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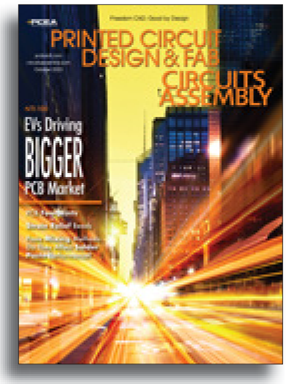

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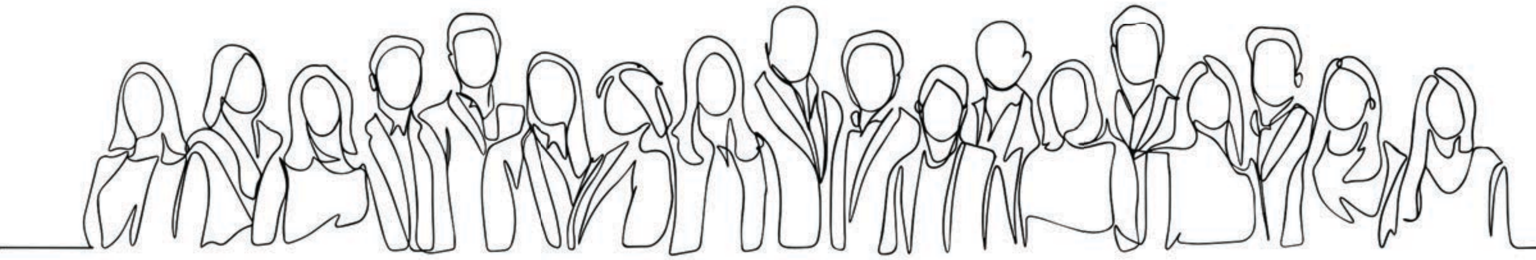

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New AI Tools Offer Look, and Questions, for Future

WHAT ROLE WILL artificial intelligence truly play in electronics design, and what will the impact be on hardware engineers?

Zuken took a step toward answering that question with its announcement at PCB West of a new AI-based tool for printed circuit place-and-route. Yet the first public mention of AIPR for CR-8000 – the actual rollout will come in the first quarter next year – poses not only a dramatic vision for a highly automated future of design but a host of new questions as well.

The new tool itself is an extension of Design Force, Zuken's layout, routing and verification tool within the CR-8000 platform. Its AI, explained Kyle Miller, Ph.D., who architected the engine, involves all three basic types of machine learning: supervised, unsupervised and reinforcement. AIPR stands for Autonomous Intelligent Place and Route, and like previously announced AI-based CAD tools, it starts with routing. The "Basic Brain" performs so-called smart routing by means of exposure to Zuken's database of PCB designs built in CR-8000. Over time, it mimics human routing, with channels organized in logical ways. Smart placement is next, at an undisclosed time.

According to Bob Potock, vice president of sales and marketing, Zuken will add IPC-2581 capability as part of the next-generation Dynamic Brain, allowing designs from other ECAD systems to be incorporated and learned.

The first two stages are working up to Autonomous Brain, a goal-based utility that the product designers, including Miller, say will use text-based inferencing whereby it detects descriptions of different parts of boards. According to Miller, four functionality levels will be used to inform local and planning decisions.

The system, notes Steve Watt, manager of PCB engineering, can learn from both good and bad designs. "The brain can be untaught if it is sent a dirty design," he said. Zuken has tested it on about 100 designs, most of the high-speed, digital variety.

Adds Miller: "PCBs are complex. They involve numerical data, geometrical data, the layers in the board, text, constraints … Autonomous Brain is multi-modal; it combines all these data and extracts the designer's intent."

The Zuken announcement came on the heels of a broadcast from Cadence, which is now tying its OrCAD X platform to a cloud-enabled solution that uses AI-powered placement to cut design time while allowing multi-user collaboration on a common job. Siemens has taken a different path, leveraging its Simcenter PLM tools with AI to fit the design to the form factor based on a mix that takes into account factors such as costs and stackup, and also uses AI in its Hyperlynx DRC and PI tools.

All these features are funneling toward a common goal: cutting the amount of time spent on design. But there is pushback, not in the least from the (very large) segment of the industry that eschews readily available automation tools such as autorouters. And what will be the impact on job security?

Those concerns, among others, were raised during a free panel session titled AI in Electronics: What Can We Expect? at PCB West. There, Miller joined a group of experts, including Michael Jackson of Cadence, Tomide Adesanmi of Circuit Mind, and Sebastian Schaal of Luminovo, who with moderator Louis Feinstein of Dassault Systèmes tackled some of the more stubborn issues surrounding higher automation.

"Will I lose my job?" seems to weigh heavily on some engineers' minds. Cadence's Jackson answered that with a definitive "no."

"It reduces the time to do the job," he said, adding "as the technology matures, that may change." Feinstein, who also keynoted the conference, noted that the number of open positions for PCB designers far exceeds the number currently employed, suggesting that automation such as AI is not only inevitable, but essential.

"It's about multiple possible solutions," chimed in Miller. AI tools can run several iterations of the same layout quickly, offering a number of options to the designer without requiring additional manual labor. "The overall control is still with the designer," he said.

Indeed, with designers in high demand due to the aging out of many veterans and the length of time and amount of knowledge it takes to develop expertise, some of the concerns about AI replacing humans are eased.

In fact, AI tools remove much of the grunt work from PCB design, Adesanmi implied. “Think about the role of an EE. We break jobs into different tasks. What will we spend our time on? Don’t be a data sheet reader. Engineers will be more architects, explorers, optimizers.”

Other questions remain. Can AI-based tools be realistically used in anything but local environments? Vendors are still working through the issues of cloud-based systems, even as users point to security concerns.

And how will time-based licenses be affected? Miller indicated it takes about five days to learn to use AIPR. But once mastered, Zuken tests showed it eliminated autorouter setup time, and cut autorouting time to 30 sec. from 15 min. That could throw a considerable wrench in the industry’s current pricing models. The consensus of CAD vendors we spoke with is some version of a perpetual license is likely ahead.

Given the broad industry resistance to using autorouters, it remains to be seen how AI-based tools will be integrated into general industry use. That said, the trend in board design is away from the traditional dedicated specialist, toward layout and placement being a small function of engineers’ overall responsibilities. That shift may finally tilt the field toward automation, and if Zuken’s vision is correct, eventually near-complete abdication to the machine.

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P.S. We welcome our new marketing coordinator Megan Fletcher, who joined us just in time for PCB West this year. She has prior experience with Textron and Sparton, and you’ll see her at several shows this fall.

Also, the call for abstracts is open for PCB East, taking place next June in the Boston suburbs. To submit, visit pcbeast.com.

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Altair ECAD Integrates Ultra Librarian Parts Library

TROY, MI – Ultra Librarian's CAD model library is now available to Altair users in several Altair ECAD verification and multiphysics solutions, including Altair PollEx, Altair SimLab, and Altair One UDE.

Ultra Librarian gives users instant access to more than 16 million symbols, footprints, and 3-D models and provides a comprehensive, cloud-based library that eliminates the need for manual building and maintenance.

"Integrating Ultra Librarian into Altair tools is a massive step for our ECAD verification and multiphysics solutions, which will give users more power than ever before," said Sam Mahalingam, chief technology officer, Altair. "Now, users have access to verified Ultra Librarian CAD models directly from within Altair desktop applications and cloud-based systems. This makes workflows far more accurate and efficient – saving time, effort, and costs."

The integration of Ultra Librarian into Altair electronics solutions gives users the ability to search, preview, and place components quickly through the web or with native CAD integrations, saving time and eliminating errors. Each model is extensively verified for accuracy and consistency with industry standards, empowering users to confidently plug models directly into their tools to see exactly how designs, components, and systems will look upon completion. This will significantly cut modeling time and ensure simulations are accurate and represent a true digital twin of their design.

Users can now utilize Ultra Librarian's models in Altair's multiphysics products for printed circuit board manufacturing verification, and thermal, structural, and mechanical simulation and beyond.

"We are excited to take this next step with Altair to give its customers more power, efficiency, and accelerated opportunities to innovate," said Manny Marcano, president and chief executive officer, EMA Design Automation. "This collaboration further enhances Altair's world class technology and will help electronic design customers in all industries increase their productivity.”

Kinwong Joins PCB Fabs with Thai Site Plans

SHENZHEN – Kinwong Electronic plans to invest CNY700 million ($96 million) in a new printed circuit board production site in Thailand, joining a host of other board fabricators migrating to or expanding in Southeast Asia to mitigate the potential impacts of trade wars between the US and China.

The site, to be located in Prachinburi province, will be built in phases depending on market needs and the company’s finances, the firm said.

Kinwong joins Shenzhen Jove PCB, Huizhou China Eagle Electronic Technology, Aohong Electronics, ASKPCB, Yahao, Shengyi and several other PCB fabricators and suppliers among those that have announced plans to expand in Thailand.

Kinwong was the world’s 15th-largest PCB supplier by revenue in 2022, with sales of more than $1.56 billion, according to the latest NTI-100 list, published this month by PCD&F/CIRCUITS ASSEMBLY.

nScrypt Receives Patent for Modular Mobile Direct Digital Manufacturing System

ORLANDO, FL – Florida-based microdispensing specialist nScrypt has received a patent for a shipping container-based modular system tailored for direct digital manufacturing.

The Modular Mobile Direct Digital Manufacturing System features exceptional adaptability in managing a vast spectrum of materials, spanning from high and low-temperature thermoplastics to formidable substances such as metals and ceramics, the company said.

“This shipping-containerized direct digital manufacturing system fulfills the promise of regional, local, and distributed manufacturing,” said nScrypt CEO Ken Church. “It can respond in real time to changing demands, even autonomously if necessary. With a system covered by this patent, anyone can 3-D manufacture almost anything, anywhere, anytime."

DDM leverages 3-D printing and additive manufacturing techniques to produce final-use components. As additive methods and materials advance, new prospects emerge to create custom-manufactured parts. This evolution within the additive realm renders numerous projects feasible, overcoming the constraints of scale economics. It empowers innovators to address a multitude of high-value design, engineering, and manufacturing dilemmas.

Apart from its 3-D printing prowess, the system includes essential 3-D manufacturing components such as an electronic component pick-and-place system and a bioreactor. Notably, through the integration of nScrypt's Factory in a Tool, this container-based system gains the capability to 3-D manufacture complete and operational electronic devices.

Besides its multifaceted functionality, this modular system presents an array of advanced features. Its collapsible design significantly improves adaptability. In addition, it comes equipped with features such as electrostatic discharge flooring, integrated communication systems (WiFi, LiFi, or satellite), ultraviolet lighting, HVAC, solar power, multi-fuel power sources, secure blockchain-based file transactions, radio frequency shielding, and even a drone landing platform.

Icape Expands German PCB Presence with Princitec Acquisition

FONTENAY-AUX-ROSES, FRANCE – Icape Group has strengthened its presence in Germany with the acquisition of Princitec, a Düsseldorf-based PCB supplier.

Since 2004, Princitec has been providing the full range of technical, sourcing and quality services associated with the distribution of printed circuit boards, and backed by a network of 11 distributors in Asia and Europe, the company benefits from the commercial capacity to meet the needs of a wide variety of industries within very tight deadlines, thanks in particular to its wide range of products, Icape Group said in announcing the acquisition.

With a base of 35 active customers, mainly located in Germany, Princitec generated revenue of €6.5 million ($7 million) in 2022, with a gross margin of around 25.5%.

With this transaction, Icape said it is unlocking a significant synergy potential while continuing to diversify its sourcing. Following the acquisition of HLT announced at the end of May 2023, the acquisition also strengthens Icape's position in Germany, Europe's leading PCB market.

"With the acquisition of Princitec, we pursue the acceleration of our external growth strategy, focusing on supply and commercial synergies and cost optimization," said Yann Duigou, CEO, Icape Group. "Princitec presents all the necessary assets to generate incremental organic growth following its integration into our group. In addition, its seasoned team, solid supplier network and customer portfolio spanning a wide variety of industries will strengthen our position in Germany, one of the world's leading markets. Our pipeline of potential acquisitions remains very strong, and we are in advanced discussions with targets covering all geographies, enabling us to reiterate our target of €30 million ($31.8 million) in additional revenue this year."

"Icape Group, in addition to its position as a leading player in our market, has a set of values in line with our DNA, focused on product quality and customer relations," said Princitec managing director Bernhard Tschampel. "Thanks to this association, our customers will benefit fully from Icape's purchasing power and unique logistics platform, which will lead to a strengthening of the quality of service provided by our teams. We look forward to collaborating with the group's German subsidiary to deploy the potential synergies between our two entities."

DuPont to Collaborate with YMT To Enhance Korean Service

SEOUL – DuPont announced a collaboration with Korean PCB manufacturer YMT to better address local customer needs.

Under the collaboration, DuPont's circuit imaging material expertise will be combined with YMT's local network. YMT has also invested in establishing a dry-film slitting facility in Ansan, Korea, and expects operations to begin in October.

"We are excited by growing our relationship with DuPont," said Peter Baek, chief business officer and vice president, YMT. "By aligning more fully with DuPont, we can leverage our strength in technical service and logistics to meet the varied needs of our customers as the industry continues to grow. We are confident that our collaboration will create long-term value for our customers."

"YMT is one of the leading companies in the global chemical material industry with strong technology development capability. We are pleased to work with YMT to advance the electronic industry and build a more connected value chain to serve our customers in Korea," said Yuan Yuan Zhou, global business director, metallization & imaging, DuPont. “We believe the win-win strategy will reinforce our circuit imaging market in Korea while YMT will expand its current product offerings by adding Riston dry films.”

TNO Presents Roadmap to Sustainable Printed Electronics

EINDHOVEN, NETHERLANDS – An estimated 1.2 metric tons of printed circuit boards annually end up as e-waste, but only a third is recycled in environmentally sound facilities. This means that around 800 million kilograms may be traded, recycled in a noncompliant and polluting manner, or end up in a landfill.

To help lower that number and develop a more ecofriendly alternative to PCBs, TNO at Holst Centre has developed a roadmap to sustainable printed electronics that promotes the development of hybrid and printed electronics (HPE). This technology is a big step forward compared to PCBs, according to TNO, but much more is needed to achieve circular production of next-generation electronics.

Transitioning from PCBs to HPE (Hybrid and Printed Electronics) provides immediate opportunities to achieve ecological benefits: reduced device thickness, lower weight, printed sensors, and additive instead of deductive manufacturing of the circuitry.

Printed electronics is a disruptive technology that is on the verge of breakthrough in the automotive, lighting and medical domains. Each use case represents a slimmer, lighter, more appealing, more practical, and less polluting alternative to the conventional device based on printed circuit boards.

However, in both types of electronics – PCBs and HPE – the circuitry and SMDs contain potentially critical, high-impact metals embedded in plastics to protect them from external influences, such as mechanical damage and moisture. As opposed to PCBs, the environmental impact of HPE can be further reduced by using recyclable, bio-based, and renewable or compostable materials.

Roadmap to sustainable printed electronics. Most, if not all, products are mass produced. A first primary focus lies with a successful market entry which is often achieved by innovative functionalities in an aesthetic product design at competitive price levels. Manufacturing of such products is often not immediately optimized for low material usage, low power usage, and a minimal carbon footprint.

Instead, single use and low recyclability are often accepted at this stage to achieve commercial success, which may be essential for the survival of the company. Petrochemical materials offer a high degree of reliability, low cost and supply security and are therefore suited for high-volume production in this first stage of the roadmap.

A first step toward increasing a product's sustainability is to address, and preferably extend, its end-of-life by enabling reparability, for instance by a modular design with repairable or replaceable components, or by enabling upgrades. Such steps do not immediately improve recyclability or reduce the environmental impact of production and the materials, but they do provide a significant improvement to the environmental impact by the simple fact that the product does not need to be replaced by a new one. Also, energy consumption during the use phase may be addressed. For some examples, such as devices containing high-power elements (e.g., lighting), optimization of power usage may be an effective means of lowering the overall environmental impact.

Following this second stage, a third step may be taken in which a product undergoes a simplification of its design with a reduction of coatings to limit material usage, production steps and overall energy consumption. Printed electronics technology offers an increasingly credible alternative to PCBs and perfectly matches this stage in the roadmap: 1) lower thickness, 2) printed functionalities instead of discrete SMD components that have a higher footprint, 3) recyclable thermoplastic polymers and 4) additive manufacturing as opposed to deductive etching of copper. Nonetheless, challenges remain in terms of costs and reliability in comparison to the PCB.

Circular use of materials requires more drastic changes, especially to enable other choices at end-of-life. When end-of-life is reached, the product needs to be dismantled into its chemical building blocks. Here, printed electronics also provides opportunities, as many of the starting materials are meltable and therefore relatively easy to dismantle. The favored cradle-to-cradle recycling approach is a possibility to further reduce the environmental impact.

Seamlessly integrated electronic products manufactured to survive rigorous testing in harsh environments cannot be disassembled so easily, however, which leaves shredding and incineration of these products as the only option at end-of-life. The plastics serve as energy carriers for metallurgic processes. While metallurgic processing at an industrial scale may be very efficient for metal recovery, the plastics are lost entirely. Recuperation of the plastics faces the challenge of achieving a high enough purity level to reach the material properties of the initial plastic. When combining plastics with coatings or metals or other plastics, purity levels plummet and only secondary use is realistic. Recycling of integrated electronics to yield metals, components and plastics separately and in a pure and circularly usable form therefore requires a method of disassembly prior to recycling. Not only does this allow circular use of all components and materials, it also enables higher recycling rates. It is therefore vital for electronics production in a circular economy to include design-for-recycling principles.

In the before-last stage, bio-based materials may be introduced as a replacement for generally used fossil-based polymers. In the final stage, biodegradability is an option for specific use cases where disposal into the environment is likely or a more effective approach to recycling. Devices applied to the human body with a limited lifetime of days to weeks are well-suited to go this far in their sustainable developments, while others intended for long-term use are less likely to benefit from biodegradability. Materials from bio-based origins are considered to be environmentally friendly, but large volume production may put additional strain on food supplies and animal feed (first-generation feedstock) or land use for non-food biomass (second generation). Algae are a promising candidate for third-generation biomass due to a very high growth rate (five to 10 times terrestrial plants). Moreover, cultivation of algae does not strain food supplies and available cultivated farmland.

BYD to Buy Jabil's Mobility Unit for $2.2B

SHENZHEN – Chinese automaker BYD's electronics unit has agreed to purchase Jabil's mobile electronics manufacturing business in China for 15.8 billion yuan ($2.2 billion).

The deal will expand BYD Electronic's customer base, product portfolio and its smartphone components business as it looks to capture Jabil's potential growth in the sector, the company said.

"The acquisition will also ensure long-term sustainable development while creating value for customers and shareholders," said Wang Nianqiang, CEO, BYD Electronic.

Jabil established a unit earlier this year that absorbed its product-manufacturing businesses in Chengdu and Wuxi, China, which will now be sold to the Chinese group.

"This transformational deal would represent the largest transaction in the history of our company, and I am thrilled to be able to work with a reputable company like BYDE to drive this business successfully forward," said Jabil CEO Kenny Wilson. "If completed, the proceeds from this transaction will enable us to enhance our shareholder-centric capital framework, including incremental share buybacks. Additionally, it will provide opportunities for further investment in electric vehicles, renewable energy, healthcare, AI cloud data centers, and other end-markets."

Kaynes to Build OSAT, PCB Fab Facilities in

India

KARNATAKA, INDIA – Kaynes Technology has signed an agreement with the Indian state of Karnataka in which the state government will invest Rs 3,750 crore ($435.9 million) for two Kaynes subsidiaries to set up a PCB manufacturing plant and a semiconductor assembly and testing (OSAT) facility.

In a BSE stock exchange filing, Kaynes said Kaynes Semicon Private Limited will lead the setup of the OSAT facility and Kaynes Circuits India Private Limited will spearhead the establishment of a PCB manufacturing plant for producing complex multilayer boards.

The investment agreement is meant to help in creating 3,200 jobs in Karnataka by harnessing collective expertise, meeting pressing demands, and making Karnataka a hub for cutting-edge semiconductor manufacturing.

Vexos Expands Operations with ControlTek Acquisition

NEW YORK – Vexos has acquired Vancouver, WA-based ControlTek, expanding the EMS provider's footprint to the US' West Coast to help meet growing customer demands. Financial terms of the deal between the two privately held companies were not disclosed.

The new facility features three SMT lines, specializes in low-to-mid volume, high mix production, and serves the medical, industrial, and aviation, space, and defense markets. The acquisition adds to Vexos' existing locations in LaGrange, OH; Markham, Ontario, Canada; Ho Chi Minh City, Vietnam; Dongguan, China; and Hong Kong.

ControlTek has significant accreditations and certifications to support these markets including ISO 9001:2015, ISO 13485:2016, AS9100D:2016, ITAR, IPC, ANSI, AS5553, and is FDA registered, and its in-house electronic design engineering capabilities, and strong new product introduction skills make it a perfect fit for Vexos, the company said in a release.

"We are delighted to announce the addition of ControlTek to the Vexos family," said Vexos CEO Paul Jona. "The strengths of ControlTek, its West Coast location and its presence in the Aerospace and Defense markets creates new opportunities. This strategic union marks a significant milestone in our journey, enabling us to extend our capabilities and better serve the diverse needs of our valued customers that seek manufacturing solutions from coast-to-coast. By combining the expertise and resources of both companies, we further strengthen our position as a leading force in the market."

The company said the addition of the Washington facility will extend the reach of its value proposition for which it is well known: its executive engagement and close interaction with its customers, combined with world-class support and services, such as design for excellence (DfX), supply chain services, the global footprint, customized material solutions (CMS) and NPI.

"For over 50 years, ControlTek has delivered EMS solutions and built lasting partnerships with our customers," said Andy LaFrazia, CEO, ControlTek. "With their extensive global presence and value proposition, Vexos will allow us to offer our customers access to a broad network of additional resources and services. With our combined expertise and shared passion for building strong customer relationships, we are excited to reach new heights."

Dixon Technologies to Build Smartphone Factory in New Delhi

NEW DELHI – Dixon Technologies is planning a 300,000 sq. ft. factory here to produce Xiaomi smartphones, as India pushes Chinese tech firms to use local assembly partners.

Dixon will invest more than 4 billion rupees ($48.2 million) over three years in the factory, which is set to be inaugurated by a government official toward the end of September.

Beijing-based Xiaomi has been compelled to partner with Dixon for smartphone assembly because India is pressing Chinese companies to localize everything from manufacturing to distribution of devices. In a similar move earlier this year, Xiaomi contracted with India's Optiemus Electronics to make its Bluetooth neckband earphones, a product it previously imported from China.

EW Healthcare Partners Invests in Enercon Technologies

NEW YORK – EW Healthcare Partners has announced an investment in Enercon Technologies to become a majority shareholder in the business.

Enercon was founded in 1980 by Walter Hebold and Ronald Marcotte and performs contract design, engineering, and manufacturing. It services customers in the medical device, life sciences, and industrial/defense end-markets. Enercon's revenues have more than doubled since 2019, when the company's new facility came online following $26 million of investment by the founders to significantly expand capacity to about 100,000 sq. ft. in support of robust demand from customers.

"We are thrilled to partner with the Enercon team to help continue their history of impressive growth, while providing additional resources and investment to further expand upon their innovative offerings for existing and future customers," said Brooks Andrews, managing director, EW Healthcare Partners. "Feedback from the market was clear in our diligence – Enercon excels when it comes to engineering and manufacturing capabilities, quality, and reliably serving its customers' needs – and we look forward to increasing the awareness of these core strengths in the years ahead."

"Enercon is excited to partner with EW Healthcare for the next stage of our company's growth," said Ryan Marcotte, CEO, Enercon. "EW enhances Enercon's already strong financial and operational position by providing expertise in Enercon's core end-markets of healthcare and medtech. EW shares our vision of growing Enercon as a platform and they align with our values and culture that our employees are our most important asset. We are thrilled to have EW as our partner."

PCD&F

ACB Group installed a **Schmid** InfinityLine DES line.

American Standard Circuits celebrated 35 years in business on Aug. 25.

Apex Circuit received a Social Empowerment Award from NGO Enterprise Asia for a public welfare project it conducted in the village of Uttaradit in northern Thailand.

Aspocomp will temporarily lay off 26 workers at its Oulu plant over the next three months in response to low delivery volumes.

Coherent, a maker of lasers, sensors, and optics for industrial use, will set up a center of excellence at the IIT Madras Research Park in Chennai, India.

High Density Packaging User Group announced that **Japan Pure Chemical Co.** has become a member.

Huawei is reportedly building up a fab stable in China to try and evade US restrictions on tools and technology.

Korea Circuit is supplying high-end automotive flip-chip BGA boards to **STMicroelectronics.**

Peters purchased a **Seho** Reflow 1.8. soldering machine.

Taiwan PCB Techvest expects its new PCB plant in Vietnam to be fully operational and ready for production in the fourth quarter.

Tanaka Precious Metals aims to establish a “Global Recycling Network” to promote the widespread recycling of precious metals.

TTM Technologies received a multiyear contract from the **US Army** to support its Air Missile Defense Planning and Control System and Integrated Battle Command System.

