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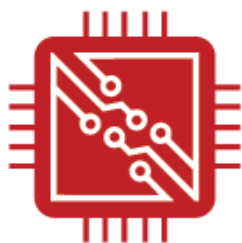
# PRINTED CIRCUIT DESIGN & FAB CIRCUITS ASSEMBLY

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- Designing for PCB Producibility
- Can Metallization Be Green?
- AuSn Solder Voiding



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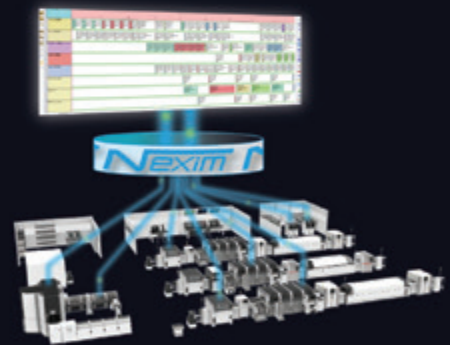
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**INDUSTRY 4.0: WHAT IT IS, AND WHAT IT'S NOT**  
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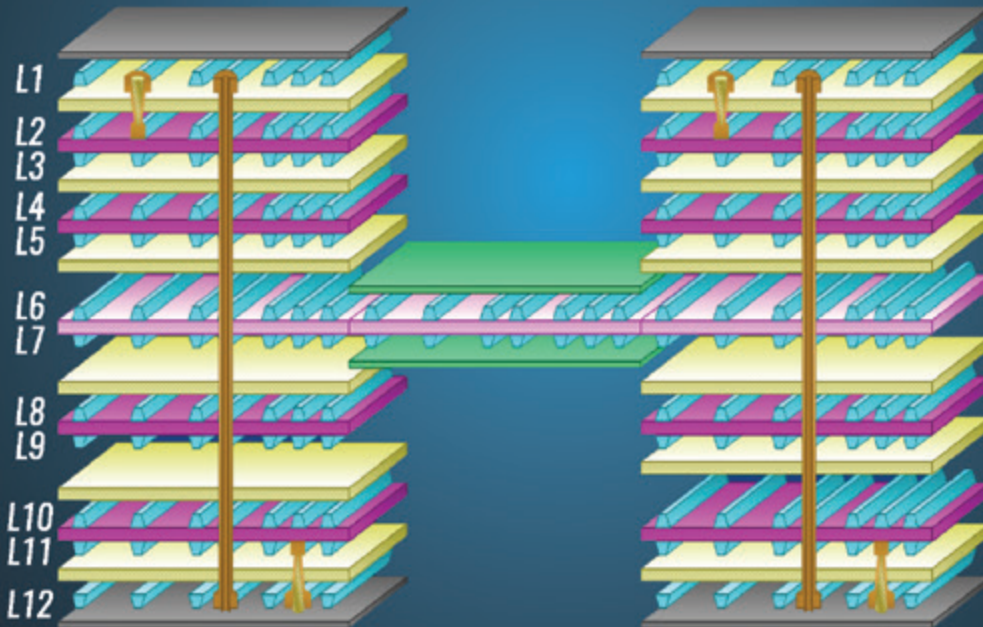


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PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY is published monthly by Printed Circuit Engineering Association, Inc., PO Box 807 Amesbury, MA 01913. ISSN 1939-5442. GST 124513185/ Agreement #1419617.

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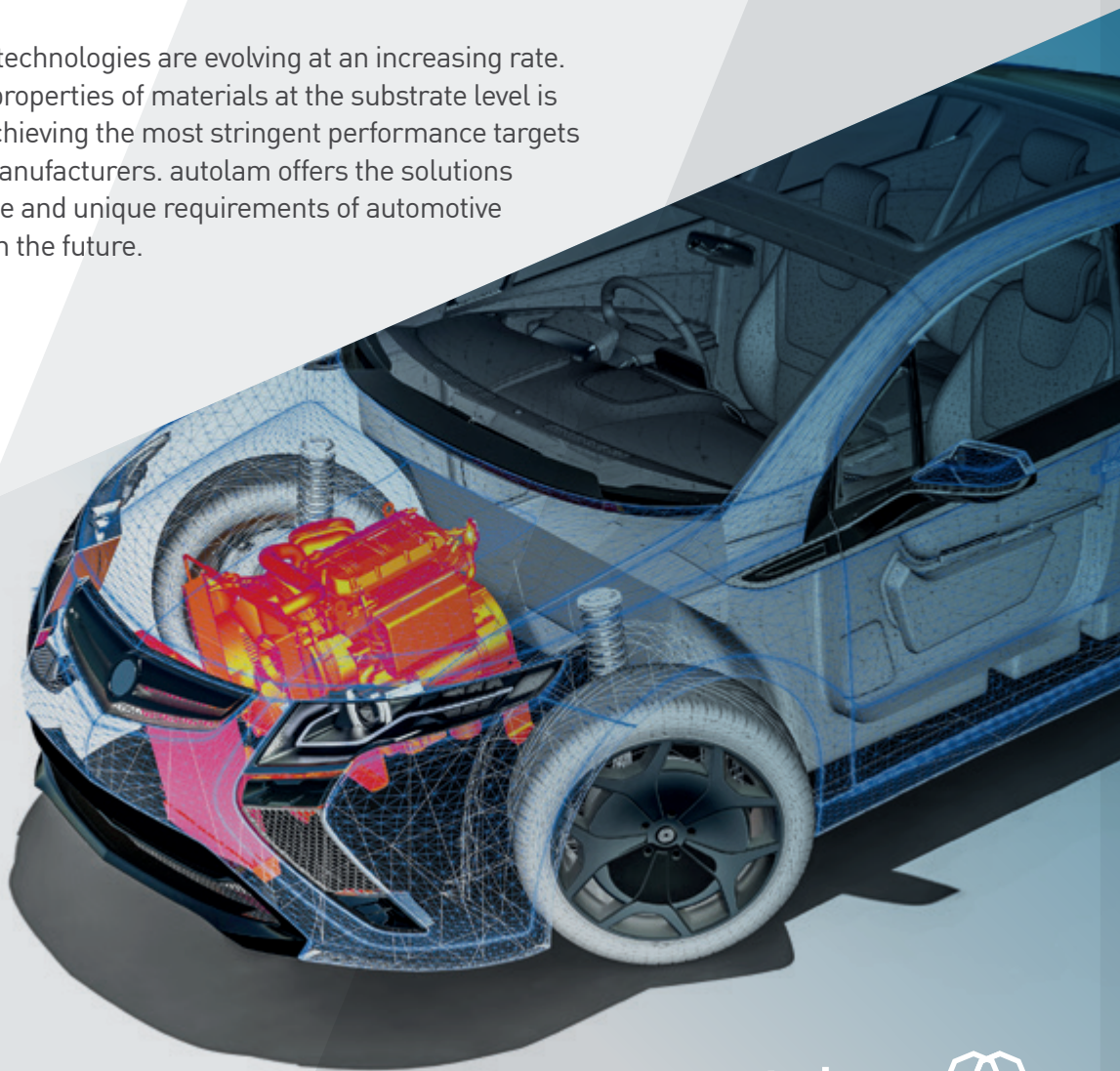
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# Keep an Eye on AI

**B**Y NOW YOU probably have heard of ChatGPT. This new artificial intelligence program mimics conversations and language in a way the general public has never seen. Per its website, its developers trained an initial model using “supervised fine-tuning”; in other words, humans provided conversations in which they acted as both user and AI “assistant.” Model-written suggestions were used to help compose their responses.

After several iterations and refinements, ChatGPT was rolled out in November and has, as they say, gone viral.

Because I’m curious that way, I had to see for myself how this worked. So I logged in at openai.com and waited patiently for my turn – it is often at capacity. After a few hours, a slot opened and I fired my first shot: *What is the future of printed circuit boards?*

Printed circuit boards (PCBs) are an integral part of modern electronics, and they are likely to continue to be widely used in the future. However, there are a few trends that may shape the future of PCBs:

1. **Increased miniaturization:** As electronic devices continue to become smaller and more compact, there is a trend towards using smaller and more densely packed PCBs. This requires the use of advanced manufacturing techniques and materials, such as microvias and high-density interconnects, to ensure that the PCBs can handle the increased complexity and density of the circuits.
2. **Use of flexible and stretchable materials:** There is growing interest in using flexible and stretchable materials for PCBs, particularly for wearable and portable devices. These materials allow for greater design flexibility and can enable the development of new types of devices and applications.
3. **Increased use of advanced manufacturing techniques:** PCB manufacturing is becoming increasingly automated and sophisticated, with the use of advanced techniques such as laser drilling, laser etching, and automated optical inspection becoming more common. This trend is likely to continue as manufacturers seek to improve the efficiency and accuracy of PCB production.
4. **Increased use of surface mount technology:** Surface mount technology (SMT) is a method of mounting electronic components onto the surface of a PCB, rather than inserting them into through-hole connections. SMT allows for higher component density and improved performance, and it is likely to become more widely used in the future.

Overall, the future of PCBs is likely to involve continued miniaturization, the use of advanced materials and manufacturing techniques, and an increased focus on flexibility and performance.

The entire process took about 45 seconds. Nothing surprising here, I noted. In fact, if anything, ChatGPT seems a little behind the times. I regenerated (their word) the response. This time, it took a bit of a green turn:

Printed circuit boards (PCBs) are an integral part of electronic devices and are likely to continue to be widely used in the future. PCBs are used to mechanically support and electrically connect electronic components using conductive tracks, pads, and other features etched from copper sheets laminated onto a non-conductive substrate.

One trend in the future of PCBs is the increasing use of flexible and stretchable PCBs. These types of PCBs are made using flexible materials such as polyimide or PET, and can be bent or stretched without breaking or affecting their electrical performance. Flexible and stretchable PCBs are being used in a variety of applications, including wearable electronics, medical devices, and flexible displays.

Another trend is the increasing use of high-density interconnect (HDI) PCBs, which are PCBs with a higher component density and smaller feature sizes than traditional PCBs. HDI PCBs are used in a variety of applications, including smartphones, tablets, and other portable devices, where size and weight are important considerations.

There is also a trend towards the use of environmentally friendly PCBs, which are made using materials and processes that are less harmful to the environment. For example, PCBs can be made using lead-free solders and recycled materials, and can be recycled at the end of their life.

In summary, the future of PCBs is likely to involve the increasing use of flexible and stretchable PCBs, HDI PCBs, and environmentally friendly PCBs. These developments will allow for the creation of smaller, lighter, and more efficient electronic devices.

A beige take, to be sure. No mention of 3-D printing, increased digitalization and robots. Undeterred, I asked a follow-up: *Will AI rule the world?*

It is not likely that artificial intelligence (AI) will rule the world in the way that is often depicted in science fiction. While AI is a rapidly developing field and has the potential to revolutionize many aspects of society, it is important to recognize that AI systems are ultimately designed and controlled by humans.

*continued on pg. 44*

# Innovative 3D X-ray System

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## PCDF People

Garmin promoted **Aaron Parker** to senior printed circuit board designer.

Google named **Brian Riley** PCB design engine at its Augmented Reality division.

Lockheed Martin promoted **Steven Bowles** to associate fellow.

## PCDF Briefs

**Ansys** in December entered into an agreement to acquire **DYNAmore**, a developer and supplier of explicit simulation solutions for the automotive industry.

**Avishtech**, a provider of PCB simulation solutions, announced the formal launch of its lab materials services and consulting.

**Cicor Technologies** has acquired German electronic components manufacturer **AFT Microwave**.

**Eltek** has received a follow-up purchase order in the amount of \$1.1 million from an existing customer in the defense sector.

**Hudian** is the latest Taiwanese PCB fabricator to purchase land in Thailand to build a new campus.

**Multicircuits** purchased a **Nordson** Mod-VIA expandable plasma system.

**Nano Dimension** received a purchase order from a large Western aerospace, defense and information technology company, for a DragonFly IV AME 3-D printer.

**TTM Technologies** and **Raytheon Missiles & Defense** have reached a multiyear, possibly \$500 million agreement to provide radio frequency assemblies, electronic hardware, and printed circuit boards for the SPY-6 family of radars.

## CA People

Benchmark named **Chris Lentz** senior director of supply chain.



ECD hired **Michael Pliska** as director of engineering. He has a master's in physics and an MBA from Portland State University and extensive electronics experience.



Indium promoted **Claire Hotvedt** to senior product development specialist. She joined Indium in 2018 as a research technologist, and later became product development specialist.

## Simmtech to Fast-Track Penang Production Line Expansion

**BATU KAWAN, MALAYSIA** – Simmtech Holdings is set to expand its production line in Penang, Malaysia through its Malaysia-based subsidiary, Sustio. The \$50 million expansion is expected to be completed this quarter, and will double the facility's HDI PCB production capacity while creating an additional 400 full-time jobs.

Simmtech opened its \$120 million Penang factory earlier this year, and the decision to expand the facility earlier than originally planned shows the company's management team's determination to invest in Malaysia, said Simmtech SE Asia Managing Director Jeffery Chun.

International Trade and Industry Minister Senator Tengku Datuk Seri Utama Zafrul Tengku Abdul Aziz said Simmtech's fast-tracked expansion of its subsidiary's operation in Malaysia proved that the country continues to be a preferred destination for high-value investments.

"This is due to our industry's strategic position in the global electrical and electronics (E&E) value chain and the availability of skilled Malaysian talent in this sector," he said.

## Icape Group Acquires MMAB Group

**FONTENAY-AUX-ROSES, FRANCE** – Icape Group, a global distributor of printed circuit boards, has acquired 100% of the shares in the Sweden-based MMAB Group.

MMAB Group is a manufacturer and distributor of PCB for small quantities and prototypes on an express delivery basis, with activities mainly focused on Scandinavia. In addition to its Northern European operations – consisting of a production factory and headquarters – the group has two subsidiaries in Eastern Europe – one in Hungary and the other in the Czech Republic – as well as a sourcing and logistics facility in China.

With more than 200 active customers in the automotive, railway, defense and medical industries, MMAB Group saw revenues of SEK 132 million (\$12.7 million) and an EBITDA of nearly SEK 20 million (\$1.9 million) over the past year.

## ECIA Publishes Publishes China Tariff Avoidance and Recovery Process Document

**ATLANTA** – The ECIA's Global Industry Practices Committee (GIPC) has published a document to update members on best practices as companies in the electronic components industry respond to the shifting political landscape regarding China tariffs.

The *China Tariff Avoidance and Recovery Process Update* document offers an outline of what the GIPC recommends to members about current practices in this arena. The document explains several pathways for tariff avoidance and recovery, with specific suggestions for how to evaluate this complex issue. The intent is to enable companies to compare their current processes with identified best practices and make adjustments as required.

"Four years ago, this Committee collected input from ECIA component manufacturer and distributor members with the goal of identifying and sharing the most efficient processes for Tariff Avoidance and Recovery based on the previous administration's tariff policies," explained Don Elario, vice president of Industry Practices, ECIA. "With the Biden administration currently reviewing the tariffs, we revisited that document and updated it with best practices learned over the last four years."

The updated China Tariff Avoidance and Recovery Process document is available only to ECIA members.

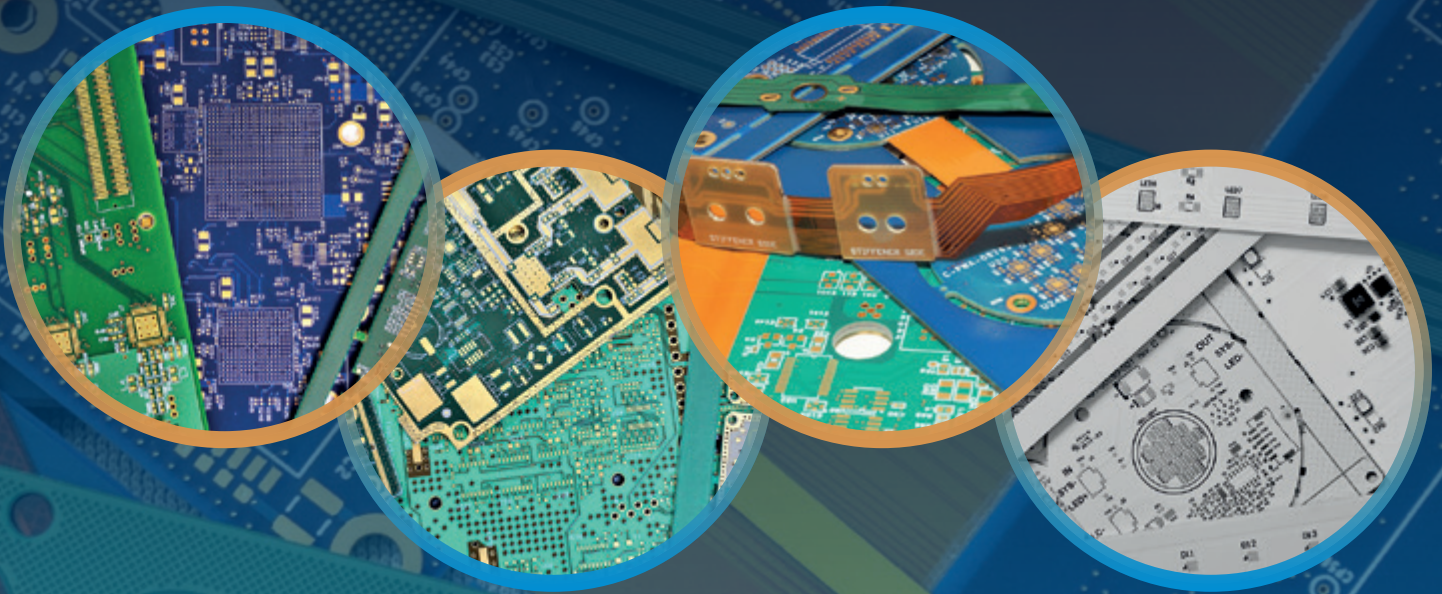


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Libra Industries appointed **Nathan Whipple** vice president of sales. He brings business development experience spanning more than 37 years in multifaceted manufacturing environments.

NASA Goddard Space Flight Center named **Bhanu Sood, Ph.D.**, deputy chief technologist.



Northrup Grumman named **Raj Kumar** senior staff engineer, Materials & Process, PCB SME. He spent the previous seven years at TTM Technologies as vice president, technology solutions, and previously was vice president of technology at Viasystems.



Panasonic North America named **Jeff Mogensen** regional sales manager. He has held high-level sales management positions at Saki, Parmi, Speedline Technologies and Amistar, among others, during his career.

Scanfil chief executive **Petteri Jokitalo** is stepping down by the end of 2023 after being with the EMS company since 2013.



Sciencescope hired **George Fanut**, (pictured left), European service engineer. He previously worked with Ami

Trade, and then later as a SMT line technician. Sciencescope also appointed **Cesar Gomez Martinez**, (pictured right), optical inspection manager for Mexico and Latin America. An industrial engineer, he has worked in the electronics industry for 25 years, within the maquiladora industry in the material supply (purchasing) and sales with distributors such as EIS for 21 years.

## CA Briefs

**Alliance Manufacturing** announced the acquisition of **TDC (Technical Devices Co.)**, a manufacturer of cleaning equipment for the electronics and PCB industries.

**CALCE** and **SMTA** will be cohosting the Counterfeit Electronics and Materials Symposium at the Manufacturing Technology Centre in Coventry, UK, in March.

**Elin Electronics** opened an IPO Dec. 20 as the EMS provider goes public.

**Foxconn** has agreed to sell its entire equity stake in Chinese chip conglomerate **Tsinghua Unigroup**.

**India Electronics and IT Minister Ashwini Vaishnaw** said that 10 million additional jobs can be created in the electronics and BPO sector in the coming two years.

## TechSearch Highlights Thermal Challenges in Advanced Packaging Report

**AUSTIN, TX** – TechSearch International's latest *Advanced Packaging Update* describes some of the thermal challenges facing the industry from mobile to high-performance computing. With increased power dissipation, companies are moving to higher performance thermal interface materials and adopting new cooling methods including liquid immersion.

