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MARCH 2021

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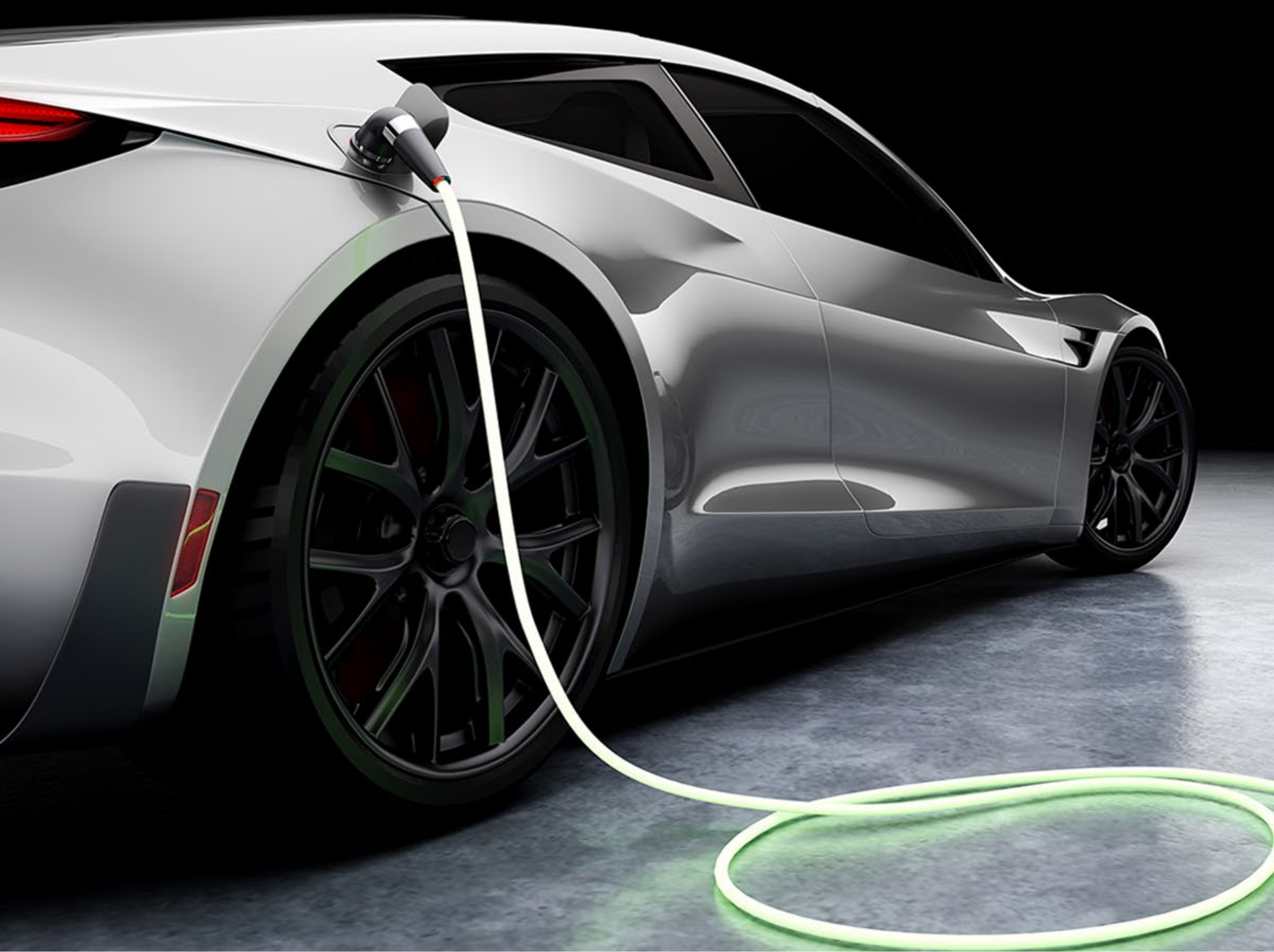

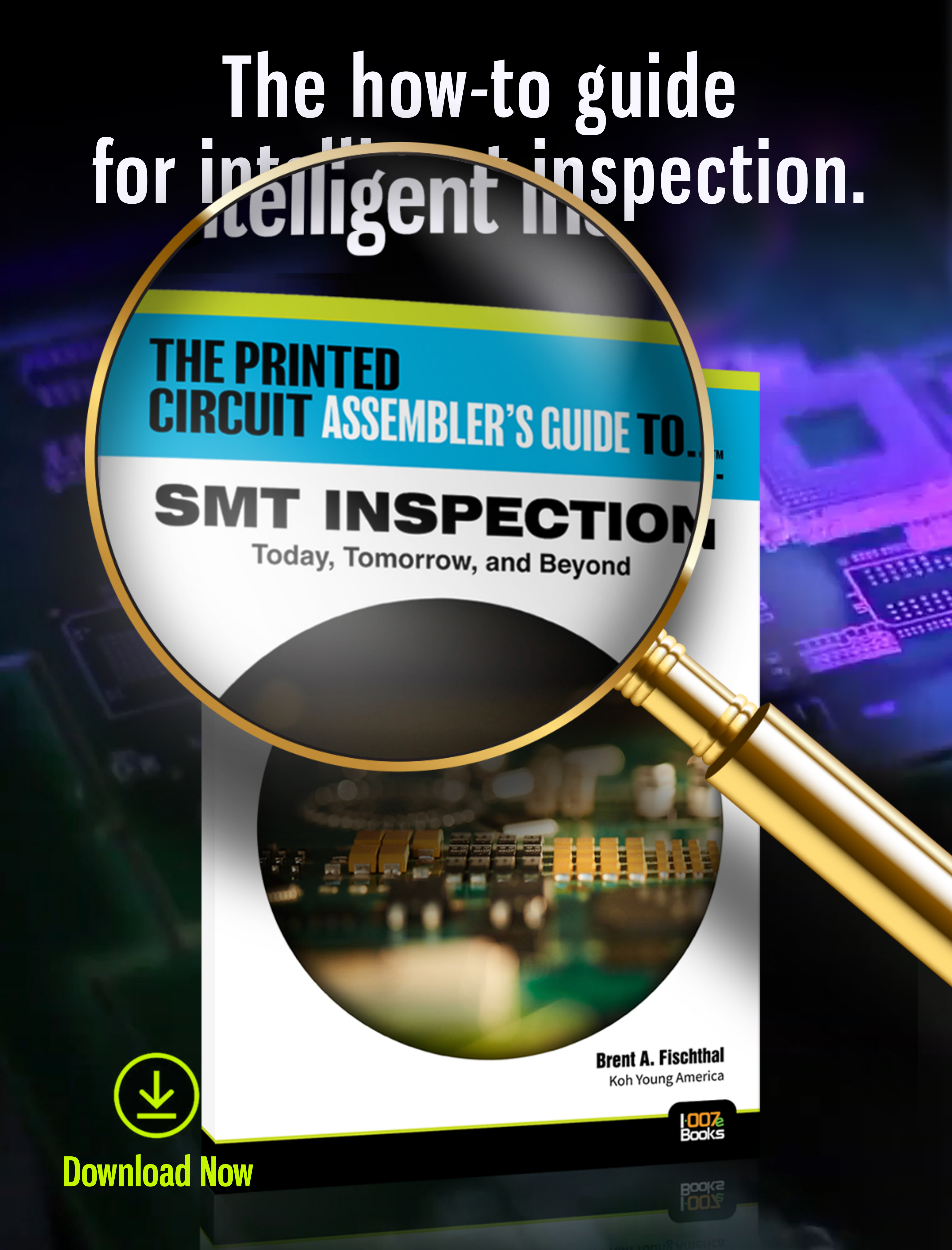
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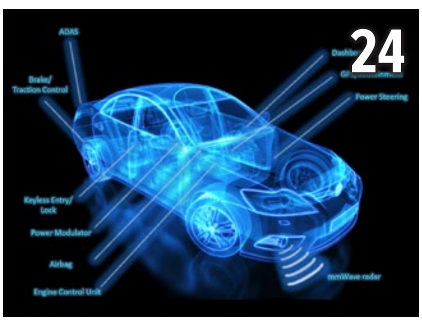
The Future of PCBs in Transportation

In this issue, we begin to map out the new landscape of transportation electronics. Transportation applications will be an active area of innovation in the coming years, as development continues in miniaturization, power management, environmental robustness and infrastructure. Strap in while we explore PCBs in transportation.

FEATURE ARTICLES

FEATURE ARTICLES



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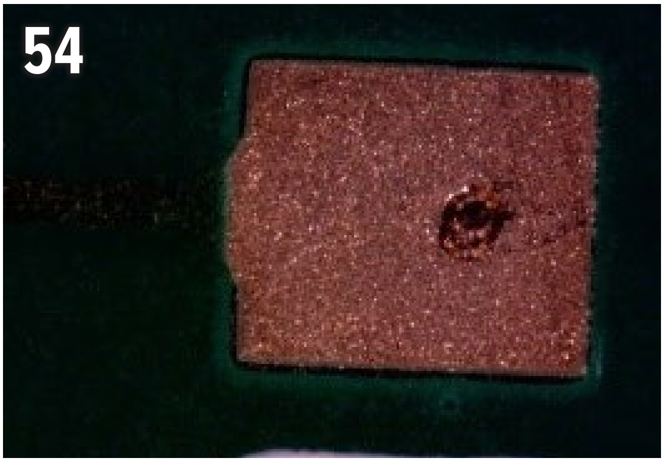

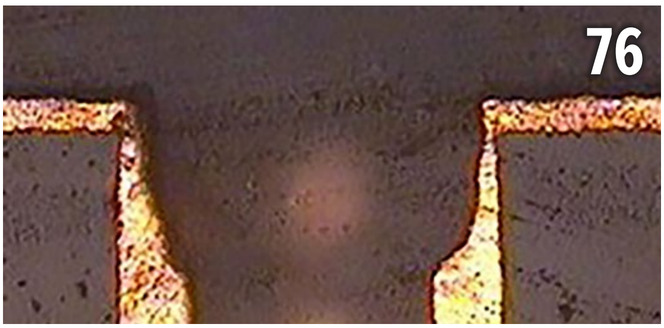

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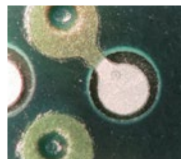


HIGHLIGHTS PCB007

DEPARTMENTS

Mapping the Future of PCBs in Transportation

Nolan's Notes

by Nolan Johnson, I-CONNECT007

Supply chain and automotive continue to be two of the hottest topics in electronics manufacturing (all of manufacturing, actually) in 2021. As I write this column, IPC APEX EXPO 2021 is just around the corner and automotive applications and requirements are woven throughout the technical program.

The news has been active as well. Not just industry news, but the mainstream news is regularly discussing these same topics. Here are some examples:

> ***The Washington Post,* February 24, 2021:**
> "The Biden administration will order a 100-day review of possible vulnerabilities in the U.S. supply chains." The article specifically calls out products central to our business: computer chips, medical gear, electric vehicle batteries and specialized minerals. The reporting attributes these shortages directly to recent automotive manufacturer shutdowns tied to these critical parts shortages. The Post wrote, "A review is just a review—no immediate consequences. It depends on what comes out of it,' said William Reinsch, who was a Commerce Department official during the Clinton administration." [1]

This review is strictly investigative, but the urgency is clear. The automotive industry is indeed experiencing "rolling brownouts" in production due to a lack of available semiconductor and electronics components. In December 2020 and continuing through February 2021, the news reported assembly plant furloughs at Tesla, Ford, and Volkswagen. These shutdowns were specifically blamed on the lack of chips in the supply chain.

And yet, vehicle development trends are only increasing transportation's appetite for semiconductors, components, connectors, boards, and conductive metals.

> **NASA, February 24, 2021:**
> In a recent press release from NASA, the U.S. space agency announced it is seeking proposals for "ground and flight demonstrations

of integrated megawatt-class powertrain systems for subsonic aircraft. The deadline for proposals for this solicitation is 5 p.m. EST April 20 [2021]. The demonstrations will help rapidly mature and transition integrated Electrified Aircraft Propulsion (EAP) technologies and associated EAP vision systems for introduction into the global fleet by 2035. Integrated EAP concepts are rapidly emerging as potentially transformative solutions to significantly improve the environmental sustainability of the next generation of subsonic transport vehicles. EAP electrical systems are being developed to replace or boost fuel-burning aircraft propulsion systems, analogous to how electric or hybrid motors are used in automobiles." [2]

I find it interesting that the vision is for an EAP solution by 2035. That's the same year that a number of global automakers plan to have 100% EV product portfolios.

Companies globally are gearing up to deliver electric vehicles. Citing multiple news releases recently regarding the partnership between Foxconn and Fisker, the two companies:

- Signed a memorandum of understanding to jointly develop a breakthrough new vehicle
- Will manufacture the vehicle at projected annual volumes of more than 250,000 units
- Announced a strategic shift in battery technology for Fisker vehicles that, Fisker claims, will extend range and overall usefulness of the electric vehicle
- Project the start of production to be Q4 2023; this will be the second vehicle introduced by the Fisker brand, following the launch of the Ocean SUV in Q4 2022

A Fisker official is quoted in news sources as saying, "The collaboration between our firms means that it will only take 24 months to produce the next Fisker vehicle—from research and development to production, reducing to half the traditional time required to bring a new vehicle to market." [3]

This statement ought to make us all sit up straight and pay attention, because the more our vehicles start to look like rolling computational platforms, the more automotive manufacturing will evolve to look like electronics manufacturing; right down to the nimble, short lead time product development. Auto makers will operate more like EMS companies, not the other way around. The lay of the land in our industry is going to change.

In this issue, we begin to map out the new landscape of transportation electronics. Undoubtedly, we will travel this way again in future issues, as there is much to explore. A key takeaway is that automotive applications will be an active area of innovation in the coming years, and that this innovation will change PCBs throughout the entire industry. As Ken Kesey said back in the 1960s, as his cohort drove their ancient school bus across the United States bound for Woodstock, "You're either on the bus or you're off the bus." Whether we choose to be on or off this development path ourselves, it will be important to keep, well, up to speed.

Finally, we continue our year of $X = X_c - 1$ continuous improvement. We are gathering your stories and successes in continuous improvement where you work. Contact us at editorial@iconnect007.com with your personal stories of reducing by one to effect improvements—we would love to hear from you. PCB007

References:

1. Biden Orders Sweeping Review of U.S. Supply Chain Weak Spots
2. NASA Takes Steps to Reduce Aviation Emissions, Invigorate U.S. Economy
3. Fisker, Foxconn Set to Collaborate on Electric Vehicle Project

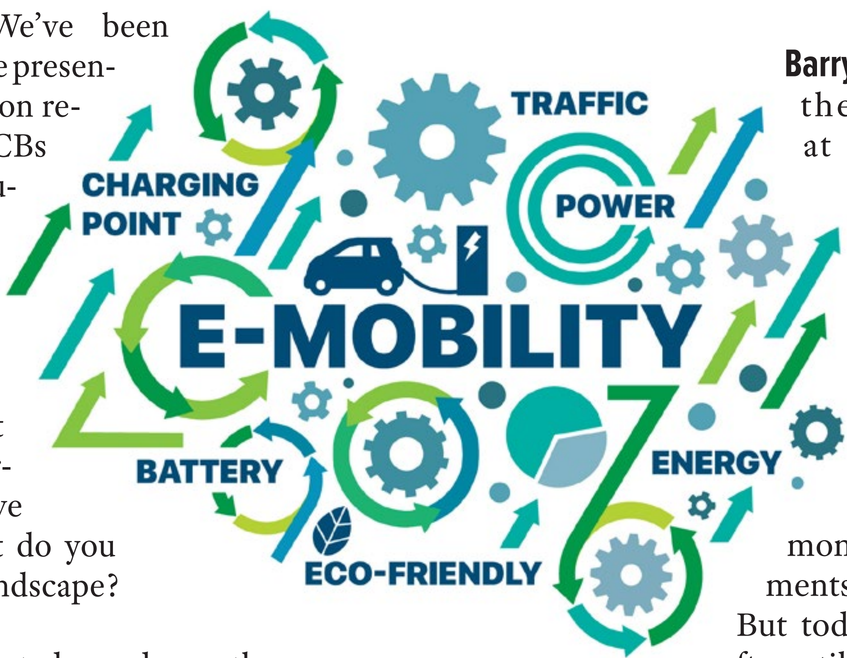
Nolan Johnson is managing editor of *PCB007 Magazine*. Nolan brings 30 years of career experience focused almost entirely on electronics design and manufacturing. To contact Johnson, click here.

PCB Requirements for E-Mobility

Feature Interview by the I-Connect007 Editorial Team

Nolan Johnson, Barry Matties, and Happy Holden speak with Christian Klein, section manager for PCBs in the automotive electronics division, about Bosch's recent presentation on PCB requirements of the future in regard to automotive and electro mobility trends and challenges.

Nolan Johnson: We've been looking through the presentation from Bosch on requirements for PCBs going on in the future, and there are quite a lot of requirements. How do you see the requirements for printed circuit board manufacturing for automotive playing out? What do you see as the future landscape?



Christian Klein: That depends on the area or on the use case. We have two big megatrends. One is electro mobility and the other one is connected cars. These megatrends require different technologies. For example, electro mobility needs substrates on which we can integrate power components at temperatures up to 160°C, perhaps even higher, as well as currents up to several hundred amps. Those are difficult requirements for these kinds of PCBs. On the other side, we have PCBs for computers. They are more like graphic cards or servers and are already used in the consumer industry, but not in the automotive environment. Therefore, we have to distinguish between these two use cases and with different requirements for the PCB. What is common is that they all need to survive the automotive environment.

Barry Matties: Since the presentation at the World Conference was looking at future requirements, are the requirements currently being met?

Klein: At the moment the requirements are being met. But today, electrical cars often still use power electronics based on ceramic substrates. For autonomous driving the requirements will increase. The new components need even more sophisticated HDI technology than before. Computers need a higher data rate; it is increasing every year. Therefore, we will be forced to use other materials in the future for the high-speed

electronics: very low loss or ultra-low loss materials with suitable Dk and Df values. These materials are normally a bit more brittle and not that robust regarding micro-cracks like the traditional materials. Taking into account the known failure modes like CAF or micro-cracks, this could be challenging.

In the automotive environment, temperature cycling and temperature storage are important parameters. But it is the humidity for which we have to be really careful. Vehicles have subsystems that are always on with low power consumption. There could be electrochemical migration in these systems. If you have to use these new materials due to the high-speed electronic requirements, then we have to be very careful. Therefore—at the moment—we have solutions, but for the next generation with bigger bandwidth and higher frequency, we have to go to other materials, and these have to be qualified.

Christian Klein

Matties: Are you looking at the cleaning standards and changing the requirements as you talk about the electrochemical migration?

Klein: Cleaning is always discussed because cleaning is quite difficult. The problem is that up to now nobody can offer the perfect cleaning solution. After assembly, some of the solder paste residuals could stay in small gaps below the QFPs and other components. That is very difficult to clean perfectly. Regarding the bare PCB itself we do not really see a problem. What is still on the board after the PCB production will evaporate during first reflow. Thereafter, it depends on the use case. If a designer makes the housing of the PCB quite tight and uses a pressure compensation element, the warm and humid air does not get directly onto the PCB itself, and dewing can be avoided. Therefore, we must be really careful in designing our units that dewing of water will not happen. Cleaning has not been a big topic because we use a specific design of our control units to avoid this dewing.

Matties: When you're designing the actual circuit board? You're taking that into consideration?

Klein: Yes, by designing the circuit board and the housing concept. More important than the board itself is the housing. It could be in the future that we have to use some fans to cool the electronics from the outside. That will change the game. Then we will need protection methods, specific components or a protective coating on the PCB. But up to now, we try to avoid this by designing a proper housing of the electronics.