Unitech Printed Circuit Board is reportedly considering a merger to expedite the establishment of its new production site in Thailand.

Welgao applied for an IPO with plans to raise 601.3 million yuan ($82.6 million) on a new PCB facility that will increase its annual production to 3 million sq. m.

CA

Altus Group has opened a facility in Cork, Ireland, to accommodate rapid growth in the country and support its customers within the region.

Aurelius Technologies installed a rooftop solar photovoltaic plant at its manufacturing plant in Kulim High-Tech Park, Malaysia.

Betamek, a Malaysian EMS provider, is investing in software and system development and implementation to facilitate factory automation towards Industry 4.0.

BTU International has added the capability to manufacture reflow ovens in Mexico.

A **Cicor Technologies** subsidiary has been rated the most crisis-proof electronics manufacturer in Germany.

DRI India Relay purchased **Hentec Industries/RPS Automation** Pulsar solderability testing and Photon steam aging systems.

Emerald EMS added an NPI center in San Jose, the EMS company's second.

Epak Electronics purchased a **Hentec Industries/RPS Automation** Photon steam aging system.

Flex is closing its Tempe, AZ, injection molding plant, laying off 50.

Foxconn invested $500 million in the Mexican state of Chihuahua, where work has begun to build two new factories in Juárez, and teamed with **STMicroelectronics** for a bid to build a semiconductor factory in India. The company also secured approval to invest $329 million in India and Vietnam.

ITW EAE opened a semiconductor technology center in Kaohsiung City, Taiwan.

LogicMark announced an agreement with **All Quality and Services** to engineer and manufacture new hardware devices.

MacDermid Enthone Industrial Solutions plans to open a second facility in Japan to serve the needs of the local automotive industry.

Naprotek purchased a **Seica** Pilot V8 Next flying probe.

NeoTech expanded its failure analysis lab at its Agave manufacturing site in Juárez, Mexico.

Scanfil will produce **Njord Medtech's** Atle 180, a new generation patient transfer solution.

StenTech installed an **LPKF Laser & Electronics** StencilLaser G6080 at its facility in Guadalajara.

Surf-Tech Manufacturing purchased a **PVA** Delta 8 selective conformal coating machine.

Tata Electronics is planning a Rs 3,400 crore ($410 million) expansion of its electronics manufacturing capacity in Tamil Nadu, India.

Terran Orbital opened a 60,000 sq. ft. addition featuring two new PCBA lines at its Irvine, CA, facility.

Tompkins Robotics named **Kardex Solutions** sales partner for its picking, sortation, and take-away automation products.

WT Microelectronics will acquire electronics distributor **Future Electronics** for $3.8 billion.

Winston Industries, a Kentucky-based manufacturer of circuit boards and industrial equipment, announced its investment of $1.2 million into its facility.

PCD&F

Rob Blomström

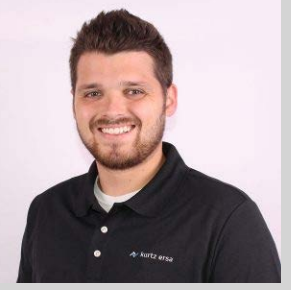
Nano Dimension appointed **Dr. Yoav Nissan-Cohen** chairman and named **Tomer Pinchas** acting CFO to cover the duties of **Yael Sandler** while she is on maternity leave.

Optimum Design named **Rob Blomström** senior PCB layout designer.

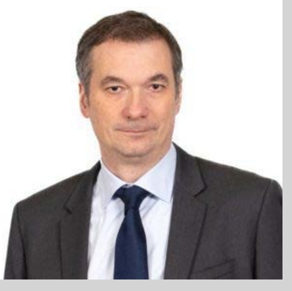
CA

David Wahl


Mathieu Kury



Ethan Jones


Christophe Sut


Satendra Singh

Bestronics named **David Wahl** president.

Benchmark named **Joe Garcia** president, Medical sector.

Danutek Hungary hired **Máté Nusser** as sales executive.

ECD hired **Seydina Diop** as a software engineer.

Frontgrade Technologies named **Denis Boulanger** senior manager, manufacturing engineering.

Indium promoted **Dr. Jie Geng** to senior research metallurgist and **Dr. Sihai Chen, Dr. Guangyu Fan,** and **Jim Hevel** to senior research chemist.

Hentec Industries/RPS Automation promoted **Russel Eiris** to electrical tech II.

Kickmaker named **Mathieu Kury** vice president, North America.

Kurtz Ersa appointed **Ethan Jones** sales manager for its rework and inspection team.

Kyzen hired **Josh Kramlick** as Americas sales manager.

PVA appointed **Aaron Fensterer** regional sales manager for the mountain territory.

Scanfil's new CEO, **Christophe Sut,** took over as of Sept. 1.

SmtXtra USA named **Tony Longo** director of sales.

Syrma SGS Technology appointed **Satendra Singh** CEO.

PCEA Training Announces Final 2023 Classes

PEACHTREE CITY, GA – PCEA Training's final five-day training class this year is set for Dec. 4-8. The program is designed for printed circuit engineers, layout professionals, and other individuals currently serving in the design engineering industry or seeking to get into it.

These instructor-led classes cover the gamut of printed circuit design engineering, from layout, place and route to specifications and materials to manufacturing methods. Schematic capture, signal integrity and EMI/EMC are also part of the comprehensive program.

There are no prerequisite requirements to enroll. Upcoming classes will be held online. All courses are led by experienced instructors.

Registration fees include the 400-page handbook, *Printed Circuit Engineering Professional,* authored by Michael Creeden, Stephen Chavez, Rick Hartley, Susy Webb and Gary Ferrari.

The course includes an optional certification exam recognized by the Printed Circuit Engineering Association (PCEA).

For information about the instructors of the course and authors of the course material, visit pceatraining.net/instructors-authors.

For information about the course overview, class format, and materials to prepare in advance for the class, visit pceatraining.net/course-overview.

To apply, visit pceatraining.net/registration for the next available class or contact Mike Buetow at pceatraining@pcea.net for additional information.

Rick Hartley Receives 2023 PCEA Leadership Award

SANTA CLARA, CA – PCEA announced Rick Hartley as recipient of the annual PCEA Leadership Award, for his lifetime service in the pursuit of educating and training PCB design engineers.

The announcement was made at the PCEA annual meeting in conjunction with the PCB West conference and exhibition.

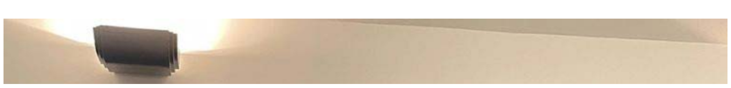
Hartley was one of the cofounders of PCEA in 2020, and was the first chair of the Conferences Task Group. He also reviewed much of the reference material in the Education section of PCEA's website. In his 50 years in the electronics design industry, Hartley has become a go-to for training on signal integrity, noise control, and EMI. He is the most popular speaker in the history of the PCB West conference, and has developed a series of webinars and workshops to train design engineers and designers.

"Rick Hartley's name is synonymous not only with design engineering, but even more importantly, with sharing what you know with your industry peers and colleagues," said Stephen Chavez, chairman, PCEA, in announcing the award. "He is a bright example of the power of determination and positivity, and he embodies the best in what PCEA offers its members and the industry."

Bob McCreight Named 2023 PCEA Membership Award Recipient

SANTA CLARA, CA – Silicon Valley chapter president Bob McCreight has been named the second annual PCEA Membership Award recipient. The announcement was made at the PCEA annual meeting in conjunction with the PCB West conference and exhibition.

McCreight has been the president of the Silicon Valley chapter of PCEA since its inception. He currently works for Tesla as a printed circuit board assembly (PCBA) designer and has been active in the printed circuit industry for more than 30 years.



Bob McCreight (left) and Rich Hartley (right) flank PCEA chairman Stephen Chavez at the awards ceremony.

"Bob McCreight is very deserving of the 2023 membership award," said Stephen Chavez, chairman, PCEA. "He has been an active contributor in our industry for many decades, and continues to provide outstanding leadership in his role as chairman of the local PCEA Silicon Valley chapter. Bob is a model for getting things done, and it gives me great pleasure to recognize him with the PCEA Membership Award."

PCB East 2024 Conference Task Group Named

PEACHTREE CITY, GA – A new slate of engineers has been named to the PCB East 2024 Conference Task Group. Troy Hopkins, senior hardware design engineer at Connect Tech Inc., will be leading the group as the chairman alongside nine other printed circuit industry veterans.

Other industry experts in the task group include Stephen Chavez, Tomas Chester, Rick Hartley, James Jackson, Matt Leary, Matthew McBride, Dale Parker, Carl Schattke and Susy Webb.

PCB EAST 2024 Conference & Exhibition

"We are thrilled to bring together this exceptional group of industry experts," said Hopkins. "Their vast experience and collective wisdom will be instrumental in curating a PCB East 2024 conference program that addresses the challenges facing electronics engineers by showcasing the latest innovations and best practices in PCB design and manufacturing.

"Together, we will ensure that this conference continues to provide massive value, empower PCB designers, and continues to drive our industry forward."

PCB East is the largest technical conference and exhibition for the electronics design, fabrication, and assembly industry in New England.

The one-day exhibition takes place Jun. 5 at the Boxboro Regency in Boxborough, MA, while the four-day technical conference takes place Jun. 4-7.

For details, visit pcbeast.com.

PCEA Issues Call for Abstracts for PCB East 2024

PEACHTREE CITY, GA – The PCEA Conferences Task Group seeks abstracts for the upcoming PCB East technical conference, coming to the Boston suburbs next spring. The conference will focus on training and best practices for printed circuit board design engineers, electronics design engineers, fabricators and assemblers.

The four-day technical conference will take place Jun. 4-7, 2024, in Boxborough, MA. The event includes a one-day exhibition on Jun. 5.

Papers and presentations of the following durations are sought for the technical conference: one-hour lectures and presentations; two-hour workshops; and half-day (3.5-hour) and full-day seminars.

Preference is given to presentations of two hours in length or more, and no presentations of less than one hour will be considered.

Abstracts of 100-500 words and speaker biographies should be submitted to PCEA. Papers and presentations must be noncommercial in nature and should focus on technology, techniques or methodologies related to printed circuit board design, fabrication, assembly, test, components or packaging, and additive manufacturing.

Submit abstracts to pcbeast.com/abstract-submission-guidelines by Nov. 10. No emailed abstracts will be accepted.

Presenters of accepted abstract(s) for the 2024 program receive complimentary access to the online proceedings and a complimentary pass to the technical conference.

PCB West 2023 Show Registration Grew 5%

PEACHTREE CITY, GA – Nearly 2,000 industry professionals, representing 36 countries and 46 states, registered for the PCB West conference and exhibition held last month. Overall attendance was up 5% year-over-year, and the show floor was completely sold out for the exhibition.

The annual conference took place Sept. 19-22, including a one-day exhibition on Sept. 20, at the Santa Clara (CA) Convention Center. It attracted engineers and other professionals from a range of printed circuit and electronics design, fabrication, assembly and advanced packaging companies.

Louis Feinstein discusses model-based system engineering during the PCB West keynote.

"PCB West isn't just a trade show; it's an amazing event that brings industry minds together and sparks innovation," said Kelly Atay, marketing program manager, ASC Sunstone Circuits, a US-based printed circuit board fabricator. "Can't wait for the next one!"

"The ICAPE team had a wonderful time at PCB West 2023!" said ICAPE USA, a supplier of printed circuit boards and electronic assemblies. "We were very impressed with the turnout!"

"We really enjoyed it, and it has given us more confidence that we should be doubling down on the US market," said Sebastian Schaal, founder and managing director at Luminovo, a provider of software for monitoring, quoting and procuring PCBAs.

PCEA also announced PCB West 2024 will take place Oct. 8-11, 2024, at the Santa Clara (CA) Convention Center. The event includes a one-day exhibition on Oct. 9.

PCEA CURRENT EVENTS

CHAPTER NEWS

Rio Grande Valley. The chapter is planning its October meeting. Doug Brooks will speak on PCB trace temperature myths (vias get hot, current density matters, and thermal vias work).

MARKET **WATCH**

CCL Demand Took Hit in 2022, Says Prismark Study

COLD SPRING HARBOR, NY – Compared to 2021, 2022 was a tough year for the copper-clad laminate (CCL) market. Some main reasons include inventory adjustments by end-market customers, declines in material ASPs, and exchange rate fluctuations. Lower demand for PCs, TVs, and consumer electronics applications impacted the conventional materials market. All these factors resulted in a sharp decline in both revenues and profits for CCL materials suppliers throughout 2022.

In 2022, the $68 billion rigid printed circuit board industry (excluding flex) consumed over $15 billion of copper clad laminates, including prepreg but excluding mass laminate – a decrease of some 19% from 2021. In area terms, the CCL market represented 664 million m^2 of rigid laminate materials, including paper, composite, FR-4, and specialty laminates/other, a decrease of more than 13% from 2021. The 2022 CCL market thus saw significant declines compared to the strong growth in 2021, caused by weak demand for end-applications (especially in consumer electronics and PCs), inventory adjustments from PCB suppliers, and the gradual stabilization of raw materials pricing. These factors together contributed to a decline in ASPs. In terms of sales, the top 10 laminate suppliers in 2022 represented 75% of the market.

The top four laminate manufacturers in 2022 were Kingboard, Shengyi Technology (SYTECH), Nan Ya Plastics and EMC, which combined represent almost half of the overall market (excluding mass laminate).

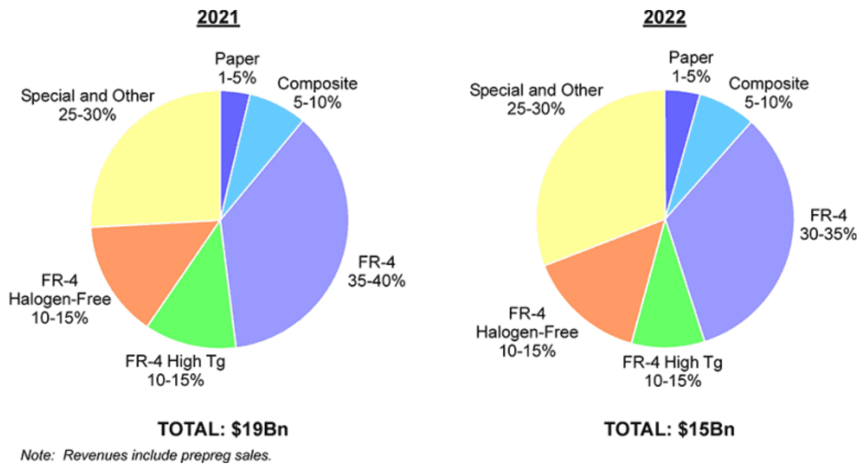


Figure 1. Rigid PCB materials by type.

The CCL market declined in 2022 in area terms due to weak demand from PCB fabricators for almost all types of CCL products. Paper, composite and FR-4 products suffered the most in 2022 as demand and ASP declined substantially.

Specialty materials managed roughly 3% growth, which was mainly driven by the demand from high-end server and networking systems. Specifically, the high-speed laminate market benefited from the high-performance computing and data center equipment markets, while the high-frequency laminate market benefited from the automotive ADAS radar and the wireless infrastructure markets. The market for laminates for package substrates was perhaps the most disappointing, as the sales of all major suppliers declined even though the package substrates market experienced continuously strong growth in 2022, especially during the first three quarters. The disconnect between the package substrate and corresponding laminate shipments was apparently due to inventory adjustments.

Although 2022 already saw a significant decline in value and volume, ASP of laminates remained above pre-pandemic levels. First-half 2023 prices continue to decline, however. – *Zoey Wang,*

Tuned In

Trends in the US electronics equipment market (shipments only)

	% CHANGE			
	MAY	JUN.[r]	JUL.[p]	YTD
Computers and electronics products	0.5	-0.1	0.3	2.5
Computers	3.9	-2.4	2.1	10.3

Storage devices	1.9	-11.9	14.6	12.3
Other peripheral equipment	-5.4	3.8	-14.5	38.4
Nondefense communications equipment	-1.9	1.4	0.2	-0.9
Defense communications equipment	-0.5	-3.4	5.1	4.0
A/V equipment	26.2	8.6	44.8	5.6
Components[1]	2.7	0.7	-1.7	1.3
Nondefense search and navigation equipment	0.2	-1.3	0.2	2.0
Defense search and navigation equipment	1.3	0.1	0.6	3.9
Electromedical, measurement and control	-0.1	0.2	-0.4	1.3

[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.

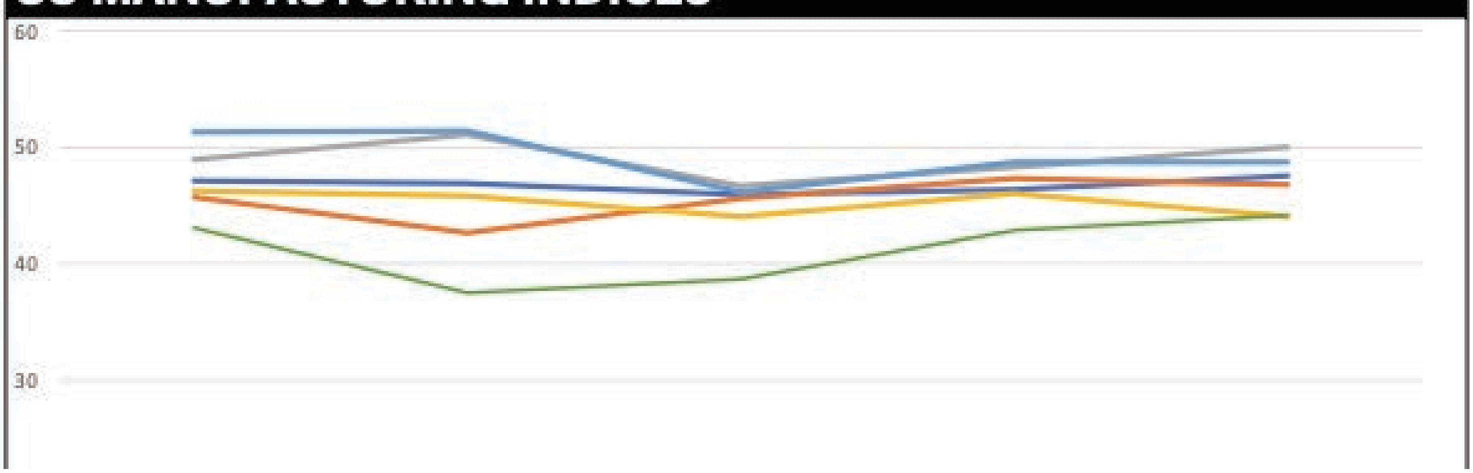
Source: US Department of Commerce Census Bureau, Sept. 5, 2023

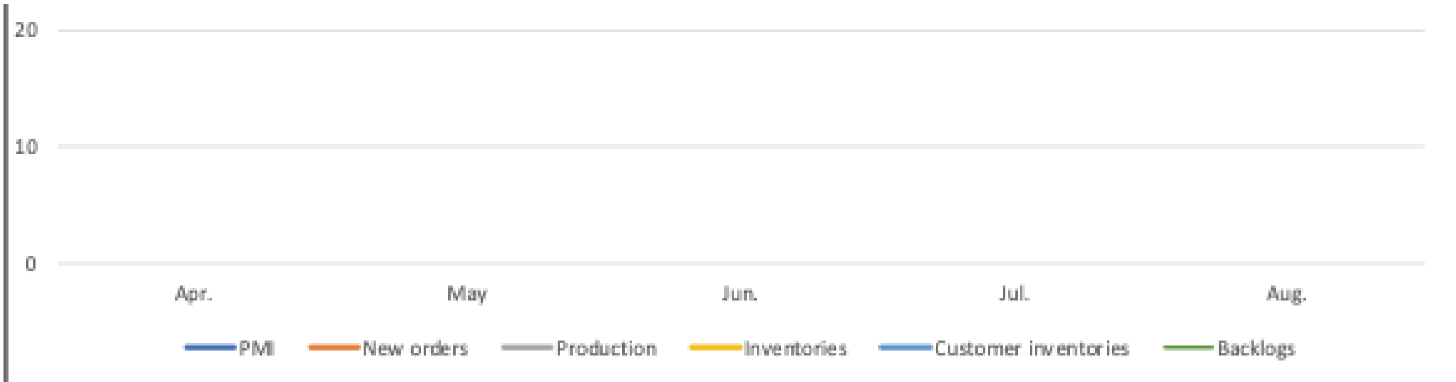
Key Components

	APR.	MAY	JUN.	JUL.	AUG.
EMS book-to-bill[1,3]	1.21	1.24	1.24	1.27	1.27
Semiconductors[2,3]	-21.4%	-21.1%	-15.7%	-11.8%	TBA
PCB book-to-bill[1,3]	0.88	0.89	0.98	1.00	1.01
Component sales sentiment[4]	88.7%	72.2%	76.3%	83.0%	90.3%

Sources: [1]IPC (N. America), [2]SIA, [3]3-month moving average, [4]ECIA

US MANUFACTURING INDICES





Source: Institute for Supply Management, Sept. 1, 2023

Hot Takes

The **global flexible PCB market** is expected to total $17.2 billion in 2023, a 12.6% drop from 2022, but a recovery is expected for 2024. (TPCA)

Worldwide **smartphone shipments** are forecast to decline 4.7% year-over-year to 1.15 billion units in 2023, the lowest volume in a decade. (IDC)

North American **EMS shipments** in August rose 2.49% over last year and 8.9% sequentially. Bookings increased 13.7% year-over-year and 8.2% from the previous month. (IPC)

Global **fab equipment spending** for front-end facilities in 2023 is expected to decline 15% year-over-year to $84 billion from a record high of $99.5 billion in 2022. (SEMI)

Vietnam's electronics sector accounts for 17.8% of its total industry, placing the nation among the world's top 15 largest electronics exporters. (Vietnam Ministry of Industry and Trade)

The **hardcopy peripherals market** in the Asia/Pacific region registered 7.2 million units shipped in the second quarter, declining by 10.2% year-on-year. (IDC)

Global **semiconductor equipment billings** dipped 2% year-over-year to $25.8 billion in the second quarter, while quarter-over-quarter billings slipped 4%. (SEMI)

India will become the new manufacturing center of the world, says Foxconn chairman Young

Liu. (South China Morning Post)

North American **PCB shipments** in August jumped 26.4% over 2022 but fell 35.7% versus July. Orders plunged 29% versus a year ago and dropped 36.8% sequentially. (IPC)

China is set to launch a new state-backed investment fund that aims to raise about $40 billion for its **semiconductor sector.** (Reuters)

PC monitor shipments declined 17.1% year-over-year in the second quarter. (IDC)

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The Challenges of Reshoring

Relocating manufacturing to the West requires more than moving factories.

FOR MUCH OF the past decade, many have touted the reshoring of electronics and especially printed circuit boards and electronic assemblies. Many reasons have been cited as to why reshoring is now taking place, from supply chain difficulties to nationalism, to the marketing optics of where products are made.

Indeed, no matter where you are from, it is always a nice feeling to buy locally, and while supply chain issues have been a serious problem over the past few years thanks in large part to tariffs and Covid, these challenges have seemed to impact all parts of the world relatively similarly. Because – or despite – these desires and challenges, the rate of reshoring, as measured by employment expansion, has been escalating, with the estimated annual number of jobs created attributed to reshoring topping 350,000 in the US alone.

That said, the challenges in successfully reshoring are still significant and basing success purely on employment levels may be misleading. Looking at the challenges, there have always been four: capital, facilities, technology and people, with now the possible addition of a fifth, inflation, to contend with. And two on the list may end up putting a cap on reshoring, at least in certain industries.

Capital is always the first challenge. Money is needed for everything from funding the analysis and planning process of where and how to move manufacturing, plus acquiring the equipment, facilities and staff to execute that plan. The past couple decades have generally been good for business. With relatively low interest rates, the cost of capital has been attractive, and capital has been readily available. More on this later.

Facilities, if not immediately available, can be built in a relatively short period of time. Determining the ideal location differs based on industry and product type and boils down to where suppliers, customers and labor are located. In any relocation of manufacturing, whether across the street or across the globe, facilities can be modified or created.

Technology is where the slope begins to get slippery, especially for reshoring electronics. This encompasses a wide assortment of inputs, first being availability of components, parts and other items needed to produce a given level of technology. Does reshoring a facility enable you to locally access them, or are you going to be reliant on a lengthy and costly supply chain?

Next is reshoring to a location with the R&D capabilities to ensure your product can be refined and remain competitive. Finally, there's the human element: are enough technically competent people available to enable a high-tech facility to operate smoothly with minimal downtime – not only on the shop floor but also in support services? One reason many businesses went offshore years ago was explicitly to have the technological resources readily available and have access to the latest in innovative technology. Reshoring requires a significant understanding of technological needs as well as a realistic understanding of available technology resources after the move. Underestimating the availability of and potential cost required for technological resources could create a costly disadvantage.

