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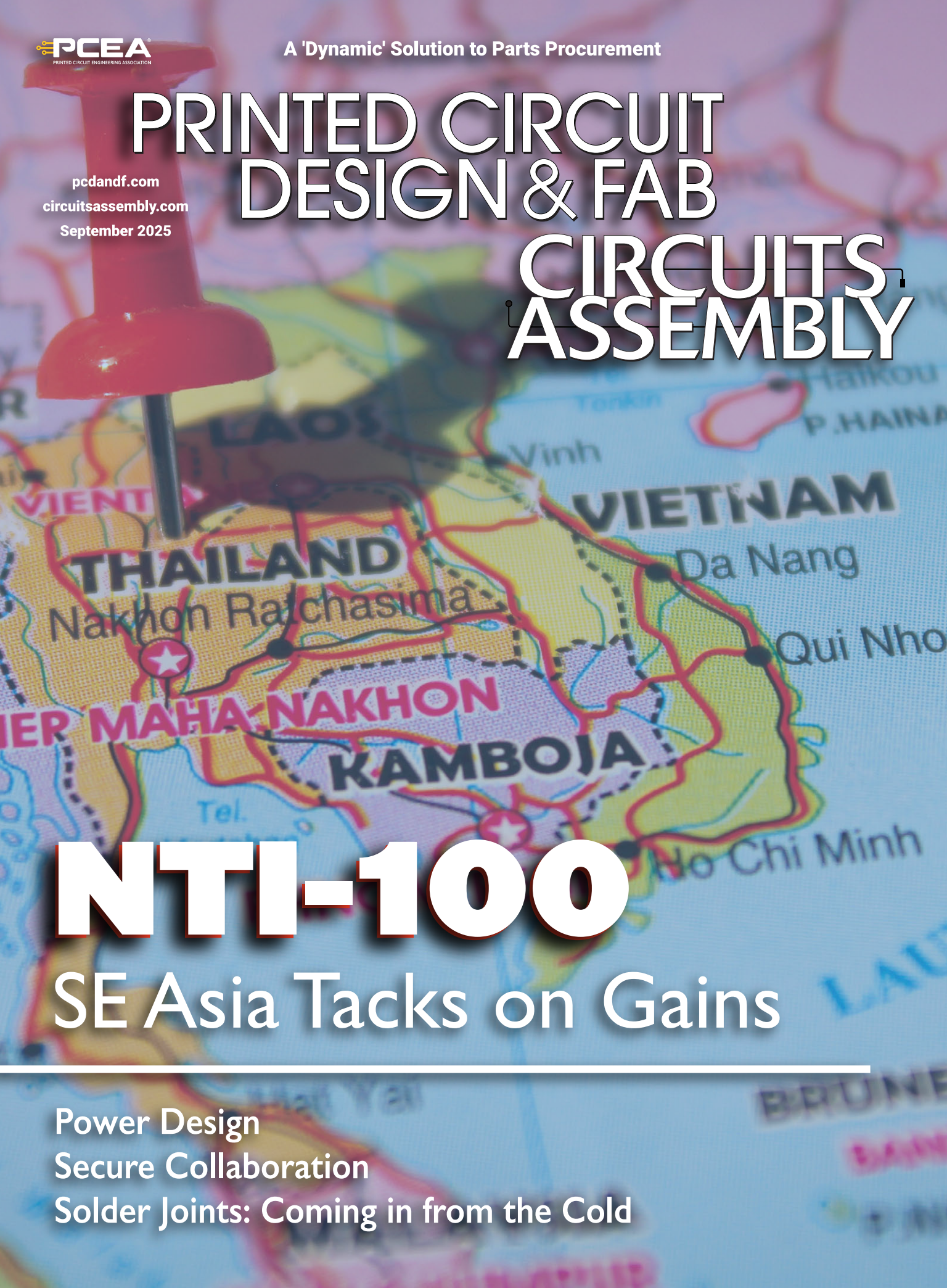

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SE Asia Tacks on Gains

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Secure Collaboration
Solder Joints: Coming in from the Cold

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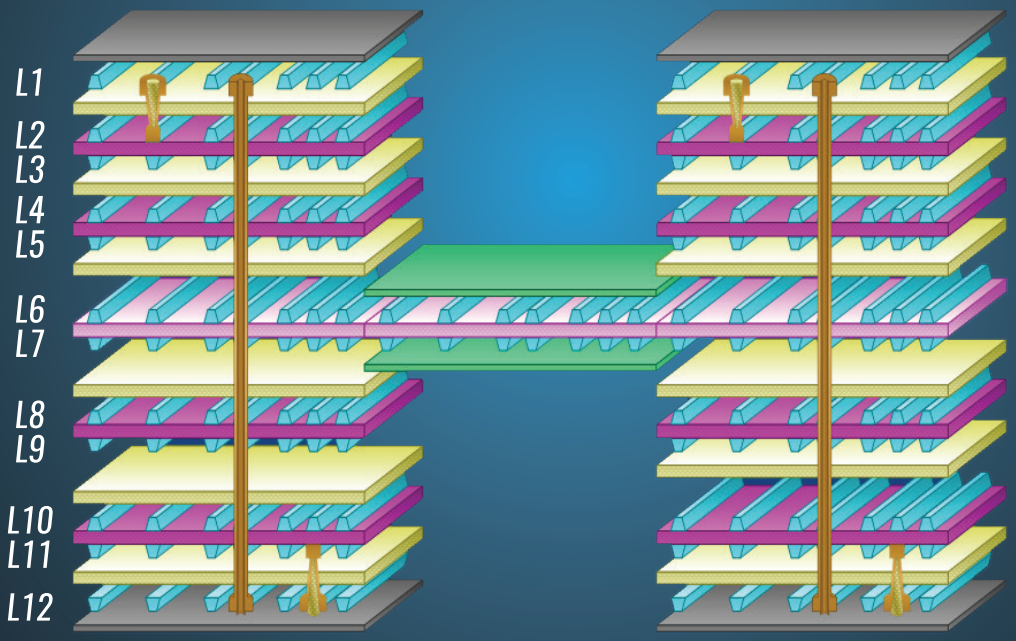