Happy Holden: Which is going to be the bigger challenge in the future: Finding the right materials that have the appropriate cost levels, or finding the right fabricators that can consistently produce quality products if they can get those materials?

Klein: That is a very interesting question because the automotive market is under a great deal of cost pressure. We have to be careful selecting technologies that can be produced at a cost level so that customers will buy it. On the other hand, the solutions have to be very robust, therefore we cannot always use sophisticated cutting-edge technology.

As for materials and suppliers, you must have the right PCB supplier who can handle different materials. With the PCB suppliers we discuss together which kind of material will meet the requirements.

For example, referring to the two use cases: One of which is a very high temperature for power electronics. If you want to assemble a silicon carbide device on PCB and want to run it at 160°C or higher, then you need specific PCB materials; you cannot use the standard FR-4 materials.

If you use a high-frequency computer in your car, then you need low Df materials for low loss. These materials are on the market, but until now, they were not fully qualified for automotive. We are looking into these materials together with the base material suppliers and reviewing our findings together with our PCB suppliers. As you see, we do the material choice together with our supply chain.

Holden: My last job before retiring was with Gentex, a very large automotive supplier. And matching the quality requirements of BMW, Audi, Mercedes, Toyota, and Nissan—it's much tougher than the military market in terms of the focus on quality. And yet it also has to be low cost. In the military market, with the high quality also goes high prices, but automotive is high volume. I once got a call to work on the F-22 fighter and I asked them, "Why are you calling me? I don't work with military HDI boards." They said, "No, we've heard and seen your papers on automotive HDI. We're going to base the F-22 on automotive requirements and quality, not military." I said, "Okay, if your focus is using automotive quality, then I can help out."

Klein: I have heard about that. Automotive often has the most severe requirements in the market, due to a long lifetime and the different environmental conditions, including temperature and humidity. Imagine, especially in the Far East, the conditions there in a parking lot. The most important concern is temperature cycling, temperature storage, and humidity.

Matties: Interesting. When you're looking for a PCB supplier, what is most important to you?

Klein: Most important is that the PCB supplier can deliver the technology at the required quality at a reasonable cost level. The long-term strategy between Bosch and the supplier has to fit. Due to the long product life cycle in automotive the suppliers have to work with us together for several years. From a technology point of view, PCB suppliers have to be excellent in quality, processes, and long-term stability. They must have excellent quality measuring tools, their whole processes have to be really well developed and documented, so that we can trust in them and that we will get the same quality today, next year, or in five years. This longevity is a reason we do not go into the most sophisticated technologies. We need a robust technology, which is cost efficient and very powerful.

We need a robust technology, which is cost efficient and very powerful.

Johnson: Christian, it would seem to me that materials and techniques are adequate but not ideal. Is that a fair summary?

Klein: I would say at the moment the materials are okay, but we are facing a lot of technology changes during these next years. Nobody really can evaluate what comes next because the technology change is so fast. We have a game-changer in e-mobility, and we have a game-changer in the servers, the automated driving car. My expectation is that in the near future the current materials will have problems. For power electronics, it's a bit more difficult than for the servers because high-temperature materials for up to 1000V are not used frequently in the automotive environment. This is special of the automotive market. Already existing materials could meet the requirement. There was some development recently, but the qualification is still ongoing.

There was some development recently, but the qualification is still ongoing.

Johnson: Do you see the biggest challenges in material selection on the electronics sensor infotainment side, or is it more challenging on the battery management drivetrain side of the vehicles?

Klein: My personal feeling is that on the computer side, there are a lot of others in the industry. There are materials available now that we can select which fit the automotive requirements regarding THB requirements, CAF and temperature cycling, and temperature storage. I think the more severe boundary conditions are with the power devices as described before. And what is new in the automotive business is to minimize the box volume for power electronics. One large fabricator said, "The one who can deliver this robust high voltage material will win the game." The reason is not only the smaller box volume but as well the lower inductive losses. You can use the energy from the battery in a better way, with less switching losses.

Johnson: How much of a role does Bosch play coordinating with materials manufacturers to develop the right kind of materials?

Klein: We cooperate not only with our PCB manufacturer but as well with the base material suppliers, doing joint qualifications and giving significant input for the development of new materials, which is their know-how and specialty.

Johnson: Christian, do you have much exposure to the infrastructure side? We've talked about what's on the vehicle, and I know that is a primary focus for Bosch but getting the electricity to the vehicles is a critical part of the ecosystem. Is that something that you have any insight into?

Klein: I personally have no direct insight in this. The electrical infrastructure itself is a business with slightly other technology than in the automotive industry. Of course, I had some interchange of opinion with this industry like train suppliers. However, they use a completely different manufacturing philosophy. The assembly often is not fully automated, and the box volumes are much bigger.

Johnson: I'm seeing in the news that major automotive companies, manufacturers here in the U.S. as well as across the globe, are starting to make commitments like, "All-electric vehicles by 2035." In your opinion, is this achievable?

Klein: At Bosch, we strongly believe in the potential of electro mobility. We've invested 5 billion euros in electrical powertrains and will invest 700 million euros this year. Currently, our powertrain electrification business is growing twice as fast as the market. At the same time, we are fast-tracking electrification, and further refining conventional powertrains. The goal is to ensure that the mobility of the future capably limits environmental impact while remaining affordable for the general public.

Matties: The big issue is the recharge cycle time, right? You can pull into a fuel station and fill up your car in about three or four minutes, but for me to fully charge my e-bike, it takes seven hours.

Klein: Yes. I agree the charging times are essential and here big progress was made. The essential point is that the infrastructure for these charging stations has to be provided. Here in Germany at the moment, hybrid cars are very popular because they combine the electrical drive in the city and the conventional combustion drive—in the future perhaps with synthetic fuels—on the highway. We at Bosch are applying IoT principles to this challenge with solutions like Battery in the Cloud to help improve performance and service life.

The essential point is that the infrastructure for these charging stations has to be provided.

Matties: You were mentioning synthetic fuel, what's the reality of that, do you think?

Klein: Achieving climate targets calls for more than electro mobility. Bosch is committed to the use of renewable and synthetic fuels so that the existing vehicle fleet can also make a significant contribution to reducing CO_2. The secret lies in synthetic, or carbon-neutral, fuels, whose manufacturing process captures CO_2. The greenhouse gas thus becomes a raw material and can be used to produce gasoline, diesel, or gas with the help of renewably generated electricity.

Matties: Are you manufacturing your own batteries as well under your brand?

Klein: For Bosch, it's important to have a technical understanding of cells. However, in-house cell manufacturing is not decisive for our success in the field of electro mobility. Bosch is relying on its systems expertise and the development and manufacture of key components of the electrical powertrain, such as the electric motor, power electronics, and battery systems.

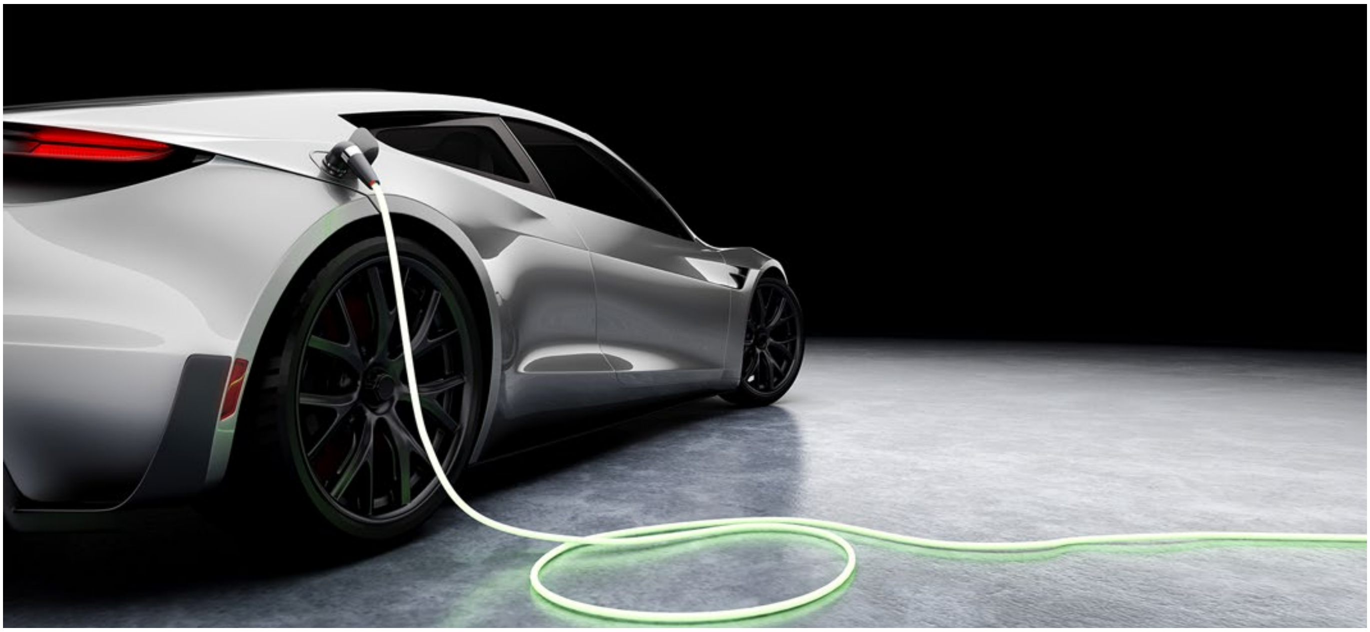
Johnson: Christian, is there anything technically that concerns you as an engineer in the automotive and transportation space?

Klein: From a quality point of view the biggest challenge is the high voltage in combination with humidity in the cars as this can happen in a tropic climate. We really have to avoid malfunctioning or creeping currents. We have to think about electronics as a system because the PCB will not solve it by itself. As an example, we have to be very careful in combining fine pitch components like QFP04 with high voltages on neighboring pins. The electrochemical interaction between other materials is a relevant factor as well. We need these materials as thermal interface for cooling the electronics. We see new high voltage effects at high humidity. Perhaps you know the standard 85°C/85 relative humidity test. It is not really field relevant, but it is used in the market as an indicator test. If we combine this test with 1,000 volts, sometimes we see new effects and we have to avoid them. This will be one of the biggest challenges in e-mobility.

Johnson: Great. Thank you, Christian. This has been very informative.

Matties: Thank you so much, Christian.

Klein: Thank you for the interesting talk. PCB007



The Future Is Electric

Feature Article by KJ McCann and Brian Zirlin
AURORA CIRCUITS

Worldwide research and development of the automotive industry began as early as the 17th century and since then has taken several different design paths, with each country forging its own innovative trail and hundreds of prototypes emerging into the market. Vehicles—with steam-powered, electric, and combustion engines—began to play a major role, not only in the Industrial Revolution, but in everyday life. Although many believe that electric vehicles (EVs) are relatively new to the market, they have actually been around since 1832. Unfortunately, for the environment at least, gasoline-powered vehicles won the race as mass production, automatic starters, and cheaper oil prices gave them the upper hand. So, where did the major innovation for EVs truly begin?

While gasoline-powered engines emerged as the leading design, they were not without fault. For that reason, General Motors released its first electric car in 1996—the EV1—however, the push to bring this car to market was feeble, resulting in unfavorable outcomes. EV1s were sold solely through "limited lease-only agreements," and only to residents of Los Angeles (California). The scant supply resulted in GM's very selective and restrictive consumer bias. These cars often landed in the hands of the elite, making the idea of owning an EV unattainable to the average consumer. Ultimately, GM decided that electric cars were an unprofitable niche of the automobile market; this resulted in the company buying back and crushing most of its electric cars. The undoing of this product line led to an industry pullback from EVs as whole.

As years went by, automotive manufacturers failed to automate and mass produce, and the product line continued its downfall. The pushback on electric vehicles continued as the Bush Administration proposed $1.2 billion in research funding to develop clean, hydrogen-powered automobiles. The federal government joined the oil and car industry to push hydrogen fuel cell vehicles, knocking EVs a decade further away. Despite the strong pushback from car manufacturers to switch to EVs, Toyota moved forward, releasing its completely alpha

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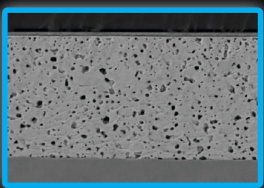

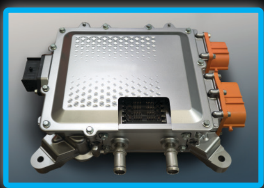

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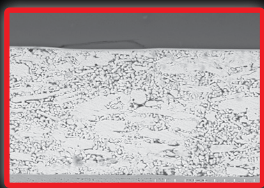

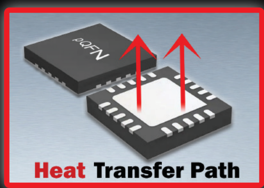

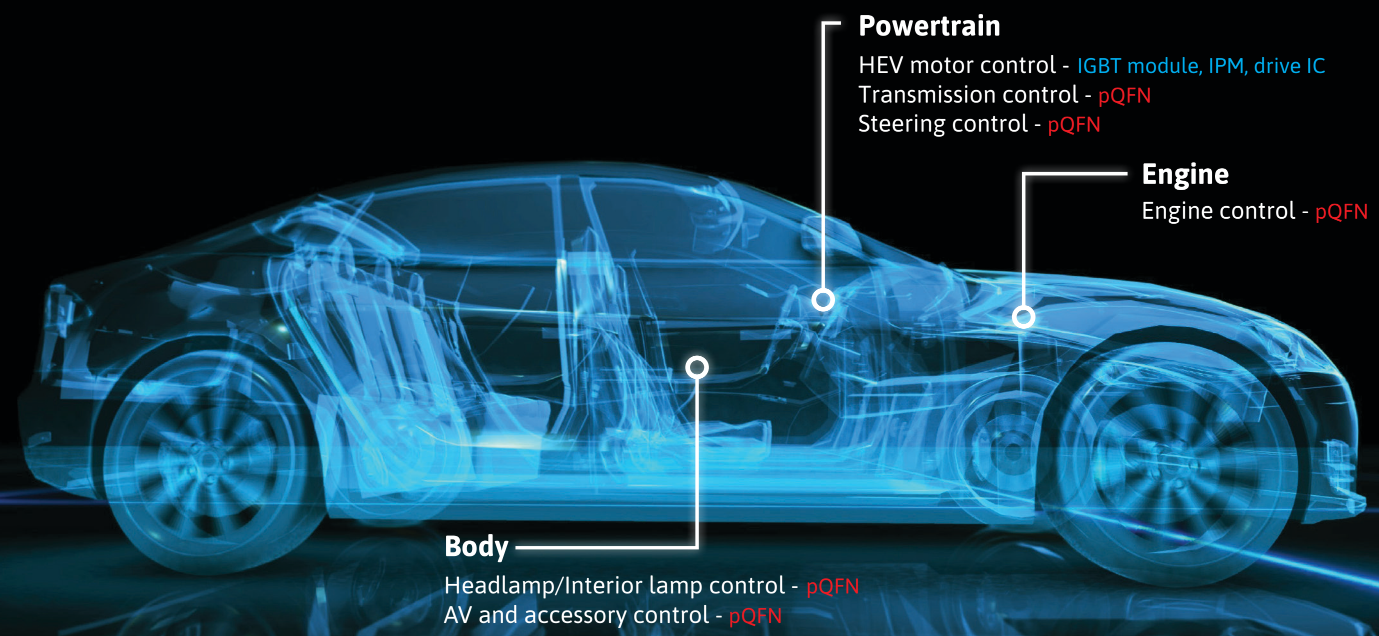

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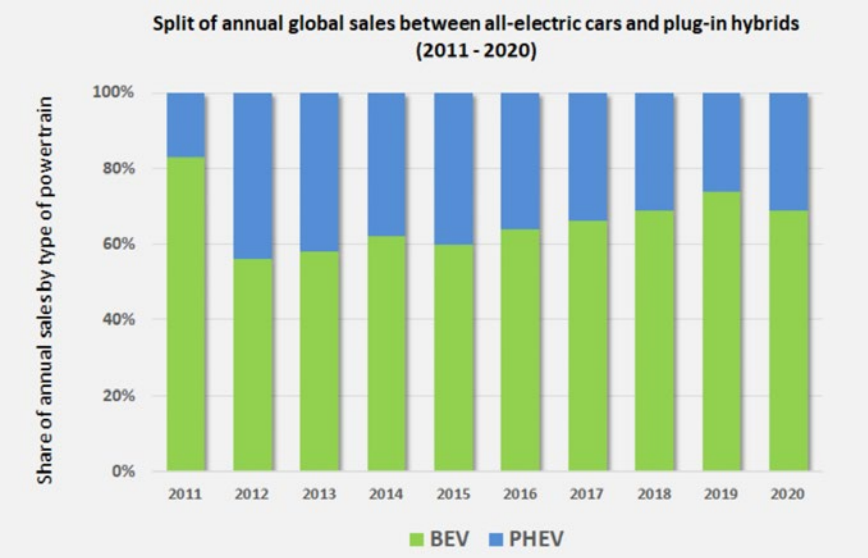

Evolution of the ratio between global sales of battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) between 2011 and 2020. (Source: Mariordo, Wikimedia)

redesigned Prius in 2003. Finally, the consumer demand for EVs met market expectations. Consumer sales surpassed monthly sales targets more than 100%. But again, these vehicles were driven by the elite and high society celebrities. In 2006, Tesla Motors, a mere startup company from Silicon Valley, promised to deliver a vehicle with the luxury feel of a sports car, combined with a range of 200+ miles. In 2008, that dream became reality when Elon Musk, chairman of Tesla, debuted the first Tesla Roadster. This sent shock waves through the automaker industry as consumers flocked to EVs in greater numbers than expected.

As a result, the automotive industry's heavy hitters transformed their businesses and began investing billions of R&D dollars into the future of electric vehicles. Sales skyrocketed from 450,000 units sold in 2015 to 2.1 million in 2019. Although these rates dropped in 2020 due to COVID-19, current projections continue to show an exponential increase in sales as energy density improves, EV infrastructure increases, and battery prices fall. So where has the industry gone and how do we continue innovation? The answer is short and sweet: mass consumption.

Is Mass Consumption Possible? What Will It Take?

As history has proven, there comes a time when innovative technology reaches a pinnacle. It is generally assumed that EVs are on the path toward market dominance, and with that, mass consumption must ensue. According to recent surveys, it is estimated that the mass consumer conversion for purchasing an EV would be $36,000. That being said, three of the best-selling EV base models are essentially there already. So, if price is not holding sales back, what is? Consumer research shows effective travel range must be considered; for the average consumer to consider an EV purchase, the battery power must last roughly 300 miles. So, if battery charge is limiting the range ability of these vehicles, why not just develop a bigger battery? Of course, it's possible, but inevitably the cost of that battery would increase the cost of the vehicle, again slowing down mass consumption. Cost and range are closely linked, as the battery is directly related to the largest cost of the car.

Let's look at an example. In 2013, the average cost of a base model Tesla 3 battery was roughly $23,000—two-thirds the price of the vehicle. Now, with current battery technology advancements, the same battery pack costs $7,000. Industry experts project that in less than two years, the cost of most EV batteries for base models will be down to nearly $5,000. This will drastically reduce the cost of EVs as a whole.

But the question remains: What is keeping consumers from buying electric vehicles? The research shows that consumers are, first and foremost, concerned about charging.