The report discusses these developments and describes thermal interface materials offered by suppliers. The report includes OSAT financials and examines economic trends impacting the industry. China's Covid lockdowns, new US exports controls, continued inflation, and the war in Ukraine are discussed. The report also examines the trends in EV charging with examples of the packages used for charging stations. Companies offering charging equipment and services are listed.

TechSearch analyzes changes in the gap between manufacturing demand and capacity for build-up substrates. Lower demand for PCs and other products has improved the overall substrate supply and demand situation, but companies without long-term supply agreements are still finding build-up substrate procurement challenging. The report highlights plans for North American suppliers of substrates.

The 72-page report includes full references and an accompanying set of more than 50 PowerPoint slides. Find the report at [techsearchinc.com](http://techsearchinc.com).

## SEMI Europe, Eur. Commission Recommend Actions to Tackle Chip Industry Skills Shortage

**BRUSSELS** – SEMI in December announced key actions proposed by SEMI Europe and European Commission (EC) representatives in consultation with semiconductor industry stakeholders to overcome the skills shortage in Europe's microelectronics industry. The actions resulted from a Dec. 2 workshop held in Brussels to support the European Chips Act and address challenges and future opportunities for developing skills critical to Europe's semiconductor ecosystem.

The workshop marked the first meeting of SEMI Europe representatives, Lucilla Sioli, director of Artificial Intelligence and Digital Industry in Directorate-General CONNECT at the European Commission, and more than 80 semiconductor industry stakeholders including representatives from SEMI Europe member companies to discuss key projects under the Pact for Skills for Microelectronics.

Workshop participants, including SEMI members Bosch, Imec, Intel and Onsemi, underscored the urgent need for training facilities, STEM graduates and a more diverse workforce, while market research firm Decision Etude and Conseil presented its recent METIS4Skills Strategy 2022 annual update. The report points to a worsening of the talent shortage in Europe since 2020.

The European Chips Act heightens the focus on the need for process engineers, maintenance technicians, process technicians and other semiconductor manufacturing workers.

"We thank the European Commission for its continuous support and collaboration with the semiconductor industry in strengthening Europe's microelectronics skills ecosystem," said Laith Altimime, president, SEMI Europe, who participated in the workshop with Christopher Frieling, director of Advocacy and Public Policy, SEMI Europe. "The European semiconductor industry must diversify its talent pool, an effort that requires funding so Europe can develop a sustainable workforce."

Chip industry stakeholders participating in the workshop in person and virtually discussed common roadblocks to hiring, shared best workforce development practices and highlighted successes of EC, national and semiconductor industry skills initiatives. The participants generated a comprehensive list of actions geared toward improving the image of the semiconductor sector to attract students and young talent, re-skilling and upskilling workers, and sustaining the push for a diverse and inclusive



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As part of the Erasmus+ project METIS, SEMI Europe will publish a summary of the workshop outcomes and recommendations for concrete follow-up actions in the first quarter of 2023. Examples of actions include:

- Create an industry image campaign to raise public awareness on how technology is shaping the future, and how workers can establish careers in the semiconductor industry.
- Remove barriers to entry in the industry for top university graduates in part by retooling immigration policies that affect the microelectronics sector.
- Harmonize workforce development initiatives within Europe and create a European University Network for Microelectronics with a focus on internship and work opportunities for students.
- Inspire children and teenagers to pursue a STEM education, recruit more STEM teachers, attract female teenagers to STEM, and replicate existing talent development initiatives for the microelectronics industry such as competitions for European teenagers to design chips.

## Katek to Acquire EMS Firm Nextek

**MUNICH** – Katek SE has signed a purchase agreement with the owners of Nextek to acquire all shares in the company, with the closing of the sale expected in the first quarter of 2023.

Nextek is a US-based supplier of high-tech and high-value electronics located in Madison, AL, and the agreement to acquire the company is Katek's second transaction in North America in the past year after the acquisition of the Canadian SigmaPoint Technologies last August.

According to a release from Katek, the acquisition is intended to expand the group's presence in North America and strengthen its access in the fast-growing Homeland Security & Defense, Medical, Energy, Highend Industrial and Aerospace sectors, which are new to Katek. Nextek generated profitable annual sales of \$37 million last fiscal year with approximately 170 employees.

"This new member of the Katek family ideally complements the acquisition of SigmaPoint, which was completed in August, as a high-volume supplier of complex electronics. Both companies benefit from the strong reshoring trend in North America, which is currently massively accelerated by the current economic and geopolitical tensions," said Rainer Koppitz, CEO and cofounder, Katek.

In addition to quickturn prototyping, Nextek offers sophisticated electronic assembly manufacturing, complete device manufacturing (box build) as well as analytical engineering, product engineering and comprehensive test services for customers in the high-tech sector.

Nextek holds AS 9100D, ISO 13485 and military technology registrations. The company has unique laboratory capabilities for testing materials and ensuring the quality required in critical applications.

John Roberts, Nextek's longtime CEO, will continue to run the site unchanged with his management team.

## EC Electronics Buys Swan EMS

**BASINGSTOKE, UK** – EC Electronics, a UK EMS provider, in December announced the purchase of Swan EMS. Financial terms were not disclosed.

Based in Abertillery, UK, Swan EMS will continue operating as an independent business from its existing premises under its current management team.

"I believe that the EC group is the perfect home for Swan," said Phil Simmonds, CEO, EC Electronics. "We are wholly dedicated to our electronics manufacturing services (EMS), and the addition of Swan will allow us to increase our cable assembly and box build capacity.

"At EC Electronics, we believe there is excellent potential for the growth of mid-sized cable assembly and electronics box build specialists in the UK and mainland Europe," he added. "Adding Swan to the EC group will significantly strengthen its UK capabilities." □

**Tyvak Nano Satellite** purchased a **Hentec/RPS Odyssey 1325** robotic hot solder dip component lead tinning machine.

**NOTE** signed an agreement to expand its plant in Norrtälje, Sweden, by around 1,100 sq. m. to increase capacity and production efficiency.

**Surf-Tech Manufacturing Corp.** has implemented two **CalcuQuote** software solutions.

**Tata Group** is in talks to acquire **Wistron's** facility in Karnataka, India, for up to 50 billion rupees (\$613 million), according to a report by the *Economic Times*.

**Pemtron Technology**, a developer and manufacturer of inspection equipment, went public on the Korea Stock Exchange on Nov. 24 under the ticker symbol 168360:KS.

**Offshore Electronics** installed a **Yamaha Z:Lex YSM20R** pick-and-place machine.

**Patton** has launched a contract electronics engineering, design and manufacturing division in Maryland.

**Precision Graphics** has opened its new EMS facility in Snow Hill, NC.

**Season Group**, an international electronics design and manufacturing services provider, announced the acquisition of all assets of **Pycom**.

**ZF Group** has signed an investment agreement with the Guangzhou Huadu District Government to build a new plant for electronics and advanced driver assistance (ADAS) products in Guangzhou.



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## Community News

**Membership.** In early December, Mike Creeden led a leadership session for existing and startup chapters. He gave updates on the association, strategic plan and education committees, and events planned for 2023. The sessions were recorded for chapter leaders who could not make the live call.

**Education.** We have received more than 50 abstracts for PCB East 2023. The Conference Task Group is led again by Rick Hartley. A PCEA Conference Abstract Selection Process will be used for the first time for this event. The target date for releasing the three-day technical program is Jan. 3, and PCB East takes place May 9-11 in Boxborough, MA.



Also, a new section on the Printed Circuit University online learning platform is dedicated to PCEA members. In addition to its paid content, PCU has added a section with free white papers and videos for any PCEA members. Learn more at <https://printedcircuituniversity.com>.



## Chapter News

**Ontario, Canada.** We held a virtual Lunch'n' Learn on Nov. 24 featuring Ata Syed, field application engineer at PFC Flexible Circuits. Syed is starting a multipart series on flex circuits. In this first session, he covered the five "W's" of flex technology:

- What is flex?
- Why use flex?
- Who should know flex?
- When to use flex.
- Where to use flex.

To view the presentation, visit <https://printedcircuituniversity.com/index.php/flex-circuits>

## PCEA Issues Call for Abstracts for PCB West 2023

**PEACHTREE CITY, GA** – PCEA seeks abstracts for its annual PCB West technical conference coming in 2023.

PCB West will be held Sept. 19-22, 2023, at the Santa Clara (CA) Convention Center. The event includes a four-day technical conference and one-day exhibition.

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 non-commercial in nature and should focus on technology, techniques or methodology. Presentations of a tutorial or explanatory nature are preferred.

All abstracts will be reviewed by the PCEA Conference Task Group on a blind basis prior to acceptance.

Abstracts for PCB West should be submitted at <https://pcbwest.com/abstract-submission-guidelines> by Feb. 3, 2023. Accepted presentations are due Aug. 18, 2023.

Speakers whose abstracts are accepted into the 2023 program receive the following benefits:

- Complimentary access to the online proceedings
- Complimentary pass to the technical conference
- Invitation to the speaker reception.



**SHARE THE KNOWLEDGE** Submit an abstract for the PCB West technical conference and join the crowd.



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## US, Mexico Advance Corporate 'Asian Migration' Plan

**WASHINGTON** – Top Mexican and US officials in December agreed on the outline of a plan to attract manufacturing supply chains to migrate to North America, in particular from Asia.

Mexico Economy Minister Raquel Buenrostro and US Secretary of Commerce Gina Raimondo indicated a specific emphasis on printed circuit boards and semiconductors, which are seen as integral to national security and economic development.

The officials hope to have a joint presentation in place in early 2023 to convince businesses of the economic advantages of producing onshore.

## IPC: Manufacturers Report Rising Material, Labor Costs

**BANNOCKBURN, IL** – Eighty percent of electronics manufacturers are experiencing rising material costs, while 77% indicate that labor costs are on the rise, according to the IPC's November *Sentiment of the Global Electronics Manufacturing Supply Chain* report. At the same time, ease of recruitment, profit margins, and inventory from suppliers are presently declining.

“Over the next six months, manufacturers expect to see increases in both labor and material costs, although somewhat to a lesser extent,” said Shawn DuBravac, IPC chief economist. “While supplier inventory is expected to improve, ease of recruiting and finding skilled talent and profit margins are likely to remain challenging.”

Despite murky global manufacturing sentiment, the manufacturing sector continues to hold up well, according to IPC's November Economic Outlook report. The slowdown has brought demand and production back into balance and enabled many manufacturers to focus on backlogs.

“Though we have seen some growth, we continue to remain somewhat cautious about the economic outlook,” said DuBravac. “Consumers continue to shift away from purchasing durable goods and return to services, and this trend is likely to continue.”

Additional data from the November economic outlook report shows that there continues to be significant economic uncertainty and this will continue to exert downward pressure on economic activity of both consumers and businesses. The ongoing slowdown will continue in the coming quarters.

“We are looking closely at any change in the rate of that slowdown,” DuBravac said.

## Hot Takes

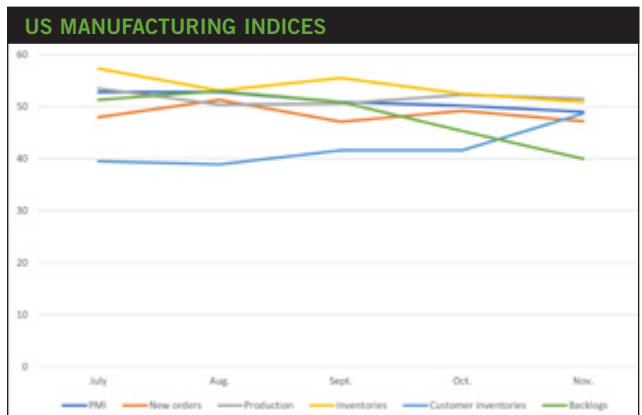
- **Semiconductor sales** fell 0.3% sequentially and 4.6% year-over-year to \$46.9 billion in October. (SIA)
- **Taiwan's PCB production value** is expected to grow to new heights in 2022 despite market headwinds facing almost the entire electronics supply chain, and will continue to advance further in 2023. (TPCA)
- Global **semiconductor equipment billings** rose 7% year-over-year and 9% sequentially to \$28.75 billion in the third quarter. (SEMI)
- **Worldwide PC shipments** totaled 68 million units in the third quarter, a 19.5% decrease from 2021. (Gartner)
- Up to \$1.4 billion in new investment is required to meet an expected surge in **demand for tin** by 2030. (International Tin Association)
- **Worldwide PC and tablet shipments** are forecast to decline 11.9% in 2022 with volumes shrinking to 456.8 million units, followed by a further decline in 2023. (TPCA)
- **Semiconductor sales** will slip 5% year-over-year to \$266 billion in 2023, declining from a 10% rise in 2022. (TechInsights)
- Publicly traded **PCB fabricators** reported revenue fell 2.26% sequentially in October but rose 14.4% year-over-year. (TPCA)
- **Smartphone shipments** will decline 9.1% in 2022, down 2.6 percentage points from the previous forecast, to total 1.24 billion units in 2022. A recovery of 2.8% is anticipated in 2023. (IDC)

INFLATION REIGNS (% CHANGE)				
Trends in the US electronics equipment market (shipments only)				
	AUG.	SEP. <sup>1</sup>	OCT. <sup>1</sup>	YTD <sup>2</sup>
Computers and electronics products	0.0	0.7	0.4	6.6
Computers	-2.0	-1.2	-0.3	0.7
Storage devices	-0.6	-2.7	2.6	14.1
Other peripheral equipment	3.0	4.4	10.8	39.7
Nondefense communications equipment	-2.8	-0.8	0.9	10.1
Defense communications equipment	-1.4	-1.4	0.9	6.1
A/V equipment	0.3	0.8	-4.9	23.5
Components <sup>1</sup>	-0.6	0.7	-0.4	13.8
Nondefense search and navigation equipment	-0.4	-0.8	1.2	1.8
Defense search and navigation equipment	2.1	0.6	0.4	0.9
Medical, measurement and control	0.5	-0.2	0.8	4.8

<sup>1</sup>Revised. <sup>2</sup>Preliminary. <sup>3</sup>Includes semiconductors. Seasonally adjusted.  
Source: U.S. Dept. of Commerce Census Bureau, Dec. 5, 2022

KEY COMPONENTS					
	JUN.	JUL.	AUG.	SEP.	OCT.
EMS (North America) <sup>1,3</sup>	1.41	1.39	1.31	1.29	1.07
Semiconductors <sup>2,3</sup>	13.3%	7.2%	0.0%	3.0% <sup>1</sup>	0.3% <sup>1</sup>
PCBs <sup>1,3</sup> (North America)	1.03	0.98	0.98	1.12	1.29

Sources: <sup>1</sup>IPC, <sup>2</sup>SIA, <sup>3</sup>3-month moving average, <sup>1</sup>preliminary, <sup>1</sup>revised



Source: Institute for Supply Management, Dec. 1, 2022



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## Remembering the Basics

Look past the scary headlines and stay focused on business plan fundamentals.

**WELCOME TO 2023.** As ready as we all try to be when beginning the annual cycle of booking orders, scheduling resources, shipping product, and oh yes, collecting payment, this year many are still tweaking their annual budgets. The effects of rising inflation and a prolonged unstable supply chain are causing many to rethink how they must operate their business to maintain margin and profitability.

Business plans always require some degree of forecasting and estimating, as well as a list of assumptions that underpin the metrics used when budgeting. In (relatively) normal years, some of these prove inaccurate, yet the majority are reliable. It could easily be argued, however, that the times we are in are not necessarily “normal” and few of the business leaders of today were around 40 years ago when inflation last escalated and was a serious economic concern. In such times as these, it is normal to find yourself rethinking basic operating assumptions and adjusting the business plan frequently to stay in step with the ever-changing cost structure and supply availability.

As daunting – if not confusing – the current business environment may appear, we must stay focused on what’s important rather than becoming absorbed by the hype. While headlines about inflation, global supply-chain logistics issues, and how they may impact the economy tend to be sensational, to me, the focus should be on the far simpler and more manageable three basics of business: profit margins, inventory management and customers.

Increasing, or at least maintaining, profit margin encompasses a variety of efforts throughout the manufacturing organization. Yes, costs are a big driver of margins and are currently impacted dramatically by the inflationary environment we are operating in. Increased costs, however, do not automatically result in decreased margins. How and from whom items are purchased can mitigate rising costs, and equally, efficiencies in manufacturing can also create savings to offset higher material costs. Finally, pricing adjustments may also be a tool to share an increased cost with the customer.

In short, maintaining margin is an all-encompassing activity that impacts all aspects of the business. During inflationary times, involving people throughout the organization is essential to both communicate the magnitude of the challenge as well as solicit ideas that may help mitigate the impact of increasing costs, and maintain or increase operating margins.

Inventory is often the first place inflation-driven cost hikes rear their head – and is often the place to

focus attention to reduce both the impact of higher costs as well as the potential shortage of materials and parts caused by supply-chain disruptions. One of the keys here is to expand your supplier base. Inventory management does not just include the level of inventory on the shelf, but from whom that inventory was sourced. Multiple suppliers can expand the options of where a material or part can be sourced, as well as open some level of competitive pricing to partially mitigate increasing costs.

Over the years, many companies have diligently reduced the number of suppliers they work with to leverage the value of the “buy” from suppliers and decrease costs. In times of inflation, that strategy may not be as valuable as having a number of diverse suppliers that compete for your business with both pricing and inventory availability. Likewise, when the global supply chain is unstable, materials and parts availability expands when multiple sources are a viable option. Seeking suppliers in different locations and with alternative sources of their own could be the critical difference between having and not having parts. Managing inventory in times of rising costs and shortages of materials and parts is always critical to business success – now more than ever.

Customers are the final arbiter of any business’s success, so remaining in constant communication with them is the single most important activity company leadership should undertake. As all businesses are experiencing the same challenges – rising costs and supply shortages – working with your customer may be not only the most valuable strategy for success, but also the easiest to implement.

Openly discussing the cost and supply challenges you are experiencing, understanding customer needs and priorities, and suggesting how a customer can assist by the visibility of or timing of their orders, lot sizes, etc., may enable you to be more efficient in the manufacturing and inventory processes, and allow you to order materials and parts in a way that the extended lead times do not negatively impact you or your customer. Most of all, when being open with customers, any price increases will be understood and be met with a far better reaction than when buyers are not involved in the process.

Focusing on the basics of business has always been the most important task of every business leader. In

*continued on pg. 31*

### PETER BIGELOW

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# What is Your 2023 PCB Procurement Strategy?

Don't be afraid to stir the pot to get the best prices from vendors.

**PRINTED CIRCUIT BOARD** buyers face a challenging environment in 2023, with rising prices for raw materials and freight, along with the continuation of tariffs. A solid board-buying strategy is going to be more important than ever. Does your firm have one?

PCB buyers who do not routinely review the performance of their vendor base are perhaps too comfortable in their jobs. It's a core buyer responsibility to keep vendors competitive in pricing, and it is management's job to ensure buyers are not so overwhelmed with other responsibilities they neglect that core duty. Management should also ensure that buyers *and* PCB salespeople are incentivized to bring prices down.

Unfortunately, I see companies that purchase PCBs make the same big mistake year after year by investing too much of their annual spend with a single supplier. That could prove to be costly in the coming year.

I understand and appreciate vendor loyalty. But in the customer-vendor relationship, which party is doing the leveraging?

Companies that stick with the one-vendor approach will have a hard time remaining competitive. "We have used this vendor for years" is *not* a viable strategy.

The problem is, as your relationship with your suppliers continues, it's easy to get complacent about pricing when a particular vendor's quality and delivery are satisfactory. It's easy to shift more work to that vendor or even to only a couple of vendors that are performing well, and then fail to keep a close eye on pricing.

Failure to regularly check what existing vendors are charging against that of potential suppliers could mean money left on the table.

If quality and delivery performance among your present vendors is comparable, you need a way to ensure you're still getting the best prices. Buyers should always work to keep vendor pricing in check. They should regularly seek offerings from other vendors to compare with the prices they're getting.

One way to do this is an activity that I call "quoting for fun." Don't hesitate to give potential vendors a shot at quoting an ongoing project "for fun." Let potential vendors know it's an existing project and you'd like to see where they stand on pricing.