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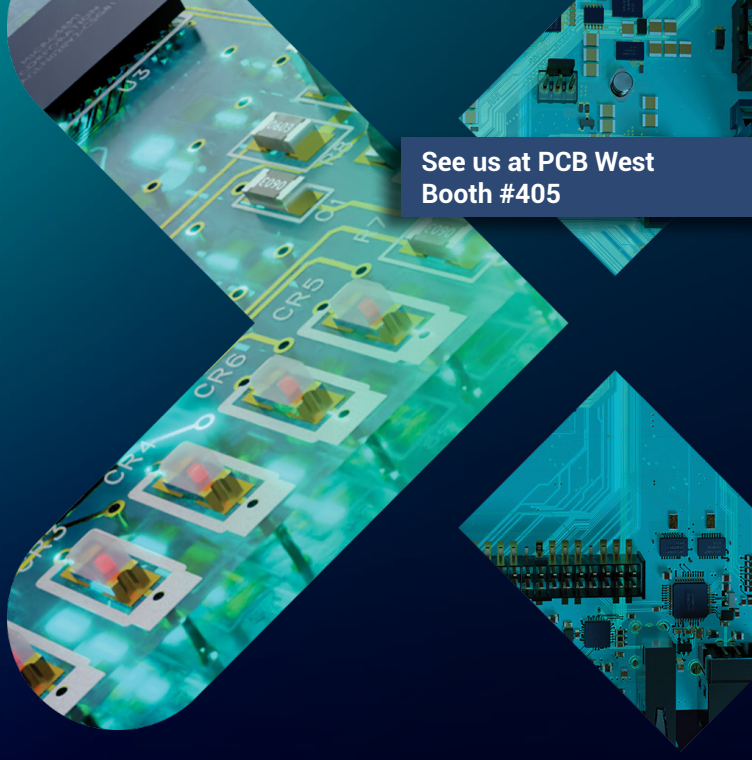

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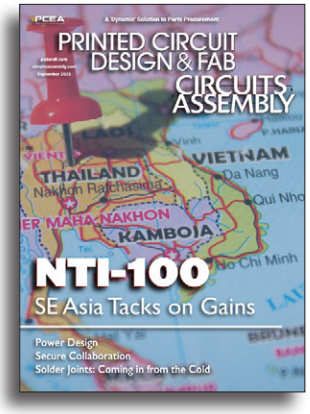
FEATURES



NTI-100 (COVER STORY)

Tracking Giants: Inside the World's Top PCB Fabricators

By layering vetted association figures with on-the-ground intelligence, the annual NTI-100 list translates imperfect inputs into a clear picture of global PCB momentum.

by DR. HAYAO NAKAHARA

SOLDERING

Cold Solder Joints

Long-term reliability hinges on whether solder truly reaches liquidus and wets the joint. This piece spotlights the "cold" solder joint that looks fine until it isn't, and the upstream design and process disciplines that keep it from forming.

by AKBER ROY

COMPONENT DYNAMICS

Where Market Intelligence Meets Distribution

How a specialist in hard-to-find or obsolete parts has also become a purveyor of "what's next?" for your supply chain.

by MIKE BUETOW

LIGHTS-OUT MANUFACTURING

Smart Factory Evolution: Innovations in Automated Production

By seamlessly linking and analyzing all data across the entire manufacturing line, new levels of transparency and efficiency can be achieved.

by AKIHIRO SENGA

SMTA WLP

The Growing Importance of DfX in AI Hardware

At the inflection where AI's hardware ambitions collide with factory realities, DfX is widening opportunities for specialized talent spotlighted by SMTAI's Women's Leadership Program.

by PRIYANKA DOBRIYAL, PH.D.

ON PCB CHAT (PCBCHAT.COM)