Availability of Chargers

Market research suggests the average EV requires a minimum of 30 minutes to charge from zero to full. Tesla Model 3 has the fastest charge on the market, but it only achieves an 83% charge within the desired 30-minute threshold. This research has led many industry experts to conclude that the largest barrier to mass market EV adoption is, in fact, the charging problem. Mass consumption simply will not happen until widespread fast charging is easily accessible, but therein lies the problem: the current design of the domestic electrical grid.

In the 1880s, Thomas Edison invented the direct current electric system (DC). At roughly the same time, George Westinghouse invented his form of an alternating current (AC) electric system. It is important to note that AC is the standard for power grids but there are technologies that require DC power. And, as you've probably surmised, batteries cannot be charged with AC power. They require a high-power inverter that can take AC power from the grid and convert it to DC for charging the EV batteries.

Just as there was a format war with AC vs. DC power back in the 1880s, a battle now rages with the formatting and standardization of charging stations. As more prototypes emerge onto the market, the lack of consistency and standardization with AC/DC converters continues to cripple mass consumption. In the United States, there are no government incentives or guidelines that unify the standardization of EV charging. However, the European Union has set up regulations that unify all charging stations (CCS plugs are legally required at every charging station). In doing so, they have highly increased the likelihood of widespread adoption of EVs as consumers can charge at any nearby station. Pressure is building to charge fast, turn over charging spaces, and standardize the cost to consumers. As EV production moves forward, it calls for standardization to increase adoption velocity in the U.S.

The obstacle to widespread adoption is known, but data suggests that while the average American lives five minutes from the local gas station, that same individual is reported to live 30 minutes away from the nearest supercharging station. Currently, there are 980 supercharging stations in the United States. Taking Tesla as our prime example, to match the five-minute average of gas stations, nearly 31,000 supercharging stations at their current cost of roughly $250,000 each, would be needed (equaling a $7.8 billion price tag). According to the Wall Street Journal, in 2020 Tesla Motors sold 499,550 units in the U.S., reporting only $721 million in income on about $31.5 billion in sales. Obviously, this is not a feasible business model. It goes without saying, "You need the infrastructure to sell the cars, but you can't sell the cars without the infrastructure." As more questions arise, manufacturers have begun to break down the design process, all the way to printed circuit boards (PCBs). Can changing the price, design, and efficiency of the smaller parts affect the infrastructure as a whole? We believe it can.

Can changing the price, design, and efficiency of the smaller parts affect the infrastructure as a whole? We believe it can.

PCBs in Electric Vehicles

From our viewpoint, it is evident that the pressure comes down to PCB manufacturers providing cutting edge, innovative, and improved electrical designs to provide charging station manufacturers with an economical solution.

One area that will require significant innovation is in copper pathways for carrying large amounts of current, removing the generated heat to protect the electronic components, and preventing battery pack thermal runaways. Studies have proven that runaway heat causes more than 50% of all electronic failures. When it comes to charging EVs, the faster you charge the battery, the more heat you generate. This leaves the fact that heat removal is essential for consumer acceptance.

This is where Aurora Circuits can be helpful to EV component manufacturers. We have experience with PCBs that have as much as 400–800 microns (25–45 oz.) of copper on one- or two-sided insulated metal substrates. Substrate metals can be either aluminum or copper with thermally conductive dielectrics to move the heat to cooling. Imagine 400 microns on two sides of a 2–4 mm copper or aluminum going to a cooling station for disposal of heat. We are also in production with a high-volume copper pedestal technology for direct heat removal from devices at a rate of 380 w/m²-°K (watts per square meter per degree Kelvin) and no dielectric in the thermal path.

The advantages of a PCB are the ease of iterative prototypes and ultimate assembly of the FETs and MOSFETs with electrical connections and heat removal. Make use of the in-house engineering team of your fabricator to solve these problems. **PCB007**

KJ McCann is director of marketing and customer relations at Aurora Circuits.

Brian Zirlin is director of sales at Aurora Circuits.

Industry Trends—Present and Future

Dan Feinberg Interviews Chris Stevens From Denkai America

Denkai is the only electrodeposited copper foil manufacturer in North America. During this conversation, Chris provides his view of present trends, the need for higher speed digital designs, as well as the overall business conditions in the past year and emerging trends.


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TTM on the Future of Transportation Design

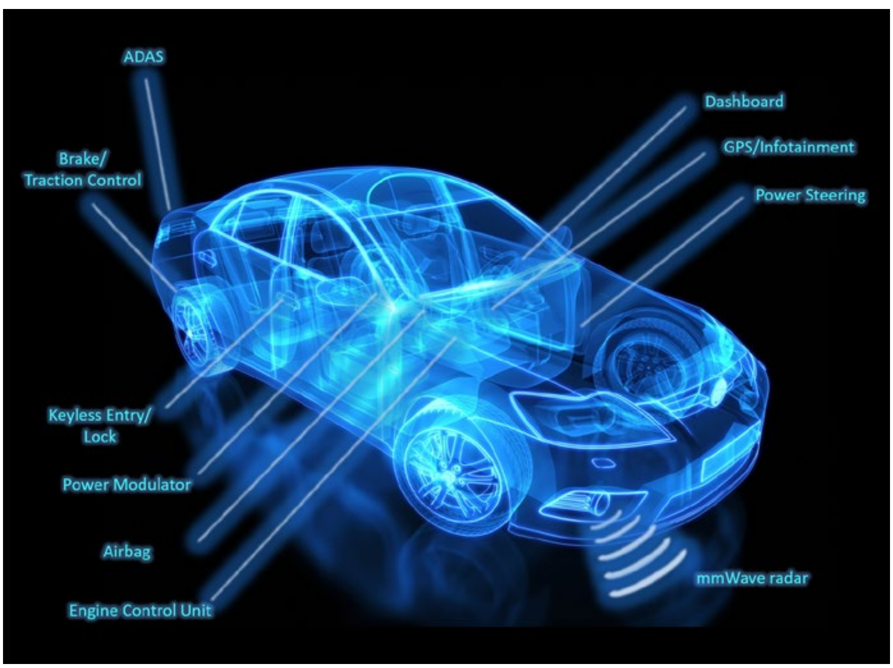
The I-Connect007 editorial team submitted a series of questions to TTM Technologies. In response, Walter Olbrich, a field applications engineering manager at TTM, provides a unique perspective on designs in automotive and transportation. These answers investigate the current "state of the market" as evidenced by what customers are sending.

Q: If we establish three main categories for transportation applications, are there clear customer trends in each category?

A: Yes, automotive electronics has changed and is continuing to change dramatically. It used to be very basic, but (of course) very reliable electronics for engine control unit (ECU)/powertrain, automatic braking systems (ABS) and body control module (BCM). Now we see several emerging and growing categories. Usually, these are split by their function into Advanced Driver Assistance Systems (ADAS), which includes autonomous driving elements and sensors, electrified drivetrain and advanced driver, and infotainment/communications. Another way to split the categories would be the functional benefit, which is connectivity, safety, and CO_2-saving.

Q: Do you see evidence of one of the categories leading or lagging? Do you see a difference in demand or need of innovation or prototyping?

A: We do not see one category taking the lead. The functionality is integrated in the car and often needs to use more than one category. Driving the demands for electronic systems and PCBs is pretty strong for all product categories. For example, it does not make sense to install the (semi) autonomic drive function as a stand-alone system. It needs connectivity to find out where the car is and eventually communicate to "X," which can be other cars, traffic lights, or control points. And does it need a connection with the car's drivetrain to give commands to the engine or steering?



Still, one category is prioritized, currently in development: prototyping and growing demand. We see high development speeds for all the electrical drivetrain projects driven by the significant growth of and demand for electric cars globally. There are a significant number of RFQs and development programs brought forward to the PCB suppliers. The emerging categories dominate the development work.

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Q: From a PCB fabricator's point of view, what are the key capabilities required for each of these categories?

Walter Olbrich

A: Here we see a clear separation into the various categories or applications. Let me start with the need for electrification; this splits into the controlling functions and the power units. The vehicle control units (VCUs) are more advanced computers that have to deal with much data for giving signals to the power controls. A hybrid car wknows when the next traffic light or sharp corner will come and reduces the power before the driver even recognizes the situation. The powertrain includes chargers, DC/DC converters, inverters, power boards, or DC breakers for the electric engine. Hybrid cars are mainly designed with 48V and have significant current on the board to realize driving or charging power. Hence, a significant heat load and thermal (heat) management method is utilized in the PCB designs. There are various concepts to get the heat out. These include utilizing lots of copper in the board in the form of thick copper layers up to 12 ounces (16.2 mils/411 μm), increasing copper thickness in selected vias, copper coins, inlays, or busbars. Other concepts include coatings or glues with increased thermal conductivity. These can be applied on the board or used as a connection to the housing or cooling element. The designer must consider the significant increases in line widths and spaces required for heavy copper layers. They are often left on internal layers only to maintain connections to fine-pitch surface mount devices soldered to the finished PCB.

Looking at the fully electrified cars, we need solutions to deal with the high current and the heat and high voltage. We are now looking at voltage levels of 450V-470V, but we see applications with 800V, 1000V, or even 1500V as future demand. At these higher voltage levels, you will see different failure modes in the boards. The board's electrical field strength may reach values where local discharges may damage or carbonize the resin and start an avalanche of these local discharges creating a high-ohm short. Solving this challenge and creating highly reliable systems means thorough reviews of the PCB design, stackup, materials, manufacturing methods, and location. Additionally, cleanliness is an essential factor to avoid introducing foreign materials/particles in the laminate and manufacturing processes, which could be the origin of such a discharge. Materials are a key factor, and we see considerable differences in the performance of different laminates. Customers benefit from collaborative efforts with experienced Tier-1 PCB fabricators.

Connectivity, infotainment, and computers for autonomous driving enablement are pushing HDI and advanced HDI technology forward. The chipsets are using high-density BGAs, which require multiple laminated layers to get the signals routed. Lines and spaces are pushing sub 100 mm/100 mm (4 mil/4 mil). Pad diameters are shrinking, making it a challenge to manufacture these boards according to IPC Class 3, and often requires design trade-off discussions. To run such products, fabricators have to invest in state-of-the-art production equipment. The most prominent element of the ADAS category is the radar and LiDAR sensors. A decade ago, these sensors were mainly used in the aerospace and defense (A&D) industry and for big equipment pieces. TTM Technologies has a long legacy of being one of the largest suppliers to the A&D sector. We can leverage our expertise to sup-

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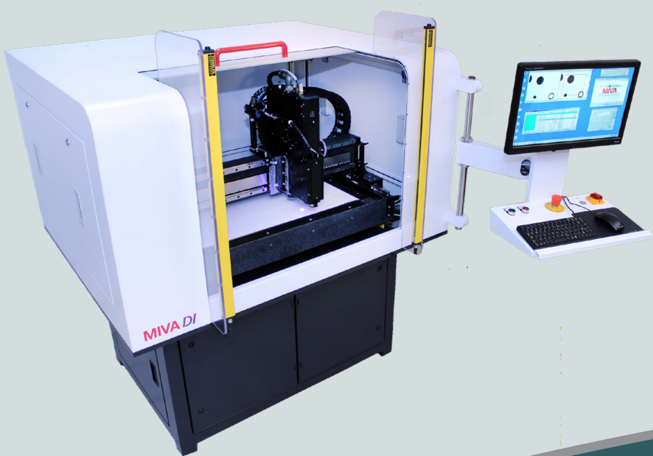

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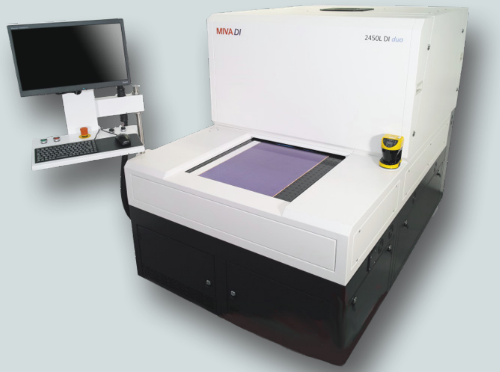

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Max Panel : 24 x 24	●	●	●	
Max Panel : 24 x 30	●	●	●	
Max Panel : 30 x 60 or 42 x 60		●		
Panel Index Capable	●	●		
Dry film resist	●	●	●	●
Soldermask	●	●	●	●
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Today's long-range radars on newer cars are tiny compared to yesterday. There has been a tremendous amount of development using PCBs as mmWave sensors. The current state-of-the-art is a hybrid, a combination of FR-4 with RF material, and microvias are used to connect to the MMICs. Other attributes such as antenna features and registration require tighter tolerances, which can be achieved with advanced equipment sets and special handling processes.

LiDAR is often a combination of a high-resolution camera with a dense charged-coupled device (CCD) chip that requires extremely tight mechanical tolerances on the board features to get the right focus. The mechanical tolerances required on LiDAR PCBs are pushing the edge of mechanical process tolerances.

Q: With all this variety and new developments, what do your customers struggle with the most?

A: Even with all the new technology elements on the boards, customers must design for manufacturability, long-term reliability, and meet industry standards and specifications. Many of the new PCB design attributes are pushing the boundaries of fabricators' abilities to maintain compliance to standards, such as IPC Class 2 vs. Class 3. TTM has a legacy of 30+ years of manufacturing PCBs for the high-reliability industry. Our experienced field applications engineers provide technical support by engaging with customers early on in their design cycle or during the design cycle. We mitigate the need to redesign the product by considering key elements such as long-term reliability and CAF resistance. You don't want to press "Ctrl/Alt/Del" when going 160 on the Autobahn, and you want your car to run for 20 years, even when living up in Canada or Finland with their long and cold winters.

A new challenge comes with new cars that are "always on." Your car senses when you approach with your keyless gadget and automatically unlocks. Charging devices may run all night long. Interior sensors tell you whether you forgot your child or dog in the car through continuous monitoring. These functions mean that the active and switched-on lifetime of electronic components in the vehicle is increasing significantly. One year has 8,760 hours. The statistic modeling of the accelerated lifetime testing needs to consider the multiple active life spans of components.

Maximum operating temperature (MOT) is rising from 130°C to a level of 150°C +. Product specifications and qualifications show a temperature cycling of up to a range of –40°C to +160°C, while temperate storage is tested at 160°C; this requires a complete set of new and reliable materials that haven't been tested for long-term reliability yet, and which will require an update of specifications in UL and IPC.

Our customers have to not only get the development and new designs done, they also need to work extensively to quantify, specify, and test the properties and functions of the new devices.

Q: If you look at the other direction, what pressure is that scenario putting to your suppliers?

A: Well, our partners who provide laminates, chemistry, and equipment are challenged in the same way. Development speed is accelerating, quality and productivity are increasing, and specs are tightening. We collaborate closely to ensure our suppliers are aware of our customers' needs and challenges, so the supply chain is flexible, and their products can meet our needs. PCB007

Walter Olbrich has been with TTM for eight years but is an industry veteran with over 30 years of experience with printed circuit boards, primarily in R&D, engineering, manufacturing, and sales/marketing. He now manages Field Application Engineering in the EU.

EV Industry Facing Bottleneck Challenges

Feature Interview by Nolan Johnson
I-CONNECT007

Nolan talks with Eduardo Benmayor, general manager at Aismalibar, about materials challenges facing the powertrain portion of the automotive EV industry. Eduardo also speaks about what he sees as the biggest challenge facing EVs—infrastructure.

Nolan Johnson: Aismalibar is in a position to have a unique perspective on some of the dynamics in automotive production. What are you seeing as major trends in automotive currently?

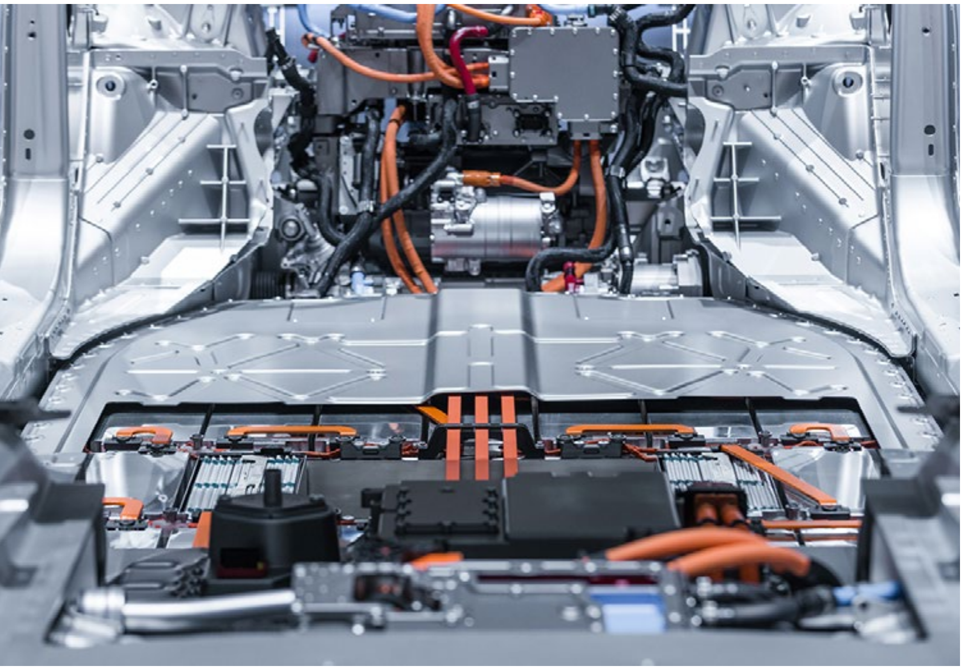
Eduardo Benmayor: As you may know, in the automotive industry the percentage of electronics inside the car is growing every year, so that's been on the table for many, many years. Right now, we see three main families of electronics inside the car. The first is related to securities, radars, detectors and all kinds of cameras. Then, we have all the power electronics, which Aismalibar is focused on: AC/DC converters, DC/DC converters, on-board charging stations or external charging stations, all related to high power and a lot of heat. The third family is telecommunications and communications of the car with external devices and the internet, which is a completely different area of the electronics business.

Eduardo Benmayor

Our business is mainly focused on how the electronics engineers are designing the heat dissipation and dielectric strength around the electronic chargers inside the car. This drives them to a lot of different problems, and all these problems are viewed with different solutions. We don't see a clear trend in the automotive industry; sometimes the big players go in one direction with IGBT technologies, others go to the MOSFET technologies, while others go with a completely different technology. There is not a standard trend, in general.

Johnson: How do you cope with that?

Benmayor: We listen to all of them, because you can study and learn from the different cases.


An example EV drive train and battery platform.

They normally ask us to offer them the best solutions, which are always focused on two main aspects. First, what Aismalibar can offer in terms of releasing heat from the electronics through metal PCB boards. That's one direction. The other direction is how much power can be applied to these inverters, AC/DC converters or DC/DC converters, granting the dielectric strength at the initial point and through the aging of the material. This is a big topic today. Let me give you a very clear example.

When designers want to increase the power of the boards, they normally tend to increase the voltage up to, let's say 600 or 800 volts constant on a power module. By applying this much current through such a thin dielectric layer, their main concern is how to keep the dielectric strength during X amount of thousand hours, combined with high temperature and high humidity. They are concerned with how to keep these high voltages running on the devices, and at the same time, keep the device stable and capable of running for a long time. This is a challenge today. Our R&D team is working very hard on how to achieve these goals, to avoid copper migration and other aspects that influence the long run of the dielectric layer in a metal PCB board.

Johnson: You touched on just a couple design and reliability challenges. What other challenges are you working through?

Benmayor: Mainly, it is the mismatch between the metal PCB boards and the solder. The mismatch is big and as temperature changes are big the problem tends to appear faster than in other electronic designs. Power boards on vehicles are operating at -110°C to +120°C, and this generates a very big mismatch between the metal core and the solder joint; the solder is affected, and we are challenged with reducing this mismatch and giving a longer lifetime to the solder joint. It's a constant challenge, and we see customers taking different directions.