Labor is the biggest challenge in reshoring, especially when relocating to North America. With a shrinking manufacturing base over the past few decades, those skills have not been a main element of schools and education. An aging experienced population has held the manufacturing jobs that have remained. Replacing those retiring manufacturing people is a daunting challenge in itself, and adding hundreds of thousands of new positions that require those same basic skills that are not taught in today's high schools, tech colleges and universities could end up being the gating challenge to successful reshoring. The engineer pool is not the problem. Rather, it is finding workers in the trades: machinists, welders and technicians operating plating lines, imaging systems, lasers, waste treatment systems, and everything else that industry needs yet is in such short supply – especially in North America.

To complicate all this, in some parts of the world inflation is now escalating at levels not seen in decades. The cost of everything from capital to facilities to technology and labor is increasing in the areas that are trying to reshore manufacturing, while in much of Asia, where the reshoring is coming from, deflation is taking place. The result is that moving from low-cost areas where costs are falling to higher-cost areas where overhead is escalating piles more complication on an already complex endeavor.

Companies will continue to review and relocate manufacturing and research facilities. For North

America to be the big winner in any manufacturing shift, providing training for workers in manufacturing plants and technical support is critical. Three decades of deemphasizing the importance of manufacturing and its required skills must be reversed, fast, so an available workforce can be amassed.

Capital cost and its availability will become a bigger challenge. With higher interest rates and more scrutiny on bank balance sheets, more attention will be needed to determine how to fund the reshoring effort. The result of all may be less reshoring and more nearshoring to locations that are politically stable, have ample technological resources, and have a readily available workforce.

While I question whether North America will be able to boast that 300,000-plus jobs have been reshored year after year, I do know that over time, more manufacturing growth will return here, and that is always good.

PETER BIGELOW is president of FTG Circuits Haverhill; (imipcb.com); pbigelow@imipcb.com. His column appears monthly.


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PCB Industry Needs OEMs to 'Chip' In

To close the gap in IC substrates, buyers need skin in the game.

THE CHIPS ACT was passed more than a year ago and not one federal dollar has yet to be awarded – although private industry has committed and started to spend billions. Once funded, the new, more advanced foundries will take years to build and start operations.

When produced, however, the chips will be useless until they are packaged and mounted on PCB platforms. The facilities, materials and knowhow to produce the substrates used to package them remain primarily in Asia – including China.

Notably, the cost to build and equip the necessary substrate and PCB facilities to produce HDI and UHDI (ultra-HDI) circuitry in volume is substantially more than that of a typical PCB or flex circuit factory, but far less than that needed for a foundry.

To provide incentives, US Representatives Blake Moore (R-UT) and Anna Eshoo (D-CA) this year introduced H.R.3249 – Protecting Circuit Boards and Substrates Act. This bill is the second iteration of this effort and has a long way to go in gaining cosponsors and approval.

Creating sustainable Western PCB and substrate sources will take time, and will not necessarily be in the country of use. Today just a handful of American and Western companies have the technology to produce some level of UHDI circuitry. To develop a secure source, the US will need more than government words, resolutions, bills and funds with heavy ropes (not just strings) attached: It needs active OEM investment and participation.

Additionally, new standards need to be established for UHDI circuits and materials. Hopefully these will initially include a performance basis. Perhaps the acceptance criteria used by IC companies can initially be used to speed things up. Trade association committees are currently working on these in China, the US and Europe. Their development will not be rapid and there will be differences to sort out.

The current demand to profitably produce sufficient volume of these substrates and circuits does not justify the needed investment. New incentives are needed to spur commitment.

New forms and partnerships are needed. Industry members need the active, trusted and focused support of their trade associations, which must work with each other for their members' benefit. The current geopolitical situation demands more than an equitable outcome. It requires a winning strategy coupled with focused actions and milestones.

During the period between 1900 and 2019 there were about 2,000 companies involved in some way with the construction of automobiles. At its peak, a reported 2,000 facilities in the US were involved in the manufacture of printed circuits. Now there are about 200 and consolidation continues.

Perhaps only those that can or will invest $100 million or more in the new substrate/PCB/FPC processes and factories will survive. Or, maybe more companies will integrate vertically. Recent examples include SpaceX, which is building a factory in Austin, TX, for the Starlink satellite internet equipment, and the new captive operations of Vicor Corp. in Andover, MA, and Schweitzer Engineering Laboratories (SEL) in Moscow, ID. Perhaps Teltonika in Lithuania has the right approach as it justifies spending $154 million for highly automated state-of-the-art PCB manufacturing to "enable it to reduce lead times, minimize supply chain risks, and become independent from third-party political decisions."

In the '80s (that's the 1980s, not 1880s), after my first few visits to the PRC after the Nixon accords, I stated we will have to learn how to deal with China as a customer, supplier, competitor and partner without losing our self-identity and security. I met Jiang Zemin during the first Nepcon show in Shanghai, when he was electronics minister and mayor of Shanghai. Shortly thereafter he was named president, and the *LA Times* asked what I thought of him. My succinct reply: "I would not want him as a competitor." China, I added, may seem a lifetime behind the US technically but would catch us in a few decades.

Now, we see the world order in a different way. Corporations (major OEMs) gave up too much too easily for the almighty dollar (and quarterly report), sacrificing long-term local suppliers (with their tribal knowledge and technologies) along the way. As they migrated to Asia and vanished from the domestic scene, so did the incentives to create the processes and materials now needed for advanced electronics.

That led me to first wonder, and often repeat: Are domains corporate or national?

Today I ponder the challenge of commercially engaging with China while eliminating security issues. How much disengagement is possible without calamitous global economic results?

I was asked if we were twitching the tiger's tail by disengagement. Let's review the situation.

China became the world's factory during the past three decades. It provided the West with products at prices that European and American companies could neither match nor resist. The PRC built massive factories and adopted automation during those years. It acquired most of the technologies needed to fill the pipelines – buying advanced chips and equipment not yet in its domestic capabilities from the West (including Taiwan) when needed. During this period China learned how to make the necessary production equipment, produce HDI circuitry, and began to provide locally produced specialty chemicals needed to build and assemble PCBs – sometimes at local subsidiaries of Western firms.

In these years the PRC built with full government support the necessary infrastructure to support its domestic industries. Meanwhile, the West let its local supply chain sources languish as it fell behind technically without the dollars necessary to maintain domestic capability. In general, the ability and skilled labor to produce HDI circuitry, substrates and even some "conventional" MLBs – a handful of companies excepted – was lost.

Then came Covid-19 and the supply chain was broken. Companies resolved to never again be put into the situation where they could not produce because of a protracted or broken supply chain. Coupled with this was the increased tensions between the US and China due to worries of security issues in parts provided by China. Tensions between the US and China over Taiwan are increasing.

Now much of the world is in recession. China currently needs the West's business as it tries to replace Western products in its home market and develop new markets elsewhere in the world. The West needs China's factories to provide many of the items it no longer produces but needs. But it wants to de-risk doing business with China.

To this end, US Commerce Secretary Gina Raimondo urged American businesses to keep investing in China after a late August visit despite increased difficulties in doing so due to China's tightened policies. Meanwhile, China is working hard to displace the US as the world leader.

As the saying goes, "May you live in interesting times."

I say, "Does it have to be **so** interesting?"

GENE WEINER is business and technical consultant at Weiner International Associates (weiner-intl.com); gene@weiner-intl.com. A longtime PCB industry executive and IPC Hall of Fame member, he was president of a copper-clad laminate company, vice president of a several specialty chemical companies and spent 25 years on the board of directors of WKK, one of Asia's largest SMT equipment distributors and EMS companies.

Spreading the Word

Are your internal processes or actions creating bad word of mouth?

YEARS AGO, I went to a communications conference in Chicago where a Japanese quality executive discussed the reason behind Japanese companies' relentless pursuit of quality. He said it all boiled down to word of mouth. Japan's cities are densely populated. Residents use mass transit and live in apartment complexes. This executive said their studies had found that when a domestic consumer had a bad experience, they were likely to tell at least 10 people on their way home from work. Having lived in Japan, I agree with that assessment and that imagery remains in the back of my mind.

The internet has exacerbated this phenomenon. Recently, I had a client who was looking for lead database options. Other clients had said good things about a database they were using, so I did a search and came up with two options: the one with positive word of mouth and a much cheaper option with good online reviews. The first vendor I contacted required watching a demo to obtain pricing and details. Their salesperson ultimately discounted the annual price based on the low volume lead search needs of my client.

The second vendor shared pricing info and service descriptions on its website, no demo required.

I put both recommendations in my marketing plan. The client opted for the one with positive word of mouth. But, they then visited the vendor website, did the demo, and a different salesperson quoted a much higher price. My salesperson then told me he couldn't honor his earlier quote because my client was now associated with the other salesperson. I explained that if they didn't honor the original price, we'd look at option two.

Long story short, I did a demo with the second option. They had all the services my client needed for thousands of dollars less. The salesperson recorded the demo, which I sent to the client. My client signed a contract two days later. Since the two other clients were coming up for renewal with the more expensive database vendor, I shared our positive experience. The pricing difference has them very interested.

In short, bad word of mouth tied to my experience may be tracking to three wins for the second database vendor in less than two weeks. The first company's inflexible process killed an order at the PO stage.

How does this track to the EMS industry? This is still a small, niche industry, so word of mouth travels quickly through EMS personnel, OEMs and the supply chain. During my EMS sales career, I heard many stories from OEM sourcing personnel about bad experiences they'd had with EMS providers they would never return to. As these supply chain professionals moved among companies, that "will never use" perspective killed multiple opportunities. I've heard stories about bad employee exits that effectively blacklisted them from good opportunities. I've also heard stories about bad employee treatment policies that limited the number of experienced people willing to work for them. In short, bad experiences get talked about and often have far-reaching consequences. Here are a few examples of bad policies/behaviors that generate buzz:

- EMS companies forcing a standardized PCB layout beyond what customers are easily able to accommodate (while this is a good Lean process control policy, it will generate bad word of mouth from customers unwilling to make the changes)
- EMS companies with a track record of mass sales team layoffs to reduce commissions. (This doesn't mean you don't lay off poor performers, but when the entire team is repeatedly recycled every two years, it sends a bad message to experienced salespeople.)
- Job candidates who accept a position and then ghost the company either on the planned first day of the job or within two weeks
- Job candidates who accept a position and use it as a hammer to increase compensation in the position they really want, and then tell the first company they got a better offer
- EMS companies that solicit bad-fit business in a recession and then ask those accounts to leave when the business situation improves
- EMS companies that automate communications processes to the point where customers only get voicemail.

Some of these examples, such as PCBA standardization, commission mitigation methods and automated phone systems have good internal justifications. All of them have the potential to improve profitability in terms of the costs they cut. When carried to extremes, however, they also generate bad word of mouth that often eliminates good opportunities. Consequently, when considering implementing these policies it makes sense to look at them from a customer or employee perspective. Does some flexibility make sense? Will the potential downside of being inflexible tarnish the brand in ways that cost more? In the case of product design standardization, is there a way to sell versus tell to motivate the needed change? Can you improve screening processes so that customers not likely to fit the standardization requirements aren't being quoted?

Within the employee behavior examples, there is no upside potential. You tarnish your brand within the EMS industry when you do this. Getting a better job today using this behavior just guarantees that if you need to move quickly in an industry downturn, there will be fewer opportunities.

The bottom line is that in today's interconnected world, word of mouth travels fast. When you have policies that generate customer or employee angst, review them to determine if more flexibility or better opportunity screening is needed. Evaluate the experience from the perspective of the person who will be impacted. In terms of career choice, recognize that your behavior as a job seeker is part of your brand. Companies are making a significant investment with every hire and at higher levels are rejecting other equally good candidates when you accept a position. Walking away from that commitment puts the company in a bind, so don't accept a position you aren't willing to stay in for at least a year.

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Wrong Steps: How Your PCB Footprints Could Be Holding You Back

A good library is built with an understanding of the manufacturing limits.

ONE OF THE primary factors in the quality of a printed circuit board design system is the makeup of the component footprints. The board can only be as good as the foundational pieces. Making it up as you go along is not a process for the long term. Errors or inconsistencies in the library account for a fair share of the feedback we receive from the fabricator. That is the wrong time to consider the fundamental building blocks of our collective occupation.

The source of the component footprints should be considered. A good cross-section of the supply chain provides the customer with schematic and layout symbols. This is, of course, to make it easier for us to implement their chips and other parts. CAD tools often come preloaded with a number of device examples to get you started.

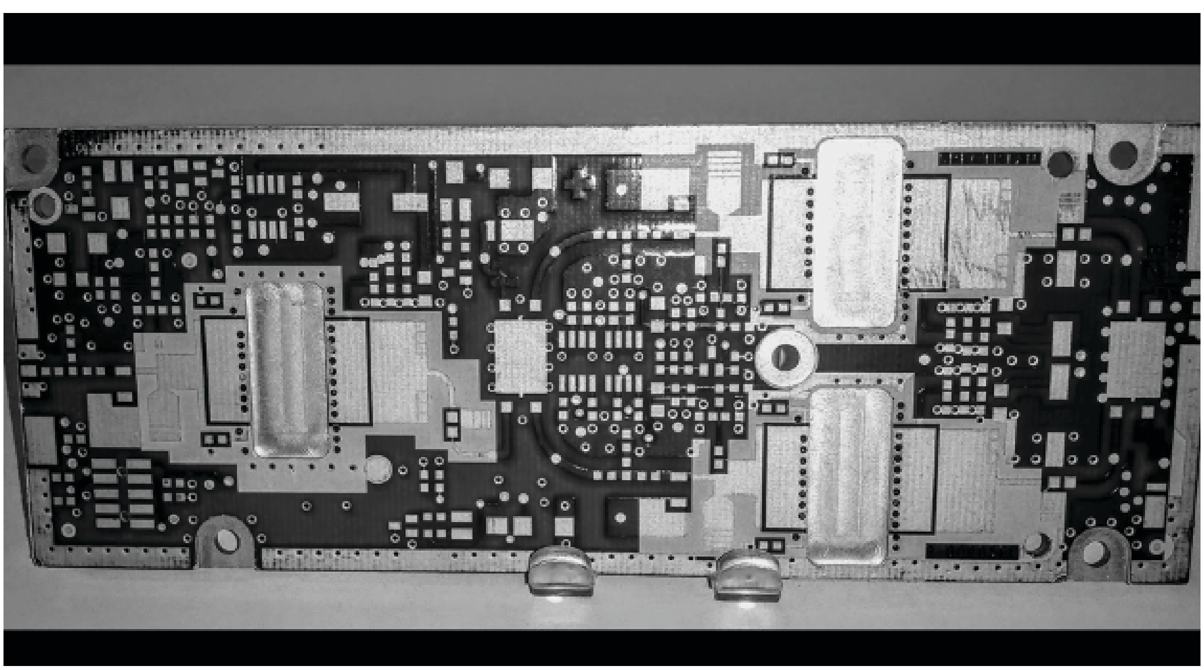

Figure 1. A vendor display case at a trade show had a copy of a Spectrian PCB it did for us. (I had called five meetings discussing the board prior to tape-out as we were doing something entirely new. Dr. Crescenzi included me in the patent regarding the rows of plugged vias along the edge of the slots. Those have a counterbore and fill process to create ground vias from layers 2-4 where layer 4 is a 1mm-thick copper slug.)

Take those “freebies” with a grain of salt. One of the ways this kind of help can get in the way is in terms of traceability. One of the more important aspects of a good library is to have one and only one instance of a particular part. Naming conventions come into play here. Many, but not all, of the baseline libraries use naming conventions outlined by IPC-7351.

Before incorporating any new files, compare the existing name to the one derived from the specification and part geometry. The goal is a level of traceability and repeatability such that you can find it in your library, if it exists. That way, you won’t create and maintain one you didn’t need.

IPC divides component footprints into three classes just as it does with bare circuit boards. Whenever appropriate, I choose Class 3. These are the high-reliability versions with larger SMD pads. The pads mainly extend on the toe-fillet side, outward from the part. These maximum material condition (MMC) layouts dissipate more heat per pin and create more distance between components. This might be applied selectively in problem areas such as power supplies.

While board space grows, the overall effect is longer component life over normal or high-density classes. Probe access for testing improves, silkscreen marking is more distinct and, finally, rework is improved with fewer lifted pads. Improve product quality with the country living. Using these symbols does not in itself make the bare PCB a Class 3 board, but it is one of the conditions to be met.

There is a corollary with going smaller than “nominal” dimensions for your components. The undersized footprints are useful in RF applications where the SMD pad creates an impedance mismatch, as it differs from the transmission line. The assembler will be happier with all the footprints of the same type. As far as I’ve noticed, nominal footprints are the mainstream choice for telecom and enterprise. Outside of the cellphone ecosystem, I have not seen much call for MMC.

Footprint library creation. The folks at Ultra Librarian or PCB Libraries could probably tell you more. These outfits compete in the Library as a Service segment. These are not the only players, but they are well-recognized in the ECAD industry. The services break down to an individual bill of materials or some form of subscription that fits your run rate on new PCB footprints.

Circling back to naming conventions, it is next to impossible to cover every conceivable permutation that surrounds a part **(FIGURE 2)**. We start with the general terms of the geometry and work from there. The general code for the BGA package is as follows:

BGA + Pin Qty + C or N + Pitch P + Ball Columns X Ball Rows _ Body Length X Body Width X Height.

Which leads us to the following footprint name for the package in Figure 2: BGA35C40P5X8_356X270X050. A few modifiers can be added as a suffix such as when pin A1 is in a different corner. The name alone, in this case, is sufficient information to create the footprint.

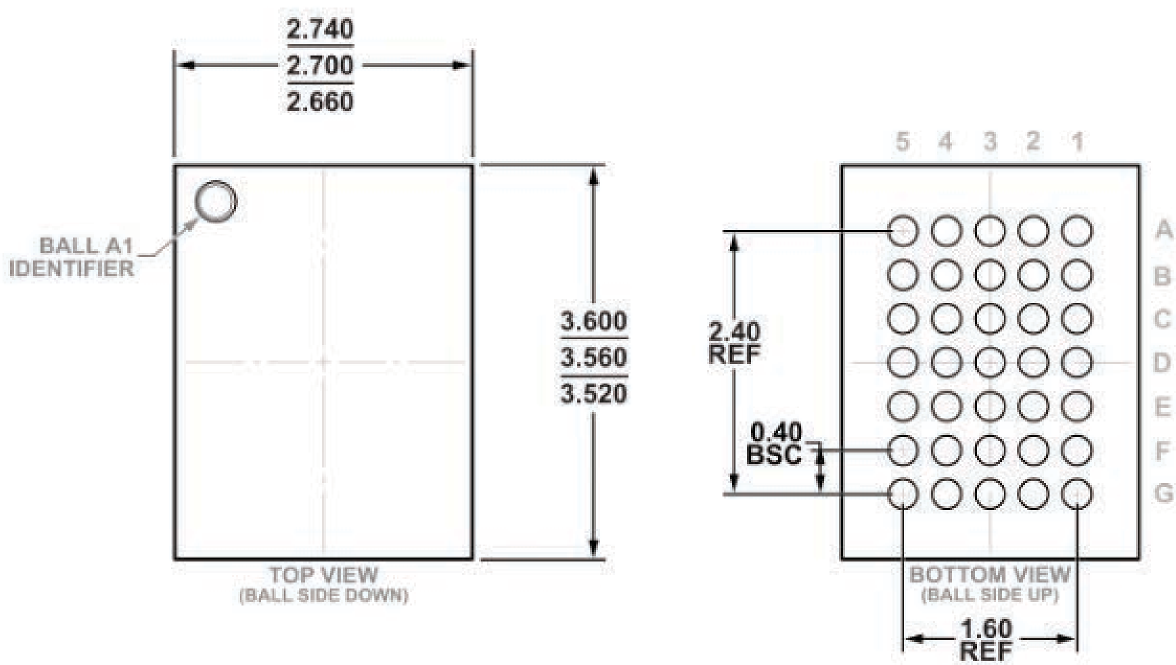

Figure 2. From this image we can derive a unique file name. The package name itself is sufficient data to generate the footprint. Other symbols are more complex and may be categorized by function or by vendor. Source: Analog Devices

Other cases may arise where some random pads are deleted and you find it next to impossible to fully describe the footprint within the available parameters. The IPC has a work-around. When a vendor chooses its own route outside of the established form factors, we use that vendor's name and their internal part number. Figure 1 shows a trio of sockets for amplifiers that require a controlled depth slot along with the pads on the wings. There's just no comparison.

Just about every surface mount connector falls into the same gap where there is no standard footprint.

It's as if they all go out of their way to be a little different to each other so that their parts are harder to replace with other brands once they've won the socket. Another thing that seems common among connector vendors is to use really tight tolerances on certain elements, especially alignment hole position and size tolerances.

Question the data sheet. In the early days of the USB-C connector rollout – about a decade back – I captured all the details of the USB connector including the hole and slot tolerances. The connector vendors had not thought to move the alignment hole and slot inboard away from the surface mount pins. With the proximity and miniscule tolerances, the fabricator balked at the fab drawing and artwork that included the intricate geometry. Many of the connector spec sheets are still ahead of the manufacturability curve.

One thing you don't want out of your printed circuit board is a DfM comment from the vendor suggesting that you shave a few SMD pins and open up the non-plated hole/slot tolerance. I didn't think that one through when I was including those values in the library part. Ensure your component vendor isn't too conservative with the source control drawing **(FIGURE 3)**.

Figure 3. The good old days circa 2014 when one of my boards was the original Chromecast. I had to adjust Google's expectations in terms of placement density. A lot of Wi-Fi dongles plus years with Qualcomm had calibrated my placement norms. They basically had data centers motivating the library, so we upgraded from max to min on spacing.

Fortunately for me, the fabricator was a subsidiary of the original design manufacturer (ODM), and I was able to insist it deliver a finished assembly that meets the requirements for the laptop notwithstanding any fabrication issues. All I needed to know was the end solution so I could incorporate those values going forward with any other boards. Best shop practice became the standard for us.

Solder mask: the linchpin between fabrication and assembly. If your naming is traceable and the geometry is acceptable to fabrication and assembly, you're on the right track. The solder mask layer is a primary concern to both fab and assembly, so don't sleep on the definition of these openings. A smooth edge is necessary for a good mask adhesion. Solder mask slivers arise when we expand the mask when it should have been contracted instead. Most component vendors prefer expanded mask. The 0.4mm pitch of Figure 1 is as fine as you can go with solder mask-defined lands.

At 0.35mm pitch on a BGA device, you're better off going with a metal pad that is 0.25mm diameter with a mask opening of 0.20mm, or something close to this. The non-solder mask-defined land accommodates the microvia-in-pad necessary for this type of device. No routing solution runs a trace between pads on anything less than a 0.5mm pitch BGA. A good library is built with an understanding of the manufacturing limits.

You still must set priorities in terms of what will be in the silkscreen. The must-have is any polarity or pin-one marks for diodes and the like. Second is the reference designator, followed by the part outline, which should be reserved for substantial components like the IC and connector types.

The library is not complete until it has been through a full cycle of product enablement. By then, a cohesive style should be in place for the details. Creating how-to documents when you get it all shaped up pays it forward to those who will be taking the mantle of librarian down the road somewhere. The job is never done.

JOHN BURKHERT JR. is a career PCB designer experienced in military, telecom, consumer hardware and, lately, the automotive industry. Originally, he was an RF specialist but is compelled to flip the bit now and then to fill the need for high-speed digital design. He enjoys playing bass and racing bikes

when he’s not writing about or performing PCB layout. His column is produced by Cadence Design Systems and runs monthly.


