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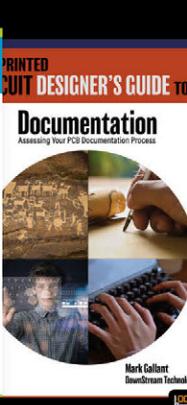
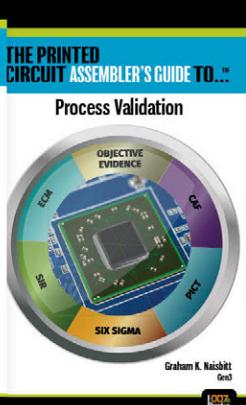
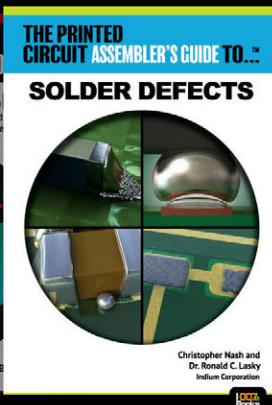
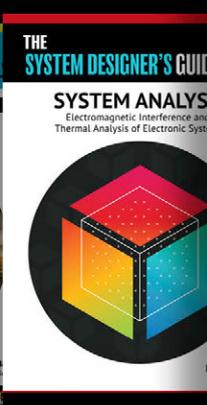
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## The European Influence

Europe is a big market with a great deal of innovation underway in PCB fabrication and assembly. For example, Europe has a leadership role in Industry 4.0 development. It is widely seen as a driving force in sustainability and environmental stewardship. Inside the printed circuit industry, Europe continues to be a ripe incubator for new processes, materials, equipment, and automation solutions. For that reason, we chose to start the new year by focusing on the European market.

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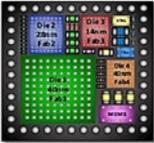
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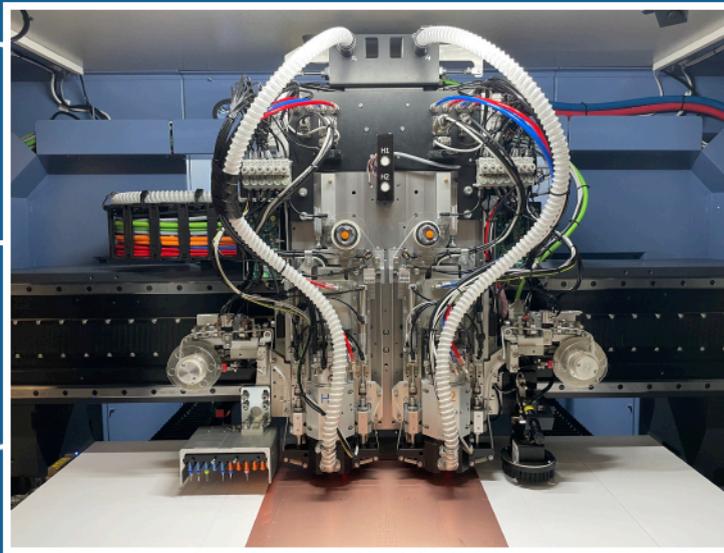
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# What's Driving Europe?

## Nolan's Notes

by Nolan Johnson, I-CONNECT007

It's not breaking news that Europe is central to much of the automotive electronics development in the world economy, but what are the actual numbers?

The global consumer electronics market was estimated at \$838.85 billion in 2020, according to Grand View Research<sup>1</sup>. With an estimated global Gross Domestic Product (GDP) of \$84.54 trillion, consumer electronics makes up roughly 1% of the entire global economy.

If we zoom into some key regions using 2020 data, we see the info in Table 1.

Now, this data is a bit “apples to oranges” in that, by deadline, I hadn't yet found any data for automotive across the EU, so while I show the EU's GDP—and with apologies to France, the UK, Italy, and all other non-German auto

companies—the automotive specific statistics are just for Germany. Even still, the European numbers give one pause: Germany alone has more gross product from automotive than either the U.S. or China. Whatever the numbers are for the rest of the EU, it's clear that automotive is a major industrial and electronics driver in Europe.

Europe is a big market with a great deal of innovation underway in PCB fabrication and assembly. For example, Europe has a leadership role in Industry 4.0 development. It is widely seen as a driving force in sustainability and environmental stewardship. Inside the printed circuit industry, Europe continues to be a ripe incubator for new processes, materials, equipment, and automation solutions. For

**Table 1** 2020 Comparison by Region

Region	Total GDP USD\$	%Global Share	% of GDP Automotive	USD\$ Automotive
USA	20.9T	18.5	6	1.249T
Europe	15.3T	18	10*	1.5T*
China	14.7T	13	5.5	802B

\* Europe is represented by numbers for Germany alone.

that reason, we chose to start the new year by focusing on the European market.

Our goal with this issue was to highlight the innovative research, development, and manufacturing efforts currently underway in the wider European region. We wanted to learn about important new technologies and solutions coming out of Europe and identify any challenges Europe is trying to overcome with its technologies. What are the hurdles? What new technologies have been adopted that have made a significant impact in the European market? Part of this may include discussion of the application markets Europe is targeting.

Some readers may already be familiar with the EIPC, a European-based, independent organization for PCB technologists to share their ideas, discuss their research, and move the industry forward collaboratively. We contacted the EIPC for this issue and spoke extensively with EIPC technical director Tarja Rapala-Virtanen. The EIPC traditionally has hosted quarterly two-day, in-person conferences. During the sporadic COVID lockdown phases, EIPC began hosting instead a monthly online “Technical Snapshot Webinar” series, with four to five presenters sharing their most recent R&D, market research, etc.

In my interview, Rapala-Virtanen said, “I would say it’s a time of innovation. The requirements are becoming harder, but engineers are clever. There are some very interesting new technologies coming.” When I asked her about the influence of automotive on the entire industry, she said, “For me, the telecom side, like 5G and automotive, are moving toward similar types of products. The new autonomous vehicles are like a small base station because they need to communicate with the network.” Her point was clear: The innovation available to us, thanks to 5G, will require further improved telecom services, which will be the ether hosting the data mesh that keeps the smart vehicles running safely. They all are developing independently, but within the automotive application, they all come together. This confluence is

the inspiration for so much of the research and development underway in Europe.

With this issue, we endeavored to bring you some sage industry perspective. The result is interviews with NCAB’s Anders Forsen, CCI Eurodam’s Alain Kahn, and Tarja Rapala-Virtanen from EIPC. Karl-Heinz Fritz at Cicor shares his perspective as a fabricator, while Dr. John Mitchell, IPC president, turns his attention to Europe in his column this month.

To capture some of the R&D work underway, we contacted EIPC Technical Snapshot presenters from the Q4 2021 webinars to talk about their recent presentations. Not everyone was comfortable sharing their work quite yet, but we bring you a peek into the work of the EIPC. The argument can be made that the information shared within the EIPC is valuable but often overlooked by U.S. manufacturers.

Finally, we turned to Israel for an interview with Ralph Birnbaum at ioTech to learn about how this company is innovating additive technologies. All in all, the work coming out of Europe is very interesting.

Of course, our columnists deliver, as ever, with dispatches from Mike Carano, Happy Holden, Steve Williams, and a new column from the PCBAA launches this month.

As this issue goes to publication, many of us will be converging on San Diego, California, for IPC APEX EXPO. From all of us here at I-Connect007, we look forward to seeing you there. **PCB007**

## References

1. “Global Consumer Electronics Market Worth \$838.85 Billion by 2020,” Grand View Research, September 2015.



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](#).



# Technology and Development Prospects for the **European** Marketplace

Feature Interview by Nolan Johnson

I-CONNECT007

Nolan Johnson speaks with Tarja Rapala-Virtanen, technical director of the EIPC, who breaks down the current state of the European market and which technologies and market segments are seeing growth.

**Nolan Johnson:** Tarja, how would you describe the current European marketplace? Is this a time of refinement? How about innovation or growth?

**Tarja Rapala-Virtanen:** I would say it's a time of innovation, but how good are they? How can they manage to do the implementation, NPI, and prototyping to show the reliability, quality, and features that can be fulfilled, while simultaneously meeting all the necessary technical requirements for the product? The requirements are becoming harder, but engineers are clever. There are some very interesting new technologies coming for the additive technologies.

**Johnson:** What are the drivers for that innova-

tion? Some of it is responding to COVID. Other parts are a response to customer demands and technology requirements.

**Rapala-Virtanen:** I think one reason the additive is pushed is sustainability. If you look at, for example, Continental, Infineon, Bosch, all these suppliers for automotive are very strong on sustainability and CO<sub>2</sub> emission. I'm from Scandinavia and, as you know, Scandinavian countries have always been active in environmental development. It's understood here that something must be done.

It's clear that the additive technology also improves the capability; instead of etching away [the copper] you only plate where it is needed and simultaneously the fine line resolution is improved. Of course, the manufacturing technology selection depends on the end customer product design, which PCB manufacturing technology is used.

**Johnson:** Correct me if I'm wrong, but automotive as an industry plays a large part in the European market.

**Rapala-Virtanen:** Yes, it does.

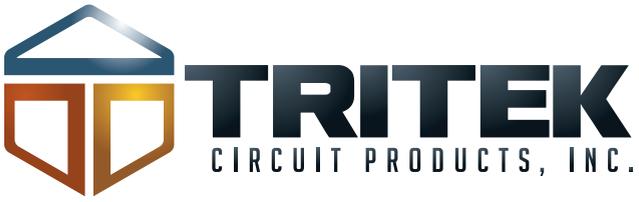
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Tarja Rapala-Virtanen

**Johnson:** And automotive plays an increasingly large part in the global market when it comes to electronics manufacturing. It seems like the requirements for automotive are quickly becoming the requirements for the industry overall.

**Rapala-Virtanen:** For me, the telecom side, like 5G and automotive, are moving toward similar types of products. The new autonomous vehicles are like a small base station because they need to communicate with the network. There is a huge amount of information and data from the vehicle which must be connected to the network all the time. For automotive, as you know, the reliability requirements are stringent.

**Johnson:** Right. It's an interesting situation in automotive. The automobile is a base station, but it must be very environmentally rugged.

**Rapala-Virtanen:** It has to be very reliable because the connection must be working all the time, without latency or dropouts.

**Johnson:** So, is there enough pressure from the market to retool the factories in Europe? Are they retooling for this?

**Rapala-Virtanen:** Yes, they have, but nobody really knows exactly what the automotive product will be, if they use the same etching and lamination processes, or if they should be ready to implement some of the new manufacturing technologies.

But it will be very interesting to watch. I don't know if it will be the telecom or automotive that will be first to implement some of the new ways of manufacturing.

**Johnson:** It sounds like it can be described as cautious investment and movement toward new technologies that are bringing smaller, finer capabilities. That includes things like additive and semi-additive, and a focus on the goal of being sustainable and green, which, of course, points to those same technologies. I suppose there also is more of a push into a smart or automated factory technology to help with those same goals of getting to be more sustainable, better margins.

**Rapala-Virtanen:** Yes, you are right, the challenge is to make the decision and select the correct technology supporting the product needs.

**Johnson:** And you need more data for tracing and better reliability, not to mention sustainability, because you have a better sense for everything in the process.

**Rapala-Virtanen:** I must say that all the PCB factories—the new ones making these very high density HDIs—are collecting a lot of data, but maybe they are not using it for anything.

**Johnson:** Making use of that data seems to be a challenge, doesn't it?

**Rapala-Virtanen:** Yes, and I don't think PCB manufacturing is the only one with that chal-

lenge. Still, because PCB manufacturing combines so many different processes, it's still limiting with maybe one critical process. That is something that will come. Is it in Industry 4.0, 5.0, or is it something else? In my opinion, the software development and implementation are the key in this challenge. First, how do you get all the equipment connected within the factory and then use the data for process control?

**Johnson:** What is the general European thinking on moving to Industry 4.0? Typically, that is applied to assembly, but what about in PCB fabrication?

**Rapala-Virtanen:** I think there are some, but it's a combination of so many different process steps that it also needs the communication of the different equipment makers. As it's necessary to get all collected data into the factory global database from where the data can then be used for overall process optimization within the different process steps.

**Johnson:** Are the fabricators in Europe asking for this, are they looking for more Industry 4.0 capabilities?

**Rapala-Virtanen:** I think they are still following what is happening, but I think that as all new investments are Industry 4.0 capable, we will see more, thanks to the equipment producers' development work. They produce the whole line which is smart factory capable. In Europe, of course, many PCB shops are still very small and now, as I understand, the loading is nice. Normally when the factory loading is good, you do everything to get the products out of the factory on time.

**Johnson:** Do you see any particularly interesting new products from any new companies with a new offering?

**Rapala-Virtanen:** I think there are the software companies combining the information

chain within the factory. And then there are, of course, some equipment manufacturers who have also been working with new and very interesting manufacturing technologies to enable the development of a new product for future needs. In Finland and Europe, both existing and new start-up companies, even before COVID, had already started their development work. They have been excited about their development, both on the hardware and software side, have been able to start NPI manufacturing, and are showing some interesting results. It's important to understand how the hardware and software will work together. I know multiple interesting new technology approaches supporting the product development have been introduced.

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**In Finland and Europe, both existing and new start-up companies, even before COVID, had already started their development work.**

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**Johnson:** What about materials or wet processes that are being developed? I would expect the motivation is to be more sustainable, but who is leading that sort of development?

**Rapala-Virtanen:** That's a good question and you are right that sustainability is, of course, included in the development; but the capability to fulfill the future end-product requirements is important. Both the material and wet process development must go hand in hand, and they also must know the future product requirement to make their material or process capable and sustainable at the same time.

Today, the tighter tolerance and variation requirements are the focus, especially in mass

production. As we all can understand, the tolerance improvement during PCB manufacturing cannot happen without simultaneous improvement of the base material and wet processing tolerances. In other words, the PCB manufacturer cannot improve, for example, the material thickness tolerances during the processing but can adjust the total board thickness by the PCB build-up design.

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**The PCB manufacturer cannot improve, for example, the material thickness tolerances during the processing but can adjust the total board thickness by the PCB build-up design.**

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**Johnson:** I like how you put that. The PCB fab can only make the material worse, which raises an interesting point as to how all this comes together. The materials manufacturers certainly are under a different set of challenges and constraints. They must develop more precise, small feature-appropriate materials. That's a challenge in and of itself. When you start getting down to the point where you have to worry about where your via hit lines up on the mesh of the fiberglass to determine whether it's going to work or whether it's high risk, that becomes a difficult thing to predict and design around.

**Rapala-Virtanen:** You are right. The material manufacturers have improved their material tolerances and simultaneously the electrical performance. Due to that, the material offering today is wide so it's important that the

whole supply chain works together, starting from the designer, to find the best options of materials and processes supporting the future product by requirements and product type. Additionally, it's important from the time-to-market point of view, that the new materials are easy to drop into the existing PCB process without big process adjustments and with the same end product reliability. So, once again, the wet process and equipment manufacturers must be included in the development work as early as possible; working together enables the best manufacturability for the new product design.

**Johnson:** As the industry responds to these requirements and these demands, is the current infrastructure able to support that and really the answer is to a point, but not as far as we know it's going to have to go. There will be a point where there needs to be investment.

**Rapala-Virtanen:** I have heard some fabs say they would like to invest in new machines in manufacturing. But simultaneously it's also mentioned that the new equipment delivery time is longer than it used to be. As you know, all lead times are getting longer: components, materials, you name it. If you think about PCB manufacturing, there are a limited number of companies which are making the equipment, and if simultaneously comes the Industry 4.0, who will be the winner?

**Johnson:** Right. That does pose a challenge.

**Rapala-Virtanen:** We are living in very interesting times.

**Johnson:** Thank you.

**Rapala-Virtanen:** Thank you as well. PCB007

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# Europe—Taking the Technical Lead on Transition to the Digital Factory

## One World, One Industry

Feature Column by Dr. John Mitchell, IPC PRESIDENT AND CEO

As the president and CEO of a global trade association, I pay close attention to how the electronics manufacturing industry is faring throughout the world. I recently spoke to Sanjay Huprikar, president, IPC Europe and South Asia operations, and Matt Kelly, IPC chief technologist, about the European manufacturing industry.

**John Mitchell:** What can you tell me about technological advances in Europe?

**Sanjay Huprikar:** There is a strong appetite in Europe to take the technical lead on the transition to a digital factory. They are clearly taking ownership of the move toward the “factory of the future” and have an earnest desire to be first.

**Matt Kelly:** I certainly agree about ownership. There is a synergy between European companies, the industry, and the government. The EU regularly solicits participation from the industry and asks for expert advice. By creating the policies driven by the industry, it ensures that the government/industry link is quite strong. The idea is that as technology advances—as with the notion of the smart factory—the need to do things better and more efficiently helps their companies be more competitive.

Europe is strongly committed to the environment and has an active interest in sustainability. These are tough issues, they are daunting and challenging to solve, and sustainability is at the top of the list.



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Matt Kelly



Sanjay Huprikar

**Mitchell:** How do European manufacturers ensure that these issues are addressed?

**Kelly:** European manufacturers seem to have a systems-based approach. They care about the electrical and mechanical design, and they talk to each other, so mistakes are not made. That impacts manufacturing and is a great concept of the full manufacturing cycle.

**Huprikar:** I agree with Matt's observation. Europeans have embraced the systems integration approach and are project management-minded about it. They have a goal, and they work to obtain it by using the right players to ensure success. As a result, Europe has taken the leadership role on technologies in automotive, industrial, and medical.

**Mitchell:** What can you tell me about European influence in the automotive and medical industries? We certainly see many European IPC members in leadership roles in our standards development committees in these areas.

**Huprikar:** We have been fortunate to have companies like Bosch, Continental Automotive, Hella, BMW, and Volkswagen actively par-

ticipating in IPC committees; and when one thinks about industrial and medical, well, Siemens is probably the most prominent name that comes to mind.

**Kelly:** Yes, Siemens has a clear leadership role, and a drive to be competitive as well as the drive to say, "You know, we can still keep our top talent working in science and engineering, but to do that, we have to be the best at it." German engineering has been coined as a mark of quality success, and that says it all.

**Huprikar:** German companies obviously have a strong reputation for engineering and high tech, but the French should not be overlooked. They are industry leaders—Thales, Airbus, Safran, Schneider Electric, Alstom, and others heavily participate in IPC.

**Mitchell:** How is Europe's workforce responding to the dynamic changes of manufacturing?

**Huprikar:** As with everyone else in the industry, they are struggling to find enough and the right kind of talent. These challenges have driven IPC to develop critical educational content to meet the needs of the market. An example is a "Fundamentals of PCBA" course

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**Kelly:** The number of people retiring and leaving is essentially the Baby Boomer population. This is the main cause of attrition for this skill set. So, it's important that we focus on the next generation of technologists and identify new ways of working with new technologies.

**Mitchell:** Where does Europe focus on the Factory of the Future or smart factory?

**Kelly:** Europe is focused on the implementation and execution of new technologies for smart factories. There is a trend toward digitization, using IPC-CFX to implement change. There is an eagerness to show others what they are doing and how they are implementing change.

**Huprikar:** A big part of modernizing and transforming factories is leveraging data to make better decisions. As Matt said, CFX is a big part of that, but in general, we have observed that European companies are laser-focused on managing and analyzing big data.

**Kelly:** There's a hierarchy of technologies. Let me give you an example. Everybody loves to talk about artificial intelligence, machine learning, and digital twin. These are all great concepts, but there are prerequisites that you must have in place before you implement them. You can't just say, "Let's go do AI or let's go do digital twin." Those cool shiny object types are great ideas that will start to take hold, but you can't do it without data and digitization, and Europe has figured that out. And that is why you see smart factory and advanced manufacturing being led by Europe.

**Mitchell:** Tell us about growth in IPC Europe.

**Huprikar:** The good news is Europeans want us to do more. There are plenty of exciting opportunities to expand our collaborations in standards, education, and advocacy. To that end, we are hiring more staff this year to support the industry. **PCB007**



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





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# NCAB Sees **Steady** Growth

Feature Interview by Nolan Johnson  
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How has Europe fared during and after the pandemic? Nolan Johnson speaks with Anders Forsen, CFO of NCAB Group headquartered in Sweden, about the current state of the market in Europe, how it impacted his company (phenomenal), and where the company is putting its focus (think green). Where does China fit into the overall picture? Anders shares valuable insight that all PCB manufacturers can benefit from.

**Nolan Johnson:** Anders, what's happening in the European region?

**Anders Forsen:** Of course, 2020 was impacted by the pandemic, which continues, but 2021 was a very strong year and we have seen a very robust recovery in almost all sectors. In 2020, we saw a quick downturn in the transporta-

tion and automotive sector while med tech increased significantly. We managed to keep our revenue rather close to 2019, and we saw tremendous growth in 2021. We actually see that in all European markets. We are up year by year about 35–40% compared to 2020, so that's huge organic growth.

You can also see much is happening in the EV charging and green tech industry. We have many projects sold to EV charging companies. We do a lot in Norway and Germany, as well as customers in Benelux selling to EV charging, so that has been growing extremely quickly. In this green tech area, there is a need for more monitoring systems and to have better control. That creates a big demand for electronics to manage that. We work in this high-mix, low-volume area, which is a typically good area for growth.

Some parts of the European market, especially Germany, have been very much driven by automotive because many car manufactur-

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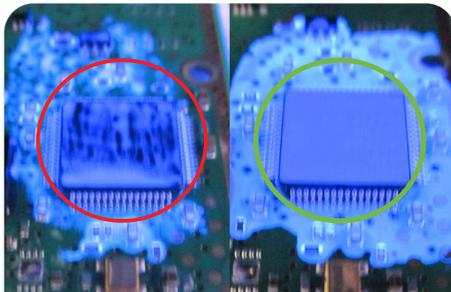


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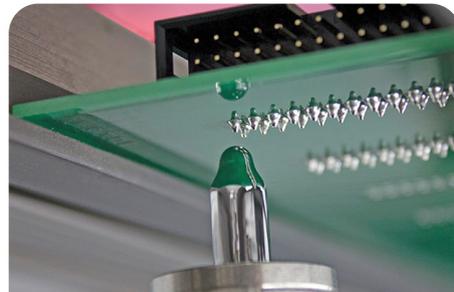
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Anders Forsen

ers are based in Germany. Not only are they extremely demanding customers, but they may be driving some of the local PCB production because some of their material requirements are tricky to get outside of Europe. Our focus in the automotive industry is predominantly on niche applications in high-mix, low-volume areas and on Tier 2 and Tier 3 customers.

**Johnson:** For those products (EV charging), is that primarily a European market, or are you seeing those products in your global mix?

**Forsen:** So far, it's mainly for European markets. We are working with several customers which are growing extremely fast and probably will sell outside Europe as well. The growth started, for example, in Norway, then they started to sell to the other Nordic countries and then to Europe. They are seeing the market grow that way.

**Johnson:** Thirty-five to 40% organic growth is dramatic. How sustainable is that? Do you see that as a bump in orders from customers, or is

this really growing into new markets that you see as being steady business going forward?

**Forsen:** We did face a weaker market in 2020 and 2021, which boosts the year-on-year comparison. You can see that orders have increased even more, but that's also due to long lead times in the factories in China, some issues with the freight situation, and so on. We have encouraged our customers to order more in advance. We have seen a stronger growth in orders, but that will probably even out in the first half of 2022. Of course, we cannot have another year with 35–40% growth, but hopefully we will have another double-digit percentage growth.