Copper migration on metal PCBs is a challenge that has only come up in the past year. It appears faster when we apply a high current through the functional copper and at the same time apply high temperature, 65-70°C with constant voltage around 1,000 V, and humidity in the 95–98% range.

When these conditions happen over a long period of time, say 1,000 to 2,000 hours, we start to see copper migration. This is well-known in the PCB industry, but with these high currents, we see the migration growing much faster than with the standard electronic PCB designs.

We have dedicated people working on the recent technology as there are many different ways to approach the reduction of copper migration. Our approach, generally, is to increase the Tg of the polymers used in our laminates. By increasing the Tg, we normally see a reduction in the copper migration. This is one thing we see right now and which we have tested multiple times. A second approach is to reduce the ionic charges on the resin, which is easy to say but difficult to achieve. The third approach relates to the influence of copper dendrites in the migration. With our corporate vendors, we want to improve, determine how to reduce these, and how to modify these dendrites on the copper to reduce the copper migration.

Johnson: You mentioned earlier that different companies are going in different directions with their solutions. What are some of the trends you're seeing from the designs?

Benmayor: We see many different electronic solutions. They vary from very complex multilayer boards where the PCB companies are making depth control in Z-axis on the PCB, embedding the non-encapsulated die inside the PCB and wire bonding. It's really high-tech technology. Of course, going this direction is very expensive.

We see other big players embedding MOSFETs inside the PCBs to improve thermal management and improve the output power of the board. This is a challenging technology and is only in the hands of a very small number of players. Other very big players are taking a more traditional path. You will see IGBTs clad to the heat sink with high technology, high thermal performance dielectric layer. Design teams go that way in the easiest part of the design, in order to have more options with different vendors, instead of locking into a unique technology. So, every big player is going in a different direction.

The very big players want to have the capacity to innovate. They want to go with their private technology so they can have a stronger position in the market in front of the automotive players. Others are more focused on a platform in which they have the capacity to reduce the costs from their vendors. There are so many different ways to approach it.

Johnson: It's fascinating that this is happening right now. It's critical, what with all the electronics in general, and electric vehicle technology in particular. Figuring out how to have a long-lived, reliable automotive solution that can operate in the tropics, the temperate latitudes, the arctic cold, all at the same time, is quite a challenge for everyone involved.

Benmayor: Nolan, you should read about the number of recalls in electronic vehicles by the big players. Thousands of cars are being recalled back to the factory to re-adjust part of the electronics; it's not a stable technology at the moment.

Johnson: Based on the work that you do, what's your opinion on the strategies that will be successful, that will play out over the years as the most reliable implementation?

Benmayor: That's a very complicated question. We have a yearly meeting with the electronics designers of the biggest car manufacturer in Spain. The last time I was there, about a year before COVID-19 restrictions, I asked the same question to one of their directors. They have, maybe 1,000 engineers designing electronics, and when I asked the question,

PCB and LED solutions are expanding in all automotive applications.

Power and charging challenges influence EV adoptions.

the director laughed. He said, "We don't know where we are going. Nobody knows where we are going. We need to push, but we don't know if we need to go to the right or we need to go to the left." His conclusion was very simple and what it told me was, ultimately, the electric vehicle is not an ideal solution. The world, the big cities, are not prepared to support this massive number of electric vehicles. There is not enough power to support this among many other logistic problems.

It was an informal conversation between us, but he gave me a very simple example that most people don't think about: "We deliver around 100 to 200 cars to our customers—the automotive shops—every week, so we can sell them to the customers." But the constant discussion was, "Are we going to deliver the electric cars loaded or with empty batteries?" If you send the cars with empty batteries, you have no capacity to charge them. If I have no capacity to charge 200 cars a week, how will my customers take the cars home? They will get stuck on the way home because the batteries aren't charged. The magnitude of using or implementing thousands of cars in the cities is just not something people think about. We are simply not prepared for this at the moment. So, we really don't know where we are going, but we know that there will be a change and we're looking for the ideal solution.

Johnson: It does seem as if everyone pays attention to the on-board vehicle applications, but the infrastructure is every bit as challenging and has many of the same environmental resilience issues. The infrastructure needs to carry a lot of current, and will require a complex, complicated rollout. Is Aismalibar looking to get involved on the infrastructure side?

Benmayor: No. Infrastructure is a thing that belongs to the big electric power companies. Of course, we are already involved in several projects related to the charging modules that will be installed in gas stations. Several of our customers are using our Aismalibar Cobritherm IMS materials for AC/DC chargers in the gas stations. They are talking about huge volumes in the following years, but we still need the power companies to support all these chargers; we are talking about 10 to 12 kilowatts per charger, so where are we going to grab the energy from in the cities?

I really don't see how the electric companies will be able to supply two or three times the required power into the big cities. Don't forget that when we have a peak of hot temperature in the summertime, the electricity in the cities is overloaded, which already creates issues. In several big cities, there is not enough capacity. Let's assume that we need to double this capacity because we need to charge the cars every day. It's not an easy thing to solve.

Johnson: That concern gets the least amount of attention in the conversation, that's for sure. And yet, the car we're talking about isn't going to be functional at all if you cannot get it charged.

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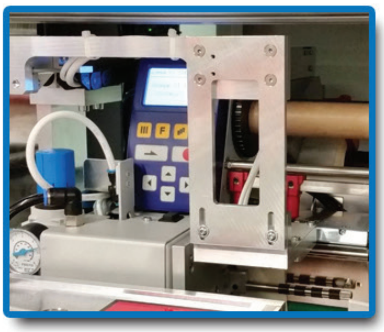

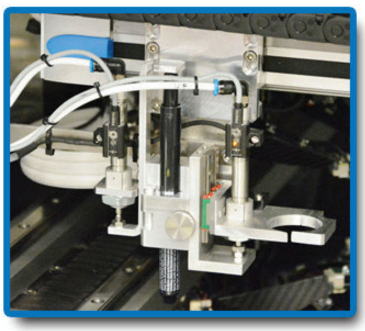

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I think you provide a great sense of what's going on. What I'm hearing is that, when it comes to implementation, especially in the powertrain, there are many different possible directions for handling the engineering challenges. It's not clear what the solutions there will be, but there will be a lot of experimentation amongst the different automakers until this settles out.

Benmayor: Yes. And a lot of recalls as a result. Also, don't forget the battery suppliers because there is not enough capacity in the world to support the demand. As far as I know there are three big battery suppliers in the world. There is a lot of concentration and the auto builders don't have enough sources to buy as many batteries as they need, so there is a big, big bottleneck here.

Johnson: The battery technology conundrum is also true. How would you sum this up, Eduardo?

Benmayor: The automotive industry is becoming very demanding. Right now, there are a lot of techniques involving headlights. Just for your reference, we are used to headlights where you switch them on in a car and they offer you light. Today's headlights are more intelligent, and capable of projecting many things onto the road to provide more accurate visibility for the driver. These techniques, combined with radar, will help the driver feel more secure, especially at night. It is really amazing to see these upcoming, incredible projects. When they give you the first shot, it's incredible to see what they are capable of doing.

Johnson: Great. Eduardo, thank you for taking the time to help us understand what's happening in materials and automotive.

Benmayor: Thank you, Nolan, for your time, also. Hope to see you soon. **PCB007**

Simplified Assembly of Aluminum Flexible Circuits

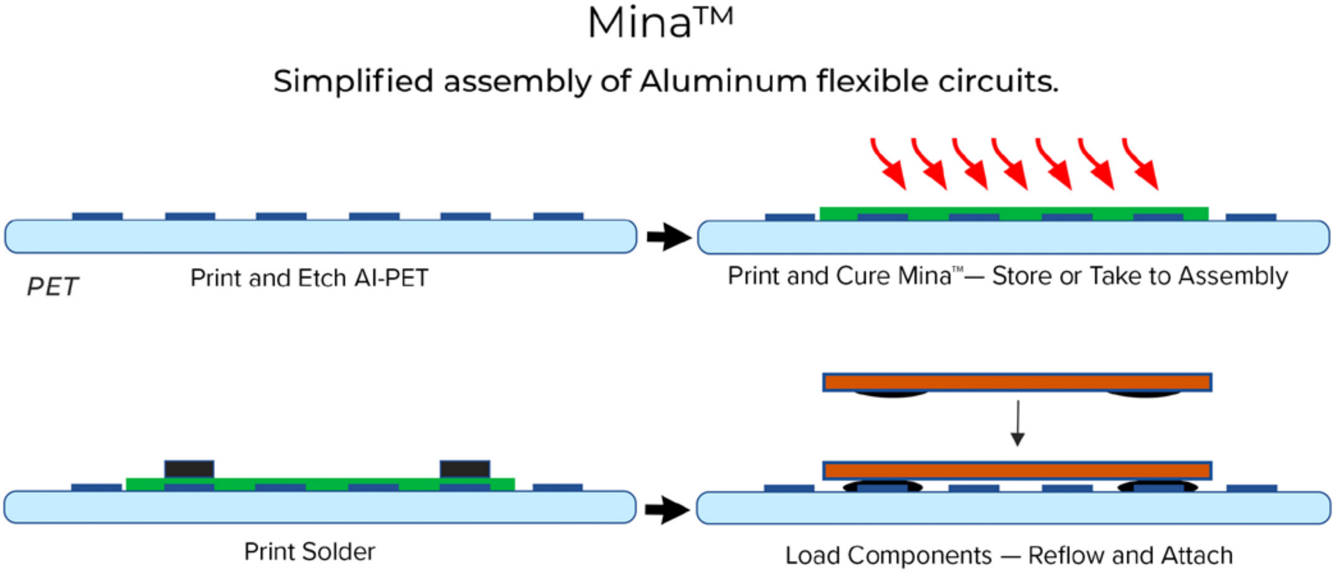
Feature Interview by Tara Dunn
AVERATEK

Flexible circuit designs that come across my desk are predominately constructed with copper and polyimide laminates. As I learn more about automotive applications, I am intrigued by the possibilities of using aluminum in place of copper and the potential to use polyester in place of polyimide. Both aluminum and polyester have traditionally been difficult to solder to. One very interesting development has been the Mina™ chemistry. This coating not only simplifies soldering to aluminum, but it also enables the ability to automate low temperature soldering to polyester. Having many questions about this process, I sat down to discuss this Mina with Divyakant Kadiwala, vice president of manufacturing for Averatek. He has been instrumental in the development of this assembly process.

Tara Dunn: Divyakant, before we jump into the conversation about Mina, could you share a brief introduction to both Averatek and your background?


Divyakant Kadiwala

Divyakant Kadiwala: Averatek is a high-tech company based in Silicon Valley. It was founded by SRI International and private investors. It has two primary products: LMI™, a catalytic ink that enables the fabrication of very high-density circuits with the patented A-SAP™ process; and Mina, a surface treatment that enables soldering to aluminum. I am VP of manufacturing and my role includes overseeing process engineering, quality control, facilities management, and business development. I am leading our efforts on productization of Mina.



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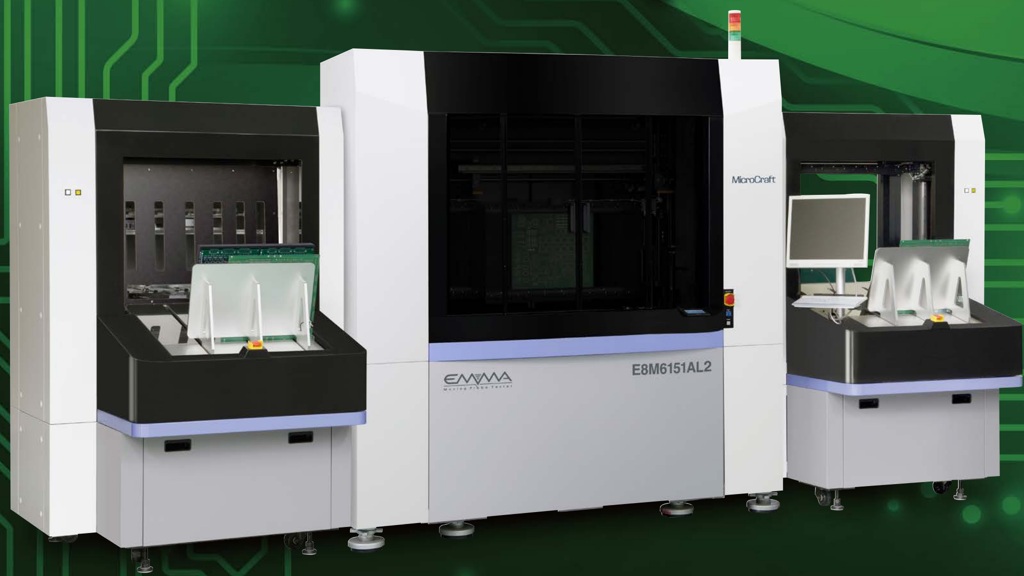

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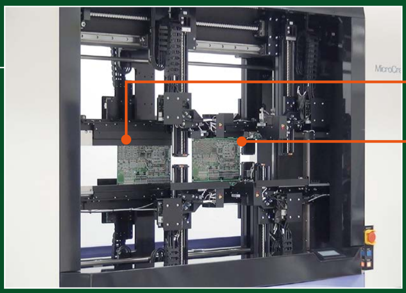

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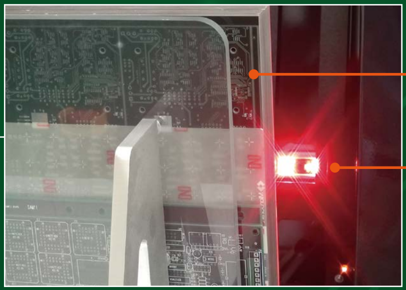

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An example of aluminum over copper.

Dunn: Thank you. Let's start the conversation with aluminum. What are the benefits of aluminum over other metals?

Kadiwala: Aluminum is the most abundant metal in the earth's crust. This makes it more easily available and less expensive compared to other metals. It has different benefits when compared to other metals based on the field of use. For example, in automobiles, its superior strength at lower weight is a significant benefit against iron and its common alloy—steel. But in the field of printed electronics, its main competitor would be copper.

Aluminum is more than three times lighter than copper. It has 68% of the conductivity of copper but has only 30% of the weight of copper. This means that a bare wire of aluminum weighs half as much as a bare wire of copper that has the same electrical resistance. This makes it the metal of choice for high voltage transmission cables. Also, it is three times less expensive than copper on an equal weight basis and six times less expensive on an actual usage basis. This is the biggest advantage that aluminum has over copper.

Dunn: Interesting. Why do you think aluminum is attractive specifically for automotive applications?

Kadiwala: Aluminum has been a boon for the automobile industry. Like any industry, the automobile industry has evolved due to various geo and political reasons over its 100-plus-year history. Whether it's the oil embargo of the 1970s or global warming due to climate change, it has been constantly under pressure to improve fuel efficiency standards.

The easiest way to improve fuel efficiency is to reduce the dead weight of the automobile and improve the efficiency of the internal combustion engine. Aluminum helps reduce an automobile's body weight by providing superior strength at lower weight when compared to steel and other alloys of iron. It also helps improve engine efficiency by providing better performance at lower weight.

Since most automobiles have their body and chassis made of aluminum, the integration of onboard electronics to aluminum is critical. Averatek's Mina can provide a soldered connection to aluminum without any plating or surface finish. It can help ease manufacturing and reduce costs.

Dunn: Aluminum has historically been difficult to assemble to. What are the challenges of soldering to aluminum?

Kadiwala: Aluminum PC boards, whether rigid or flex, are limited in use due to challenges associated with soldering components to aluminum pads. This is because all aluminum surface is covered with a layer of aluminum oxide. Although self-limiting, this oxide layer cannot be overcome by flux in existing solder systems during reflow. It thus prevents the formation of a metal-to-metal bond. Even if this oxide layer is removed using etchants and fluxes, a new layer forms in situ upon exposure of clean aluminum to the atmosphere. This prevents the use of conventional SMT methods for attaching SMDs to assemble PC boards.

Dunn: Can you expand on a couple of ways that Mina could be utilized in automotive applications?

Kadiwala: Integrating electronics with the aluminum body and chassis of the car is an integral part of its manufacturing and design. Since aluminum is not easy to solder to, mechanical "crimp" and "pigtail" connections are common options.

Mina can provide a soldered joint instead of these mechanical connectors. It can help attach aluminum wire or PCB to aluminum chassis for grounding or other such connections. It can also help with attaching copper to aluminum PCB where applicable.

Dunn: This is exciting. With any new process, reliability is always a concern. What type of reliability data has been gathered?

Kadiwala: Flexible PCBs were made using an Al 9-mm/PET 38-mm substrate and components were soldered using low temperature Sn/Bi/Ag solder paste. The fully assembled PCBs were then subjected to these tests:

- K-09 – "Damp Heat, Cyclic (with Frost)"
- M-04 – "Vibration"

Both these come under the LV-124 European automobile standards.

1. Characteristics of the Test K09—"Damp Heat, Cyclic (with Frost)"
   - Chamber temperature: without cold phase: 23°C to 65°C; with cold phase: −10°C to 65°C
   - Chamber humidity: 95% RH
   - Duration: 10 d = 10 cycles at 24 h
   - Cycling: 5 cycles with cold phase, then 5 cycles without cold phase
   - Operation of samples: here not operated (usually intermittent operation = 30 s on, then 30 s off)
2. Characteristics of the Test M-04—"Vibration"
   - Chamber temperature = 8 h, profile between −40 and 80°C
   - Broadband random vibration according to vibration profile D in LV-124 → 5-2000Hz → 30.8 m/s^2 → X-axis, Y-axis, Z-axis → 8 h each axis

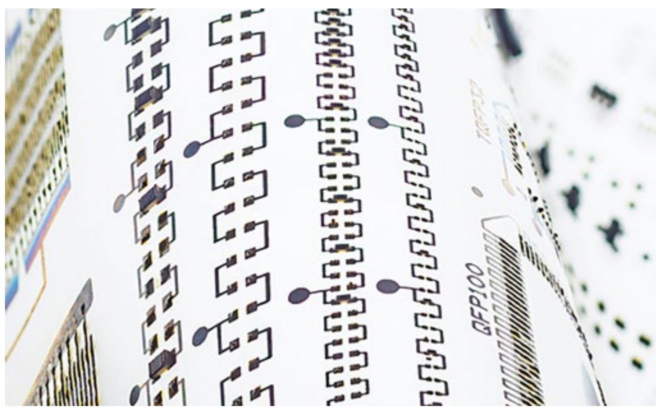
Dunn: What materials does Mina work well with? Rigid, flex materials, others?

Kadiwala: Mina works well with both—flex and rigid materials. The alloys of aluminum that we have proven for our customers include Al1235, Al6061 and Al5052.

Dunn: Understanding the benefits of aluminum over copper and understanding the benefits of flexible materials such as polyester, the combination seems like a natural fit for automotive applications and a wide range of other applications. Which markets do you see as the early adopters of Mina taking advantage of the simplification of the soldering process for these materials?

Kadiwala: In addition to automotive, we see significant interest from the LED, SmartTag, and heat-sink and high-power industries.

The LED industry would not only benefit from lower costs due to cheaper Al-PET substrate but also it would be a better product. A soldered LED operates much cooler compared to one attached using conductive epoxy. Based



Mina is a simple pretreatment for aluminum that makes it as easy as soldering to copper.

on information from a large LED manufacturer, the lifetime of an LED doubles with every 10°C reduction in operating temperature. Thus, soldered LED panels will be more reliable.