This will provide a useful benchmark against which to measure your current vendors' pricing. And if there is a significant per-board price difference – especially if there are quality or delivery issues with a current vendor – it may turn into more than just fun. It may give you another vendor to add to your base.

While a few pennies per-board difference in price

is not worth switching vendors if you're happy with existing ones, it's wise to always keep your options open. This practice will also help keep your vendor base on its collective toes. Let vendors know right at the beginning of your relationship that you'll be regularly evaluating their performance in all areas, including pricing.

Other ways to stir up your PCB cost pot include:

**Price checks.** A vendor that is too comfortable with your business will usually charge you more. Let all your vendors know you will be testing the waters and comparing their pricing to others. Then be sure you follow through on that. Don't be reluctant to bring on new vendors if necessary.

**Keep a scorecard.** How often do you review the performance of your vendors? A vendor that is regularly evaluated for on-time delivery and quality acceptance in comparison to its competitors will generally also offer better pricing.

**Vendor visits.** Demand your vendors pay a visit to your operation. The more business they do with you, the more visits should be required. The more excited the vendor is about your operation, the better the service and pricing will be. If a vendor doesn't visit, this means they are too comfortable with your business and that likely means you're paying too much.

**Pay on time.** The one thing the vendor should never have to worry about is on-time payment. Consistent payment makes it easier for you to demand better service and pricing.

**Get trained.** Training in the right way to buy PCBs will show you how to leverage your annual spend, negotiate for lower board pricing, and get better payment terms. It will also give you the confidence to move business from one vendor to another, when necessary. A well-trained buyer will be able to strengthen and manage a high-performing PCB vendor base.

Henry Ford said it best: "Competition is the keen cutting edge of business, always shaving away at costs." That applies to PCB vendor pricing as well. Keep your vendor base on its toes. You can lower costs, with minimal risk to your manufacturing operation, by ensuring all your vendors feel the need to remain competitive.

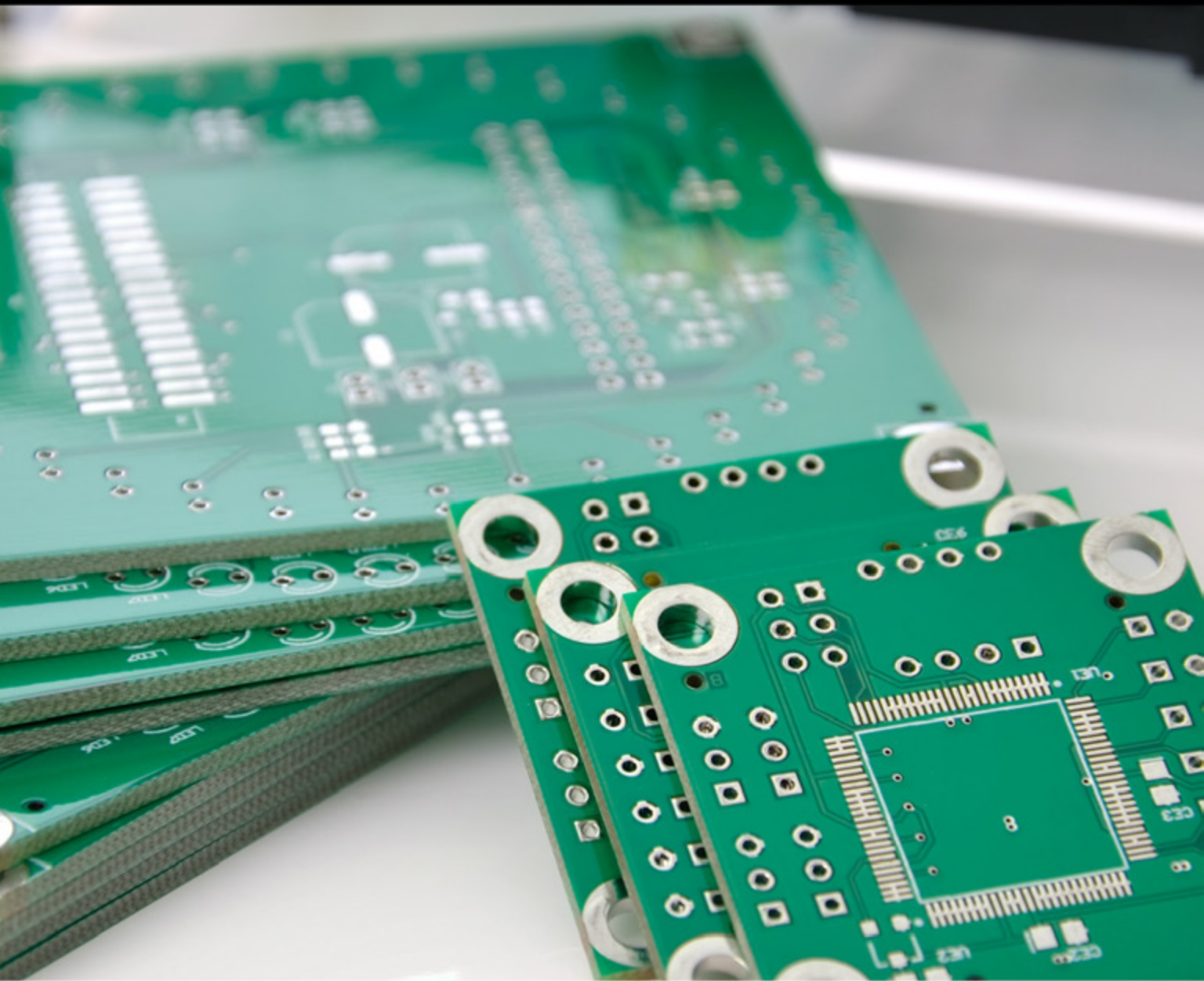
For 2023, supplier diversification is vital to your success. □

## GREG

### PAPANDREW

has more than 25 years' experience selling PCBs directly for various fabricators and as founder of a leading distributor. He is cofounder of Better Board Buying (boardbuying.com); greg@directpcb.com.





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# Home Design

The quarantine may have created the biggest shift in how PCB design works.

**AS A CAREER** PCB designer, I've seen a lot of waves break over the electronics industry, but not since the very foundation of electronic computer aided design (ECAD) have I seen such a significant paradigm shift in our work practices. From the mid-20th century onward, computers have become involved with our design efforts. Aerospace and automotive industries led the way along with universities; about the only places where computers were available in those days.

I went to school for this in 1988, the year the telephone system moved from Alexander Graham Bell's analog technology to a digital system. Four years prior, the US Congress used antitrust law to break up AT&T into numerous regional "Baby Bells." This set off the telecom revolution that led us to today's information saturation.



**FIGURE 1.** A little more modern than my first laptop, this Zenith unit is aboard the museum Battleship Missouri in Pearl Harbor.

**The first wave of PCs.** Back then, the "Big Three" service providers were Compuserve, Prodigy and AOL. Prior to that were so-called Bulletin Board Systems (BBS) where my primitive computer could connect over

the old phone system at baud rates that would be laughable in today's world. Let's just say that 56K dialup would have been crazy talk.

The computer had no hard drive, only a pair of floppy drives. They weren't the 1.4MB kind either. The OS actually ran on one of the 360KB floppy disks. A piece of connectivity software called X-Modem ran in the other slot and allowed me to specify such things as the number of bits, (8) whether to use a stop bit (yes), whether to have duplexing (full) and finally whether to use odd, even or no parity (even).

The sound of a "dial up" session – that series of various beeps when the two machines connect over phone lines – is an audible manifestation of the two devices agreeing on a protocol. If the wrong parameters were entered for the host device, then the text on

the screen would be garbled. Imagine if the "internet" were some fellow who had a total of eight telephone lines running to his house. That's how many of us could be online at a given time. Good thing the ol' computer had redial.

The day when that computer became obsolete due to the rise of the big three was the second time PCB design underwent such a significant sea change. The digital revolution was on. Winners in the portable computer market would be sorted out in the field of innovation. Battles played out over such things as battery life, screen resolution and megabytes of double

data rate random access memory (DDR) that could be listed on the marketing material.

The effect on PCB design, with regard to the available software, was the ability to assign multiple nets to a bus and generate sets of rules regarding those groups of nets. We had to design the machines that helped us design even more machines. Graphics support went from that text-only display screen to ever

more vivid imagery driven by, of all things, gamers. The wider graphics pipelines required more out of the central processors, which started adding pins while decreasing their sizes.

**Computers hit the road.** Meanwhile, the mobile revolution was setting up to be the next game changer. No longer tethered, mere conversations gave way to texting, and even sharing a picture or two. South Korea was ripe for cellular technology, primarily because it had very little in the way of telephone wires out in the rugged countryside.

Cellular towers made a lot of sense for their country, but they also traveled well. When Qualcomm, which started the 3G cell tower business, sold it to a company in Finland, my company made the pivot

**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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to South Korea, which had collectively decided to become an exporter.

Time marched on and cellphones became smartphones by combining as many features as possible under the screen. Of course, the largest feature was the battery, because, as with the personal computer, a technology race was on and run-time was one of the battleground metrics.

Then it was time for PCB designers to start thinking small. Mobile devices for the consumer market gained a focus on thin and light in addition to durable and powerful. Miniaturization brought the microvia and all the stack-up conditions that apply to sequential lamination. Managing core vias with just one central via is difficult on its own.

The way I see it, a few watershed moments have altered the course of PCB design history.

- Going digital, using computers to design better computers.
- Computers becoming more connected to each other. Edge routers and other infrastructure were needed, and layer counts went up.
- Computing going mobile and shrinking the playing field. Chips and boards became smaller, faster, and more efficient, and board technology had to keep pace with the ever-tightening geometry, while upping the importance of SI/PI issues.
- Being able to work from anywhere without the boundaries of space and time.

This last point is unlike the others in that it wasn't so much a technological breakthrough but rather a societal imperative that made it happen. I would point back to the trust busters of 1984 as the closest parallel in this regard.

**Office space: not what it used to be.** Over the years, tech companies have consolidated around the idea of desks lined up in rows rather than separated by cubicles or actual walls. In every case, the bulk of our jobs took place on the monitors.

Kickoff meetings and design reviews found themselves in a dedicated room.

The meeting rooms themselves were adapted ahead of the quarantine to include large wall monitors. This allowed people from other buildings around the campus to join remotely. I can recall the meetings of the Xbox design team prior to all of this where most of the people in the meeting were not actually in the room. I came into the office every day but was lucky if I saw my manager twice a week.

That turned out to be good training for what was to come. All the pieces finally came together. Portable computers with enough power, fast and secure connections, and software geared toward online collaboration have coalesced around the global pandemic to kickstart a process that has proven rather successful. It would be difficult to put that genie back in the bottle.

The upshot is that I could, in theory, move to Colorado and take my job with me. Conversely, I could accept an offer in Colorado and not have to move if that was my desire. This opens pretty much all the job opportunities regardless of location. Don't think your manager hasn't realized this! A PCB designer with any kind of a track record has a good chance of working where they choose.

Of course, not all companies are on board with remote work. I'm not judging them, but I do think that it would limit the talent pool to a geographic location.

This leaves a very important source of diversity off the table: the rest of the world's PCB design talent.

All I must do is start scrolling through my many connections to see how we run the gamut of backgrounds. Open-minded orgs will reap the benefit and so will we. Even an office-first culture is better than an office-only deal. If you need another reason to convince someone that PCB engineering is a good career choice, just point to how portable and thus liberating it can be to design printed circuit boards for a living. □



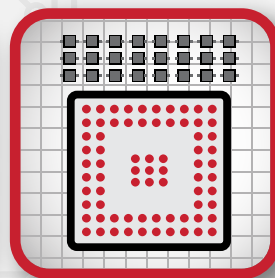
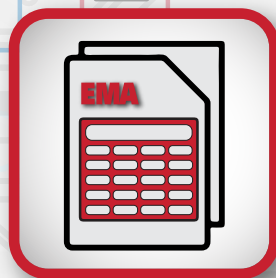
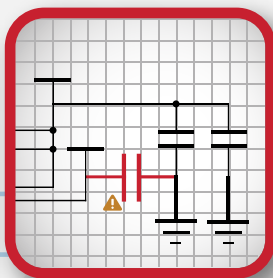
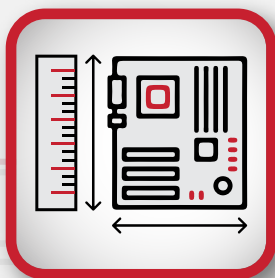
**FIGURE 2.** Cell towers flourished like dandelions as we all became more connected to each other and then to our shared data.



**FIGURE 3.** Office, sweet office? The GoPro headquarters is what you'd expect, so I go there once a week by choice.

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# The Green Movement Has Some Caution Lights Ahead

Switching to electric vehicles may save the planet, but there are challenges along the road.

**THE TREND TOWARD** automotive electrification has established car makers and tier ones among the electronics industry's biggest customers. We all continue to see a significant proportion of our activities and sales revenues associated with the drive for safer, cleaner, more reliable, and more entertaining vehicles.

Among the most interesting technologies is autonomous driving, which is bringing vast quantities of sensors on board – radar, lidar, infrared, camera modules – not to mention the signal processing and software needed to turn that data into real-time driving instructions. Then, of course, there is the transition to all-electric drivetrains, slated to become mandatory in several major markets by about 2030. With that, our takeover of the automobile will be complete!

Like many other consumer-electronic products, we can describe the generic EV drivetrain in a fairly straightforward block diagram: the battery and its management system (BMS), inverter, motor drive, and electric motor. Of course, nothing is as simple as it looks, and each of those blocks is an infinite source of technical minutiae to be understood, overcome, and perpetually re-engineered and re-optimized.

A key consideration is the powertrain operating voltage, which has important implications for us in the PCB industry. Increasing the voltage enhances energy efficiency and power delivery, and as some platforms are pushing toward 800V operation, we need PCBs that can handle this safely. It calls for a suitable comparative tracking index (CTI) to prevent arcing across the board surface that can cause component failures and fires.

High-CTI substrates were first formulated in the early days of domestic appliances, when substances – such as washing powder – were found to present a fire risk when they contaminated the board and arcing occurred. High CTI is also a requirement in applications such as electronic gasoline forecourt pumps for dusts or other substances that could promote arcing, leading to potentially problematic fires.

The CTI of ordinary, basic materials is under 100V, while so-called Level 3 materials can handle up to 175-250V. While today's best materials can go up to about 600V, we've got work to do to raise the CTI for circuits operating at 800V and design and qualify suitable materials for future generations of EVs.

As I suggested earlier, the operating voltage is minutiae compared to some of the larger questions regarding sustainable mobility. Electricity lost the "battle of the fuels" to internal combustion a century ago. The situation is different now as today's EVs are seen as the way to achieve a clean and sustainable future. But

is this really accurate? As we work to build a future powered substantially by energy recovered from renewable sources such as wind and solar, the battery EVs we are driving today fit well with the vision. That green grid lies some way in the future, however, and moving rapidly to e-mobility is not so great for the planet today.

The technology needs customers in order to develop, and a cultural change must also take place. But EVs have some associated sustainability issues, particularly around the use of rare materials such as platinum, cobalt and lithium. Lithium battery technologies are by far the best we have. Right now, however, there is no satisfactory way to recover the metal from end-of-life batteries. An article in *Nature* suggests an average single car battery pack contains about 8kg of lithium and the world currently has enough reserves – about 21 million tons – to sustain conversion to EVs until the middle of this century.

What are the alternatives? Synthetic fuels could be an option. Biodiesels are already widely used in industrial applications, not only in road-going vehicles but also small boats and generators. Hydrogen and fuel-cell vehicles have for a long time been seen as an alternative to battery EVs and could make up a part of the e-mobility mix. However, the electricity needed to produce hydrogen by electrolysis is subject to the same caveats as electricity for recharging EVs: a cleaner grid based on renewable energy sources is needed before we can fully realize the environmental benefits.

One alternative could be nuclear. It's free from carbon emissions as well as the geographical constraints on wind, solar and hydro power, although public perception is mixed. If that perception could be changed to recognize its track record as one of the very safest sources of electricity production, nuclear could produce more than enough energy to power the change to e-mobility; a sustainable way to produce hydrogen at low cost and recharge our lithium batteries.

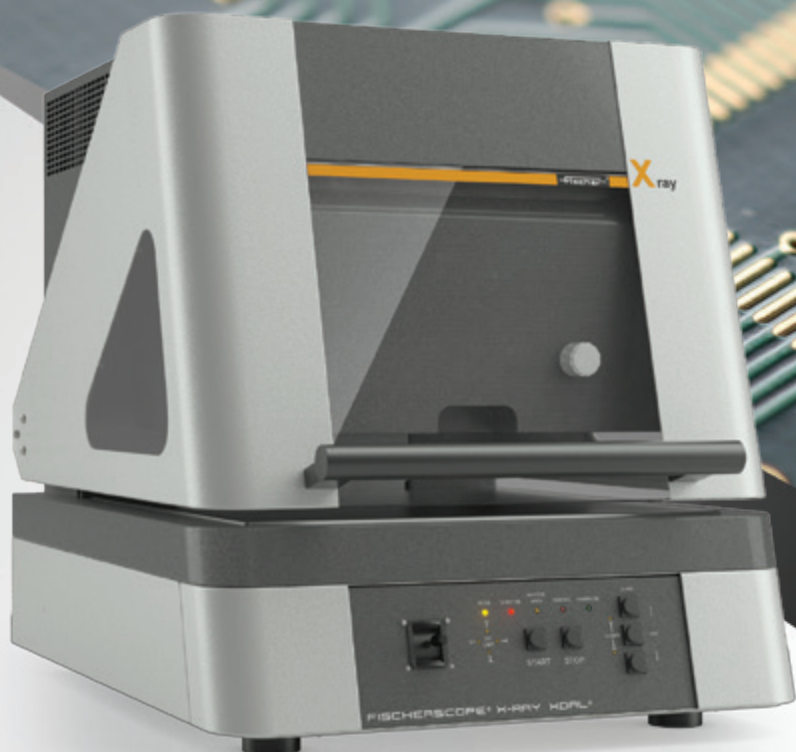
Ultimately, no obviously problem-free way exists to get rapid, clean personal mobility in the style we have enjoyed since the first "motor cars" appeared nearly 140 years ago. Many technical challenges need to be overcome. But, we are technologists. Of course, we can do it. It may be expensive, however. While some predictions claim EVs will reach price parity with conventional combustion-engine vehicles by about the mid-2020s – due, in part, to the rapidly falling prices of lithium batteries – it has been calculated that the grid upgrades needed for them to become our preferred transport will cost \$1,700 to \$5,800 per vehicle. As Kermit the Frog said, "It's not easy being green." □

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# DfM: The Devil is in the DESIGN DETAILS

A design can look good on paper, but has it been vetted for manufacturing? by **STEPHEN CHAVEZ, MIT, CID+, CPCD**

Printed circuit board assembly: What comes to mind when you hear, read, or think that term? What does or should this mean to a printed circuit board designer or a printed circuit engineer? Is it an afterthought within the overall process of designing and manufacturing your product in the rush to get your product to market the fastest while trying to minimize your cost?

For me, what pops into my head is design for manufacturability or excellence (DfM or DfX), which includes fabrication and assembly – but let’s not forget producibility as well.

Let’s first understand what is meant by design for manufacturing. It is a design technique for accounting for all the constraints of the assortment of parts that constitute the final product after assembly. DfM focuses on minimizing the complexities involved in manufacturing operations as well as reducing the overall part production cost.

Now, let’s understand what is meant by producibility. It is the relative ease of manufacturing a product or system. Quality in design focuses on concurrent development of the total system using capable manufacturing processes, leading to a producible, testable, sustainable and affordable product that meets defined requirements.

I strongly believe that assembly (manufacturing/production) and producibility need to be accounted for from the earliest conceptual stages in the design process. Collaboration and integration among all key stakeholders of the product to be designed are essential in the quest for success in printed circuit engineering.

From building component libraries to finalizing layouts, assembly and producibility must always be considered important factors to address. It’s one thing to get a technical query (TQ) from a fabricator regarding the PCB, but it’s significantly different when issues present themselves downstream in assembly or production.