**Johnson:** That's still some very strong growth. Based on the NCAB business model, which uses a network of fabricators that you work with, has this growth been a capacity challenge for you?

**Forsen:** No, not really. We may have seen a little during winter 2021 because all the factories were at full capacity. But the beauty of our business model and our size is the strong relationships we have with our factories. We aim to be one of their top three customers, hence they prioritize us. When there are some issues, we have a much easier time getting boards out of those factories and seamlessly into another appropriate factory.

We have a huge factory management team in Asia—some 90 in China and 10 in Taiwan—working with the factories daily; they manage to secure a high delivery reliability for our customers. In this respect, you can see that the pandemic has highlighted some of the advantages of working with NCAB, as smaller traders or direct buying customers have not been able to travel. No one has been able to visit the factories in China, for example, and maintain their relationships. But since we have so many people onsite in China and Taiwan, we can be there daily developing the factories, making

sure that they prioritize us. That's gone well and we have been able to cope with the growth in a very good way.

**Johnson:** Let's pivot to technology. What are you seeing out of your European customers regarding emerging technology or needs in the boards that they're fabricating?

**Forsen:** Typically, it is the standard board, four to six layers. But we can see that the miniaturization demands PCBs get smaller and smaller. That means you must have higher layer count and more complex boards. You can see it slowly trend upward.

**Johnson:** In Europe, what are the design team pain points? What are they struggling with the most that they talk to NCAB about?

**Forsen:** We see a lot of customers struggling with components, meaning that they must redesign a lot of products because they must have a second alternative to the components that they had before. We see customers struggling with component shortage, while getting the PCBs is not their main issue. That means we had to redesign a lot of products. We see new part numbers and new revisions in that way. I think that has been a very general trend this year.

**Johnson:** Is the European market healthy? Is it well-positioned to be sustainable and competitive on a global market?

**Forsen:** I think it's very healthy. We see a trend in that direction, which strengthens the European market. I also think that looking into, especially, the industrial segment then the nearshoring is important in that way. We can see that the EMS or CM companies that are working with

high-mix volume are very healthy and growing a lot. Of course, you will not see a lot of production for the high-volume consumer market go to Europe; that's already gone. But the trend is showing stronger growth in the industrial applications.

**Johnson:** What do you see for the European market in the next three to five years? How is it going to evolve? What's it going to respond to?

**Forsen:** We see growth in most areas. We have reviewed both some external and internal studies, and we see that the consumer market is not growing as much as before. There's more growth in industrial and green tech. Many European companies are at the forefront and developing this kind of product. There are very frequent revision changes, so they are not really gaining on transferring the assembly to Asia. I think the ones that are working with the high mix, low volume, those CMs or EMS companies, seem to be rather healthy and are growing.





**Johnson:** With that sort of a good, healthy reorganization of EMS companies' assembly function in Europe, that makes a lot of sense. Does that shift your mix at NCAB? With a global network of fabricators, are you able to then regionalize to match up or does that even matter?

**Forsen:** It doesn't really matter. Still, we say that the PCB market is about \$65 billion plus, with the high mix, low volume, which is our core business, at about one third (about \$20 billion). We have about 1.5–2% of the world market share, so there is still a lot to grab out there. In that respect, I think we are gaining on the fact that the high mix, low volume, the industrial segment, is growing because that is where we can add value. We see about the same trend in the U.S. market, as well as European market. So, I think they also see that the industrial segment is growing in a good way.

However, we see this trend in production of PCBs, that there are still no new factories open-

ing in Europe and the ones there are having difficulties investing in new equipment, new machinery, and so on. So, there's still that potential for less production in Europe, while with back-sourcing or taking back some of the high mix, low volume, the need for PCBs will continue to grow in Europe. That means there will be a growth market for companies like us because we can give so much more service. We can still act as a local player and give the customers technical support as the local factories did before.

**Johnson:** For companies wanting to supply the European market with equipment, materials, substrates, or components somewhere upstream in the supply chain, from your perspective, what do they need to do to succeed right now?

**Forsen:** Of course, they need to have a local presence. One main difference between

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Europe vs. the U.S. is that in Europe you have a lot of smaller countries and local languages. To be able to sell and give great customer support, you typically need to speak the local language. Even if everyone speaks English more or less, it's an advantage to speak French with the French guys, in German with German guys, and so on. Customers are asking for faster support because things are happening rather quickly and you develop new products, new ideas at a faster speed than before and then they need response time, which might be quicker.

**Johnson:** So, it's about business methods more than technology or R&D that they can bring to the market. It comes down to just doing good business. Any other advice you might have or insight you want to share about where the end market is?

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**If you look at the PCB trading market, it's still very fragmented. There are many smaller companies, and we believe we will see a consolidation going forward.**

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**Forsen:** If you look at the PCB trading market, it's still very fragmented. There are many smaller companies, and we believe we will see a consolidation going forward. We have made several acquisitions in NCAB over the past couple of years. We think that trend will continue. Twenty years ago, when all the factories closed, it was the management teams remaining. They could rather easily start some kind of trading business.

There might be some, maybe 50-60 companies, doing PCB trading, everything from \$5 million to \$20 million in revenue. They have managed to grow to a certain stage, but now they are facing increasing customer demands on, for example, quality and sustainability which are difficult for a smaller company to manage. Now, many of them are managers and owners, but they're in their 60s now, so we think there will be a consolidation phase. That will change the market, and we intend to play a leading role in that consolidation.

**Johnson:** In the news recently we've seen that NCAB has made some acquisitions that bring more engineering expertise to your team.

**Forsen:** We have added on a lot of engineering knowledge to support our customers. It's always the customers who do the design. But then we do the design for manufacturing and support them to see how we can help effect changes for more efficient and sustainable production, for a higher yield, or use some different material, and so on. That's tricky because there are not so many factories left, and not so many people in the business who know how to produce a PCB.

So, that's a good way through acquisitions to recruit these kinds of resources and the more we can provide customers with technical and engineering skills, the better service and competence we can provide them with.

**Johnson:** That's an interesting point about the declining knowledge base in the industry. Without the factories in a region, you don't have the expertise on how to manufacture in the first place. Thank you so much.

**Forsen:** The same to you. Thanks a lot. PCB007



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# An Inside Track on the European Market

Interview by Nolan Johnson

I-CONNECT007

Alain Kahn of CCI Eurolam discusses European market trends. With his extensive background in the European PCB market, Alain provides a needed perspective on Europe's changing views on PCBs, China's dominance, and how to attract young people into industrial jobs.

**Nolan Johnson:** Alain, before we start our discussion, will you give us some of your background?

**Alain Kahn:** I have been working in this business since 1968. I am probably one of the oldest remaining PCB guys; perhaps there is another one in Europe or even in the U.S., but I think it's relatively rare to have such a long career. I started work in a family company, most of which acted as a distributor for General Electric USA. At that time, there was a product called Textolite, which was a laminate, epoxy glass. It was manufactured by GE, by the way, in Coshocton, Ohio.

At that time, our company had two people—myself and my business partner Bernard Bismuth. We were young. Bernard was an engineer and had been selling laminates to the PCB industry here in France. We did this for about 10 years, and the market was growing, so we suggested to GE to build a masslam factory in the Paris area as we knew GE eventually wanted to have a factory in Europe.

We opened it in 1981, and as we had a left-wing government in France, GE decided to stop, so we took over their part in the masslam operation. Not long after, GE decided to retire from the European market, and eventually from this business. Now we had the possibility to distribute for a French company making laminates called Drouet Diamond. Unfortunately, they went into bankruptcy after three years and were taken over by Nelco.

But it created a big problem for us because we were an important laminate distributor already distributing Arlon and we were changing for the second time in a few years as a supplier of laminate.

We established an efficient partnership with the German Dynamit Nobel, but after 10 years,

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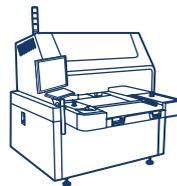
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their mother company decided to close the laminate division. Nevertheless, in 1993 we started a partnership with Isola, which lasted for 20 years, and we were successful. Isola was also sold to TPG, and the management decided to end our partnership. One positive point, our German operation (warehouse and industrial services, like cutting laminate in panel) is now installed in Duren, in the Isola industrial park. In 2014, to replace Isola (which had been our largest supplier), we were inspired to start a fruitful relationship with Elite Material (EMC) that gave us representation in 40 countries of the EMEA region. We have been distributing all over Europe—DuPont Pyralux, Arlon, Kingboard and recently Rogers—and we have the most complete offering of laminates.

In the past 30 years, we have completed our offer of consumables for the PCB, assembly, and printed electronics industry. We cover all of Europe with four logistics and services operations locations in France, Germany, United Kingdom, and Spain, and we have sales offices in Italy and Russia. In the future, we intend to install new operation/offices in Eastern Europe. In 2021, we acquired the Dutch com-

pany Adeon, a European leader in the distribution of equipment for PCB manufacturing. This line is very complementary for us and allows us to increase our expertise for the profit of our customers.

We are now obviously the luxury seller of laminates, whatever they have: high speed, the high Tg, low Tg, double-sided, polyimide, etc.

**Johnson:** That is an amazing history, cutting across most of the history of our industry. I'm curious about the industry now. What is your perspective on what's happening in the European market?

**Kahn:** I do not pretend to be the specialist on this question, but I have an idea. This year the increase of the European market is impressive.



I've heard that Europe has something like 25% of the market (price increase and volume combined) compared to 2019, which was a slow market, of course. Compared to Asia, it's about the same, and much bigger than the U.S. We see a very positive future.

For us, we have been facing a total decline of the European PCB market, but which was recently stabilized. For 15 years, it really went down, and we were not expecting a recovery.

But as we grew first geographically, we introduced products not related to electronics and assembly. The assembly market wasn't declining as much because it was easy for big OEMs to import PCBs. So, the decline was mainly in PCBs and the market was going to China. Something like 90% of the PCBs sold in Europe were coming from China. Then two important things happened. One is the grace to your former president, who started an economic war with China. That pushed other countries to think that perhaps they would have to manufacture at home; the Americans do not want to buy from China.

Second, COVID happened, and Europe realized that every industrial product—masks, for example—is a strategic product. They realized that there was no more industry in Europe, they were very dependent on China, and it could be a problem. Since then, there has been a widespread tendency in Europe to support “reindustrialization relocation” with the French government, including the PCB shops.

Some PCB shops received money from the EU government. Inside Europe, of course, it's controlled. And investors are coming back. So, you now have more focus on PCBs and electronics, in general. This is driven by the industry. In Europe, the main industry in terms of volume is automotive, and it's clear that electronics will be needed because of electric and autonomous vehicles.

There are some other strong industries in Europe, like aeronautic and military. Airbus, for example, is very prominent, and now is more active than Boeing, for whatever the reason.

For many years, France was unable to sell its military plane, the Rafale. But just recently, they sold 80 Rafale to the Arab Emirates. One reason is that many Arabic countries (or even Europeans) feel that the U.S. is not very reliable in its defense of Europe and the Middle East. I don't say it will be a lot of PCBs, but the PCBs for Rafale will not be made in China.

Sustainable energy also drives the electronics market. Europe is very concerned about energy usage, green energy, etc. To make sustainable energy, you need electronics. Lastly, we have artificial intelligence, 5G, with many new startups in Europe run by good engineers trained at good universities.

With this, you have investors from all over Europe, as well as the United States, who are putting money into the startups. With this new industry, they won't be buying PCBs in Europe because of volume, but it will be prototypes





they want to develop. Hard to say if it will be successful, but there does seem to be a trend in Europe that using electronics will continue to grow. As well, there is some tendency not to buy from China. This is my view of the market. We are feeling positive, if not yet wholly optimistic, and I think this trend will continue for some years.

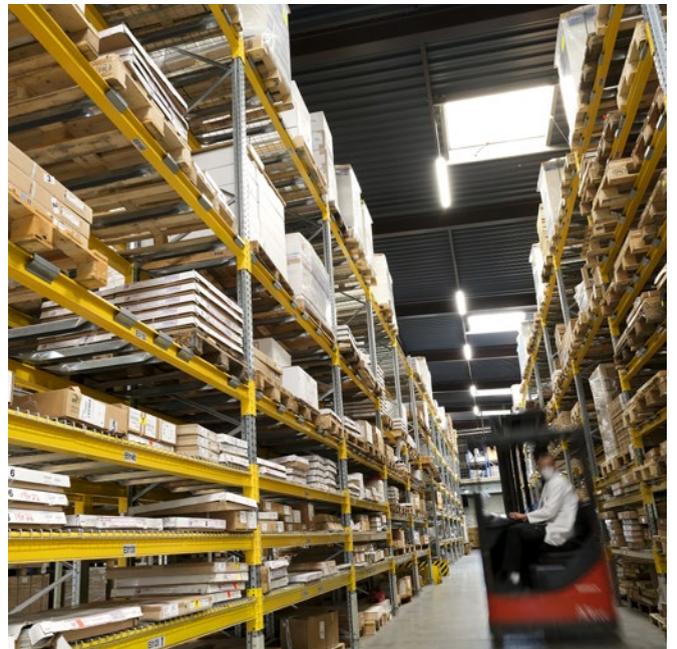
I think we will see that in the United States as well. The U.S. is generally a little late in some cases, but when you want to do something, you do it. From what I'm reading, this story of reindustrialization of electronics in the U.S., Canada, perhaps Mexico, will happen also. Having been in the industry for so long, I'm always saying I will be the guy who turns off the lights; I will be the last one of my generation. Now that there's a new generation, I say, "No, you have to continue because this will be a growing business."

**Johnson:** Looking forward to the next five years or so, on a technical level, how do you see the market in Europe changing?

**Kahn:** In my opinion, the big problem with PCBs was about money. This company was not profitable or had poor profitability, so it didn't have confidence from the bankers and there was no money. In this market, the problem is the equipment and the people, but let's start with the equipment. Europe has been late in having the most high-tech product. As an example, let me use a company we bought this year, Adeon, which is a distributor of equipment like CIMS, ATG, and DIS.

You can go on the site and you will see what companies are presenting. Two years ago, I said, "Look, if the market is going to be better in Europe, they have to invest because the machines may not be obsolete, but they are old. Now we see that this division is doing well because they are buying new, high-tech machines. That equipment will allow us to do high-tech product because whatever happens, volume PCBs and low-tech products will never be made in Europe. It's finished.

When you speak about the future of PCBs, you have two important markets. The future is substrates. You have AT&S, which is investing in both substrates and some in flexible laminates. Companies are using flexible PCBs for aero or other special products, such as military. A lot of startup companies are developing new product using printed electronics.



Printed electronics has a strong future as there is a trend toward manufacturing high-tech product. For that, you need two types of equipment, and you need both high-tech and low-tech people. You need the engineers and technicians. We have good universities, so we have a lot of good engineers. It's more complicated for operators, but it's going to come back because now, the workers don't know what to do. In France, for example, we have seen the government's ministry of industry say something like, "Industry is not a bad word. You young people can work in industry. It's no longer the coal mine."

But it takes time to get young people to be more attracted to industry, whatever it is, not just PCBs. You also need qualified people. We have them, but probably not enough. All of Europe is investing in training its young people for the various businesses in electronics, and it's the first time in many years that we have seen this trend, so I'm optimistic. Now, between what we want and what we do may be a little different.

**Johnson:** With all your years of experience in the industry, do you have any advice for the industry moving forward?

**Kahn:** It's hard to give advice. We are a distributor with high-tech services, and we have very strong support. We are here to support our product, to help the customer use the product, or when they have the equipment, to make the equipment work. This is our job. But, as has happened before, when we tell a customer or PCB shop, "You should do this," they say, "But you don't know my customer, so we want to stay as we are." It's true, we don't know. You can ask my company anything about understanding the product we are selling to support you when you use the product. If it's equipment, we are there to install the equipment, maintain it, and make it work. I ask my people to always stay a part of whatever strategy or what they think.



Alain Kahn

If someone asks, I will say what I think, but they never ask us now. They are intelligent and do what they think is best. For many years, my advice was to tell the French government to do more industry. We have met people, not only us, who say, "Look, the industry is going down." They don't care. So, we must fight. They say, "We are going to be a service country. What is a PCB? We don't need them; we can buy them in China. It's very easy to buy in China." But they change. Very clearly, they changed.

My best advice is to gain support from your government, your region, your city. Some PCB shops located in cities were told, "We don't want you anymore in the city because of the pollution. You are not allowed to pollute France. We don't want a factory. We prefer to have educated or white-collar people." But this is changing in Europe, which is good and important.

**Johnson:** This has been excellent. Thank you so much for taking the time to share your thoughts.

**Kahn:** Thank you very much. PCB007

*All CCI Eurolam equipment photos used in this article © David Vicent.*

# Cicor Adapts to Changing Market Conditions



Feature Interview by Nolan Johnson  
I-CONNECT007

Cicor Group is a Swiss-based manufacturer of highly complex PCBs and hybrids. Nolan Johnson recently chatted with Karl-Heinz Fritz, vice president of development and technology, about how his company has adapted to the changes brought on by the pandemic, particularly its effect on the European market.

**Nolan Johnson:** What are the market drivers that Cicor is responding to currently?

**Karl-Heinz Fritz:** The main market driver is the ongoing miniaturization of electronic systems. Combined with the need for a higher level of connectivity and more functionality, more features have to be integrated. Of course, the form factor of devices should not increase or even be reduced. During the pandemic, the demand for services along the whole value chain has increased, which we are the perfect partner for.

**Johnson:** How are you adapting to changing market conditions, or is that even necessary for Cicor?

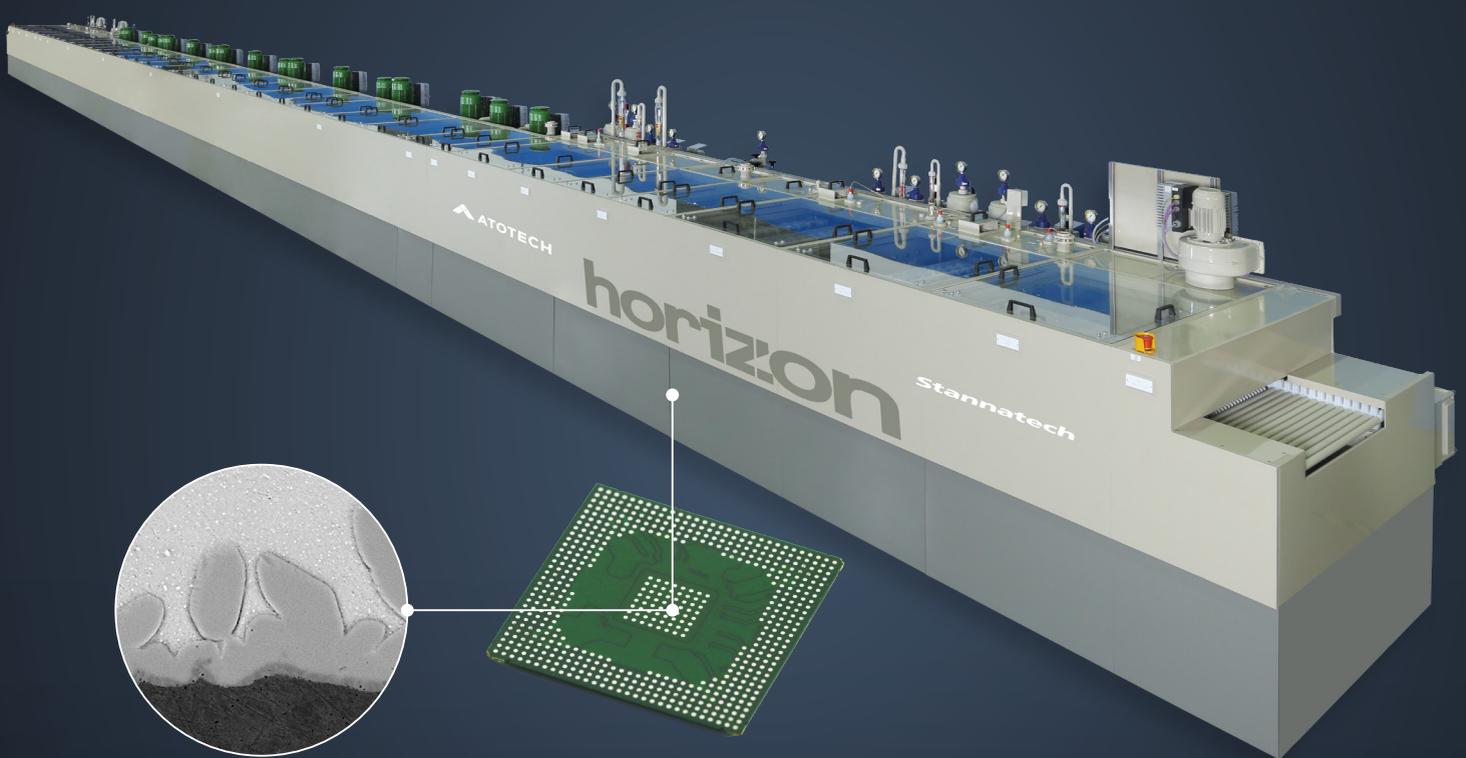
**Fritz:** There are some shifts in technology, which I'll discuss. From an organizational standpoint, the pandemic required that changes had to be made. For example, in-person meetings had to be replaced by virtual meetings or events. This had to be done quickly, as the pandemic hit all of us somewhat unexpectedly. We've now adjusted to a more virtual work environment.

Of course, supply chain topics, such as material shortages, are something we have to deal with. But then, our competitors must deal with those challenges as well.