SmartTags have more components and are larger in size compared to generic RFID tags. They use a lot more silver epoxy and thus are more expensive to make than RFID tags. Also, SmartTags are designed to be used multiple times while RFID tags are usually meant for single use. Hence, longevity is important for SmartTags. A tag made with its components soldered will be more reliable and cheaper compared to one made using silver epoxy.

Heat management is important for high-power devices. Aluminum is commonly used to build heat sinks. Soldering a high-power device to aluminum would require a plated surface finish like ENIG and ENEPIG. These add costs and so other means like thermal tape, etc., are used at the cost of performance and life of product. Mina addresses all these issues by enabling direct soldering to aluminum heat sinks.

Dunn: Divyakant, thank you so much for talking with me about the Mina process. Working with flexible circuits for many years, it is always exciting to learn about new applications that change the way we look at flex assembly and integration.

Kadiwala: Thank you, Tara. **PCB007**

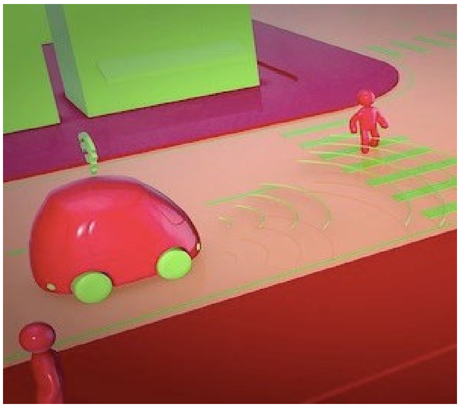
Editor's Note: This column was originally published in the March 2021 issue of *Design007 Magazine*.

Tara Dunn is the vice president of marketing and business development for Averatek. Dunn is also a regular I-Connect007 columnist.
Click here to read Flex Talk.

Enevate Receives Funding for Fast-Charging EV Battery Technology

Enevate, a pioneer in advanced silicon-dominant lithium-ion (Li-ion) battery technology featuring extreme fast charge and high energy density for electric vehicles (EVs) and other markets, announced that it has secured an $81M Series E funding.

"As our fast-charge technology is implemented, we see a day in the not-too-distant future when EV drivers will be able to pull up to drive-thru charging stations that will look much like today's gas stations, charge up and be back on the road in five minutes," said Enevate CEO Robert A. Rango.



Enevate said that the investment would enable the company to significantly expand its pre-production line designed to guide EV and other battery customers toward implementing larger-scale battery manufacturing utilizing Enevate's silicon anode-based batteries. With this latest funding round, Enevate has raised $191 million to date.

"This latest funding reflects our investors' confidence in our progress with our customers, our technology, and our team," said Rango.

Hadi Zablit, chairman of Alliance Ventures, a partnership of Renault, Nissan and Mitsubishi, stated, "As an investor, we believe Enevate's technology possesses a combination of advantages that is highly attractive to both the EV and power tool battery markets."

Enevate works with multiple automotive OEMs and EV battery manufacturers, enabling them to utilize existing manufacturing infrastructure with minimal additional investment, facilitating the next generation of EVs that will eliminate customer pain points with EV ownership."

(Source: Business Wire)

RAIG (Reduction-Assisted Immersion Gold) for Gold Surface Finishes

The Plating Forum

by **George Milad,** UYEMURA

RAIG was introduced a few years ago to meet the requirements of newer designs. Since its inception, more designers are finding RAIG gold to be a viable alternative to standard immersion gold. RAIG gold is a mixed-reaction bath that functions as immersion gold; with a reducing agent, it also functions as an electroless (autocatalytic) bath.

The reactions start simultaneously with the introduction of the substrate (nickel, palladium, or copper). Because the immersion reaction is a displacement reaction, it diminishes over time as the substrate becomes less available for deposition. The electroless reaction continues, relying on the reducing agent present in the electrolyte, rather than on substrate availability. RAIG gold is limited in how much gold it can deposit, as compared to a pure electroless gold. It is ideally suited for deposits of 3–6 µin.

Curbing the immersion reaction and allowing gold thickness to build autocatalytically expands the operating window by allowing thicker gold to deposit without nickel corrosion. A thicker gold layer (3–6 µin), is beyond the capability of standard immersion gold electrolytes, but is desirable for many applications, as it widens the operating window for gold wire bonding.

Figure 1 shows the relationship between gold thickness and the strength of the wire bond.

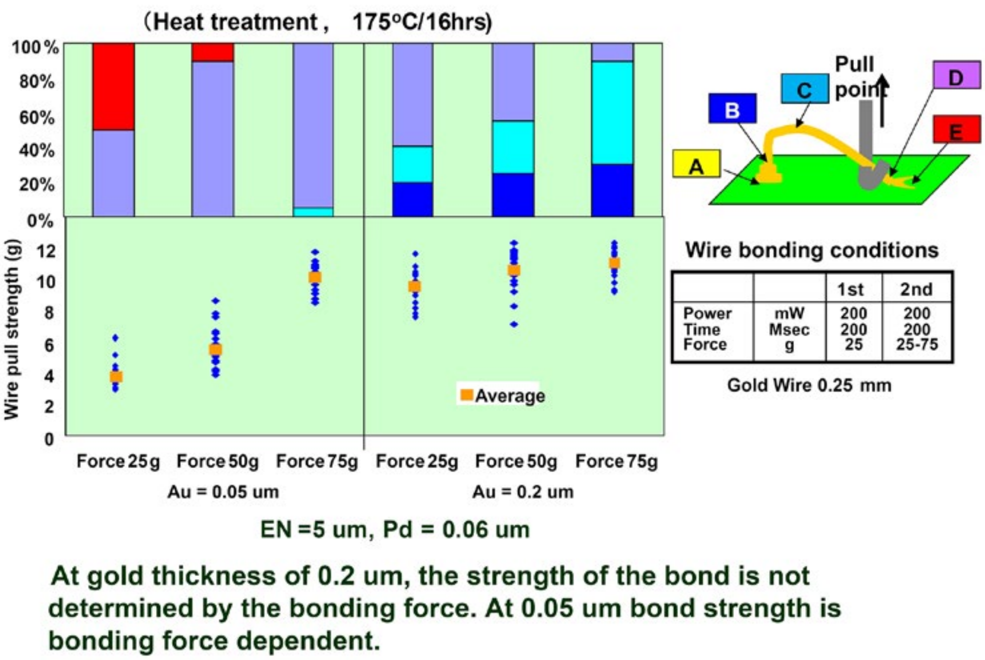


Figure 1: The effect of gold thickness on the operating window of the bonding force.

Two thicknesses of gold, 0.05 µm (2.0 µin) and 0.2 µm (8.0 µin) were bonded using a 0.25 mm gold wire at three different bonding forces (25, 50 and 75g force). Ultrasonic power (mW) and time (sec) were held constant. The wires were then pulled and the break point in the wire was recorded. Bond lifts (E) and brakes at the heel of the bond (D) indicated weak or non-reliable bonds. Break points (B and C) were indicative of a reliable bond.

The data shows that both thicknesses could produce robust joints. However, the thinner (0.05 µm) gold required a higher gram force to form a reliable bond. The thicker gold (0.2 µm) produced reliable bonds at lower gram force, opening the operating window for the bonding parameter.

For gold wire bonding applications, designers prefer to specify a gold thickness of 3–5 µin, which is beyond the capability of immersion gold. Increasing dwell time in an immersion gold bath is the most common cause of nickel corrosion.

Increasing dwell time in an immersion gold bath is the most common cause of nickel corrosion.

RAIG Applications

RAIG gold is an immersion gold replacement for ENIG, ENEPIG and EPIG. It meets the design requirement for thicker gold with no nickel corrosion, in a single plating step.

ENIG

ENIG is a common gold surface finish that is solderable and aluminum wire bondable. It is also used as a contacting surface. ENIG is non-electrolytic and does not require bussing or connectivity during plating. It is ideal for SMT pads. The choice of chemicals and the conditions of plating are important to avoid corrosion of the nickel. Nickel corrosion, also referred to as "black pad," occurs in the gold bath. Immersion gold deposition is, in essence, a corrosion or displacement reaction. If conditions are not controlled, nickel may go into solution at the expense of hydrogen ions without gold deposition, creating nickel corrosion.

Under controlled plating conditions, nickel corrosion does not occur. It can occur, however, if the nickel deposit is uneven, the gold bath pH is too low, the gold concentration is below spec or the dwell time in the bath is too long. Such conditions are usually avoidable, except when the design requires thicker immersion gold (in excess of 2.5 µin).

Some manufacturers attempt to achieve this thickness by extending the dwell time in the gold bath, however, immersion gold baths are not designed to deposit more than 2.5 µin. If higher gold (3–5 µin) is a design requirement, another gold deposition system must be used. Two alternatives are electroless gold and reduction-assisted immersion gold (RAIG).

Electroless gold is not common at PWB manufacturing sites. Electroless gold requires an immersion gold strike prior to electroless deposition. Adding another gold bath is a costly proposition. RAIG gold is a single bath that can deposit 3–5 µin of gold without corrosion.

ENEPIG

This finish is gaining a lot of traction. ENEPIG forms the most reliable solder joint with lead-free solder and is also a gold-wire-bondable surface. In a previous column, I discussed the possibility of nickel corrosion beneath the palladium layer under certain condition, one being extended dwell time in an immersion gold bath to achieve higher gold thickness. The use of RAIG gold allows for a thicker deposit without nickel corrosion.

EPIG vs. EPAG

EPIG (electroless palladium/immersion gold) and EPAG (electroless palladium autocatalytic (electroless) gold) are nickel-free surface finishes that prevent the signal loss associated with electroless nickel deposits. They are widely valued for high frequency RF applications.

As discussed, thicker gold (greater than immersion gold) increases the wire bond operating window. EPAG is promoted as the answer to the thickness limitations of immersion gold. Autocatalytic gold requires an immersion gold underlay and is a difficult bath to control. RAIG gold deposits a higher gold thickness than immersion gold in a single gold plating step. The hybrid EPIG/EPAG using RAIG gold produces the desired thickness without the complexity of an additional electroless bath.

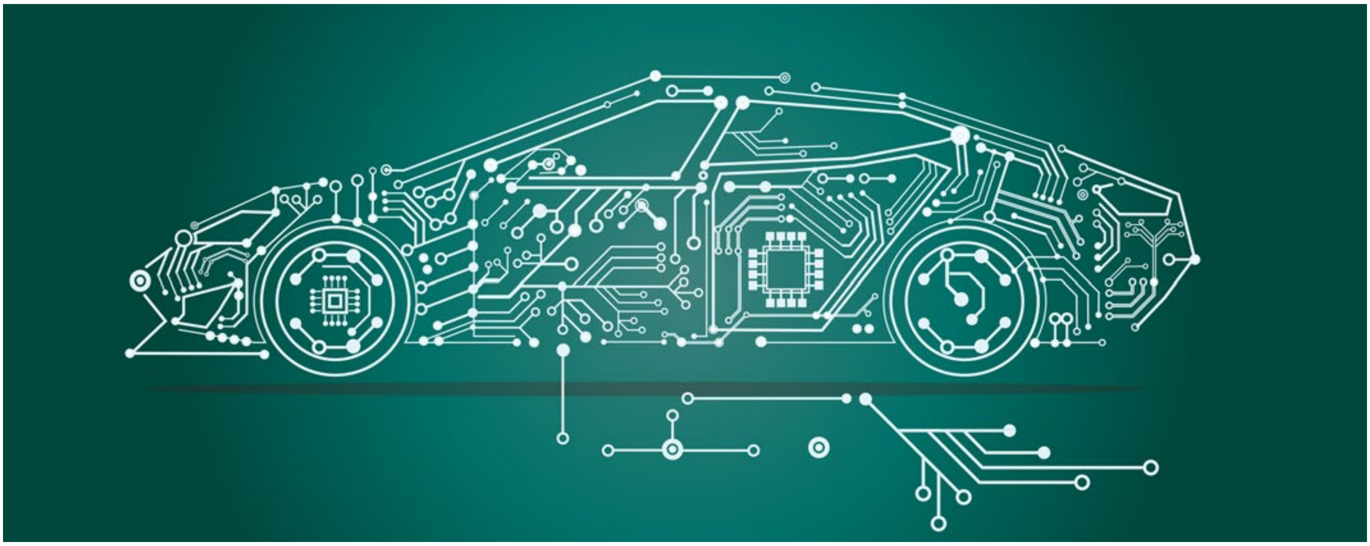
The concept of reduction-assisted immersion gold RAIG baths is coming into its own as more manufacturers and OEMs recognize its benefits, most notably the ability to deposit a thicker layer of gold (3–6 µin) with no corrosion of the underlying nickel, in a single gold plating step. **PCB007**

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

Best Practices for Metallization of Complex HDI Panels

Pete Starkey Interviews Bill Bowerman From MacDermid Alpha Electronics Solutions

Bill Bowerman and Pete Starkey discuss process improvement strategies for the elimination of weak microvia interfaces, and Bill's presentation at the IPC APEX EXPO 2021 Technical Conference.



Process Survivability, Reliability and Robustness Testing for EVs

Feature Article by Bob Neves
MICROTEK LABORATORIES

Electric vehicles encompass more than just automobiles. Trains, subways, ships, motorcycles, scooters, skateboards, and even aircraft are now going electric. Electric vehicles have unique power needs that directly affect the manufacturing and reliability of the printed circuit boards (PCBs) used in them. Drive train and environmental control systems require PCBs with the ability to process significant power to interact with and control them. Adding to the power needs of electric vehicles are the dozens of support, monitoring, entertainment, and safety systems that have become a part of the vehicle experience we expect.

In combustion engines, power generated from fuel was used for all mechanical and electrical needs with a surplus of energy remaining. The elimination of the combustion engine has forced power to now be carefully managed and conserved as it all needs to be stored locally and there is not much extra that can be wasted.

The power used by an electrical system is equal to the current flowing through the system multiplied by the voltage drop across the system. This means that in order to obtain significant power for your electrical system, you can increase current, voltage, or some combination of both. In addition, the energy storage systems on the vehicle must balance increases in voltage and current to maximize power distribution. These increases in current and voltage create unique issues for the PCBs used in these high-power systems. Increased current requires thicker copper conductors while increased voltage requires more spacing between conductors to prevent electrical leakage. Increased power going through the PCB also generates heat, causing expansion which increases stress to the PCBs' via structures and can contribute to long-term degradation to its insulation systems.

The desire for high reliability in our vehicle electrical systems has driven us to try to better understand the factors that affect the long-term interconnection and isolation reliability of the electrical circuits that comprise a PCB.

As the via structures that interconnect components and layers in a PCB are typically the weak point in a conductive circuit, testing requirements have rapidly evolved, attempting to assess the process survivability, robustness, and reliability of via structures.

Process survivability, reliability testing, and robustness testing are terms that tend to be confused with each other and lumped into "reliability testing." Let's clarify these terms and show how they fit together into the PCB world so that it is clearly understood what it means when each is used.

Process Survivability

Process survivability testing is the simulation of the environmental stresses experienced by the PCB during the component attachment process including any repair or rework that might be allowed prior to the product going into use in the field. This means that a representative test sample must be subjected to multiple exposures of the test temperatures utilized for component attachment and rework/repair processes. As this represents what could happen to a PCB during component attachment, process survivability simulation should be performed prior to any reliability or robustness testing. The IPC recently published IPC-TM-650 2.6.27B that defines assembly reflow process survivability testing for via structures. This test method defines the testing of via resistance during the simulation of a convection reflow oven environment. The results of this testing will allow understanding of whether the vias can survive the multiple reflow/rework/repair processes that are allowed during component attachment. An extension of this test is also sometimes used as a robustness test where reflow simulation cycles are repeated until via structure failure.

Reliability Testing

Reliability testing is the process of creating an environment for test samples that significantly accelerates the factors influencing a PCB's performance during its expected life. The results from testing in this environmental acceleration can be evaluated using mathematical models (Weibull, etc.) in order to predict the expected life of the product in the field. Reliability testing attempts to maximize acceleration factors actually seen by the product during its life and eliminate acceleration factors that cannot be directly correlated to real life use.

In order to assess the long-term reliability of via structures, thermal shock/cycling is performed on test samples in accordance with IPC-TM-650 method 2.6.7.2 between -55°C to (T_g - 10)°C. Keeping the upper temperature to which the samples are exposed to 10°C below the T_g ensures that the expansion rate of the material is consistent with what is expected during the life of the PCB. The resistance of single vias or daisy-chains of vias is monitored during thermal shock/cycling and resistance increases over time are indicative of cracking or separation in the via structure(s).

When assessing the long-term reliability of a PCB's insulation system, testing for conductive anodic filaments (CAF) in accordance with IPC-TM-650 method 2.6.25 is normally performed. This testing exposes parallel via structures to 85°C and 85% RH environment while placing a 100 VDC potential across them. Electric vehicle electronic systems often run at voltages well above 100 V and variations of CAF testing up to 4000 VDC have been done at my lab, Microtek Laboratories China (www.TheTestLab.cn). There is no standard for CAF testing at voltages above 100 VDC and custom fixtures, cabling and safety systems must be deployed to properly perform high-voltage CAF testing.

Robustness Testing

Robustness testing is essentially reliability and/or survivability testing plus. The plus includes environmental or electrical acceleration factors that cannot be directly correlated to the factors that influence a PCB's long-term

performance during its expected life. This creates stresses that accelerate failures faster than possible with reliability testing. Robustness testing is used in situations where obtaining faster results is more important than directly understanding life expectancy in the field. These types of tests typically expose PCB test samples to temperatures above the material's glass transition temperature (T_g) or pressures higher than 1 atmosphere. These conditions create stresses and acceleration factors that are not seen during a product's normal life. These types of tests are useful when comparing materials, processes, or products to each other. After exposure to the extraordinary test conditions of robustness testing, observations point to the "better" one, but that may or may not mean that the better one will outperform "worse" ones in a product's real-life use environment.

For via structures, robustness testing usually means thermal shock/cycling between 25°C and 190-260°C, well above the T_g of the PCB's material. Z-axis expansion rates of the PCB's substrate material above T_g are 4–10 times what is experienced below T_g and causes extreme stress to the via structures that does not occur during the product's life. These additional acceleration factors speed the via structure's time to demise but creates difficulty when trying to correlate the results to real world operating conditions.

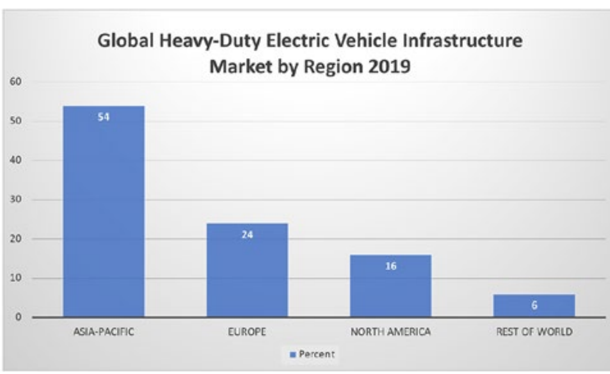
All the process survivability, reliability testing, and robustness testing of via structures can be performed using a HATS²™ tester. The HATS²™ tester can test a wide variety of PCB test coupons at temperatures from -55°C to 260°C. Please visit www.HATS-Tester.com for more information. **PCB007**

Bob Neves is chairman/CTO of Microtek China, and vice chairman of the board at IPC.

Heavy-Duty EV Charging Infrastructure Market Set for Strong Growth

The heavy-duty electric vehicle charging infrastructure market is anticipated to grow at a healthy 35.07% CAGR over the period of 2018–2030, reveals the current Market Research Future (MRFR) report. The heavy-duty electric vehicle charging infrastructure, put simply, is a complete assembly for transferring electricity from the electric grid and distributing electricity to charge electric vehicles like trucks and e-buses.