Here’s why. At the PCB fabrication stage, there is still potential (time) to make a change to a design to ease manufacturing (fabrication) before it is set in stone. Once a PCB is fabricated, it’s in a physical state that cannot be changed

without serious ramifications. At the assembly or production stage, the PCB is already locked in. At this point in the overall process, it is what it is! It’s too late and too far downstream to address “design” changes to the PCBA at hand. The potential for rework, workarounds, or worse, revisions of a PCBA become extremely costly.

Throughout my career as a printed circuit engineer, I have engaged with other PCB designers, design engineers and manufacturing engineers (fabrication and assembly) at industry trade shows like IPC Apex and, especially, PCB West. From the newest generation of PCB designers and engineers to seasoned veterans, it amazes me to hear how the accountability of assembly or producibility details, which must be addressed early in the process to ensure successful PCB assembly, are still often overlooked or fall much lower in the list of design priorities when it comes to printed circuit engineering.

I often hear horror stories from both sides, from design engineering teams to manufacturing and producibility engineers. For instance, the inability to place connectors on an assembly because the outer shell of the connector was not accounted for in the library during part creation, and now there is component-to-component interference.

Another example is edge connectors placed too close to each other at the edge of a PCB. The land patterns together fit perfectly in the design at layout but are physically impossible for human interface once at assembly.

Then there are component solderability issues with land grid arrays (LGAs) or bottom-termination components (BTCs), and component toe and heel fillet issues, component courtyard issues, and design for test (DfT) issues.

Don’t get me started on designs that are almost impossible to rework, or designs that require extensive customization to assemble from the very beginning. This includes designs with lots of manual component placement in combination with automated component placement. Depending on the requirements, the product may see multiple thermal cycles throughout the assembly process before it leaves manufacturing and ships out. Now, because of the potential of excessive thermal

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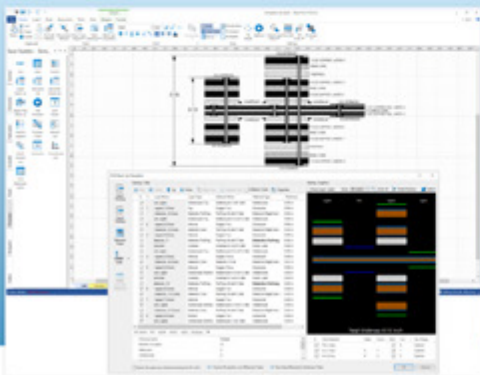
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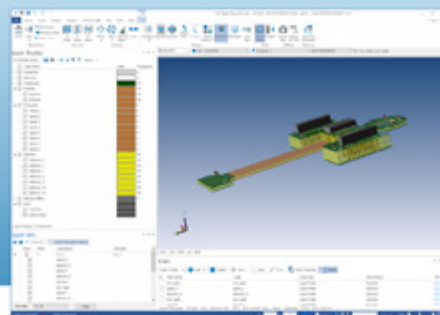
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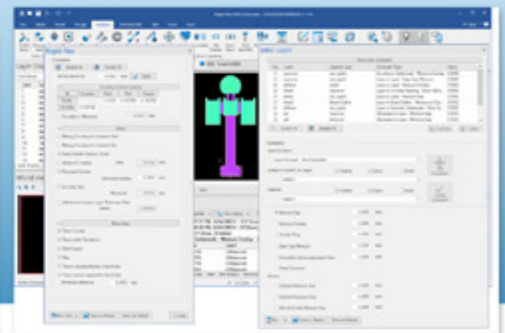
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cycles, latent product failures are potential nightmares. A few other horror stories I'll mention include mixing lead-free and lead (Pb) components on the same assembly, as well as those conformal coating nightmares. I can go on and on with horror stories when it comes to assembly and production.

I can usually point out one factor at the core of these horror stories. Assembly or producibility were not accounted for, or were a vague thought, during the design process of a product. The design was completed without that key assembly and producibility stakeholder involvement upfront. The product was designed and figuratively thrown over the wall to manufacturing, with the highest expectations from the project team that there will be no issues manufacturing or assembling their product. With a wave of hands like a magician, presto: Manufacturing will resolve any issues and return with an assembled product.

This is not what happens, of course. Personally, I find that engineering approach inadequate and disrespectful to the manufacturing assembly and producibility professions when it comes to printed circuit engineering. We have encapsulated the three competing perspectives today's circuit engineer must meet for success. **FIGURE 1** visualizes this design triangle.

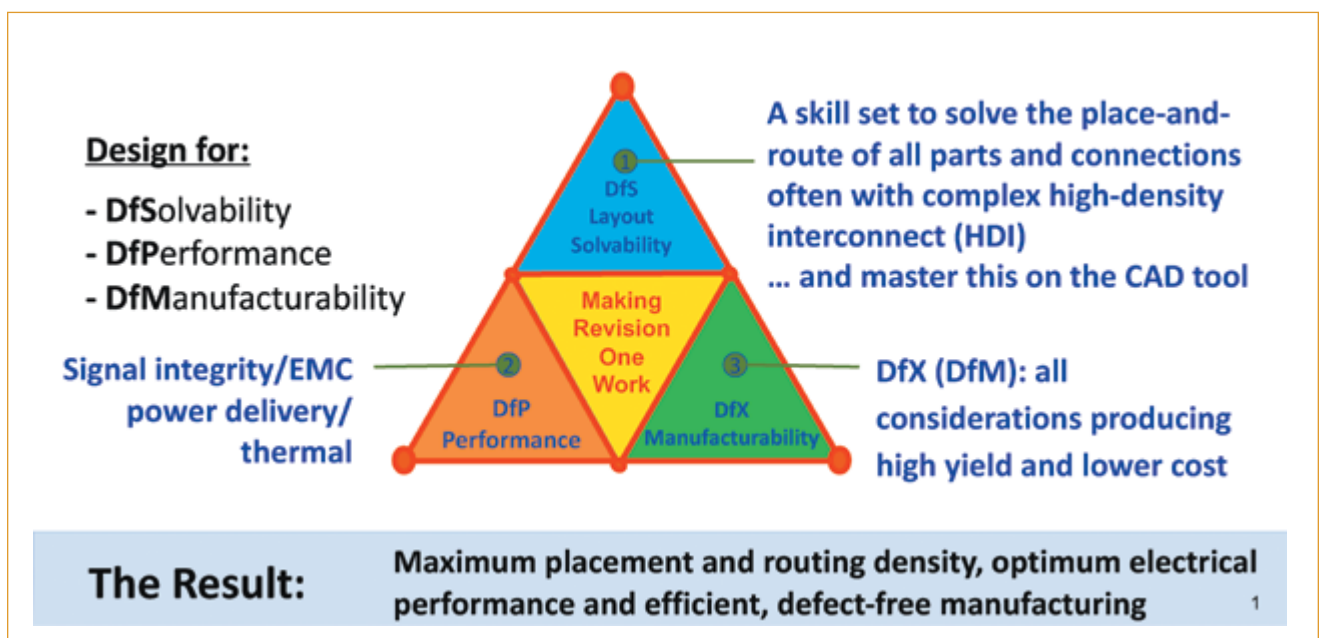
In engineering, we often hear the phrase, "The devil is in the details." When it comes to PCB assembly and producibility, many details need to be accounted for. More specifically, they need to be addressed upstream in the process. These details, when not considered or incorporated early in the design process, can potentially become your worst nightmare downstream in manufacturing (production). Assembly and producibility issues often lead to extensive rework, schedule delays, and project budget overruns. In the worst cases, it may be catastrophic, especially if components cannot be assembled to the PCB, or if assembly takes an enormous and extensive

effort. That's why it is very important to understand the depth of the concept of DfA and producibility, and why these key factors are so important when it comes to successful PCBA manufacturing. It's also important to have the manufacturing/production feedback loop in place and maintained with engineering to ensure continued multidiscipline and multidomain collaboration for success from design to manufacturing.

Collaboration between design and manufacturing and how those two disciplines exchange data are important as well. It should be bidirectional. By doing this, we enable lessons learned from manufacturing to be fed back to design. That bidirectional loop (read: data exchange) influences the design and ensures minimal risk at fabrication and assembly. To do this, we utilize intelligent data formats such as ODB++ and IPC-2581. These types of data formats enable detailed communication of design intent from engineering to manufacturing. The value we gain is an optimized, integrated collaboration that contains all the information needed for manufacturing while minimizing errors during the data exchange. And, it provides a continuous feedback loop of lessons learned from manufacturing assembly back to design engineering.

Success starts from the beginning by bringing the assembly and producibility stakeholders to the design table, along with all other vital stakeholders of the PCB design, to ensure a greater potential for success downstream. Upfront collaboration and breaking down the silos between disciplines and domains is the key to downstream success. Today's EDA tools can create digital threads, or digital twins, that can reduce the costs of trial-and-error and respins.

As stated, success in printed circuit assembly starts early in the process. Manufacturing and assembly fluency, which include producibility, requires understanding industry specifications. Most printed circuit industry specifications are devel-



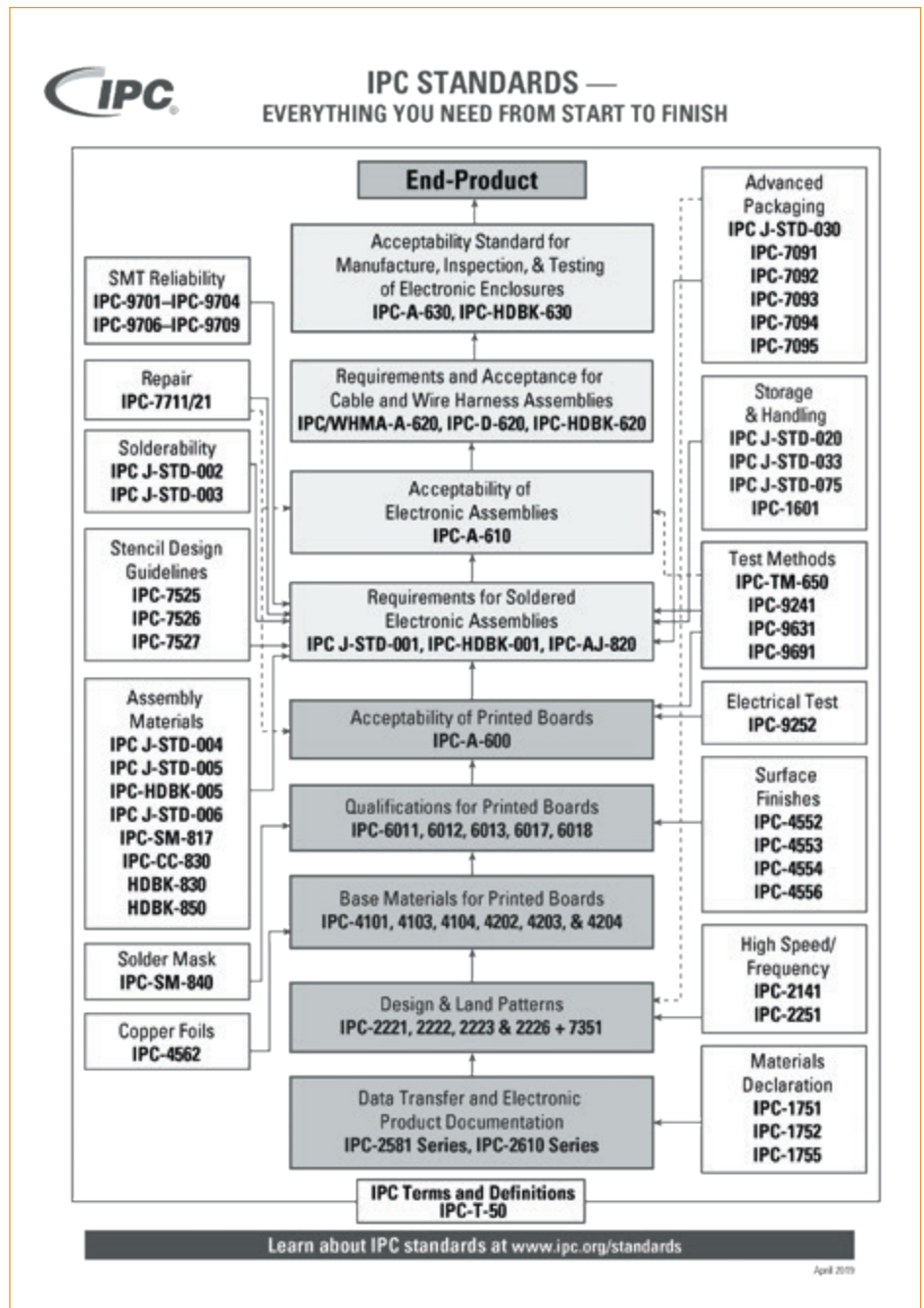
**FIGURE 1.** The design triangle. Today's circuit engineer must meet three competing perspectives for success.

oped by IPC. The IPC standards are created to aid and guide development and offer a common language for printed circuit engineering and manufacturing. Many IPC specifications tie design to assembly; see **FIGURE 2** for a list of the IPC standards related to the PCB process.

IPC also produced a free resource called *IPC Checklist for Producing Rigid Printed Board Assemblies*. I highly recommend this 28-page document to anyone involved with printed circuit engineering and manufacturing. A copy, along with a few other key documents, is available at [ipc.org/ipc-standards-related-resources](http://ipc.org/ipc-standards-related-resources).

When it comes to printed circuit assembly in today’s environment, the devil is in the details, and when it comes to assembly and producibility, there are a lot of details to account for. Make sure all key stakeholders, including manufacturing and producibility, are brought to the table early in the process. Customer requirements, the required performance class and producibility level, and what we are designing and building are extremely important to know and fully understand. As stated in *IPC Standards: What Every Manufacturer Should Know*, “Electronics are at the heart of millions of products, from aerospace and defense, to automotive, information technology, telecom, manufacturing, retail, healthcare, and more. Our lives depend on electronics in everything we do.” □

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**FIGURE 2.** The IPC standards tree, showing the list of specifications from design to assembly.

*ROI, continued from pg. 18*

these uncertain times, when inflationary costs and inventory availability are ever-changing, sticking to the basics is still the surest way to succeed. Customer communication and involvement are critical, and actively involving all in the organization to both understand the challenges and solicit input is essential. Most of all, don’t be afraid to tweak your business plan, frequently and continually, as changes take place, events unfold, and customer input is received. □

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# PRACTICES FOR SUSTAINABILITY in PCB Metallization

A comparison of energy, water and chemical use for two common processes. **by LENORA CLARK**

“We will make decisions based on sustainability, Lenora.” I heard the words clearly. I understood the tone in his voice and the impact it would mean for the industry moving forward. Interestingly, it was not the only time I would hear that same statement within a few weeks.

Over the past years, the term “sustainability” had been something of a buzzword. We see it in our everyday lives and, honestly, I don’t always understand it. We have eliminated plastic bags at many stores, but now I’m collecting reusable bags by the handful. What are customers supposed to do with all these bags? Many end up in the trash, especially when they are being handed out similarly to a disposable product. Is it better that they are not plastic, or is it just as bad because we are creating the same level of waste?

This makes my head hurt. I need to see things in a basic form to make sense of it and determine if it is an improvement – or not.

Now my customers have started asking about sustainability comparisons for chemical processes in printed circuit board manufacture. My thought is to start with the basics: Energy usage. Water usage. Chemical consumption. These are things I can track and show without worrying about the type of energy used at the fabricator, or the price of energy regionally, let alone daily fluctuations. I start with tangible concepts.

When we look at chemical processing or what we call wet chemistry, a few inputs immediately come to mind for energy usage. The solutions must be heated to achieve performance, solution flow or movement is critical in delivering material to the board’s surface and within the holes, and circuit boards need to be transported through the process. All aspects use energy. This is in the form of heaters, pumps to create and deliver solution, and motors that drive the boards through the process equipment.

The next resource is water usage. Rinse quality is critical to the success of the product. A consistent flow of fresh water to remove residual chemicals from the board’s surface and holes is essential. Poor rinsing can result in quality and performance issues later in manufacture or final build.

Last is chemical consumption. This is how much material is

used to create a successful product. It will vary for each process type and for each step within that process. To ensure a good product, continuous replenishment of fresh chemicals is necessary to keep everything in balance. A well-balanced formulation results in controlled plating rates or etching rates and ensures brightness or proper grain structure, and overall balance delivers the desired outcome. Chemicals leave the bath through absorption onto the circuit board, drag out of solution from the plating tank or chemical breakdown.

It is important to look at all aspects of a process when delivering the information to the customer. Depending on the region, some areas may be of greater concern than others. When the PCB technology teams at end-users began making these requests, I expected their areas of concern could be different from those of a circuit board fabricator. Yes, all parties are conscious of power, water and chemical usage, but to requalify a process for a small improvement can be a major strain on an end-user. I have been in the industry long enough to know that a minimal improvement is not perceived to be worth the time, money or resources to make a change. It is best to show a process change that will have a “double-digit improvement over the incumbent.”

Internally, we have begun calculating kilowatt-hour (KWh) consumption for segments of our business, so I understand that certain areas have a greater energy footprint than others. I decided to start with one of the more complex processes in PCB fabrication, one that is highly resource-intensive. It is one that every board experiences: primary metallization. The most common is electroless copper plating. I hope to shed some light on specific details that we as a chemical supplier focus on, details that might not be clear to end-users or others in the supply chain.

Primary metallization, sometimes termed “making holes conductive,” takes a dielectric substrate and deposits a conductive layer for subsequent electrolytic copper plating. It is necessary to make the dielectric conductive and further build copper pathways that carry electric current. As stated, the most common process used is electroless copper plating in a vertical application. After the resin and copper are properly cleaned and prepared, parts are processed through a palladium solution, a

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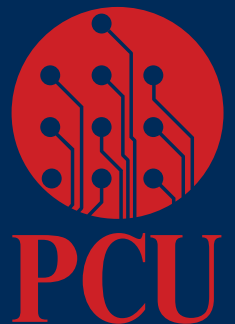
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step called activation. Palladium is a catalyst for copper deposition and adsorbs to the surface of the dielectric material. This gives the copper an active site to bond.

The electroless copper cycle is a multistep process with complex chemical baths. It contains different metals to deliver the palladium, reduce it and then plate copper. All are required to achieve uniform coverage. The copper plating bath itself uses reducing agents and chelators. It is an operation that requires close attention to all process parameters for success. Though there are complexities to the system, it accounts for 80% of the market share and has been a viable process since the 1950s. It is used for all market segments and board design types.

An alternative, simplified process is called direct metallization. Direct metallization uses a carbon or graphite seed layer to make the holes conductive prior to electrolytic copper plating. A conditioning step creates a uniform charge over the surface. In the coating bath, the carbon material electrostatically coats the entire board. Unwanted carbon on the copper foil or innerlayers is etched away prior to electrolytic copper plating. It is called direct metallization because clean copper innerlayers entering the electrolytic plating bath result in a direct copper-to-copper bond. (By contrast, in an electroless copper process, the palladium and thin copper layer stand between the innerlayers and the electrolytic plating.)

Direct metallization uses three chemical steps that are very stable in nature. It does not require metals or chelating agents in the formulation, which makes for easier control of the chemical constituents. It has been on the market for over 30 years but is considered the newer technology. It is heavily used in flexible circuitry and low-loss materials due to its process capabilities. It is the primary metallization of choice for the handheld and substrate package markets due to its ease and short cycle times when manufacturing multilayer high-density designs with microvias.

**Resource Reduction**

The reduction in resources for direct metallization becomes clear when you compare the two processes. **TABLE 1** shows the chemical and rinse steps required for each. Direct metallization can be run in a single pass mode, but to deliver the worst-case figures I have chosen a double-pass process (known in MacDermid Alpha as Blackhole Double Pass). To normalize the vertical and horizontal applications, consumption of two production lines manufacturing 20,000m<sup>2</sup> per month are compared.

Electroless copper has seven chemical steps and six rinse steps. Direct metallization has three chemical steps, one of which is used twice, and three rinse steps. For the electroless process, the chemical baths on average run at higher

temperatures than they do for direct metallization (**TABLE 2**). Immediately, a reduction in water usage is realized. **FIGURE 1** compares water usage for one day: 25,000 liters for direct metallization and 84,000 liters for electroless. It is a 70% reduction in water used per day.