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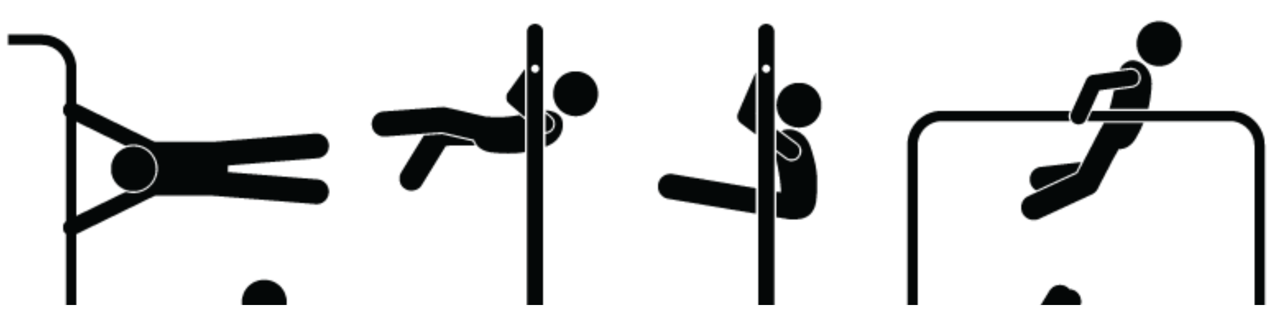
DESIGN **BEST PRACTICES**

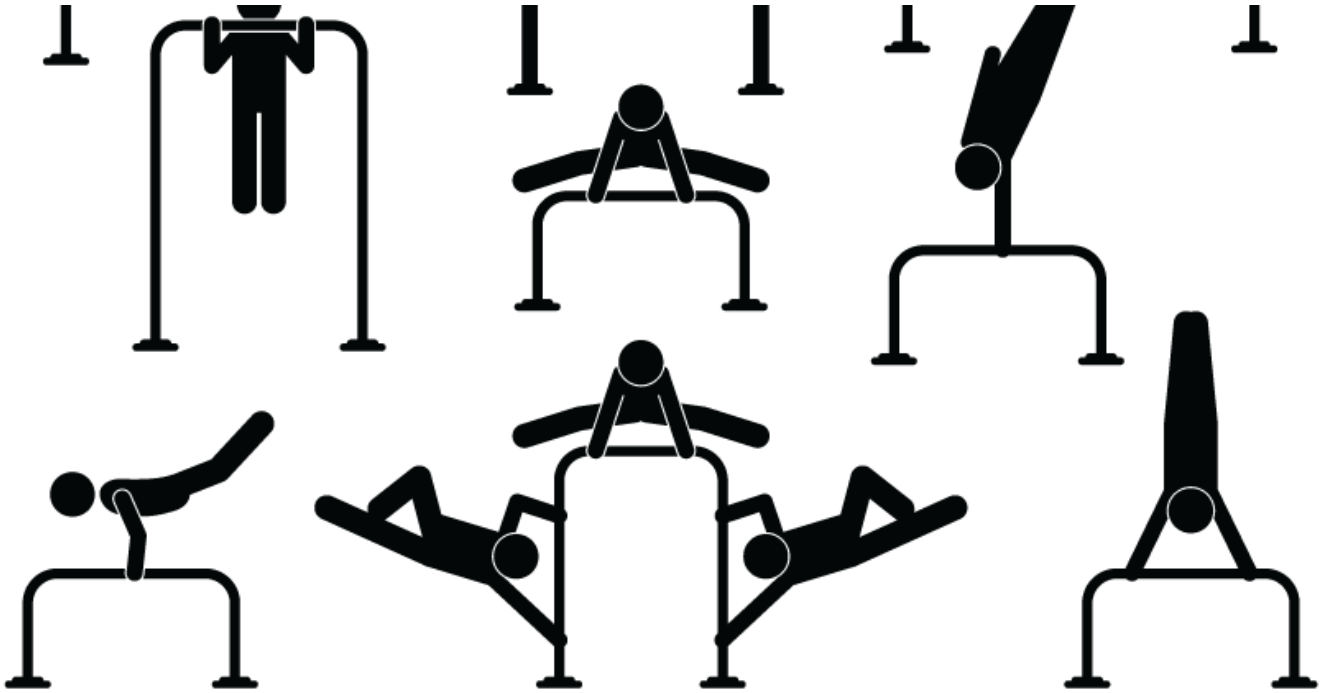
Breaking Down Design Barriers

Concurrent design allows simultaneous integration and collaboration throughout the design process.

WITH THE COMPLEXITY of today's electronics designs, the traditional linear approach to PCB design and development is outdated and lacking efficiency. The evolution of PCB design and development methodology has led us to the age of digital thread and the digital twin. Getting to market in the shortest amount of time, with highest quality of product, and at the lowest project cost is the goal for most. There is no room for errors throughout the entire design cycle, or costly project delays. This is where concurrent design can make a huge impact. Concurrent design is an approach that changes the way projects are conceived, developed and executed. It prioritizes multidomain collaboration, iterative processes, and cross-disciplinary communication.

Concurrent design, also known as simultaneous engineering or parallel design, is a methodology that aims to break down barriers between different stages and disciplines of project development. It involves multiple disciplines and multiple domains simultaneously integrating and collaborating throughout the entire design process from the very beginning. The days are long gone where multiple disciplines and domains working in silos was best practice – if it ever was. Unlike the traditional linear approach, where one phase is completed before moving on to the next, concurrent design encourages teams to work in parallel, sharing insights, ideas and expertise throughout the project lifecycle.





With concurrent design, multiple engineers can work simultaneously in the same project database in real time. More specifically, within the same PCB schematic, constraints and layout database. With multiple team members attacking a design simultaneously, typical design edits will appear dynamically to all active users within the database. Constraint edits are performed in a controlled and methodical process to mitigate any design rule conflicts that may present themselves while making rule changes within the constraints.

Key benefits of concurrent design are:

- **Enhanced collaboration:** Concurrent design encourages diverse teams, with experts from various disciplines, to collaborate closely. This fosters an exchange of ideas, leading to innovative solutions that might not emerge in a siloed environment.
- **Faster time to market:** By allowing different stages of the design process to occur simultaneously, concurrent design reduces project timelines. This can be particularly advantageous in industries where rapid product development is crucial to staying ahead of the competition.
- **Improved problem solving:** Complex challenges often require insights from different angles. Concurrent design can help designers identify potential issues early in the process and address them before they escalate.
- **Reduced rework:** With constant feedback and cross-disciplinary input, the chances of errors or

misunderstandings are minimized. This leads to fewer revisions and less rework, ultimately saving time and resources.

- **Flexibility and adaptability:** In rapidly changing environments, concurrent design allows teams to adapt to new information and shifts in priorities more effectively, as they are already accustomed to dynamic collaboration. The ability for engineering teams to adapt to design changes on the fly and minimize the negative impact they have on the project schedule and budget is significantly increased.

With the evolution of today's engineering teams and EDA tools, concurrent design is the superior approach to PCB design and development. As an example, while creating or editing the schematic, you could have two or three users actively working simultaneously. This means you can have multiple electrical engineers (EEs) working in the schematic at the same time. You can also have multiple PCB designers working in the layout at the same time. In either scenario, multiple users can actively provide effort all at the same time and all in the same database in real time.

Multiple EEs and PCB designers working simultaneously (in parallel) in one project database is the essence of concurrent design. The level of human effort that can now be harnessed and translated to raw horsepower to get the job done faster at a higher quality, more efficiently, and on schedule is the true beauty of concurrent design. Implementing concurrent design within the project design cycle significantly increases the potential for reducing the overall project schedule while enabling multidisciplinary and multidomain collaboration to produce a better-quality product faster. It enables optimization of multidiscipline integration and collaboration within the PCB database as well as optimized team utilization. The value to get from this is you can accelerate design cycle time, reduce development duration and cost, as well as improve design process optimization and efficiency. With real-time concurrent engineering, you can also enable simultaneous multiuser and multidiscipline contributions. This is what makes concurrent design methodology a game changer.

Concurrent design is a powerful evolution from traditional linear project development, enabling teams to embrace collaboration, adaptability, and innovation. By involving diverse experts from different domains and disciplines from the outset and creating iterative processes, you can achieve quicker results, higher-quality outcomes, and a more efficient allocation of resources. As technological complexities increase, embracing and implementing concurrent design methodology is the key to staying ahead in our evolving industry.

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role as a senior product marketing manager with Siemens EDA, his focus is on developing methodologies that assist customers in adopting a strategy for resilience and integrating the design-to-source Intelligence insights from Supplyframe into design for resilience. He is an IPC Certified Master Instructor Trainer (MIT) for PCB design, IPC CID+, and a Certified Printed Circuit Designer (CPCD). He is chairman of the Printed Circuit Engineering Association (PCEA); stephen.chavez@siemens.com.

The Digital Doctor Will See You Now

Mobile health is a pandemic-driven change that could benefit everyone.

THE PANDEMIC HAS driven countless changes in behavior, lifestyles, working patterns, and our values. Many of us are taking a keener interest in our health than before and we're using the technology in our pockets to help keep on top of our wellbeing. Mobile health, or m-health, is a growing market that already hit $60 billion in 2022 and is predicted to top $300 billion by 2030.

We know that the sooner we seek help with an illness, the better the prospects for a satisfactory outcome. Despite this, many of us, upon noticing any unusual signs, are inclined to "wait and see." That's usually less than ideal and sometimes has dire consequences. M-health not only permits better self-awareness by enabling continuous monitoring of our own vital signs, but can also overcome procrastination by automatically reporting any worrying signs as soon as they become apparent. A suitable response and – if necessary – a care plan can then be configured quickly, leading to faster recovery. Our devices can effectively take us to the (digital) doctor at the first sign of trouble. This should contribute to better health and longer lives for everyone. It may also reduce the overall load on healthcare services by helping more people avoid acute conditions that can be costly and time consuming to treat.

It's also clear that m-health will lead to an explosion in the quantity of potentially sensitive personal data gathered into the systems that manage our care. This is necessary to accumulate digital knowledge regarding the indicators for various conditions, so that systems can become progressively better at detecting illnesses in their early stages and recommending the best course of action. Moreover, this knowledge will be based on real case data and therefore should be accurate and unbiased.

On the other hand, automated collection of personal health-related data raises questions about privacy that need careful handling. There will likely need to be a cultural shift, or perhaps a generational shift, before automation becomes widely accepted. Surveys suggest that about one-third of people today would be happy to share such data, while the remainder would be more guarded. Also, care delivery traditionally comes with the "human touch." For many, this provides essential comfort and reassurance. It will take time for automated systems to gain acceptance. Advocates for automation will point to the potential for easier and faster access to services, shorter wait times, and fewer instances of misdiagnosis due to human error. There is also a civic aspect to sharing health data that helps automated care systems to learn and hence support patients better.

We can probably expect younger generations to accept more readily that a machine will analyze their data in the first instance and suggest the most appropriate action. Of course, the human touch must remain detectable and will likely provide oversight and guidance, intervening where necessary.

Now that it's possible to monitor vital signs continuously, and so identify trends early to determine the best response, there is a clear parallel with condition monitoring of industrial equipment. In the same way that an early warning of any need for adjustment or minor repair to a machine can help minimize disruption in the factory, condition monitoring for people could help us all stay healthier for longer and get the treatment we need at a time that's convenient. Maybe even before any symptoms become apparent.

While we, as technology fans, can celebrate the many innovations currently happening throughout this sector, we must also acknowledge that the medical field is traditionally not open to disruptors. Changing practices, and acceptance of new approaches, is likely to take a long time.

For now, we can say that there is an uptick in the numbers of people interested in monitoring their health and diet. With instances of diabetes increasing worldwide, particularly Type 2 diabetes, new and less invasive ways of measuring blood insulin and glucose are becoming available. Traditional and inconvenient pin-prick tests can now, thankfully, be replaced with sensors worn as a patch. The data from these patches can drive automatic prompts when an injection is necessary or enable an app to make dietary recommendations to help manage the condition.

These and other improved medical sensors are part of a market for data-collection devices that is growing quickly, currently at about 16% CAGR. They are an intrinsic part of the m-health revolution, the perception layer that feeds our smartphones, which then handle data aggregation, filtering, and connecting with healthcare providers.

High-tech industries, of course, are deeply involved in developing smart sensors, which need to be small, low-power, minimally invasive, and comfortable to wear. We in the PCB business are familiar with issues like bio-compatibility and the properties of flexible substrates that can be conformed to wear against the skin, or folded or rolled for installation in a larger wearable device.

Engineers and scientists must continue to innovate in this space. Some important requirements include improving the user friendliness and usability of devices and sensors for m-health. I was intrigued recently by the possibilities created by a new shape-shifting haptic display developed at the Max Planck Institute in Stuttgart and the University of Colorado Boulder, which could enable us to digitize touch, replicate the response of human tissue, and even automatically convert text to braille.

Although – as with attitudes to data sharing – we can expect younger generations to be the most accepting of wearable medical technology, it's true that we tend to need more care as we become older. While there is clearly always scope for improvement, accepting the role of technology and automation in our healthcare is a step we must all be prepared to take along the road to better wellbeing.

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ROUGHLY **SPEAKING**

Changing PCB Trace Dimensions

Models can reveal what design rules "forgot."

A PICTURE IS worth a thousand words, and that is especially true when evaluating the impact of changing trace dimensions in your printed circuit board.

The capabilities today of visualizing, in a matter of seconds, the complexity of the electromagnetic fields in one's printed circuit board are astounding. Twenty years ago, software tools to help designers make informed decisions were limited to numerical outputs or very rudimentary images. Often one required a significant level of understanding of the physics involved as well as a solid imagination to properly visualize the electromagnetic field lines and their significance. Even then, most visualizations were representations, not actually calculated fields displayed over the actual board and components. Many tools today provide unprecedented insights through such visualizations, equipping and enabling quick and intelligent decision making by designers on an unprecedented level.

I recall – and I hope you had a similar experience – a science class that used iron shavings and a magnet to make visible the once invisible magnetic fields as in **FIGURE 1**.

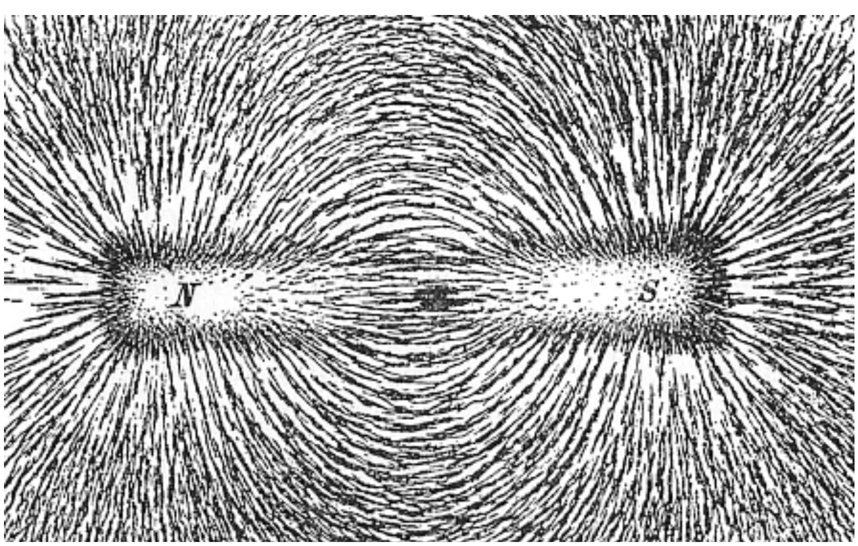


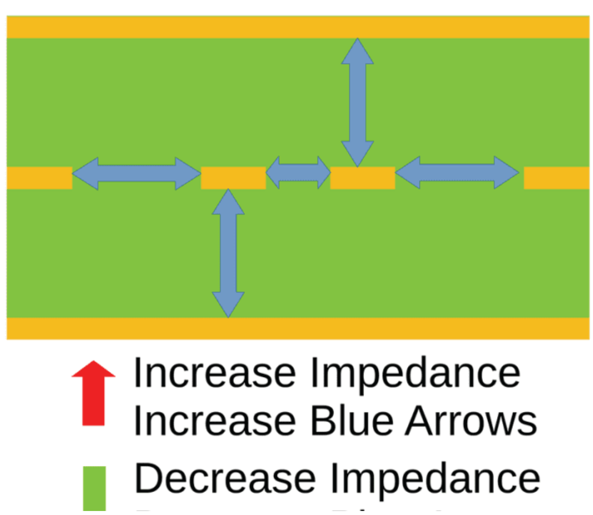
Figure 1. The magnetic field of a bar magnet revealed by iron filings on paper.

(The figure shows the magnetic field of a bar magnet revealed by iron filings on paper. A sheet of paper is laid on top of a bar magnet and iron filings are sprinkled on it. The needle-shaped filings align with their long axis parallel to the magnetic field. They clump together in long strings, showing the direction of the magnetic field lines at each point. The image is from N. Henry Black and Harvey N. Davis, *Practical Physics,* The MacMillan Co., 1913.)

Sometimes visualizations like that are more important in successfully conveying what is important than what raw numbers articulate. It is why Microsoft Excel is a much-loved tool for even making simple graphs! Would you rather see a picture and grasp immediately the information needed to decide, or spend time trying to remember or figure it out through deduction?

Having a reference for quickly and easily remembering which parameters of a transmission line impact the impedance in each direction is very helpful for pre-layout design decisions. One could begin by looking at the reduced version of the telegrapher's equations; the lossless characteristic impedance of a transmission line is SQRT (L/C), where any increase in the capacitance of the trace reduces the impedance and vice versa. As we increase the inductance, we also increase the impedance.

Since capacitance and inductance are primarily determined by the dimensions of the traces and their distance from references, it stands to reason that quickly recognizing the nature of the changes to those dimensions will impact the impedance is important. A quick graphic, as in **FIGURES 2A** and **2B**, helps identify the direction of dimension change and the corresponding direction of the change in impedance.



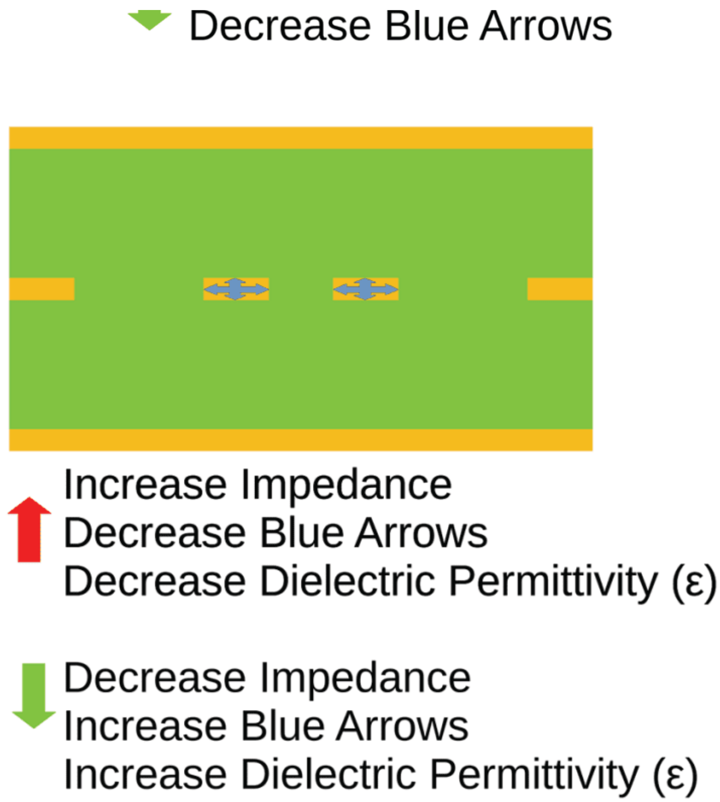
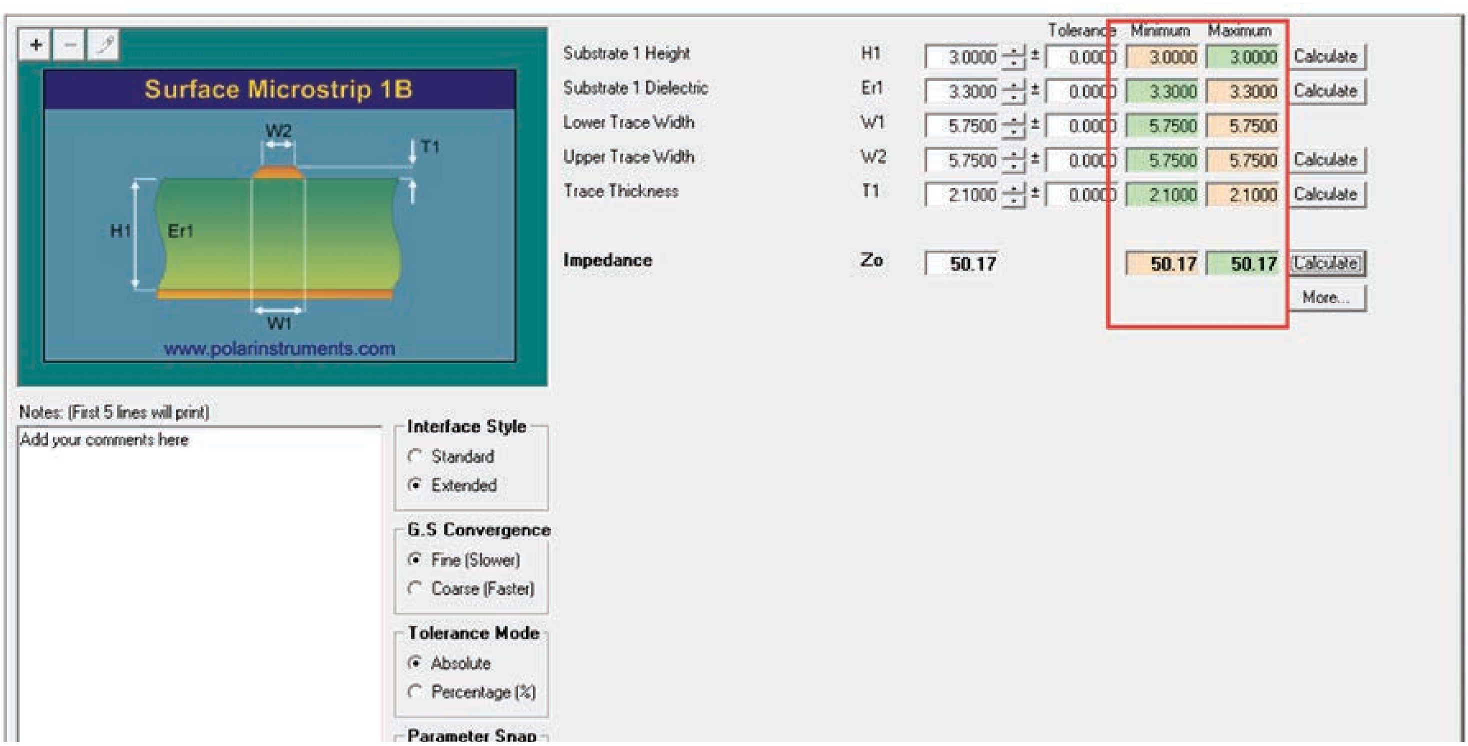


Figure 2a (top) and b (bottom). Z charts.

Some engineering tools provide built-in references, like the color-coded reminders in Polar Instruments Si8000 to help remind the user **(FIGURE 3)**.



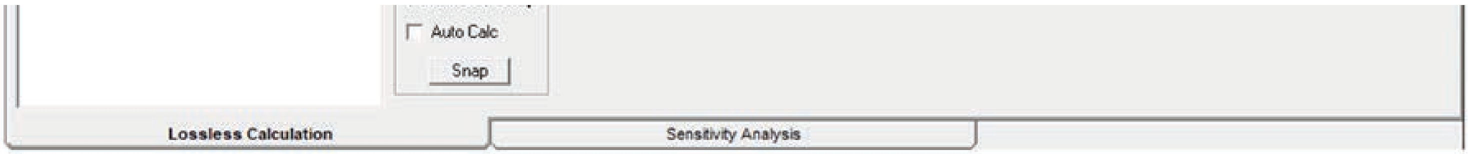


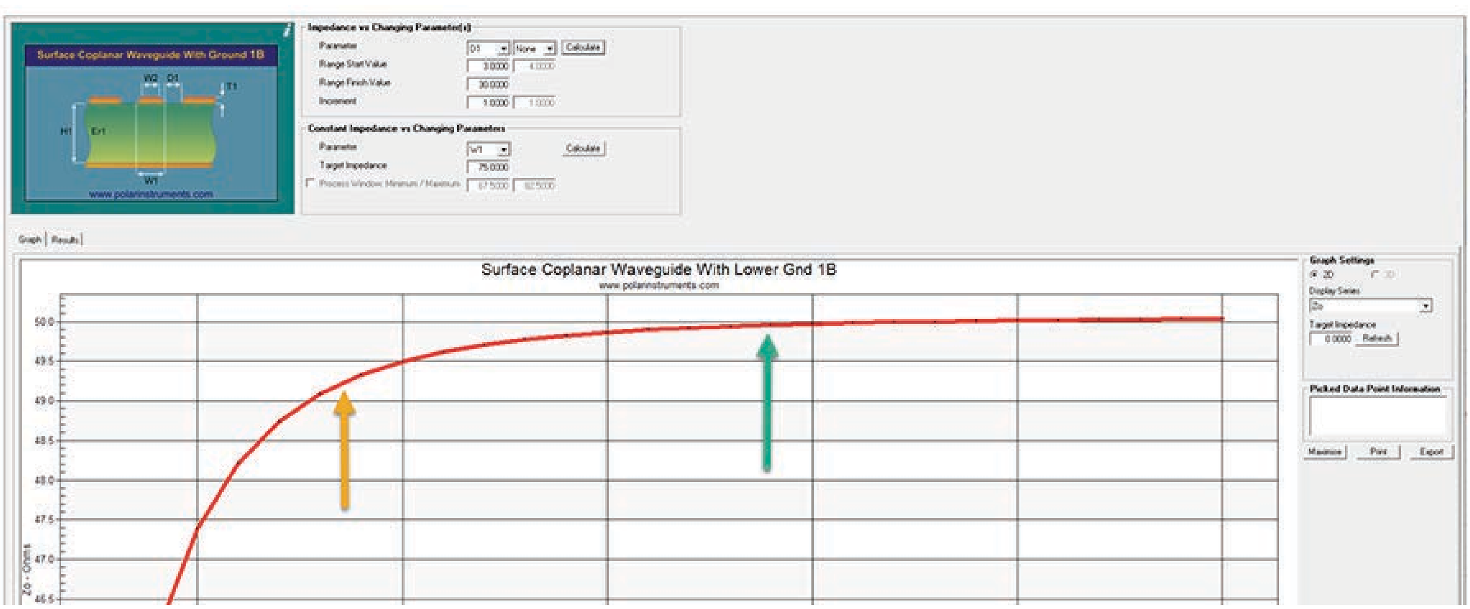
Figure 3. Color chart, produced in Polar Instruments' Si8000.

