transistor and four passive components. To say things have come a long way since then is a huge understatement.

Only one thing may have matched the meteoric pace of progress in our industry—market expectation. Exponential advancement has become the norm, and this is now achieved through an aggregation of improvements, rather than a large leap in one aspect such as chip lithography (Moore's Law), or processor frequency scaling (Dennard).

It's a small step from acknowledging this reality to adopting a holistic view that acknowledges the contribution each aspect of the system can make toward the overall performance and that seeks to optimize the interactions between them. Accordingly, in cutting-edge applications, we no longer have the luxury of treating the PCB as merely a medium for mounting and connecting components. At high signal speeds in particular, the properties of the substrate, copper foil, and trace geometries govern whether the system can deliver the required performance.

Many within the industry already understand that the PCB has become a high-tech component in itself, particularly those departments working on applications in automotive radar, 5G, and satellite communications at multi-gigahertz frequencies.

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Low-Loss Substrates

These applications are operating close to the limits of the capabilities typical materials can offer. Resistive loss mechanisms, including the skin effect in copper conductors and dielectric losses due to the molecular dipole moment in the insulating substrate need to be understood and carefully managed. The cumulative effect of the tiny losses in signal energy and associated thermal dissipation incurred with every signaling transition becomes appreciable. If not properly addressed, these losses demand more powerful transmitters, more sensitive receivers, and extra thermal management than are practicable within the typical constraints on power, as well as size, weight, and cost that usually prevail.

There are growing demands for low-loss substrates to address high-performance systems, spanning applications from high-end servers and telecom infrastructure all the way to mmWave 5G, satellite, and radar applications.

By enhancing aspects of PCB laminates, it has been possible to produce low-loss substrates that can handle demanding applications in data centers and telecom switches, for example. Optimizing the fiber weave effectively minimizes micro-variabilities in signal-path characteristics that cause distortions such as signal skew, which ultimately give rise to excessive noise and signaling errors. Attributes such as drilling performance and resistance to CAF (conductive anodic filament) formation are also improved.

For applications operating at the highest frequencies in use today, ceramic-filled and PTFE-based materials are achieving the lowest loss factors in the industry. The molecular structure of PTFE (polytetrafluoroethylene) arranges fluorine atoms as spirals around the carbon backbone to create a rod-like stiff cylindrical shape that has no dipole moment. This absence of any dipole moment negates the oscillations set up in conventional substrate dielectrics due to repeated polarization caused by signal current. This is manifested as an extremely low dissipation factor (Df) that helps to reduce signal losses.

Today's state-of-the-art low-loss PTFE substrate formulas have Df in the region of 0.0015. On the other hand, the material retains a favorable value of dielectric constant (Dk), which can be about 2.6. These properties give designers more freedom to optimize the conductor trace width and foil-layer thickness than is possible with other low-loss materials, which can help improve both the affordability and reliability of the resulting circuit board. The value of Dk is also extremely consistent over temperature and frequency.

In addition, PTFE has generally stable physical characteristics. The entropy change on melting is low, which ensures a high melting point. As a thermoplastic, there is no glass-transition temperature (Tg) and PTFE is also resistant to oxidation or chemical attack. As a result, its properties are consistent over time. Adding a micro-dispersed filler system allows the coefficient of thermal expansion (CTE) to be controlled.

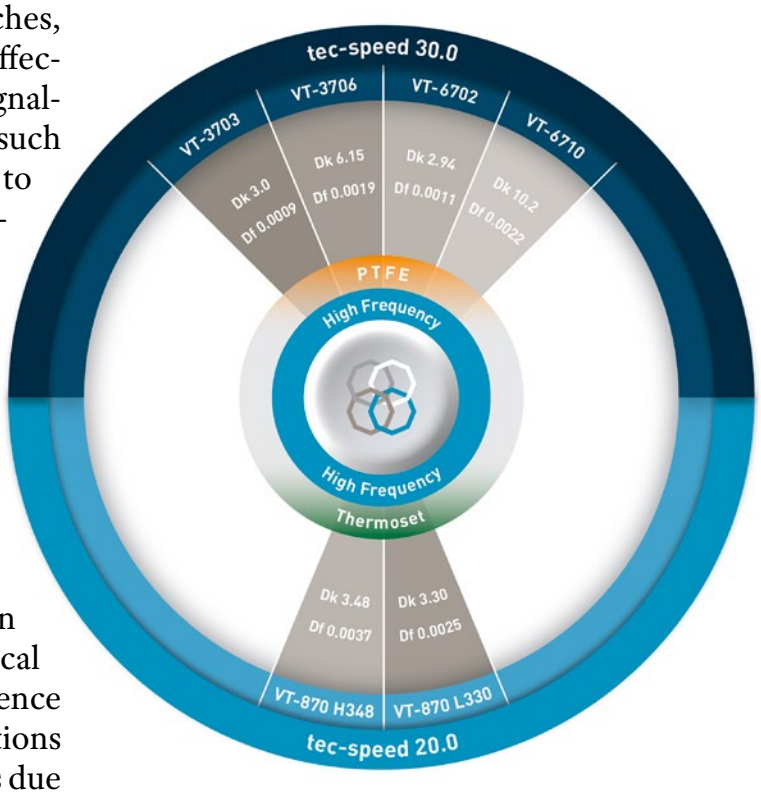

Figure 1: Ventec high frequency product solutions.

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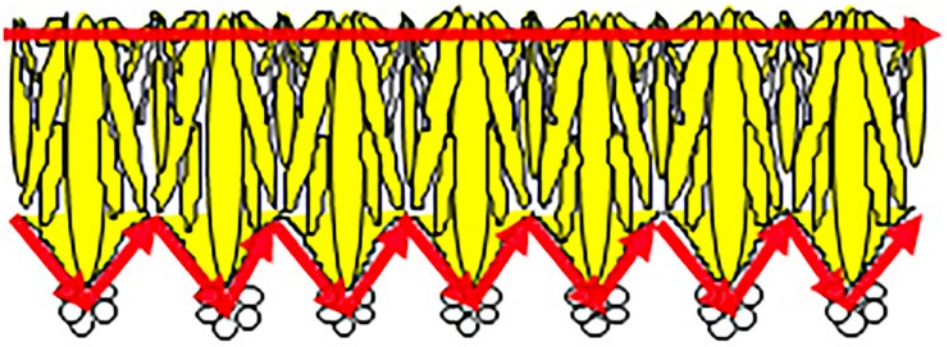

Figure 2. Skin effect in copper foil at 100 MHz.

PTFE in Practice

Currently, PTFE is the best material technology we have today for applications that require low loss at high frequencies. It is the base for commercial low-loss materials such as Ventec's tec-speed 30 series (Figure 1). These are used in applications such as antennas for 77-81 GHz automotive radar, traffic detection radar, low-noise power amplifiers and antennas for wireless communications, and satellite communication systems.

However, working with PTFE brings its own challenges that must be overcome. Because relatively little energy is gained on melting, the material does not flow, even when molten, such that processing is usually achieved by sintering. Moreover, attaching copper foil to PTFE is difficult owing to the extremely low surface energy. This low surface energy, of course, is the property that gives PTFE its excellent nonstick characteristics in lubricants and cookware.

Pure PTFE is also extremely challenging as far as processes like cutting and machining are concerned. Blending PTFE with ceramic fillers improves the mechanical stability and optimizes the overall performance. The composition and ceramic particle size can be adjusted to optimize manufacturability and in-application performance of the resulting substrate.

To assist with the adhesion of copper foil, a certain degree of roughness is desired in the bonding surface of the foil. On the other hand, the impact of the skin effect at high signal frequencies must be considered. At 10 MHz, the skin depth is about 21 microns whereas the standard copper foil has overall thickness up to 35 microns and a profile depth (surface roughness) of up to 10 microns. In this case, the skin depth is greater than the profile and the current path can be relatively unaffected. At 100 MHz, where the skin depth is only 6.6 microns, the current-carrying channel is affected by the peaks and troughs of the surface profile and suffers from increased path length and resistance (Figure 2).

Low-profile (5.0-9.9 microns) and very low profile (sub-5 micron) copper foils can help alleviate problems caused by the skin effect. Most recently, almost-no-profile (ANP) copper has been developed. While these are certainly effective in improving high-frequency signal performance, attaching very low-profile foils to PTFE substrate remains extremely challenging and requires proprietary know-how.

The Future for Low-Loss Substrates

Today's advanced low-Df, low-Dk PTFE materials are the best low-loss formulas the industry has and will likely remain so for some time. With further development, they will undoubtedly become more cost-effective and easily used in a wider variety of applications, particularly as more and more of these are expected to push toward higher frequencies striving to match those market demands for more features, more data, and faster performance. **PCB007**

Alun Morgan is a technology ambassador at Ventec International Group.

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2/3 of electronic industry companies have difficulty finding production workers.[1]

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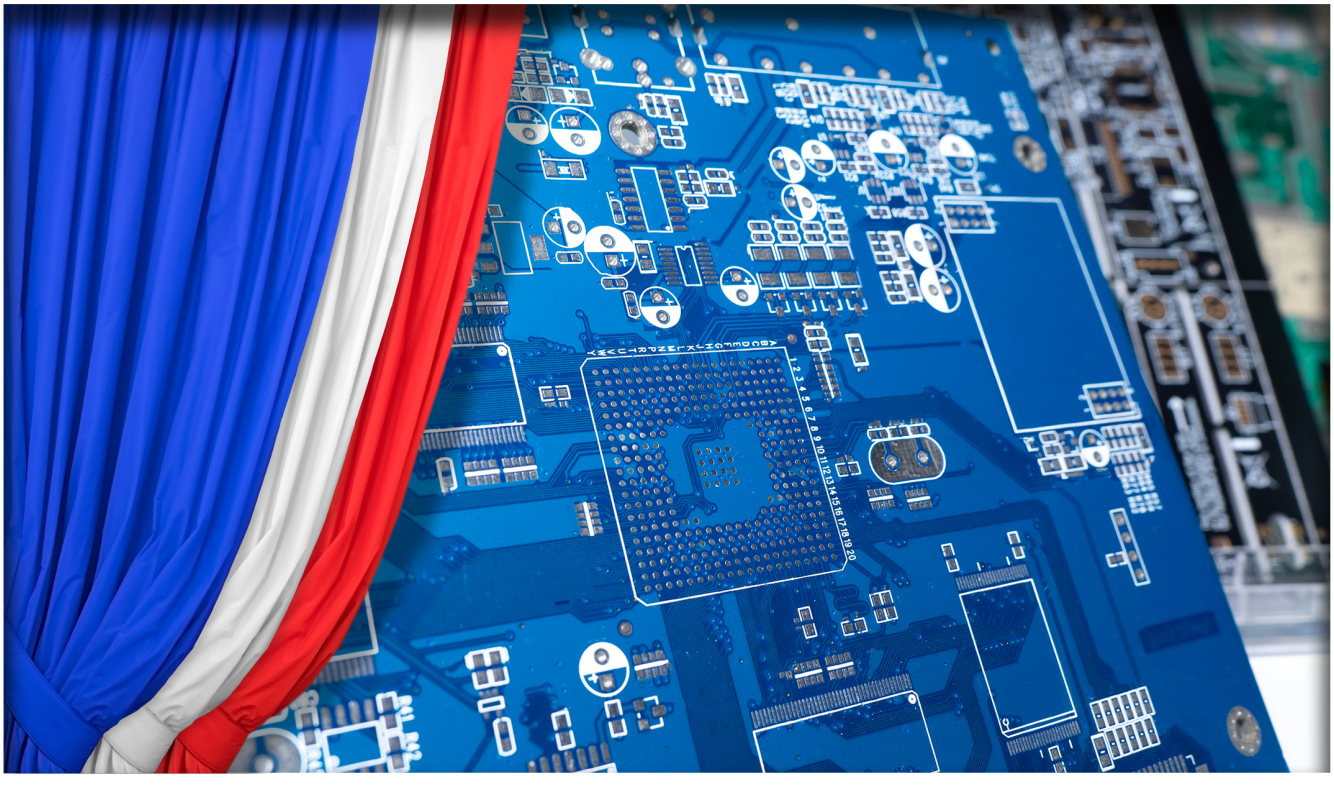
[1] IPC. (2017). Findings on the Skills Gap in U.S. Electronics Manufacturing.