Energy usage can be viewed per month or per square meter. Assuming again both lines are producing 20,000m<sup>2</sup> in a month, the electroless copper line uses 147,000KWh and direct metallization uses 62,250KWh. Dividing by 20,000 to realize the energy per square meter comes to 7.35KWh and 3.11KWh, respectively, or a 58% reduction in power (**FIGURE 2**).

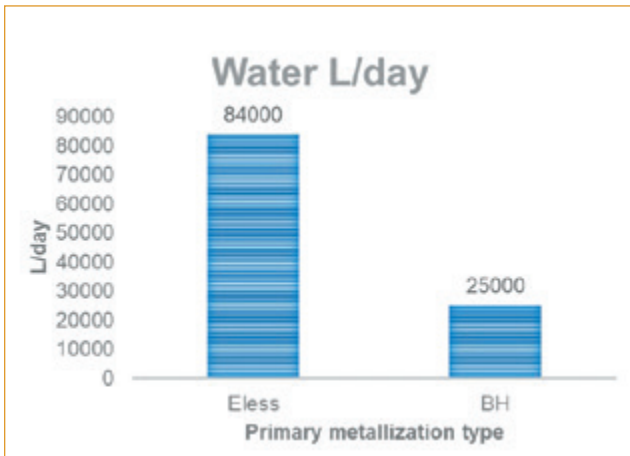
The final resource of chemical usage is a bit more complicated. A chemical solution can go out of balance in multiple ways. This is due to metals plating out of solution, materials being dragged from the plating tank on the board surface or in holes and chemical breakdown. The main challenge plaguing the electroless copper plating bath is the Cannizzaro reaction.<sup>1</sup> This reaction happens immediately upon mixing. In our case, the caustic and formaldehyde form sodium formate and methanol. The chemical byproducts are likely not the main concern of this

**TABLE 1.** Metallization Chemical and Rinse Steps

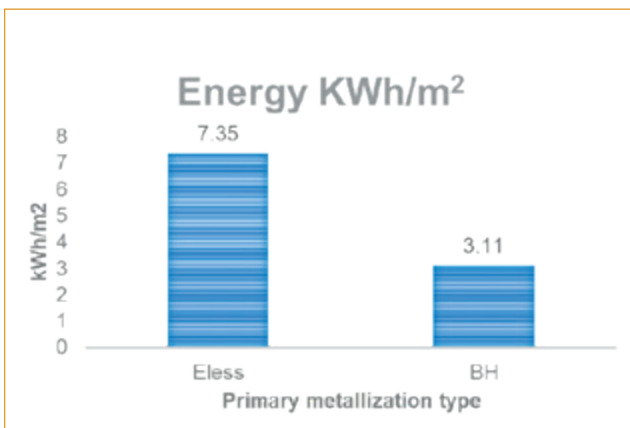
Direct Metallization	Electroless Copper
Cleaner	Cleaner
Cascade rinse	Cascade rinse
Direct metallization #1	Conditioner
Blow + dry	Cascade rinse
Conditioner	Micro-etch
Cascade rinse	Cascade rinse
Direct metallization #2	Pre-dip
Blow + dry	Palladium Catalyst
Post-etch	Cascade rinse
Cascade rinse	Accelerator / reducer
Dry	Cascade rinse
	Electroless copper
	Cascade rinse
	Dry

**TABLE 2.** Comparison of Metallization Processing Temperatures

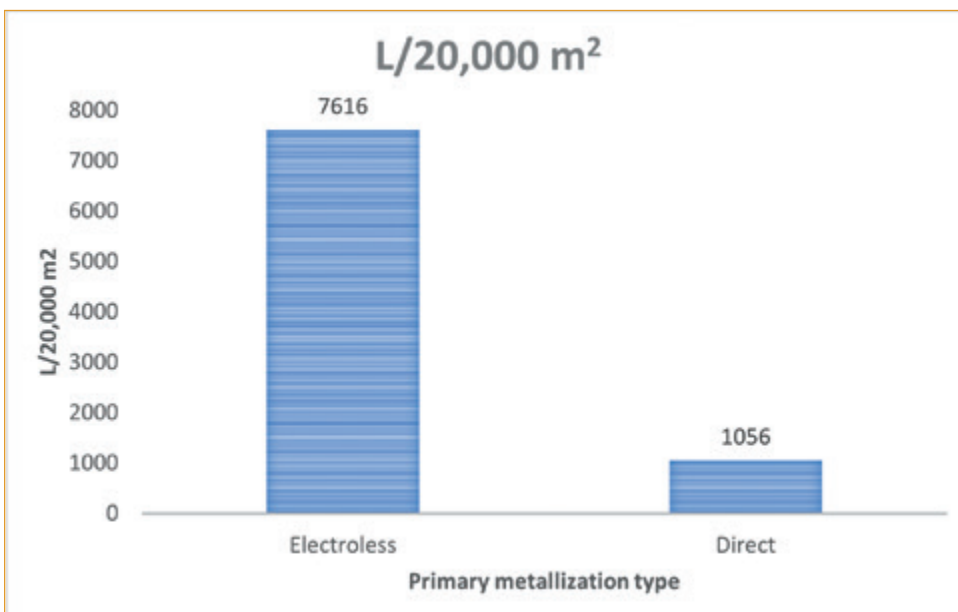
Direct Metallization		Electroless Copper	
Bath	Operating Temp.	Bath	Operating Temp.
Conditioner	24°C	Cleaner	50°C
Direct metallization #1	33°C	Conditioner	52°C
Conditioner	24°C	Micro-etch	38°C
Direct metallization #2	33°C	Palladium pre-dip	25°C
Post-etch	34°C	Palladium catalyst	33°C
		Accelerator	50°C
		Electroless copper	45°C



**FIGURE 1.** A double-pass direct metallization process uses 70% less water per day than electroless copper, based on a line producing 20,000m<sup>2</sup> per month.



**FIGURE 2.** Direct metallization also uses about 58% less energy than electroless copper.



**FIGURE 3.** Likewise, this direct metallization process reduces chemical usage by 86%.

audience, but what should be understood is that growth in these materials puts the bath out of balance. It is necessary to bail out or remove a certain volume of the bath regularly to decrease the growth of side products and replenish with fresh chemistry. This, in combination with multiple metals being deposited on the board, causes high chemical consumption over the course of each bath life. Comparing chemical consumption of electroless copper to direct metallization shows the greatest difference in resource usage. The usage per month of the 20,000m<sup>2</sup> processes are 7616L and 1056L, respectively (**FIGURE 3**). The direct metallization process reduces chemical usage by 86%.

### Reliability Effects

The utility savings are evident when comparing the two processes. Of course, the next question is regarding reliability of the process and resultant product. Carbon and graphite direct metallization are always processed horizontally, which delivers the same solution to all surfaces without the isolation zones created when running a vertical process in magazine form. Racking vertically is most common for electroless copper. A horizontal process is available but with extensive floor space required and some limitations when switching between substrate types.

Another substantial difference between the two is the effervesce created during processing. Electroless copper creates bubbles that can get captured in holes or in microvias. This will hinder coverage and subsequent copper plating. This will not happen in direct metallization; no bubbling occurs in the coating bath.

Direct metallization utilizes stable chemicals that enable a wide operating window and no dramatic changes are needed when moving from one substrate material to another for the coating process. Direct metallization has served many markets successfully for over 30 years and a host of reliability data are available. It is a proven solution for sustainability. □

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1. Cheryl A. Deckert, Ph.D., "Electroless Copper Plating – A Review: Part I," *Plating & Surface Finishing*, February 1995; <https://www.nmfrc.org/pdf/p0295g.pdf>.

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# Voiding Characteristics of AuSn SOLDER PASTE FLUX VEHICLES Applied in High-Power LED Module Array Applications

Narrowing the choices of the best flux vehicle.

by JENNY GALLERY AND THUY NGUYEN

A high-power LED (light-emitting diode) is defined as an LED package that operates at 1W of power or higher. LEDs are semiconductor-based diodes that emit light when a forward voltage is applied. This permits a small form factor to produce a lot of light while maintaining fantastic efficiency, permitting a single LED to pump out hundreds, or even thousands, of lumens. The high-power LED market thrives on the widening application base of LEDs, specifically in the automotive industry, due to an increasing number of government initiatives that promote energy conservation and efficiency. Other factors that contribute to their use include small size; long life and continuous usage; less power consumption and low voltage; and an increasing number of high-brightness applications.

High-power LEDs provide not only much higher levels of light output than traditional LEDs, but also higher levels of performance, which leads to a longer lifetime of the device. The tradeoff is that a large amount of heat is generated, and in a small, localized area. Since the temperature per unit is so high with high-power LEDs, a high-melting and high-reliable solder is required for assembly. Also critical to the LED assembly process is a void-free solder interface between the diode and its substrate. This provides the thermal and electrical connections needed to generate a stable transmission of light and permits efficient heat transfer to maintain the temperature stability of the device.

80Au20Sn paste is generally chosen as the solder material in high-power LED applications due to its high-melting temperature and reliability in high-volume production. While there is a high upfront cost of investing in luminaires that use high power LEDs as the light source, the optical

power, lumen maintenance and reliability of high-power LEDs often translate to a return on investment significantly higher than that from using low- to mid-power LEDs. To meet market demands of a void-free solder interface, voiding in the solder joint should be below 15%.

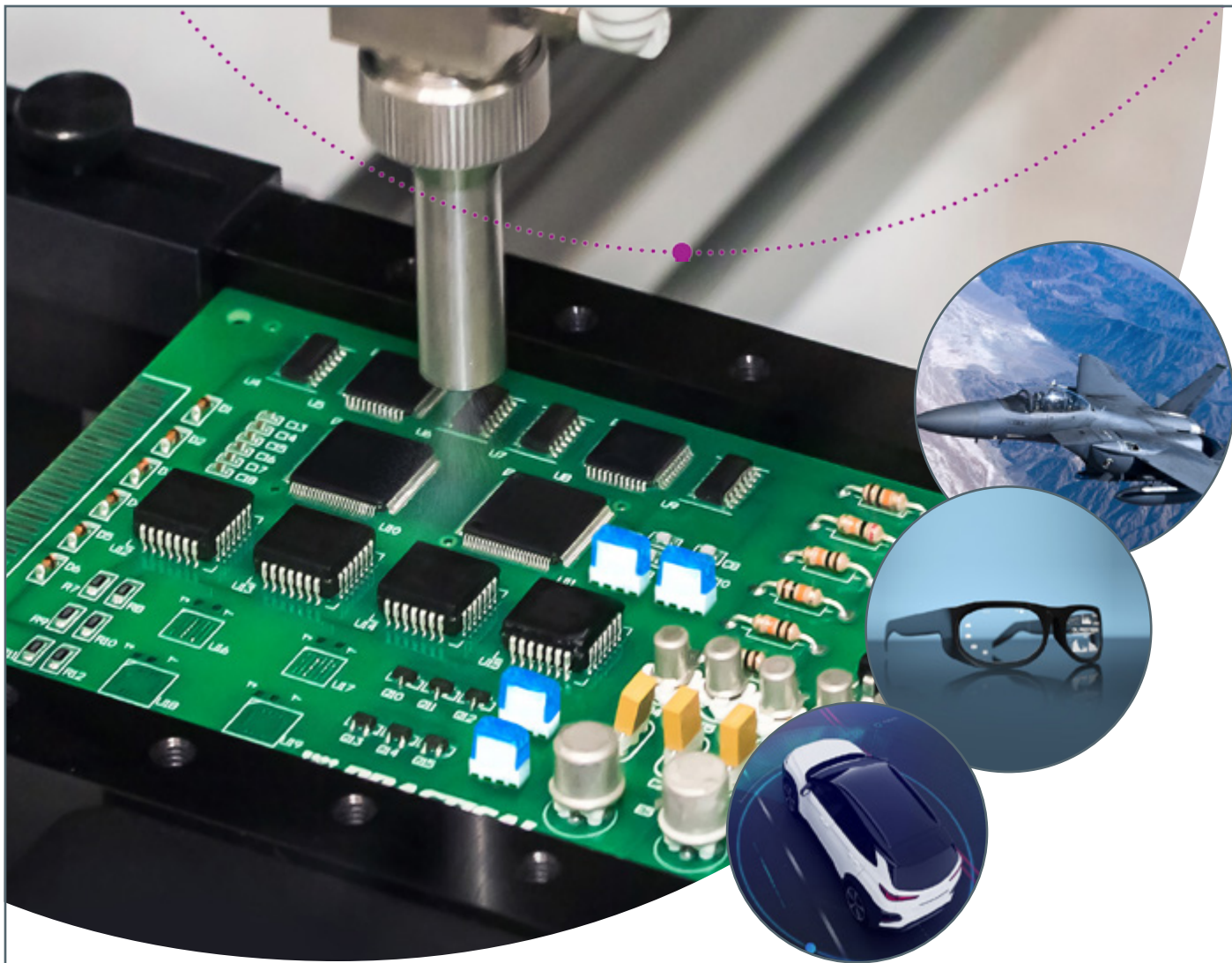
Two no-clean and six water-soluble flux vehicles were mixed with 80Au20Sn solder powder to analyze the voiding characterizations of each 80Au20Sn solder paste. The results will determine the best 80Au20Sn paste offerings, one no-clean and one water-soluble, for the high-temperature/gold market; specifically for use with high-power LEDs.

## Experimental and Results

The experiment began by mixing 80Au20Sn Type 5 solder powder with each flux vehicle to create eight 93% metal-load 80Au20Sn solder pastes (TABLE 1).

TABLE 1. Materials Used

Alloy	Flux Vehicle	Powder Size	Metal Load (%)	Amount per EFD Syringe (gm)
Indalloy 182 (80Au/20Sn)	Indium3.2	5-MC	93	10
Indalloy 182 (80Au/20Sn)	NC-SMQ51SC	5-MC	93	10
Indalloy 182 (80Au/20Sn)	Indium8.9HF	5-MC	93	10
Indalloy 182 (80Au/20Sn)	Indium10.9HF	5-MC	93	10
Indalloy 182 (80Au/20Sn)	WS-446HF	5-MC	93	10
Indalloy 182 (80Au/20Sn)	Flux A	5-MC	93	10
Indalloy 182 (80Au/20Sn)	Flux B	5-MC	93	10
Indalloy 182 (80Au/20Sn)	Flux C	5-MC	93	10



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Each 80Au20Sn solder paste was hand-stenciled onto six Cu coupons in a 3x3 square formation (FIGURE 1). A program was created for automated die placement on the Juki pick-and-place machine, which placed nine Cu dies on each Cu coupon (FIGURE 2). The coupons were then reflowed through a BTU furnace with an optimized profile on the back of a DART board – three coupons in air, and three coupons in a nitrogen atmosphere (FIGURE 3).

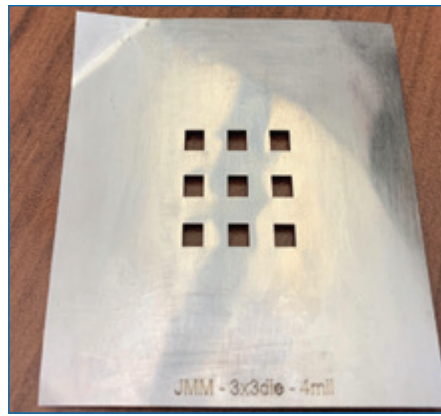


FIGURE 1. The 3x3 square Cu coupon.

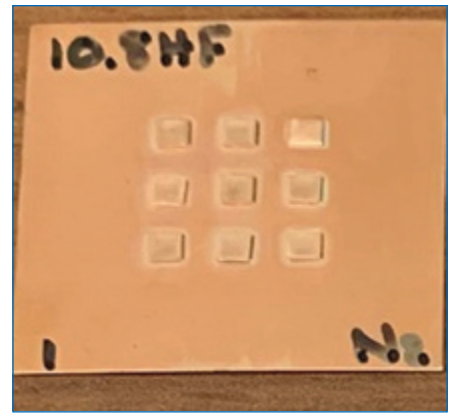


FIGURE 2. Dies were then placed on each coupon.

Each coupon was analyzed for data collection using a Yxlon x-ray camera and a voiding calculator. As the die orientation in the tape-and-reel packaging was not specified, dies were placed on the coupons in both “cup up” and “cup down” positions (FIGURE 4). “Cup down” positions have a tendency to trap voids, potentially skewing the data, so only the dies placed in a “cup up” orientation were used for voiding analysis (FIGURE 5).

Data were interpreted using the one-way ANOVA data analysis and Tukey-Kramer comparisons in air and nitrogen environments (FIGURES 6 and 7).

Reflow performed in a nitrogen atmosphere reduced voiding across all flux vehicles. The flux vehicles with the lowest statistical voiding were WS-446HF and Indium3.2 for air reflow and Indium3.2 and NC-SMQ51SC for nitrogen reflow. Additionally, experimental formulation, 926-



FIGURE 3. Profile of the reflow oven.



FIGURE 4. The “cup up” and “cup down” configurations.

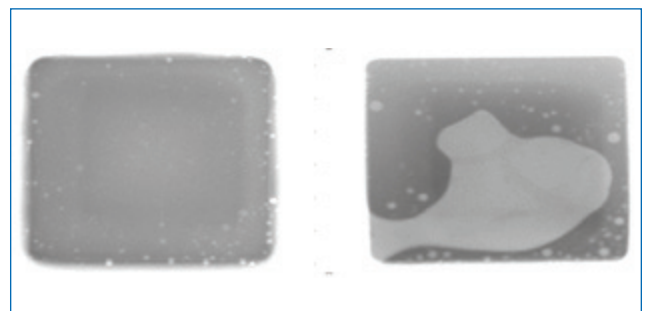


FIGURE 5. Dies placed in a “cup up” orientation were used for voiding analysis.