Design rules are also excellent for quick reminders, although it is important to remember Eric Bogatin's design rule of thumb #0: "Use Rules of Thumb Wisely." I once had a customer call me for support because the impedance waveform measurement from their time domain reflectometer (TDR) of the test coupon did not match the simulations with the field solver.

Now in this case, a few things had gone sideways, but one glaring issue was this fabricator's insistence that the coupon design not matching the 2-D simulated cross-section was perfectly fine because the guard traces were "sufficiently far away and didn't need to be modeled" based on a design rule. Well, things were not fine, and that is why they were calling!

They had followed a design rule for maintaining a keepout distance of 2.5x the distance to the nearest reference plane; missing that another design rule stipulates that one must also watch for 2.5x the width of the trace! As the trace in question was wider than the thickness of the laminate, the keepout needed to be greater than they had accounted for.

Visualizing parallel traces and seeing their impact on the impedance can sometimes be difficult to do intuitively or even manually. But with the advent of better visualizations from the Sensitivity Tab in Si8000, one can sweep a range of values quickly to display a graph of the changing impedance **(FIGURE 4)**.



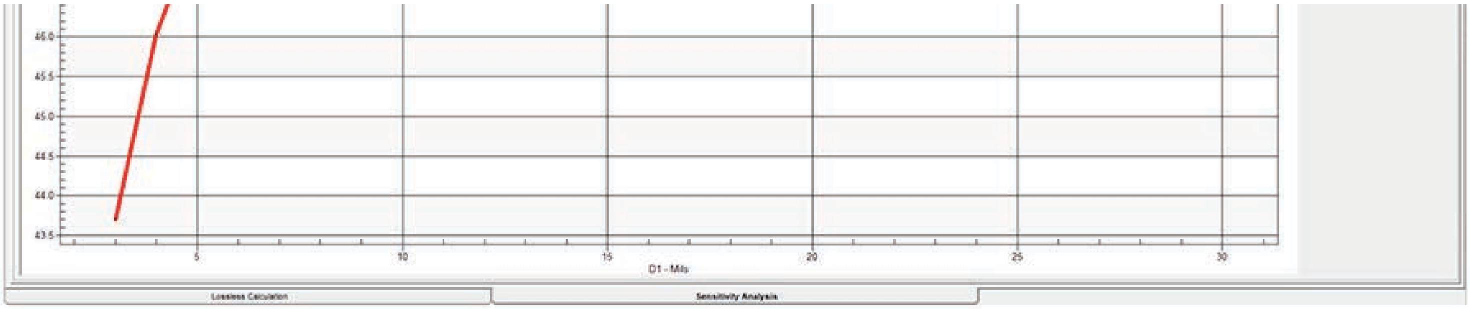


Figure 4. Impedance changes, graphed in Polar Instruments' Si8000.

In this case, we can see that the original keepout distance, marked with the yellow arrow, is not sufficiently far enough away, and that the green arrow marks where one can ensure the traces are sufficiently far apart.

The board had some other issues, but this was just one step in the process of communicating to the fabricator that the rules they had followed were incomplete. Furthermore, the fabricator was now equipped with the ability to calculate and articulate, with visuals, the minimum keepout distances to other internal resources as well as to its customers. It is easy for one to look at the plot and see where the red line of the modeled impedance stops changing.

Design rules exist to help make the engineering and fabrication process easier, and visualizations of the behavior in the printed circuit board are becoming more complex and available every year **(FIGURE 5)**.

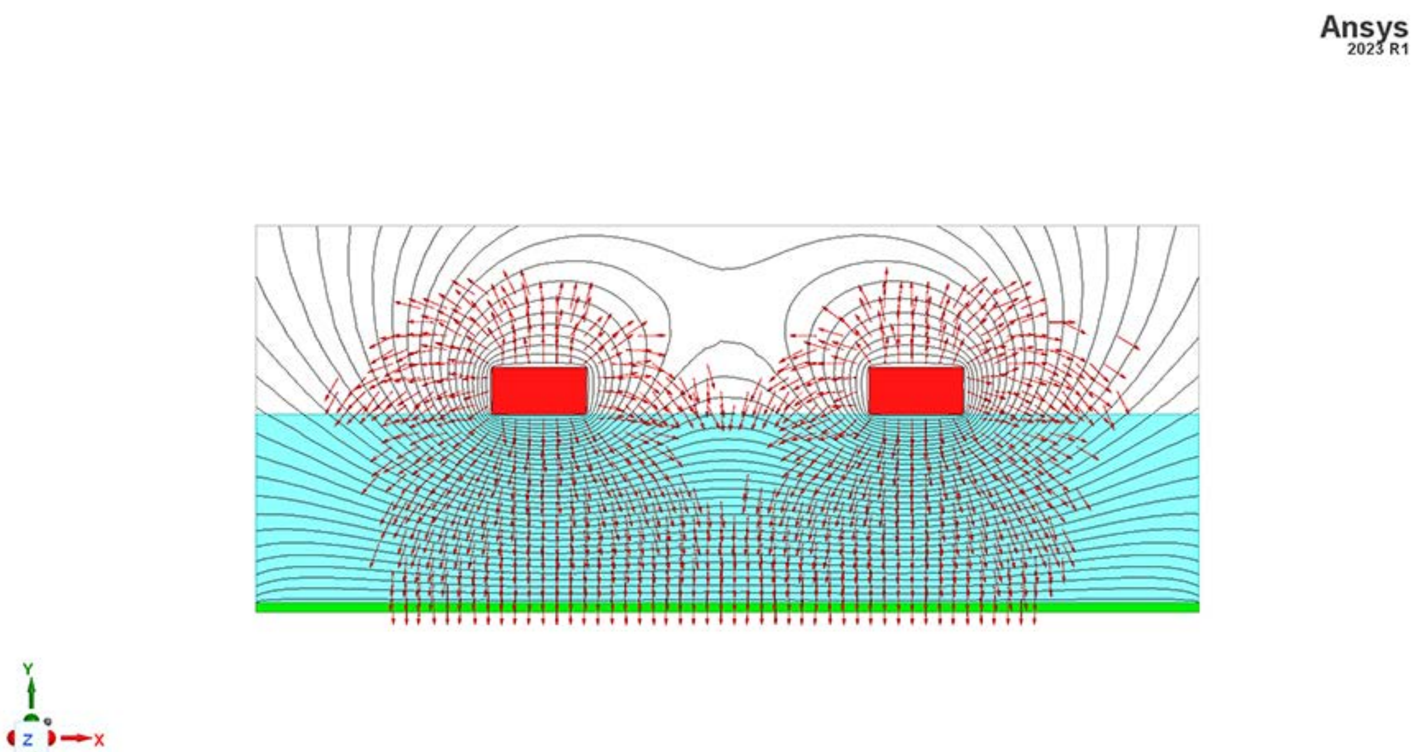


Figure 5. Visualization of EM fields of a differential pair using Ansys.

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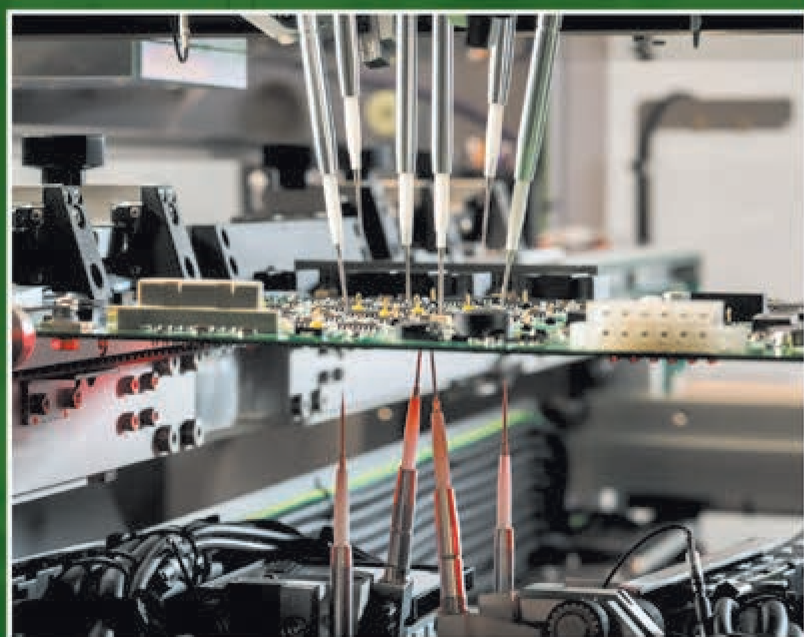

Relieving the Strain

Should you add a strain relief bead to your rigid-flex circuit?

YOU ARE PUTTING the finishing touches on your new design and feeling pretty good – you have made both the mechanical and electrical teams happy. At least mostly happy. One nagging issue remains: Should you add a strain relief fillet or bead to the interface between the rigid and flex portions of your circuit?

IPC-2223 discusses strain relief and considerations for and against. An estimate may be that about 50% of all designs include stain relief, and the rest do not. Keep in mind that the guidance below applies to both rigid flex and also to flex with FR4 or metal stiffeners. How do you decide if yours needs it?

First, let's discuss the role of the strain relief bead. At its core, the goal is to avoid a very sharp bend of the flex right at the rigid/flex interface. Some are concerned resin may flow out from the rigid material that could create a sharp edge, and the flex may be bent sharp enough to be damaged by the sharp rigid or resin edge.

Application of the bead causes the bend to start some distance away from the edge and distribute the bend along the arc. There are several reasons you might use strain relief and some where you may not.

When to use it. The primary use case for strain relief is when the flex is very thin and flexible, the bend radius is tight, and there is high likelihood the bend will take place right where the flex exits the rigid section. This is a fairly small percentage of designs. It typically means the flex is only one or two layers, or maybe up to four layers if unbonded. Flex layers are usually signals, and at most one plane layer. These thin flexes are at the greatest risk of some type of damage due to localized excessive strain, either bending sharply or even twisting stresses. The strain relief bead adds value in these cases.

The other good case for the strain relief is when the flex must bend sharply as soon as it exits the rigid in order to fit within the assembly or chassis enclosure.

Bend radius is also a determining factor. Generally, if the flex is bent less than 90°, there is no need for strain relief. The value is far greater on parts with 90° and 180° installations. Keep in mind that sometimes you may need to bend to 135° or 180° just to do the installation, even if the result is 45° or 90°. So consider the act of installing, not just the end state.

And when to not to. Like any feature, however, strain relief comes at a cost. It is a manual process performed one part at a time. So, if it is not needed or advised, it is a possible opportunity for cost savings. When can we avoid it?

When the flex length between rigid sections is quite short, adding strain relief will reduce the total flex available to complete the required arc. This will lead to a smaller effective bend radius, which may negatively impact compression and tension strain on the inner and outer diameter. For example, if the flex length is 0.500″ (12.7mm) or less, the strain relief applied at both ends could consume upwards of 40% of the total flex length. IPC-2223 suggests a bead width of 1.0-2.5mm.

You may be able to require a small bead on your drawing, but even if it were half that width, it would consume 20% of the flex length. Driving to a smaller bead width naturally diminishes the value of the bead itself, as it protects less and less of the interface zone. Keep in mind, to achieve a smaller bead, the supplier must carefully apply and monitor the bead application. The viscosity of the material permits it to flow and spread to some degree prior to curing. As you drive the requirement smaller, you will be driving the unit cost higher.

IPC-2223 also advises against applying a bead when the vertical height from the flex surface to the top of the rigid (Layer1) is less than 0.010″ (0.254mm). Reason: Keeping the bead height that low is very difficult. As a result, the bead will protrude above the surface of the outer layers of the board and may interfere with the solder paste screening process.

Beyond these two examples, there are other cases where the bead is not as valuable.

When the flex is three or more layers bonded together, the natural stiffness of the flex will cause the flex to bend in a full arc from rigid-to-rigid section unless you specifically bend it in a particular location. As layer count rises, the ability to bend the flex tightly near the rigid edge is very limited, and the bead adds little value.

There are also those rigid-flexes with six to 20 layers of flex made up of unbonded pairs of layers. As the layer count rises, the cumulative effect of all the material impacts the natural radius as the part is bent. The strain relief has little impact on high-layer-count flex.

Copper content in the flex must also be considered. If the flex uses heavier copper, like 2oz. (70µm), it is harder to bend. Similarly, if multiple plane layers are in the flex delivering power and ground or shielding, they will be far more mechanically robust than sparse signal layers. The plane or shielding layers protect the internal signal layers. They reduce the potential risk from twisting or torsional strain. The load on the exterior plane layers would need to be tremendous to cause damage to a trace on an internal flex layer.

Finally, if the bend is naturally located well away from the rigid-to-flex transition, then the bead is serving no mechanical purpose and can be omitted in this case.

Still not sure what to do? Get your fabricator's opinion. I often suggest that you start without the bead and add it if validation testing indicates it is needed. Bending tests can be run on samples to determine if the strain relief is providing a margin of safety that you need in the application.

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Will IC Package Substrate Makers be Next to Rule?

Massive investment suggests the segment could occupy a major portion of the largest fabricators' production.

by DR. HAYAO NAKAHARA

The heartbreak of the pandemic of 2020-21 is receding, but printed circuit fabricators continued to feel the supply-chain reverberations throughout the past year. The rollercoaster gyrated from a sharp dip to an intense high, with demand for consumer electronics, autos and other electronics resulting in tight inventories and long lead times. Then came the inevitable slowdown. Regionalization, currency swings and price cuts played havoc with manufacturers' order books and financials.

That's the picture drawn by this, the 26th NTI-100 report. As in the past several years, a rough conclusion is "big gets bigger and faster." Due to exchange rates that were favorable to the US dollar in 2022, the author thought there would be changes in the rankings, but they remained approximately the same as in 2021. Japanese fabricators were a surprise. Despite a 20% loss in value against the US dollar, their world ranking remained almost the same as in 2021. Domestic customers wanted to get PCBs from within the country because of supply-chain disruptions in China, resulting in good order intake.

As in the past, the author would like to thank various trade organizations and many firms and friends who provided vital information that enabled the compiling of this report. Any errors in this report are the responsibility of the author.

Currency Swings

Currency fluctuation in 2022 was wild, as seen in **TABLE 1**. Five currencies dropped more than 10% in value against the US dollar. The Japanese yen lost 20% of its value. At the time of this writing, the exchange rate was ¥146/$1. Taking advantage of this lowered value of yen, the number of foreign tourists flocking to Japan is larger than the peak prior to the Covid pandemic.

Table 1. Average Exhange Rates (local currency/US dollar)

Currency	2017	2018	2019	2020	2021	2022	22/21
China yuan (RMB)	6.758	6.616	6.910	6.903	6.402	6.732	-5.15%
Japanese yen	112.93	110.44	109.01	106.77	108.98	131.43	-20.68%
Taiwan dollar (NTD)	30.44	30.16	30.93	29.47	27.64	28.98	-4.85%
Korean won	1,131	1,101	1,166	1,180	1,136	1,292	-13.73%
Thai baht	33.92	32.32	31.03	31.27	31.76	35.06	-10.39%
Singapore dollar	1.334	1.349	1.364	1.38	1.333	1.379	-3.45%
Malaysian ringgit	4.32	4.035	4.123	4.203	4.11	4.40	-7.06%
Vietnamese dong	22,721	23,001	23,203	23,201	22,879	23,121	-1.06%
Philippine peso	50.44	52.7	50.82	49.62	49.94	54.52	-9.17%
Indonesian rupiah	13,440	14,236	13,799	14,559	14,195	14,851	-5.33%
Canadian dollar	1.297	1.296	1.327	1.34	1.244	1.302	-4.66%
Inidan rupee	64.87	68.43	70.39	71.12	73.36	78.01	-6.69%
Mexican peso	18.95	19.00	19.25	21.5	20.13	20.12	0.05%
Russian ruble	58.31	62.78	64.69	72.412	73.12	76.495	-4.62%
Swiss franc	0.98	1.022	0.994	1.38	0.967	0.99	-2.38%
UK pound	0.81	0.75	0.784	0.78	0.721	0.812	-12.62%
Euro	0.886	0.844	0.894	0.8677	0.839	0.9515	-13.41%

NTI summary from www.exchangerates.com

The author started the NTI-100 study 26 years ago to understand world PCB production. The NTI-100 list is a byproduct of this study. Included are fabricators that produced at least $100 million in revenue in 2022. There are many mergers and acquisitions around the world, and it is hard to track them all, yet doing so is critical to compile the list. The most difficult region is China. To the Chinese they may not be so complicated, but to this author many fabricators in China are elusive when it comes to financial reporting. Educated guesses were necessary, and the need for educated guesses is becoming a source of errors. The rankings are relative. Don't take them so seriously.

The $100M Club

This year's NTI-100 report segments the rankings in groups of 25 **(TABLE 2)**. Under careful examination, you can understand the trend of "big gets bigger and faster."

Table 2A. Largest PCB Fabricators in 2022, 1-25

Rank	Maker Name	Country	Local Name	Growth	2021	2022
1	Zhen Ding Technology	Taiwan	瑧鼎科技	10.5%	5,349	5,913
2	Unimicron	Taiwan	欣興電子	34.4%	3,608	4,848
3	DSBJ	China	東山精密	6.5%	3,044	3,241
4	Compeq	Taiwan	華通電脳	21.2%	2,176	2,637
5	Nippon Mektron	Japan	日本メクトロン	4.2%	2,442	2,545
6	TTM Technologies	US	TTM Technologies	10.9%	2,249	2,495
7	Tripod	Taiwan	健鼎科技	4.4%	2,174	2,270
8	Nanya PCB	Taiwan	南亜電路	23.8%	1,802	2,231
9	Shennan Circuits	China	深南電路	0.4%	2,071	2,078
10	Ibiden	Japan	イビデン	6.0%	1,803	1,907
11	AT&S	Austria	AT&S	12.6%	1,671	1,882
12	Kingboard PCB	China	建滔集団	-0.3%	1,738	1,682
13	HannStar Board	Taiwan	瀚宇博徳	-16.3%	1,997	1,646
14	SEMCO	S. Korea	삼성전기	10.9%	1,467	1,616
15	Kinwong	China	景旺電子	10.3%	1,416	1,562
16	Young Poong Group	S. Korea	영풍그룹	12.1%	1,359	1,523
17	Kinsus	Taiwan	景碩科技	19.0%	1,231	1,464
18	Wus Group (TW+CN)	Taiwan	楠梓電子(滬士電子)	11.0%	1,286	1,415
19	Flexium Technology	Taiwan	台群科技	12.7%	1,227	1,383
20	Shinko Electric Ind	Japan	新光電気工業	4.0%	1,289	1,345
21	Simmtech	S. Korea	심텍	24.3%	1,056	1,313
22	BH Flex	S. Korea	베에이치플렉스	61.9%	803	1,300
23	Meiko	Japan	メイコー	10.6%	1,151	1,273
24	AKM Meadville	China	安捷利美維	15.0%	1,068	1,228
25	Victory Giant	China	勝宏科技	6.1%	1,104	1,171
	Top 25 Total			**11.60%**	**46,581**	**51,968**

Source: Dr. Hayao Nakahara/N.T. Information Ltd., August 2023
In $US millions with average 2022 exchange rates

Table 2B. Largest PCB Fabricators in 2022 , 26-50

Rank	Maker Name	Country	Local Name	Growth	2021	2022
26	LG Innotek	S. Korea	LG이노텍	-4.0%	1,210	1,162
27	Gold Circuit (GCE)	Taiwan	金像電子	23.4%	919	1,133
28	Daeduck Electronics	S. Korea	대덕전자	33.9%	771	1,032
29	Suntak	China	崇達科技	-0.2%	891	872
30	Nitto Denko	Japan	日東電工	19.5%	730	872
31	Shenzhen Fast Print	China	深圳興森快捷電路	6.2%	749	795
32	Taiwan Techvest (TPT)	Taiwan	志超科技	-20.1%	949	733
33	Fujikura	Japan	フジクラ	6.8%	687	733
34	Sumitomo Elect. Ind.	Japan	住友電気工業	53.0%	468	716
35	ASK PCB	China	奧士康	3.0%	659	678
36	Olympic	China	世運電路	17.9%	558	658
37	CMK	Japan	日本シーエムケー	3.0%	620	638
38	Chin Poon	Taiwan	敬鵬工業	-3.5%	629	607
39	Unitech	Taiwan	燿華電子	29.0%	466	601
40	Murata Manufacturing	Japan	村田製作所	5.7%	530	560
41	Dynamic Electronics	Taiwan	定穎電子	-2.8%	543	528
42	Shengyi Electronics	China	生益電子	-3.1%	542	525
43	APEX International	Taiwan	泰鼎電路	0.7%	511	514
44	Career Technoogy	Taiwan	嘉聯益科技	0.5%	506	508
45	Founder PCB	China	方正印刷電路	4.9%	476	500
46	Isu-Petasys	S. Korea	이수페타시스	37.6%	363	498
47	Sun & Lynn	China	深聯電路	2.4%	483	495
48	Kyocera	Japan	京セラ	8.3%	457	495
49	KCE	Thailand	KCE Electronics	31.0%	370	483
50	Gul Technology	Singapore	Gul Technology	21.6%	393	478
	Top 26-50 Total			8.60%	15,480	16,814

Table 2C. Largest PCB Fabricators in 2022, 51-75

Rank	Maker Name	Country	Local Name	Growth	2021	2022
51	China Eagle (CEE)	China	中京電子	3.7%	437	454
52	Ellington	China	依頓電子	5.2%	432	454
53	Wuzhu	China	五株科技	-17.2%	533	441
54	CCTC	China	汕頭超声印製板	2.9%	428	440
55	Bomin Electronics	China	博敏電子	-17.3%	523	433
56	Hongxin Electronics	China	弘信電子	-12.8%	476	415
57	Kyoden	Japan	キョウデン	14.9%	347	399
58	GD Keixiang Kingshine	China	広東科翔電子	17.0%	335	392
59	Guangdong Junya	China	広東駿亜電子	-5.7%	405	382
60	Sanmina	US	Sanmina	3.0%	330	340
61	Red Board	China	紅板	-8.0%	355	327
62	Lincstech	Japan	リンクステック	7.6%	304	327
63	SI Flex	S. Korea	에스아이플렉스	17.5%	268	315
64	Taihong Circuit Industry	Taiwan	台豊印刷電路工業	34.9%	229	309
65	Transtech	China	江蘇伝芸科技	4.2%	285	297
66	Shenzhen Sunshine	China	深圳明陽電路	6.2%	275	292
67	Guangdong XD Group	China	広東興達(佳康集団)	-4.0%	302	290
68	FICT	Japan	エフアイシーティー	14.2%	247	282
69	MFS	Singapore	MFS Singapore	16.6%	241	281
70	Delton Technology	China	広州広合科技	-9.1%	308	280
71	Ichia Technology	Taiwan	毅嘉科技	18.1%	223	264
72	DAP	S. Korea	디에이피	13.2%	234	256
73	Shirai Denshi	Japan	シライ電子	11.8%	224	250
74	ACCESS	China	珠海越亜半導体	5.2%	237	249
75	STEMCO	S. Korea	스템코	-15.6%	289	244
	Top 51-75 Total			**1.80%**	**8,267**	**8,413**

Table 2D. Largest PCB Fabricators in 2022, 76-100

Rank	Maker Name	Country	Local Name	Growth	2021	2022
76	APCB	Taiwan	競国実業	-23.6%	314	240
77	Haesung DS	S. Korea	해성디에스	27.2%	184	234
78	Shenzhen Jove Enterprise	China	深圳中富電路	6.7%	214	228
79	Daisho Dennshi	Japan	大昌電子	9.1%	209	228
80	Würth Elektronik	Germany	Würth Elektronik	12.0%	200	224
81	Camelot PCB	China	金淥電路科技	12.7%	197	222
82	Onpress	China	安柏電路	-10.6%	244	218
83	Summit Interconnect	US	Summit Interconnect	11.1%	180	200
84	Somacis	Italy	Somacis	11.1%	180	200
85	Kunshan Huanxing Grp	China	昆山華新電子集団	-18.5%	242	197
86	Guangzhou GCI	China	広州杰書科技	4.6%	187	196
87	Kyosha	Japan	京写	14.6%	162	186
88	Jia Li Chuang	China	先進電子(珠海)	47.5%	124	183
89	Shihui Fushi	China	四会富仕電子科技	16.1%	156	181
90	Amphenol PCB	US	Amphenol PCB	16.1%	155	180
91	Jiangxi Union Gain	China	江西聯益電子科技	9.8%	146	177
92	Liang Dar	Taiwan	良達科技	4.2%	167	174
93	TLB	S. Korea	티엘비는	24.6%	138	172
94	Changzhou Auhong	China	常州澳弘電子	10.7%	159	171
95	Glorysky	China	惠州市特創電子	8.4%	158	171
96	Leader-Tech	China	深圳上達電子	-34.8%	252	164
97	SZ Minzhenhung	China	広東明正宏電子	-14.4%	190	163
98	Dongguang Hongyuen	China	東莞康源電子	-3.4%	169	163
99	New Flex	S. Korea	뉴플렉스	33.6%	122	163
100	Hyunwoo	S. Korea	현우	14.1%	142	162
	Top 76-100 Total			**4.50%**	**4,591**	**4,797**