Uncovering the Electronics Ecosystem



Interview by Nolan Johnson
I-CONNECT007

Nolan Johnson speaks with Will Marsh, vice president of TTM Technologies and president of the Printed Circuit Board Association of America, about the work the PCBAA has been doing in Washington, D.C., to get the industry better recognized by the country's decision-makers. Marsh is optimistic, not only about the companies and individuals joining the effort, but in the recognition by Capitol Hill to secure the nation's defense systems.

Nolan Johnson: Let's start with talking about PCBAA's mission. What are the programs to accomplish that mission? We've been covering legislation here in the U.S. to bolster semiconductors. How do we, as an industry, bring that same attention to PCB?

Will Marsh: About a year ago, TTM was engaged with an advocacy effort on Capitol Hill. We realized that one voice wasn't enough and that we needed to reach out to our peers, our competitors, and our competitive mates, and seek their support as an industry voice. And that's exactly what we did.

In April 2021, we legally and formally formed with five founding companies: Calumet, Insulectro, Isola, Summit Interconnect, and TTM Technologies. Since then, we've grown to 15 members and there are 12 other companies and individuals who have reached out to me and are interested in joining.

Our growth pattern has skyrocketed thanks to interviews and publications, such as yours and others, that are allowing us to speak on

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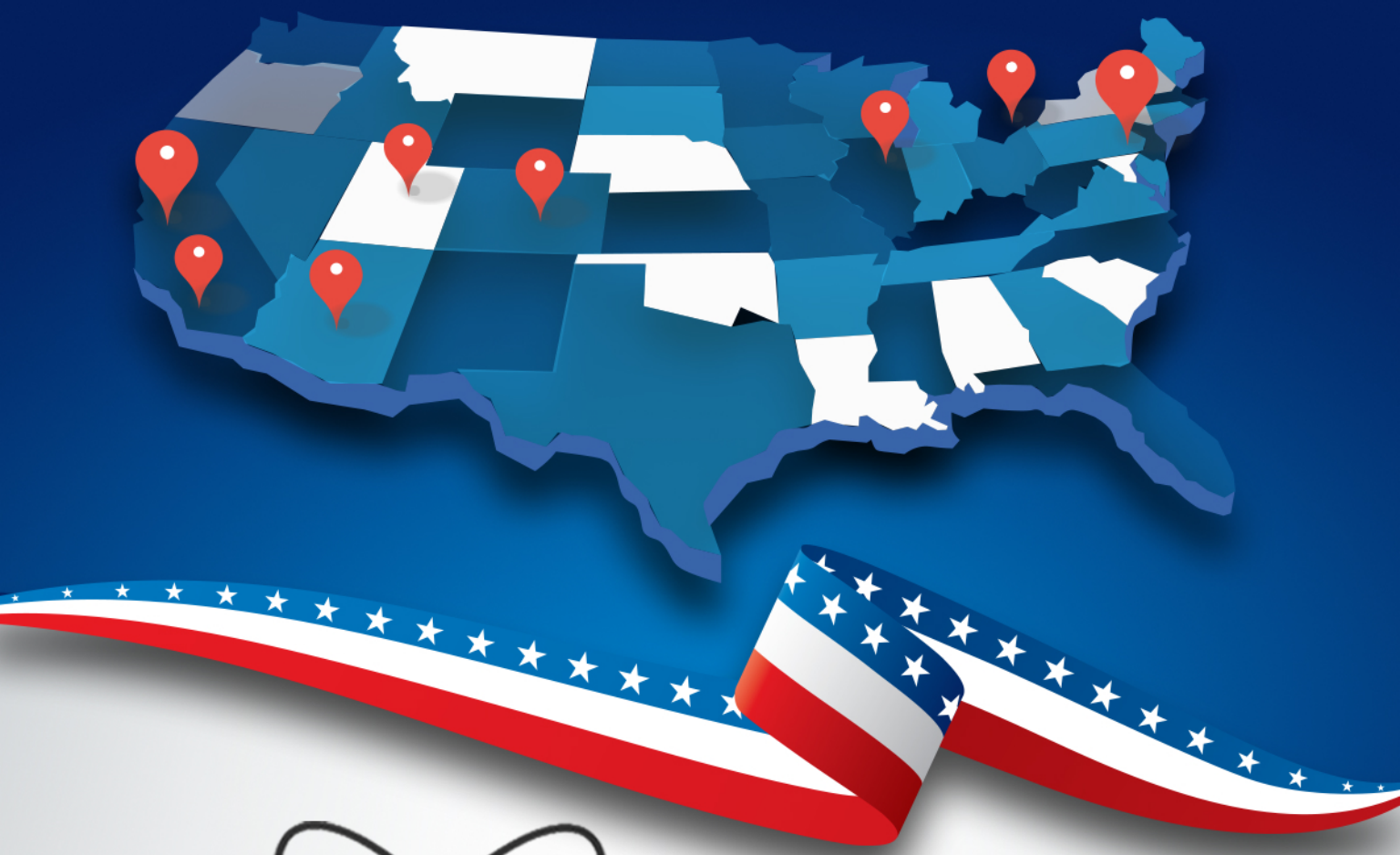

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Will Marsh

behalf of the printed circuit board industry, the printed circuit board assemblers, and the critical material suppliers. From TTM's perspective, we are unable to produce bare printed circuit boards without certain chemicals and critical materials. So, we consider the critical material suppliers to be imperative in our journey.

We discovered that most of the attention in Washington, D.C., was being spent discussing onshoring or reshoring of the semiconductor industry and the chip manufacturers. We started to tell our part of the microelectronics ecosystem story and how printed circuit boards are part of an ecosystem and not just about chips. We found that members and staff on the Hill, the White House National Security staff, Department of Commerce, and Department of Defense staff that we briefed were unaware of a larger electronics ecosystem.

We created a three-word phrase that helped place us in the ecosystem, tied to the semiconductor industry: "Chips don't float." They have a home; they have a foundation. As important as semiconductors are, if the chip is the brain, the board is the body. If we as a country don't address the ecosystem story—and we'll get into some statistics of why we're doing this for our industry—then this is a "to do" about nothing. What happens if we build all the semiconductor chips in America, but we are fully 90% reliant on Asian and European firms that deliver boards?

You can see some of the problems associated with supply chain that define risk and that define national security implications. This three-word phrase has begun to resonate in a microelectronics ecosystem story, whereby people are now saying printed circuit boards are imperative in this overall journey. We are proud of that.

Johnson: Tell me about the three pillars of PCBAA.

Marsh: They are the mission statement for the association. First is promoting domestic production of PCBs flat out, as well as assemblers and critical materials suppliers. The second pillar is enhanced domestic supply chain security and resiliency. As I said earlier, our dependency on foreign supply chains was realized during the early COVID months.

The third pillar is creating initiatives for fair market conditions. Our industry in America competes against other companies in America. But as an industry, we are competing against other countries. There are many foreign subsidies being plowed into Asia because they want to be the global monopoly for all electronics. So, advocating for fair market conditions means we're looking for demand for signal dissipation by the government to be able to compete internationally.

Why do I say that? First, section 224 of the fiscal year 2021 National Defense Authorization Act added printed circuit boards to the definition of microelectronics. Now we have a seat at the table within the Department of Defense. We are defined as part of microelectronics.

Johnson: Fully recognized.

Marsh: That's important because of the following two statistics. First, the domestic PCB industry is literally still contracting over the past 20 years. We have gone from over 2,500 PCB/PCBA domestic companies to less than 145 in 20 years. Second, 20 years ago the U.S. controlled 26% of the global market share for printed circuit boards. Today that market share number is 4%. While I don't know the statistics for semiconductors that are produced overseas. I believe it's in the range of 70–80%. You can see the trendline that our domestic industry has followed over the past 20 years.

Johnson: I saw recently that the U.S. market share for semiconductor production is 13%. That lines up with your overseas number.

Marsh: In the U.S., that's correct. I participated in the Semiconductor Industry Association (SIA), Washington, D.C., virtual client, and the fact sheets they provided were fascinating, astonishing, and scary.

When we provided the information in briefings to the Departments of Defense and Commerce, which recognize "145 companies" by their industry surveys, it was widely accepted that this is not a secure nor resilient supply chain for national security purposes. For Department of Defense purposes, to depend on U.S. companies to provide products for U.S. ITAR-qualified capabilities weapon systems, this industry must at least be acknowledged as a potential problem. Our job has been to get everyone to acknowledge the problem, and we do that through three ways: educate, advocate, and legislate.

Johnson: That must be concerning to the DoD.

Marsh: When we talk about the companies declining, we put it in the context of global market share declining. That ties in Department of Defense from a national security and an economic security standpoint. The last administration and the current administration have both acknowledged that microelectronics, as an ecosystem, is considered one of the top six technology pillars that the Department of Defense must protect. Not only do we now have a seat as defined by section 224 microelectronics, but we are also talking about an ecosystem issue at the highest level for national security purposes. That's a good thing.

Secretary Heidi Shyu runs the research and engineering division as undersecretary of defense for R&E. She's now putting the dollars and the policies in place to acknowledge there's a problem, not only with our industry, but shoring up the supply chain domestically, so that she has supply for the things that the Pentagon needs to buy. That's a pretty important position to have.

The final point before we dive into each pillar is that the Department of Defense is also in the process of qualifying printed circuit boards under the Defense Production Act (DPA) Title III. You must have a presidential determination to be on a list, to qualify for emergency use of funds for particular technologies or capabilities. For example, the hypersonics industrial base is right above printed circuit boards; both are being added or qualified.

You must have a presidential determination to be on a list, to qualify for emergency use of funds for particular technologies or capabilities.

What that also says to the industry is that Defense and Commerce recognize that there's a trend going down and want us to be on the presidential determination (DPA) list. As we saw under COVID, Trump invoked DPA titles.

That allows emergency spending in areas where your capabilities might be blocked or where they need immediate attention.