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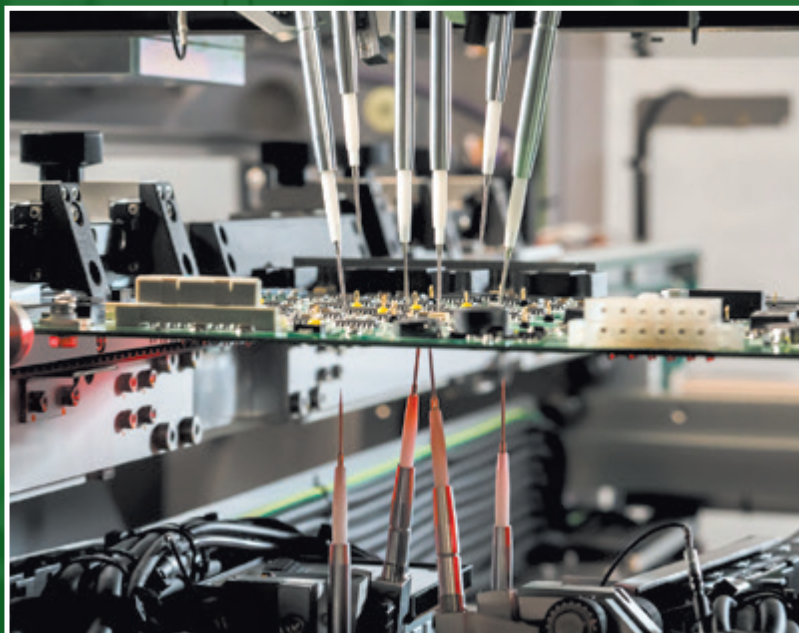
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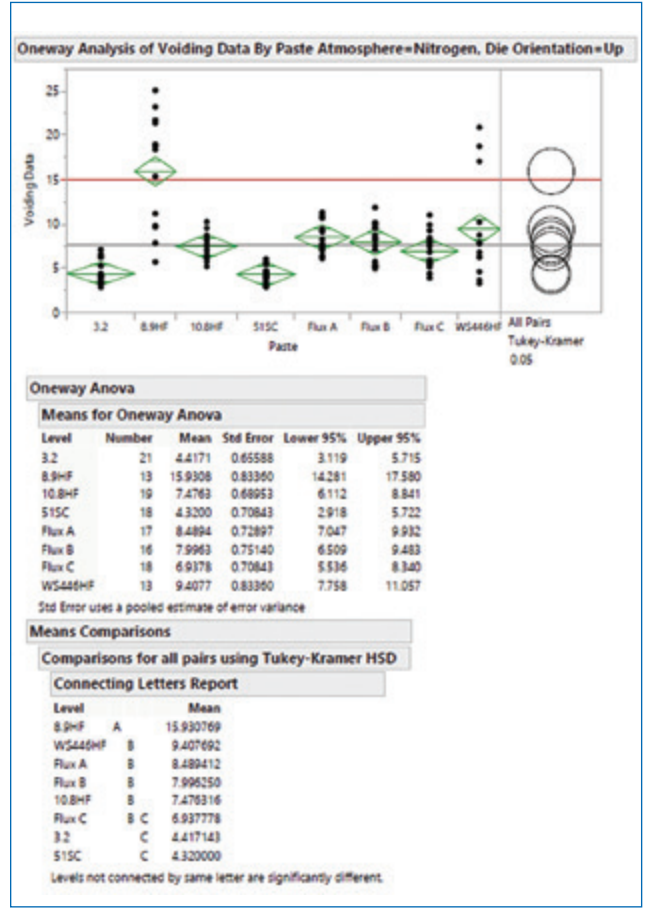
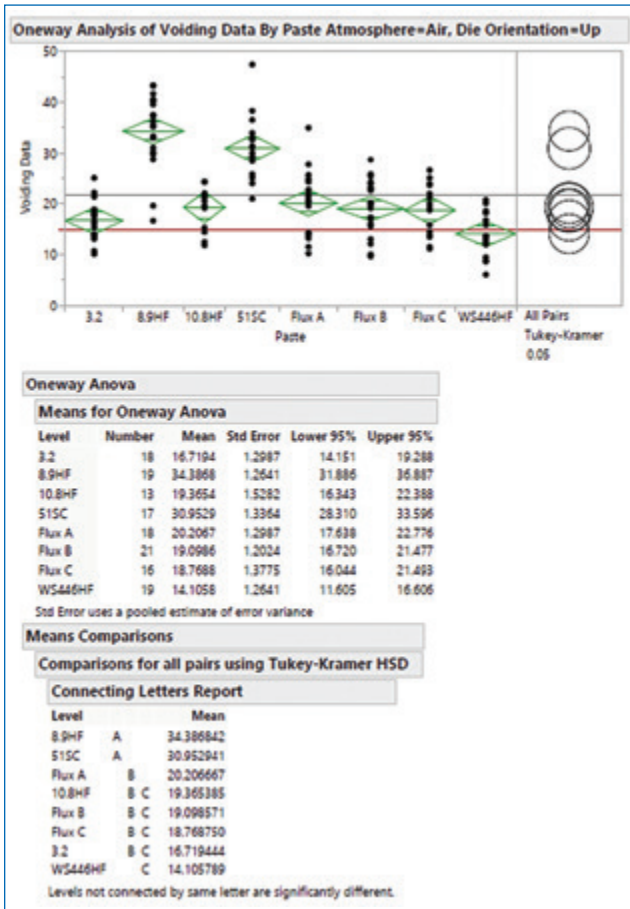


FIGURE 6. One-way ANOVA and Tukey-Kramer data comparisons in air ...

FIGURE 7. ... And in nitrogen.

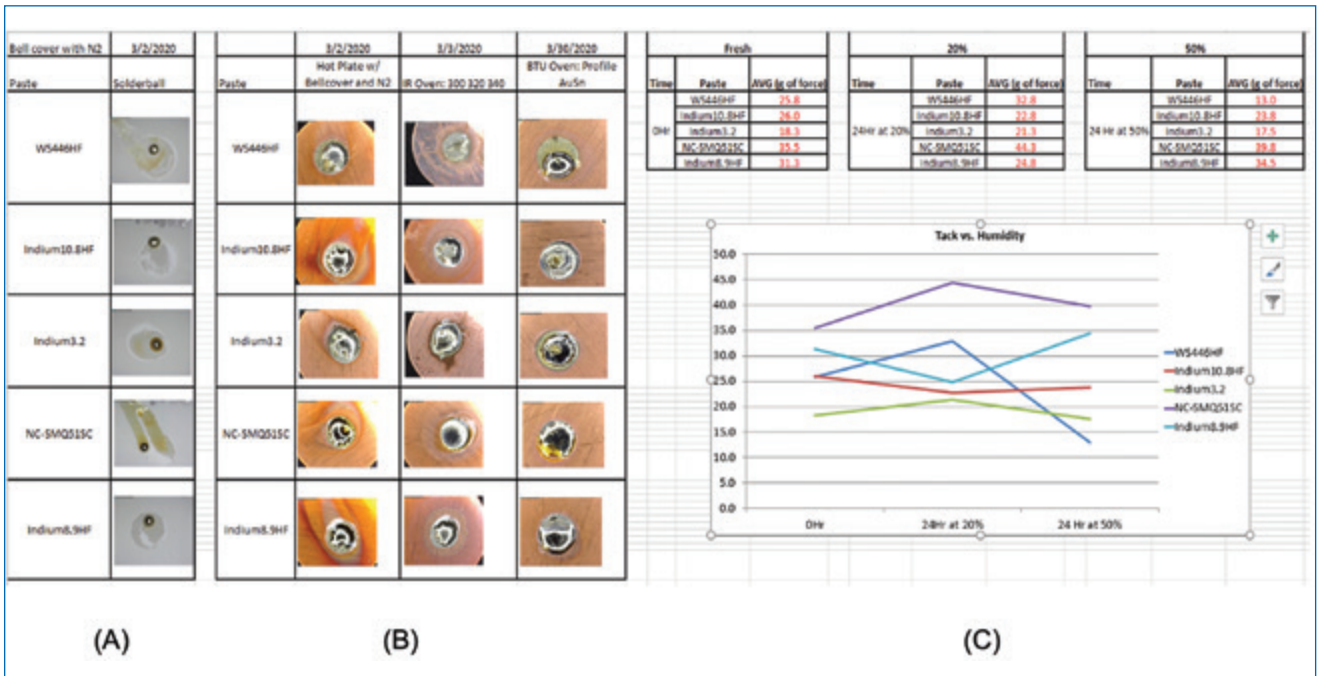
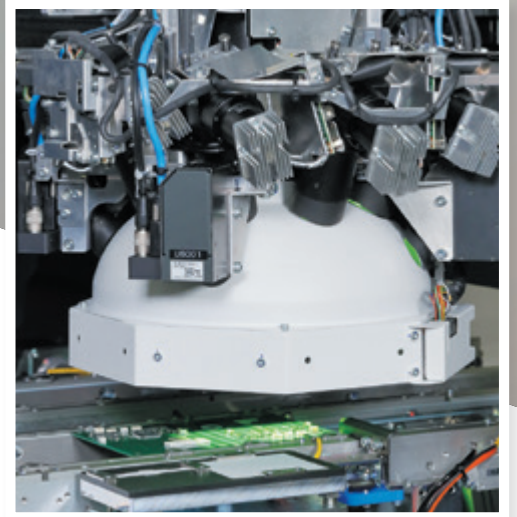


FIGURE 8. Flux vehicle tests for (A) solderball testing, (B) wetting testing, and (C) tack versus humidity.

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9-5, showed promising results when used in a nitrogen atmosphere.

Three additional supporting tests were performed on flux vehicles WS-446HF, Indium 10.8HF, Indium3.2, NC-SMQ51SC, and Indium8.9HF: (A) solderball testing, (B) wetting testing, and (C) tack versus humidity (FIGURE 8).

Solderball testing (A):

- Each solder paste was reflowed on a hot plate with a bell cover, which was set at 325°C; each was then purged under nitrogen.
- Images were taken to compare the coalescence of each solder paste to create a ranking from best to worst.
- NC-SMQ51SC>Indium3.2>Indium8.9HF>Indium10.8HF>WS-446HF

Wetting testing (B):

- Each solder paste was reflowed in different oven conditions under nitrogen for comparison: hot plate with bell cover (left), infrared oven (center), and convection oven (right).
- Images were taken to compare the wetting performance from best to worst.
- NC-SMQ51SC>Indium3.2>Indium10.8HF>WS-446HF>Indium8.9HF

Tack versus humidity (C):

- Each AuSn solder paste was measured for tack. This measured whether the AuSn solder paste held its tackiness from fresh conditions to 24 hrs. in different humidity environments.
- WS-446HF was unstable in a higher humidity environment. Indium8.9HF was unstable in a lower humidity environment. NC-SMQ51SC, Indium3.2, and Indium10.8HF were stable for both humidity environments.

## Conclusion

Flux vehicles NC-SMQ51SC (no-clean) and Indium3.2 (water-soluble) performed best for voiding percentages in a nitrogen environment, while WS446HF (water-soluble) and Indium3.2 (water-soluble) performed best in air. Additionally, NC-SMQ51SC (no-clean) and Indium3.2 (water-soluble) outperformed all others in subsequent solderball, wetting, and humidity versus tack testing.

While almost all flux vehicles tested in a nitrogen environment met market demands for a void-free solder interface of <15%, NC-SMQ51SC and Indium3.2 were determined to be the best 80Au20Sn paste offerings currently available when encompassing all the testing parameters. For the high-temperature/gold market, NC-SMQ51SC and Indium3.2 have the proven performance necessary for specific, but not limited to, use in high-power LED array applications.

While the number of data points used is not ideal to form a concrete statistical conclusion, the trend is promising and leaves open the possibility for further testing. To gain more

supporting data for voiding testing, ensuring all dies are in the “cup up” position prior to placing them on the coupons will achieve a consistent number of data points. Comparison of the initial calculated voiding percentages can be performed using an automated program on a Nordson Dage x-ray to compare to the data acquired from the Yxlon x-ray. Eventually, with the ever-improving science and technology of solder materials, other flux vehicles can be selected to test for compatibility with high-power LED applications allowing for a potential expansion of the current product line. □

**JENNY GALLERY** is a product specialist for the high-temperature business (gold and braze products) and **THUY NGUYEN** is a technical support engineer at Indium Corp. (indium.com); jgallery@indium.com.

*The Route, continued from pg. 6*

AI systems are created to perform tasks and make decisions based on the data and algorithms that are fed into them. While they may be able to perform some tasks more efficiently than humans, they are not capable of independent thought or decision-making in the same way that humans are. Therefore, it is unlikely that AI systems will be able to take control of the world or rule over humans in any meaningful sense.

That being said, AI has the potential to greatly impact and transform many aspects of society and the way we live and work. As such, it is important for individuals, organizations, and governments to carefully consider the potential consequences of using AI and to develop appropriate policies and regulations to ensure that it is used ethically and responsibly.

So there you go. If this is where AI is at, we humans are still safe.

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# Bravo, LACROIX!

Buoyed by acquisitions and a resplendent new flagship manufacturing center, the French EMS is prepping for a sustainable future. **by MIKE BUETOW**

In October 2021, France President Emmanuel Macron unveiled “France 2030,” the nation’s strategy to reinvent several key domestic sectors, including automotive, aerospace and green industry.

On a smaller scale, European-headquartered businesses are adopting measures similar to those in the US, India, Vietnam and elsewhere to ensure a strong domestic manufacturing base. The ability to build products sustainably and at scale undergirds the trend.

Lacroix is a perfect example of one of those businesses. Based in France, with operations worldwide, the conglomerate is perhaps best known for its electronics manufacturing

services, although its history dates to 1945.

And while Europe has a history of supporting its nations economically, even industrial powerhouses like France have not been immune to the call of lower-cost regions.

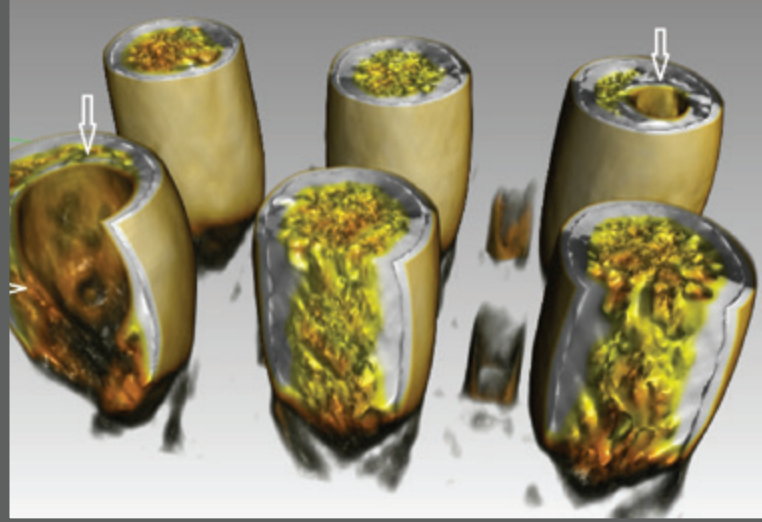
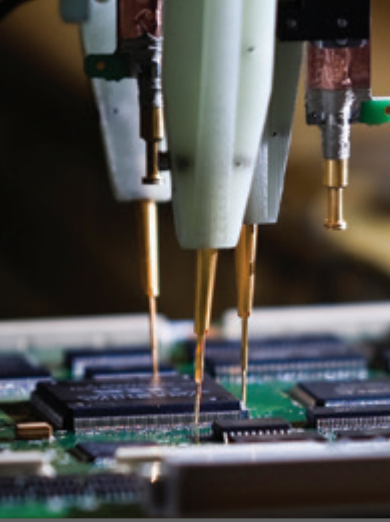
A new chapter is beginning, however, and Lacroix is intent on writing its place in electronics manufacturing history.

Says Stéphane Klajzyngier, president, Lacroix North America: “Our mission is trying to serve technology environmental and societal issues. A lot of what we do, whether it’s our Lacroix products or EMS, you see a strong driving factor to make products that are useful for the planet, robust, secure.”

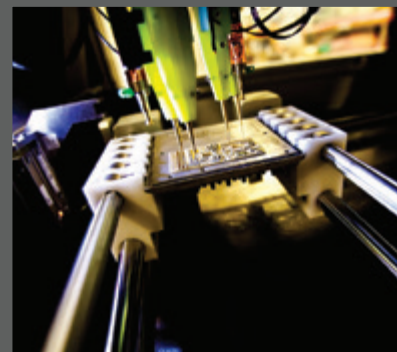
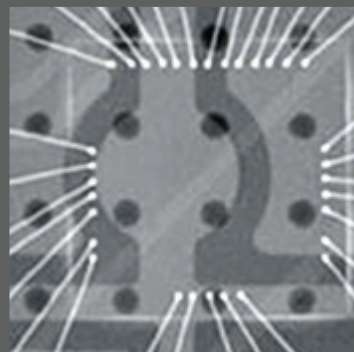
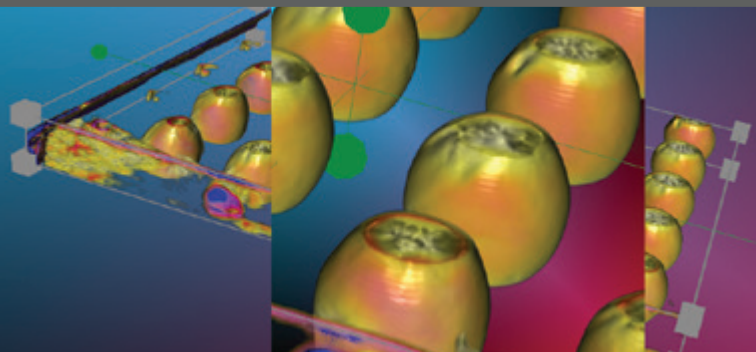
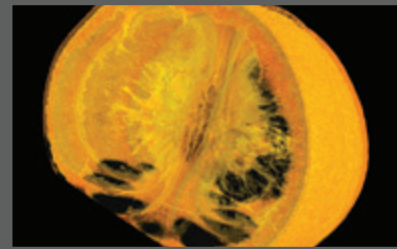
At the core of this movement is Symbiose, Lacroix’s new-



**FIGURE 1.** Exterior view of the Symbiose facility in France. (Photos courtesy of Lacroix.)



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est facility, which opened last year in Beaufreau-en-Mauges, France (FIGURE 1). Eighteen months in the making, the 19,000 sq. m. (205,000 sq. ft.) building replaces the 12,000 sq. m. Saint Pierre Montlimart site. Yet despite the larger footprint, Lacroix has outfitted the factory with state-of-the-art robotics and automation that will allow it to increase its expected revenue by some 70% with the same number of workers (TABLE 1).

The automation and green features of Symbiose are eye-opening, but to understand the future, it helps to look at the past.

### '3 in 1'

Even for an industry with almost as many business models as companies, Lacroix stands apart. Its unusual ownership structure includes the Bedouin family (Vincent, CEO and chairman, and Nicolas, COO and EVP), which owns 62% of the firm. Approximately 34% of the shares are held by the public, with another 3% owned by the company. Employees own 1%. Maxway Technology, the Chinese EMS, is also a minority shareholder of Firstronic, which Lacroix acquired in 2021.

Its businesses are myriad. Electronics is the largest, with about \$519 million in revenue expected in 2022, boosted by the aforementioned Firstronic acquisition (FIGURE 2). But there's also Smart City (\$130 million), which started almost 100 years ago in road signs and now focuses on mobility solutions (equipment and solutions). The unit supplies simple, complete solutions for optimizing and digitalizing cities and regions. Its expertise is based on three pillars: road safety, traffic management, and smart lighting.

And there's the Environment unit, at about \$83 million the smallest of the three businesses, which focuses on network efficiency for utilities infrastructure (smart grids, dataloggers, etc.), such as heating, ventilation, and air conditioning (HVAC); and remote monitoring and managing of water and energy infrastructures.

Regarding the Smart City and Environment products, Lacroix Electronics builds everything except various older legacy part numbers. They share six connected and complementary manufacturing plants with a common design center, named Impulse.

Today, Lacroix has 5,300 employees and expects to finish fiscal 2022 with revenues of about €700 million (\$742 mil-

lion), with Europe, Middle East and Asia making up 80% of the overall revenue and North America the remainder.

Growth has topped double-digit the past 10 years. The deal to acquire a majority stake in Firstronic fueled the recent surge, of course, but organic sales were up more than 11% year-over-year through the first three quarters last year, suggesting strong underlying markets.

Lacroix also grew 13.7% organically in 2021, although the addition of Firstronic added \$140 million in revenues and EBITDA above 9% to the picture.

EMS sites are located in Beaufreau-en-Mauges; Zriba, Tunisia; Kwidzyn, Poland; and Willich, Germany; with the Firstronic deal adding locations in Grand Rapids, MI, and Juarez, Mexico. The Impulse design center resides in Cesson-Sevigne,

France; and the international purchasing office is located at Maxway Technology in Shenzhen.

Key markets for electronics include automotive (lighting, power train, interior, battery management systems actuators, which is primarily built in the US, Poland and Tunisia); smart homes and buildings (Tunisia, France, Poland); industrial, including test and measurement, process control, energy (all plants); civil avionics and defense, including in-cabin and instrumentation (France and Germany); and healthcare, primarily diagnosis and monitoring (Symbiose).

Lacroix has 45 SMT lines worldwide. Some common systems are maintained across all

geographies, including inspection, although placement varies. Regional maintenance support is a major factor, as vendors' support infrastructure varies by geography.

The design center is a specific advantage, featuring close to 100 electronics design engineers, split evenly between hardware and software. Most are sited about an hour north of the French plant in Cesson-Sevigné, near Rennes. Functions include mechatronics, cloud connectivity, mobile apps, energy-related developments, IoT, AI (boosted by an acquisition which doubled the size of the design center), cybersecurity ("because we do our own products which are for vital infrastructure"), power management, and PCB layout. Having embedded systems design in-house helps Lacroix "stay close" to semiconductor OEMs.