Table 2E. Largest PCB Fabricators in 2022, 101-125

Rank	Maker Name	Country	Local Name	Growth	2021	2022
101	Aikokiki	Japan	愛工機器	25.0%	128	160
102	Ji'An Munkan	China	吉安満坤科技	-12.4%	177	155
103	Song Shan Electronics	Taiwan	松山電子	-10.4%	162	154
104	Toppan Printing	Japan	凸版印刷	10.9%	137	152
105	CHPT	Taiwan	中華精測科技	3.5%	146	151
106	Jiangxi ZLE	China	江西中絡電子	-13.4%	173	150
107	Forewin FPC	China	福菜盈電子	-23.4%	194	149
108	Oki Printed Circuit	Japan	沖PCB	1.4%	146	148
109	KSG	Germany	KSG	6.6%	137	146
110	Schweizer Electronics	Germany	Schweizer Electronics	25.0%	117	146
111	Jinagsu Difeida	China	江蘇迪飛達電子	-4.9%	152	144
112	SZ Xinyu Tengye	China	深圳新宇騰跌電子	5.5%	137	144
113	Theme Int'l Holdings	China	栄暉集団	5.5%	137	144
114	Kunshan Wanzhen	China	昆山万正電路板	-3.7%	141	136
115	Sichuan Intronics	China	四川英創電子	-10.3%	150	134
116	Xusheng Electronics	China	江西旭昇電子	-13.6%	155	134
117	Fuchnagfa	China	信豊福昌発	8.1%	121	131
118	Jiangsu Suhhang	China	江蘇蘇杭電子集団	-19.2%	158	128
119	SDG Precision	China	三德冠精密	-3.8%	130	125
120	Brain Power	Taiwan	欣強科技	-21.9%	160	125
121	Welgao	China	江西威尓高電子	-2.7%	128	124
122	Xiamen Guangpu Elec.	China	光苒電子股份	11.8%	110	123
123	Palwonn	Taiwan	競華電子	-47.0%	237	122
124	APCT	US	APCT	16.5%	103	120
125	Trustech	China	深圳全成信電子	-10.2%	133	119
	Top 101-125 Total			**-5.60%**	**3,669**	**3,464**

Table 2F. Largest PCB Fabricators in 2022, 126-139

Rank	Maker Name	Country	Local Name	Growth	2021	2022
126	Longyu PCB	China	龍宇電子(梅州)	-18.8%	146	119
127	ACCL	Taiwan	博智電子	19.0%	100	119
128	Yamamoto Mfg.	Japan	山本製作所	9.2%	109	119
129	Longteng Electronics	China	湖北龍騰電子	14.8%	102	117
130	HT Circuit	China	永捷電子	1.3%	111	113
131	First Hi-Tech	Taiwan	高技企業	-4.4%	163	111
132	Zejiang Leuchtek	China	浙江羅奇泰克科技	-9.4%	121	110
133	Shinko Manufacturing	Japan	伸光製作所	4.8%	105	110
134	Shenzhen QD Circuit	China	深圳強達電路	2.9%	105	109
135	Gangzhou Beyond PCB	China	贛州超跌	7.9%	101	109
136	Plotech	Taiwan	柏承科技	-18.4%	130	106
137	Concord Electronics	China	江蘇協和電子	-6.3%	110	102
138	Meizhou Ding Tai	China	梅州鼎泰電路板	19.8%	84	101
139	Zhongshan Baoyuejia	China	中山市宝悦嘉電子	5.3%	95	100
	Top 126-139 Total			**-2.30%**	**1,582**	**1,545**

IC package (IC PKG) substrate fabricators did well in 2022, except for Ibiden and Shinko Electric, whose fates depend heavily on Intel, which did poorly in the second half of 2022 due to poor PC sales. In the first half of 2023, the semiconductor business was still poor. July brought signs of recovery, but the revenue increase is lukewarm. It is expected, however, that the semiconductor business will heat up in 2024 and 2025. That's good news for IC PGK substrate fabricators. In 2022, the IC PKG substrate sector of PCB production amounted to slightly more than 20% of total PCB production in value.

Automotive PCB fabricators also enjoyed good business in 2022 because of strong EV shipments. Price competition is said to have been almost "ugly" in China, however. Newcomers to this sector dropped prices to capture market share, which dragged down profits among traditional automotive PCB fabricators.

Strong sales of PCs, tablets, smartphones, etc., induced by remote work and study in 2020-21 due to the pandemic created mini booms for these products. The boom ended in 2022. As a result, motherboard fabricators for these products suffered.

Several fabricators "disappeared" from 2021 to 2022. Compare the lists of those two years: Some lost revenue in local currencies, and some did so because of currency exchange rates.

The top 21 Japanese fabricators are shown in **TABLE 3**. Ceramic circuits are not considered in these tables.

Table 3. Largest Japanese PCB Fabricators (≥$100m), 2022

Rank	Maker Name	Local Name	Growth	2021	2022
1	Nippon Mektron	日本メクトロン	4.2%	2,442	2,545
2	Ibiden	イビデン	6.0%	1,803	1,907
3	Shinko Electric Ind.	新光電気工業	4.0%	1,289	1,345
4	Meiko	メイコー	10.6%	1,151	1,273
5	Nitto Denko	日東電工	19.5%	730	872
6	Fujikura	フジクラ	6.8%	687	733
7	Sumitomo Elect Ind.	住友電気工業	53%	468	716
8	CMK	日本シーエムケー	3.0%	620	638
9	Murata Manufacturing	村田製作所	5.7%	530	560
10	Kyocera	京セラ	8.3%	457	495
11	Kyoden	キョウデン	14.9%	347	399
12	Lincstech	リンクステック	7.6%	304	327
13	FICT	エフアイシーティー	14.2%	247	282
14	Shirai Denshi	シライ電子	11.8%	224	250
15	Daisho Dennshi	大昌電子	9.1%	209	228
16	Kyosha	京写	14.6%	162	186
17	Aikokiki	愛工機器	25%	128	160
18	Toppan Printing	凸版印刷	10.9%	137	152
19	Oki Printed Circuit	沖PCB	1.4%	146	148
20	Yamamoto Mfg.	山本製作所	9.2%	109	119
21	Shinko Manufacturing	伸光製作所	4.8%	105	110
	Total		**9.4%**	**12,295**	**13,445**

In $US millions. Average 2022 exchange rate: ¥131.43/US$1

Brief Analysis

Nine fabricators produced more than $2 billion in output in 2022 and 25 others had revenues greater than $1 billion, three more than in 2021. This is despite the loss in value of all countries' currencies against the US dollar.

Taiwan's output of $30.3 billion by fabricators on the list and China's $26.1 billion account for 65% of the total of the 139 fabricators on the NTI-100 in 2022. In the 1980s, the combined output of these two countries was infinitesimal. They will continue to increase their world share when their continuous investment is considered, a major portion of which is in Thailand. In fact, all top Taiwanese PCB fabricators are building new plants in Thailand, although a few are investing in Malaysia and Vietnam.

Every region saw local production grow in 2022 **(TABLE 4)**, while Taiwanese fabricators produced the largest value of PCBs in all its companies' factories worldwide. **(TABLE 5)**

Table 4. Estimated PCB Output by Region, in 2022 Exchange Rates

Region	2021	2022	YoY Change
Americas	3,400	3,520	3.53%
Germany	745	790	6.04%
Rest of Europe+Russia	1,280	1,370	7.03%
Middle East & Africa	145	155	6.90%
West Total	**5,570**	**5,835**	**4.75%**
China	54,205	56,720	4.64%
Taiwan	10,900	11,930	9.45%
S. Korea	7,220	8,570	18%
Japan	5,945	6,560	10.34%
Thailand	3,175	3,350	5.50%
Vietnam	3,110	3,200	2.90%
Asia Total	**85,805**	**91,670**	**6.83%**
World Total	**91,375**	**97,505**	**6.71%**

In US$millions. Source: N.T. Information Ltd., March 2023

Table 5. Estimated World PCB Ouput by Nationality, 2022

Rank	Nationality	PCB Output	World Share
1	Taiwan	31,170	31.97%
2	China	30,430	31.52%
3	Japan	15,490	15.90%
4	S. Korea	10,400	10.67%
5	US	5,010	5.14%
6	Austria	1,900	1.95%
7	Germany	790	0.81%
7	Singapore	750	0.77%
8	Thailand	500	0.51%
9	India	350	0.36%
10	Others	715	0.72%
	World Total	**97,505**	**100%**

In US$millions. Source: N.T. Information Ltd., March 2023

Zhen Ding Tech produced 6% of the world production. Its chairman claimed that ZDT aims to produce 10% of the world PCB production by 2030.

Zhen Ding Technology or ZDT for short (臻鼎科技) is listed on the Taiwan Stock Exchange (TSE). Its consolidated revenue is reported here. ZDT is also listed at Shenzhen Stock Exchange under the name Avary Holdings (鵬鼎控股). Avary Holdings reports revenue from China only and it does not include its IC PKG substrate subsidiary, Leading Tech (礼鼎半導体). Its website is leadingics.com/cn. Leading Tech is stock listed separately, and had revenue of $180 million (all from IC PKG substrates). ZDT has another subsidiary, Boardtek in Taiwan, which ZDT purchased several years ago. Boardtek specializes in high-frequency PCBs and is one of the leaders in automotive PCB for radars.

LG Innotek experienced a revenue loss. The author does not know why.

The aggregate output of the top 139 fabricators was $87 billion in 2022 **(TABLE 6)**. The author estimates that the remaining 2,400 fabricators worldwide produced about $10 billion.

Table 6. NTI-100 Distribution by No. of Entries and Revenue, 2022

Nationality	No. Entries	2021 Revenue	2022 Revenue	YoY Change
Taiwan	27	27,404	30,306	10.6%
China	64	25,739	26,085	1.3%
Japan	21	12,295	13,445	9.4%
S. Korea	14	8,406	9,990	18.8%
US	5	3,017	3,335	10.5%
Europe	5	2,305	2,598	29.7%
SEA	3	1,004	1,242	23.7%
Total	**139**	**80,170**	**87,001**	**8.5%**

Source: N.T. Information Ltd.

Based on the above, the total output in 2022 is estimated to be about $97 billion. Some $9 billion of the total came from assembly operations by PCB fabricators, making the total “bare board” output in 2022 $89 billion, of which $17.7 billion came from IC PKG substrates. In other words, IC PKG substrates held about a 20% share of the total PCB output in 2022.

IC PKG substrate fabricators are investing about $30 billion in the next several years. When these investments start producing substrates, it is conceivable that up to 25% of the total PCB output may come from IC PKG substrates in the future.

TABLE 7 shows the IC PKG substrate production in 2022. Japan’s output appears small because the conversion from the yen to the dollar was made using an exchange rate of ¥131.43/$1. If the average 2021 exchange rate is used, the $4.1 billion would have been $5.02 billion. To compare the output of various countries, it is necessary to use a common currency. Traditionally, such comparisons are made using the dollar, which distorts the picture, unfortunately.

Table 7. IC PKG Substrate Production, 2022

Region	Output
Taiwan	6,690
S. Korea	4,720
Japan	4,140
China	1,450
Other	700
Total	**17,700**

Output is by corporation nationality, not factory location. In US$millions. Source: N.T. Information Ltd., March 2023

TABLE 8 shows the author's forecast of IC PKG substrate output using 2022 exchange rate. If the currency exchange rates return to 2021 levels, the $22 billion forecast for 2025 could be $25 billion. The author often wonders what sort of exchange rates the world forecasters are using.

Table 8. IC Substrate Production Forecast

Year	2020	2021	2022	2023F	2024F	2025F
IC PKG substrates	11,580	16,100	17,700	15,900	18,000	22,000

In US$ millions. Source: N.T. Information Ltd., August 2023

DR. HAYAO NAKAHARA is president of N.T. Information; nakanti@yahoo.com. He is the world's foremost authority on the printed circuit board market worldwide.

'A Seamless Solution'

With new leadership at the helm, Freedom CAD is looking to the future while maintaining its standards.

by TYLER HANES

Freedom CAD has been offering electronic product development and PCB design services since its inception in 2003, but the core team behind the company has been together since the early '90s.

Figure 1. Freedom CAD COO Scott Miller speaks to a exhibition visitor at PCB West 2023.

That leadership has built the company into one of the largest design service bureaus in the US, offering design and engineering services for more than 150 customers per year – many of whom have been customers since the early days.

“We have a long history, and with that, we have a long history with our customers,” said COO Scott Miller.

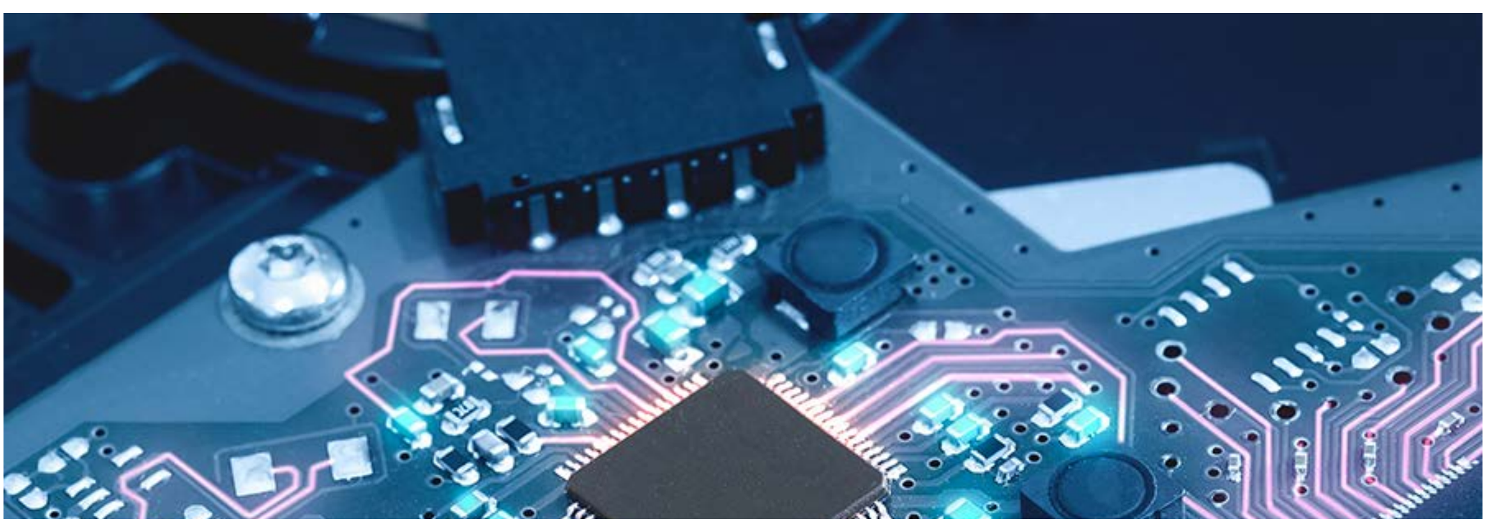
While those decades of experience have helped build up the company, Freedom CAD earlier this year appointed a new CEO, Brian White, and named his brother, Patrick White, vice president of operations to guide the company into the future and deal with the growing challenges of talent recruitment and new technology.

‘From CAD to the Lab’

Freedom CAD typically works with three types of customers, said Miller, including those that have no in-house hardware development capabilities, those that have in-house capabilities but lack room or resources for peak demands, and those looking for someone to step in to handle more advanced technologies that are beyond their comfort level.

While design service bureaus have traditionally focused on PCB layout, Freedom CAD has developed into a company that can offer engineering services such as electrical, mechanical, and signal and power integrity while still maintaining its strong skills in layout.

One of Freedom CAD’s strengths is the ability to enter a project anywhere along a customer’s timeline – whether helping with the initial design steps and working from there or jumping into the middle of the project to help a customer with just one step, Miller said.



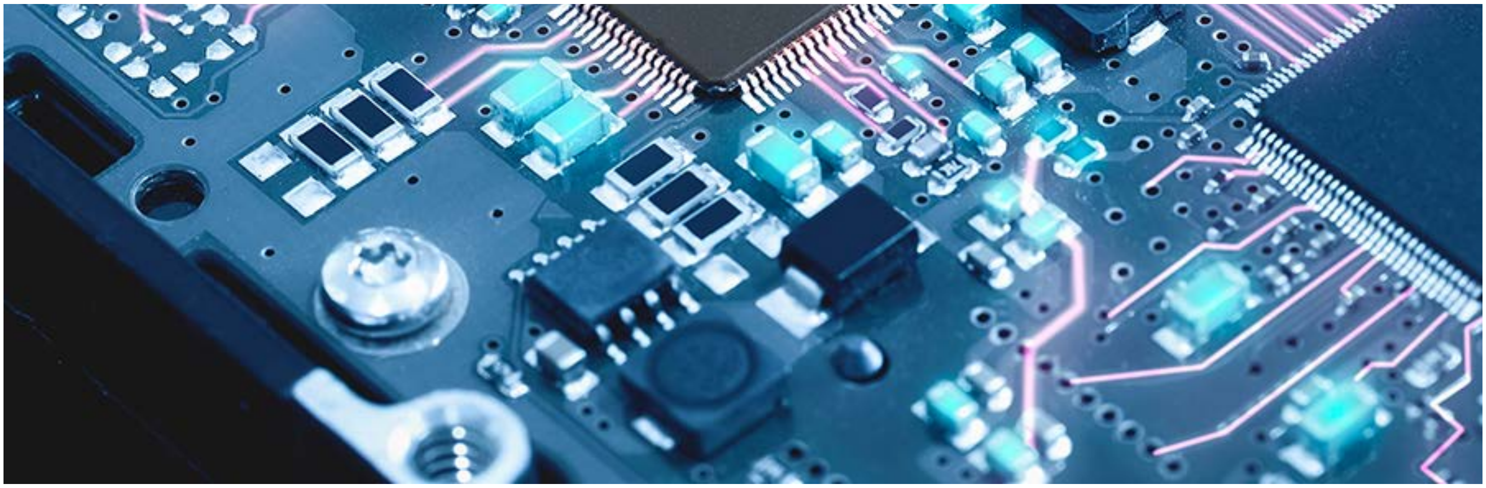


Figure 2. Freedom CAD's services include PCB layout, engineering and component procurement.

"Customers can enter at any point along the way," he said.

Once through the engineering effort, Freedom CAD also provides a turnkey solution for manufacturing, or "getting from CAD to the lab," as Miller describes it.

While the company doesn't do any manufacturing itself, it does have longstanding relationships with board fabricators that take a project to the manufacturing stage.

"We'll procure the components, and contract manufacturers will do the assembly work under our direction," he said. "That allows us to provide a customer with a seamless solution from concept to parts in hand in the lab."

On the design front, Freedom CAD works with the four primary design programs used throughout the industry: Cadence Allegro, Altium Designer, and Siemens' Xpedition and PADS tools.

It is also a certified design partner with Siemens' Valor NPI, which can help catch design errors that the four CAD flows might miss, and the Freedom CAD team is adept at preparing that DfM (design for manufacturing) data into reports that can save headaches in the manufacturing process, said CEO Brian White.

"They can be confident that they can take that data to the manufacturer, and they'll have everything they need in a standard format," he said. "And that saves time and prevents a lot of back-and-forth with the manufacturer."

One of the key ideas behind the creation of Freedom CAD was having the scale to work with multiple customers on multiple projects all at the same time, Miller said.

He said the R&D process typically involves peaks and valleys in demand, so the company has worked to overlay those peaks and valleys with each other to maintain a balanced workload through the year.

Freedom CAD averages around 150 customers per year, with many having multiple projects during that time, and that scale was an important factor in developing the Valor process, because many other similar companies are too small to pay for the software or have experts on hand to interpret the data, Miller said.

“Because of our scale and the fact that we deal with so many customers, it affords us the opportunity to provide our customers with a consistent level of quality and assurance,” he said. “Whether you’re a billion-dollar customer or a ten-thousand-dollar customer, you’re getting the same level of quality coming out the door.”

With the component shortages of the past few years, many companies have approached Freedom CAD for help redesigning a board after they were unable to source a specific part, while others simply want assurances that the part they’re using will be available in the future, Miller said.

He said when working with a customer on engineering or layout, Freedom CAD’s team will find out what components are available and what issues may bubble up in the near future, and then fit those new parts into the design before it gets to the production stage.

“We do a lot of that analysis during the design process, so by the time the design is complete and we’re ready to go to fabrication, we’ve tried to iron out all the obstacles that would prevent us from going into production and getting a quickturn prototype,” Miller said.

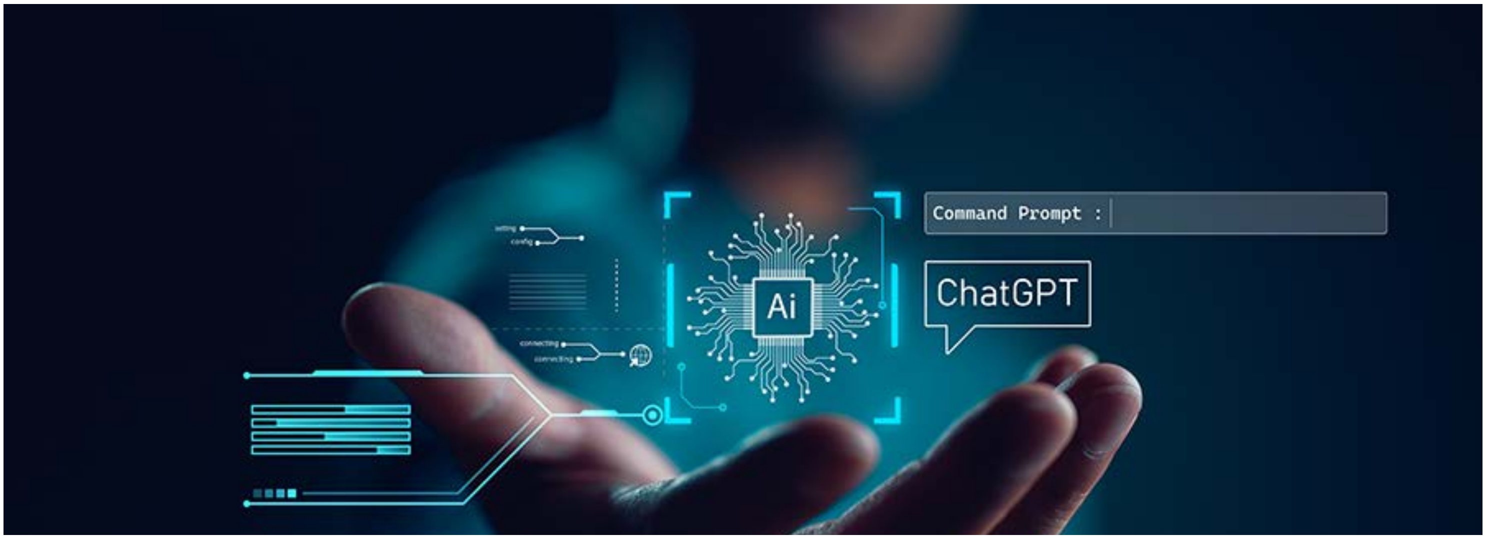


Figure 3. If AI performs layout, customers will still need engineering services, Freedom CAD says.

New Leadership

Earlier this year, the company promoted former executive vice president Brian White to the role of CEO, and Brian's brother, Patrick, has taken over as vice president of operations.

The industry as a whole is seeing more designers reaching retirement age, and while some of them have continued to work, the need is growing for new designers – as well as new leadership, Miller said.

"Not only do we see the graying of the industry at the design level, but also at the management level," he said. "A lot of the design service bureaus are run by the 'gray hairs,' and we've recognized that and turned this over to Brian and Pat."

Patrick White is a product of Freedom CAD's designer training program put into place 18 years ago, and he is working to improve the program and recruit the next generation.

"I've found that the career path isn't necessarily a tough sell, because they don't need a four-year degree to get into it while earning a good income," he said. "It's not a well-known job or career path, but once people do learn about it, it can be a good option for people just out of college or high school."

While the job isn't hard to sell, finding the talent to fill the job can be a challenge, and Patrick White said his personal experience in Freedom CAD's training program is helping him recognize that talent and develop it for a long career.

Back when he started in the training program 15 years ago, he said the experience was not very structured, with no specific person training him and moving between whichever projects were available at the time.

Since began overseeing the training, he has tried to put a little more structure into it and provide focused, deliberate training that builds on lessons learned while also providing mentors who can guide trainees along the way.

PCB design doesn't typically have concrete right or wrong answers, so it's important to let young designers get hands-on in the design process and come face-to-face with the different priorities and tradeoffs that they'll see as part of the job – and then get repeated feedback from their trainer about what they did well and what they need to work on, Patrick White said.

"Getting people in the door, I don't think is a huge challenge," he said. "It's just a matter of organizing our resources and having a mentor to build their confidence."

PCB design is a lot like a trade such as an electrician, where you can read a lot about the job going in, but you really need a lot of on-the-job training before you can do it on your own, said Brian White.

"It's kind of the same experience in this industry, where you really need that hands-on experience," he said. "That's where you really learn how to do it. A book can't teach you all the ins and outs."

The Rise of AI

With the growing ability of artificial intelligence to take over some of the work normally done by human labor, tech companies have made inroads to develop AI tools for design, Miller said.