As an association, we can say for our industry that we believe the messages we have been delivering for a year and a half are really starting to resonate at the highest levels of government and with the decision-makers, to recognize that our industry needs demand signals and support.

Johnson: Let's dive down into education legislation, etc. What are some of the programs that you have currently underway with PCBAA? How are you affecting this change in awareness?

Marsh: Thank you for that question. They're really not programs, they're policies. For the last two cycles of the National Defense Authorization Act, the association has been focused on creating a debate and a discussion within the Department of Defense about dual use and COTS (commercial off-the-shelf) dependencies on foreign supply chains, and putting in place acquisition regulations by January 1, 2027, that prohibit the Pentagon from buying printed circuit boards from Russia, Iran, North Korea, and China. That's important because a lot of the U.S. companies that have foreign supply chains have recognized there's a demand signal for reshoring.

But now there's a line in the sand, if you will, drawn by the Department of Defense. President Biden just signed into law the FY22 National Defense Authorization Act. Section 851 states that by January 1, 2027, DoD is prohibited from buying from those four countries for certain defense security systems for commercial and dual use. That's a huge deal. It tells major suppliers—Honeywell, Microsoft, and others—that if you have foreign supply chains and you sell to the Department of Defense (which by the way, is the largest discretionary budget in the federal budget) you must think differently.

To be clear, section 851 just says you can't buy from those four countries. It doesn't say you can't go to NATO allies; it doesn't say you shouldn't bring half that work home. But what we're seeing already is the commercial and dual use industry starting to raise their hand and say, "We recognize the 2027 issue, and we need to start having discussions with the domestic U.S. industry."

Johnson: That creates scrutiny along the entire supply chain.

Marsh: Absolutely. It's a ripple effect. As more work comes back to American shores, that's increased volume and capability throughput capacity for American companies.

Now, let me add two more things to policies and bills we support that help our industry. Obviously, everyone's heard of the $52 billion CHIPS Act, right? As we speak, the authorization bill doesn't have money associated with it, but that obviously is a semiconductor reshoring incentive package. Within that bill, $2 billion is headed to the Pentagon for advanced packaging, of which the printed circuit board industry is part of advanced packaging. We see that as advantageous.

We have been helping advocate for passage of the CHIPS Act that is now built into the America COMPETES Act of 2022, as well as USICA on the Senate side. There are many bills that will primarily benefit the semiconductor industry. Our message has been res-

onating at the ecosystem level whereby the printed circuit board industry is now capable of participating. Those are big bills, and that's why they're not signed into law yet.

Johnson: So far, we've talked about multiple examples for DoD participation and that is important. We're talking national security. However, the defense electronics marketplace is a small chunk of the overall appetite for electronics in the United States. How does this work with DoD help to create demand or production or capabilities that aren't just for national security?

Marsh: You have to point Washington at past successes in order to be more successful. You must be able to say DoD was an early adopter for this policy, or this program. Then, the rest of the federal agencies take note and step up their adoption. You must start somewhere. Our "somewhere" was convincing the Pentagon that the dependency on foreign supply chains for DoD systems might not be known to you, but it's known to us. That's why we started at DoD. We plan to advance this message through Commerce, Homeland Security, and the Intelligence community, whereby our goal is to reduce the dependency on foreign supply chains.

Now, we're not going to come back 100%. We won't grow back to 26% global market share overnight, but it's certainly going to be better than 4%. All our successes that we can point to legislatively create an opportunity to grow our industry as opposed to staying silent.

Johnson: Is your overall objective to grow our global presence back, or is it enough to make sure that our critical national security needs are entirely self-contained?

Marsh: It is absolutely to make sure our critical national security needs are entirely self-contained. If we can't defend, or if we can have resilient domestic supply chains that feed the national security of the country, then all things commercial become irrelevant. You must be able to stand on your own for this to work. Again, we're not advocating for 100% onshore, rather that there's an issue that we need to start addressing in our ecosystem. Now we can point to specific sections of laws, D.C. bills, congressional bills, but it all comes down to supply chain issues.

We've been recognizing that we have supply chain issues; we've been raising our hand. I gave you four examples of D.C. decision-making entities with whom we've met: White House National Security staff, Department of Commerce, Department of Defense and, of course, Congress. Those four entities are very concerned about U.S. supply chain. You got a good taste from the Trump executive orders which looked at certain industries, followed by the Biden 100 Day Review, which recognized electronics as an issue. Supply chain issues are where we're focused. There are many ways for us to solve that problem as a standalone industry, but government demand signals are a big help.

Of course, we're also saying that if you bring some of that work back to domestic shores, then you'll bring back some of that know-how and that wherewithal and/or you train it up here. The whole point is that we might be producing 4% domestically, but we're also providing all that capability overseas for those people to become experts in it. We want to be able to

have a workforce that is trained and producing it in America.

Johnson: The pioneering members of PCBAA are generally very large, tier one industry. And as we look more closely at the pillars—STEM and the like—it starts to hint that PCBAA sees pure R&D, and disruptive technologies, as an area to nurture. Is that, indeed, an area that the PCBAA wants to encourage?

Marsh: In terms of disruptive capabilities?

Johnson: For example, there is a lot going on right now with the heterogeneous integration roadmap and how that's going to change packaging. There's also other tech that isn't in the mainstream yet. Is there room to really grow our industry as a leader in technology development again?

Marsh: I think so. There's a demand signal; there are policies; there are programs that put money on contracts for people to work with DoD, to ensure that there's a supply for the Department of Defense. You'd have to have an early adopter or a lead executive agent to do these things. Now, commercially, I think we're already doing that as an industry. There are people on our membership page who are already thinking about and acting on some of the things you've mentioned.

Since April, our goal has been to make decision-makers aware that there's a problem, and to identify solutions. What is the problem? There is a gap. We are in the infant stages of helping the government understand solutions. We've made enormous strides legislatively of making sure that an organization like the Printed Circuit Board Association of America was in a seat when people were having microelectronics ecosystem discussions.

Johnson: A lot of defense electronics is very tried-and-true, old school by intent. In the supply chain, many of those legacy components are going away. How do we protect that part of the defense industry?

Marsh: There are two ways to answer that. We know from an OEM perspective, from a big defense prime contractor's perspective, that should we have disruptive and/or next-gen capabilities research-engineered and manufactured here; it increases their ability to engineer systems better. Those advanced capabilities allowing us to do things differently domestically only enhances the product. There are limitations to what can be engineered right now because, as you said, they're working with old, tried-and-true packages. But if you add in a capability that has been approved, demonstrated, and validated within a customer base, now you're giving those engineers at those major primes and major commercial companies the ability to start to engineer a product differently.

Keep in mind that there are so many legacy systems, not just within the federal government, but within the commercial sector. You're always going to have people punching out all their products. The Department of Defense, under the Printed Circuit Board and Interconnection Executive Agent, has a door in the Pentagon for the executive agent for our industry; they have a facility that produces legacy boards for extreme legacy weapon systems that industry is no longer producing. The DoD is producing printed circuit boards for really, really old weapon systems that have not been modernized.

Johnson: They take their own responsibility for that.

Marsh: They rely on industry to help them with engineering and certain manufacturing processes. But there's a manufacturing capability within the Department of Defense itself. And that's a good thing because sometimes what they're trying to produce are one-off, two-off boards for a system that might be coming to the end of its life expectancy.

Johnson: Is there room in this for the smaller fabs, the boutique? For example, the U.S. has a high percentage of high-mix low-volume PCB manufacturing. How do these shops participate?

Marsh: Yes. There's room for anybody in our industry: little, medium, or large. I mentioned at the onset, TTM is the country's largest printed circuit board manufacturer with 16 manufacturing sites in 10 states. I met a small PCB manufacturer based in Southern Virginia and his main issue was that it's really hard to invest in very, very expensive equipment when you're producing low volume. It's on us to promote larger legislative initiatives that come with real federal dollars, and which allow all manufacturers to participate.

The Department of Commerce and Department of Defense thrive on competition. They promote it. In many instances, the way an RFP or an RFI is written skews toward the small- and medium-sized folks. They want to see these folks survive; they don't want to see just 10 PCB companies in America. They want to see 200 or 500. Are we going to get to 2,500 again? I doubt it. But we are creating opportunities for the small- and medium-size folks to participate at a larger level.

Johnson: Look ahead 24 months. What effect on the industry do you want to see from PCBAA's work? What's your goal?

Marsh: I would like our PCBAA mission and message to be on par with the SIA's message and mission of full, heightened awareness at the federal level that we have a domestic resilient national security and economic security problem; that we have to work as a team to address an ecosystem problem, not just a semiconductor issue. We've already embarked on that.

Johnson: Will, thanks so much.

Marsh: Thank you, Nolan. PCB007

Additive Reality

Isolated Raindrops Announce the Storm

By Luca Gautero

It is an early January evening after office hours. Despite my best New Year's intentions of a good balance between work and personal life, when I hear the ding of an incoming email I decide to check it anyway. It's a message from the U.S., where Don Monn of Taiyo has just given his view on the inkjet market.

Something he says immediately strikes a chord, "What I can tell you is … there are well over 20 installations … between North America and Europe. There are another five or six already committed to be installed in the first quarter of 2022."

I do my best to keep track of sales in the inkjet market and Monn's numbers don't add up for me; other equipment manufacturers must have sold some machines and we missed them in our count. The missing ones were not documented by press releases or similar announcements. Thanks to the help of a few colleagues and my professional network, the accounting of tools reached the 20 installations.

Since 2017, every six months (more or less) a press release reports a tool being installed. Rumors of other installations tell us that this number is at least twice as high. Combining what we know with what is rumored comes out to one tool per quarter, so hearing Monn say that five or six installations will be completed within one quarter represents a sudden increase. The "drizzle" of the past years now has a different look; it's a tipping point. Previously isolated raindrops have announced a storm. Luckily for us, this "climate change" will bring along environmentally friendly manufacturing.

To read this entire column, click here.

Material Application for Mini Backlight Unit

Feature Article by Aaron Chen
WAZAM NEW MATERIAL CO. LTD.

In 1980, FR-4 was used in about 90% of the materials used to make PCBs. Over time and as technology developed, electronic devices relentlessly integrated into every area of our lives. The constant acceleration of upgrading meant endless challenges and opportunities for CCL suppliers. Wazam New Material Co. Ltd., is a CCL supplier that strives to meet the needs of its end customers and provide comprehensive solutions.

One example is the mini backlight unit (MBLU) application material. Since 2021, mini LED backlight has become the focus of mainstream technology improvements. As the size of chips and optical distance becomes increasingly smaller, the assurance of a product's reliability has put even stricter demands on the reliability of the whole supply chain.

A deviation that was acceptable before has become intolerable. As seen in Figure 1, with the same deviation, the effective soldering area has reduced from 50% to only 5%. To improve the performance rate and the effectiveness of the LED die bonder, PCBs must have products with sizes that are more stable.