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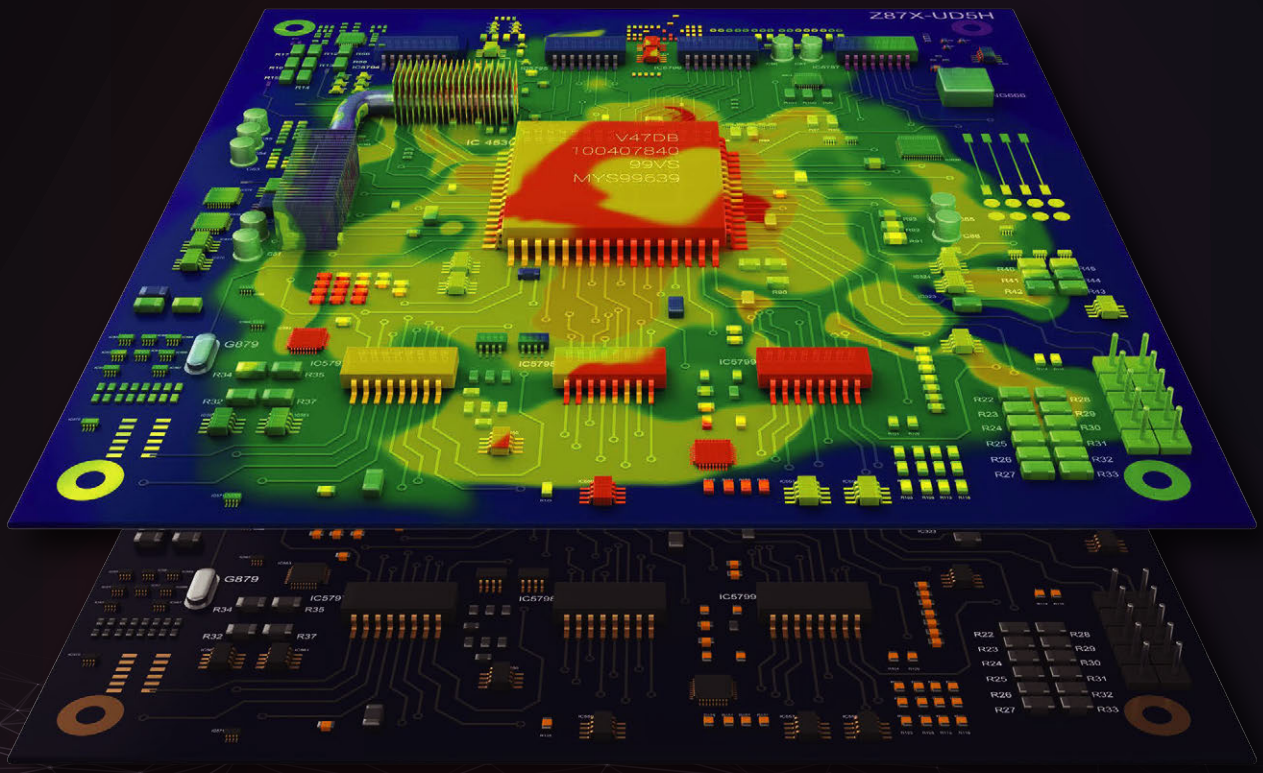

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Technology Reigns (and Rains) at PCB West

PCB WEST HAS, since its inception, been the leading conference for printed circuit board design and manufacturing.

One reason for that is the intense focus on what the industry needs in terms of training. Another is, besides the educational aspects, it can be fun, surprising and occasionally even provocative.

Years ago, the conference founder Pete Waddell introduced a session called EDA Face-to-Face, where CAD vendors took to the stage and addressed questions straight-on from their users. As you might imagine, the back-and-forth sometimes got a little heated. One particular memory includes a couple users, fed up with the lack of bidirectional electronic data transfer, roiling the crowd with their public callout of the major ECAD companies for not modifying their tools to permit data in.

Eventually the vendors stopped volunteering to participate. But over time, it should be noted, they eventually started offering bidirectional data capability. Sometimes being loud matters.

As AI makes its move into ECAD, PCEA has kept up by introducing the AI Roadmap for Electronics and adding presentations on AI to our array of conferences. Panelists for our presentations were typically vendors, and they did a nice job promoting the potential of the technology.

This year, however, we are taking a page from the past and shifting the spotlight to the users. On Oct. 1 (aka Free Wednesday) this year, the theme of one of our panels is "What Users Really Think of Today's AI." The esteemed group features a pair of designers, an assembler and a supply chain expert. The panelists have examined the various AI-assisted tools for their companies, and the goal is to help enlighten those slower to adopt what works – and what doesn't. Expect some surprises!

I'm equally excited for the Free Wednesday session on "The Future of PCB Design: Looking 2-5 Years Ahead, What is Coming?" Like the panel, the talk will touch on AI. Still, the larger focus will be on other changes ahead, including heterogeneous packaging, textile-integrated microelectronic systems, high-speed/high-current, optics and even the future origin of designers. If you want to know where the industry – and possibly your career – is headed, you'll want to catch this session.

Not to bury the lede, but the panels sandwich this year's keynote, which promises to be scintillating. While past addresses have featured CEOs of major ECAD companies and leading technologists at companies like Meta, I honestly can't recall a time we've invited a leader from a startup to take center stage.

Until this year, I mean.

I'm excited to announce Jackson Schultz, head of engineering at Rainmaker, as keynote of PCB West 2025.

Schultz leads the design and integration of Rainmaker's autonomous cloud seeding system, which is grabbing attention across a stream of major media outlets, not to mention private equity firms, which have funded the company to the point it is moving into a 70,000 sq. ft. facility this fall.

With a background in unmanned aerial vehicles (UAVs) with Anduril and test instrumentation architecture with Regent Craft, Schultz is exquisitely suited to describing the range of atmospheric sensors, flight controls, lidar, radar and other technologies used in the pioneering company's weather radar and modeling techniques.

Schultz hits the podium at 11 a.m. on Oct. 1, so be sure to arrive early.

And while you're at the show, stop by the PCEA booth or grab one of the staff or board members with a PCEA badge and share your input. It's what we're here for!

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

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Siemens Launches PartQuest Design Enablement

MUNICH – Siemens Digital Industries Software in August introduced the PartQuest Design Enablement portfolio, a new digital environment aimed at enhancing how electronic component manufacturers connect with customers. Designed to streamline operations and deliver personalized digital experiences, the platform integrates product discovery, BoM intelligence, collaboration tools and digital support into one cohesive ecosystem.