Right now, those fledgling tools still need a guiding hand from a person to perform the job, but it's something that will continue to be developed and improved upon, he said.

"That's something that we really have to keep an eye on," he said.

Miller said the development of those AI tools have been part of the driving force behind Freedom CAD's shift from layout to offering more engineering services, because if AI is eventually able to lay out a board at a human level, customers will still need those engineering services.

"We're not ignorant of it," he said. "We know AI is going to affect everybody – and it's already beginning to – and our industry isn't immune to it."

AI can also be a point of optimism for the industry as well, as it is part of the continuing growth of electronics in daily life, said Brian White.

With electric vehicles hitting the road, the Internet of Things connecting the household, and the rise of drone companies and private space travel, the need for circuit boards should continue to grow into the future, he said.

"It feels like a good place to be because we don't see that need going away any time soon," he said.

The variety of electronics coming through the door is also one of the selling points when talking to a potential recruit, and Freedom CAD was built to be able to handle whatever new technology is next to rise, Miller said.

"We don't know what the next horizon's going to be, but we do know that electronics are evolving, and we're in a good position to provide a breadth of services and be able to engage with customers in different ways," he said. "And that's really our mission."

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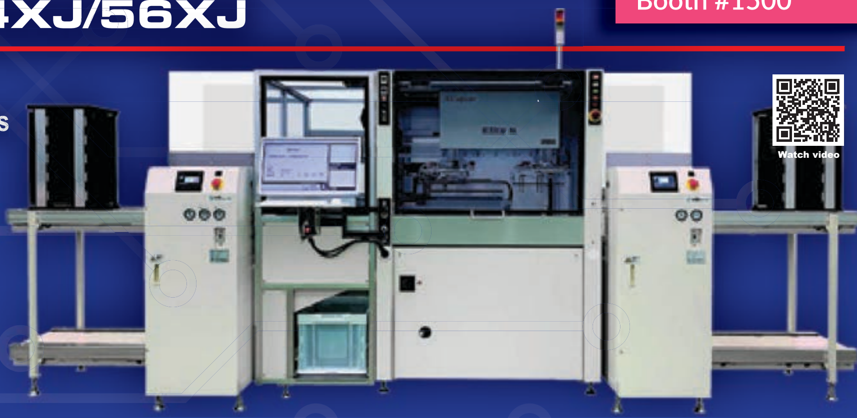

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IMS

Advanced Substrates for Power-Dense Applications

Enhanced insulated metal substrates are effective for wide-bandgap semiconductor power modules.

by **STEVE TAYLOR**

Step on the pedal of a modern electric vehicle (EV) and you will feel quick, smooth acceleration. This smooth acceleration is due to improvements in converting DC battery energy into three-phase AC power that controls torque and speed. Although most headlines focus on advancements in EV battery design, it is improvements in power switching in the traction inverter that has led to better performance and power management in the vehicle's propulsion system.

The demand for advanced high-performance power systems is far-reaching. Many industries are searching for innovative materials and technologies that will meet the needs of next generation power electronics. Trends in the marketplace are toward more compact power devices that can operate under extreme conditions. Higher temperatures, higher switching frequencies and higher blocking voltages are in demand, while efficiency and reliability issues are obstacles that need to be overcome.

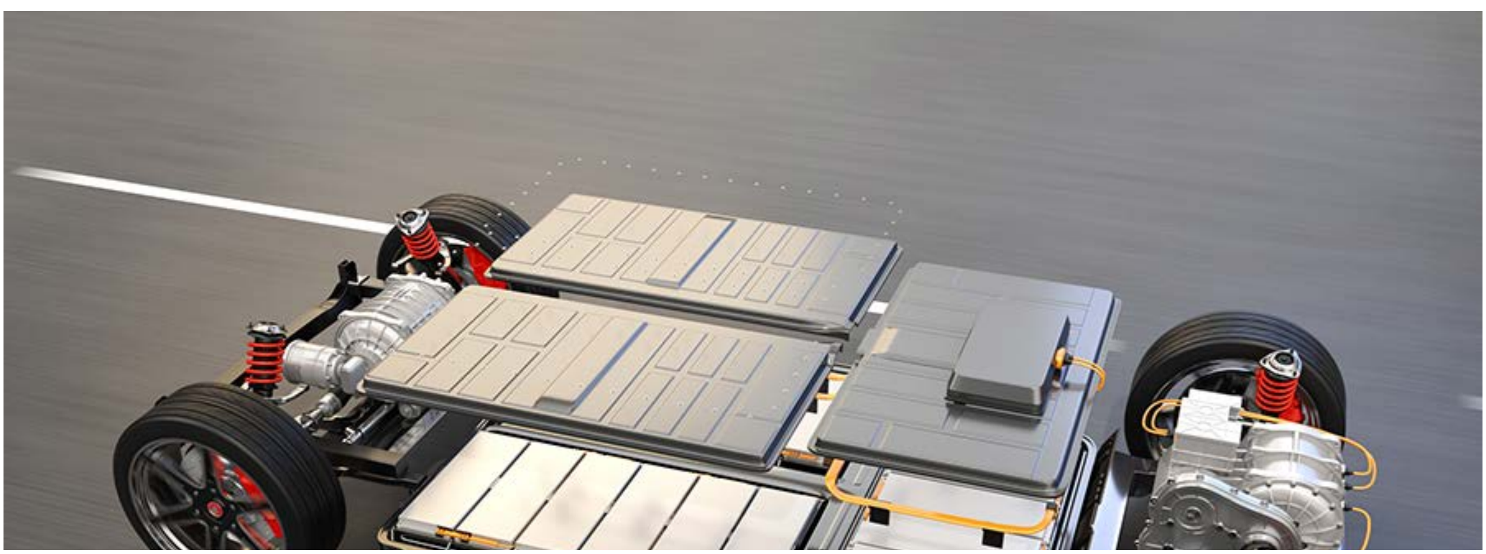

Figure 1. Automotive traction inverter.

An emerging technology of considerable interest is wide-bandgap (WBG) metal-oxide semiconductor field-effect transistors (MOSFETs). Based on silicon carbide (SiC) or gallium nitride (GaN), WBG MOSFETs possess higher thermal conductivities and blocking voltages than conventional silicon (Si) based MOSFETS, making them better suited for handling higher power densities and higher temperatures.

While WBG semiconductors are capable of superior performance under extreme conditions where excessive heat is a major concern, this capability is useless without advancements in the substrates upon which these devices are mounted. Power-dense applications of next-generation power electronics will require advanced substrates with advanced thermal, electrical, and mechanical performance.

Substrate Types

Traditional power module substrates. Traditional power modules are constructed on direct-bonded copper (DBC) substrates consisting of a ceramic isolator, typically low-cost Al_2O_3 (aluminum oxide), sandwiched between two layers of copper (Cu).

FIGURE 2 shows a standard DBC half-bridge power module with single-sided cooling. Traces, die attachment, wirebond landing and termination attachments are on top. The bottom layer is used as a contact area for mounting a heat sink or other cooling structure.

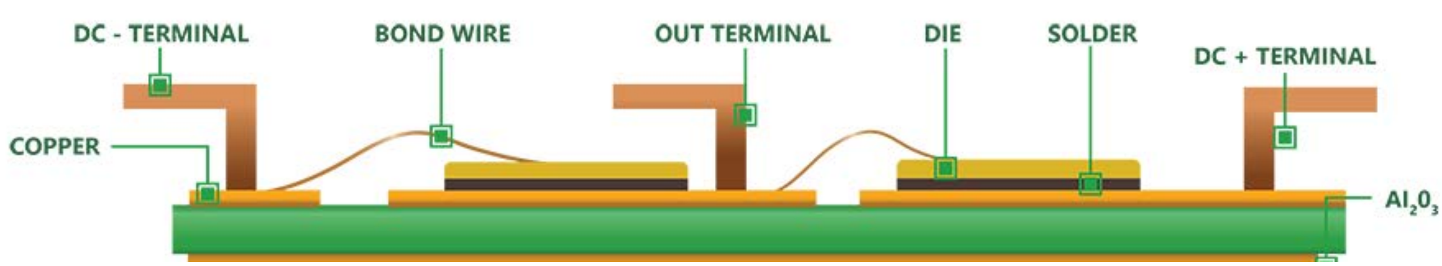

Figure 2. DBC-based half-bridge power module.

Standard DBC substrates have worked well for traditional silicon-based power modules. When exposed to extreme temperature fluctuations, however, they experience considerable mechanical stress due to differing coefficients of thermal expansion (CTEs), leading to early system failures.

Low breakdown voltage of Al_2O_3 is another limitation. In most power electronic applications, the cooling system is grounded, therefore the ceramic in the DBC substrate must possess a high enough breakdown voltage to survive the voltage potential between the top layer nodes and the ground.

Alternative DDC ceramics. Some improvements in thermal performance have been demonstrated by utilizing different ceramic materials such as AlN (aluminum nitride) and Si_3N_4 (silicon nitride), but they have not yet sufficiently overcome fundamental challenges.

AlN DBC shows improved heat transfer and higher breakdown voltage compared to Al_2O_3 DBC, but AlN is brittle, requiring thicker layers to compensate. Flatness fluctuation due to CTE mismatch of copper and AlN during temperature cycling can affect long term reliability, as well.

Si_3N_4 DBC substrates are mechanically stronger than AlN DBC and offer better heat transfer than Al_2O_3 DBC, but bonding Si_3N_4 to copper is a much more difficult and costly operation.

Insulated metal substrate (IMS). IMS is a novel improvement to DBC for power electronic applications. Novel dielectric polymer-ceramic coatings can be used to insulate the conductive layers in power module substrates. The dielectric polymer is applied between a metal (typically aluminum or copper) base and the copper circuit layer, providing many benefits including excellent electrical isolation, superior heat transfer and durability. IMS materials are known to have excellent dielectric strength and can be processed in very thin layers to reduce the overall thermal resistance of the substrate. The basic structure of an IMS substrate is shown in **FIGURE 3.**

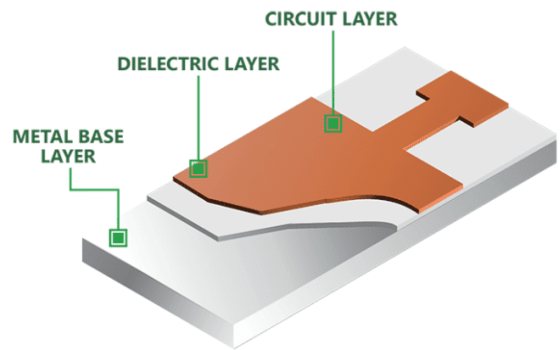

Figure 3. Structure of IMS substrate.

Graphite thermal management solutions. Graphite has long played an important role in thermal management of power electronics due to its high thermal conductivity and low density compared to copper and aluminum. For example:

- Thermal interface materials infused with graphite assist with heat dissipation, improving the heat flux of aluminum heat spreaders up to 50%.
- Natural-graphite-sheet (NGS) is a relatively new development now used successfully for heat sinks, improving air-cooling in power converters. NGS heat sinks are lighter weight and substantially reduce diode junction temperatures compared to conventional aluminum heat sinks.

Advanced thermally annealed pyrolytic graphite. TPG has emerged as a promising high-performance thermal management solution. TPG is a synthetic form of graphite formulated via a high-temperature chemical vapor deposition process and heat treatment above 3,000°C to create a highly aligned anisotropic multilayer graphite structure with very high in-plane (x-axis) thermal conductivity (>1500W/m^{2}K). Due to its relatively brittle nature, it is embedded in metal (typically copper) for protection and to make it available for direct die attach. Properly oriented, TPG also achieves excellent thermal conductivity (>700W/m^{2}K) in the through-plane (z-axis) and the cross-plane (y-axis).

A novel approach toward meeting the needs of next-generation high-power electronics involves an integrated solution that combines IMS and TPG technologies to create higher-performance IMSwTPG substrates. **FIGURE 4** shows an IMSwTPG half-bridge power module with single-sided cooling.

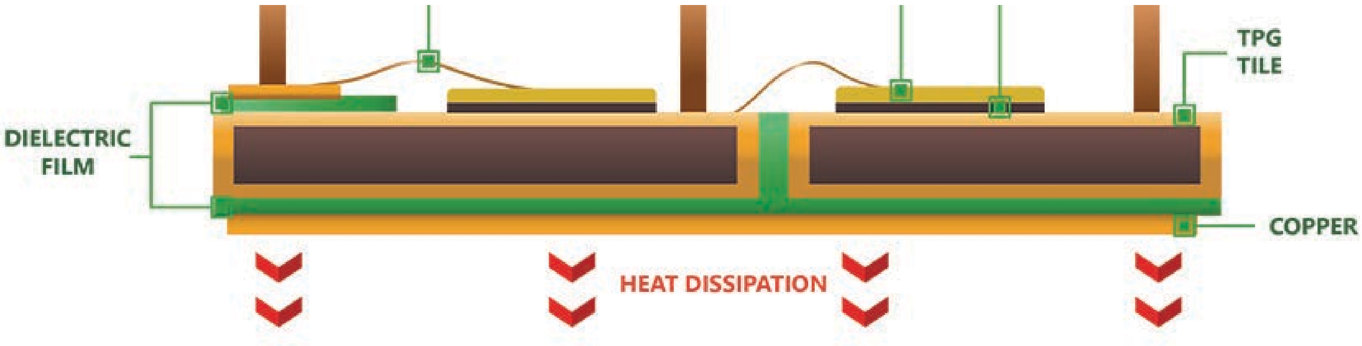

Figure 4. IMSwTPG-based half-bridge power module.

IMSwTPG substrates outperform conventional DBC substrates by simultaneously achieving higher thermal conductivity from TPG and excellent mechanical and thermal properties of IMS.

The concept has been rigorously researched and tested. The following provides highlights of recent independent analyses performed by experts in the industry to validate the novel IMSwTPG substrate for higher performance WBG power devices.

Finite Element Analysis (FEA) – Setup

FEA simulations were run for WBG power modules based on AlN DBC and IMSwTPG substrates with six SiC MOSFETs (M1-M6) mounted in parallel. Electrical and thermal operating conditions were representative of one-sided liquid cooling commonly used in automotive applications. Steady-state and transient simulations were conducted.

FIGURE 5 shows the module layout for the FEA simulations. **FIGURE 6** shows the expanded structure of the IMSwTPG substrate.

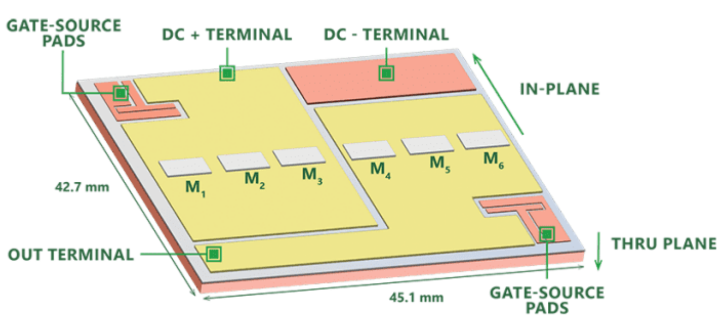

Figure 5. Test module layout.

DBC substrate consists of a 640μm-thick AlN ceramic insulator sandwiched between 300μm thick copper planes. IMSwTPG substrate is constructed with 1.10mm-thick TPG tiles hermetically encapsulated inside 0.25mm-thick Cu skins and isolated from the bottom copper layer using a 152μm-thick TCLAD HT dielectric polymer-ceramic film layer.

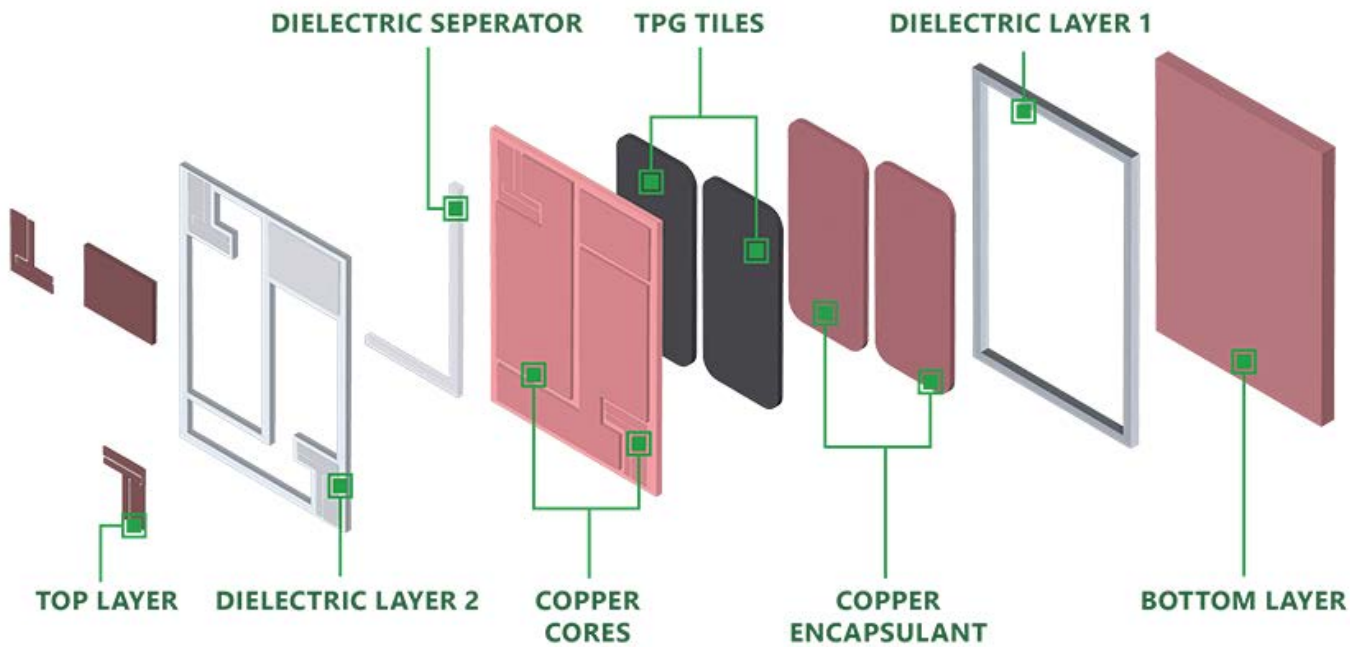

Figure 6. Expanded IMSwTPG structure.

FEA Results

Steady-state FEA simulations predict that heat spreading across the AlN DBC would be limited and concentrated around the SiC MOSFETs. In contrast, the steady-state FEA simulations predict better heat spreading within the IMSwTPG substrate and reduced junction temperatures of the SiC MOSFETs due to a reduction in thermal impedance.

Transient FEA simulations predict that this type of substrate would strongly influence the transient junction-to-coolant thermal impedance (Zth). Between 10 ms and 1 sec., the simulations showed the IMSwTPG substrate outperforming the DBC substrate by more than 40%.

To quantify the impact on the module's current carrying capability, current density was calculated at various conditions. The results predict that the IMSwTPG substrate can provide a 10% increase in device current density compared to AlN DBC.

Experimental

Thermal performance tests were set up to match the anatomy and conditions of the FEA simulations and included both steady-state and transient analyses. Additionally, the electrical performance of the IMSwTPG power module was evaluated at static and dynamic conditions.

SiC MOSFET die surface temperatures were measured using an infrared (IR) thermal camera.

Die junction temperatures and temperatures on the base of the substrate were directly measured by thermocouples. Three different liquid coolant temperatures were used (25°, 45° and 65°C) with regulated flow rate. Power losses across each die were measured by probing the current through the device and the voltage across the terminals.

FEA Simulations Validated

FIGURES 7 and **8** show thermal images of test modules under steady-state conditions and at 25°C coolant temperature. These images clearly indicate better heat spreading within the IMSwTPG-based module, in agreement with the FEA results.

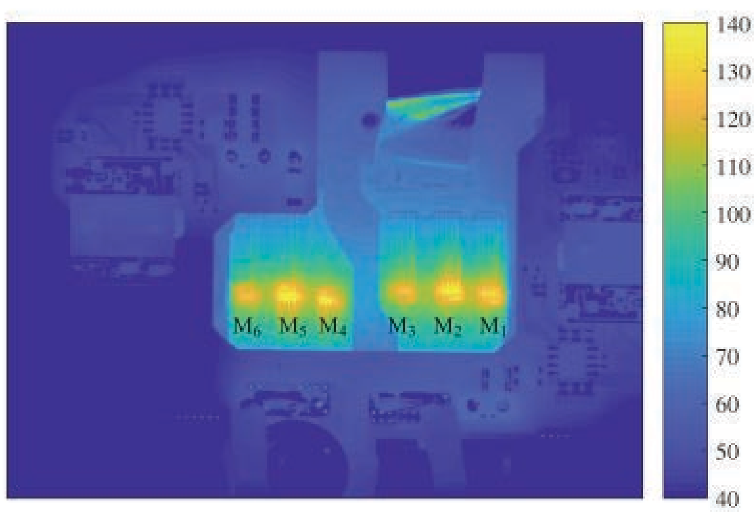

Figure 7. DBC substrate.

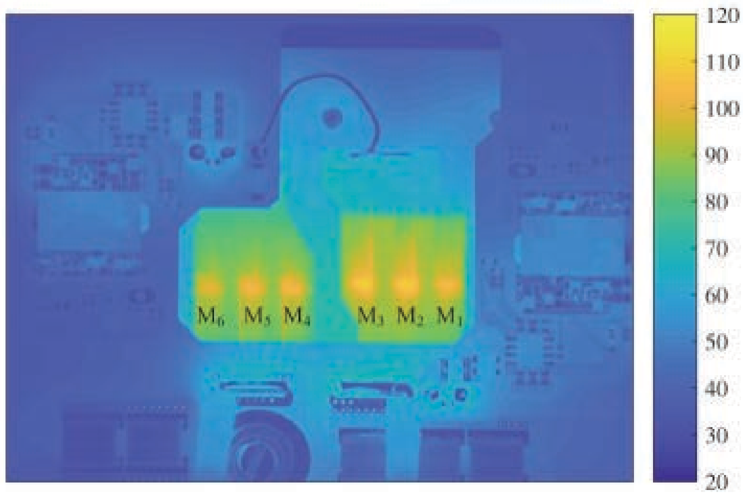

Figure 8. IMSwTPG substrate

FIGURE 9 graphically compares transient thermal impedance (Zth) of the SiC MOSFET dies on the DBC and IMSwTPG substrates. The observed reduction in thermal impedance between 10 ms and 1 sec. is well-matched with the FEA results.

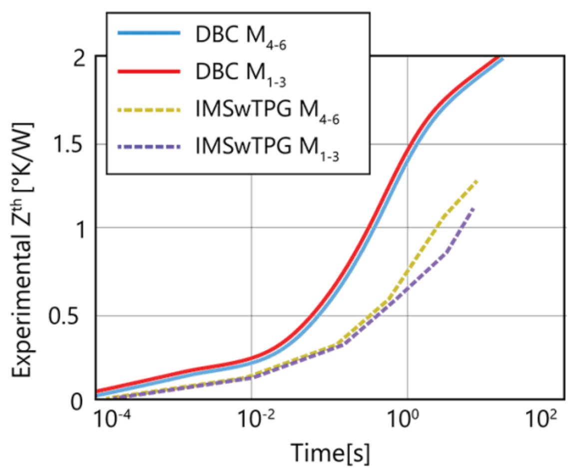

Figure 9. Comparison of transient thermal impedance on DBC and IMSwTPG.

Additionally, static and dynamic electrical characterizations of the IMSwTPG-based module under high current and voltage conditions indicated that the graphite core had virtually no impact on the ON-state resistance and switching performance of the SiC MOSFET dies.

Complete test details are available in Gurpinar.[1]

Conclusion

Moving from an AlN DBC to an IMSwTPG solution will enable superior performance of next generation wide-bandgap power modules.

Combining high-thermal conductivity from TPG with superior mechanical and electrical properties from IMS achieves better heat distribution throughout the power module due to:

- Up to 40% reduction in transient thermal impedance,
- Up to 17% reduction in junction-to-case thermal resistance of SiC MOSFETs, and
- Up to 10% increase in device current density.

Also, it has virtually no impact on the ON-state resistance and switching performance.

REFERENCES

1. E. Gurpinar, *et al,* Graphite-Embedded High-Performance Insulated Metal Substrate for Wide-Bandgap Power Modules," *IEEE Transactions on Power Electronics,* vol. 36, no.1, https://ieeexplore.ieee.org/abstract/document/9119164.

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Honoring the Best in Electronics Assembly

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CIRCUITS ASSEMBLY
Service Excellence Awards Ceremony

DATE Tuesday, October 10, 2023

TIME 11 a.m. to 12:00 noon

LOCATION Minneapolis Convention Center, Room 200AB

CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS

CIRCUITS ASSEMBLY

Shaken or Stirred?

Does the paste mixing methodology affect print performance?

SOLDER PASTE FORMULATION technology has come a long way. What once had to be treated with precise handling – limited exposure time on the stencil, rotations, refrigeration protocols, etc. – even as early as 10 years ago has changed dramatically. Solder paste chemistries are so robust today, in fact, some don't even require refrigeration.