Figure 1: With the same deviation, the effective soldering area has been reduced from 50% to 5%. (Source: ASM Pacific)

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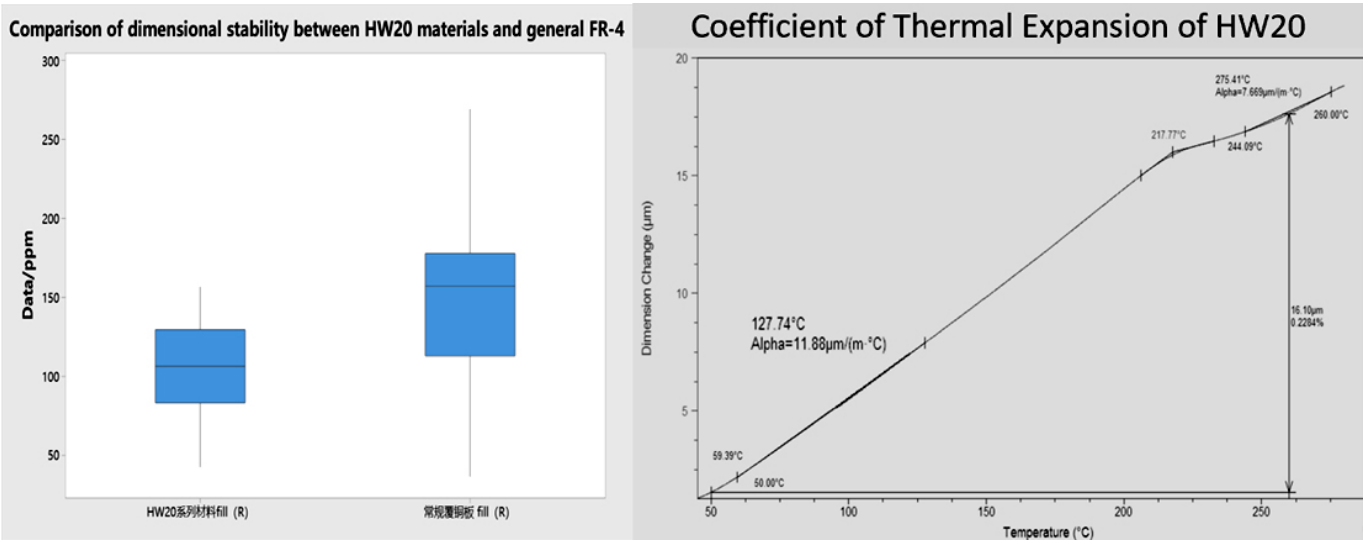

Figure 2: Comparsion of dimensional stability of HW20.

The traditional FR-4 material's thermal expansion rate is around 0.04%. As we brought in the polyimide resin, the heat resistence and size stability has been improved. Together with carefully selecting the filler materials and readjusting the proportion, Wazam was able to reduce the material's thermal expansion rate to about 0.015%. Its CTE (coefficient of thermal expansion) decreased to 11.88 µm/(m·°C).

From the Optical Dimension

MBLU application requires materials with higher reflectivity. Materials must go through high temperature procedures such as reflow soldering. LED chips and driving IC will produce heat while working, therefore, not only do we have high requirements for the material's heat resistence, but we need it to maintain outstanding reflectivity.

The traditional FR-4 material's thermosetting resin's color is yellow; with long term usage and heating, its color will change even more and therefore cause a reduction in reflectivity.

Generally, CCL design has three resin systems: phenol formaldehyde resin, epoxy resin, and polyimide resin. The traditional design generally applies to the epoxy resin system. Regular epoxy resin is deteriorated and discolored by heating. However, lipid ring clan epoxy resin is excellent in weather fastness, pellucidity, and heat resistence, which can improve the color-changing problem. Lipid ring resin has a relatively low melting viscosity, which can cause the board to be uneven when pressure molding under heating. To solve this problem, some regular epoxy resin can be added to adjust the material's fluxility, and therefore improve the accuracy of board thickness. When the mixture of regular epoxy resin and polyimide resin is less than 50%, it won't affect the lipid ring resin's function in resisting color changing.

As we know, titanium dioxide can be used as a filler during the copper-clad laminate (CCL) fabrication process. Studies have shown that titanium dioxide has two types: anatase titanium dioxide and rutile titanium dioxide. Anatase titanium has good reflectivity within visible light shorter wavelength area, while rutile titanium dioxide has long term durability and great color fastness. After conducting hundreds of experiments, constantly adjusting the ratio of lipid ring resin, polyimide resin, epoxy resin, anatase titanium, and rutile titanium dioxide, we finally found an appropriate proportion. Because of that, we have successfully produced a CCL that has high reflectivity within the visible light zone, great color fastness, high heat resistance, good

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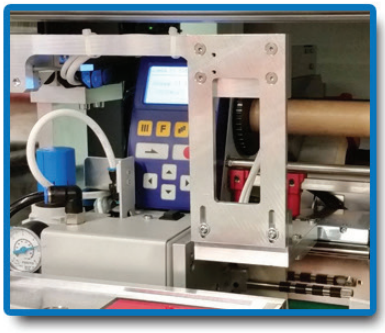

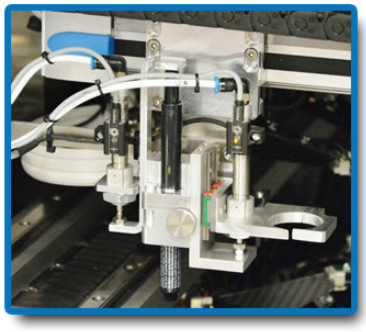

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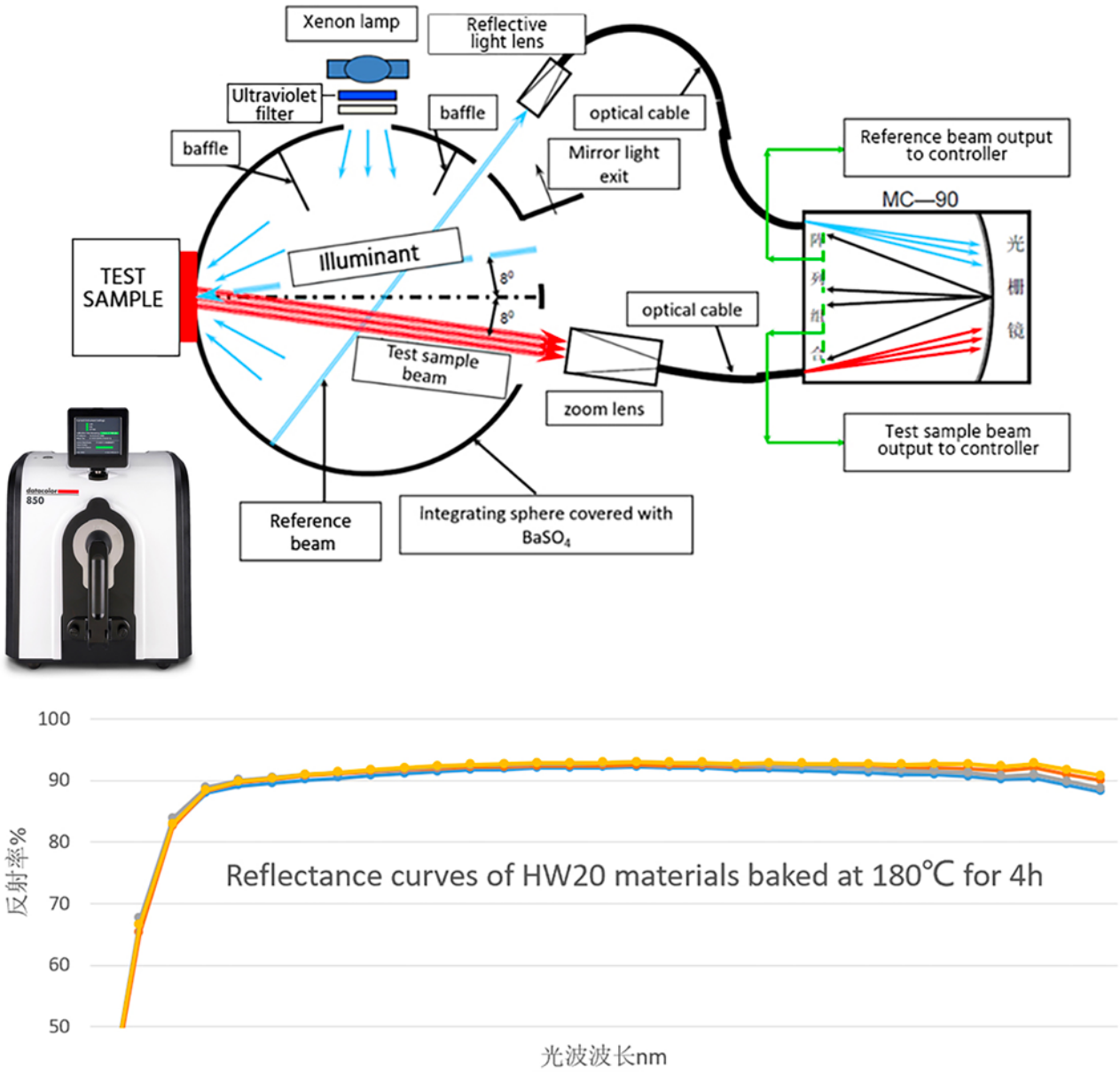

Figure 3: Reflectivility test equipment and test data diagram.

thermal expansion rate, and more precision in thickness.

From the Marketing Dimension

MBLU's application sits in the consumer class, where customers are relatively sensitive to prices. Overpricing makes it difficult for the product to expand into the marketplace.

In addition, for customers with special packaging requirements, Wazam has developed a CCL with great thermal conductivity, which reduces the running temperature of the material and improves the usage power of the LED chip. **PCB007**

Aaron Chen is overseas marketing director of Zhejiang Wazam New Materials Co. Ltd.

MilAero007 Highlights

High-Voltage Circuit Design Guidelines and Materials ▸

The Hubble telescope, the Cassini-Huygens mission, and other exploratory spacecraft utilize high-voltage DC power supplies for everything from vidicon camera tubes and mass spectrometers to radar and laser technologies. NASA has experienced performance problems with the 1.5 kV supplies because—as a 2006 report stated—"designers did not take the high-voltage problems seriously in the initial design."

Calumet Electronics Receives 'World-class Team' Award from Northrop Grumman ▸

Calumet Electronics Corporation received a World-class Team award from Northrop Grumman Corporation for its outstanding performance. The award recognizes companies that have demonstrated exceptional support and commitment to Northrop Grumman's business objectives through "delivery performance, outstanding program support, superior technical achievement, and cost performance/competitiveness and continuous process improvement."

Four Industry Rising Stars Recognized at IPC APEX EXPO 2022 ▸

In recognition of their leadership roles and support of IPC standards, education, advocacy, and solutions to industry challenges, four of the industry's best and brightest were presented with an IPC Rising Star Award at IPC APEX EXPO 2022. Award recipients were Tim Burke, Francisco Fourcade, Thomas Marktscheffel, and Christina Rutherford.

Real Time with... IPC APEX EXPO 2022: The Supply Chain and Markets ▸

Pete Starkey interviews Mark Goodwin, COO of Ventec International, on the impact of the current supply chain condition. Their conversation also covers aerospace and the U.S. market.