Microchip Technology is among the first to adopt the platform, demonstrating its value during the Microchip MASTERs event. Siemens showcased how PartQuest Design Enablement, combined with Celus design automation and Microchip components, can accelerate the design process.

Siemens says the platform enables manufacturers to engage more deeply with engineers while improving operational efficiency and decision-making.

DSBJ to Launch High-End PCB Site

SUZHOU – Dongshan Precision Manufacturing (DSBJ), the parent of Multek, announced plans in August to invest up to $10 billion in a high-end printed circuit board campus designed to support next-generation computing and artificial intelligence applications. The initiative marks a push to enhance the company's capabilities in advanced PCB manufacturing, crucial for high-performance AI chipsets and data infrastructure. The company didn't disclose the site location, capacity or expected completion date.

The investment will go toward state-of-the-art facilities capable of producing complex, high-density PCBs tailored for demanding AI workloads. This move comes as China sees demand for advanced computing hardware, especially in light of US restrictions on Nvidia AI chip exports, which has fueled a secondary market for repair and maintenance.

DSBJ aims to position itself at the forefront of the AI supply chain by delivering the reliable, high-spec components needed for evolving technology stacks. While project specifics are still under wraps, the development is expected to boost local innovation, generate employment and reinforce the company's role in the global electronics ecosystem.

Ventec Breaks Ground on Thailand Facility

AYUTTHAYA, THAILAND – Ventec International Group has officially broken ground on its first Southeast Asian manufacturing plant here. The 35,000-sq. m. site is expected to begin trial production in the first quarter of next year and reach mass production by the second quarter.

The site is located near Bangkok's port and airport, and will produce copper foil substrates and adhesive sheets for high-performance applications, including automotive, aerospace and AI computing.

Ventec's 35,000-sq. m Thailand facility.

Chairman Yu-Tzu Wang emphasized that the Thai facility will "optimize the company's global supply chain layout" and "significantly enhance production capacity and service capabilities." The move builds Ventec's presence in a key electronics hub and supports customers across Thailand, Southeast Asia, Europe and the US.

Avary Holding Greenlights Huai'an Park Expansion for PCB Capacity and AI

HUAI'AN PARK – Zhen Ding Technology said Avary Holding's board in August approved a Huai'an Park expansion, committing roughly $1.1 billion (RMB 8 billion) through 2028 to boost high-end PCB capacity aimed at AI infrastructure.

The plan includes two new fabs and advanced equipment to scale MSAP, HDI and high-layer-count (HLC) production for servers, optical communications, humanoid robotics, smart vehicles and edge AI devices.

Avary is a subsidiary of ZDT. The Huai'an investment is an element of the group's capex strategy and targets mid-to-

long-term demand for high-precision, high-layer boards across the AI server and connectivity stack.

Kaynes Circuits Launches PCB Project in Tamil Nadu

THOOTHUKUDI, TAMIL NADU – Kaynes Circuits India has announced an investment of ₹49.95 billion ($570 million) to establish an electronic component manufacturing facility in Thoothukudi, Tamil Nadu. It marks the state's first major foray into high-end PCB production.

The facility will produce advanced 74-layer PCBs, HDI and flexible boards, high-performance laminates, camera modules and wire harness assemblies. Projected to create around 4,700 jobs, the plant will help make Thoothukudi a hub for electronics and electric vehicles, situated near VinFast's upcoming EV plant.

Industry experts say this anchor investment reflects a larger shift in India's electronics strategy, moving from assembly toward deep-tech component manufacturing. It also aligns with the country's growing component production initiatives under the government's ₹22.9 billion investment plan.

Wright Industries Acquires Exception PCB

ANDOVER, ENGLAND – Wright Industries in August announced its acquisition of Exception PCB, returning the high-reliability printed circuit board manufacturer to British ownership. The company, now part of the Connexion Technologies group, means to reinforce the UK's domestic manufacturing base.

"Bringing Exception PCB back from Asia into UK ownership strengthens our national manufacturing resilience," said Craig Wright, chairman and CEO, Connexion Technologies. "It aligns with UK Government objectives and opens new opportunities to innovate, invest and lead."

"This is a proud moment for British engineering," added Kamal Berberi, general manager, Exception PCB. "Joining Connexion Technologies will allow us to expand our strategic capabilities and customer offerings."

Wright Industries' move highlights a broader trend toward reshoring industrial capacity to the UK. The deal is also expected to support skilled jobs and long-term economic value in the region.

Polymatech Completes PCB Fab Plant in Estonia

CHENNAI – Polymatech Electronics last month announced the commissioning of its state-of-the-art printed circuit board manufacturing facility in Estonia.

The new facility features a roughly 10,000-sq. ft. cleanroom equipped with cutting-edge machinery, capable of producing up to 50,000-sq. m of multilayer high-density interconnect (HDI) PCBs annually.

Polymatech Electronics' new plant is the first large PCB site built in Europe in years.

The site also has capacity for building flex circuits, SLPs, HDI PCBs, rigid-flex, IC substrates, RF PCBs, and high-density modules.

"Our European-made PCBs, crafted with European expertise and adhering to the highest quality standards, are in high demand across various high-end applications," said Eswara Rao Nandam, CEO, Polymatech Electronics. "This facility underscores our commitment to innovation, quality and precision, positioning us to deliver tailored, engineered solutions to some of the most demanding industries."