NPI is performed at the plant level, and Lacroix's electronics assembly team gets involved at the product definition level

TABLE 1. Plant Comparison

	St. Pierre Montlimart	Symbiose
Mfg. plant (sq. m.)	5,250	10,500
Employees	450	450
Revenue (euros)	70M	120M

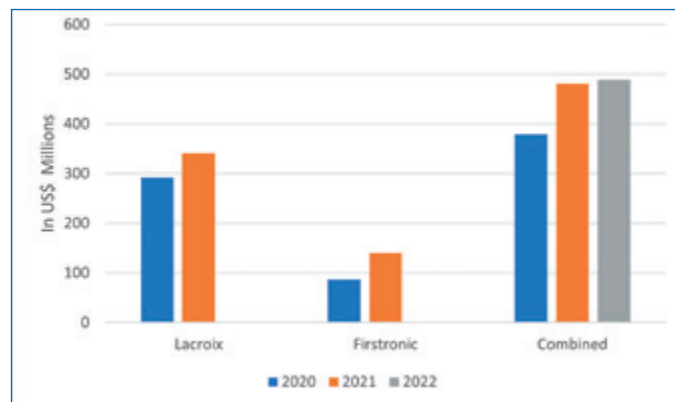


FIGURE 2. The Firstronic acquisition was immediately accretive to revenues and EBITDA.

for internal products.

DfX is largely done at the plant level, says Klajzyngier. Valor is used in EMEA, but the design rules need to be aligned with those in the North American plants, a process that should be completed in 2023.

The plants have their specialties. Defense builds are performed in France because of the custom design and proximity to the customer. High-volume automotive with simple assemblies typically go to Poland, although some programs are being introduced in France. Box build is performed in France, and about 80% of product is box build.

## Common DNA

Management glowingly describes the Firstronic integration. “We had been in a relationship for five years,” explained Klajzyngier. “If there is one philosophy, a good acquisition is when you have 70%

of common DNA. Below 50% is oil and water. At 100%, you learn nothing; you just gain market share. Here, we have much in common but much to bring to one another. The sales [commercial] approach for Firstronic and North America has proved very successful. Lacroix, being larger, has some technologies and processes that can be shared, a bigger spend which is good for getting purchasing synergies and market segments

that are not being addressed. Many customers on both sides of Atlantic are already customers on both sides or engaged to quote both US and European needs.”

One of the plusses has been the retention of the Firstronic management team, including John Sammut, who remains chief executive of Firstronic, and Jochen Lipp, who is chief operating officer. Both retained financial stakes in the company post-acquisition.

In 2017, Sammut told us bench strength is a key to building a culture of success. Klajzyngier agrees. “In general, our strategy is to build as much depth as possible in the management team. Ultimately, our success is all about our people. Our key employees effectively *are* the company, so we’re continually looking for ways to recruit, retain and incentivize the best employees we can find in every function of the company.”

Even without the acquisition, Lacroix has been preparing for growth. Its suppliers and customers spent months working with the EMS firm on the development of Symbiose. Klajz-

yingier says the symbiotic partnerships inspired the name of the campus. (Given this, it should come as no surprise Lacroix’s customers voted it the **CIRCUITS ASSEMBLY** Service Excellence Award winner for companies with revenues of \$500 million or more.)

## The Digital Plant

From the outset, Symbiose focused on industrial innovation: automation, digitization, Lean manufacturing and Kanban. And every process was looked at in terms of its sustainability. As such, the new site has reduced CO<sub>2</sub> emissions – its emissions are 2.5 times less per square meter than the Saint Pierre plant. A rainwater recovery system captures water; and light power consumption has been reduced by 55%. The solar roof has 10,000 sq. m. of photovoltaic panels that produce one-third of its electricity needs. Outside are nature’s gardeners:

sheep for eco-grazing and bees for biodiversity.

Indeed, it seems Lacroix is not only positioning itself to build the technologies needed for the type of environment it anticipates its own employees and customers will eventually live in, but is trying to help conceive and design those very same environments.

A planned community looms nearby, including housing and adjacent commercial enterprises. While conceived pre-pandemic, according

to Claude Bourget, director of the Beaupréau plant, “The Covid health crisis demonstrated the need within France to encourage domestic manufacturing. The Mauges Communauté near our facility values the concept of a living environment where workers have good quality of life and short commutes between home and the factory. We see our activities as interconnected. Forging close links between rural areas and high technology, as exemplified by the Symbiose project, promotes the relocation of French industry and expansion of employment opportunities for workers living in those communities. Within the factory we also have a goal of social innovation in workspace design, availability of natural light and access to green space, to provide our workers with good workplace quality of life.”

This philosophy extends to the very product being built. “The sense that we need to ‘save the planet’ is very high in Europe,” says Klajzyngier. “If a product is not exactly addressing that, we wouldn’t necessarily [not build it]. But if it’s bad



**FIGURE 3.** Automated guided vehicles (AGVs) automate the material picking function as part of the Symbiose Exotec stockroom system.

for the environment, we would walk away.”

Symbiose features five SMT lines, the number of which could be more than doubled as needed. All are set up in the classic straight-line flow, including the dedicated prototype line.



**FIGURE 4.** An operator finalizes a kit pulled by an AGV in the Exotec automated stockroom.



**FIGURE 5.** AGVs transport material to workstations in the Symbiose facility.



**FIGURE 6.** A production operator completes setup on one of the Symbiose SMT lines.

Towering over the lines resides the Exotec Skypod inventor storage system (**FIGURE 3**). Two stories high, the €2.5 million investment (some of which was paid by the state) was installed last February. Once data are transferred to the picking list, seven robots pick from the thousands of boxes. The robot-managed FIFO inventory has resulted in a 33% productivity improvement and eliminates 40% of wasted non-value-added activity time, Bourget said. At this time, the system feeds components for box-builds.

Located just feet from the SMT lines are the inventory stores. A pair of Totech dry cabinets house up to 35,000 SMT reels, each is bar-coded and managed as a unique product. Parts are transferred via AGVs to and from the warehouse and SMT lines (**FIGURE 5**). A VCcount inline system checks quantities, and software syncs component storage, prep and delivery to lines. (“Automation allowed us to reduce the warehouse size,” Bourget says.) Moisture-sensitive parts are managed automatically. The €2 million capital investment is paying off with a 60% productivity gain.

On the lines are DEK Horizon printers supporting Euro-placer and ASM placement machines (**FIGURE 6**). The dedicated low-speed line for prototypes can place 15,000cph, as can a low-speed line for high-mix, low-volume (HMLV) products. Lacroix can perform up to 15 changeovers per day on the low-speed lines.

They are buttressed by a pair of 40,000cph SMT lines for medium-mix, medium-volume products, and one high-speed line (100,000+cph) for high-volume work. Demand for the latter is expected to grow, Bourget said.

Inspection plays a big role. 3-D SPI and Parmi Xceed 3-D AOI are in use, and QA resides at the end of each line to validate quality and perform touchup. An offline Nordson Dage x-ray sits nearby for BGA inspection.

Other standalone machines include a Panasonic NPM manual inserter for through-hole component placement (mostly radial and axial parts, but also coils, connectors and exotic through-hole components). This machine, Bourget says, permits Lacroix to build boards locally that otherwise would go to Tunisia.



**FIGURE 7.** Flexible work cells provide an easily adjustable, ergonomic work environment for higher-level assembly in the Symbiose facility.



**FIGURE 8.** Repetitive tasks such as test load/unload are automated at Symbiose and other facilities.

Ersa Versaflow is used for selective soldering and a Nordson Asymtek conformal coater is also on the floor.

A robotic tester opens fixtures and places boards for in-circuit test (FIGURE 8). Finally, an MSTech Laser marker etches codes on PCB panels for tracking.

Shop floor machines are cloud-connected. Some data are stored in the cloud, some are local to the plants. “We are extremely serious about being secure about data and where they are stored,” says Klajzyngier.

The site is currently running three shifts.

The omnipresent AGVs were the result of an intense and collaborative review. “We are part of the WeNetwork cluster,” said Klajzyngier, in which a group of four competitors cooperated to test AGVs. “We had multiple EMS testing different brands. We made a collective choice. It was a way to duplicate testing.” (The Panasonic NPM placement machine in use was also studied in WeNetwork collaborative tests.)

## AR Gets Real

Another example of advanced technology is something Lacroix calls the “augmented operator.”

Explains Klajzyngier: “It’s a project right now. We have a rough AO in Germany that assists with a laser-pointing device for manual insertion. We propose the exact component the operator needs to place. The project in France is one level about that, where you enter all the manufacturing descriptions at that time and it will propose and follow the board if it’s not exactly placed with augmented reality to tell the operator what needs to be done in terms of manual insertion. Another application is to use camera recognition for complex parts, to check all mechanical dimensions: Instead of doing it manually, we use a cobot with a camera.”

The AR tools are said to have user-friendly human/machine interfaces that allow an operator to be up and running with a maximum of four hours of training.

Lacroix is also investing in simulation tools like Advanced Planning and Scheduling. It is deployed now in France, where APS is used to analyze forecasts and run scenarios.

“One module inside is IBP [an SAP solution for Advanced

Planning and Scheduling],” Bourget said. An AI tool that analyzes forecasts and helps with planning, IBP answers ‘what-if’ scenarios. “Like, if my customer needs 20% more, can I do it? Normally this is done through ERP, which is cumbersome.

“Before, we had to simulate as if it were a real demand, [then] had to cancel everything. [IBP] works like a digital twin of the plant to do simulations.”

All customers are managed digitally. It starts with an advanced ERP (SAP HANA) and includes the aforementioned IBP. That launches through electronic data interchange (EDI) to send orders to suppliers. Optical character recognition reads and pays invoices, and also reads incoming goods.

In yet another instance of competitor collaboration, Lacroix uses the “Agatha” component price comparison tool, which is connected to its network of distributors. Agatha traces component pricing and availability and places the order if the best conditions are met. Two or three French EMS helped build this tool by Precogs, including Lacroix.

Says Bourget: “There’s a driving force to have a fully digitized end-to-end solution.”

Asked if Lacroix has performed any pre- and post-Agatha comparisons to determine the time savings for developing bill of material costs, Bourget demurs: “The savings are significant. But we cannot disclose the numbers.”

Lacroix has studied vendor-managed inventory but opted to do it themselves. “We have made comparisons and it was usually US plants that would have a vendor working in the warehouse to do advanced preparation,” explains Bourget. “There is a gap between how they work in the US and same size level of consumption.... We are not in the habit [of doing that in Europe].”

We have seen more highly automated plants, although not necessarily with this type of high-mix product flow. And we have seen plants that are highly green-centric. But Lacroix Symbiose is the first to mesh the two at such a high level.

Asked about other examples of sustainability, such as reducing waste streams, that are ongoing or planned at Symbiose, Bourget answered, “We are working closely with our customer’s project teams to improve packaging by reducing material waste, favoring recyclable materials, and proposing the use of reusable packaging with the organization of a packaging recovery loop between our clients and the factory.”

Klajzyngier sums up the transformation this way: “It is radically different today from 10 years ago. It was siloed. Now we are all working together to address common goals. What’s driving us is trying to, when we respond with RFQs, are we addressing products that are good for the planet? Because at the end, that’s the identity of the Group.”

Congratulations to Lacroix, the CIRCUITS ASSEMBLY EMS Company of the Year for 2022. □

*Ed.:* All photos are courtesy of Lacroix.

MIKE BUETOW is president of PCEA; mike@pcea.net.

# Teaming with Customers in Continuous Improvement

Deep dives on defect resolution, one at a time.

**MOST MEDIUM-TO-HIGH** volume electronics manufacturing services (EMS) providers design their new product introduction (NPI) process to identify issues in printed circuit board (PCB) layout, overall product design or process flow that create defect opportunities. Unfortunately, a key challenge in the EMS industry is convincing customers to adopt those recommendations. Additionally, some design or process issues escape NPI or pilot production, not becoming evident until a product is running at full volume. SigmaTron International's team in its Acuña, Mexico, facility is working to change those dynamics one customer at a time.

The NPI process does include design for manufacturability (DfM) recommendations. The pilot run of 10 to 30 pieces is reviewed by the facility's engineering team to determine any issues. When issues are identified, they are communicated to the customer in a document that includes photos along with recommendations on how best to improve the process. Not all customers respond to these recommendations, however.

This year, the team began adding an enhanced communication process on a customer-by-customer basis to better make the case for adopting design recommendations. They started with the most complex product, and plan to focus on all products where this type of approach may be beneficial. The process is based on Deming's Plan-Do-Check-Act (PDCA) cycle of improvement. Within the cycle, defects are identified, potential root causes are analyzed until the correct root cause becomes apparent, a corrective action is implemented, and then the results are validated to ensure the corrective action solved the problem.

The team starts with a weekly analysis of in-process defects on a specific program, focusing on the most important issues. Within the facility's quality data collection process, every defect is recorded on the line, by station, by model number and with all routing data. Typically, there are not more than five issues per product. The team does a full analysis of the highest defect and lists possible causes. The root causes are evaluated with core tools that may include Pareto charts, fishbone diagrams, design of experiments (DoEs) or Gage R&R studies of equipment. Once the root cause is identified and validated, corrective actions are implemented, and their results are assessed for effectivity. The next week, the next highest defect is analyzed. While a slow process, this deep-dive approach enables the team to eliminate the root causes of the bulk of a project's defects systematically.

Typically defects fall into two categories: design or process issues. Resolving process issues is considered the facility's responsibility and the team analyzes and rapidly implements corrective actions. Design issues are presented to the customer with corrective action recommendations. At this point, the quality, cost and delivery impact implications of the changes are now more evident to the customer. That said, even when the customer agrees, implementing recommended design changes can take time if raw material inventory must be consumed before the change is cut in.

One positive result of the communication channel opened by this approach has been customer adoption of the facility's design rules related to equipment constraints for new products.

The engineering team is also looking at return material authorization (RMA) activity on one program. The team has weekly or biweekly meetings to share their analysis and findings with the customer's team. In some cases, there is no fault found when an RMA is tested. In other cases, the fault is related to damage at the customer's facility or the EMS provider's facility. When damage occurs in Acuña, the root cause is identified and corrective actions implemented. When damage occurs in the customer's facility, the engineering team discusses options for preventing reoccurrence with the customer's team. Typically, the cycle time from receipt of RMA parts to shipment of repaired parts is two to three weeks.

This approach to enhancing quality-related customer communication helps customers better understand the benefits of addressing design issues in product development or during NPI. It builds trust and creates a problem-solving culture within both teams as issues develop, which is particularly beneficial when the root cause may be related to something only the customer has the power to change. While doing a deep dive on only one issue per week may seem slow, given the finite number of issues, this approach will eventually lead to significantly improved quality. □

**JORGE PENA** is director of quality control at SigmaTron International (sigmatronintl.com) in Acuña, Mexico; jorge.pena@sigmatronintl.com.



# The PCB Industry Matrix

A one-size-fits-all approach leaves no room for life's uncertainties.

## CERTAINTY HAS ITS devotees.

It is a truth universally acknowledged that some prefer deference to authority, as opposed to independently determining a course of action, making responsible decisions on their own and accepting the consequences. It's so much easier when others call the shots; all one must do is acquire marching orders and execute accordingly. No muss, no fuss. One sleeps through the night unburdened by what-ifs. The shot-callers are the only ones who are sleep-deprived.

"In order for you to recertify in 2023 as our valued supplier-partner, you must complete the attached RFQ, which requests a firm, fixed-price estimate for the following services: flying probe testing; in-circuit testing; boundary scan/JTAG testing; cross-section services; CT scanning services; x-ray inspection and failure analysis services; dye-and-pry services; and reports for all the aforementioned. You will find quantities on the x-axis, with services above listed on the y-axis. Please insert pricing in US dollars in the intersecting cells. Pricing will be valid through December 31, 2023, inclusive, and will be the unchanging basis for awarding all purchase orders for those services throughout 2023. There will be no exceptions, and no revisions allowed, during the applicable period."

Except: How do you distinguish between the single-board job and the multi-board job? How do you separate the 300-net test from the 5000-net test? What if Engineer A wants this job in 10 working days, while Engineer B needs that job overnight? What happens to cost – and lead times – when a project receives an 11th hour ECO, two days before scheduled shipment? Last year, one failure analysis job for this customer cost \$2,500. A second cost \$135,000.

How does a pricing matrix capture that much variability? What happens if (crazy, improbable hypothesis, admittedly) a pandemic-induced supply chain delay of key components erases assembly cycle time, leaving a fraction of the quoted lead time for test development and actual testing, over a holiday weekend, when extra time must be paid according to state law? How does one add a Jerk Factor, adding ease/unease of doing business to the calculation?

In real life there are many deviations from script.

Yet people persist in attempting to encapsulate a year's worth of human inexactitude in one simple spreadsheet for easy, formulaic price selection.

Management craves certainty. Damn them.

Budgets must be written.

Bonuses, and promotions, are rewarded for promoting stability. It's human nature.

Never mind the built-in instability of 9 to 11% inflation.

This is small cog thinking. Small cogs in big commercial enterprises feed the demands of very big flywheels. Flywheels with pensions.

So much for commercial certainty. A second cohort desiring similar outcomes works for the government, or government-directed programs. That means rules to be followed. No questions asked. Many clipboards, literal and online. Boxes checked. DocuSign NDAs. Two-factor authentication. Third-party administration. Certifications and authentications. EFT details. All to simplify paperwork. And negate the tiresome need to send out each project for quoting. Because. Leaving more time for, well, sending out new matrix RFQs. In quintuplicate. Thus, the flywheel turns.

If someone wants to step up and be authoritative and declare unequivocally, "This is the way things are going to be," then there will always be a raft of followers predisposed to follow orders. For them, following is the thing. The same Universal Truth applies in government-directed activity. Passivity enables regular taxpayer-funded work hours.

"Wouldn't it be so much simpler if you could produce a one-time chart listing ICT fixture and program prices, with net counts on the x-axis, and estimated engineering time on the y-axis, and expedite factors on the z-axis? Then we wouldn't have to bother you once a month for pricing, and our management would have their budget for the year, using your chart as their foundation (stretching our imaginations for a moment to envision bureaucrats brainstorming in 3D)?"

Management loves charts. Damn them again.

Yes, it would be simpler and somehow comforting. So would a single tax rate. As would world peace.

Consider this:

"We understand you offer flying probe test services. What do such services cost?"

*Lots of money. If you have to ask, you can't afford them.*

"Seriously, what does this service cost?"

*Seriously, to answer your question with any degree of precision, you need to tell me about the parameters of your board. Otherwise, the only answer I can give you is at best an educated guess based on averages and probabilities and hourly rates, which are subject to much change, by countless factors. Inevitably, such vagueness ignites suspicion and launches misunderstandings. Or, to paraphrase Shakespeare, I'll dispense with a whole lot of sound and fury, signifying nothing. But the plumb I dispense will make your manage-*

## Robert Boguski

is president of Datest Corp. (datest.com); rboguski@datest.com. His column runs bimonthly.





ment happy, filling a box. Knock yourself out.

“Are you competitive?”

Define “competitive.”

Being the lowest cost among three identical competing services.

*Nope. And proudly so: in this business, it is a documented fact that you get exactly what you pay for. Sometimes good, hard, and well-deserved. If low price is your sole or primary criterion for awarding business, then this will be a brief conversation. We wish you luck identifying two competing services doing exactly what we do, with technical specificity, at the low price you wish to pay. You’ll need it.*

Let market forces teach them. We’re busy. Our time is worth money.

Or this:

An EMS company is informally known in the business as “The Children’s Crusade,” given its penchant for hiring eager college graduates to staff its lower procurement and program management ranks. Those hired possess an abundance of ambitious energy; a consequent willingness to work short, intense bursts of extraordinary hours; and an almost breathtaking lack of technical knowledge of the items they are purchasing, managing, or otherwise administering. A million-dollar test system thus becomes another eight-digit line item on a spreadsheet, below a one-cent nylon washer and above a ceramic capacitor. Click here and in it goes to the shopping cart, squeezed next to the Boeing 777. Discounts for all are available in volume to qualified buyers.

To make matters more interesting, The Children’s Crusade rarely assigns its children’s names to emails, relying instead on disembodied job functions or department responsibilities. Therefore, an email from “Operations” could have its origin in five different sources, each of them anonymous. Purchasing instructions, and technical statements of work (SoWs) are of the cut-and-paste variety. This EMS company thinks this arrangement is a good thing, permitting homogenization of job functions, authority, and low-level responsibility. They also think they are really smart in effectively setting up clerks with college degrees.