According to the report, there are numerous factors propelling the heavy-duty electric vehicle charging infrastructure market growth. Some of these include the increasing adoption of electric cars, people in Germany, the UK, Norway, and China increasingly switching to electric cars, favorable government subsidies and policies, and demand for electric cars as they reduce carbon footprints on the environment and also produce fewer emissions which are responsible for smog and climate change.



The additional factors adding market growth include the growing need for energy-efficient commuting and support from the government for electric cars and their charging infrastructure through tax rebates, subsidies, and preferential policies.

On the contrary, the high price involved in initial investments for fast charging, the need for better batteries, the charging time of electric cars being higher than fossil fuel cars, especially in level 2 and level 1 charging, the compatibility of charging not being uniform, and the current trend of pricing and grid capacity of electric cars being higher than that of their fossil counterparts may limit the global heavy-duty electric vehicle charging infrastructure market growth over the forecast period.

(Source: Market Research Future)

Homing in on the Target

Testing Todd

by Todd Kolmodin, GARDIEN SERVICES USA

Although electrical testing provides a beneficial safeguard against an electrically inferior product reaching a customer, it does require adherence to critical processes. One of those processes is the inspection for witness marks or pin marks. The caveat of electrical test is that it needs to be done but at the same time, optimally, there should be no evidence it was performed. This can be a difficult process, especially on some of the more delicate finishes such as immersion silver or soft gold. The horrors of a complex multilayer order scrapping because of one stuck test pin during electrical test keeps sales personnel awake at night. Therefore, a robust inspection process is necessary.

In the past this was not as critical, as bare copper is robust and HASL could easily be reworked. However, as surface finishes have advanced and pad sizes reduced, a stuck fixture pin or overly aggressive flying probe compression can be catastrophic. In Figure 1, we see an example of severe damage caused by a malfunctioning test fixture. In most cases this scenario is fatal to the product.

A live inspection process is the most successful approach to minimizing loss due to test damage. This is not just limited to inspecting the product (which we do) but must include steps prior to that before product is even tested. Although this is more critical with fixture testers, inspection of the test probes, clamping mechanism, and automatic handlers (if applicable) should be inspected prior to testing on flying probes as well. For fixture testers it becomes more in-depth. First, you have the fixture itself which, depending on the scenario, may be a new build or an older repeat part where the fixture was stored for a length of time. This requires inspection of the fixture for missing or bent pins, faulty assembly, or damage incurred during storage. Next is the fixture integration to the fixture tester.

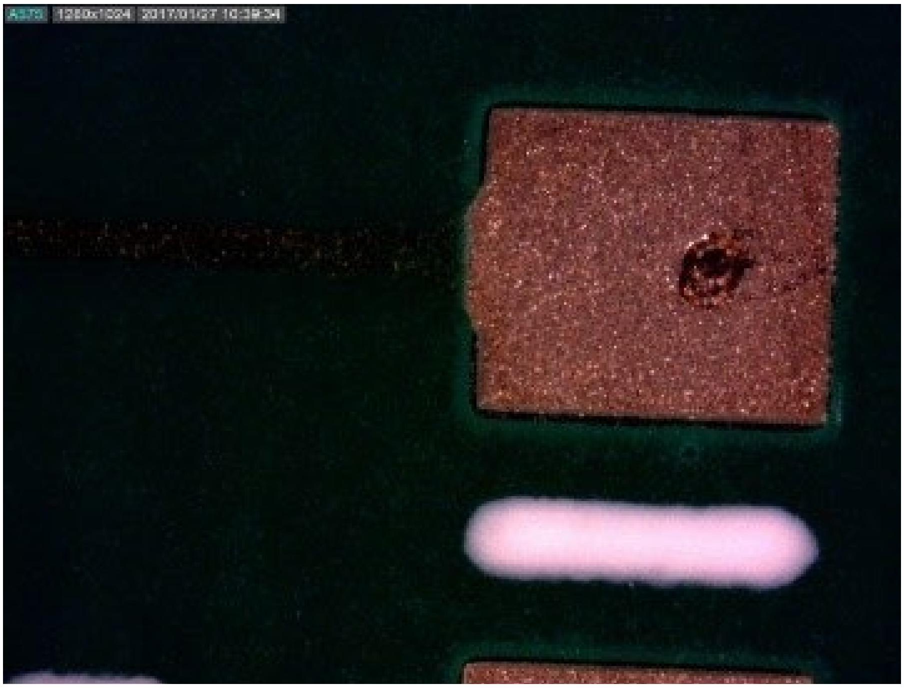


Figure 1: Fixture damage.

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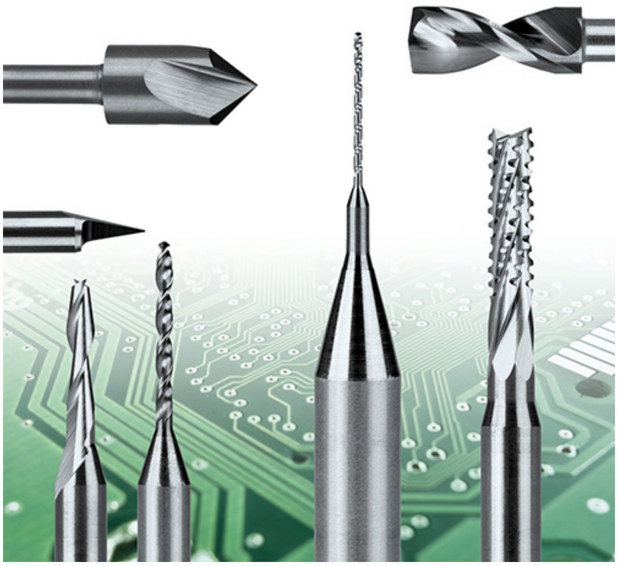

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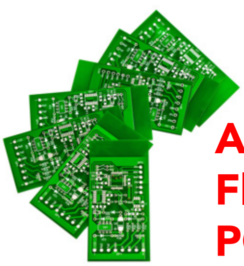

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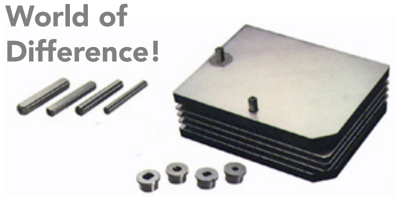

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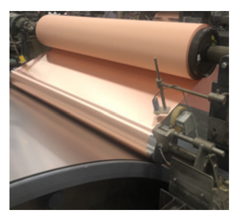

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The fixture needs to operate freely with no stuck pins. The largest variable contributing to damage is a bent pin or pin side-loading (pin sticking to the side wall of grid stripper plate), which locks the pin from free movement. Once this has been performed the electrical validation should take place. This includes a continuity and isolation test against a copper sheet (continuity) and non-conductive sheet (isolation.) These tests conclude the following:

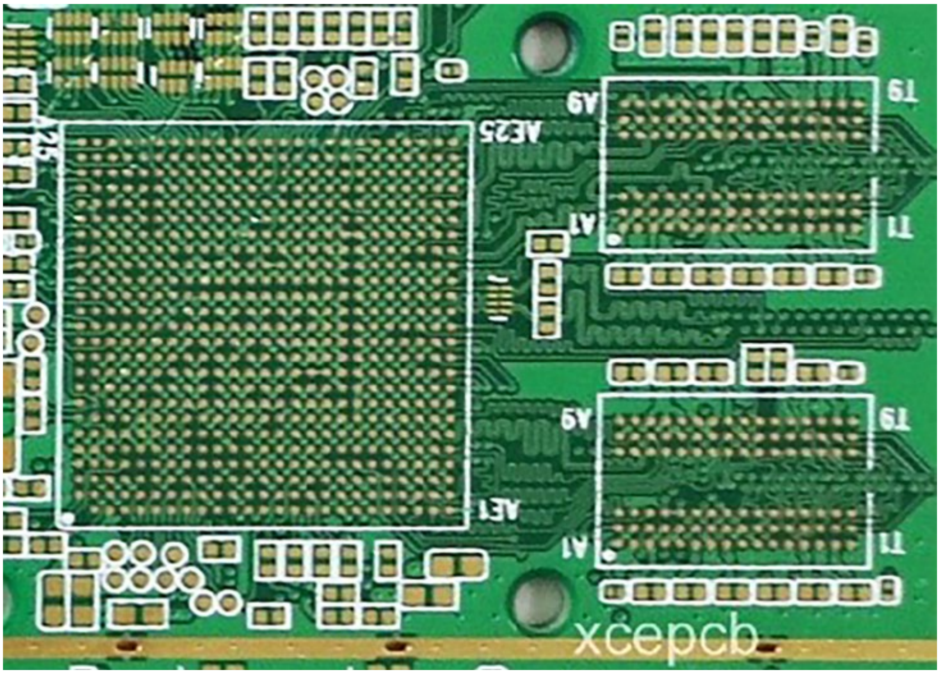


Figure 2: An example of higher-density areas that should warrant greater scrutiny.

1. Continuity: All pins are moving freely and conduct correctly to the fixture tester electronics. This will also identify faulty connections or missing pins.
2. Isolation: Provides validation that no shorts exist in the test matrix, either pin-to-pin in fixture or faulty test electronics.

It should only be after these critical setup steps are performed that the product be committed to test. When to inspect is now the question, isn't it? Absolutely. On fixture testers the optimum scenario is to run a test cycle on a pre-scrap board if one is available. However, many times there are none available and a live board must be used.

(Personal note: If the fixture has a diary or log of past performance, do not just use the logged compression values! This can be fatal as mechanical changes may have been made due to maintenance or service repairs.)

Always run at the least possible compression to provide desirable results. Once the board has been tested, regardless of the result, it should be inspected for witness marks. Do not trust your eye alone as with product technology today you will not be able to perform a valid inspection with the naked eye. It should be viewed under a scope.

Now, what to inspect? The examination should cover the entire board, but significant detailed inspection should isolate on the high-density areas and small pads. These areas are more prone to heavy witness marks as the pins are usually quite small and are more susceptible to damage. Figure 2 shows an example of higher density areas that should warrant higher scrutiny. Once the inspection is complete it can be determined whether continuing with testing is allowed or intervention is required. Intervention is usually an adjustment in compression or perhaps replacement of a test pin or two.

Once testing has begun it is recommended that an inspection matrix be created. How often should we inspect the product during the process? Inspecting 100% of a large order is counterproductive, I understand. Therefore, the matrix is necessary. Should we inspect every 10, 20, or 50? Early rules suggest first, middle, and last board of an order. This can work if the order is only 10–15 boards. Worst case scenario if the fixture test causes damage, it would be caught at the inspection interval. If we had 15 boards, we could catch it after board 5, or board 10. Although it could result in a loss of product it would be limited due to the inspection interval. It may be your local process to inspect all boards in that size of order and this is fine. The question really is based on large orders. We should still inspect the first and last board but if we wait until the middle of a large order, we could lose a significant amount of product, especially if the order is 100 pieces or larger. Here is where QMS discretion is advised. The matrix could break down the order by percentage and create an interval for inspection or it could simply state that on orders of X pieces or larger, every X board needs to be inspected. This allows containment quickly should a fatal error occur during test. It must also be noted that there should be a referee inspection done during these inspection intervals. This is simply referred to as a "buddy check." It is proven that the second set of eyes may capture a witness mark defect that is overlooked by the primary inspector. Repeatedly inspecting small pads and lines can be monotonous and pattern recognition fatigue can cause the visual senses to tire.

So now we have a setup process and a good understanding of the inspection process, and how, where and when to do it. Again, this all is part of the continuous improvement and quality assurance discipline. We need to own our processes and live them as well. Having integral steps in a process where it requires more than one person during a KPI check or inspection is always beneficial. This is by no means a knock to the primary operator but as humans, we can get tired, fall into repetition, and with that comes an increased margin for error.

As newer technologies emerge the ultimate solution would be to add AVI (automated visual inspection) to the final FA process. Even though we are inspecting the boards at regular intervals there remains a margin for error. Using a process where the test is performed and then an AVI is used to scan the surface of the board and sort by "pass" and "fail' would capture any and all surface defects.

Line = ET Tester + AVI Inspection + Auto sort pass/fail.

Another item to mention is where the mark may be placed. Many specifications call out the probing area "allowed." Many times, mechanical drawings may state a "pristine area" of the pad. This cannot have any marks whatsoever. It can be difficult many times, but when it's unavoidable, the absolute lightest contact must be made. In Figure 3, we show very light contact in a high-density BGA.

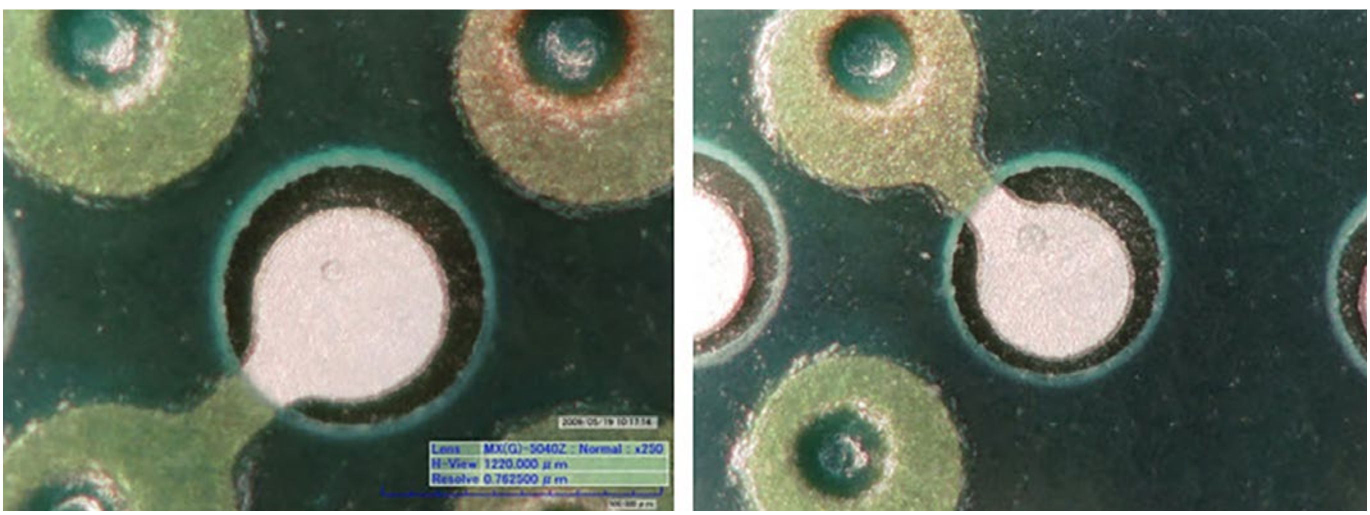


Figure 3: Very light contact in a high-density BGA.

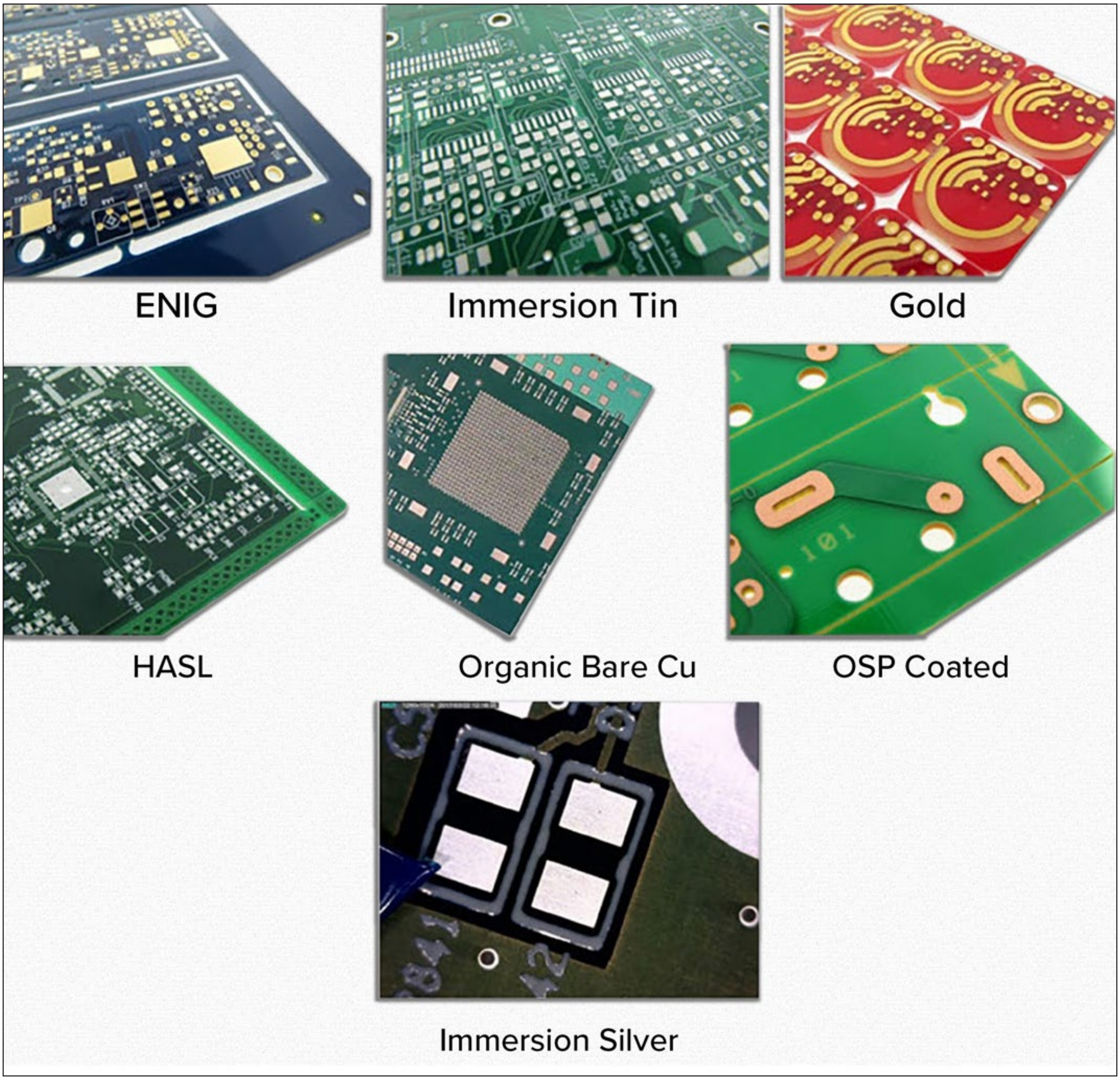


Figure 4: Some routine finishes.

Today's extreme densities and small pads are getting to the point that pinned fixtures are no longer the solution and flying probes or high-density wired dedicated fixtures are required.

I close with some finishes (Figure 4) that we come across routinely. By far the most susceptible finishes are the soft gold and immersion silver families.

Stay safe! **PCB007**

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

Supplier Highlights

Ventec UK Continues to Maintain Highest AS9100 D Quality Compliance ▶

Ventec International Group Co., Ltd. is pleased to announce that the company's European headquarters in Leamington Spa, UK, continues to maintain highest AS9100 Revision D compliance in accordance with the Aerospace Supplier Quality System Certification Scheme following successful completion of its surveillance audit.

New DuPont Production Line in Circleville Slated for Completion in 2H 2021 ▶

DuPont Interconnect Solutions, a unit of DuPont Electronics & Industrial, has announced its $220 million expansion project at the Circleville site is expected to be completed in the second half of 2021.

Kemmer Praezision Partners with Insulectro ▶

In this interview, Nolan Johnson and Gregor Dutkiewicz discuss Kemmer Praezision, their new working partnership with Insulectro, and some of the recent market challenges in mechanical drill bit technology.