**Johnson:** How has the European market shifted in the past two years?

**Fritz:** The material supply situation especially caused issues for the automotive industry, which has been heavily hit. This material shortage is not just affecting electronics

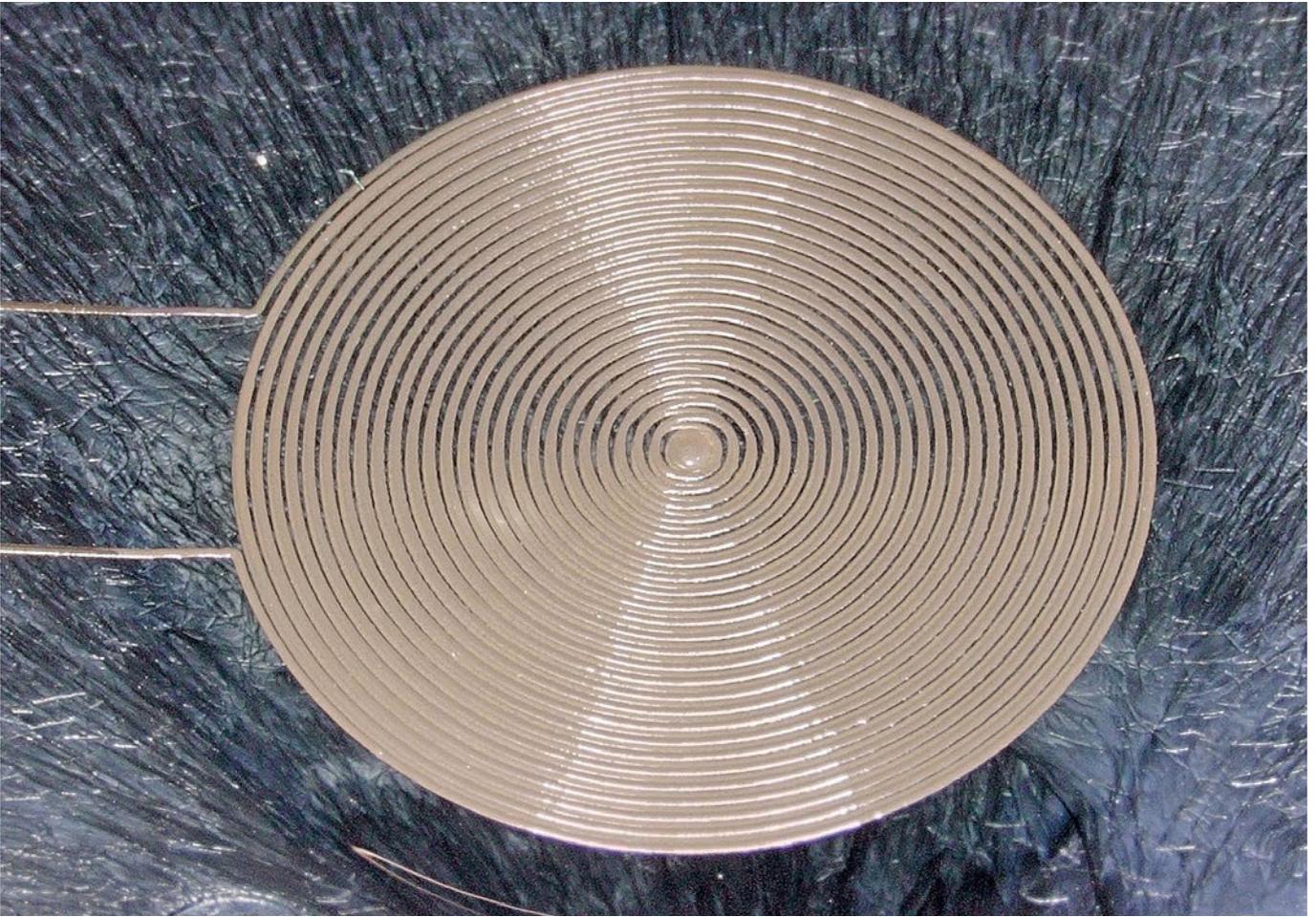
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manufacturers. For example, companies are currently facing a shortage of magnesium, which has become a very important material used to save weight in vehicles.

Several board manufacturing companies have tried to broaden their customer base and reduce their dependency on the automotive business. Our focus markets are medical, industrial, and aerospace/defense, which have been more stable, so we've not shifted as much.

**Johnson:** What do you see as the direction for the European market in the next two years?

**Fritz:** The move toward e-mobility will definitely create the need for adaptation as new requirements have to be fulfilled. The implementation of 5G will also have a significant influence on development and manufacturing activities. Base materials with adjusted dielectric properties will be needed. Combined

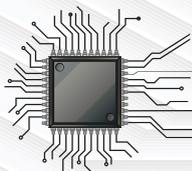
with new manufacturing methods like mSAP and SAP, these materials will be enablers of improved performance and signal integrity. In our core markets we see an increasing demand for more sophisticated applications.

**Johnson:** How do these changes guide R&D? Are there specific new projects you can discuss?

**Fritz:** As mentioned, we are looking into new and improved materials and production processes. This will enable us to provide products with enhanced performance, a higher level of functional integration and signal integrity.

**Johnson:** Thank you, Karl-Heinz, for sharing these insights.

**Fritz:** Thank you, Nolan. PCB007

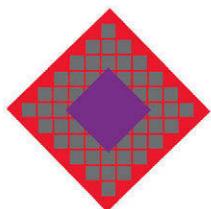


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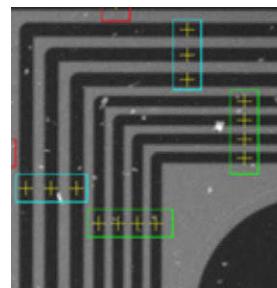
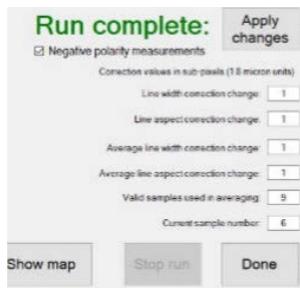
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# A Peek Into EIPC's Technical Snapshot Webinars

The EIPC is a network of professionals in the electronics industry providing a platform to exchange business and technology information for the success of the European electronics industry. EIPC has supported over 100 member companies since 1968, including suppliers of machinery, materials, and software tools to the PCB industry, along with PCB manufacturers and OEMs.

Business owners, senior management, and key technical staff find that the EIPC provides an efficient platform for following and pursuing new developments in the industry.

Tarja Rapala-Virtanen, EIPC technical director, says, "EIPC has traditionally held two technical conferences a year but, as we're all too well aware, it has not been possible to organize these face-to-face events during the last two years, so we have opted to host an online Technical Snapshot once a month."

The Technical Snapshot is a series of webinars where EIPC member and non-member companies; PCB material, process and equipment companies; research institutes; and uni-

versities can share their ongoing research with the audience joining the webinar. Webinars focus on current topics that play a large part in the day-to-day business of our industry and are of interest not only to the members but to the entire supply chain.

Creating this platform enables everyone to share new technologies and market information, as well as provide the opportunity to talk to PCB industry experts.

The webinar includes three snapshot-style presentations, approximately 15 minutes each, with a roundtable Q&A at the end. "The key idea is to provide a short and productive view of the industry's most current and interesting topics," Rapala-Virtanen says.

The articles on these next several pages highlight just a few of the technical topics presented at the webinars in 2021, and insight into what's happening in the European marketplace.

I-Connect007 technical editor Pete Starkey regularly reviews the Technical Snapshot Webinars. [Click here](#) to read the most recent review. The next webinar is scheduled for Jan. 19.

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## Alun Morgan's productronica Slide Show

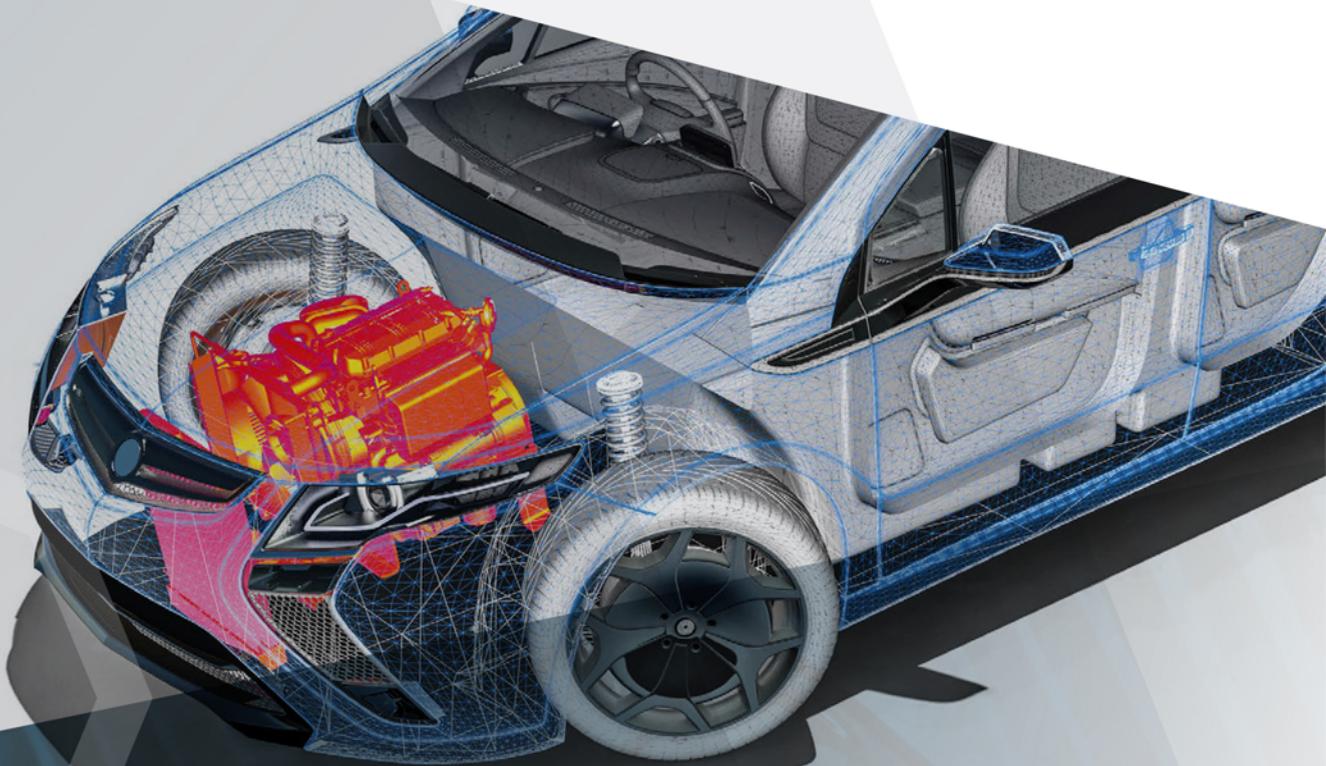
I-Connect007 has been bringing you interviews with a variety of technologists who attended productronica 2021 in Munich, Germany. As part of our continuing coverage of this event, we present this exclusive slide show of photos taken by our good friend Alun Morgan, technology ambassador for Ventec International Group.





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# Multilevel Additively Manufactured Electronics: Nulman and Schleicher Elaborate

Interview by Nolan Johnson

I-CONNECT007

For this interview, I initially reached out to Michael Schleicher, CID+, to comment on his recent presentation on additively manufactured electronic circuits during an EIPC Technical Snapshot webinar. Schleicher is a PCB designer at SEMIKRON Elektronik GmbH & Co. KG. The EIPC presentation could be considered a preview to the paper Schleicher will be presenting at IPC APEX EXPO this month.

During my correspondence with Schleicher, he recommended including Jaim Nulman, PhD, in the conversation as well. Nulman is chief technology officer and executive vice president at Nano Dimension and is also presenting a paper this month at IPC APEX EXPO.

**Nolan Johnson:** What is the multilevel additively manufactured (AME) process?

**Jaim Nulman:** Multilevel and multi-material additively manufactured electronics (AME) is a fabrication process where electronic cir-

cuits and devices are created from the ground up on a sacrificial substrate or on an existing structure. It is a 100% digital fabrication process where at least two materials, typically one conductive and one dielectric, are simultaneously deposited layer by layer based on the desired electronic functionality. Being a digital process, the materials are deposited only in the needed areas; hence, no need to drill or laser cut, and therefore no waste. Furthermore, it enables direct fabrication of passive components such as capacitors, coils, and resistors; and naturally enables embedding of components. This capability reduces the parasitic elements that arise from surface mounted technologies.

**Johnson:** In your paper, Jaim, you point out that AME provides “freedom to design electronic devices with essentially a form factor.” Tell us about that.

**Nulman:** Basically, the AME design and fabrication technology is not constrained by 90 degrees/perpendicular designs and the single

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Jaim Nulman

trace thickness per layer required by traditional PCB fabrication processes. The digital 3D nature of the AME technology enables vias in any angle and with curved approaches between the layers the vias connect; this enables higher packing density and circuit speeds. Since digital 3D fabrication enables a build of such circuits in the 3D space, one could even consider the elimination of the term “layers” in an electronic circuit.

**Michael Schleicher:** From my perspective, this is one of the major advantages to creating individual 3D-shapes of (small) electronic systems to use maximal volume of the available “3D construction space.” Usually, PCB design has lateral traces and vertical vias (holes). Both were manufactured in different processes.

Additively manufactured electronics are not limited to lateral and vertical constructions; “any angle” connections could be used, and it is still manufactured within one machine.

**Johnson:** In your paper, Michael, you define a dPCB as a digital printed circuit board. Are there multiple methods to create a dPCB? Can you elaborate?

**Schleicher:** I greatly appreciate the pioneering work done by Nano Dimension and the success it has achieved for the industry. From my point of view, the entire industry is looking for ways to use digital printing.

In the area of construction of metal, plastic, and ceramic components, intensive research is being carried out into possible applications for digital printing. In addition to the inkjet process, there are other promising processes that are still more or less in the research stage.

There are publications and reports from IDTechEx and Yole. The online AME Academy from Nano Dimension has further examples of digitally printed circuit boards already presented. Some additional investigations in electronics are presented in the field of MID (molded interconnect devices<sup>1</sup>), and research is being conducted into methods of producing circuits and circuit carriers using various printing principles. The current state of development is presented annually at the MID Congress (Germany).

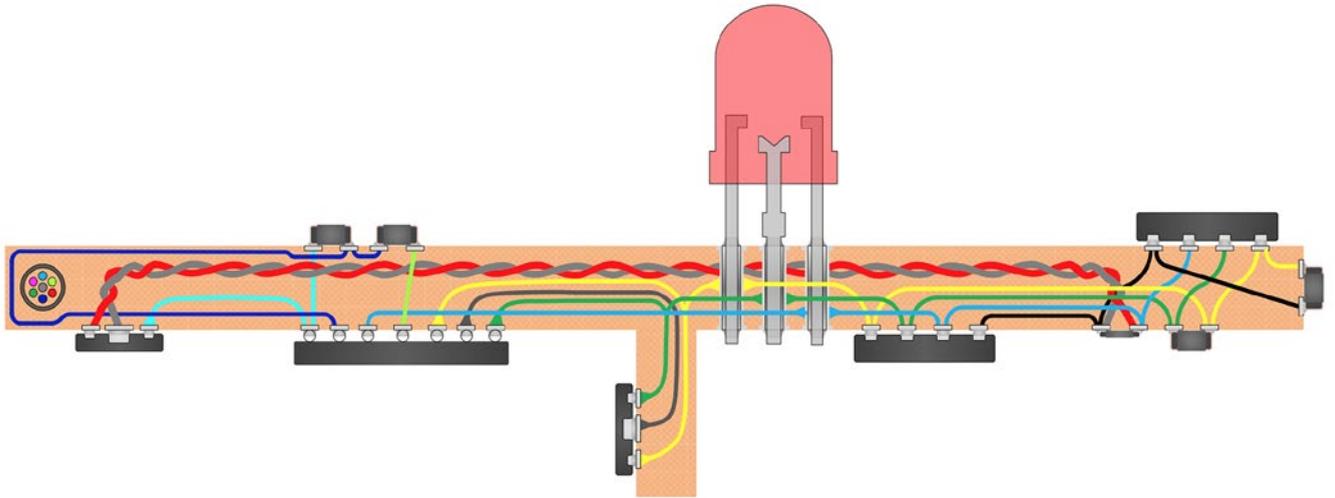
Similarly, there is a great deal of interest in new manufacturing methods for electronic circuit carriers in the Organic and Printed Electronics Association<sup>2</sup>. Here, too, the state of the art is presented at the annual LOPEC congress and trade show (Germany).

From my point of view, this shows how digital printing technologies are being used and further developed for the manufacture of a wide range of applications. What will be developed in future times? This is still open, but the trend is clear and unambiguous.

The 3D electronics working group of the FED e.V. (Fachverband Elektronik Design) is in exchange to MID e.V. and oe-a.

**Johnson:** The structures formed by AME are quite different from those of a traditional PCB. Would you elaborate?

**Nulman:** The digital nature of AME fabrication that includes 3D structures enables the formation of connecting devices with wires only, no



An example of possible design elements.

vias, shielded wires such as coax, and different shapes of the overall circuitry. Hence twisted wires, pair, triple, etc., can be fabricated within the build, eliminating the need to use external circuit wiring. As published in several electronics-related journals, coils, capacitors, and multi-shape/multilevel antennas can be fabricated as an integral part of the electronic circuit with capabilities that cannot be matched by PCB fabrication, not only in terms of cost but also in electronic performance.

**Schleicher:** Even if it is not always obvious, there are now a great many patents in the field of PCB layout. If you do a search, you will also find some on the topic of “twisted pair” routing for conventionally manufactured PCBs. However, the realization is that twisted pair is a useful method of transmitting fast switching signals.

The actual goal of twisted pair is to maintain the signal integrity and thus the signal quality as good as possible. For this purpose, the forward and return conductors are “coupled” as well as possible. Ideally, the cable could still be sheathed with a shield. This is how we all know it from network cables.

In a printed circuit board, the conductor width and the distance to a reference layer are usually calculated to achieve a certain impedance of lateral connections. With the existing

possibilities, the corresponding lines can be routed with any layout tool nowadays. For vertical connections it is more difficult. There are several workarounds with which the desired impedance can be achieved with more or less success/effort.

Here the possibility of digital printing offers an almost optimal solution. There is no longer any layer dependency. The lines can be routed and produced at the optimum distance from each other. Of course, if you look closely, there are limitations, such as a certain surface roughness due to the arrangement of the “voxels” on the printed product. In my estimation, this will be optimized considerably in the future.

**Johnson:** What equipment is required to manufacture with AME techniques?

**Nulman:** The most common and highest throughput is delivered using inkjet-based equipment with at least two printer heads, one for dielectric and one for conductive inks. Other techniques include aerosol, dispensing, and LIFT (laser induced forward transfer). The equipment also has integrated energy sources for ink curing, drying, and sintering. The AME fabrication technology, while giving the freedom of design, is also a heavily integrated technology between the materials (inks), deposi-



Michael Schleicher

tion heads, algorithms, and controls. While the traditional industrial inkjet printer heads have trace size limitation estimated to be around 40 microns, technology is already under development that will enable micron-size trace width. This can be compared to the evolution of optical lithography in the semiconductor manufacturing industry. Some equipment includes pick-and-place for components.

**Schleicher:** From my point of view, as described by Jaim, there are several ways to produce AME. The Dragonfly from Nano Dimension is a very important example here. But there are also other manufacturers who can produce additively manufactured electronics with other processes and equipment. The advantage of the inkjet process is the parallel operation of several nozzles per print head and the parallel operation of several print heads in one machine.

But it should not be forgotten that additive manufacturing techniques can also be applied to other parts of electronics production. At SEMIKRON, we print silver sinter paste (functional fluid) using the inkjet process (drop on demand). Another example in printed circuit

boards is solder resist, which is already printed in several layers on the base material or the copper printing tracks using the inkjet process.

There is also research in Germany in functionalization of surfaces on 2D or 3D shapes. Here, metal is printed onto the surface using inkjet processes and cured by using LED lasers arrays. Thus, for example, the application of a gold surface in the plugging area of printed circuit boards (or other applications) could be carried out without an electroplating process.

As indicated, it is important not to describe the term and technology too narrowly. Development here is still relatively in its infancy. I think when we look back in about 10 years, it will be considerably easier to see what was right.

**Johnson:** How does AME improve fabrication tolerances?

**Nulman:** AME improves fabrication tolerances in X, Y, and Z directions. In all these directions the mechanical movement of the equipment in the process stage and the motion of the material sources is in the micron range. Simultaneously, the materials are deposited layer by layer to micron accuracy. Hence, the tolerances in AME are much tighter than in traditional PCB fabrication. As an example, landing pads for vias can be eliminated, thus increasing the trace density.

**Schleicher:** Thank you for the question. I always have to smile a little here. Nowadays, we are used to asking about the details, where improvements occur, and where it is better than the current state of the art. The important message is that the technology allows “densification” of electronics in the same package space. Furthermore, a simplification in the wiring is made by omitting the different process and procedure steps. By manufacturing the entire circuit carrier within one process, the tolerances will be reduced.

I would like to give an additional answer with a small example. Our 12-year-old son

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can help us to manufacture our products and applications easier, faster, cheaper or the same cost, by implementing more functionality. Here, demonstrations help to show simple problems and solutions for this. An important aspect, however, is whether the new methods offer the possibility of solving previous problems in a simpler and more elegant way.

From our point of view, the current applications of the technology are in the field of research and prototyping. In my opinion, it is very important to con-

sider how this technology can be implemented from the designer's point of view. Because of this I worked on the IPC presentation.

**Johnson:** Is AME being used in production environments today?

**Nulman:** Some low-volume, very high-performance circuits are being fabricated by AME technology. As the electronics industry learns the capabilities of this technology and commits to it, the equipment and materials will evolve to high throughputs and state-of-the-art performance that will enable the volume production. In addition, the CAD systems will evolve to enable the freedom of design and incorporate ECAD and 3D MCAD features.

**Schleicher:** A company in Germany bought the machine few years ago and is working on product ideas and applications. During my visit a year ago, I was able to talk intensively with the user of the machine. However, the company works in the field of defense, and we exchanged only general experiences. **PCB007**

#### References

1. [www.3d-mid.de](http://www.3d-mid.de)
2. [www.oe-a.org](http://www.oe-a.org)

**Michael Schleicher** is a PCB designer in Development IPM, Systems, Design and Lab, SEMIKRON Elektronik GmbH & Co. KG.

got an audio book about Johannes von Gutenberg this Christmas. I was not so familiar with the details of the story, which was that it took about 17 years before the idea was turned into printing the first Bible on 648 pages. In the process, he developed the type of artwork, the color, and the printing process over all those years and improved them again and again. But I don't want to wait that long. Today, we can print color daily newspapers with detailed images in runs of millions within one night.

From my point of view, the process technology of the second development generation is commercially available on the market. Thus, a door has been opened to introduce future improvements. The input for the iterations comes from the demands of the machine suppliers, but also from market expectations.

**Johnson:** Where is AME finding application currently?

**Nulman:** Most of the users today are focused on RF applications and unique solutions required by the defense industry. Some companies are using AME for in-house prototyping, verification, and optimization of new designs, hence reducing the product release cycle time.

**Schleicher:** Here at SEMIKRON, probably like many other companies, we have asked ourselves where additive manufacturing processes

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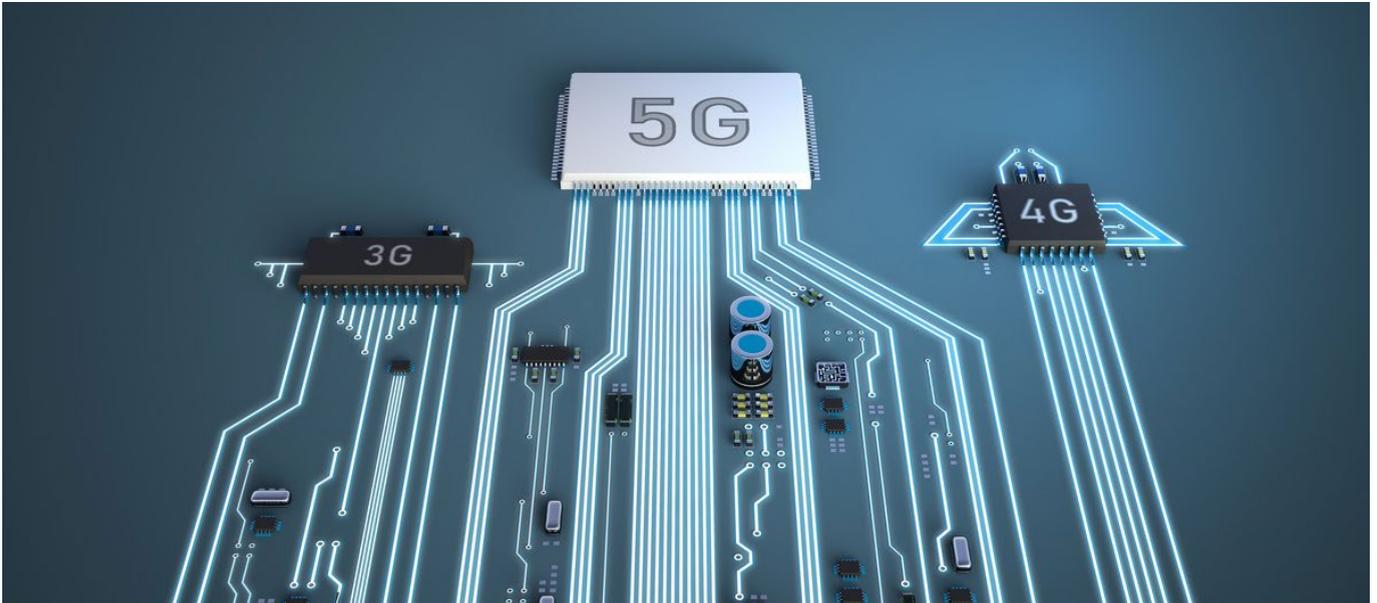
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# What is **Impacting** and **Challenging** PCB Technology in Europe?