The Estonia facility underscores Polymatech's evolution from a component supplier to a product-centric solutions provider. "Since incorporating the Company on Nov. 18, 2024, and commencing operations on Aug. 8, this facility exemplifies our dedication to quality, reliability, and customer-centric innovation," said Tarja Rapala, director, Polymatech Electronics and head of PCB Business. "With meticulously maintained equipment and a highly skilled team, we are poised to deliver rapid, sustainable PCB solutions and foster strategic partnerships across Europe."

Dr. Allen Nejah, chief innovation officer, Polymatech Electronics, added, "This facility is a remarkable achievement that enhances our ability to deliver sophisticated PCB solutions for Europe's technological and defense sectors. This facility portfolio includes high-speed PCBs, advanced HDI PCBs, high-frequency PCBs, and multilayer configurations – up to 48 layers – designed for high-end electronics."

Wipro Launches Electronic Materials Division

NEW DELHI – Wipro Infrastructure Engineering (WIN) has unveiled a new business division, Wipro Electronic Materials, aimed at manufacturing high-performance base materials for PCBs. The move marks a strategic expansion into the electronics manufacturing space.

As part of this initiative, WIN will invest approximately $60 million to build a copper-clad laminate (CCL) facility in Karnataka. The plant is expected to generate around 350 jobs and will have the capacity to produce over 6 million sheets of copper-clad laminates and associated pre-impregnated materials annually.

The investment aligns with India's growing push for electronics manufacturing self-sufficiency and represents a step toward diversifying its advanced materials capabilities.

VVDN Expands with New UAE EMS Facility

FREMONT, CA – VVDN Technologies has announced the establishment of a new manufacturing facility in the United Arab Emirates, expanding its global footprint to serve customers across the United States, Europe and the MENA region. The site, scheduled to become operational within four weeks, reinforces the company's backward integration strategy.

The UAE facility will support PCB assembly, automated product assembly, mechanical manufacturing and testing and validation, covering sectors including telecom, MedTech, automotive, cameras and industrial automation. By adding capacity in the region, VVDN aims to accelerate time-to-market.

Gourab Basu, senior vice president, manufacturing commercials, said the UAE expansion reflects VVDN's commitment to meet rising global demand. "Positioned as a gateway between the East and West, the UAE enables seamless access to diverse markets," he noted. "This expansion reflects VVDN's dedication to bringing manufacturing closer to its global clientele while meeting the increasing demand for high-quality, commercially competitive solutions with a quick-turnaround."

VVDN Acquires GGS Engineering

FREMONT, CA – VVDN Technologies has acquired GGS Engineering Services, expanding its engineering research and development (ER&D) portfolio across the automotive, MedTech and aerospace sectors. GGS brings more than two decades of expertise in mechanical design, analysis, simulation and technical publications.

The acquisition grows VVDN's capabilities in innovative product development, cost optimization and scalable engineering talent. VVDN aims to address industry demands ranging from vehicle electrification and cabin design to medical device precision engineering and aerospace component development.

GGS will continue to operate under the VVDN umbrella, with its leadership team remaining in place. VVDN CEO Puneet Agarwal emphasized that the acquisition strengthens the company's global value proposition and positions it to expand aggressively in the multi-billion-dollar ER&D market.

Cicor Finalizes MADES Acquisition, Expands

A&D Reach in Europe

BRONSCHHOFEN, SWITZERLAND – The Cicor Group has completed its acquisition of MADES SAU, a Málaga-based electronics manufacturer formerly owned by the Latecoere Group.

With this move, Cicor builds its presence in the European aerospace and defense (A&D) sector, while making its strategic entry into the Spanish market. MADES, which employs around 100 people and generated EUR 29 million ($23 million) in revenue last year, brings additional capabilities in mission-critical electronics and industrial applications. Cicor emphasized that the acquisition will not affect its yearly sales guidance of CHF 620 million to 650 million ($754 million to $774 million) and is not expected to be impacted by recent US tariff changes.

PCD&F

Amphenol will acquire **Trexon** for about $1 billion.

Electroninks named **Insulectro** distributor of its MOD inks for additive manufacturing and advanced semiconductor packaging in North America.

HyProMag USA has signed a feedstock supply and site share agreement with global electronics recycler Intelligent **Lifecycle Solutions**.

Ji'an Shengyi Electronics is investing 20 billion yuan ($2.8 billion) in an intelligent manufacturing high-layer-count circuit board project.

Kinwong will invest about $700 million to expand high-end PCB capacity, upgrading its Zhuhai site.

University of Maryland, Georgia Tech and **University of Notre Dame** researchers introduced DissolvPCB, a novel 3-D printing-based method to fabricate fully recyclable electronic circuits.

Metallium is advancing its Texas e-waste processing plant toward December with 60 tonnes of printed circuit board scrap to de-risk ramp-up.

Nvidia and **AMD** will give the US government 15% of China chip sales revenue in exchange for export licenses.

TechSearch's latest *Advanced Packaging Update* explores how larger CPU substrates are driving packaging innovation, new materials and concern over warpage and thermal management.

Virginia Polytechnic researchers developed a recyclable circuit board material that works like plastic but behaves more like memory foam fused with metal. And it still carries a charge – even when bent, cut or broken.

CA

AIM Solder appointed **Covermat** distributor in Thailand.

Amber Enterprises plans to invest over ₹800 crore ($91 million) to build a copper laminate plant in Mysuru under India's electronics component manufacturing plan.

Amber Group, an Indian EMS, is set to acquire a 40% stake in **Unitronics,** an Israeli maker of industrial automation and control systems.