Absolute EMS Completes AS9100 Rev D Recertification with Zero Findings ▸

Absolute EMS, Inc., a provider of turnkey and consignment manufacturing services, is pleased to announce that it has successfully completed its 2022 surveillance audit for the AS9100 Rev D SAE International Aerospace Standard, again with zero findings.

Collins Aerospace Completes Air Launched Effects Demonstration for U.S. Army Future Vertical Lift Program ▸

Collins Aerospace has successfully demonstrated a ready-now Mission Systems solution to support the operations of Air Launched Effects (ALE) from Army Aviation's Enduring and Future Vertical Lift (FVL) fleet.

Keytronic Announces Q2 Results ▸

Keytronic Corporation, a provider of electronic manufacturing services (EMS), announced its results for the quarter ended January 1, 2022.

NASA Selects Developer for Rocket to Retrieve First Samples from Mars ▸

NASA has awarded a contract to Lockheed Martin Space of Littleton, Colorado, to build the Mars Ascent Vehicle (MAV), a small, lightweight rocket to launch rock, sediment, and atmospheric samples from the surface of the Red Planet.

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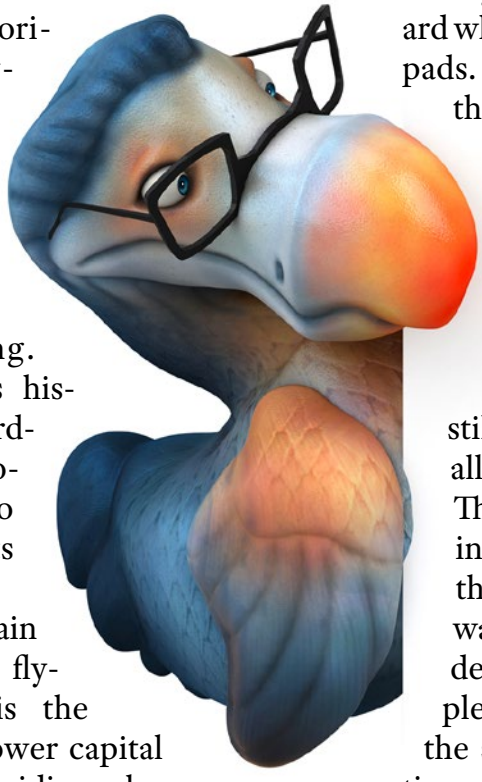
Has Universal Fixture Testing Gone the Way of the Dodo?

Testing Todd

by Todd Kolmodin, GARDIEN SERVICES USA

Although flying probe testers have become commonplace in today's manufacturing theatre, one must wonder if the fixture tester, specifically the universal grid or "pin in hole" fixture, has any valuable use in the electrical test arena. The advancements in flying probe technology are undisputed with the new abilities to do many of the tests that benchtop testing historically required. Flying probe testers can provide standard continuity tests, Hi-Pot, buried passives, inductance, impedance, and even IR testing. Many of these tests historically required hardware mock-ups to provide the footprint to administer these tests effectively.



Of course, the main advantage regarding flying probe testers is the cost. They provide lower capital investment while providing a large solution platform to many of today's requirements. There are some who make the argument that flying probe testers remove the necessity of fixture testing altogether.

While this may be true to some extent, it is not altogether accurate. It can be argued that some of the earlier universal fixture solutions may be obsolete. For example, the earlier 1-inch and 2-inch pin-in-hole fixture solutions cannot provide test solutions for today's complex designs. Density issues of modern designs don't allow the use of headed pins. Historically, headed chisel pins were optimal for plated through-hole (PTH) probing, but were a hazard when direct-probing surface mount (SMT) pads. Over-compression of the fixture tester to the test fixture could cause damage to the SMT pad, ultimately scrapping the PCB. So, in that example some of the older fixture solutions may be obsolete.

However, we had to evolve. Headed chisel pins gave way to featureless music wire technology. These pins, either crimped or non-crimped, still allowed probing of PTH features while allowing a safer direct probe to SMT pads. These new pins also allowed direct probing of more complex designs while keeping the fixture to a single pass solution. This was a hindrance in the earlier headed pin designs, as complex designs required multiple passes (multiple fixtures) to accomplish the same result. This required extra drilling time and increased cost. Further, the headed chisel pins had a limitation to the size available. The newer featureless pins did not have such a limitation. Unfortunately, the caveat is that more guide plates are required to translate the pin successfully from the probe plate to the universal grid electronics. However, it can be

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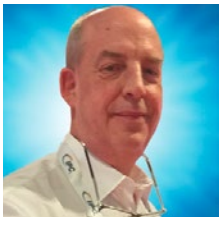
argued that in the end the overall drilling time is insignificant, as you may still be using the same fixture drilling time to build the multi-pass headed pin fixture as you would to build the music wire single pass fixture. The hardware cost ultimately will be less as no redundancy testing is required with the single pass vs. the multi-pass fixture.

The hardware cost ultimately will be less as no redundancy testing is required with the single pass vs. the multi-pass fixture.

Now, with the fixture testers themselves, there are some challenges with the legacy universal grid machines. These machines typically presented a 0.100-inch grid configuration and had only one active test matrix. This only allowed single-side fixtures or wired clamshell combinations. Although still viable equipment, they present challenges when testing today's PCBs. Double-sided universal grid machines with the 0.100-inch grid configurations are also still available through various aftermarket venues. These provide less costly alternatives but still can present challenges. Most universal grid testers used today are of the double-density or tighter grid configurations. These are better suitable for music wire fixtures and allow higher success rates for maintaining single-pass test solutions.

Now with that said, let's get back to the question as to whether the universal fixture is dead. We know that flying probes can provide many solutions to today's requirements. They can even provide automated tests that historically required fixtures, either universal or hard-wired. However, one very important aspect of the fixture tester vs. flying probe that will never be successfully met by the flying probe is providing "simultaneous test" of the PCB. What I mean here is the ability to stimulate or interrogate all nodes of the PCB at the same time. Flying probes use an "adjacency window" where isolation or shorts testing is done node-to-node based on the adjacency of one node or network to another. Other nodes or nets outside the adjacency window are not tested for shorts to that primary node. With fixture testers this isolation or shorts test is provided simultaneously to all nets to one another. Further, the continuity test on a flying probe, regardless of how many arms are available is only testing a finite number of nets at a time. The fixture tester will test them all at the same time. Yes, it's still just the continuity test and both machines do the same thing, but the fixture tester does this all at once, giving it a major speed advantage.

The other significant item to note is that many aerospace, medical, and high reliability products have requirements that state, "Simultaneous test required." This statement alone in a customer specification or procurement document negates the use of flying probe, period. There is no viable argument that a flying probe can provide a simultaneous test of all nets to one another in one single pass. Only the fixture tester with its full parametric test can provide this solution. Therefore, the fixture tester will live on. Whether it be a universal grid or wired dedicated, the simultaneous test will aways require a fixture tester of some flavor. Also, the fixture tester will always have the advantage in high volume applications. Although the flying probe has made electrical test costs significantly lower, it will never be able to compete in high volume theatres against tight deadlines. Long live the fixture. **PCB007**



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

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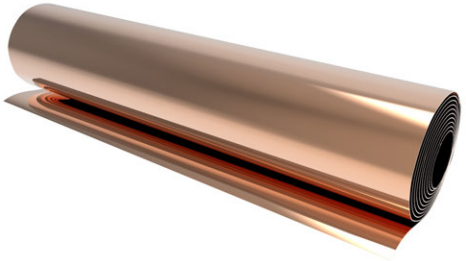

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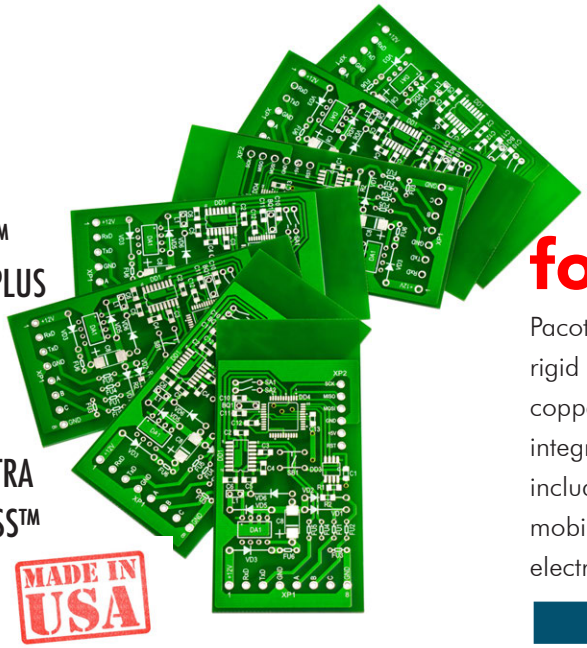

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Our Introduction to the Electronics Industry

The New Chapter

NEW COLUMN by Paige Fiet and Hannah Nelson

IPC's Board of Directors previous student liaison, Paige Fiet, and current student liaison, Hannah Nelson are combining their talents as new columnists for I-Connect007. In this column, they will share their thoughts and experiences as student engineers and the transition to the workforce. Here, they discuss their backgrounds in the electronics industry and their position on the Board of Directors.

Paige Fiet: My name is Paige Fiet. I recently graduated from Michigan Technological University with my Bachelor of Science in electrical engineering. In January 2022, I joined TTM-Logan as a process engineer in the solder mask department. Prior to graduating from MTU, I served as president of the IPC Electronics Club at MTU as well as the student board member on IPC's Board of Directors.

Hannah Nelson: My name is Hannah Nelson. I am currently a junior electrical engineering major at Valparaiso University with a minor in mathematics. I am the president of the IPC student chapter at Valpo, and I currently work as a co-op engineer for Caterpillar Inc. I am also

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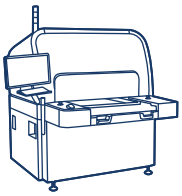

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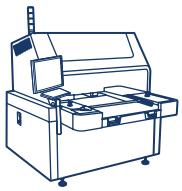

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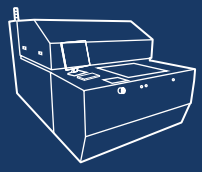

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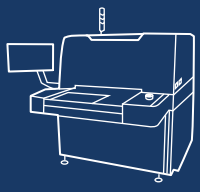
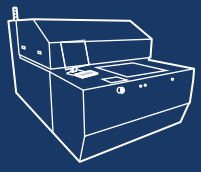
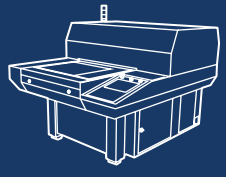


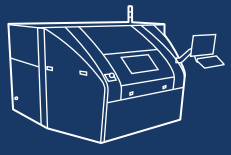
Automated Optical
Shaping



Solder Mask
Direct Imaging



Inkjet/Additive
Printing



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Hannah Nelson, Wendy Gaston and Paige Fiet at the Women in Electronics event at IPC APEX EXPO 2022.

serving one term as the IPC Student Director on IPC's Board of Directors.

Fiet: I was first introduced to the electronics industry via my first two internships at Avon Protection Systems in Cadillac, Michigan and Calumet Electronics in Calumet, Michigan. How about you, Hannah?