Feature Article by Jan Pedersen  
NCAB ELMATICA

Some of us who have been around for a while have observed how PCB technology has developed through the past 40–50 years. Compared with the development of technology in the packaging or computer industry, PCB technology has moved quite slowly.

## Was It Better in the '70s?

Back in the 1970s, right after I finished school, I was working close to Oslo in a PCB plant for single-sided PCBs. I saw how other factories started to produce two-layer plated-through-holes and soon multilayer PCBs. Visionaries and trendsetters at that time claimed single-sided PCBs would reach end of life 10–15 years later. Well, it's now four-plus decades later and they are still in the market.

Production technology has improved and developed through the years. At some point, we crossed some limits for traditional plating, drilling, and imaging methods. In the past 20 years, we have seen how the chemical processes have developed to enable very small holes in the same PCB thickness; drilling is not just drilling any more, and imaging is moving away from screen printing and even leaving films behind.

## What Is Happening With PCB Miniaturization?

Still, we do use copper base layers, holes to connect, and solder to attach components. My focus in this article is mainly my own observations of the PCB miniaturization levels we see today. I hope I am not stepping on too many toes.

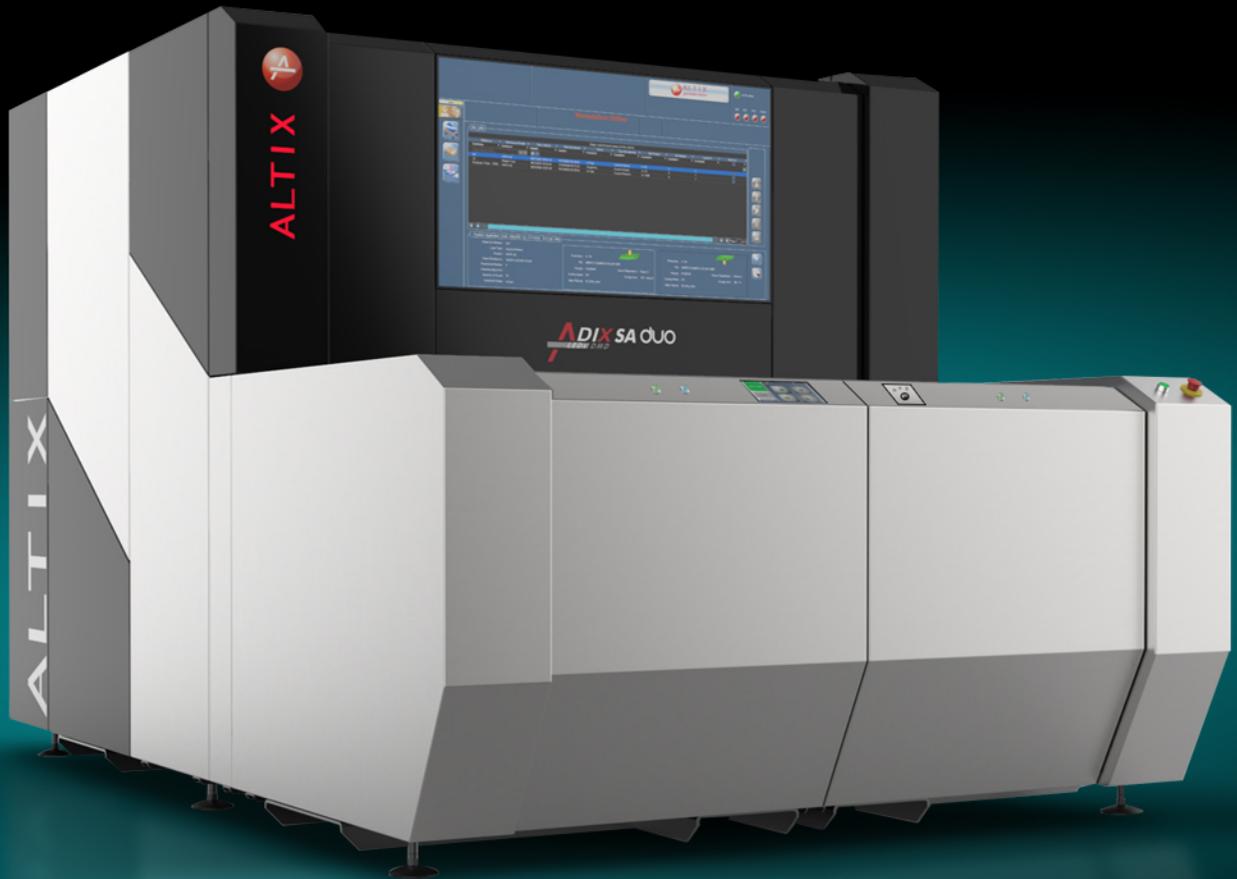
As recently as three to four years ago, a resolution of 60–75 micron was the general capa-



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bility we could expect from volume manufacturing of PCBs, except for those few factories involved in smartphone manufacturing. Then something happened.

The miniaturization level we see today started with the development of integrated circuits in the 1950s and '60s. The technology we find inside an IC from that time is in some ways the same miniaturization level being developed in the general PCB industry today. What does that tell us? That the technology to produce smaller line and space PCBs has been there for a long time, just not utilized by the PCB suppliers until recently.

So, what happened? As usual, technology development is driven by demand. Very few factories will develop and invest in future technologies without a reliable forecast or demand. As mentioned, the smartphone and related devices have already moved into IC miniaturization levels. If you look inside a device, such as a smartphone, you will find what we call substrate-like (SL) PCBs, with a line and space below 30 mm. Inside BGA components you find substrates with the same level—what is called organic interposers or IC substrates.

## A Manufacturing Market Vacuumed by the Big Players

All these types of SL PCBs have been made by a small number of PCB factories, and some of them are almost what we call captive facilities. If you try to place an order with the AT&S

factory producing PCBs for Apple, you will understand that Apple doesn't allow spies into their facilities—not even the subcontractors.

Doors closed! So, what shall we do if we need a substrate-like PCB, but we are not Apple or Samsung? Well, there are a few suppliers out there, but far from being able to meet today's needs. As a PCB supplier, we have seen the demand growing slowly over the past two years.

Today, designers of 5G-related products such as filters seek suppliers of SL PCB that can take on sample orders for product development with short lead times, and to reach the market delivering small volumes with reasonable lead times. That is almost impossible today. A few smaller and larger PCB manufacturers have seen this and are in the process of investment and technology development at this level. The customers still need to wait six to nine months before we can see some capacity out there.

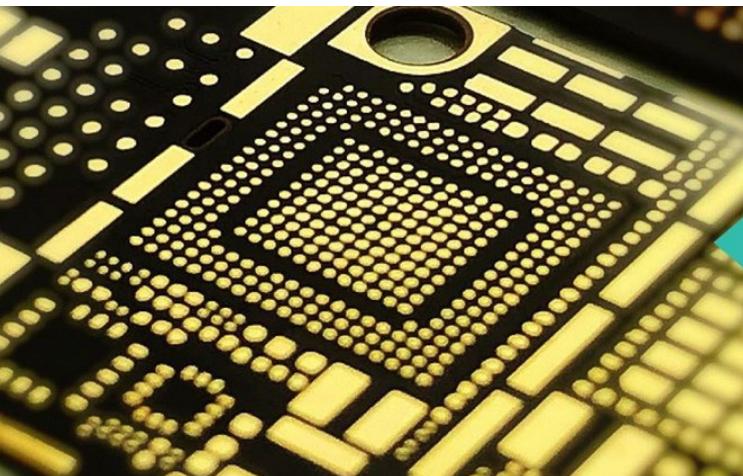
## SL PCB Market Forecast

I have seen very few market reports on SL PCB related levels until recently. I am co-chair of IPC's Ultra HDI task group D-33AP, and to be able to develop a guideline we needed market intelligence to support the need of a guideline, supported by standards. We are scheduled to get a report in January and will review it at our Ultra HDI session at IPC APEX EXPO.

A reliable market forecast is crucial for investment and development plans for all parts of the value chain. Somehow, all of us outside the smartphone industry forgot to look into the fortune-telling crystal ball some years ago. Suddenly the demand for SL PCB is there, but very few suppliers are ready.

In Europe we have a few that have moved into this area, but typically those suppliers also have customers that traditionally seek miniaturization, such as the hearing aid device providers.

In an EIPC snapshot webinar in 2021, one of Europe's top PCB facilities gave a presentation on peak technology. There are a few factories in Europe that can produce down to 25 mm line and space, but if you need an SL PCB below





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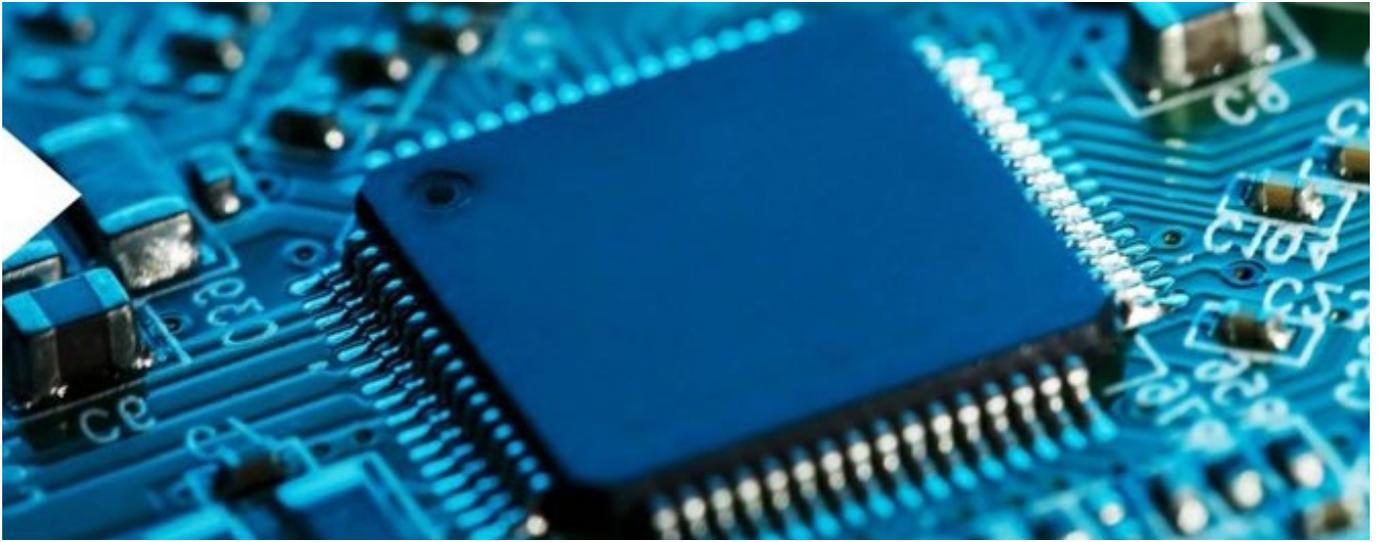
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25 mm, the realistic source today is Asia—and with extreme lead times.

## The Drivers for the European SL PCB Market

The implementation of 5G, driven by governmental initiatives, is the main motivator for the European market. The influence of tablets and wearables is less dominant in Europe simply because these products are produced in Asia. But we may see some demand from AI, industrial robots, and semiconductor solutions in automotive applications that may create opportunities in Europe.

The market for SL PCB in Europe in 2020 was approximately US\$72 million. With a CAGR of 11-12% we can expect around US\$175 million in 2028. This is a quite conservative prediction based on the assumption that most of the SL PCB will be made in Asia and the prediction of a global SL PCB market of US\$4.8 million in 2028 at a CAGR rate of around 18%. Compared to the total European PCB market with a CAGR around 2.5-3% that is a substantial growth and a good indicator for investments into SL PCB manufacturing capabilities for quick turn of small volume orders.

## Wrapping It Up, and How to Get Involved?

The development of PCB technology reached the level of substrate-like PCBs by the

introduction of smartphones and other wearables. Today we see a fast-growing need for SL PCB even outside those well-known industries, basically driven by AI and 5G demands. The CAGR of SL PCB is today much higher than the traditional PCB technology, including normal HDI levels. This will be a substantial driver for investments in the next few years.

For more information and involvement, IPC APEX EXPO in San Diego will have an Ultra HDI technical seminar track that includes SL PCB. A full forecast will be presented. That conference and the UHDI task group is highly recommended. Here we discuss the main technologies needed to reach the required miniaturization level, such as the difference between a pure subtractive process and the so-called semi-additive process variations.

Only together can we change the industry, and improve the standards, technologies, and the communication. **PCB007**

### Resources

1. IndustryARC: European Printed Circuit Board Market—Forecast (2020-2025)
2. IPC TG D-33AP Ultra HDI
3. IPC SL PCB market forecast to 2028



**Jan Pedersen** is senior technical advisor, NCAB Group-Elmatica and a regular contributor to the I-Connect007 column, "The PCB Norsemen".

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# Disruptive Chip Packaging Developments in PCB Fabrication



Feature Interview by Nolan Johnson  
I-CONNECT007

At the October 2021 EIPC Technical Snapshot webinar, Jan Vardaman, president and founder of TechSearch International gave a presentation on “Chip Package Choices, Challenges and Trends.” I-Connect007 reached out to Vardaman to get an overview of exactly how these new packaging techniques will change the printed circuit board chain through design and manufacture.

**Nolan Johnson:** What factors are driving innovation in chip packaging?

**Jan Vardaman:** With the introduction of advanced semiconductor nodes there is a need for smart packaging to provide the economic advantages that have been traditionally achieved with silicon scaling. While it is pos-

sible to fabricate integrated circuits (ICs) that are larger than reticle size, it is not economical given the yield loss (defect density), mask cost, and manufacturing cost of the advanced nodes.

**Johnson:** What is heterogeneous integration? What does it provide as an advantage?

**Vardaman:** Heterogeneous integration is defined as two or more dissimilar die assembled into a standard package that provides a functional subsystem. It can include MEMS sensors, passives, filters, and/or antennas. Drivers for heterogeneous integration differ slightly between high-performance applications and other applications. Combinations of memory and logic in the same package are increasingly common for high-performance applications. The need for reduced latency is driving the increased adoption of high-band-

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width memory plus logic. Integrated photonics is also moving into production where an ASIC and photonics chip will be combined in the same package.

In the wireless market, the drivers are integration, form factor, cost, and shielding. For wearable electronics, the drivers are low power, cost, miniaturization, and high yield assembly. In some cases, customers need highly integrated solutions. Drivers include low cost, greater performance, low power, and easy design-in where there is a low entry barrier. Time-to-market is critical.

**Johnson:** In your presentation, you discuss several packaging techniques. You also concentrate on “chiplets.” How do you see chiplets changing the packaging landscape?

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## Chiplets are a heterogeneous integration solution that can move the industry into the next semiconductor era.

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**Vardaman:** Chiplets are a heterogeneous integration solution that can move the industry into the next semiconductor era. While it is technologically possible to continue scaling monolithic die, the economics do not favor it. The use of chiplets will become a game changer in the new era for companies that can master the design. The adoption of chiplets will have as great an impact on the semiconductor industry as the movement from peripheral pad layout to area array designs.

A chiplet is a functional circuit block and includes reusable IP blocks. A chiplet is a physically realized and tested IP with a standard or proprietary communication interface

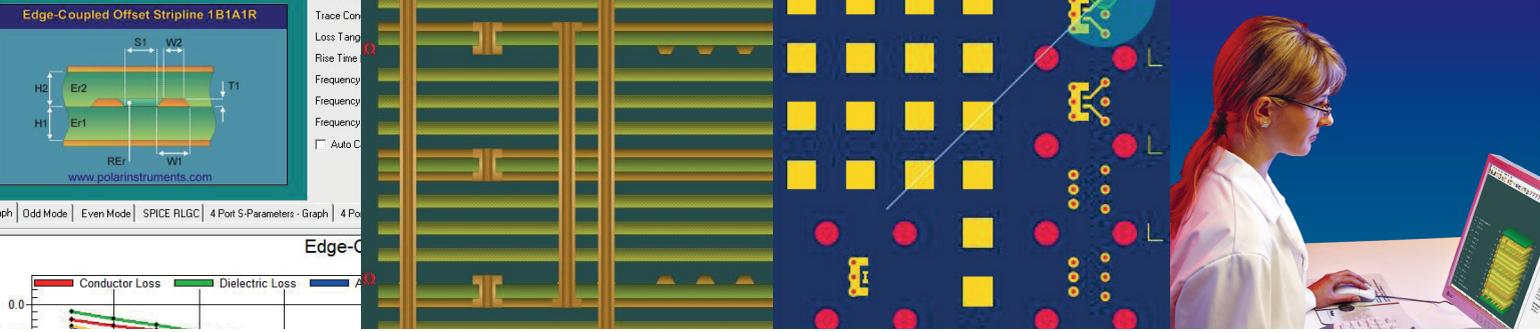
between IP blocks. A chiplet functions with other chiplets, so the design must be co-optimized, and the silicon cannot be designed in isolation.

**Johnson:** At the end of your presentation, you ask, “Many package options: which one do I choose?” What do you see as the answer to that question?

**Vardaman:** There is no one package that meets all needs. Package selection depends on the application, reliability requirements, routing density requirements, power efficiency and power delivery needs, maturity of package technology and supply chain, thermal performance requirements, test considerations, and relative cost vs. alternatives.

**Johnson:** Please introduce us to TechSearch International, Inc. What is your role in the packaging marketplace?

**Vardaman:** TechSearch International, Inc., founded in 1987, is a market research leader specializing in technology trends in microelectronics packaging and assembly. Our goal is to provide the latest information on technology developments and market trends in the semiconductor packaging and assembly market. We are known for our accurate, timely, and relevant analysis. Multi- and single-client services encompass technology licensing, strategic planning, and market and technology analysis. TechSearch International professionals have an extensive network of more than 22,000 contacts in North America, Asia, and Europe. **PCB007**

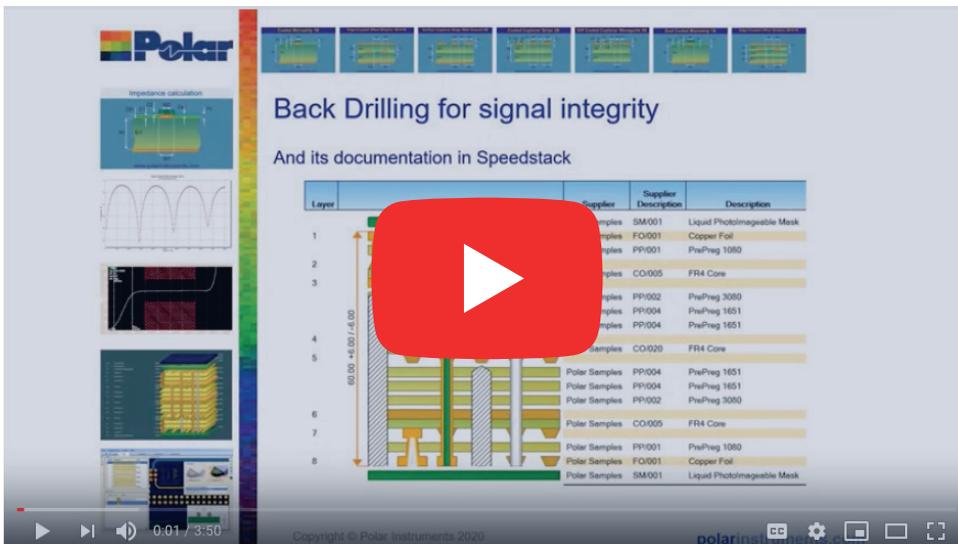


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# CLAD Features ‘Truly Disruptive’ Technology

Feature Interview by Dan Beaulieu

I-CONNECT007

In this interview, I-Connect007 columnist Dan Beaulieu visits with Ralph Birnbaum, director of business development at ioTech Group Ltd., a new Israeli company. Ralph shares information about the company’s new and unique additive products including CLAD, a truly disruptive technology. Their product allows for tighter controls and thus finer lines and spaces.

**Dan Beaulieu:** Hi Ralph, will you share the history of ioTech?

**Ralph Birnbaum:** Sure. Over the past five and a half years, we have worked under the radar, developing a groundbreaking technology for additive manufacturing. The co-founders are Hervé Javice (CEO) and Dr. Michael Zenou (CTO). Hervé formerly worked at Atlas Capital in London, where he was a board member and member of the investment committee for their \$4 billion alternative investment funds. Hervé earned his MBA from the Harvard Busi-

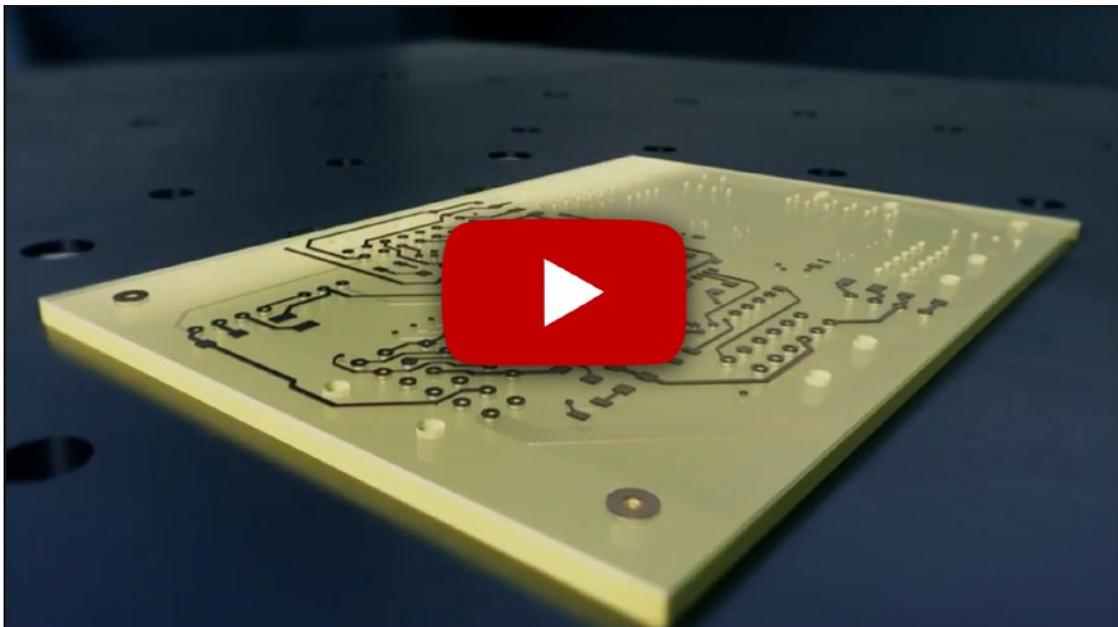
ness School. Michael is a leading expert in laser-assisted deposition. He worked for many years at Orbotech, where he designed their first-in-kind copper printer for PCB repair. Michael has a PhD in physics from the Hebrew University.