Ucamco Announces Simultaneous Releases for UcamX and Integr8tor v2020.12 ▶

Ucamco announced that moving forward they will release new versions of their flagship products, UcamX and Integr8tor, simultaneously.

Atotech Prices Initial Public Offering ▶

Atotech Limited, a leading specialty chemicals technology company and a market leader in advanced electroplating solutions, has priced its initial public offering of 29,268,000 of its common shares at $17.00 per share.

Altix Receives Repeat Order for Multiple Roll-to-Roll Direct Imaging Equipment ▶

Trackwise is a dynamic company specializing in the manufacture of length-unlimited multilayer FPCs using Improved Harness Technology™ as well as PCBs for infrastructure antennas.

CCI Eurolam Group Names New Business Development Manager ▶

CCI Eurolam Group has named Carsten Doelfs as senior business development manager of PCB Laminates for EMEA. A veteran in the industry, he has held key positions in PCB manufacturers and global CCL maker, Isola, for 27 years.

Aismalibar Adds Arkeo Stack to Library of Software Tools ▶

Aismalibar thermal conductive laminates has added Arkeo Stack software to their library of software tools aimed at offering additional "value add" for their customer base.

MacDermid Alpha to Promote Latest Interconnect Tech, Present on Microvia Reliability at 2021 Virtual IPC APEX EXPO ▶

MacDermid Alpha Electronics Solutions, leaders in innovative electronic interconnect technologies, was scheduled, at press time, to present their recent product releases and latest innovations, at the IPC APEX Virtual Conference and Expo.

Developing New SIR Standards

Feature Article by Graham Naisbitt
IPC COMMITTEE CHAIR

Background

The current IPC TM-2.6.3.7 SIR test is targeted at typical applications. That is where the minimum PCB feature is separated by more than 200 µm, and the voltage is within the approximate range of 10 to 100V. The test duration states not less than 72 hours; by committee agreement this was to revert to 168 hours, but evidence is now available that flux residues may lie dormant for beyond 500 hours in service, and hence there is a need for a three- or four-week test.

There are two developing different technology regimes:

1. High voltage (~1000V) electronics for electric vehicles.
2. Low voltages and fine pitch devices (~2V and <100 µm feature size) in the medical and space industries.

The existing TM-2.6.3.7 is not appropriate for these technologies. For example, in the high voltage testing standard ISO PAS 19295:2016(E), electric components or circuits are required to operate with a maximum working voltage between 30 V a.c. (rms) and 1,000 V a.c. (rms) or between 60V d.c. and 1500V d.c

An impetus for a new test has been created by the removal of the ROSE test from Rev G of JSTD-001. There is a desire to qualify cleaning efficacy underneath bottom-terminated components (BTC) by using a modified SIR test, along with a new test vehicle that can take advantage of low-cost test vehicles, and use SIR patterns underneath the BTC to evaluate cleaning efficacy.

Following on from a current HDP User Group project into corrosion, a method will be produced to look at pitting and crevice corrosion through solder mask. Here, a modification of the SIR technique is proposed to evaluate solder mask integrity and uses a new test vehicle.

Aim

The aim here is to develop new SIR standards to cover the low and very high voltages, and validate the developed approach with

a Gauge R&R study, all under the auspices of IPC. The work will build on the approach in TM-2.6.3.7 but will tailor the approach appropriately for the two technology areas. TM-2.6.3.7 will also be updated from the current 2007 version, with incorporation of the new B53 pattern which incorporates a 200 µm SIR pitch pattern. The new standard will also look at test duration, which will include an option to test for at least 500 hours and possibly beyond 1,000 hours.

The cleaning efficacy SIR evaluation, and the corrosion of solder masks, will follow a similar path, with the development of test vehicles, dummy components, and a test protocol. The IPC SIR committee 5-32b will lead the development of the documents and organise a round robin trial with Gauge R&R validation.

Funding

The standards will be written as now within 5-32b, by voluntary work. Production of the samples might be funded by IPC, and then the intercomparison work by the collaborators will take place at their expense.

Methodology

For these we need a consensus on the track and gap for the patterns. Our current point is 25 V/mm, with the 200 µm (B53) and 500 µm (B24) patterns. For the low voltage application, it is envisaged that the test voltage of 2V and ~50 µm track spacing, and this will lead to 40 V/mm. With high voltage testing an anticipated field strength of 500 V/mm is expected, hence with a 1000V test the feature spacing will be 1 mm.

It has been demonstrated that electrochemical processes will not always scale with feature size, or SIR pattern pitch, and the applied voltage. Hence, careful consideration must be given to the applied test, and the conditions of the test must be applicable to the use case. If not, the produced data can be valueless. Therefore, new test coupons will be required and the input from the wider industry is essential to define the requirements.

New material systems are known to have a long incubation period before the onset of corrosion; periods of up to 500 hours have been noted. Testing at >1000V may generate failure modes that occur over relatively long distances and hence may take even longer times, test durations of over 1,000 hours may be required.

Proposals for the cleaning efficacy SIR evaluation and the corrosion of solder masks will be brought forward.

Validation

When the committee agrees, the test methodology, the method, and chosen test vehicles need to be validated. Previously an intercomparison was organised jointly by IPC and the IEC, and the results were reported and published as IEC TR 61189-5506. This report compared the response using SIR patterns with 500 µm, 318 µm and 200 µm conductor separation. The test coupon used for this was IPC B53 Rev A. These results are now an important part of the updating of TM-2.6.3.7. The development work described here plans a similar exercise with the to-be-developed standards and test vehicles.

Work has already started and there is a Rev B to IPC B53, the development of which was intended as a potential replacement for IPC B24, B25 and B25A coupons. A further refinement of the B53 to the B55 has also been designed which contains an extra pair of patterns with 50-µm spacing. Both of these new boards are shown in Figures 1 and 2.

The plan is to start this work imminently and produce the necessary draft standards and test vehicles. An A team would be formed, and it is anticipated that this may include the following partners:

- GEN3: UK—Graham Naisbitt and Dr. Chris Hunt
- Electrolube: UK—Phil Kinner
- Precision Analytical Laboratories; Kokomo, USA—Joe Russeau
- Magnalytix: USA—Mike Bixenman

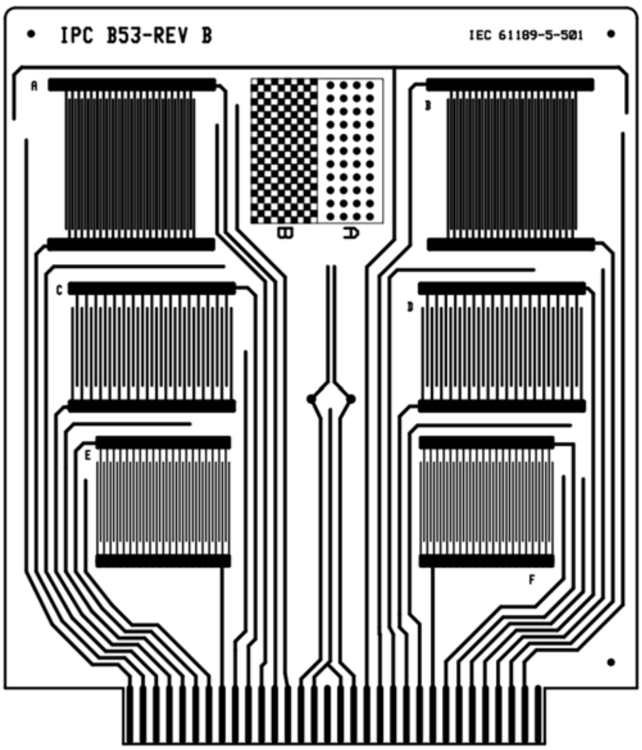


Figure 1: IPC B53 Rev B.

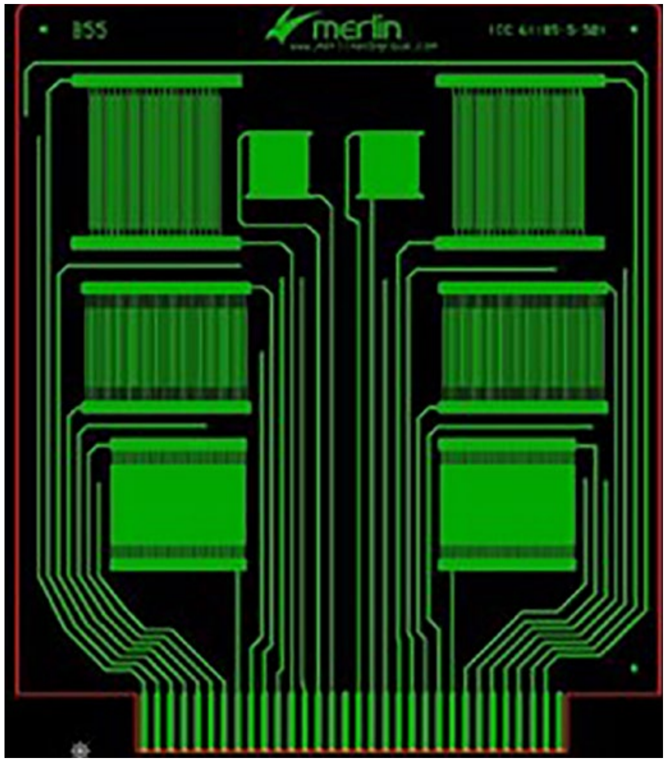


Figure 2: Proposed IPC B55.

- Robert Bosch: Germany—Lothar Heneken
- Hytek: Denmark—Poul Jool
- Nihon Genma: Japan—Hagio-san
- Medtronic: USA—TBD
- Alpha Assembly Solutions: USA—Karen Tellefsen

This entails assessing electrochemical reliability using SIR/ECM testing.

The J-STD-001 requirement is to produce acceptable "Objective Evidence."

It was agreed at the meeting, that a flowchart is required (Figure 3).

As can be seen in Figure 3, SIR/ECM

5-30 Additional Development Work

Following the release of WP-019 and the meeting of 5-22A ROSE AT (Rhino) on Thursday, June 4, 2020, IPC advised that there is a requirement to provide better support to the industry with a suitable test protocol beyond IPC 9202 and IPC 9203.

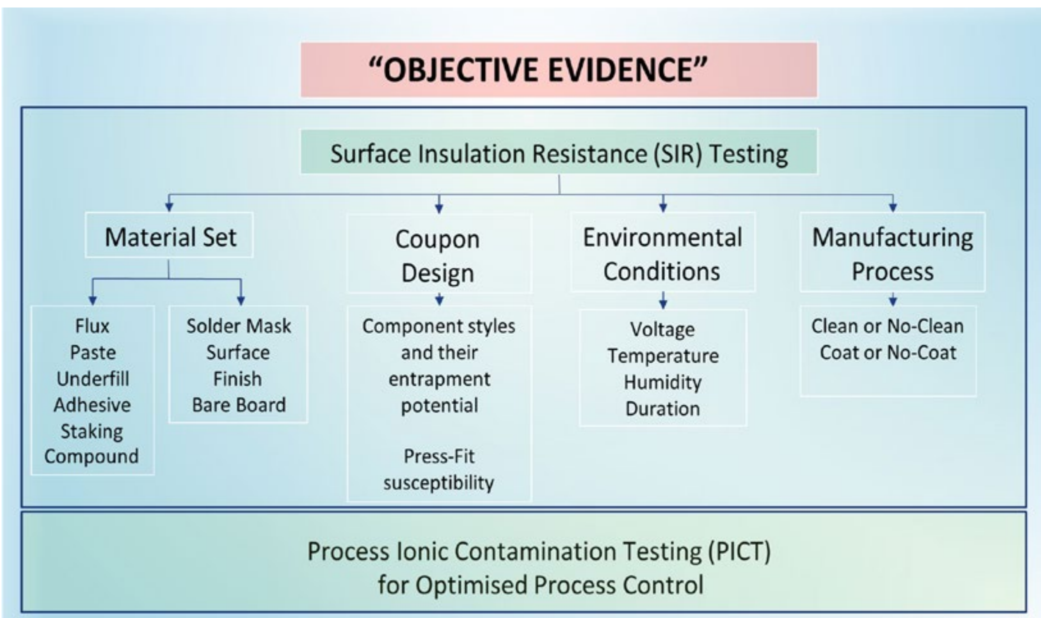


Figure 3: Example flow chart of requirements.

- 5-30 Cleaning and Coating Committee
  - 5-31 Cleaning and Alternatives Subcommittee
    - 5-31d Cleaning Handbook Task Group
    - 5-31g Stencil Cleaning Task Group
    - 5-31j Cleaning Compatibility
  - 5-32 Cleanliness Assessment Subcommittee
    - 5-32a Ion Chromatography/Ionic Conductivity Task Group
    - 5-32b SIR and Electrochemical Migration Task Group
    - 5-32c Bare Board Cleanliness Assessment Task Group
    - 5-32e Conductive Anodic Filament (CAF) Task Group
  - 5-33 Coating Subcommittee
    - 5-33a Conformal Coating Task Group
    - 5-33awg Conformal Coating Requirements Working Group
    - 5-33b Solder Mask Performance Task Group
    - 5-33c Conformal Coating Handbook Task Group
    - 5-33d Solder Mask Handbook Task Group
    - 5-33e Legend Inks Task Group
    - 5-33f Potting and Encapsulation Task Group
    - 5-33g Low Pressure Molding Task Group

Figure 4: 5-30 The Cleaning and Coating Committee Group.

measurements have broad requirements across many different materials and processes most of which fall into the purview of the 5-30 Cleaning and Coating Committee Group (Figure 4).

Action Points arising from the drivers of this development work as they pertain to the various sub-committees 5-30 are:

- 5-32a: I have asked for a revision of 2.3.25 re-adapted as a process control test
- 5-32b SIR/ECM has already prepared a "Process Control Characterisation Test using SIR" that goes beyond the soon to be published IEC 61189-5-502 Standard
- 5-32c Cleanliness Assessment and 5-32e CAF will be required to consider bare laminates, surface finishes and solder masks
- 5-33a Conformal Coating should consider adopting the IPC B53 test coupon
- 5-33b Solder Mask should consider adopting the IPC B53 test coupon

It is anticipated that the respective committee chairs will agree to take forward the proposed action plan.

This document is submitted for review and consideration of all involved committees in IPC. PCB007

Graham Naisbitt is vice-chair 5-30, chair 5-32b, and vice-chair 5-32e. Naisbitt is the author of *The Printed Circuit Assembler's Guide to Process Validation*. You can also watch our roundtable discussion on the subject here. Please also listen to this audio interview from IPC APEX EXPO 2021.

Electronics Industry News and Market Highlights

Nokia, Brazilian Research Group CPQD Partner to Develop 5G ORAN Solutions ▶

Nokia has announced a partnership with Brazil's Telecommunications Research and Development Center (CPQD), an independent government-affiliated research body, to jointly develop applications and solutions based on the Open RAN (O-RAN) compliant near-real-time RAN Intelligent Controller (RIC).

Aramco, AEC Launch Cybersecurity Solution, Designed and Manufactured in Saudi Arabia ▶

Advanced Electronics Company, a Saudi Arabian Military Industries (SAMI) company, has signed an agreement with Aramco to launch a new cybersecurity product designed and manufactured in the Kingdom. Known as a "data diode," it is the result of cooperation between the two companies on designing and manufacturing the product.

TELUS, Google Form Strategic Alliance to Bring Digital Transformation to Key Industries ▶

Google Cloud and TELUS announced a strategic alliance to co-innovate on new services and solutions that support digital transformation within key industries, including communications technology, healthcare, agriculture, security, and connected home.

Avnet, ON Semiconductor Accelerate IoT Innovation with New Development Framework ▶

Leading global technology solutions provider Avnet and ON Semiconductor, driving energy efficient innovations, have joined forces to create a framework that helps OEMs more rapidly develop end-to-end Internet of Things (IoT) devices.

Headset Advisor: Can You Hear Me Now? ▶

Dan Feinberg and Nolan Johnson recently spoke with David Merritt of Headset Advisor, a company that specializes in supplying headsets to businesses and call centers of all sizes. They discuss the company's business model, how the pandemic has affected their business, and how the needs of employees have changed in the past year.

Siemens, MaRS to Accelerate Innovation for Startups in Development of Autonomous, Connected Vehicles ▶

Siemens Digital Industries Software and MaRS Discovery District, a Toronto-based innovation hub, have partnered to provide over 1,400 Canadian science and technology companies with access to Siemens' Xcelerator™ portfolio of software and services to support and accelerate the development of autonomous and connected vehicle technologies.

WISeKey Combating Counterfeit, Extending AIoT with arago's AI, Automation ▶

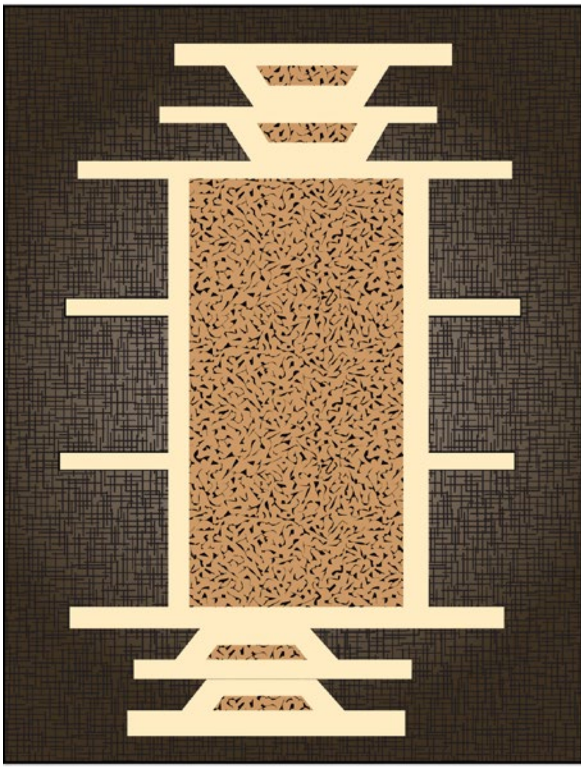
WISeKey International Holding Ltd, a cybersecurity AI IoT platform company, has announced that its solution for brand protection is now able to minimize counterfeiting and fraud by adding AI to the trusted digital identities of goods and luxury products to track and protect any item in real-time.

TLPS Paste-Filled Vias for HF PCBs

Article by Catherine Shearer
ORMET

The electronic packaging industry is undergoing a revolutionary convergence between the printed circuit board segment and the semiconductor packaging segment. New streamlined and hybrid package architectures are emerging to meet future product requirements—particularly for mobile electronics and wireless infrastructure to support industry megatrends like 5G and autonomous driving. There are new challenges for forming electrical interconnections between different types of package elements while maintaining high volume manufacturability and reliability across a spectrum of operating environments.

In particular, the use of high speed and high frequency dielectric materials complicates the PCB fabrication process. Generally, these low-loss and low-Dk materials are not amenable to multiple lamination cycles due to the nature of their chemistry; however, conventional PCB fabrication techniques that circumvent this problem by using plated-through-holes introduce undesirable resonance structures and consume precious real estate that could otherwise be used for routing.



Transient liquid phase sintering (TLPS) paste (such as that manufactured by Ormet) can be used to effect vias to either augment or replace sequentially formed plated microvia interconnects, which necessitate multiple lamination cycles, as well as plated through-holes (PTH) with their attendant loss of routing density and lossy stubs. TLPS-filled Z-axis interconnect layers can be fabricated in parallel with individual X-Y trace layers or PCB subconstructions of multiple layers with PTH, interleaved, and laminated in a single cycle. The circuit layers, thus electrically joined through the Z-axis, can be of the same or different materials, complexity and native construction. The adhesive surrounding the TLPS interconnects and mechanically joining the circuit layers can be prepreg or film adhesive and can be selected for its dielectric and mechanical characteristics. With an appropriate adhesive layer, the TLPS Z-axis interconnect concept is extendable to applications outside of PCB construction including area array assembly and thermal transfer.