Nelson: My first introduction to the electronics industry was leading Valpo's student IPC chapter, although I did not become fully immersed in the industry until the IPC APEX EXPO 2022. What made you want to pursue engineering?

Fiet: Engineering was an easy choice for me. Both my father and brother are engineers. I always liked problem solving and "getting my hands dirty" so engineering just came naturally. What made you choose engineering?

Nelson: Engineering, to me, is a way I can creatively innovate my own thoughts and ideas into physical technology, but it hasn't always been that way. I originally resented engineering and thought of the career as a chore that my mother wanted me to pursue, but as soon as I stepped on the Valparaiso University campus, I knew the career I chose was my vocation. The career choice soon began to engulf every aspect of my life—how I spent my time, who my friends were, and how I spoke to my peers. I know we both have experience serving as presidents of our IPC student chapters. What was that like for you?

Fiet: I spent a year as president of the IPC Student Chapter at MTU. Unfortunately, the year of my presidency began in parallel with the COVID-19 pandemic. However, I saw the resilience in my peers as we met with sponsor companies and industry experts to learn more about the electronics industry. The IPC Education Foundation was incredible in working to develop online content for our students. We were able to watch webinars for career panels and take training classes through their website.

Nelson: As the president of Valpo's chapter, it is incredible to see the growth in the program. As the chapter continues to grow, it seems like the creativity of our students also grows, as do the programs that they are presented with. There is still so much growth for skills that students need before they enter the workforce, but that is what our chapter is trying to help.

Fiet: I'm so glad you've had that experience. When I was a junior in college, I was just starting to figure out what I wanted to do post-graduation. What part of the electronics industry are you thinking about working in?

Nelson: Well, as a current junior, I graduate May 2023 and I am honestly still trying to figure out my future career. Currently though, I am passionate about exploring the renewable energy and aerospace divisions of the electronics industry.

Fiet: You have a really bright future ahead of you. I am very impressed with what I've seen so far, and I could not have chosen a better successor for my position on IPC's Board of Directors. The Board was wonderful to work with and I really learned a lot about the varying aspects of the industry and what's important to each of them. It was also exciting to share feedback from a student's perspective. What did you think when you first met the Board at IPC APEX EXPO?

Nelson: My first time meeting the board was incredible. The best part was understanding that even though they are well respected in their careers, they are people too. They have not only mentored me to find my passion in the electronics industry, but they have also given me the opportunity to help bridge the gaps that I see in my own education. How was the transition from college to a professional career?

Fiet: I think the transition was made easier due to my internship experiences. I was able to learn from industry professionals who mentored me on workplace etiquette, enhanced my problem-solving skills, and who support me even now. You have some internship experiences, don't you Hannah? What has that been like?

Nelson: At first, I thought the transition between school and my internship was difficult, but what helped me was networking with other company employees. I was not only able to learn more about Caterpillar's company culture, but I was also able to realize that these individuals were there to help me grow throughout my internship.

Fiet: It's been nice getting to know you, Hannah.

Nelson: You as well, I'll see you at IPC SummerCom. **PCB007**

Paige Fiet is a process engineer at TTM-Logan. **Hannah Nelson** is a student at Valparaiso University. Both are in the IPC Emerging Engineer Program.

Supplier Highlights

Real Time with... IPC APEX EXPO: Fire Up the (Ink)jets ▸

Don Monn of Taiyo America discusses the benefits of inkjet solder mask and how it helps streamline the manufacturing process. Monn also discusses the recent acquisition of Circuit Automation, a manufacturer of solder mask coating and vertical drying equipment.

It's Only Common Sense: The Show is Done, So Now What? ▸

Did you attend IPC APEX EXPO 2022? If so, you made some good contacts, you talked to a lot of people, spent time with potential customers trying to convince them to buy your goods and services, and with the right vendors checking out their products and goods trying to figure out what equipment and services would be good for your company.

Cirexx Adds to Excellon Cobra Laser Fleet ▸

Cirexx International announced that they have acquired and installed a fifth Excellon Cobra laser machine. The hybrid Laser is equipped with both CO2 and UV laser technology.

Additive Reality: Isolated Raindrops Announce the Storm ▸

It is an early January evening after office hours. Despite my best New Year's intentions of striking a good balance between work and personal life, when I hear the ding of an incoming email, I decide to check it anyway. It's a message from the U.S., where Don Monn of Taiyo has just given his view on the inkjet market. Something he says immediately strikes a chord...

Real Time with... IPC APEX EXPO 2022: Industry Icons Reflect ▸

In this special interview, industry icons Happy Holden and Dick Crowe share an historical perspective from their many years in the industry. Dick also announced his retirement from Burkle after nearly 60 years in the industry, and he discusses his plans.

Altix Receives Direct Imaging Order for Fine Line Prototyping ▸

Altix is delighted to announce that the CEA-Liten has ordered an Adix SA for fine line applications to be part of their research activities focused on micro and nanotechnologies, smart digital systems and renewable energy.

Atotech Names Klaus-Günter Vennemann to Board of Directors; Brian Bernasek Resigns as Director ▸

Atotech, a leading specialty chemicals technology company and a market leader in advanced electroplating solutions, announced that Brian Bernasek, a member of the company's Board of Directors, has resigned as a director as of January 31, 2022.

Ucamco to Release UcamX v2021.12 and Integr8tor v2021.12 ▸

Ucamco is proud to release UcamX v2021.12 and Integr8tor v2021.12. These new versions of their CAM and Pre-CAM software include dozens of additions, new options, fixes and general improvements to increase productivity.

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Leadership 101— The Law of Priorities

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 Law 17 of the 21 Irrefutable Laws of Leadership.

The Three Rs

To understand the Law of Priorities, there are three questions to ask yourself and that must be embraced during the journey to become a great leader. They are:

1. What is required that only I can do?

No matter how high up you are in the leadership food chain, we are all accountable to someone. We also have responsibility to the important people in our lives, like our spouse, parents, children. All these people influence how we prioritize the things in our lives, and any list of priorities must start with what is required from us.

Here's how to use it: if you're doing something that's not necessary, you should eliminate it. If you're doing something that's necessary but does not need to be necessarily done by you, delegate it. The longer you use the Law of Priorities, the shorter your "to do" list should be.

2. What gives you the greatest return?

As a leader, you should spend most of your time working in your areas of greatest strength, a lesson that often gets lost with many leaders. While it's key to get out of your comfort zone occasionally, do it within your area of strength. A great basketball player should be focusing on basketball, not trying to improve baseball skills (channel Michael Jordan). We all use the 80/20 rule in our businesses, but it applies equally to leadership. Basically, it says that 80% of your activities will create 20% of your results

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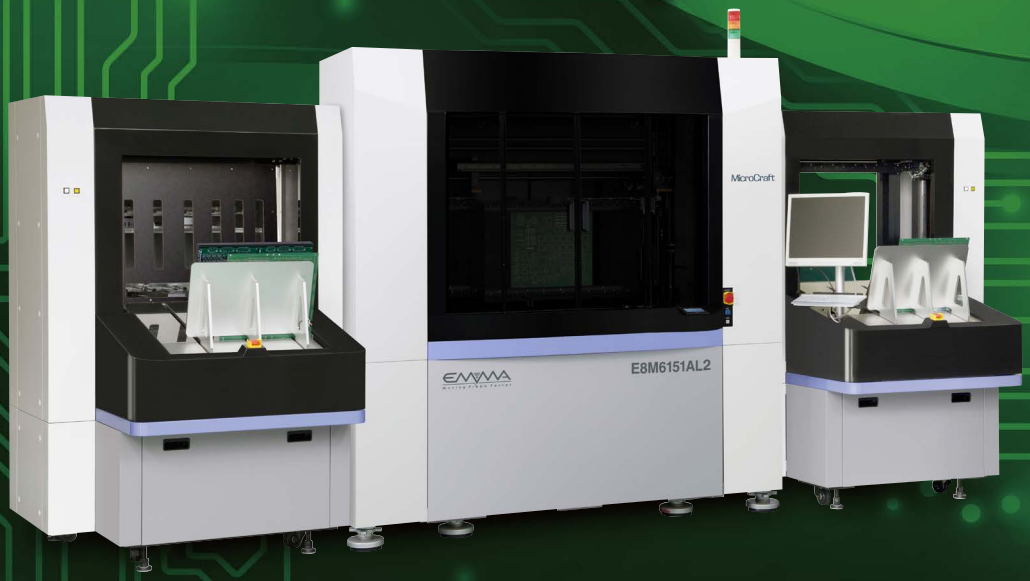

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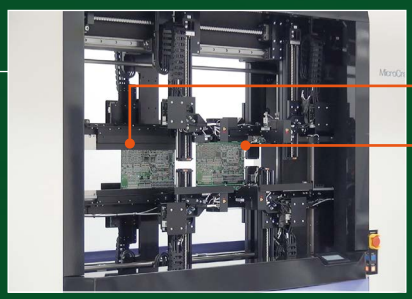

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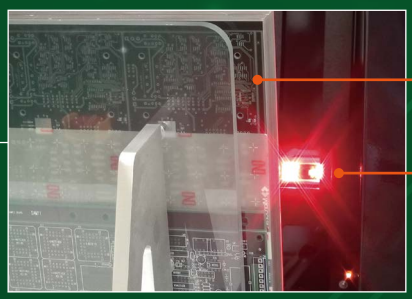

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and 20% of your activities create 80% of your results. The key is to identify 20% of your activities that bring you the highest return on investment, focus on them, and delegate the 80%. Now let's expand on this principle; if there's something on your list that can be done at least 80% as well by someone else, give it to them. The magic of this is that once they learn it and improve, they might be able to do it better and faster than yourself.

It's important to keep in mind that just because you can do something does not mean that you should do it. Remember, activity is not necessarily accomplishment.

3. What brings you the greatest reward?

This final question relates to personal satisfaction. The older I get, the more I realize that life is too short not to do the things you love. I love reading, training, and empowering others. I also enjoy improving systems and overall organizational performance. Another joy of my life is to spend time with my family. I love to travel and connect with people (not too often, though, as I value my alone time). All these things energize me and allow me to maintain a high level of passion for the important things in my life.

The bottom line: Prioritize your tasks by following the three steps listed above. Once you understand what your focus is, you will be able to prioritize your "to do" list and make things happen faster. The best leaders can satisfy multiple priorities with each activity, which enables them to increase their focus while reducing their number of actions. This might be an easier journey for some and harder for others.

Follow these guidelines and the Law of Priorities and you will truly be surprised at the results. Focus on enhancing your leadership skills to lead by example and the results will be epic. **PCB007**

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

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TOP TEN

EDITOR'S PICKS

Real Time with... IPC APEX EXPO: Update From PCBAA

PCBAA Chairman Travis Kelly sits down with Nolan Johnson to discuss the new association's recent activities and future plans. The Printed Circuit Board Association of America is focused on advocating for manufacturing in America.

Real Time with... IPC APEX EXPO 2022: The Supply Chain and Markets

Pete Starkey interviews Mark Goodwin, COO of Ventec International, on the impact of the current supply chain condition. Their conversation also covers aerospace and the U.S. market.