**Beaulieu:** Impressive. What is your background and your role at the company?

**Birnbaum:** I have a PhD in engineering, but after a few years in development, I switched to the commercial side. I used to work for Orbotech, where I marketed the LDI printer. I am now director of business development. I am forging partnerships between ioTech and various companies, both customers and ecosystem partners, such as material suppliers and technology partners. I also work on marketing strategy with my colleagues

**Beaulieu:** What does that encompass?

**Birnbaum:** Among other things, I am working with both vendors and customers to develop the next generation of application technology.



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Ralph Birnbaum

**Beulieu:** Now let's get specific about the company. What do you do exactly?

**Birnbaum:** Over the past five years, ioTech has been busy perfecting its CLAD deposition technology. CLAD stands for continuous laser assisted deposition. The first deliverable is the IO-300 laser-assisted deposition printer. The system is incredibly versatile. It can be used for any application where multiple materials need to be deposited on any type of substrate, including non-planar surfaces.

Our first application is depositing solder paste. We can achieve resolutions as low as 100  $\mu\text{m}$ , offer the flexibility of digital printing, and do so at industrial level, high speed, jetting thousands of droplets every second.

Our second application is the deposition of adhesives and coating materials, such as for gaskets, camera modules, packaging, MEMS devices, and other components.

We are also developing a digital and green electronic circuit manufacturing process that offers a fabless solution to PCB manufacturing. The process delivers metallization, multi-layers, solder mask, pad finish and legend using industrial grade materials and resolutions down to 20  $\mu\text{m}$ —all in one machine.

Figure 1 shows a single layer PCB of 35 mm x 50 mm printed on an FR-4 substrate. The patterning is at 100  $\mu\text{m}$  resolution, but higher resolutions are possible too, down to 50  $\mu\text{m}$  lines. We can go down to 20  $\mu\text{m}$  at the expense of speed. In this case, the copper paste is from Israeli startup Copprint, and the solder resist is from Taiyo Ink, but we can accommodate other materials as well.

No other system is capable of printing copper and solder mask together, reducing the number of process steps. It also reduces the environmental impact considerably.

We already successfully validated the concept with five materials (copper, dielectric, solder mask, silver, and legend) and we have started beta testing the system in a production site. It's exciting because it's the first time a system prints conductors, dielectrics, and solder resist together.

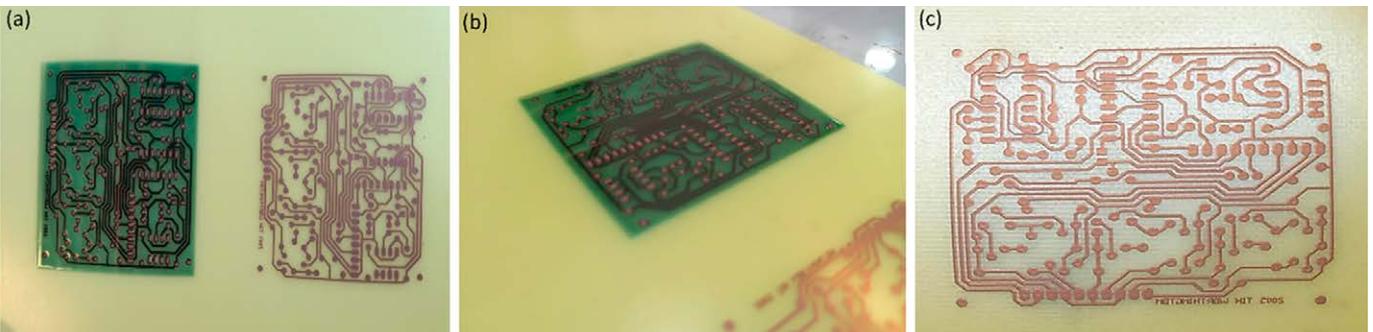
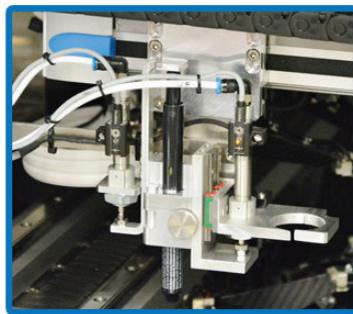


Figure 1: Single layer PCB showing both copper metallization and solder mask coating.

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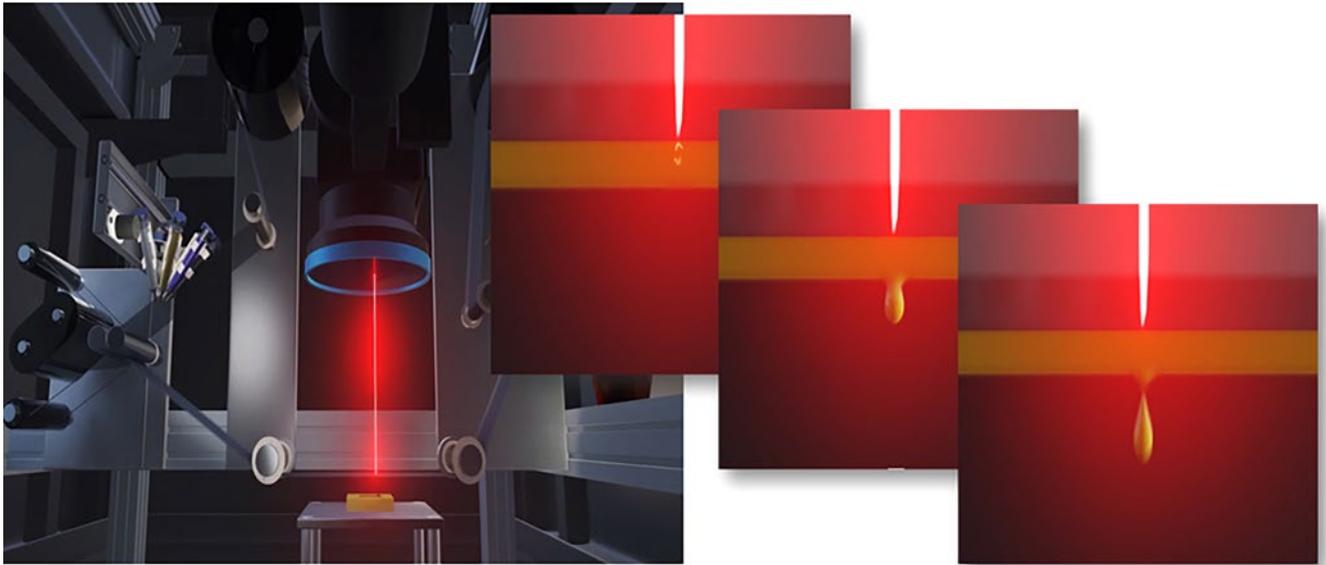


Figure 2: Pulse-laser jetting onto the substrate.

There are also applications in the semiconductor packaging segment, where we are working with some of the leading OSATs.

**Beaulieu:** Will you explain more about CLAD?

**Birnbaum:** It is a proprietary technology we developed for additive manufacturing based on the laser induced forward transfer (LIFT) technology. A material, evenly coated on a transparent carrier film, passes under a laser. The laser applies a short burst of energy to it. This releases perfectly consistent drops of material onto the substrate below. The material drops can then be sintered or cured inline within the same machine. A great benefit is that this technology works for solder and polymers as well as for metals and ceramics. Up to six materials can be printed at the same time.

**Beaulieu:** Can you dig down a little deeper on what the product does?

**Birnbaum:** Sure. Any surface where you want to deposit one material onto another can find benefits with this technology. All along the electronics supply chain, whether it is creating an entire multi-layer HDI PCB, copper traces and filling vias, or only the solder mask, depos-

iting the solder paste, replacing the wire bonding, printing gaskets and conformal coating, or conductive adhesives for die bonding, CLAD technology can address it. We will be rolling out one application at a time, starting with solder paste balls, and solder mask, but we can currently print fine copper traces and perfectly fill vias without bubbles.

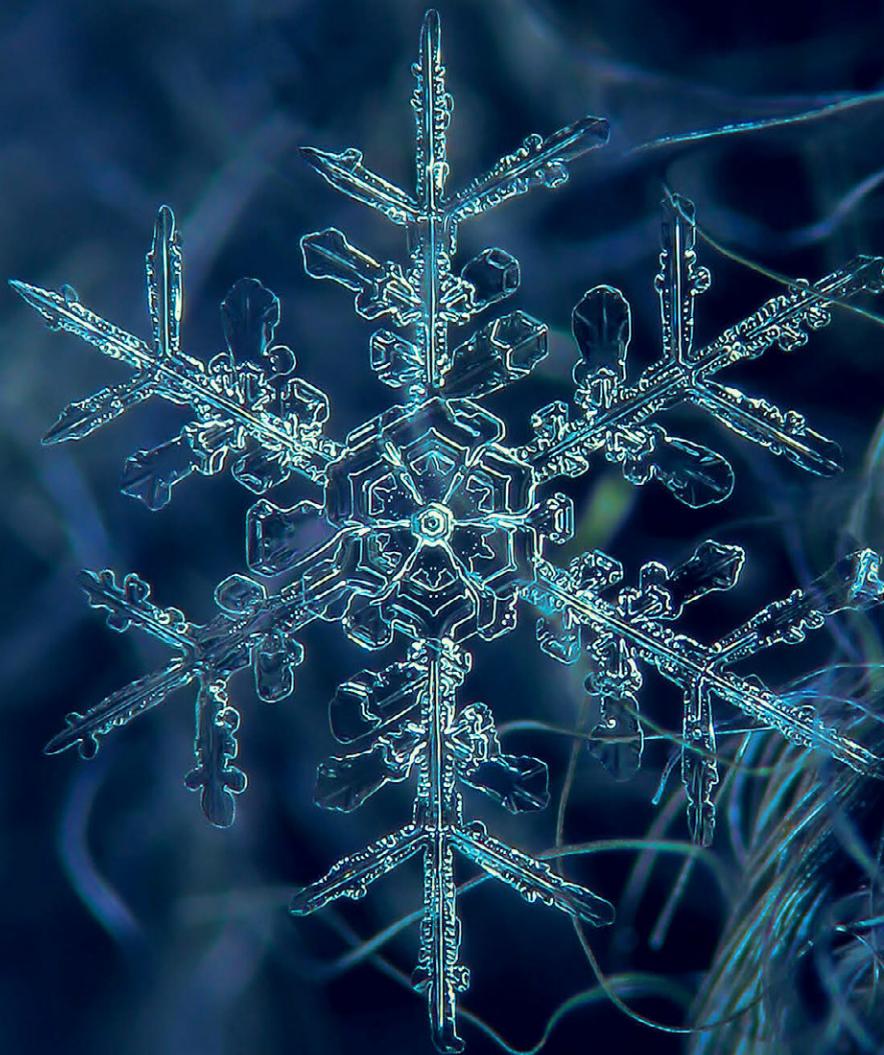
**Beaulieu:** What do you feel sets it apart?

**Birnbaum:** CLAD combines the benefits of multiple technologies, going beyond the limits of what is possible today. How do we compare with current technologies? Versus dispensing and aerosol, our technology offers much greater speed. Compared to screen printing, we bring digital design flexibility both in geometry and in co-planarity. Versus lithography, our process is much simpler and greener. Compared to inkjet, we go beyond prototyping and offer a production system that is compatible with industry standard materials.

**Beaulieu:** Who will this product benefit? Who are your potential partner customers?

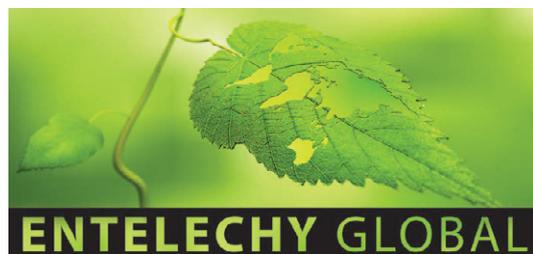
**Birnbaum:** Leading innovators who face challenges associated with production of new

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designs, where current equipment yields are very low, or cannot handle innovative design at all. As a digital technology, medium- to high-mix, medium-volume manufacturers will benefit from our technology. High-volume users of dispensing equipment will also benefit from our system's much higher speed.

It's for any relevant industry player that faces advanced demands from their end customers and who reach the performance limits of current technologies.

Once we introduce our solution for complete PCB manufacturing, you will see a significant industry disruption also allowing reshoring. PCB manufacturing will come closer to end-users and higher labor cost countries will regain the ability to compete. Our technology will make PCB manufacturing eco-friendly for the first time.

In most cases, ioTech's IO-300 printer can print designs that are currently unprintable and that just cannot be manufactured today. But high-mix, low-volume manufacturers will also benefit from an attractive ROI on this solution.

---

## Our technology will make PCB manufacturing eco-friendly for the first time.

---

**Beaulieu:** What else can you share about it?

**Birnbaum:** Our technology is clean. No etching chemicals are involved in the process. It is thrifty. This is an additive technology, not subtractive. With copper prices increasing, this can only get more attractive. It has a small footprint. Sometimes several stations can be replaced with just one. And it will bring our customers significant new business opportunities. We can print standard industry-certified materials digitally, fast, and at high resolu-

tion. No adaptation to any additive manufacturing technology constraints is required. The ability to print six materials concurrently is a great competitive advantage. It makes it possible to print complex multi-material products, such as multi-layer HDI PCBs. And the technology is protected by a robust portfolio of patents.

**Beaulieu:** What do you find to be exciting about this company?

**Birnbaum:** ioTech is a typical ultra-innovative Israeli startup, with a great technology, achieving a lot with limited resources. We are very fortunate to have the backing of two major companies in the electronics industry, Henkel and ASM Pacific Technology. We officially launched the product at productronica, where we won the productronica Innovation Award for PCB and EMS, as well as the Elektor Fast Forward first prize for best new start-up. We have already sold two machines and our first machine has been installed at a production site for beta testing.

Everyone we speak with is excited about being able to print standard industry materials. This is what has prevented additive manufacturing from making a dent in the electronics industry so far, since no electronics manufacturer would replace certified materials with material approximations. The fact that we can digitally print standard industrial materials at high speed and high resolution is a major game changer.

**Beaulieu:** What makes you a good company?

**Birnbaum:** The combination of the R&D team, headed by our CTO, an innovation leader with 50 patents in laser deposition, with the business acumen of our CEO and the commercial team, gives us a tremendous edge. Our team comes from excellent universities (Imperial College, Hebrew University, Harvard Business School, Weizmann Institute, INSEAD, and

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the Technion) and has professional experience from great companies such as HP, Stratasys, Orbotech, Elbit, and McKinsey. We are thorough, flexible, and customer focused.

We have the backing of industry majors: ASM Pacific Technology is a leading electronics equipment manufacturer; Henkel is a leading electronics materials manufacturer; this is a perfect strategic combination.

**Beaulieu:** Where is the company positioned in the marketplace?

**Birnbaum:** For semiconductor packaging, on the innovation frontier. High end, as well as high mix, low- to medium-volume, and a clear innovation driver.

**Beaulieu:** Where do you see your company in three to five years?

**Birnbaum:** I think our customers will be changing the way mid- to high-end PCBs are manufactured. We will continue to develop applications for the electronics industry in PCB, IC substrates, SMT, and semiconductor packaging. By then, our technology will enable fast innovation in many industries. Our customers will spearhead supporting IoT, Industry 4.0, and 5G developments. Five years from now, we may branch out into other manufacturing industries where our technology is needed to move to the next level, such as aerospace, medical/dental, automotive, etc.

**Beaulieu:** How about new product development?

**Birnbaum:** We will continue rolling out applications as we optimize the printer in other areas. We can already print multi-layered HDI PCBs, and we will continue to optimize it for commercial release. In parallel, we also have additional complementing technologies, already patented, that will be added to our initial product lines as well as into new products.



Figure 3: The IO-300, ioTech's additive manufacturing 3D printer.

**Beaulieu:** How do you see the industry doing now that we are nearly post-COVID?

We sincerely hope that we will see a speedy global recovery trend. But likely, the world will have to adapt to living alongside COVID. Our technology will help companies manufacture onshore and inhouse, avoiding disrupted supply chains as were apparent during the epidemic.

**Beaulieu:** Ralph, do you have any final thoughts?

**Birnbaum:** Our customers and partners keep on bringing new applications. We do our best to accommodate those requests within the framework of our current capabilities. CLAD is an extremely innovative technology, with a very wide scope and appeal.

**Beaulieu:** Thank you Ralph, that was very interesting and informative as well. I wish you and ioTech the best of luck in the years to come.

**Birnbaum:** My pleasure Dan, thank you for providing us with this opportunity. **PCB007**

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# **ein** Electronics Industry News and Market Highlights



## **LPKF Opens Biolab for ARRALYZE Technology ▶**

In its 45-year history, LPKF has repeatedly developed groundbreaking technologies and opened new markets in the electronics, research and development, automotive and solar sectors.

## **CEOs Call on Congress to Strengthen U.S. Semiconductor Research, Design, Manufacturing ▶**

The Semiconductor Industry Association (SIA) applauded a letter recently sent to congressional leaders by a broad coalition of 59 CEOs and senior executives urging swift action to fund the CHIPS for America Act and enact a strengthened version of the FABS Act to bolster U.S.-based semiconductor research, design, and manufacturing.

## **Keysight Joins Anterix Active Ecosystem Program to Advance Private LTE Broadband Deployments ▶**

Keysight Technologies, Inc., a leading technology company offering advanced design and validation solutions, has joined the Anterix Active Ecosystem Program to help advance private Long-Term Evolution (LTE) broadband deployments in the United States.

## **Enevate Ramping its Pioneering Battery Technology to Address Global EV Battery Demand ▶**

Enevate, a pioneering battery innovation company featuring extreme fast charge and high energy density battery technologies for electric vehicles (EVs) and other markets, exceeded its goals for 2021.

## **Siemens' New mPower Solution Gains Certification for TSMC's N7, N5 Technologies ▶**

The significant power and performance advancements of TSMC's N7 and N5 processes make them ideal for next-generation mobile, artificial intelligence, high-performance computing, and network connectivity designs, as well as other high-performance digital and mixed-signal applications.

## **Qualcomm Technologies, Opel Bring Cutting-Edge In-Cabin Experiences in Stylish New Opel Astra ▶**

Qualcomm Technologies, Inc., and Opel Automobile GmbH (Opel) announced that the upcoming Opel Astra—Opel's latest addition to its compact class of electrified vehicles—will utilize next-generation Snapdragon® Automotive Cockpit Platforms.

## **Elbit Systems of America, KMC Systems Open Cambridge Innovation Center ▶**

Elbit Systems of America celebrates the grand opening of its new Cambridge Innovation Center—a fresh and modern engineering design and ideation space—in Cambridge, Massachusetts.

## **Stellantis, Foxconn Partner to Design, Sell New Flexible Semiconductors for Automotive Industry ▶**

Stellantis N.V. and Hon Hai Technology Group (Foxconn) announced the signing of a non-binding memorandum of understanding to create a partnership with the intent to design a family of purpose-built semiconductors to support Stellantis and third-party customers.

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# A Voice in Washington for American-Made PCBs

## American Made Advocacy

**NEW COLUMN:** by Travis Kelly, PCBAA

If you spent the holidays searching in vain for a present, waiting days for a rental car, or wondering why your package was still “in transit,” you’re not alone.

Millions of Americans feel the economic effects of the COVID-19 pandemic, and many are starting to appreciate the way advanced electronic components underpin our way of life. Shortages of everything that run on electronics (and these days, what doesn’t?) have disrupted life in ways that were hard to imagine just a few years ago.

Facing an anxious public, Congress and the current administration are pushing for investment in domestic semiconductor manufacturing to reduce our dependence on overseas

manufacturing. The nearly \$52 billion CHIPS Act is a welcome start, but it’s not the end of the story. Truly “building back better” requires that policymakers consider the entire supply chain.

That’s where a new focus on printed circuit boards is required, and a new voice for that industry is needed.

PCBs are a \$60 billion global industry that over the past 20 years has moved away from the United States at an alarming rate. At one time, the U.S. produced over 26% of the world’s PCBs. Today that number is down to 4% and the number of domestic PCB manufacturers has decreased from 2,500 to only 145 companies. As COVID-19 brought into vivid focus,





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dependence on other countries created a supply chain risk to everyday consumer technologies as well as critical national security applications.

The Printed Circuit Board Association of America was formed to address these issues through pursuing three major objectives:

## 1. Support the domestic production of PCBs.

Foreign subsidies have led to artificially low prices on PCBs produced abroad. It's time to level the playing field for producers that choose to manufacture PCBs in the United States and for purchasers who choose to improve their supply chain resiliency by purchasing domestically manufactured PCBs.

## 2. Enhance domestic supply chain security.

Without robust and secure domestic supply chains, the production of electronics for critical commercial and national security systems is not sustainable. It's time for the United States to support the microelectronics industry the way other nations have done: by creating an environment that enhances our domestic producers' ability to compete globally.

## 3. Advocate for initiatives that create fair market conditions.

America's reliance on overseas manufacturing for PCBs arose out of unfair market dynamics. Foreign governments subsidize PCB companies, flooding the market with excess capacity and artificially low prices. This creates unfair market conditions which puts U.S. companies at a significant competitive disadvantage. This needs to change to allow American microelectronics manufacturing to flourish.

As we head into a new year, there are reasons to be optimistic. Less than a year after it was formed, our association has grown to over

a dozen members, and there is a steady stream of more companies interested in joining.

Our public education campaign and advocacy efforts in the halls of Congress have begun to pay off. Lawmakers are more aware of the impact of a lopsided microelectronics ecosystem largely controlled by other nations. A growing number of elected officials support the need for a resilient supply chain and the benefits of reshoring microelectronics manufacturing, and have influenced favorable legislation. For instance, the recent National Defense Authorization Act contains language that promotes domestic production of critical microelectronics.

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**Our public education campaign and advocacy efforts in the halls of Congress have begun to pay off.**

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While our team celebrates the progress we've made, we understand the hard work that remains in front of us. We have a unique opportunity to secure our electronics supply chain, reinvigorate high-tech manufacturing, and maintain America's leading technological edge.

The PCBAA believes in—and fights for—market fairness and a level playing field on which U.S. PCB manufacturers can compete and win. If you're interested in joining our effort, please [visit us online](#). **PCB007**



**Travis Kelly** is the CEO of Isola and current chairman of The Printed Circuit Board Association of America or PCBAA. This column will appear regularly.

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# MilAero007 Highlights



## DoD Faces Growing Risks from Reliance on Lead in Electronics ▶

The U.S. defense community is facing a small but growing problem that is increasingly undermining U.S. military readiness and technological dominance. The problem is lead—specifically, the lead-alloy solders that traditionally have been used to attach electronic components to printed circuit boards (PCBs). Over the last 15 years, the commercial electronics industry has shifted to lead-free solders, prompted by environmental health regulations in Europe and elsewhere. However, the U.S. Department of Defense (DoD) and its contractors never made the switch and are still heavily reliant on leaded solders. Now, leaded electronics are becoming harder to find and more outdated.