Apple in August announced an additional $100 billion commitment to its American Manufacturing Program as part of a total $600 billion investment to expand US production and supply chain operations.

ASMPT and **SMarTsol Technologies** have opened an advanced competence center in Guadalajara.

ASMPT will close its Shenzhen manufacturing facility, impacting about 950 jobs, as part of a global restructuring to boost efficiency. China accounted for 38% of ASMPT's revenue last year.

Benchmark Electronics has completed delivery of 24 AI-enabled mobile vehicle surveillance systems with radar to **US Customs and Border Protection.**

Blackline Safety expanded its in-house quality assurance program with upgraded inspection equipment, in-lab testing capabilities and a larger team.

BMK commissioned a heavy-duty conformal coating line with selective jetting and curtain applicators.

Circuit Check acquired **Solution Sources Programming** (SSP), a Silicon Valley-based provider of integrated test and programming solutions.

Clemsa installed a **Europlacer** SMT placement line.

Distron installed a **Juki** Cube inline selective soldering system.

ECD named **AMS** exclusive UK distributor.

EETech Group acquired **Breadboard,** developer of an AI-powered supply chain automation platform.

Federal Electronics Mexico installed a **Heller** reflow oven.

FlashPCB installed a **Heller** 1809 MKII reflow oven with a KIC ProBot automatic profiler.

GNG Electronics, a refurbisher of laptops and other electronics devices, set a date for its pending IPO.

Libra Industries purchased an **Amada** fiber-laser system for its Guaymas, Sonora facility.

Microtronix has breathed new life into a formerly defunct cellphone manufacturing facility in Durban, South Africa.

Motorola's former CEO last month warned that smartphone assembly in America still faces the same hurdles it did a decade ago, especially when it comes to labor and supply chain fragmentation.

MSI plans to boost US production capacity, with California plant output potentially exceeding its initial 60% target amid new tariff pressures.

Parmi appointed **Prosperar Solutions** representative in Brazil.

Promex Industries added UV laser depaneling and advanced SPI systems.

SisTech Manufacturing expanded its electronic manufacturing capabilities, enhancing PCB assembly, conformal coating and obsolescence management.

Yamaha Motor Corp. U.S.A. Robotics Division announced a new low-cost equipment program designed to help electronics manufacturers start production or expand capacity in North America.

YJ Link has opened a 7,272-sq. meter factory in Mexico to expand PCB handling equipment production.

Zestron added an **i-Tech** EPS 75 pallet cleaning system to its Manassas, VA, technical center.

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AT&S CFO **Petra Preining** will step down from the executive board this month.

Agile Circuit Technology Group announced a new executive team to lead its unified UK PCB manufacturing operations: CEO **Dean Curran**, CFO **Malcolm Millar**, COO **Mark Aitken**, CCO **David Riddle** and CPO **Michelle Kirk**.

LiveWire named **Justin Fleming** senior printed circuit board designer.

TTM Technologies named **Edwin Roks** president and chief executive. He succeeds **Tom Edman**, who is retiring.

Summit Interconnect named **Lianna Marrero** account manager.

US Cargo Systems named **Gerry Callahan** senior electrical engineer.

CA


Farid Anani


Frank LaBarbera


Andy Seager


Karthik Vijay


Jim Barnes


George Hsu


Erik Miller


Greg Smith


Eric Lakin


Edward Pechin


Anna-Maria Tuominen-Reini


Vitaly Michalchuk

Creation Technologies named **Farid Anani** VP global manufacturing engineering.

Flex promoted **Frank LaBarbera** to senior director, business development.

Indium Corp. promoted **Andy Seager** and **Karthik Vijay** to key leadership roles supporting growth across the EMEA region.

Generac promoted **Jim Barnes** to executive vice president, global supply chain.

Koh Young named **George Hsu** managing director of Koh Young Taiwan.

Kyzen has promoted **Erik Miller** to chief operating officer and named **John Norton** Northeast regional manager.

MacDermid Alpha Electronics Solutions appointed **Ravi Bhatkal** vice president, strategy, India.

Panasonic Connect has named **Daniel Perry** regional sales manager.

Stentech promoted **Greg Smith** to technology director.

TT Electronics promoted **Eric Lakin** to CEO.

Unigen named **Darshana Gadkari** vice president of program management, **Kenny Lai**, sr. vice president of business operations, and **Tien Nguyen** vice president of operations in Newark, CA, and **Gary Yeoh** director of operations, Malaysia.

ViTrox Americas has named **Edward Pechin** technical support manager.

Scanfil appointed **Anna-Maria Tuominen-Reini** chief supply chain officer and group management team member.

Screaming Circuits promoted **Vitaly Michalchuk** to manager of business growth and development.