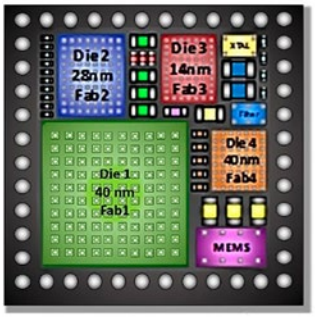
Trouble in Your Tank: Surface Preparation—The Foundation of the Photoresist Imaging Process

The photoimaging process is one of the first steps in the PCB fabrication process. In order to ensure that the image of the circuitry conforms as close to the desired design as possible (i.e., lines and spaces), surface preparation of the copper foil surface is one of the most critical success factors. Employing the optimum mix of surface cleaners and microetchants will provide a clean surface with sufficient surface area to promote dry film adhesion.

Real Time with... IPC APEX EXPO: John Mitchell Shares Thoughts on the Show

John W. Mitchell, president and CEO of IPC, shares his thoughts with Barry Matties about the return of the in-person IPC APEX EXPO after a two-year hiatus. Hint: He was very positive about it.

Happy's Tech Talk: Semi-Additive Processes and Heterogeneous Integration



The semi-additive processes (SAP) are not new. I first used them with a novel process back in 1978. MacDermid had a novel SAP process called PLADD II (PLAted Additive). It was an anodized aluminum foil applied to laminates that we could easily etch off after drilling and continue with a special electroless copper for thin metallization.

The Right Approach: Leadership 101—The Laws of the Picture and Buy-in

Good leadership always makes a difference; unfortunately, so does bad leadership. This leadership truth continues as we will be talking about Laws 13 and 14 of the 21 Irrefutable Laws of Leadership. I am sure that everyone remembers the childhood phrase "Monkey see, monkey do." When boiled down, this is exactly what the Law of the Picture teaches.

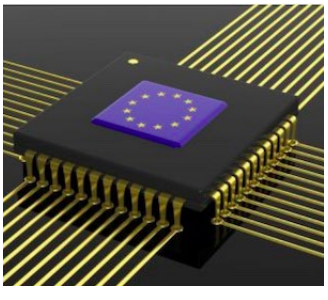
North American PCB Industry Sales Up 16.9% in December

IPC announced the December 2021 findings from its North American Printed Circuit Board (PCB) Statistical Program. The book-to-bill ratio stands at 1.17.

Real Time with... IPC APEX EXPO 2022: Latest Trends in PCB Manufacturing Equipment

Torsten Reckert, president of all4-PCB, discusses their product lines with Andy Shaughnessy, I-Connect007 editor. In this conversation, they look at the latest trends and requirements from the industry.

IPC Welcomes the European Chips Act



The electronics manufacturing industry is welcoming the release of the European Commission's European Chips Act with its strong support for advanced packaging and calling for its swift implementation as part of a broader and equally important strategy to rebuild the European electronics manufacturing ecosystem.

ICAPE Group Acquires CEBISA France

ICAPE Group and CEBISA France, a printed circuit board supplier based in Lisses (91), have signed an agreement to acquire 100% of CEBISA's activities by the French subsidiary of ICAPE Group. The transaction was effective at the end of February.

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Skills and abilities required:

- Proven experience as operations supervisor or similar role
- Knowledge of organizational effectiveness and warehouse management
- Experience with ISO9001 or similar QMS
- Experience in budgeting and forecasting/ familiarity with business and financial principles
- Excellent leadership ability and communication skills (English)
- Outstanding organizational skills
- Qualification in distribution, logistics, transportation, or business studies is preferential

What's on offer:

- Excellent salary & benefits commensurate with experience

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European Product Manager
Taiyo Inks, Germany

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

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

Skills and abilities required:

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

What's on offer:

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

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Career Opportunities

MacDermid Alpha ELECTRONICS SOLUTIONS

R&D Scientist III, Orange, CT

Job Description: The scientist will be a leader in technology for plating chemistry development, electrolytes, and additives. The position is hands-on, where the ideal candidate will enjoy creating and testing new aqueous plating processes and materials to meet the most demanding semiconductor applications related to Wafer-Level Packaging and Damascene. The qualified candidate will work as part of the R&D team while interacting with scientists, product management, and application engineers to commercialize new products for the advanced electronic solution business.

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Prototype Engineer, Sawanee, GA

Job Description: The purpose of this position is to provide direct technical and customer support for the Electronic Polymers (EP) product line of the Semiconductor Solutions Group for existing products as well as new and developmental products. The position is responsible for leading the team with customer builds and proof of concept designs directly engaging with customers. The position will lead a variety of technical, customer support, quality, marketing, process, and production related projects.

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Regional Manager
Midwest Region

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

DETAILS OF FUNCTION:

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

QUALIFICATIONS:

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

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

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Career Opportunities

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Application Engineer/ Program Management

Responsibilities

- Gain understanding for customer and specific project requirements
- Review customer files/drawings, analyze technical, application, stackup, material, and mechanical requirements; develop cost-effective designs that meet requirements
- Quote and follow up to secure business
- Work with CAD: finalize files, attain customer approval prior to build
- Track timeline and provide customers with updates
- Follow up on prototype, assist with design changes if needed, push forward to production
- Work with customer as the lead technician/program manager or as part of FCT team working with an assigned program manager
- Help customer understand FCT's assembly, testing, and box build services/support
- Understand manufacturing and build process for flexible and rigid-flex circuits

Qualifications

- Demonstrated experience: PCB/FPCB/rigid-flex designer including expertise in design rules, IPC
- Demonstrated success in attaining business
- Ability to work in fast-paced environment, on broad range of projects, while maintaining a sense of urgency
- Ability to work as a team player
- Excellent written and verbal communication skills
- Must be willing to travel for sales support activities, customer program support and more.

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

Responsibilities

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

Qualifications

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

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Career Opportunities

MacDermid Alpha ELECTRONICS SOLUTIONS

Technical Marketing Specialist
Waterbury, CT

JOB DESCRIPTION:
Responsible for providing technical knowledge and support to marketing communications professionals. Cross training and acting as liaison between the Innovation and the Marketing Communications teams for both Circuitry Solutions and Semiconductor Solutions.

Chemist 1
Waterbury, CT

JOB DESCRIPTION:
Perform analysis—both chemical and mechanical—of customer-supplied samples. These include both structural and chemical testing using various instruments such as SEM, Instron, ICP, and titration methods. Perform various failure analysis functions, including, but not limited to, chemical analysis, SEM analysis of customer parts, and cross-section evaluation.

Applications Manager
Waterbury, CT/New England Region

JOB DESCRIPTION:
Applications Manager in the Electronics Specialties/Circuitry Solutions group to provide applications process knowledge, training and technical support of new products leading to sales revenue growth. Requires working through the existing sales and technical service organizations to leverage this knowledge globally. Experience in multilayer bonding along with dry film and solder mask adhesion processes a plus.

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Engineering Project Manager Graphics/Film

The primary purpose of this position is to manage Process Development, Process Scale Up and Capital projects in the Global Process Engineering Group (GPEG) function.

THIS INCLUDES:

- Managing the complete life cycle of the highly complex projects including approval of the projects, the planning and execution of the projects, and then the closeout of the projects to ensure planned results are achieved on a timely basis.
- Develop budgets timelines, and ensure progress to plan, as well as tracking project achievements.
- Define projects' objectives and ensure progress to plan, as well as tracking project achievements.
- Interface with internal customers to agree upon specifications, deliverables, and milestones.
- Represent project and the team and present project results to customers and internal management.
- Recommend new process and tools to achieve advanced project management.
- Manage project status in the form of formal briefings, project update meetings, and written, electronic, and graphic reports.
- Address problems through risk management and contingency planning and present solutions and/or options to executive management.

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Career Opportunities

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

Wet Process Engineer

ASC, the largest independent PCB manufacturer in the Midwest, is looking to expand our manufacturing controls and capabilities within our Process Engineering department. The person selected will be responsible for the process design, setup, operating parameters, and maintenance of three key areas—imaging, plating, etching--within the facility. This is an engineering function. No management of personnel required.

Essential Responsibilities

Qualified candidates must be able to organize their own functions to match the goals of the company.

Responsible for:

- panel preparation, dry film lamination, exposure, development and the processes, equipment setup and maintenance programs
- automated (PAL line) electrolytic copper plating process and the equipment setup and maintenance programs
- both the cupric (acid) etching and the ammoniacal (alkaline) etching processes and the equipment setups and maintenance programs

Ability to:

- perform basic lab analysis and trouble-shooting as required
- use measurement and analytical equipment as necessary
- work alongside managers, department supervisors and operators to cooperatively resolve issues
- effectively problem-solve
- manage multiple projects concurrently
- read and speak English
- communicate effectively/interface at every level of the organization

Organizational Relationships

Reports to the Technical Director.

Qualifications

Degree in Engineering (BChE or I.E. preferred). Equivalent work experience considered. High school diploma required. Literate and functional with most common business software systems MS Office, Excel, Word, PowerPoint are required. Microsoft Access and basics of statistics and SPC a plus.

Physical Demands

Exertion of up to 50 lbs. of force occasionally may be required. Good manual dexterity for the use of common office equipment and hand tools.

- Ability to stand for long periods.

Work Environment

This position is in a manufacturing setting with exposure to noise, dirt, and chemicals.

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Career Opportunities

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Pluritec North America, ltd., an innovative leader in drilling, routing, and automated inspection in the printed circuit board industry, is seeking a full-time field service engineer.

This individual will support service for North America in printed circuit board drill/routing and x-ray inspection equipment.

Duties included: Installation, training, maintenance, and repair. Must be able to troubleshoot electrical and mechanical issues in the field as well as calibrate products, perform modifications and retrofits. Diagnose effectively with customer via telephone support. Assist in optimization of machine operations.

A technical degree is preferred, along with strong verbal and written communication skills. Read and interpret schematics, collect data, write technical reports.

Valid driver's license is required, as well as a passport, and major credit card for travel.

Must be able to travel extensively.

apply now

INSULECTRO

Are You Our Next Superstar?!

Insulectro, the largest national distributor of printed circuit board materials, is looking to add superstars to our dynamic technical and sales teams. We are always looking for good talent to enhance our service level to our customers and drive our purpose to enable our customers build better boards faster. Our nationwide network provides many opportunities for a rewarding career within our company.