## Zulki's PCB Nuggets: Cleanliness is Next to Reliability ▶

Today's PCBs are highly populated with increasingly smaller device packaging. As a result, these advanced device packages are extremely difficult to clean due to tight densities and configurations, especially with bottom terminated components. Current OEM system designs and those on the drawing board are driving these newer technologies, which are the foundation of advanced PCB assembly and manufacturing.

## Sparton's Bill Toti Retires; Tracy Howard Tapped as Next President & CEO ▶

Sparton President and Chief Executive Officer Bill Toti has retired after leading the company for three years, including through the company's transition to Elbit Systems of America during 2021.

## Defense Speak Interpreted: Who Won the Project Convergence War Game—Evil Chaos or JADC2? ▶

I know you have been on the edge of your seats since my Defense Speaks September column, “What Does Convergence Mean to Defense?” or back to my February column, “So, What's a JADC2?” While I tackled some other government defense topics, I realize I have left you hanging concerning the big interservice war game maneuvers, Project Convergence (PC), which tested out the information connection described in the JADC2 effort. I know, you thought after my “Son of JEDI” description of a cloud-based information flow, that all service branches would soon be coordinated and talking to each other smoothly.

## Isola Materials Support Military LEO Satellites ▶

Isola Group, a global innovator in materials for printed circuit boards (PCBs), has announced its low-loss I-Tera® MT40 circuit materials supporting multilayer printed circuit boards (PCBs) for military- and commercial-grade low-Earth-orbit (LEO) satellites.

## CyberOptics Features Best-in-Class Inspection Systems Powered by MRS Sensor Technology at APEX ▶

CyberOptics Corporation, a leading global developer and manufacturer of high-precision 3D sensing technology solutions will demonstrate the SQ3000 Multi-Function system for AOI, SPI and CMM in Booth #2541 at the 2022 IPC APEX EXPO, scheduled to take place Jan. 25–27, 2022, at the San Diego Convention Center in California.

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# Surface Preparation—The Foundation of the **Photoresist Imaging** Process

## Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

### Introduction

The photoimaging process is one of the first steps in the PCB fabrication process. 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. The fabricator has numerous options and should determine the optimum process by accounting for the type of copper foil used as well as the classes of soils to be removed. More on copper foil types in a future column.

One may call the surface preparation process the foundation of the imaging operation. Surface preparation is critical for resist performance and increases the process latitude of the resist lamination, exposure, and development processes yet to come. Reasonable yields at 4 mil lines and spaces are no longer the norm in today's high density and ultra-high density interconnect technology. The need to support advanced packaging and IC substrate production is pushing the envelope on the imaging process.

### The Options

There are several options available. In addition to pumice and aluminum oxide surface preparation, chemical cleaning as a means to ensure optimum photoresist adhesion has gained significant popularity. In this case, only chemical processes such as acid cleaners and microetchants are employed. However, chemical cleaning is more than simply utilizing microetchants to restructure the copper surface. First the chromate conversion coating must be dealt with.

### Chromate Conversion Coating

All copper foil and/or laminate producers process the foil through an anti-tarnish treatment to prevent oxidation of the copper surface. This treatment is based on chromic acid. The chromic acid treatment provides a hydrated chromate film on the copper that prevents copper oxidation. While preventing oxidation is necessary during storage, the chromate must be removed prior to microetching. Failure to remove the film completely will lead to differential or step-etch during the microetching process. The step etch will leave the cop-



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per surface with a non-uniform topography. This non-uniformity will invariably lead to less than optimum photoresist adhesion. The potential for resist to “lock” into some of the non-uniform areas on the foils is quite high, mainly due to the extreme peaks and valleys in the surface profile. The best remedy to prevent this situation is to completely remove the chromate film.

In the past, tarnish resistance was accomplished by immersion of the copper foil into a solution containing chromate ions. Yates and others further improved upon this method with an electrolytic technique to enhance the oxidation resistance of the copper foil<sup>1</sup>. Others later improved upon this invention with the introduction of zinc chromate<sup>2</sup>.

One should never underestimate the tenacity of the chromate film. This is precisely why I recommend a strong mineral acid cleaning step prior to pumice, aluminum oxide or chemical microetching. It is much more effective to

enhance the resist adhesion when a good chromate removal process is online prior to these additional processes.

## Chemical Cleaning and Microetching

First, a review of various chemical cleaning methods is warranted. It is well known that the definition of cleaning is “making the soil soluble in a solvent.” I don’t remember who is responsible for this quote, but it is something I have not forgotten. Basically, one should understand what the composition of the soils is and what the proper solvent or solvents are best suited to remove those soils. Chemical compositions designed to remove soils are endless. As an example, Table 1 provides a succinct summary of those processes. One should also contact the chemical supplier to extract advice and counsel on proper operating parameters, equipment compatibility and costs.

There are some suppliers that provide one-step chromate remover/microetchants.

**Table 1** Chemical Cleaners and Microetchants

Cleaner class	When to use	Contraindications	Comments
Alkaline cleaners	Use with inner layers prior to oxide or oxide alternative processing. Will also remove light organic soils.	Will not remove copper oxides or chromate coatings.	Watch for foaming formulations as these may cause issues with cross-contamination.
Acidic soak cleaners	Can be used in spray or immersion mode. If used in spray mode, ensure the chemical is low- or non-foaming.	Will not microetch. May, with the help of certain surfactants, remove light organic soils.	Combinations of nitric, sulfuric and hydrochloric acids make excellent chromate removal chemistry. Look at individual acid formulations as well. Phosphoric acid is another good acidic cleaner.
Microetchants (persulfates, hydrogen peroxide/ sulfuric acid, cupric chloride)	Can be used in spray or immersion mode. Control copper removal with proper control of operating parameters.	Not designed to remove organic soils.	Easy to use. Some etchants can be closed-loop, i.e., recover the etched copper as a copper sulfate salt.

Idea for Table from IPC document 740 (Process Effects).

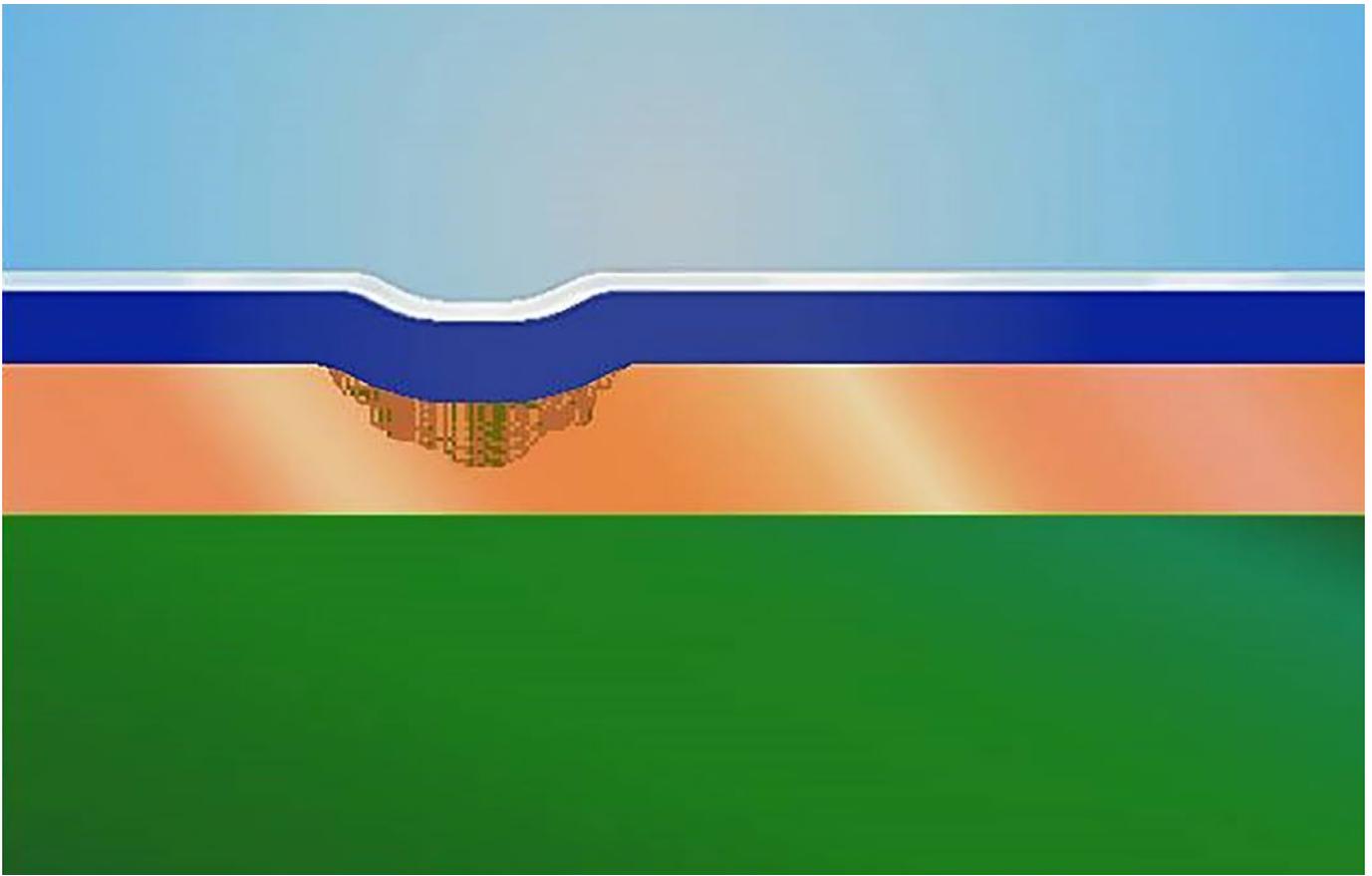


Figure 1: Poor photoresist conformation. (Source: IPC)

Again, one should consult the supplier's technical datasheet for the proper use and indications. From this writer's standpoint, the chemical cleaning process is more efficient and effective with at least two separate chemical steps—one as a chromate/soil remover and the second as a copper removal/copper microetchant.

### Basic Chemical Microetching Processes

The fundamentals of chemical microetchants are quite simple: remove oxides from the surface and restructure the copper foil. The latter means to roughen or create a topography for the copper that enhances photoresist adhesion without excessive copper removal. There are several key points to consider here. First, it is much more effective to create a uniform topography without excessive copper removal if the copper foil surface is already devoid of oils, soils, and chromates. Thus, the first step

in the surface preparation process is to provide a virgin surface so that the microetch can perform its function. When there are soils and chromates remaining on the surface, the microetch will create areas on the surface that, for lack of a better term, are referred to as differential or step-etch. The topography will exhibit areas of high peaks and low valleys that can promote resist lock-in. Conversely, if there are areas on the foil surface that have deep trenches in the foil due to differential etch, there are concerns with poor resist conformation (Figure 1). In this case, the resist never completely adheres to the copper in these areas. There is a gap that allows for other chemicals to remove copper during the develop-etch-strip process. When other processes can remove the copper that was designed to be protected by the resist, the consequence is an open circuit. At the very least one will experience neckdowns in the circuit traces.

With respect to microetchants, the two most commonly used are:

- Persulfate based (sodium or potassium)
- Hydrogen peroxide-sulfuric acid

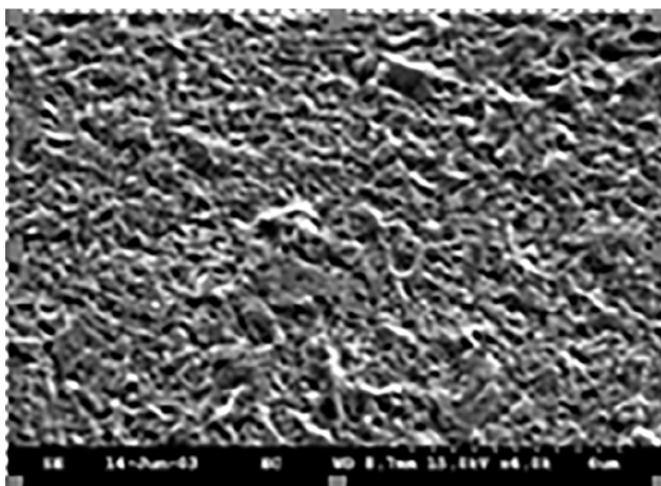
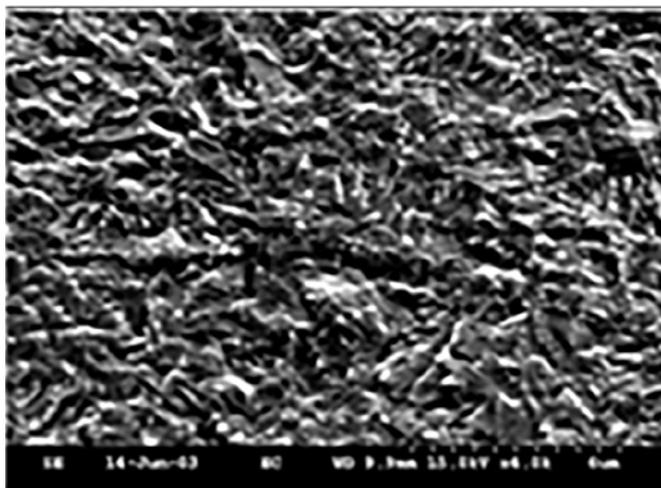
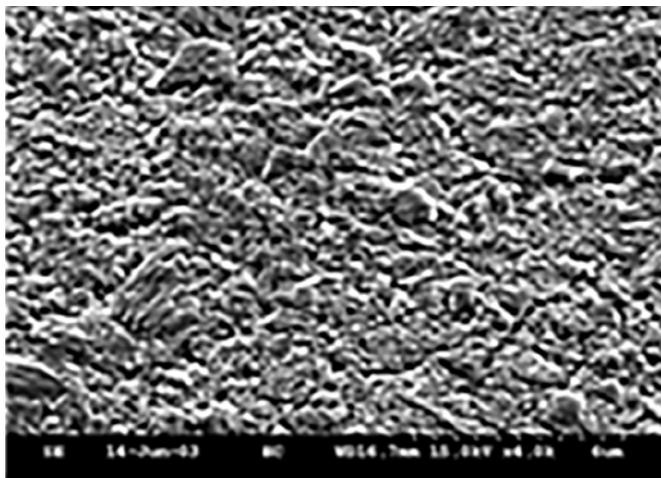


Figure 2: Hydrogen peroxide-sulfuric (top), oxone (middle), and sodium persulfate (bottom).

Persulfate-based processes tend to create a much more roughened topography than does hydrogen peroxide/sulfuric acid-based processes. However, when the chromate conversion coating is thoroughly removed, both etchants are effective. As shown in Figure 2, the different generic microetches impart stark differences in topography. One must take these differences into account when evaluating chemical clean processes and adhesion.

The angular grain structure promotes sufficient adhesion of the resist to the copper surface. It is important to recognize that an overly roughened surface is detrimental to good resist adhesion as well. In general, a more uniform surface roughness is beneficial for resist adhesion. Extremely rough and non-uniform surface profile leads to areas on the surface where the resists does not contact the copper surface.

## Summary

“Making a soil soluble in a solvent.” That is a simple but accurate definition of cleaning. In the case of copper foil surfaces, this suggests that organic soils, chromate anti-tarnish coatings, and oxides must be removed from the copper prior to microetching the foil. The former is accomplished with acid cleaners containing mineral acids, surfactants, and other functional materials. Once a clean virgin copper surface is obtained, the fabricator is then able to increase the surface area of the foil with a chemical microetch. **PCB007**

## References

1. U.S. Patent 3,853,716
2. U.S. patent 4,387,006



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

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# Semi-Additive Processes and Heterogeneous Integration

## Happy's Tech Talk

by Happy Holden, I-CONNECT007

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.

In his Tech Talk column, Karl Dietz wrote about SAP many times from 2000 to 2010.<sup>1-5</sup> In a 2010 column, Karl included a table (Table 1) to show the relationship between copper thickness, resist thickness, and resolution capabilities of processes.<sup>5</sup> Karl devoted many Tech Talks to “fine-line imaging” and to related

topics such as photoresist adhesion, developing, fine-line etching, stripping, and pattern plating.

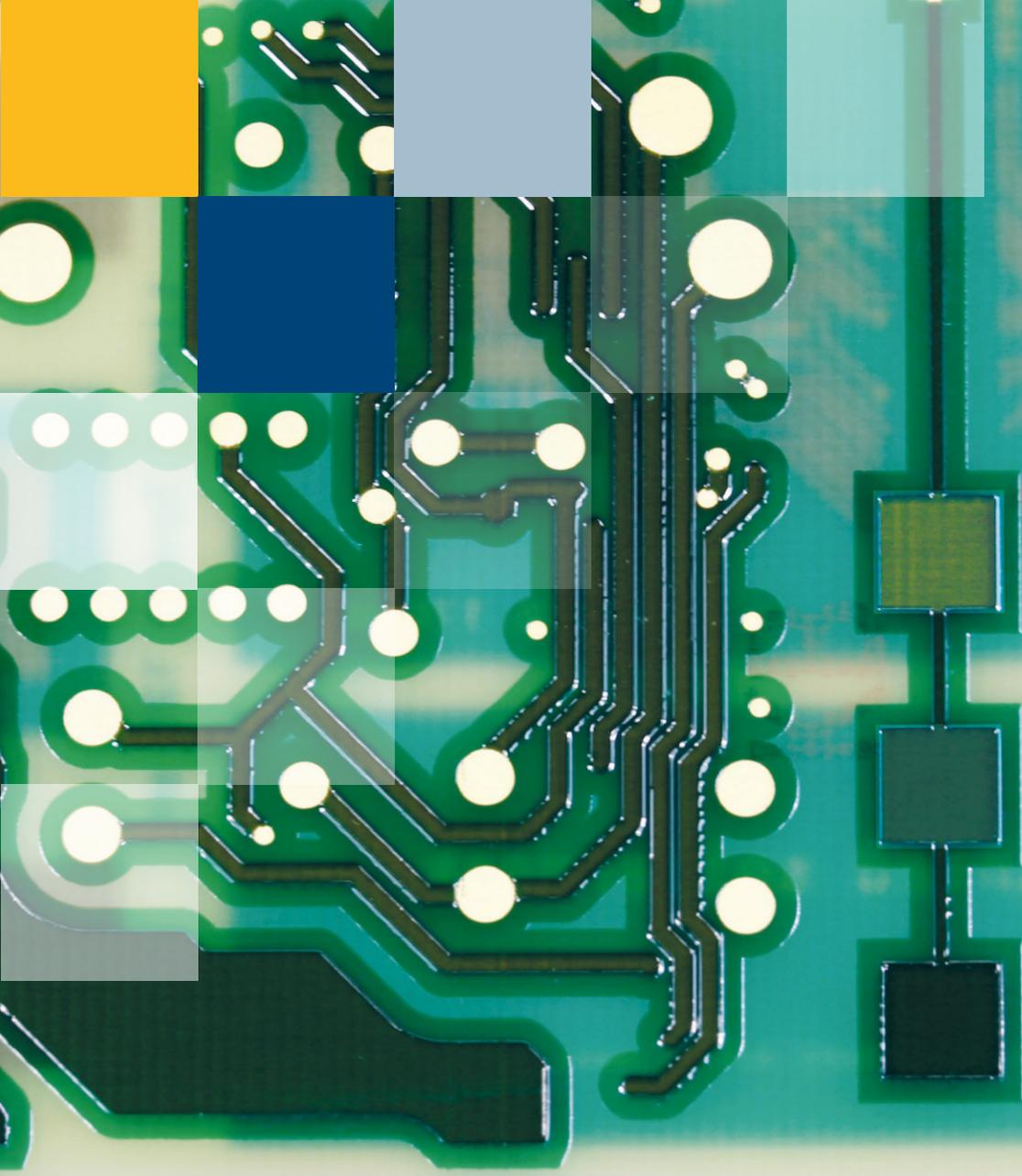
### Semi-Additive Processes

The older mSAP processes used thinned copper, usually to nine or five microns, from half-ounce foil or very thin copper foil (usually with a peelable protection). They would usually have a flash copper strike and may use tin plating as the etch resist.

The IC substrates (for flip-chips) were always the leading edge of this technology, from 2005 onward, but quickly converted to the use of the Ajinomoto build-up film (ABF) from Japan

Process	Traditional tent/etch	Traditional plate/etch	Cu Thinning + Tent/etch	CU Thinning + plate/etch	MSAP	SAP for FC-BGA
Resolution produced	> 75 $\mu\text{m}$	> 50 $\mu\text{m}$	> 60 $\mu\text{m}$	> 35 $\mu\text{m}$	> 30 $\mu\text{m}$	>10 $\mu\text{m}$
Vendor Cu thickness	.5 oz Cu = 18 $\mu\text{m}$	.5 oz Cu = 18 $\mu\text{m}$	Cu thinning to 5-8 $\mu\text{m}$	Cu thinning to 5-8 $\mu\text{m}$	Ultra-thin foil 2 $\mu\text{m}$	None
Electroless Copper	3 $\mu\text{m}$	3 $\mu\text{m}$	2 $\mu\text{m}$	2 $\mu\text{m}$	1-2 $\mu\text{m}$	< 2 $\mu\text{m}$
Panel Cu or strike plating	25-35 $\mu\text{m}$	None	20-20 $\mu\text{m}$	2-3 $\mu\text{m}$	2-3 $\mu\text{m}$	None
Pattern Copper	None	20-30 $\mu\text{m}$	None	15-25 $\mu\text{m}$	15-25 $\mu\text{m}$	15-25 $\mu\text{m}$
Etching resist thickness	D/F 30-50 $\mu\text{m}$	Sn 5 -10 $\mu\text{m}$	D/F 20-40 $\mu\text{m}$	Sn 5 - 7 $\mu\text{m}$	None	None
Average Cu thickness to be etched	50 $\mu\text{m}$	20-25 $\mu\text{m}$	30-35 $\mu\text{m}$	8 $\mu\text{m}$	6 $\mu\text{m}$	Electroless Cu only: (<2 $\mu\text{m}$ )
End market	Consumer	Consumer	Cellphone	Substrate	Substrate	FC-BGA

Table 1: Relationship between copper thickness, resist thickness, and resolution capability of process.<sup>5</sup>



inkjet

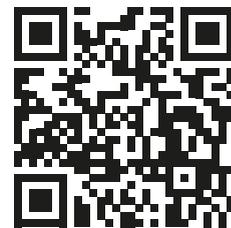
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3,5 kV



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that was additive electroless on the bare-etched, vacuum laminated dielectric films.

The advanced-modified SAP (amSAP) processes did away with the copper strike and further exploited the thin-copper foils.

Averatek's new A-SAP™ (or pure additive) starts with a treated copper foil on the laminate, but after drilling, the copper foil is etched away. This allows a new generation of nanoparticle Liquid-Metal Ink™ catalysts to be used to prepare the surface for fine-grain electroless copper application. After pattern electroplating and resist stripping, this electroless copper, being only around 0.7 to 1.2 microns thick, permits a flash etch without any etch resist. These processes are seen in Figure 1.