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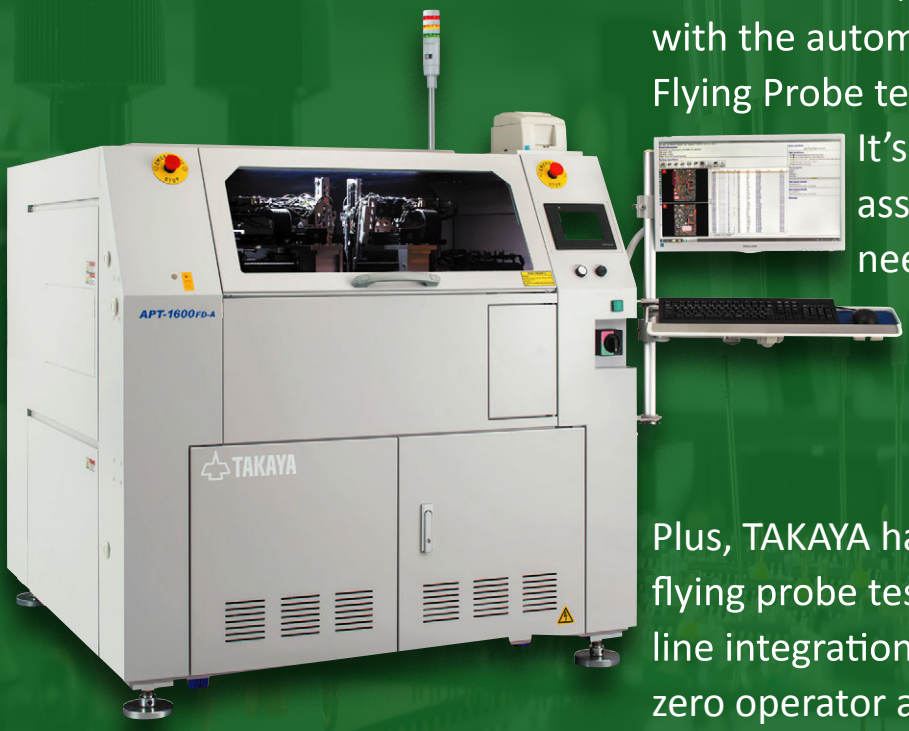

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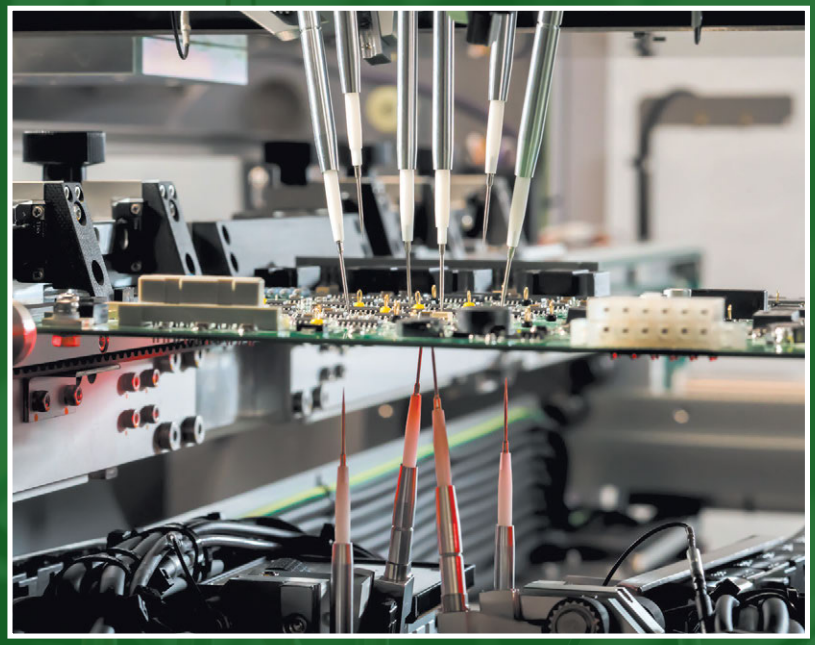

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FGPA Horizons Conference to Colocate with PCB East 2026

PEACHTREE CITY, GA – FPGA Horizons will colocate its technical conference and exhibition with PCB East 2026 at the DCU Center in Worcester, MA, next spring.

The FPGA Horizons technical conference will take place Apr. 28 – 29, 2026, concurrent with the PCB East technical conference, which takes place Apr. 28 – May 1.

The exhibition takes place Apr. 29 at the DCU Center.

FPGA Horizons was established by Adiuvo Events, with its inaugural conference to be held Oct. 7 in London. It was founded by Adam Taylor, a chartered engineer and fellow of the Institute of Engineering and Technology.

"Adam Taylor and Adiuvo have presented and exhibited at our past events and we are beyond thrilled to now welcome them as a partner for PCB East 2026," said Mike Buetow, president of PCEA. "The attendees and exhibitors for their highly anticipated technical event are complementary to our traditional printed circuit board design and manufacturing audience, and we see immediate synergies ahead."

"Colocating FPGA Horizons with PCB East brings together two deeply connected communities," said Adam Taylor, founder of Adiuvo Events. "It's a natural fit that will spark fresh ideas and showcase the next wave of innovation to a highly engaged technical audience."

For information about PCB East, visit pcbeast.com. For information about FGPA Horizons, visit fpgahorizons.com.

PCB West Keynoter Wants to 'Make it Rain'

PEACHTREE CITY, GA – Water may be the enemy of electronics, but technology could be the salvation for eliminating droughts.

That's the thesis of Jackson Schultz, head of engineering at Rainmaker Technology, who will keynote PCB West this fall. Schultz heads the design and integration of Rainmaker's autonomous cloud seeding system, which works with nature to encourage precipitation, provide more freshwater, and mitigate drought and water scarcity globally. Rainmaker provides water for farms, watersheds and ecosystems, fortifying growth and stewarding the natural world. The company designs, builds and deploys weather-resistant drones, advanced meteorological radar systems, and atmospheric analysis software to achieve this. The pioneering platform uses a range of atmospheric sensors, flight controls, lidar, radar and other technologies.

Jackson Schultz

Rainmaker currently serves government customers in multiple US states and countries around the world.