Accordingly, the RFQ from them reads like this:

“Please provide a quote for in-circuit test development and testing, using the (incomplete) files provided on our FTP site (login credentials and file password provided in separate email). Please quote fixture and program prices separately. Also please quote a third line item, individual test costs. We wish to reserve the option of having the fixture and program installed on our machine, at our facility, or having our designated supplier retain the fixture and program at their facility with responsibility for ongoing testing, as needed.”

The RFQ continues:

“For test pricing, please quote the following quantities: 1, 230, 253, 688, 759, 2750, 3035.”

These quantities were not made up. They were taken from an actual RFQ. Passed down faithfully, no doubt, from an OEM RFQ.

And finally:

“Please acknowledge receipt of this RFQ and submit your company’s best pricing within 24 hours of its receipt.”

Children say the darndest things.

To which we as adults respond:

*Dear Operations (we strive always to make relations warm and personal), your Request for Quotation is received and acknowledged. Once all data are received, it will take roughly 3 to 5 working days to provide an in-circuit test development quote. Twenty-four-hour turnaround is not possible because many files are missing; first and foremost, usable CAD. The file labeled CAD you provided is missing component placements and, therefore, useless for program quoting purposes. Once a complete set of working files to the correct revision is received, then the quote countdown will start.*

*Pricing will consist of three elements: Program (fully debugged), fixture, and unit test cost. Additional engineering and support will be billed at an hourly rate. You will have the option of having the fixture and program installed at your site (installation charge separate, at*

*engineering rates), on a configuration-compatible machine to ours; or have the setup remain at our facility for future testing (no installation charge necessary).*

*With respect to test pricing, we will quote a unit price that is applicable for all quantities. Pricing for one is the same as pricing for 688, or for 3035 for that matter. Test time remains the same, regardless of quantity being tested; therefore, there are no economies-of-scale accruing from larger quantities, and unit time associated with larger quantities may actually be longer in duration given excessive failure rates and their associated troubleshooting time.*

We could use this RFQ as a proving ground to test a long-held fantasy of ours: tilt the tester to a 45° angle and see if it runs faster downhill, thus allowing us to pass the savings gravity confers. Who knows, inclined testing could hatch a breakthrough, producing additional savings when one leaps from batches passing that critical inflection point between quantities 230 and 253. From the mouths of babes might emerge wisdom after all. The quest for certainty renews itself with each generation.

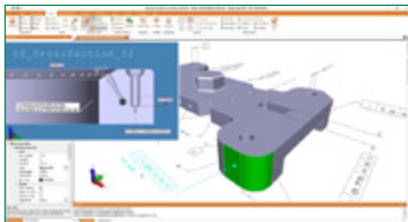
Then we wake up. □

## "TILT THE TESTER TO A 45° ANGLE AND SEE IF IT RUNS FASTER DOWNHILL."

## AVISHTECH GAUSS SUSTAINABILITY TOOL

Gauss Sustainability software assesses design-specific CO<sub>2</sub>-equivalent emissions for printed circuit board designs. Assessment includes the full set of raw materials as well as all process steps and yield losses. Enables lifecycle analysis and lifecycle impact analysis to comply with standards like Greenhouse Gas Protocol, ISO 14404, ISO 14064 (-1 and -2), and ISO 14067, and carbon emissions reduction initiatives. Analysis includes full impact of stackup and BoM, impact of different energy grid choices for each constituent of the stackup and panel size and panelization scrap. Available as a standalone or an add-on to Gauss Stack.

**Avishtech**  
avishtech.com



## KISTERS 3DVIEWSTATION

3DViewStation supports Model Based Definition (MBD) processes – which means that all production-relevant product information is stored in the digital 3-D model right from the start. Supports use of annotated 3-D CAD models and visualizes annotations on the source file quickly and easily. Also supports the reading of PMI (Product Manufacturing Information) from numerous sources such as Catia, Creo, NX, JT, STEP as well as 2 D PDFs with attached JT. Users can create their own 3D annotations or markups and save them again in 3DVS, JT, STEP (AP242), 3D-PDF, 2D-PDF. Different revision levels can be easily compared. Own markups such as lines, texts or position number graphics can be added and saved again as PMI in Kisters' own format 3DVS or neutral formats such as STEP or JT. All capabilities of 3DViewStation can be used either independently or in conjunction with a leading system. Comes in desktop, VR-Edition and HTML5 WebViewer versions plus the online collaboration tool VisShare. All product flavors are intended to be used

together with a PLM, ERP or other management system product configuration or service and spare part applications, providing all necessary APIs. HTML5-based WebViewer solution available for cloud, portal and web solutions, which does not require client installation. All file formats can be used in combination with the intelligent navigation and hyper-linking features to address the needs of complex integration scenarios.

**Kisters AG**  
kisters.de/en

## MECHNANO FORMULA1 ADDITIVE MANUFACTURING RESIN

Formula1 additive manufacturing resin leverages carbon nanotubes (CNTs) to deliver isotropic static dissipative properties to 3-D-printed parts without compromising mechanical performance and with zero concern for z-axis breakdown or carbon sloughing. Uses MechT to detangle and separate CNTs and disperse them into a Masterbatch to be used for increasing performance in additive manufacturing materials. Resulting discrete tubes can be tailored to specific mechanical property performance requirements and deliver previously unattainable enhancements such as 50% increase in tensile strength, 200% increase in toughness, or 850% increase in tear resistance. Provides improved mechanical properties and ensures homogeneous electrical properties. Achieves 100% ESD coverage with precise ESD values.

**Mechnano**  
mechnano.com



## PASTERNAK FIELD-REPLACEABLE CONNECTORS

Field-replaceable connectors feature frequency coverage to 65GHz, plus SMA, 2.92mm, 2.4mm and 1.85mm connector options with many pin types, including glass bead feed-through or a tab contact, or a pin in a dielectric. Assist in easily replacing damaged connectors without

accessing sealed components, and EMI gaskets provide shielding against RF interference. Contacts mate with five-pin diameters ranging from 0.009" to 0.036". Two-hole and four-hole flange types make for easy assembly in hard-to-reach areas where flexibility is required.

**Pasternack**  
pasternack.com

## ROHM CSL1901 LEDs

CSL1901 series of 0603-size (0.6in x 0.3in)/1608-size (1.6mm x 0.8mm) LEDs are optimized for low-light applications for use in indicators and numeric displays in factory automation equipment (i.e., PLCs) and communication control equipment such as modems and routers. Reduces brightness variations by half and color sifting by 3nm under low-light conditions. Available in a lineup of five colors in 0603 size.

**Rohm Semiconductor**  
rohm.com

## VISHAY MOSFET AND DIODE POWER MODULES

Mosfet and diode power modules are designed specifically for on-board charger applications. Offer all circuit configurations required for AC/DC, DC/DC, and DC/AC conversion in on-board charging applications – input/output bridges, full-bridge inverters, and power factor correction (PFC) – across a wide range of power ratings. Compliant with AQG-324 automotive guideline and can be combined to provide a complete solution for electric and hybrid vehicles, in addition to e-scooters, agricultural equipment, railways, and more. EMIPAK package can accommodate a range of custom circuit configurations in the same 63mm x 34mm x 12mm footprint, enabling higher-power density than discrete solutions while providing flexibility to use each module in different power stages for industrial and renewable energy applications, including welding, plasma cutting, UPS, solar inverters, and wind turbines. Exposed Al<sub>2</sub>O<sub>3</sub> direct-bonded copper (DBC) substrate provides improved thermal performance, while optimized layout helps to minimize stray inductance for EMI performance. PressFit pin locking technology permits easy PCB mounting and reduces mechanical stress on the substrate, while baseless structure

increases reliability by reducing number of solder interfaces.

Vishay  
vishay.com



### AVEN OPTIVUE LED MAGNIFICATION LAMP

OptiVue LED Magnification Desk Lamp fits on a desk while being powerful and efficient in handling assembly, workshop or inspection applications. Features flexible 11" gooseneck arm; 4", 5-diopter (2.25x magnification) round glass lens; 36 ultra-bright SMD LEDs; and weighted base for added stability. Includes removable fixing ring for easy lens replacement.

Aven  
aventools.com



### AVEN PROVUE SOLAS MAGNIFYING LAMP

ProVue Solas allows users to switch between two interchangeable magnifying lenses for maximum flexibility. XL58 model includes 8-diopter lens (3x magnification), or optional 5-diopter lens (2.25x magnification, sold separately). Features 60 ultra-bright SMD LEDs with brightness controls, a fully enclosed spring-balanced arm and protective lens cover. Each model is compatible with two lenses to help optimize for the right applications, and includes a heavy-duty mounting clamp that securely mounts to the side of workbenches.

Aven  
aventools.com



### FUJIPOLY CF210A THERMAL GAP FILLER

CF210A thermal gap filler incorporates carbon fibers along with traditional fillers. Carbon fibers permit higher thermal conductivity while remaining compliant. Compliance is closer to a much lower conductivity gap filler such as SARCON PG25A. Has a stable thermal resistance, regardless of compression. Offered in thicknesses from 1.5mm to 2.5mm in 0.5mm increments and is available in sheets 130mm x 130mm (suggested usable is 120mm x 120mm).

Fujipoly America  
fujipoly.com



### HENKEL LOCTITE ABLESTIK ATB 125GR DIE ATTACH FILM

Loctite Ablestik ATB 125GR is a high-reliability nonconductive die attach film suitable for wirebond laminate and lead frame packages, compatible with small- to medium-sized die, and formulated to provide excellent workability and processability. Offers controlled thickness and flow, no resin bleed, consistent fillet formation and bond line stability before and after cure, as well as high-reliability, Automotive Grade 0 performance for both laminate and lead frame designs, making it a good candidate for applications across consumer, automotive and industrial. Features low modulus and low coefficient of thermal expansion (CTE) properties at room temperature, with a high modulus at wire bonding temperature to ensure high-reliability performance. Is said to demonstrate strong adhesion on Ag, Cu and PPF metal lead frames and laminate substrates, has low

ionics to facilitate Cu wire bonding, and provides excellent processability and workability for all processing steps (lamination, dicing and die pick-up) on dies ranging in size from 0.5mm x 0.5mm to 3.0mm x 3.0mm. Available in 25Ωm thickness; custom thicknesses available on request.

Henkel  
henkel-adhesives.com



### INDIUM LED PASTE NC38HF

LED Paste NC38HF combines superior wetting performance with excellent stencil print transfer efficiency to satisfy the broadest range of process requirements for miniLED applications. Offers printability down to 60μ apertures with excellent compatibility with the current size of miniLEDs and as future die continue to miniaturize. Is said to feature consistent and tight solder deposit spread across multiple prints and excellent response-to-pause characteristics and minimal voiding on tight-pitch components to ensure joint strength on small components. Also offers on-wet open (NWO) performance using superior oxidation barrier technology, enabling reduced solder ball and solder beading defects and enhanced graping performance, plus enhanced slump performance with minimal bridging during the assembly process, improving yields for tight-pitch components.

Indium Corporation  
indium.com

### METCAL CV SERIES SOLDERING SYSTEM UPGRADE

Firmware update for the Connection Validation Series soldering systems brings several new and improved CV features, including cartridge optimization capabilities, enhanced traceability, improved solder joint reliability, and more. Introduces CV Production Mode to provide much faster feedback on intermetallic compound (IMC) formation and help



improve production efficiencies, as well as additional soldering capabilities such as modes for advanced process control, maximizing soldering efficiencies. New Cartridge Optimization function measures, stores and uses information about exact electrical impedance of each soldering cartridge used. Other features and functions include Approved Cartridge Lists, Tip Clean Reminder, Operator Login Functions, and Supervisor Lockout.

**Metcal**  
metcal.com



### NORDSON SELECT SYNCHRO SELECTIVE SOLDERING SYSTEM

Select Synchro selective soldering system uses a unique, synchronous motion increase throughput, improve cost-of-ownership, and provide flexibility for high-volume PCB assembly applications. Is said to reduce the time spent conveying boards as much as 25% while boosting throughput 20-40% for most applications. Configurable with multiple solder pots, with the system balancing the process for efficiency and flexibility while delivering superior solder joint reliability. Machine size can be as much as four times shorter than a typical selective soldering system while still accommodating boards as large as 680mm x 2500 mm. Includes improved process controls for closed-loop wave height check and automatic adjustment, fluxing process controls, process camera for viewing nozzles, and board warpage control.

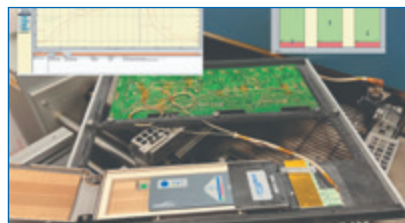
**Nordson**  
nordson.com



### PVA VALVE KIOSK STAND

Valve Kiosk Stand features 18 valves that cover an array of applications including dispensing, gasketing, conformal coating, thermal interface material, underfill, jetting and potting. Also features three 15.6" touch screen interfaces with an interactive user interface. Includes removable valves for closer inspection and in-depth breakdowns of each valve: Overview, X-ray, Operation, Applications and Dispense Patterns. Customers can navigate by industry, application, valve type or "request help." Dispensing can extend across numerous industries and applications that require dosing in an accurate and controlled manner.

**PVA**  
pva.net



### SOLDERSTAR SLX THERMAL DATALOGGER

SLXThermal Datalogger now comes with an extension to measure vacuum level in a reflow oven. Interface has advanced measurement adapters to verify parameters within the vacuum stage. Features zero-setup for quick and easy measuring and recording of process parameters from any soldering process. Noise-free measurements from up to 12 temperature channels while simultaneously measuring from other secondary process parameter sensors. Works seamlessly with the latest version of the Solderstar profile analysis software, which comes on all SLX units.

**Solderstar**  
solderstar.com

### TEST RESEARCH TR7500QE PLUS 3-D AOI

TR7500QE Plus 3-D AOI includes a high-speed top camera and four side-view cameras. Side-view cameras inspect innerlayer bridges, hidden lifted leads and other out-of-sight defects.

**Test Research Inc. (TRI)**  
tri.com.tw



### VITROX V95I ARV SOLUTION ROTATOR

V95i Advanced Robotic Vision (ARV) Solution Rotator is an additional hardware option to V9i ARV that is designed to fulfill final assembly inspection requirements in box-build and PCBA products. Enables auto-conversion between inspections of PCBAs and box-builds within a system. Also enables five-sided inspection for both complete or in-process box-build assemblies, increasing inspection coverage as it helps reach areas beyond the limitations of the robotic arm. Fully integrated with V9i ARV.

**Vitrox**  
vitrox.com

### ZESTRON VIGON SC 200 STENCIL CLEANER WIPES

Zestron Vigon SC 200 stencil cleaner wipes manually remove solder pastes and adhesives from electronics assemblies. Water-based chemistry formulation provides exceptional cleanliness while ensuring operator safety. Polyester non-woven wipes offer excellent wet strength, reduce staining and lint left behind on the stencil, and increase cleaning protocol consistency. Compatible with nanocoated stencils. For use in manual and prior to automatic cleaning processes. Low-lint wiping material. Safe alternative to alcohol-based cleaners.

**Zestron**  
zestron.com

# In Case You Missed It

## 3D Printed Electronics

“3D Printed Electronic Circuits from Fusible Alloys”

*Author:* Bartłomiej Podsiadły, *et al.*

*Abstract:* This work aims to evaluate the possibility of fabricating conductive paths for printed circuit boards from low-temperature melting metal alloys on low-temperature 3D-printed substrates and mounting through-hole electronic components using the fused deposition modeling for metals (FDM) for structural electronics applications. The conductive materials are flux-cored solder wires Sn60Pb40 and Sn99Ag0.3Cu0.7. The deposition was achieved with a specially adapted nozzle. A comparison of solder wires with and without flux cores is discussed to determine whether the solder alloys exhibit adequate wettability and adhesion to the polymer substrate. The symmetrical astable multivibrator circuit based on bipolar junction transistors (BJT) was fabricated to demonstrate the possibility of simultaneous production of conductive tracks and through-hole mountings with this additive technique. Additional perspectives for applying this technique to 3D-printed structural electronic circuits are also discussed. (*Electronics*, November 2022; <https://www.mdpi.com/2079-9292/11/22/3829>)

## Flexible Electronics

“Universal Assembly of Liquid Metal Particles in Polymers Enables Elastic Printed Circuit Board”

*Authors:* Wonbeom Lee, *et al.*

*Abstract:* An elastic PCB is a conductive framework used for the facile assembly of system-level stretchable electronics. E-PCBs require elastic conductors that have high conductivity, high stretchability, tough adhesion to various components, and imperceptible resistance changes even under large strain. A liquid metal particle network (LMPNet) was assembled by applying an acoustic field to a solid-state insulating liquid metal particle composite as the elastic conductor. The LMPNet conductor satisfies all the aforementioned requirements and enables the fabrication of a multilayered high-density E-PCB, in which numerous electronic components are integrated to create highly stretchable skin electronics. Furthermore, the authors could generate the LMPNet in various polymer matrices, including hydrogels, self-healing elastomers, and photoresists, thus showing their potential for use in soft electronics. (*Science*, Nov. 10, 2022, [www.science.org/doi/10.1126/science.abo6631](http://www.science.org/doi/10.1126/science.abo6631))

## Solder Reliability

“Low-Cycle Fatigue Behavior of Sn-0.3Ag-0.7Cu-0.5CeO<sub>2</sub> Composite Solder Alloy”

*Authors:* L. Li, Z.H. Li, Y. Tang and G.Y. Li

*Abstract:* The low-cycle fatigue behavior of Sn-

0.3Ag-0.7Cu-0.5CeO<sub>2</sub> composite solder alloy was studied. The results show that the fatigue life exponent and material ductility coefficient of the composite solder alloy are dependent on both temperature and frequency. A modified Coffin-Manson model considering the influence of frequency and temperature was put forward, and the relationship between temperature and the frequency exponent, low-cycle fatigue life exponent, and material ductility coefficient was established. The modified model has a good elimination effect on the influence of different frequencies and temperatures on the low-cycle fatigue life of the composite solder alloy. (*Journal of Electronic Materials*, Oct. 8, 2022; <https://link.springer.com/article/10.1007/s11664-022-09958-0>)

“Mechanical Shock Testing and Failure Analysis on Mixed SnAgCu-BiSn and Full Stack BiSn Solder Joints of CABGA192 Components”

*Authors:* Haley Fu, *et al.*

*Abstract:* Heterogeneous, mixed SAC-BiSn alloy solder joints as well as homogeneous BiSn alloy solder joints of the 14mm x 14mm CABGA192 daisy-chained component were subjected to multiple shock drops. The test vehicle board and shock testing conditions were as specified in JEDEC JESD B111A. Four component land sites were on this board, two lands of a solder mask-defined (SMD) design and two of a metal-defined (MD) design. The top two performing low-temperature ductile metallurgy solder pastes from previous project evaluations were chosen for evaluation for this leg using a 14mm x 14mm CABGA192 package assembled on an OSP board surface finish. Homogeneous SAC solder joints, formed using a generic SAC 305 solder paste, were tested for comparison. In-situ monitoring of the component-to-board daisy chains was used to document component failure and a Weibull analysis was completed based on these failures to compare the performance of mixed and homogeneous solder joints formed with various solder pastes. The Weibull plots and failure interfaces observed were disparate for the two types of component sites with different land patterns. The Weibull analysis showed that for solder joints assembled on MD lands, three of the four LTS BiSn solder joints performed 28-44% better than the SAC leg. However, one of the heterogeneous, mixed BiSn-SAC solder joint legs on MD pads exhibited the lowest characteristic life of all legs tested. Most failures for the SMD pattern component sites were very close to the solder joint to PCB land interface, whereas failures for the MD land patterns were exclusively in the laminate under the PCB lands. (*Proceedings of SMTA International*, November 2021; <https://smta.org/page/knowledge-search#search/entry-details/620c30ddde1b0c07217ff5de/>)

This column provides abstracts from recent industry conferences, technical journals and company white papers. Our goal is to provide an added opportunity for readers to keep abreast of technology and business trends.