With these new, improved catalysts and electroless copper products now available, Table 2 shows the newer

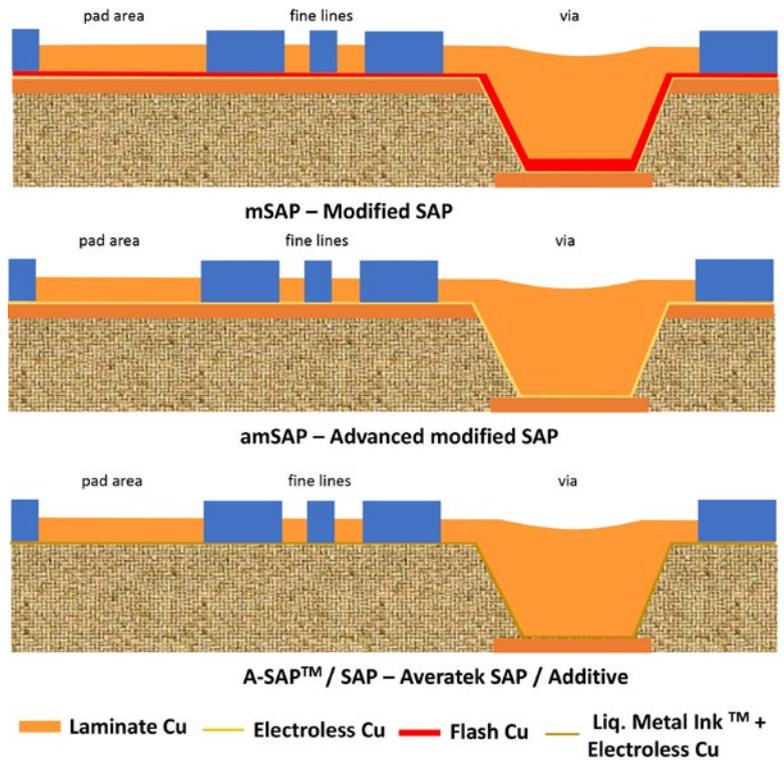


Figure 1: The three common SAP processes: mSAP, amSAP and A-SAP™. (Source: Atotech)

	Panel Plate (thin Cu Clad)	mSAP	amSAP	A-SAP™	SAP
Lines & Space	> 35 μm	> 30 μm	> 20μm	> 15 μm	> 5 μm
Cu Clad	2 – 18 μm	2 – 5 μm	< 3 μm	17 μm->0	0
Electroless Cu	0.35 – 0.5 μm	.35-.5 μm	1.0 μm	1.0 μm	1.0 μm
Blind Via Dia.	100 μm	80 μm	60 μm	60 μm	25 – 40 μm
Blind Via Pad	160 μm	135 μm	110 μm	110 μm	25 – 80 μm
Flash Cu	2 – 5 μm	< 2 – 5 μm	No	No	No
Panel Plating	15 – 20 μm	Yes	No	Yes	No
Pattern Plating	No	Yes	Yes	Yes	Yes
Etch Resist	Dry Film/LDIR	No	No	No	No
Primary Material	FR4s	FR4s	FR4s	FR4s / ABF	+ABFs
Avg. Copper to be etched	17 -29 μm	4 – 10 μm	< 3 μm	0.7 – 1.2 μm (electroless Cu)	0.7 – 1.2 μm (electroless Cu)

SAP=Semi Additive Process; mSAP=Modified Semi Additive Process;  
amSAP=Advanced Modified Semi-Additive Process; Averatek Semi-Additive Process

Table 2: Comparison of various fine-line processes including the new A-SAP™ from Averatek.

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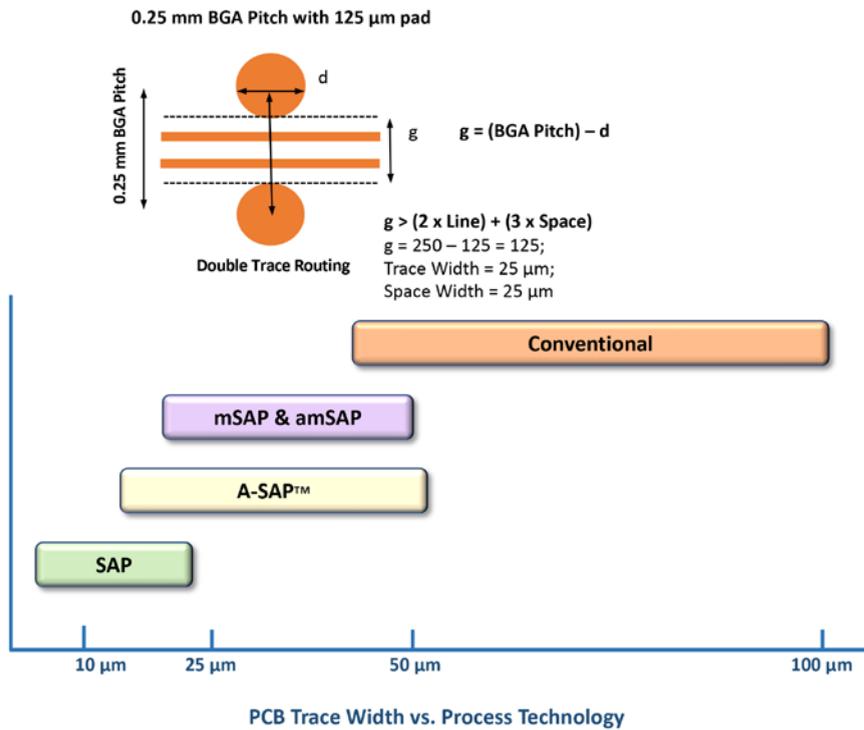


Figure 2: Trace and space for 0.25 mm pitch BGA and evolving trace width reduction with new processes. (Source: IEEE Heterogeneous Integration Roadmap)

capabilities of various SAP processes including the SAP and pattern plating for the ABF process used for flip-chip and other IC packaging substrates.

The trend is clear that organic (PCB) substrates are continuing to evolve down to less than five-micron trace/spaces. The most important characteristic is the surface smoothness and planarity of the dielectric. Figure 2 shows the reduction of trace/space as a function of device pitch and SAP process technology, as portrayed in the 2019 IEEE Heterogeneous Roadmap.<sup>6</sup>

## Direct Metallizations

Considerable advances have been made in the direct metallization processes to replace electroless copper, introducing a simpler and less costly process for mSAP/amSAP. The proven direct metallization systems have added a new copper etch of 0.2–0.3 mm to eliminate carbon from the copper surfaces.

The simplified metallization process (compared to electroless copper) is shown in Table 3. While the direct metallization process is easier to control, it also has the advantage of one-third the space required and is environmentally friendly.

## Heterogeneous Integration

The constant reduction in semiconductor transistor geometries have created a situation where it appears less costly to break up very large, complex dies into smaller dies and combine them with “modular” dies, now named “chipslets” and tiny discretes on an organic substrate using these exceedingly small traces and spaces along with very tiny vias as a “system-in-package”—now referred to as

STEP	Electroless Copper	STEP	Carbon Technology
1	Clean/condition	1	Clean/condition
2	Rinse	2	Rinse
3	Microetch	3	Carbon-based dispersion
4	Rinse	4	Dry
5	Pre-dip	5	Microetch
6	Activation	6	Rinse
7	Rinse	7	Anti-tarnish
8	Acceleration	8	Rinse
9	Rinse	9	Dry
10	Electroless Copper		
11	Rinse		
12	Acid dip		
13	Rinse		
14	Anti-tarnish		
15	Rinse		
16	Dry		

Table 3: Process comparisons of metallization for SAP.<sup>7</sup>

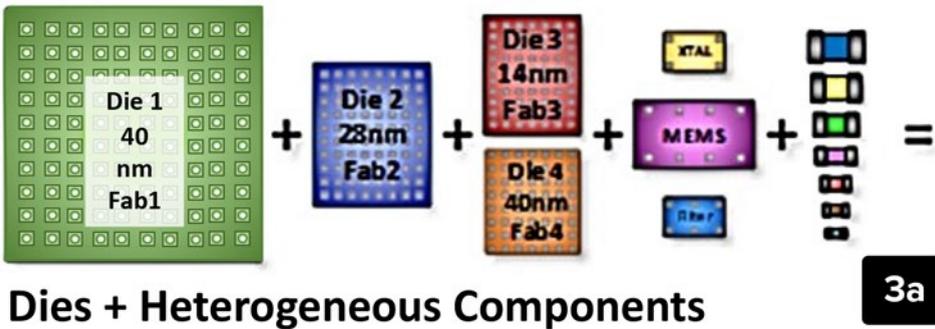


Figure 3: Heterogeneous integration takes various dies and discrete components and integrates them onto fine-line substrates (such as PCBs). (Source: IEEE HIR)

“heterogeneous Integration.” This can be seen in Figure 3.

The design trade-offs will be between trace geometry and its losses and innerlayers using

YOLO Development about the future of packaging for these electronics out to 2030 is uncertain, as seen in Figure 5. There are overlapping capabilities currently down to 5/5-micron L/S

ultra-HDI technologies. This is where the innovative technology of VeCS<sup>8</sup> will provide vertical traces to any innerlayer using less space, easy plating and reduced electrical parasitics.

The increasing complexity of HIR will add more functionality to these substrates and result in modules, as seen in Figure 4, that will contain IC chips of various materials/connections, embedded components, RF/antennas, optical waveguides and even energy storage.

### Conclusion

The prediction from

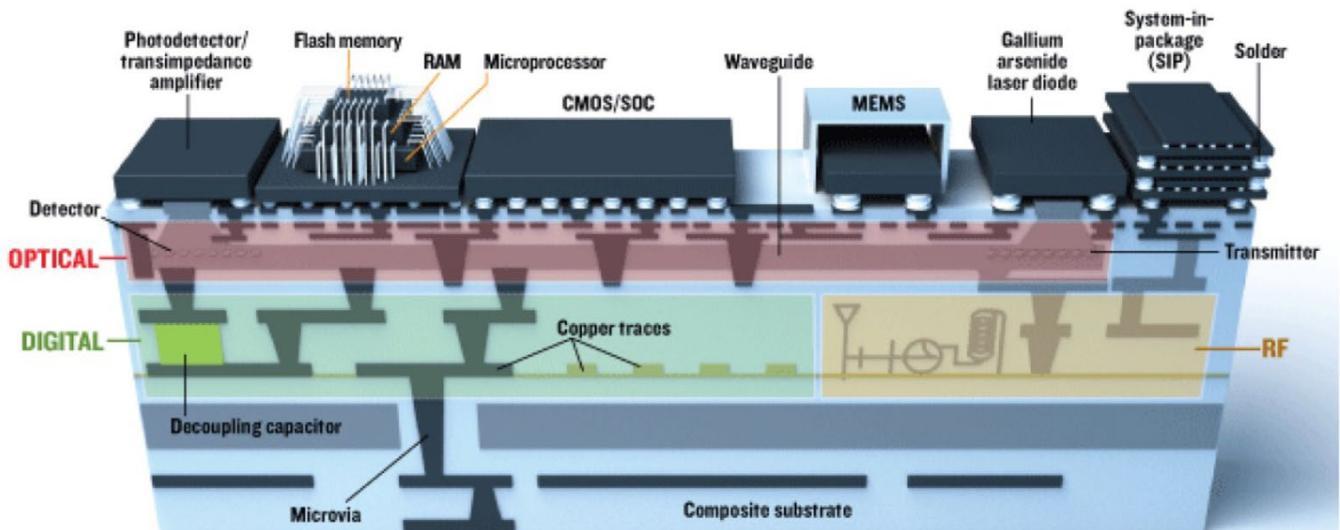


Figure 4: Vision of heterogeneous integration from the IEEE Roadmap (Source: IEEE)

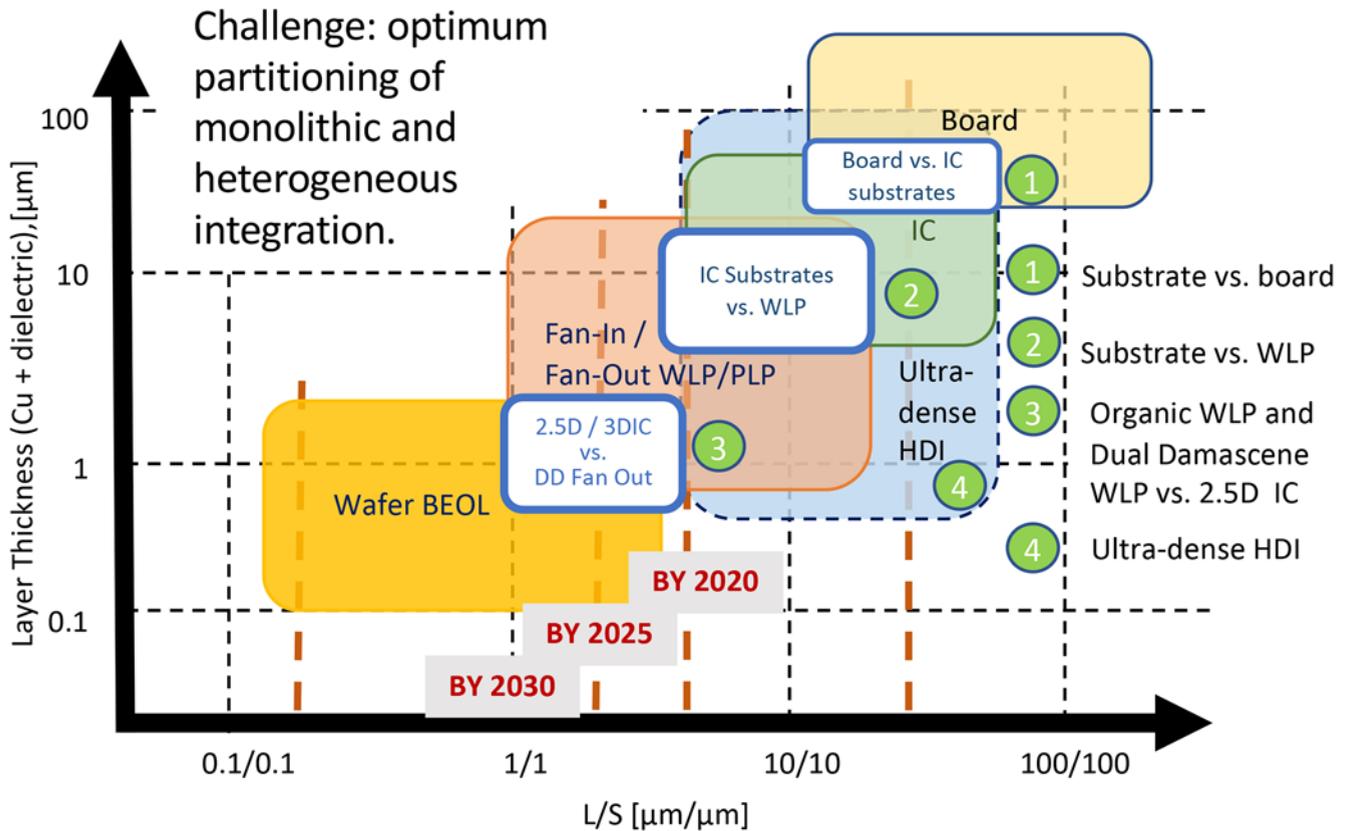


Figure 5: The trade-offs between dielectric thicknesses and trace/space geometries for heterogeneous integration is the overlapping technologies of PCBs, IC substrates, ultra-HDI, WLP/PLP and wafer interposers—back-end of the line (BEOL). (Source: YOLE Development<sup>9</sup>)

and this will continue over time down to under 1/1 microns by 2030. **PCB007**

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**Happy Holden** has worked in printed circuit technology since 1970 with Hewlett-Packard, NanYa Westwood, Merix, Foxconn, and Gentex. He is currently a contributing technical editor with

I-Connect007, 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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<sup>1</sup>IPC. (2017). Findings on the Skills Gap in U.S. Electronics Manufacturing.



# Supplier Highlights



## Atotech Reports Q3 2021 Results, Narrows 2021 Full-Year Guidance Range ▶

Atotech, a leading specialty chemicals technology company and a market leader in advanced electroplating solutions, reported financial results for the third quarter of 2021. The company maintained its revenue guidance and narrowed the Adjusted EBITDA guidance range for the full year 2021.

## DuPont Announces Acquisition of Rogers Corporation ▶

Rogers Corporation announced that it has entered into a definitive merger agreement to be acquired by DuPont in an all-cash transaction that values Rogers at approximately \$5.2 billion.

## The Big Picture: Cybersecurity and Hardware Security ▶

Wherever I go, I am pleasantly reminded of the role our industry plays in everyday lives. From the sight of people texting and calling loved ones on their phones, to children laughing and playing with their high-tech toys, to doctors and nurses using advanced med tech to keep someone alive. These moments remind me of how important the safety and security of our work is.

## Nano Dimension's Revenue Increased by 107% in 9 Months, 206% in 3 Months ended September 2021 ▶

Nano Dimension Ltd., an industry leader in additively manufactured electronics (AME), printed electronics (PE), and micro additive manufacturing (Micro-AM), announced financial results for the third quarter ended September 30, 2021.

## KLA Opens AI-Advanced Computing Lab at Indian Institute of Technology ▶

KLA Corporation announced the opening of two important facilities in Chennai, India, supporting the company's investment in innovative research and talent development.

## Unimicron Holds Sustainability Co-Prosperity Award ▶

Unimicron implements sustainable supply chain management regularly holds annual supplier meetings and commends excellent suppliers there. Since the COVID-19 epidemic broke out globally in 2020, and with the efforts of all citizens, the domestic epidemic is still under control, but in the face of the epidemic, we must still be cautious.

## Additive Reality: Your Company Drops Open the Inkjet Printer Box, Now What? ▶

The moment will come when some of readers will advance from interest to complete involvement with the technology. This will be a fun ride as you will experience first-hand the concepts seen so far in this column. However, we all know that any reliable technology relies on one healthy, not so exciting, good habit: preventive maintenance.

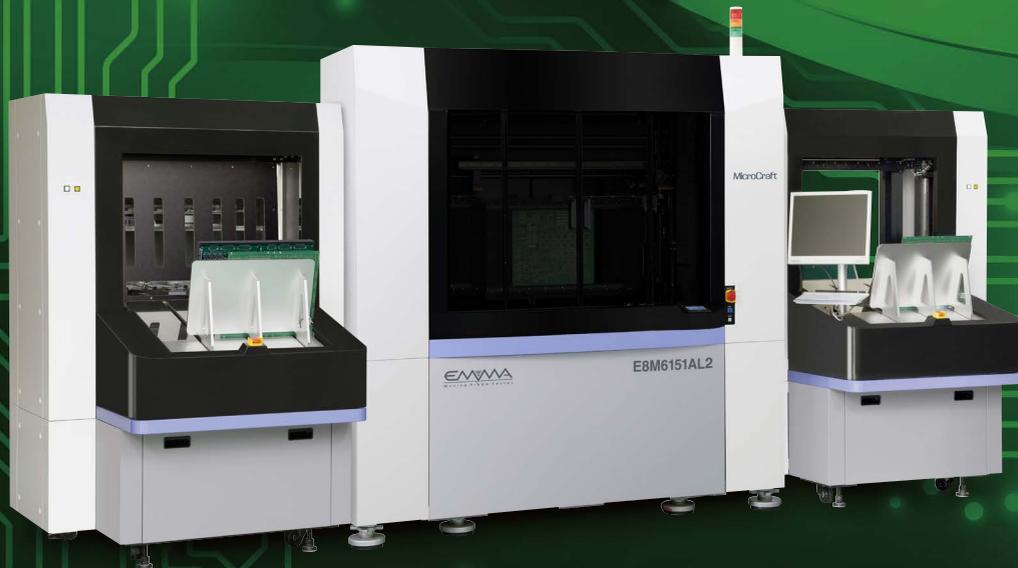
## Weyls Named Vice President, Circuitry Solutions for MacDermid Alpha ▶

MacDermid Alpha Electronics Solutions, a global supplier of integrated solutions from our Circuitry, Assembly and Semiconductor division that provides unmatched capabilities in electronics design and manufacturing, announces the appointment of Erik Weyls as vice president of its Circuitry Solutions division.

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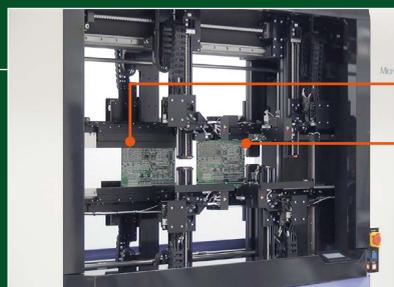
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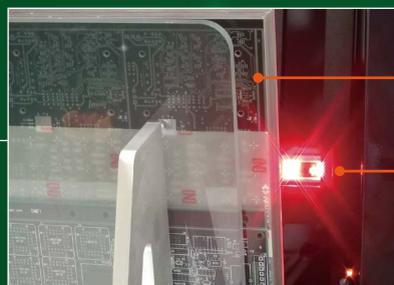


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# Leadership 101—The Laws of the **Picture** and **Buy-In**

## 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 laws 13 and 14 of the “21 Irrefutable Laws of Leadership,” developed by John C. Maxwell.

### The Law of the Picture

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. As with most of the

21 Irrefutable Laws of Leadership, they play off very basic human nature attributes; in this case it is the tendency of people to mimic the behaviors of their leaders. When a leader demonstrates behaviors that lead to success, people follow. But the same is true when a leader demonstrates bad behaviors. So, how do you take measure of yourself?

### Look in the Mirror

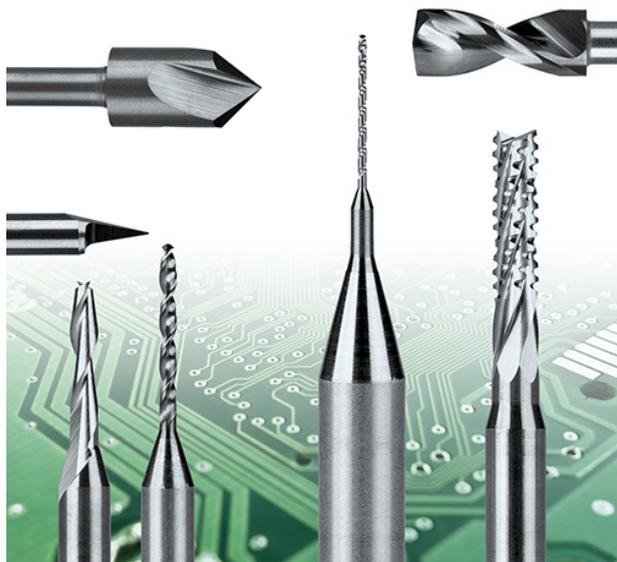
A good, honest assessment of ourselves is the starting point to understanding how oth-



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ers see us. Use the following questions to connect with yourself. Do I:

- Know my values and the message I want to project?
- Live my message and lead by example?
- Walk the talk?
- Do what's right, not what's easy?
- Know my people and communicate on their level?
- Place integrity over expedience?
- Believe in others?
- Offer direction and hope?

And the most important question: “Would I want me as a boss?”

These are all required attributes of a great leader, and a foundation to the Law of the Picture. You might even want to consult a colleague (family and friends may be biased) for an independent assessment of where your actions don't match up with your values. Your colleague might be calling your baby ugly, but this feedback must be taken in a constructive way and without getting defensive. One of the leadership training exercises I do is to ask the participants to make a list of their perceived leadership qualities. I tuck that away for now and during a later session I ask the same group to make a list of the qualities they would like to see in their employees:

integrity, loyalty, work ethic, whatever they may be. Then we compare the two lists, which is usually an eye-opening event for some of them and a good roadmap for improvement.