TLPS pastes, which metallurgically bond to circuit pads, offer both high performance and versatility of installation that is conducive to high manufacturing volumes. Sintering pastes can be formulated with a variety of particle sizes and flow behavior, allowing this technology to provide a spectrum solution to applications from filled microvias in either a printed circuit board or semiconductor package scale, to printed bumps for interconnection of subassemblies, to thermal interfaces with embedded heat sinks.

TLPS pastes, which metallurgically bond to circuit pads, offer both high performance and versatility of installation that is conducive to high manufacturing volumes.

PCB constructions continue to increase in complexity resulting in ever more difficult-to-fabricate high aspect-ratio PTHs and increasing lamination cycles with dielectrics that do not tolerate multiple laminations well. TLPS paste-filled via layers offer an opportunity to circumvent many of these problems. Using TLPS paste via layers, high-aspect-ratio PTHs can be broken into manageable sizes and joined in a single lamination. Likewise, for high-density interconnects (HDI), double-sided circuits can be fabricated in parallel and microvia anywhere interconnects can be made with the TLPS paste via layers—also in a single lamination. Besides eliminating low-yielding process steps and substantially reducing cycle time, the use of TLPS via layers also improves high frequency circuit performance by eliminating lossy stubs. A logical extension of this long-proven PCB fabrication method is embedding discrete passive components in the same process in which the Z-axis interconnects are formed.

Catherine Shearer

TLPS pastes have been specifically engineered for thermal stability post-lamination. The sintering reaction of the TLPS metallurgy, which happens concurrently with the curing of the prepreg/lamination adhesive, essentially 'thermosets' the metallic network. The sintered vias do not remelt below 400°C but do have a fully reversible modulus drop at about 190°C to mitigate the high expansion of PCB laminates through their glass transition temperature. This combination of features enables the TLPS vias to withstand multiple lamination and assembly cycles without degradation, as well as provide compatibility with harsh environment operation. These robust features have resulted in TLPS paste via layers' successful deployment as Z-axis interconnect in military and aerospace applications for over two decades. PCB007

Catherine Shearer is head of Conductive Paste R&D at Ormet.

MilAero007 Highlights

Wild River ISI-56 Platform Accelerates SerDes Testing ▶

Al Neves, founder and CTO of Wild River Technology, speaks about the release of their new ISI-56 loss modeling platform. Al explains why it was so critical that this tool meets the stringent requirements of the IEEE P370 specification (which he helped develop), and why he believes this is currently the best tool for SerDes testing and characterization.

X-Rayted Files: The Dark Side of the Chip Shortage—Counterfeits ▶

As the world slowly recovers from the COVID-19 pandemic, another problem plagues the global economy: the electronic component shortage. What some economists have deemed to be a decade of immense prosperity and growth, the "Roaring Twenties" started with a hiccup.

BAE Systems Backs Local Tech Company with Global Defense Capability ▶

World leading 3D volumetric display technology developed by South Australian company Voxon Photonics has won new work with BAE Systems' UK-based submarine business and the Australian-based Hunter Class Frigate program.

New Defense Electronics Group Invites Industry Participation ▶

The U.S. Partnership for Assured Electronics is inviting electronics manufacturers and related companies to participate in its programs, highlighting the opportunities to collaborate with industry peers and the U.S. government. The USPAE was established in 2020 with a mission of ensuring the U.S. government (USG) has access to resilient and trusted electronics supply chains. The USG has many electronics needs, especially for defense- and security-related missions, and the USPAE is lining up funding and collaboration opportunities to address those needs.

USPAE Launches $42M DoD Consortium ▶

The I-Connect007 editorial team recently interviewed Chris Peters, Kevin Sweeney and Shane Whiteside, members of the U.S. Partnership for Assured Electronics (USPAE), about the award the association received from the Department of Defense to create the Defense Electronics Consortium. In this conversation, they discuss the objectives of the consortium, which was created to help the government identify and address potential risks in the electronics industry.

Defense Speak Interpreted: So, What's a JADC2? ▶

The term JADC2 was prevalent in the late 2020 debate about the National Defense Authorization Act. It is a new way defense is using electronics to shape battle strategy. JADC2 is Defense Speak for "Joint All Domain Command and Control." Sounds impressive, doesn't it, but what does that mean?

Brain-to-Brain Communication Demo Receives DARPA Funding ▶

Wireless communication directly between brains is one step closer to reality thanks to $8 million in Department of Defense follow-up funding for Rice University neuroengineers.

Process Defect Anomalies, Part 1—The Case of Etch Resist Attack

Trouble in Your Tank

by Michael Carano, RBP CHEMICAL TECHNOLOGY

Introduction

Troubleshooting process-related defects is not as simple an exercise as we would like to believe. The printed wiring board fabrication process is a complex set of mechanical and chemical processes containing multiple steps. When even one of the process steps is not in control, end results can be disastrous. Further confounding the engineer responsible for solving these issues is often the over-reliance on the belief that the defect noted in a certain process step had its genesis in that step. And this assumption is often incorrect. Experience has taught us that while the defect may be detected only after a particular process step (e.g., voids in the via after electrolytic plating), the origin of that void may have been in the PTH process or the result of poor drilling. These are just a few examples. To be successful in determining the problem and root cause identification, one must look at the defect holistically.

In a future column, I will present a few suggested approaches to problem solving and defect mitigation. For now, I present a view of some defects where at first glance the origins are not obvious.

The Case of the Etch Resist Etch-out

When voids in the PTH are detected after etching, it is quite easy to assign root cause to the etching operation. While there are no complete voids seen in Figure 1, one can surmise that the thin areas will eventually form a void or voids. While it is true that the etching operation is what is in action here, the etching process was deemed in control and there were no etch-out voids seen on other part numbers.

Take a closer look at the cross-section. What is noted first on the pads? There is a noticeable tapering of the copper indicating that the tin etch resist did not hold up to the etchant. True, the tin either was absent initially, or was of insufficient thickness to withstand the action of the etchant. In addition, there is a thinning down of the copper in the plated through-hole indicating the same. So, why can't the engineer

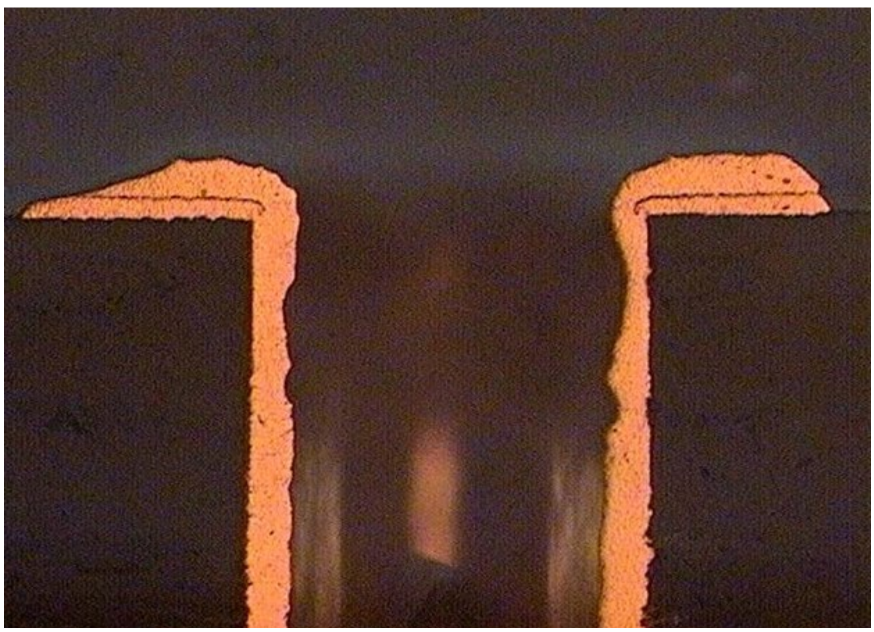


Figure 1: Note the ragged copper where the tin etch resist has been removed by the etchant.

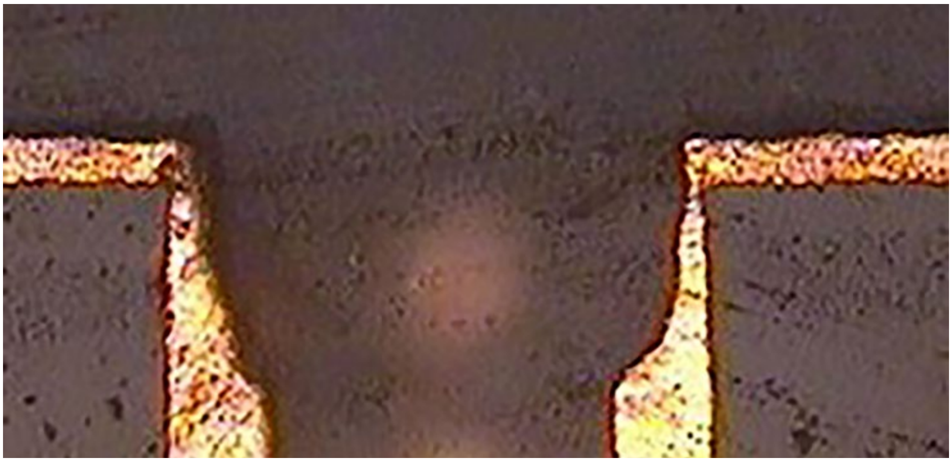


Figure 2: The tapering of the copper plating moves from the center of the hole to the knee and pad of the hole.

blame the etching operation for the condition shown in Figure 1? There is further evidence in a section shown in Figure 2.

As shown quite clearly in Figure 2, there was an issue related to the tin plating. There is sufficient thickness of copper as the plating moves down the plated through-hole.

When presented with this situation, the troubleshooting team should approach the problem-solving exercise as follows:

Available methodologies are the TQC PDCA process: Plan–Do–Check–Act; and the Six-Sigma DMAIC process: Define–Measure–Analyze–Improve–Control. Both are used in formal problem-solving exercises. Many of you are also familiar with the General Scientific Method:

- Define the question/make observations
- Gather information and facts
- Form hypothesis
- Perform experiments and collect data
- Analyze data
- Interpret data and draw conclusions
- Summarize results

In a future column, I will present a more detailed discussion of problem-solving and methodology. For purposes of this month's column, a less formal approach is used.

The engineers and operators determined the etching process was in control. Data supports that statement. Not all part numbers processed by the fabricator exhibited this condition.

Looking back on the plating operation, samples of randomly selected part numbers not yet etched were checked for tin plating thickness. While plating thickness within the vias met minimum thickness requirements (0.30-0.35 mils), there were pads showing considerably less tin (0.12-0.15 mils); and even thinner on the knees of some holes.

Armed with this information, the team determined as a first approach to review the tin electroplating process as well as any issues in the control of the tin process. The information gathered provided the following:

- Tin plating thickness was within specification in the holes
- Tin plating thickness on some part numbers showed very thin tin on the surface (pads) but not within the vias
- Electrical connections were checked to ensure that sufficient current was flowing from the power supplies to the cathodes (the boards)
- Tin plating was non-uniform on the pads (in many cases) and very thin over the knee of some of the larger diameter vias (in most cases this occurred randomly)

Now, as a point of further information, the fabricator was using a semi-bright tin plating process. This included controlling two separate organic addition agents. One of the additives is a grain refiner and wetting agent designed to insure a more even plating distribution across the panel. The second additive is used to improve throwing power, especially in small diameter vias. Upon further analysis, it was discovered that the ratio of the two additives were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out of the normal operating range. In this case, the second additive was much higher in concentration in the working plating solution. This caused the tin plating to be suppressed in areas of the board including the pads and the knees of the vias. The thin plating is then susceptible to attack by the etchant, leading to voids or, at the very least, thin copper in those areas.

While the case described here happens all too often, there are several other potential causes that will be presented in Part 3. PCB007

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

Transportation in the News

Transportation news, and particularly automotive news, has had its share of coverage across many platforms. This brief index highlights just some of the recent news reporting in I-Connect007 since October 2020. I-Connect007 understands the importance of electronics in the transportation industry and will continue to report on new and upcoming developments in transportation technology. For now, please click the links below to read back on what you may have missed.

Zoox Reveals First Look at Autonomous, Purpose-Built Robotaxi

dSPACE, LeddarTech to Drive Development of Lidar Innovations for Self-Driving Cars

NXP Announces Radar Sensor Solutions for 360-degree Safety Cocoon

Autotech Co Hong Kong Limited Completes Two-Year Autonomous Research Project

electronica Virtual 2020: Automotive Conference Keynotes
Pete Starkey, I-Connect007

OmniVision, Ambarella and Smart Eye Partner on Driver Monitoring, Videoconferencing Camera Solution

Volvo Cars Now Designing, Developing Electric Motors In-house

X-Rayted Files: A Century of X-Rays in the Automotive Industry, Part 2
Bill Cardoso, Creative Electron

GM Marks Progress Toward All-Electric Future with Factory ZERO

Foxconn Aims to Enter Global Electric Vehicle Market

Würth Elektronik Sponsors Students' Solar Car Projects

Trackwise Signs Flex PCB Agreement with UK EV Manufacturer

X-Rayted Files: A Century of X-Rays in the Automotive Industry, Part 1
Bill Cardoso, Creative Electron

AT&S Contributes to CHARM Solution for Autonomous Driving

Lattice Extends Industry-leading Security and System Control to Automotive Applications

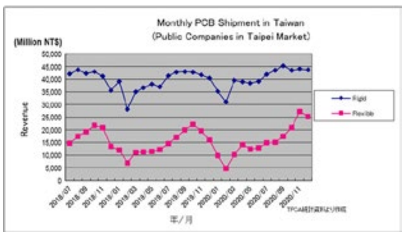
DigiLens Brings Ultra-Compact CrystalClear AR HUD to Any Auto Dashboard

DEKRA Expands Automotive Testing, Certification Services in Asia

Aeva and ZF Bring First FMCW LiDAR to Automotive Production

Editor Picks from PCB007

1 EPTE Newsletter: Taiwan Releases 2020 PCB Production Numbers ▶



The Taiwan Printed Circuit Association (TPCA) released December's shipment data. Full year data is also posted for 2020, so it's time to review the industry's performance.

2 Predicting a 'Roaring Twenties' Innovation Boom ▶

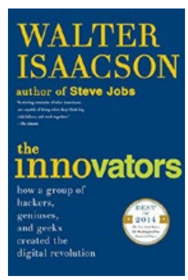

Hailey Mckeefry

The 2020s have not started as anyone would have wished. The COVID-19 pandemic has exposed weaknesses in supply chains and in global manufacturing, yet this could still be the most innovative decade ever.

3 North American PCB Industry Sales Begin 2021 Up 4% ▶

IPC announced the January 2021 findings from its North American Printed Circuit Board (PCB) Statistical Program. The book-to-bill ratio stands at 1.14.

4 Joe Fjelstad's Book Review: The Innovators ▶



"The Innovators: How a Group of Hackers, Geniuses, and Geeks Created the Digital Revolution" by Walter Isaacson is the best technology history book I have ever read, and at the same time one of the most engaging and entertaining. It is a forte of Isaacson to write biographies of great people. I have read his other books on Leonardo da Vinci, Steve Jobs, Ben Franklin and Albert Einstein and found them equally brilliant. Isaacson has a number of other titles I have yet to get to. He is a singularly great storyteller.

5 Better to Light a Candle: Chapter 11—Expanding and Adapting in the Face of the Pandemic ▶

The loosely affiliated team that is working this one aspect of the future staffing shortfall has accepted the working title, "Electronics Manufacturing Technical Education Project." It exists to support and facilitate post-secondary educational programs for next generation electronics manufacturing staff here in North America.

6 Insulectro to Distribute Indubond® Lamination Presses from Chemplate Materials SL ▶


Victor Gallego

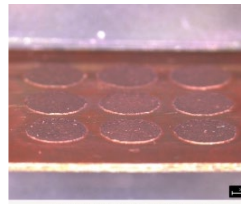
Insulectro, the largest distributor of materials for use in the manufacture of printed circuit board and printed electronics, has announced it will distribute InduBond® lamination presses and supplies manufactured by Chemplate Materials SL of Barcelona, Spain.

7 The PCB Norsemen: Attacking the Loophole That Does Not Exist ▶


Jan Pedersen

When producing PCBs, we follow IPC standards for Qualification Performance and Acceptance from design, through production, to customer incoming inspection and acceptance. However, there is always a way of writing a standard and a different way of interpreting it.

8 Kuprion Introduces ActiveCopper Filled Thermal Vias ▶



Kuprion, Inc., a spinout of Lockheed Martin, has introduced ActiveCopper™ Filled Thermal Vias, leveraging a patented technology breakthrough that addresses the increased reliability demands of heat and power dissipation for complex, advanced high-performance systems.

9 Trouble in Your Tank: Process Management and Control—Benchmarking Best Practices ▶


Mike Carano

Minimizing defects and improving yields is especially important as technology is becoming ever so complicated, and additional focus must be placed on yield improvements. This is where process management and control must be front and center.

10 The Right Approach: Leadership 101—The Law of the Lid ▶

In this second installment of Leadership 101, it is wise to review the premise of this series: Good leadership always makes a difference; unfortunately, so does bad leadership. Here, Steve Williams discusses the first of 21 Irrefutable Laws of Leadership, The Law of the Lid.

Career Opportunities

How Do Your Team Members Stack Up?

Find industry-experienced candidates at I-Connect007.

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

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We're Hiring!

Atlanta Georgia Facility

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

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

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

Qualifications:

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

What We Offer:

- Excellent salary and benefits commensurate with experience

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

apply now

Circuit Engineering

Planning Engineer

Experience

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

Responsibilities

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

Quality Engineer/Manager

Experience

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

Responsibilities

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

Sales Associate/Customer Service

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

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

Contact: Felix Simon: +1 (847) 867-7942

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Career Opportunities

Manncorp™

SMT Operator
Hatboro, PA

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

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

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

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

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

apply now

Manncorp™

SMT Field Technician
Hatboro, PA

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

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

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

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

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Career Opportunities

Career Opportunities

I-007e EDUCATIONAL RESOURCE CENTER

Webinar: For more information about the iamcam concept, please request the iamcam webinar video via presales@ucamco.com.

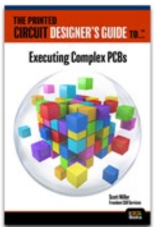
Roundtable: “Use of IMS Thermal Materials in Multilayer Stackups for Power Applications” with Ventec International Group and Excello Circuits.

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

Thermal Management: A Fabricator’s Perspective

by Anaya Vardya, American Standard Circuits

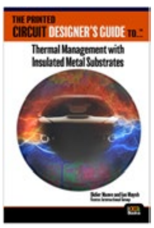
Beat the heat in your designs through thermal management design processes. This book serves as a desk reference on the most current techniques and methods from a PCB fabricator’s perspective.



Executing Complex PCBs

by Scott Miller, Freedom CAD Services

Readers will learn how to design complex boards correctly the first time, on time. This book is a must-read for anyone designing high-speed, sophisticated printed circuit boards.



Thermal Management with Insulated Metal Substrates

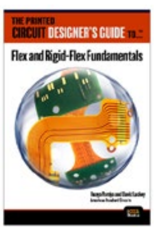
by Didier Mauve and Ian Mayoh, Ventec International Group

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

Fundamentals of RF/Microwave PCBs

by John Bushie and Anaya Vardya, American Standard Circuits

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



Flex and Rigid-Flex Fundamentals

by Anaya Vardya and David Lackey, American Standard Circuits

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

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

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