Given this advancement, a recent conversation about some analysis our team performed was a bit surprising. During our printing evaluations, the solder paste material wasn't processing as it should, so one of the material supplier's application engineers came in to assist. We explained the problem and he asked, "Are you manually stirring the material or putting it in a machine to rotate?" When we responded that we were doing the latter, he said, "Don't."

Given how far paste material stability has progressed, this response had our team wondering if solder paste mixing was even necessary. Does it introduce variations into the stencil printing inputs that are best left alone? And, if mixing is required, is hand stirring superior to machine blending? Although we thought we knew the answers, we decided to test our hypotheses. Using an industrial Type 4 standard SAC paste most often sourced for our lab work (not from the supplier mentioned above), printing tests were run on an unstirred pot of solder paste from three locations: top, center, and bottom of the jar. As expected, the three samples revealed significant print differences. The material from the top had the worst printing results with tremendous variations in the KPIs, which was due to separation (metal particles from flux). With metal content most concentrated at the bottom of the jar, the particle-flux imbalance there also presented issues. The stiffer nature of the material made transfer efficiency inconsistent. One would also assume that reflow soldering and joint intermetallics, which we didn't test, would also be negatively impacted.

With confirmation that material mixing is (as expected) required for consistent print results, the second part of our analysis set out to compare hand stirring to machine blending. After manually mixing the material for thirty seconds, the same stencil printing analysis was conducted using solder paste from the top, center and bottom of the container. Each sample had consistent printing results, indicating that stirring by hand is an acceptable method.

Next, jars of solder paste were placed into the mixing machine and blended for five, 10, 15 and 30 minutes. Temperature measurements of the solder paste were taken after each five-minute interval, and the pastes mixed for five and 10 minutes were printed for evaluation. Again, paste was taken from each container's top, center and bottom. Both samples printed without issue and within normal standard deviations. It should be noted, however, that our analysis revealed that every five minutes of solder paste rotation by machine increased the material temperature by 1°C. Certainly, at five minutes, the slight increase in temperature – which also changes the viscosity – is negligible. That's within a room temperature change that you might see in a factory, so not significant. Leaving the material in the mixer for longer, however, may have an impact on the material's printability. Considering that solder paste material specifications generally recommend 21°C as the temperature at which to print for optimal results, it seems a bit of a gamble to push the temperature up by another three or four degrees Celsius by over-mixing.

Therefore, if using an industrial mixing approach, five minutes would be our suggested maximum blending time. However – and this is a BIG however – we do know that solder pastes come in a variety of chemical formulations with many composition variations. This, combined with the recommendation from one supplier not to machine mix their paste, might indicate that hand stirring anywhere from 30 to 60 sec. is the safest bet. Hand mixing works, it doesn't take long, and there is no risk of overmixing and altering the temperature to a non-ideal, amalgamated state.

Naturally, if your organization has had no issues with its solder paste mixing routine and results are high yield, carry on. But, when in doubt, hand stirring is the best default.

CLIVE ASHMORE is global applied process engineering manager at ASMPT (asmpt.com); clive.ashmore@asmpt.com. His column appears bimonthly.

PCD&F

CADENCE DESIGN SYSTEMS ORCAD X ECAD

OrCAD X Platform is a cloud-enabled system design solution that offers improvements in ease of use, performance, automation and collaboration. Streamlines the system design process and empowers designers through cloud scalability and AI-powered placement automation technology, enabling up to 5X reduction in design turnaround time. Includes layout productivity improvements based on the Cadence Allegro X Platform and provides complete backward data compatibility with OrCAD and Allegro technologies. Improves productivity with real-time access to data management via the Cadence OnCloud Platform, is optimized for small and medium businesses by offering a new, easy-to-learn and easy-to-use PCB layout canvas while retaining the power of industry-proven engines, enables faster time to market through significantly enriched electrical constraints, performance improvements and integration with the broader Cadence system design and analysis portfolio, and cloud-hosted collaboration allows multiple designers to work concurrently on the same layout design.

Cadence Design Systems

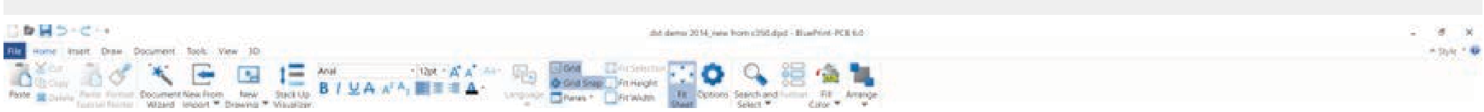
cadence.com

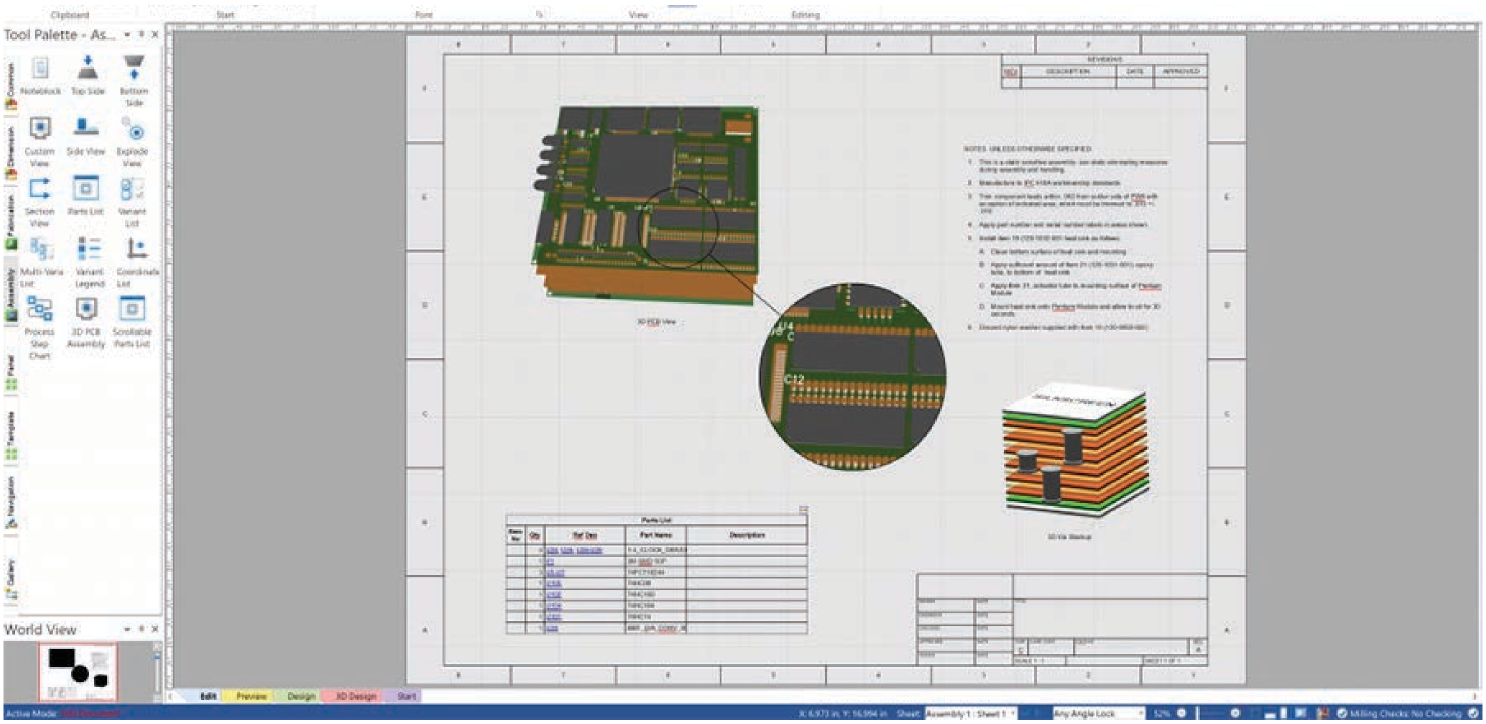
DOWNSTREAM TECHNOLOGIES CAM350 V. 15 CAM

Cam350 v. 15 introduces a new Stencil Design Tool Kit that facilitates creation of PCB paste mask stencils using imported manufacturing data, as well as new Subscription Products that make design for manufacturing (DfM) accessible to more engineers and designers. Also features user-requested enhancements in Netlist and Design Compare, Auto-Align Layers, Panel Design Integrates with BluePrint-PCB and Cadence Allegro Integration.

DownStream Technologies

downstreamtech.com

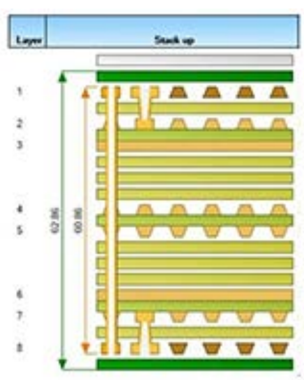




DOWNSTREAM TECHNOLOGIES BLUEPRINT V. 7 DOCUMENTATION TOOL

BluePrint v. 7 introduces modifications to reference designation functionality that minimizes rework to PCB assembly drawings after an ECO is performed, and the addition of the Document Compare module that assists users in discerning changes between document package revisions.

DownStream Technologies
downstreamtech.com



POLAR INSTRUMENTS SPEEDSTACK VER. 23_09

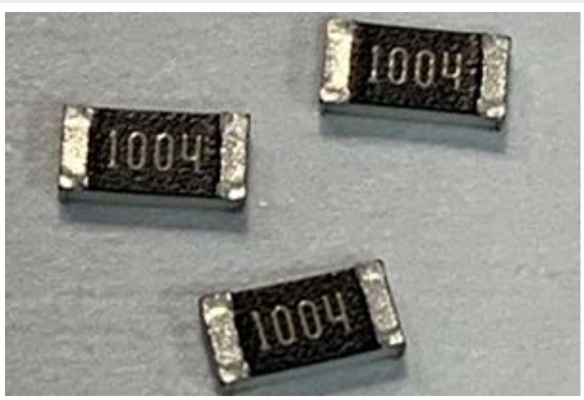
Speedstack Version 23_09 includes the following enhancements and fixes: 1) Printing: Soldermask-To-Soldermask Thickness Line now correctly aligned when ident/coverlay/peelable is above or below the Soldermask; 2) Printing: Added options to turn off Number of Panels, Circuits Per Panel, Cost Per Circuit that appear under BOM table; 3) Graphics: Fixed the instance of multi-selected materials de-selecting when right-mouse button is clicked on them (to bring up context menu); 4) Drill DRCs now highlight the correct drill in the graphics; 5) BOM Table aligns correctly when BoM is just one line over the page; 6) DRC Added extra data to Drill DRC errors to help identify drill.

Polar Instruments
polarinstruments.com

STACKPOLE RNCP RESISTORS

Stackpole RNCP thin film chip resistor series now features 1210, 2010, and 2512 sizes. Features high precision with tolerances down to 0.1% and TCR as low as 10ppm, and anti-sulfur capability with shifts of less than 2% under EIA-977 testing. Does not require a lead-containing dielectric glass, providing an RoHS-compliant solution without exemptions, and provides a low-cost, reliable thin-film solution for high-volume products by incorporating high-speed manufacturing processes.

Stackpole Electronics
seielect.com



STACKPOLE RNCV THIN FILM RESISTORS

RNCV resistors utilize thin-film technology to achieve high voltage ratings, high stability, and precision not achievable by thick-film high voltage chip resistors. Offered in the following sizes and voltage ratings: 0805 rated 450V, 1206 rated 700V, 1210 rated 1000V. Resistance values range from 121K to 3M in tolerances down to 0.1%, and TCR as low as 25ppm. Is said to have exceptional stability over industry standard tests, including shifts of less than 0.1% for most and 0.25% for the 85°C/85% relative humidity/10% biased humidity test. Also has anti-sulfur performance with less than 1% shift under ASTM-B-809-95 testing at 105°C.

Stackpole Electronics

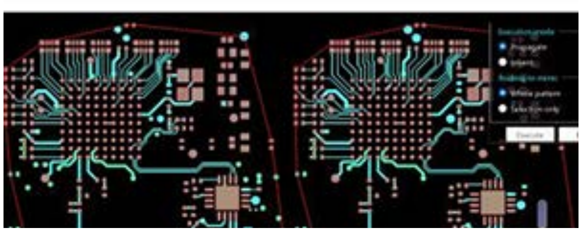
seielect.com

VISHAY R3T2FPHM3 RECTIFIER

R3T2FPHM3 combines a 3A, 600V standard rectifier with a 200W Transzorb TVS in the same FlatPAK 5 x 6 package. Features a temperature range from -55° to +175°C and is suitable for high-reliability automotive applications, including secondary protection for sensor units, distributed airbag modules, and low power DC/DC converters in power distribution systems. Saves PCB space, simplifies layouts, and lowers overall costs by combining two different technologies in a single package. When paired in series with a standard TVS, offers designers a complete >24V solution with a low clamping ratio. Features forward voltage drop of 0.86V and breakdown voltage of 27V. ESD capability complies with IEC 61000-4-2, air discharge and contact mode; MSL moisture sensitivity level of 1 per J-STD-020, LF maximum peak of 260°C; and molding compound features a UL 94 V-0 flammability rating. RoHS-compliant and halogen-free, and comes in AEC-Q101 qualified version.

Vishay

vishay.com



ZUKEN CR-8000 2023 ECAD

CR-8000 2023 features streamlined design sheet integration that allows users to merge sheets from diverse designs, enabling the incorporation of various elements or the utilization of template designs as a solid foundation, as well as a new feature that excludes sensitive information before external sharing and a feature that streamlines documentation by enabling copying, editing and seamless integration of circuits and text elements. Expanded design efficiencies include reuse template routing that allows placement of identical areas of components and routing based on a single instance, plus an interactive contour routing feature that aligns seamlessly with existing patterns and board shape, and a feature that allows users to examine the routing of a trace path by visualizing a cross-sectional view that showcases the trajectory across various layers. Also consolidates signal integrity, power integrity, and EMI analysis tools into new bundles, with enhanced user interaction, MultiCore CPU support, and compatibility with extensive datasets. AI/ML-assisted modeling and new Power Integrity checks elevate design and analysis prowess.

Zuken
zuken.com

CA

ASTRONICS APMARS AND APDT TESTER

ATS-AutoPoint Multi-Axis Robotic System (APMARS) and ATS-AutoPoint Desktop (APDT) automatically diagnose circuit board assembly and component malfunctions. Fully automate the test and diagnostic capabilities of Astronics' PinPoint hardware and TestVue software. Integrate circuit card diagnostic and test requirements, obsolescence issues, and life cycle sustainment needs. ATS-APMARS features dual flying probes that eliminate errors, reduce time of test, and increase system availability, providing greater confidence in test outcomes and required maintenance and support actions. ATS-APDT is a desktop system with a single robotic probe that can be scaled to include a second probe. Either system has optional custom cabinet to contain PinPoint hardware or select third-party instrumentation.

Astronics

astronics.com

EMIL OTTO EO-G-005 AND EO-G-007 FLUXES

EO-G-005 wave-soldering flux has relatively high activity despite a low solids content of around 4%. Applicable by spray fluxer, and flux residues are significantly less critical after wave soldering and can be rated as noncorrosive.

EO-G-007 no-clean flux is for wave and selective soldering. Contains organic, halogen-free, activating additives specially adapted for soldering processes. Developed in combination with lead- containing and lead-free solders and specially adapted to soldering thermal requirements, and based on a novel formulation to stabilize and improve application process compared to conventional water- or partial water-based fluxes. Features a solids content of 7%.

Emil Otto

emilotto.de

KRYLEX KURA-LOW ADHESIVE

Kura-Low electronics adhesive enables bonding at thermal cure temperatures as low as 60°C. Comes in highly RT-stabilized, one-part, pre-mixed formula. Enables RT stability between three to five days, or up to six weeks depending on the product formula. Available in multiple curing formats: dual cure format, UV + Heat, for camera module, active alignment and lens bonding applications; thermal-cure-only system, for structural bonding applications, e.g., OLED display, enclosure bonding, etc.; and snap cure, for inline processing.

Krylex
krylex.com

METCAL BVX-250 FUME EXTRACTOR

BVX-250 Fume Extraction System is a two-port portable fume extractor that offers HEPA filtration and several innovations for changing the filter, exhausting the air, and communicating with the operator. Front-facing filter allows the HEPA filter to be changed quickly without manipulating the system, and the pre-filter is in a separate front-facing compartment and can easily be changed by the operator as needed. Includes a 360˚-rotating exhaust diverter that directs exhaust away from the operator, and also includes new features such as a large LED status ring and direct connectivity to Metcal CV and GT soldering systems, and the ability to enable easy-to-view filter notifications from either touchpoint. Also enables use of a “smart fume extraction” setting when connected to CV or GT soldering system that allows extractor to run only when soldering iron is active.

Metcal
metcal.com

MRSI 705HF DIE BONDER

MRSI-705HF high-force die bonder is a new variant of the MRSI-705 platform. Comes with heated bond head that can apply up to 500N of force during bonding process, while providing heating up to 400°C from the top. Is for advanced applications such as sintering for power semiconductors and thermocompression bonding for IC packaging. Has flexibility and robustness of MRSI-705 platform, which can handle multiple die and process applications with auto-tool changing and laser soldering, eutectic with top and bottom heating, epoxy stamping, and dispensing in one machine.

MRSI Systems
mrsisystems.com

SHENMAO PF734-S SOLDER SPHERE

PF734-S low-temperature BGA solder sphere is for low-temperature ball attachment processes. Is built upon an improved low-temperature alloy PF734 and outperforms conventional low- temperature alloys like Sn42 and Bi58. Features enhanced mechanical properties, ensuring product reliability under rigorous testing conditions such as thermal cycling and thermal shock. Is complemented by low-temperature no-clean flux SMF-80 and water-soluble flux SMF-WC63.

SMF-80 eliminates post-reflow cleaning while maintaining reliability and insulation with minimal flux residue, and SMF-WC63 is said to offer outstanding cleanability, and any flux residue post-reflow can be easily cleaned with water. Both are halogen-free and fully comply with RoHS, RoHS 2.0, REACH, and other relevant environmental standards.

Shenmao
shenmao.com

ROHM BD5310XG-CZ/BD5410XG-CZ ICS

BD5310xG-CZ/BD5410xG-CZ series of Hall ICs are for automotive applications requiring magnetic detection. Features a 42V withstand voltage that enables direct connection to a primary (12V battery) power supply and a wide operating supply voltage range of 2.7V to 38V. Unique internal topology is said to reduce power consumption by approximately 20% over general products to achieve a current consumption of 1.9mA. Comply with the AEC-Q100 (Grade 1) automotive reliability standard, while incorporating multiple protection circuits required for vehicle systems. BD5310xG-CZ series is a unipolar detection type, while the BD5410xG-CZ series provides latch-type detection. A total of 11 models offered in detection magnetic flux densities, ranging from 2mT to 28mT.

Rohm Semiconductor
rohm.com

TRI TR7700 SIII ULTRA AOI

TR7700 SIII Ultra incorporates advanced AI algorithms, smart programming, and metrology measurements for precise inspection coverage. Achieves speeds of up to 60 cm^2/sec while guaranteeing stability, accuracy, and precision during every inspection cycle. Also comes in dual-lane configuration (TR7700 SIII Ultra DL) to enhance productivity in high-speed inspection scenarios. Integrates seamlessly into smart factories, to empower data-driven decisions and heightened efficiency through real-time SPC trends. Supports current smart factory standards, including IPC-CFX, IPC-DPMX, and IPC-HERMES-9852.

Test Research, Inc.

tri.com.tw

VITRONICS SOLTEC ZEVAM+ SOLDERING MACHINE

ZEVAm+ selective soldering machine has been redesigned to accommodate board sizes up to 510mm x 510mm (20in. x 20in.). Designed for high-mix, low-volume manufacture. Prevents bridging for pitches up to 1mm (40mils) pin-to-pin distance even with longer leads and increased drag speed, and enables use of maintenance-free non-wettable nozzles for more consistent soldering results over time. Integrated with a non-wettable nozzle that is 3-D printed from stainless steel and hard chromized for maintenance-free infinite life. Delivers a wider range of flux droplets, increased accuracy, and faster cycle times. Closed-loop flux volume control is available for greater consistency and traceability and a second flux tank allows refilling on-the-fly.

Vitronics Soltec

itweae.com/products/vitronics-soltec

In Case You Missed It

Adhesives

"Sustainably Sourced Components to Generate High-Strength Adhesives"

Authors: Clayton R. Westerman, *et al.*

Abstract: Nearly all adhesives are derived from petroleum, create permanent bonds, frustrate materials separation for recycling, and prevent degradation in landfills. When trying to shift from petroleum feedstocks to a sustainable materials ecosystem, available options suffer from low performance, high cost or lack of availability at the required scales. Here the authors present a sustainably sourced adhesive system, made from epoxidized soy oil, malic acid and tannic acid, with performance comparable to that of current industrial products. Joints can be cured under conditions ranging from use of a hair dryer for 5 min. to an oven at 180 °C for 24 hr. Adhesion between metal substrates up to around 18MPa is achieved, and, in the best cases, performance exceeds that of a classic epoxy, the strongest modern adhesive. All components are biomass derived, low cost and already available in large quantities. Manufacturing at scale can be a simple matter of mixing and heating, suggesting that this new adhesive may contribute towards the sustainable bonding of materials. (*Nature,* Sept. 13, 2023, https://www.nature.com/articles/s41586-023-06335-7)

Impedance Measurement

"Design, Implementation, and Characterization of a Compact Lock-in Add-on for Low-Frequency Impedance Measurements"

Authors: Sara Pettinato, *et. al.*

Abstract: The authors present a cost-effective compact solution for ultra-low-frequency impedance measurements, operating in a wide range, from 1mHz to 250kHz. Coupled to a lock-in amplifier, the designed circuit is based on a Howland current pump cascaded by a precision current divider to set the conversion factor at 100nA/V, 1μA/V, or 100μA/V. Therefore, it is possible to generate very low-current signals to measure resistive impedances up to 100MΩ. In addition, a feedback network is inserted to null the voltage drift induced by leakage currents and offset voltages, thus permitting measurement of low-capacitance loads, experimentally tested down to 10nF. Remarkably, the feedback network allows measurements in the presence of high voltage bias of the load, and experimental results performed up to 60V demonstrate the excellent stability of the designed system, thus a high voltage compliance. The proposed circuit is particularly interesting for the conditioning of both resistive and capacitive sensors and it is likely to be an effective solution for implementation of a portable instrument for measuring signals from biosensors. (*Electronics,* August 2023, https://doi.org/10.3390/electronics12163406)

Medical Electronics

"A System for Bioelectronic Delivery of Treatment Directed Toward Wound Healing"

Authors: Prabhat Baniya, *et al.*

Abstract: Researchers developed a wearable system for bioelectronic delivery of treatment directed toward wound healing. The system consisted of a 3-D printed custom polydimethylsiloxane (PDMS) delivery device integrated with a printed circuit board. Both the PCB and the PDMS had corresponding through-holes with metal connection pins covered in silver epoxy, permitting physical and electric integration. The modularly built system included solution-containing reservoirs, implanted electrodes, and capillary tubes filled with hydrogels.

The team demonstrated three designs for the PCB component: one wired and the other two powered by batteries with as well as without inbuilt memory. The PCB wired version used an externally located voltage controller to activate the device, whereas the one powered by batteries used a microcontroller unit (MCU) that enabled programmed voltages to be applied, as well as a deep sleep module to extend battery lifetime. The PCB powered by batteries with inbuilt memory was used to document delivered currents, enabling the verification of the therapeutic dosage delivered.

The devices were delivered hydrogen ions in C57B6 and wild-type murine models in vivo, and

fluoxetine was delivered using simulated wound environments ex vivo. The PDMS was employed as a bridge between biological specimens such as a wound site and typical electrical components. Once a positive voltage was applied across the reference (RE) and working electrodes (WE), drug ions were pulled through the working electrode to the wound site as a substitute for indigenous sodium ions at the reference electrode. Each PCB included four actuation pathways wherein current could be measured by connecting resistors in parallel with voltages supplied via the MCU or an externally located controller. The wired system relied on connecting the PCB to an external voltage controller and included computer-aided design (CAD) assemblies of the PDMS and PCB subsystems. (*Scientific Reports,* Sept. 7, 2023, https://doi.org/10.1038/s41598-023-41572-w)

Soldering

"Lower Temperature Soldering Using Supercooled Liquid Metal"

Authors: Ian Tevis and Dipak Paramanik

Abstract: Lead-free solder metal alloys can be formed into supercooled liquid metal microcapsules and used to create solid full metal interconnects at dramatically lower processing temperatures. These alloys can be made with or without bismuth. The technology encapsulates known and established RoHS compliant solder alloys inside a thin oxide/organic shell nanofilm that keeps the metal in a metastable supercooled liquid state at ambient temperatures. The thin oxide/organic shell can be mechanically broken or chemically dissolved to release the liquid metal that then rapidly solidifies all without requiring heat. The novel solder interconnect technology avoids thermal damage to components and materials, or quality issues caused by coefficient of thermal expansion mismatch. (*Journal of Surface Mount Technology,* July 2023, https://doi.org/10.37665/smt.v36i2.36)