Monkey see, monkey do.

## The Law of Buy-In

Anyone who has experienced an implementation of any new project will have seen

this law in action. There are two paths these things can take, and let's use implementing a new QMS for illustrative purposes:

1. Imposing a canned set of procedures, work instructions and forms, and telling the workforce, “This is the new way of doing your job.”
2. Involving the people who actually do the work from day one to be key contributors in developing the new procedures, work instructions, and forms.

Which do you think has the highest success rate? (Rhetorical question). This is what the Law of Buy-In is all about as it relates to leadership.

*“The Law of Buy-In: People buy into the leader, then the vision.”*

—John C. Maxwell

As we look at the reason why people don't buy into a leader's vision there are ample examples in our work and personal lives, politics, churches, marriages (the list is endless). It doesn't matter how strong the vision is, the leader can't be successful if they can't move others to action or change; in other words, buy-in.



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Cutting and structuring with UV and/or CO<sub>2</sub>
- + **Space saving compact design**  
Integrated loader / inline version also available
- + **Best power/size ratio in market**  
10-20W UV-Power = Increased process speed in thicker materials  
3kW CO<sub>2</sub> peak power = Less number of pulses required  
Efficient optical train = No AOM required  
Less downtime, gas refills on site
- + **Pulse stabilizer**  
Pulse-for-pulse energy and peak power control = pulse repeatability  
Large process window and stability
- + **North American technology and support center**  
Online and on-site first level service  
OEM Software



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[burkleamerica.com](http://burkleamerica.com)

## Backward Thinking

Many people have it backward, which is the fundamental reason they fail. They believe that if the cause is good enough, people will automatically buy-in and follow. But it doesn't work that way. People don't follow worthy causes; they follow worthy leaders. People buy into the leader first, then the leader's vision.

With apologies to my good buddy Kevin Costner, "If we build it, they will come" doesn't transfer well to leadership. Look at some of the leaders you admire and aspire to be like, then look at who follows them (Facebook definitely doesn't count). I would bet a boatload of beer that the folks on your list inspired their followers way before they bought into their vision. In fact, I would double-down and bet that they could do a 180-degree pivot in their vision and wouldn't lose a single follower because

people believe in the leader first, and the vision second.

Follow these guidelines and the Laws of the Picture and Buy-in, 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. My high school buddy Bert said it best when he famously commented:

*"Setting an example is not the main means of influencing others, it is the only means."*

—Albert Einstein PCB007



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

contact Williams, [click here](#).

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## Additive Reality

# A Report From 2021 (Drop)tronica



by Luca Gautero

After months of social distancing, productronica brought people and ideas together in a single place. Its most pragmatic demonstrations were the tools on the floor of the B3 Halle at the München Messe. The fair had representations for almost all equipment needed for PCB manufacturing and inspection. Three of these tools were solder mask inkjet printers from different brands, as was the case in 2019—a sign that business has continued, albeit at a slow pace, through the pandemic period. However, this year there was another vibe, this time about additive manufacturing. At the entrance, an animation on a giant screen showed how a company is delivering a bottom-up approach for PCB prototyping—an inspiring manufacturing frontier on display at the doors.

This was a good start, although the real positive vibe about inkjet came from the many discussions with interested companies, technological partners,

and competitors. From the companies, we learned that the production pressure of the past few months is good for business even though it leaves little room to put attention on future technologies. From the technological network, we learned that, even if the attention was limited, inkjet was the hottest discussion topic for the week. Even technology suppliers that have ground in solder mask, both traditional and additive, reported this overwhelming enthusiasm for the inkjet option.

When we had a discussion at our booth, we asked for a business card and entered that information on a sheet. These entries helped to organize follow-up discussions, in agreement with GDPR laws. However, an interesting perspective emerged when looking at them in an aggregated manner. What emerged were expansions and green field operations. All these plans had one contingency in mind: securing a PCB board supply in Europe. It's easy to look at recent events, such as trade wars, the Suez Canal obstruction, and the pandemic, but in my view, these are linear events.

To read the rest of the column, [click here](#).

# Why Choose Fein-Line?

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

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

Fein-Line Associates specializes in:

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

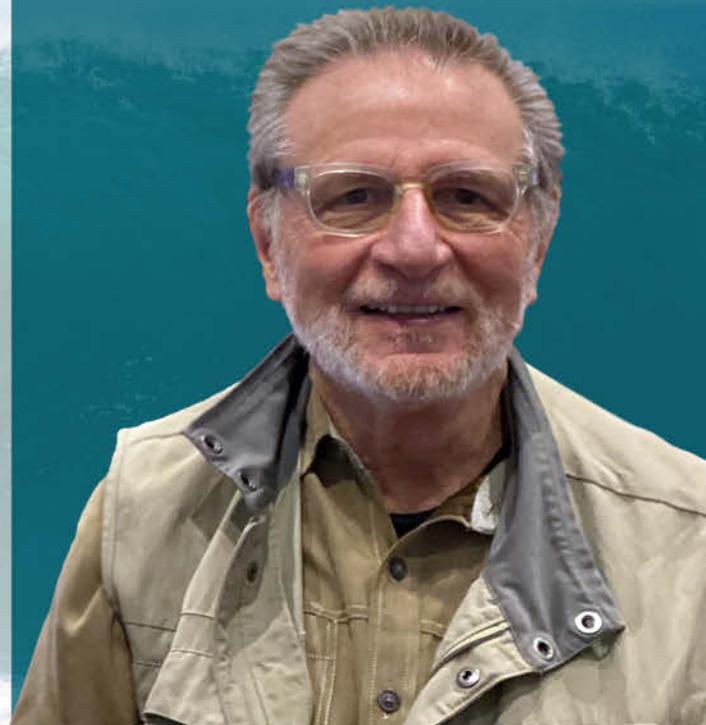
**Fein-Line Associates**

P.O. Box 73355

San Clemente, CA 92673

Telephone: (949) 498-7866

Email: [baer@feinline.com](mailto:baer@feinline.com)



Dan (Baer) Feinberg



[www.feinline.com](http://www.feinline.com)



Pete Starkey

## EIPC Technical Snapshot Review: Semi-additive Processes

The development of ultra-high-density PCBs and packaging substrates using semi-additive and additive manufacturing processes was the theme of the 13th Technical Snapshot webinar presented by EIPC on November 24. It was introduced and moderated by technical director Tarja Rapala-Virtanen. Daniel Schulze, application engineering manager at Dyconex in Switzerland, explained that with their long-established capabilities in ultra-high-density PCBs in flex, rigid-flex and rigid multilayer technologies, it was logical for Dyconex to apply their expertise to the development of specialist IC substrates.

## Innovative Circuits Inc. Chooses atg Flying Probe Technology for High-speed Electrical Test



atg Luther & Maelzer GmbH confirms the order for high-speed

bare board testing technology in Innovative Circuits.

## The Mission of the New Printed Circuit Board Association of America

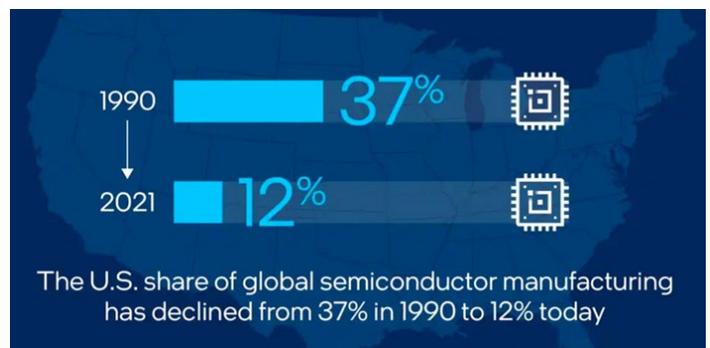
Barry Matties recently met with Travis Kelly to discuss the formation of the Printed Circuit Board Association of America (PCBAA), a consortium of U.S.-based companies he chairs to support U.S. domestic production of PCBs. PCBAA was established on three pillars, and Travis explains how they intertwine with each other—and with other similar organizations in the industry.



Travis Kelly

## Fein-Lines: Who Will Maintain Control of Global Chip Manufacturing?

Will the U.S. gain back significant share of global chip manufacturing or continue to decline and become less relevant in this critical area? Back in 1990, the U.S. dominated the world in its use of chips, with about 40% of the total global production made in the United States. That number was down from its peak, but it was still significant. Much has changed in 30 years. Today the U.S. supplies approximately 12% of the global chip market, even though U.S.-based companies use a much higher percentage of the chips.



## Insulectro Passionate About Educational Programs

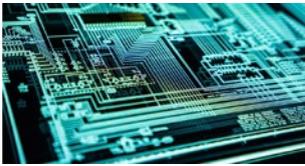
Ken Parent, Chris Hunrath, and Michelle Walsh discuss their educational and training vision, programs that they are bringing to the industry, and why. There's a gap, they say, in the talent pool from entry level to engineers. "There's a huge demand now," says Chris Hunrath. "The quicker we can fill that gap and train new people, the more PCBs can be built and more of the new products and technology will be accepted into the industry."



## American Standard Circuits Adds Ormet Paste Capability

West Chicago-based PCB fabricator American Standard Circuits has recently incorporated the Ormet Paste Process to their capabilities, enabling next generation z-axis interconnects.

## Test and Inspection: Far Beyond Opens and Shorts



Gardien Vice President Todd Kolmodin talks about test and inspection market drivers from his perspective as a test service provider. Andy Shaughnessy and Happy Holden go down the "microvia rabbit hole" with Todd, as well as explore how OEM design requirements are driving test and inspection functionality and processes.

## Punching Out! Year-End Preparation for Selling a Business

Here are some items that every business owner should review on an annual basis. The year-end is a good time to remind your CPA to clean up income statement and balance sheet items that are no longer relevant. If the company has only internal financials, have the CPA do a compilation.



## Alun Morgan's productronica Slide Show



Alun Morgan

I-Connect007 has been bringing you interviews with a variety of technologists who attended productronica 2021 in Munich, Germany. As part of our continuing coverage of this event, we present this exclusive slide show of photos taken by our good friend Alun Morgan, technology ambassador for Ventec International Group.

## Altix Discusses Trends in U.S., European and Asian Markets

In this interview with European Editor Pete Starkey, Altix President Jerome Van Straaten, and Sales and Marketing Director Frederic Baradel discuss their strategies for addressing customers in the U.S. Europe, and Asia, as well as the trends they're seeing in technology around the globe.

For the latest news and information, visit [PCB007.com](http://PCB007.com)

# Career Opportunities



## Is your team growing?

**Find industry-experienced candidates at I-Connect007.**

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

In addition, your ad will:

- be featured in at least one of our newsletters
- appear on our [jobConnect007.com](http://jobConnect007.com) board, which is promoted in every newsletter
- appear in our monthly [Careers Guide](#), emailed to 26,000 potential candidates

Potential candidates can click on your ad and submit a resume directly to the email address you provide, or be directed to the URL of your choice.

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GOOD FOR THE INDUSTRY



# Career Opportunities



## 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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MACHINES FOR PRINTED CIRCUIT BOARDS

## Field Service Engineer Location: West Coast, Midwest

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.**

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# Career Opportunities



## 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](mailto:shawn.arbid@omron.com)

[apply now](#)



## 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.

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# Career Opportunities



## Galvanic Systems Director

Whelen Engineering Co. seeks FT Galvanic Systems Dir. in Charlestown, NH to lead technical team to optimize GreenSource Fabrication, LLC Division's first-gen equip. by applying PCB mfg. concepts per cust reqs. Ensure process engg. meets co.'s needs; develop and validate process changes; plans to improve process capability using statistical & root cause analysis & eval'ing equip, including Atotech equip, thru design of exper & testing; travel int'lly 15-25% to eval biz plan & strategy to markets. Min reqs: U.S. Bach degree or foreign equiv. in chem sci or chem engg; knwl of entire PCB mfg. process, including process flows, indiv. processing steps, & tooling, w. knowledge of PCB pattern plating, including subtractive etching processes, additive processes, and printable techs as demo'd by 12 yrs' exp. in PCB industry; Theoretical knwl of PCB Plating Processes, including MLB, HDI, and SLP-type PCB fab processes, as demo'd by 10 yrs' exp w. PCB plating processes; 5 yrs' exp working w. Atotech Equipment prod lines & their specialty chems; Prior work exp in R&D enviro. including app of lab analysis concepts and knowledge of cross section and wave form patterns.

Apply to: Corinne Tuthill,  
ctuthill@greensourcefab.com or at  
GreenSource Fabrication, LLC,  
99 Ceda Rd, Charlestown, NH 03603

apply now



## Service Engineer Schmoll Laser and Direct Imaging

Reports to: Field Service Manager  
Location: North America

### SUMMARY:

Provide expert-level service on multiple laser drilling and direct imaging product lines. Maintain high customer satisfaction, timeliness, accuracy, efficiency, cost effectiveness, and safety.

### DUTIES AND RESPONSIBILITIES:

- Install, commission, and maintain Schmoll products at customer sites. Perform modifications and retrofits as needed.
- Troubleshoot, diagnose, and calibrate products via telephone or at customer sites.
- Handle a wide variety of problems, issues, and inquiries.
- Provide training for customers and others in the effective operation, calibration, and maintenance of all products.
- Lead the project management team for retrofit/upgrade requests and recommendations for Schmoll equipment until the end of commissioning and final payment.
- Assist customers with potential optimization of their machine operations and work with clients on application improvements.

### QUALIFICATIONS:

- Must possess a valid driver's license, clean driving record, major credit card (for business travel), and passport.
- Ability to read and interpret technical documentation, compile reports, and compose routine correspondence, define problems, collect data, and draw a valid solution.
- Must be able to travel extensively, partly international, to support customer needs. While Burkle makes every attempt to avoid Sunday and Friday evening travel, sometimes it is required.

apply now

# Career Opportunities



## 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.

apply now



## Sales Manager New Business Development (m/w/d) – Sales Territory: Germany

CML Group is a global leader in the Printed Circuit Board industry, specialized in PCB manufacturing and sustainable PCB supply solutions. Our products are made to the highest quality and reliability standards, including automotive requirements.

For the expansion of our target markets, we need you to generate new business, drive new projects from RFQ stage and manage the customer relationship.

### Your responsibilities:

- Develop new customers and build long-term customer relationships
- Understand the customer requirements and acquire new contract enquiries from all market sectors
- Proactive market and customer research
- Identify new potential electronic industry sectors
- Result-oriented sales management including support and consulting on new projects
- Independent management and organization of your accounts
- Price and contract negotiations with customers and contractual partners

### Your profile:

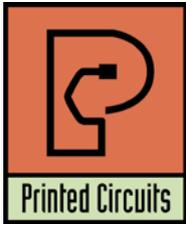
- Several years of professional experience in sales and key account management
- Knowledge of printed circuit board production/industry would be an advantage
- Fluent in Business English and willingness to travel internationally
- Flexible and an open-minded mentality
- Strong communication skills, team player
- Self-motivated, well-organized, professional
- Your home base is in Germany

Interested? Looking forward to your application!  
Please send your application to [hr@cmit.support](mailto:hr@cmit.support)

For more information visit  
[www.cml-globalsolutions.com](http://www.cml-globalsolutions.com)

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# 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 3<sup>rd</sup> 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

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# Career Opportunities



## 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.

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**ventec**  
INTERNATIONAL GROUP  
騰輝電子

## Customer Service Representative, UK

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

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

### Skills and abilities required for the role:

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

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

### What's on Offer:

- Excellent salary & benefits commensurate with experience

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

Please forward your resume to [HR@ventec-europe.com](mailto:HR@ventec-europe.com)

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# Career Opportunities



Fuji America Corporation is a rapidly growing electronics assembly equipment distributor. We support the factories of the future and smart factories globally. We offer an exciting and challenging career for a software support engineer and an applications engineer who want to join our growing company.

## Software Support Engineer

As a software support engineer for Fuji America Corporation, you will be a customer-facing technical advisor with the opportunity to solve technically complex problems for our proprietary software. As a trusted advisor to our customers, you will have influence over a broad range of solutions that create business value. As a valued member on our team, the software support engineer will use advanced troubleshooting methods and tools to solve technically complex problems. These highly complex, escalated problems require broad and in-depth product knowledge, as well as exceptional troubleshooting skills.

- Field installation of proprietary software/ automation equipment throughout North America
- Field troubleshoot, repair, training, and process support of proprietary software
- Provide remote and on-site technical support
- Troubleshoot Windows 10/Windows server installing, configuration, and support
- Networking experience—setting up and supporting networks.
- Exposure and/or experience with Oracle or Microsoft SQL server databases
- Strong verbal communication skills with both customer and other technical depts.
- Flexibility to travel and perform job assignments on short notice
- Strong aptitude with current computing applications and networking processes

### Experience

- Bachelor of Science in computer science or related field preferred

## Applications Engineer

As an applications engineer, you will be responsible for doing cycle time and studies in preparation to make recommendations of Fuji products for customers' applications. Support implementation of activities within the technical center such as customer visits, demonstrations, evaluations, testing, inspection of Fuji products, including peripheral equipment from other vendors.

- Assist sales representatives in technical aspects relating to machine and software functions and utilization.
- Assist sales representatives and customers with providing CTA (Cycle Time Analysis) to them for recommending Fuji products to customers' specific applications. This includes the sFAB machine as well as all other SMT machines.
- Schedule and perform product demonstrations on all available types of equipment and software to potential and existing customers.
- Test and evaluate existing as well as new technologies on equipment and software performance and reliability.
- Assist in the coordination of any new FAC projects by utilizing your full potential.
- Responsible for the setup of the equipment and its demonstration for various trade shows.
- Assist FAC staff in any technical issues which may require attention.
- Assist in the coordination of design and manufacture of customs tooling for placement equipment.
- Perform inventory checks every six months according to the schedule and manner regulated by the company, if applicable.

### Experience

- Minimum five years programming/computer experience
- Bachelor's degree preferred

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# Career Opportunities



## 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.

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## Test Engineer (TE-MD)

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

- Candidates must have at least three years of experience with in-circuit test equipment. A candidate would develop and debug our test systems and install in-circuit test sets remotely online or at customer's manufactur-

ing 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.

[apply now](#)

## 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.

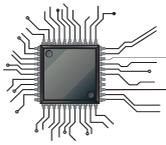
Contact us today to learn about the rewarding careers we are offering. Please email resumes with a short message describing your relevant experience and any questions to [careers@ttci.com](mailto:careers@ttci.com). Please, no phone calls.

We proudly serve customers nationwide and around the world.

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# Career Opportunities



## MivaTek

Global

### Product Manager

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

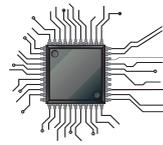
The product manager role will serve as liaison between the external market and the internal design team. Leadership level involvement in the direction of new and existing products will require a diverse skill set. Key role functions include:

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

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

For consideration, send your resume to [N.Hogan@MivaTek.Global](mailto:N.Hogan@MivaTek.Global). For more information on the company see [www.MivaTek.Global](http://www.MivaTek.Global) or [www.Mivatec.com](http://www.Mivatec.com).

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## 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](mailto:N.Hogan@MivaTek.Global) for consideration.

#### More About Us

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

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# Career Opportunities



## SMT Operator Hatboro, PA

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

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

### Duties and Responsibilities:

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

### Requirements and Qualifications:

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

### We Offer:

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

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## SMT Field Technician Hatboro, PA

Manncorp, a leader in the electronics assembly industry, is looking for an additional SMT Field Technician to join our existing East Coast team and install and support our wide array of SMT equipment.

### Duties and Responsibilities:

- Manage on-site equipment installation and customer training
- Provide post-installation service and support, including troubleshooting and diagnosing technical problems by phone, email, or on-site visit
- Assist with demonstrations of equipment to potential customers
- Build and maintain positive relationships with customers
- Participate in the ongoing development and improvement of both our machines and the customer experience we offer

### Requirements and Qualifications:

- Prior experience with SMT equipment, or equivalent technical degree
- Proven strong mechanical and electrical troubleshooting skills
- Proficiency in reading and verifying electrical, pneumatic, and mechanical schematics/drawings
- Travel and overnight stays
- Ability to arrange and schedule service trips

### We Offer:

- Health and dental insurance
- Retirement fund matching
- Continuing training as the industry develops

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# Career Opportunities



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

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

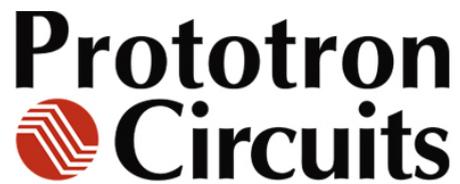
All interested candidates should contact Arlon's HR department at 909-987-9533 or email resumes to [careers.ranch@arlonemd.com](mailto:careers.ranch@arlonemd.com).

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](http://www.arlonemd.com)

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## 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](mailto:danbbeaulieu@aol.com)

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# Career Opportunities

## SIEMENS

### Siemens EDA Sr. Applications Engineer

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

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

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

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

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### Logistics Assistant

Koh Young America is looking for a Logistics Assistant to assist and oversee our supply chain operations. Working alongside a Logistics Specialist, you will coordinate processes to ensure smooth operations using a variety of channels to maximize efficiency. You must be an excellent communicator and negotiator well-versed in supply chain management principles and practices. Also, you should be meticulous with a focus on customer satisfaction. These attributes are ideally complemented by a Bachelor's in Supply Chain Management or equivalent professional experience in the manufacturing industry.

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

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

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# Career Opportunities



**BLACKFOX**

Premier Training & Certification

## IPC Instructor

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

*Independent contractor,  
possible full-time employment*

### Job Description

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

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

### Qualifications

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

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

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

Send resumes to Sharon Montana-Beard at  
[sharonm@blackfox.com](mailto:sharonm@blackfox.com).

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**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](mailto:mfariba@uscircuit.com)

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# Career Opportunities



**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.

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# 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.

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

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# Career Opportunities



**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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**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](http://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.

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## Latest I-007eBook

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

by Michael Gay, Isola

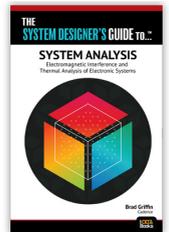
This book provides the reader with a clearer picture of what to know when selecting which material is most desirable for their upcoming products and a solid base for making material selection decisions.

**Get your copy now!**

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

by Brad Griffin, Cadence

In this book, the author focuses on EM and thermal analysis in the context of data center electronics systems. This title also has a **downloadable companion guide** for end-to-end solutions to today's design challenges.



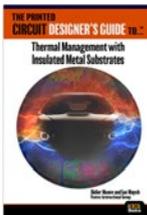
## I-007eBooks The Printed Circuit Designer's Guide to...



### **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

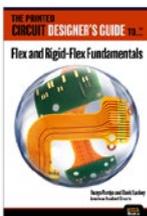
Considering thermal issues in the earliest stages of the design process is critical. This book highlights the need to dissipate heat from electronic devices.



### **Fundamentals of RF/Microwave PCBs**

by John Bushie and Anaya Vardya, American Standard Circuits

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



### **Flex and Rigid-Flex Fundamentals**

by Anaya Vardya and David Lackey, American Standard Circuits

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

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# PCB007

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