We are looking for talent with solid background in the PCB or PE industry and proven sales experience with a drive and attitude that match our company culture. This is a great opportunity to join an industry leader in the PCB and PE world and work with a terrific team driven to be vital in the design and manufacture of future circuits.

apply now

Career Opportunities

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

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

Laminator Technician

Nature of Duties/Responsibilities

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

Education/Experience

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

Wet Process/Plating Technician

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

Purpose

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

Nature of Duties/Responsibilities

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

Education and Experience

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

Production Scheduler

Main Responsibilities

- Development and deployment of a level-loaded production plan
- Establish manufacturing plan which results in "best possible" use of resources to maximize asset utilization
- Analyze production capacity of manufacturing processes, equipment and human resource requirements needed to produce required products
- Plan operation manufacturing sequences in weekly time segments utilizing production labor standards
- Maintain, align, and communicate regularly with internal suppliers/customers and customer service on key order metrics as per their requirements
- Frequently compare current and anticipated orders with available inventory and creates replenishment plan
- Maintain master distribution schedule for the assigned facility, revise as needed and alert appropriate staff of schedule changes or delays
- Participate in periodic forecasting meetings
- Lead or participate in planning and status meetings with production, shipping, purchasing, customer service and/or other related departments
- Follow all good manufacturing practices (GMPs)
- Answer company communications, fax, copy and file paperwork

Education and Experience

- High school diploma or GED
- Experience in manufacturing preferred/3 years in scheduling
- Resourceful and good problem-solving skills
- Ability to make high pressure decisions
- Excellent written and verbal communication skills
- Strong computer skills including ERP, Excel, Word, MS Office
- Detailed and meticulous with good organizational skills
- Must be articulate, tactful and professional at all times
- Self-motivated

apply now

Career Opportunities

Manncorp™

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

Manncorp™

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

OMRON
SPI AOI AXI

Account Manager
(SPI | AOI | AXI)

Omron Automation Americas is actively seeking an energetic and focused Account Manager to help support our Automated Inspection Solutions product business (SPI, AOI and AXI).

This position is based within any major city covering the Western-US region (including Dallas, Austin, Phoenix and Northern/Southern California). The goal is to work independently and alongside our strong rep. partners in the territory to further expand our business in industries and market segments where we have high potential for continued success and growth.

This is a rare opportunity to join the dynamic team of professionals at Omron and work for a true, industry leader.

To learn more about this exciting role, please contact us directly via:

shawn.arbid@omron.com

apply now

Ucamco

Sales Engineer
Germany, Austria, Switzerland, Southeastern Europe e.g. Italy

Ucamco is looking for a sales engineer for our front-end software in the German-speaking area (Germany, Austria, German Switzerland) as well as adjacent markets in the South and East.

Ucamco is a market leader in PCB CAM, pre-CAM software and laser photoplotters with more than 35 years' experience developing and supporting leading-edge, front-end tooling solutions for the global PCB industry.

Responsibilities:

- Selling software solutions
- Selling support contracts and upgrades
- Developing and implementing customer acquisition plan
- Organizing and taking part in roadshows, seminars, exhibitions
- Follow up of current customers and sales
- Contributing insights into the marketing plan
- Reporting to Ucamco's sales director

Requirements:

- Fluent in German, good knowledge of English; other languages a plus
- Frequent traveling to prospects and customers– live contact is important
- Feeling for technical software
- Motivated to succeed as a solution seller
- Strong empathy for the customer
- Self-starter, able to work independently, organized
- Honest, trustworthy, dependable, credible
- Sales and technical expertise in PCB industry a big plus
- Knowledge of market and customer base in German speaking area a big plus
- Used to working from home office
- Traveling to headquarters in Gent (Belgium) for sales and customer meetings
- Good feeling for software is more important than strong sales experience

This is a salary-based position with a commission plan, company car, expense reimbursement, and benefits like health insurance.

apply now

Career Opportunities

The Test Connection, Inc.

Rewarding Careers

Take advantage of the opportunities we are offering for careers with a growing test engineering firm. We currently have several openings at every stage of our operation.

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

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

Associate Electronics Technician/ Engineer (ATE-MD)

TTCI is adding electronics technician/engineer to our team for production test support.

- Candidates would operate the test systems and inspect circuit card assemblies (CCA) and will work under the direction of engineering staff, following established procedures to accomplish assigned tasks.
- Test, troubleshoot, repair, and modify developmental and production electronics.
- Working knowledge of theories of electronics, electrical circuitry, engineering mathematics, electronic and electrical testing desired.
- Advancement opportunities available.
- Must be a US citizen or resident.

apply now

Test Engineer (TE-MD)

In this role, you will specialize in the development of in-circuit test (ICT) sets for Keysight 3070 (formerly HP) and/or Teradyne (formerly GenRad) TestStation/228X test systems.

- Candidates must have at least three years of experience with in-circuit test equipment. A candidate would develop and debug our test systems and install in-circuit test sets remotely online or at customer's manufacturing locations nationwide.
- Candidates would also help support production testing and implement Engineering Change Orders and program enhancements, library model generation, perform testing and failure analysis of assembled boards, and other related tasks.
- Some travel required and these positions are available in the Hunt Valley, Md., office.

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Sr. Test Engineer (STE-MD)

- Candidate would specialize in the development of in-circuit test (ICT) sets for Keysight 3070 (formerly Agilent & HP), Teradyne/ GenRad, and Flying Probe test systems.
- Strong candidates will have more than five years of experience with in-circuit test equipment. Some experience with flying probe test equipment is preferred. A candidate would develop, and debug on our test systems and install in-circuit test sets remotely online or at customer's manufacturing locations nationwide.
- Proficient working knowledge of Flash/ISP programming, MAC Address and Boundary Scan required. The candidate would also help support production testing implementing Engineering Change Orders and program enhancements, library model generation, perform testing and failure analysis of assembled boards, and other related tasks. An understanding of stand-alone boundary scan and flying probe desired.
- Some travel required. Positions are available in the Hunt Valley, Md., office.

Contact us today to learn about the rewarding careers we are offering. Please email resumes with a short message describing your relevant experience and any questions to careers@ttci.com. Please, no phone calls.

We proudly serve customers nationwide and around the world.

TTCI is an ITAR registered and JCP DD2345 certified company that is NIST 800-171 compliant.

apply now

Career Opportunities

ICAPE GROUP
The power of precision

PCB Field Engineer–North America Operations

ICAPE Group is a European leader for printed circuits boards and custom-made electro-mechanical parts. Headquartered in Paris, France, we have over 500 employees located in more than 70 countries serving our +2500 customers.

To support our growth in the American market, we are looking for a PCB Field Engineer.

You will work in our North America technical center, including our U.S. technical laboratory, and will be responsible for providing technical and quality support to our American sales team.

You will have direct customer contact during all phases of the sales process and provide follow-on support as required.

RESPONSIBILITIES INCLUDE

- Feasibility recommendations
- Fabricator questions and liaison
- Quality resolutions
- Technical explanation (for the customer) of proposals, laboratory analysis or technology challenges

REQUIREMENTS

- Engineering degree or equivalent industry experience
- 5 years' experience with PCB manufacturing (including CAM)
- Excellent technical understanding of PCBs
- Experience with quality tools (FAI, PPAP and 8-D)
- Good communication skills (written and oral)

Communication skills are essential to assist the customer with navigation of the complex process of matching the PCB to the application.

SALARY

Competitive, based on profile and experience. Position is full time in Indianapolis, Ind.

apply now

Prototron Circuits

Sales Representatives

Prototron Circuits, a market-leading, quick-turn PCB shop, is looking for sales representatives for all territories.

Reasons you should work with Prototron:

- Serving the PCB industry for over 30 years
- Solid reputation for on-time delivery (99% on-time)
- Excellent quality
- Production quality quick-turn services in as little as 24 hours
- AS9100
- MIL-PRF- 31032
- ITAR
- Global sourcing
- Engineering consultation
- Completely customer focused team

Interested? Let's have a talk.
Call Dan Beaulieu at
207-649-0879
or email to
danbbeaulieu@aol.com

apply now

Career Opportunities

MivaTek Global

Field Service Technician

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

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

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

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

More About Us

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

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SIEMENS

Siemens EDA Sr. Applications Engineer

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

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

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

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

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Career Opportunities

ARLON ELECTRONIC MATERIALS

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

- **Engineering**
- **Quality**
- **Various Manufacturing**

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

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

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

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

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

CAD/CAM Engineer

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

ESSENTIAL DUTIES AND RESPONSIBILITIES

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

ORGANIZATIONAL RELATIONSHIP

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

QUALIFICATIONS

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

PHYSICAL DEMANDS

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

apply now

Career Opportunities

APCT
Passion | Commitment | Trust

APCT, Printed Circuit Board Solutions: Opportunities Await

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

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

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

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

apply now

BLACKFOX
Premier Training & Certification

IPC Instructor

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

Independent contractor, possible full-time employment

Job Description

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

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

Qualifications

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

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

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

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

apply now

Career Opportunities

U.S. CIRCUIT

Plating Supervisor

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

Competitive benefits package.
Pay will be commensurate
with experience.

Mail to:
mfariba@uscircuit.com

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eptac
TRAIN. WORK SMARTER. SUCCEED.

Become a Certified IPC Master Instructor

Opportunities are available in Canada, New England, California, and Chicago. If you love teaching people, choosing the classes and times you want to work, and basically being your own boss, this may be the career for you. EPTAC Corporation is the leading provider of electronics training and IPC certification and we are looking for instructors that have a passion for working with people to develop their skills and knowledge. If you have a background in electronics manufacturing and enthusiasm for education, drop us a line or send us your resume. We would love to chat with you. Ability to travel required. IPC-7711/7721 or IPC-A-620 CIT certification a big plus.

Qualifications and skills

- A love of teaching and enthusiasm to help others learn
- Background in electronics manufacturing
- Soldering and/or electronics/cable assembly experience
- IPC certification a plus, but will certify the right candidate

Benefits

- Ability to operate from home. No required in-office schedule
- Flexible schedule. Control your own schedule
- IRA retirement matching contributions after one year of service
- Training and certifications provided and maintained by EPTAC

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I-007e EDUCATIONAL RESOURCE CENTER

Latest I-007eBooks

The Printed Circuit Designer's Guide to... High Performance Materials

by Michael Gay, Isola

This book provides the reader with a clearer picture of what to know when selecting which material is most desirable for their upcoming products and a solid base for making material selection decisions. **Get your copy now!**

The Printed Circuit Designer's Guide to... Stackups: The Design within the Design

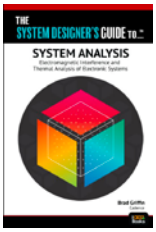
by Bill Hargin, Z-zero

Finally, a book about stackups! From material selection and understanding laminate data-sheets, to impedance planning, glass weave skew and rigid-flex materials, topic expert Bill Hargin has written a unique book on PCB stackups. **Get yours now!**

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

by Brad Griffin, Cadence

In this book, the author, Brad Griffin of Cadence, focuses on EM and thermal analysis in the context of data center electronics systems. Be sure to also **download the companion guide** for end-to-end solutions to today's design challenges.

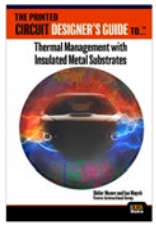


I-007eBooks The Printed Circuit Designer's Guide to...

Thermal Management: A Fabricator's Perspective

by Anaya Vardya, American Standard Circuits

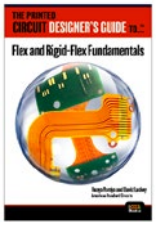
Beat the heat in your designs through thermal management design processes. This book serves as a desk reference on the most current techniques and methods from a PCB fabricator's perspective.



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.



Flex and Rigid-Flex Fundamentals

by Anaya Vardya and David Lackey, American Standard Circuits

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

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

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