His keynote takes place Oct. 1 from 11 a.m. to 12 p.m. at the Santa Clara (CA) Convention Center.

Schultz previously worked on Anduril's Altius UAV platform designing, integrating and testing various capabilities. At Regent Craft, he developed the seaglider's test instrumentation architecture from the fiber optic strain gauges to time series databases.

He is a graduate of Georgia Tech in electrical engineering.

PCB West will be held Sept. 30 – Oct. 3 at the Santa Clara (CA) Convention Center. The event includes a one-day exhibition on Oct. 1.

Users to Lead 'AI in Electronics' Panel at PCB West

PEACHTREE CITY, GA – A special free panel session on "What Users Really Think of Today's AI" will take place at PCB West on Oct. 1 at the Santa Clara (CA) Convention Center starting at 10 a.m. PST.

The one-hour panel, which is free to all conference and exhibits-only attendees, will discuss how the promise of AI is transforming electronic design and manufacturing, but also explore why adoption is harder than first expected.

The panel will be moderated by Phil Marcoux, an electronics industry expert with over 50 years of experience in electronics manufacturing. Panelists include: Alex Zannos of Pensa Technologies (design), Matthew Leary of Newgrange Design (design), Farzam Moshtagh of Epoch International (assembly) and Jackson Schultz of Rainmaker Technology (assembly).

“The panelists, who are users rather than suppliers, have examined various AI-assisted tools for their companies,” said Phil Marcoux, interim general manager of Epoch International. “Attendees are encouraged to hear and question their experiences, and provide opinions from their own experiences, which could help shape changes that enable the acceptance of AI-assistance.”

PCB East 2026 Booth Space Now Open to Any Exhibitor

PEACHTREE CITY, GA – The exhibition floor for PCB East 2026 is now open to any prospective exhibitor, the Printed Circuit Engineering Association (PCEA) announced. The exhibition takes place Apr. 28 at the DCU Center in Worcester, MA, a new location for PCB East.

Attendance for the PCB East 2025 exhibits rose nearly 4% year-over-year, PCEA added. Attendance among the exhibits-only category was up 15% from a year ago.

Concurrently, the four-day technical conference will take place Apr. 27 – May 1, 2026.

“Since its return in 2021, PCB East has sold out each year, and we fully expect it to do so again,” said Frances Stewart, vice president of sales and marketing at PCEA. “Attendance at the show was up again in 2025, and attendees have noted the access to vendors and each other as the primary reasons why they come to PCB East.”

Companies interested in exhibiting should contact Frances Stewart at frances@pcea.net for details.

PCEA to Hold Annual Meeting at PCB West

PEACHTREE CITY, GA – PCEA will hold its annual meeting on Sept. 30 at the Santa Clara (CA) Convention Center during the PCB West trade show.

PCEA will review its key programs, including its Certified Printed Circuit Engineering training and its chapter development and membership.

The meeting is open to all Association Members and interested parties.

Also, annual awards for leadership and membership will be presented.

Fall PCB Design Training Classes Scheduled

PEACHTREE CITY, GA – PCEA Training this fall will hold two scheduled sessions of its industry-leading Certified Professional Circuit Designer (CPCD) training and certification program.

Upcoming class dates are:

- Sept. 12, 19, 25 Oct. 10, 17
- Nov. 3, 10, 17, 24, Dec. 1

The five-day instructor-led course is for printed circuit engineers, layout professionals and other individuals currently serving in the design engineering industry or seeking to get into it.

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

Each class is 40 hours long and includes a copy of *Printed Circuit Engineering Professional,* a 400-page handbook on circuit board design, and the optional certification exam recognized by PCEA.

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

To enroll, visit pceatraining.net/registration.

PCEA CURRENT EVENTS

ASSOCIATION NEWS

Certification. The following recently passed the PCEA Certified Printed Circuit Designer exam:

- Devin Hart
- Joseph Thomas

Conferences. Abstracts for next year's PCB East technical conference are due Oct. 3. The conference, the largest of its kind in New England, takes place next spring in the Boston suburbs and focuses on training and best practices for printed circuit board design engineers, electronics design engineers, fabricators and assemblers. Submit abstracts at https://pcbeast.com/abstract-submission-guidelines.

Networking. The PCEA Discord server brings together engineers and designers from around the world on a private channel to discuss technical questions and career opportunities. To join, contact PCEA. Recent conversations covered implementation of ESD rings on circular boards, migrating designs between CAD tools, block diagrams and power budgets, and whether there should be an industry-standard definition of each level of "PCB Designer."

CHAPTER NEWS

Richmond, VA. We held a casual gathering in August to help local hardware folks connect and start shaping what this community could become. We are looking for input on future technical talks, shop tours, educational sessions (virtual or in-person), or collaborative projects. Contact: Michael Burns.

Portland, OR. Our Oct. 23 meeting is scheduled at the Portland State University Electronics Prototyping Lab. Contact: Stephan Schmidt.

See us at PCB West
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MARKET **WATCH**

Is Thinner Core Technology Ahead for Tomorrow's CPU Substrates?

AUSTIN, TX – Larger substrate sizes for AI, network switch and server CPUs are driving the development of new package structures as well as materials and processes for substrate fabrication. One of the major concerns with a large substrate is warpage; other concerns include material sets to support the larger body size, including thermal interface materials to help dissipate heat.

That's according to TechSearch International's latest *Advanced Packaging Update*. The 100-page report examines these trends and includes a section on thermal interface materials (TIMs) under development for large-body packages.

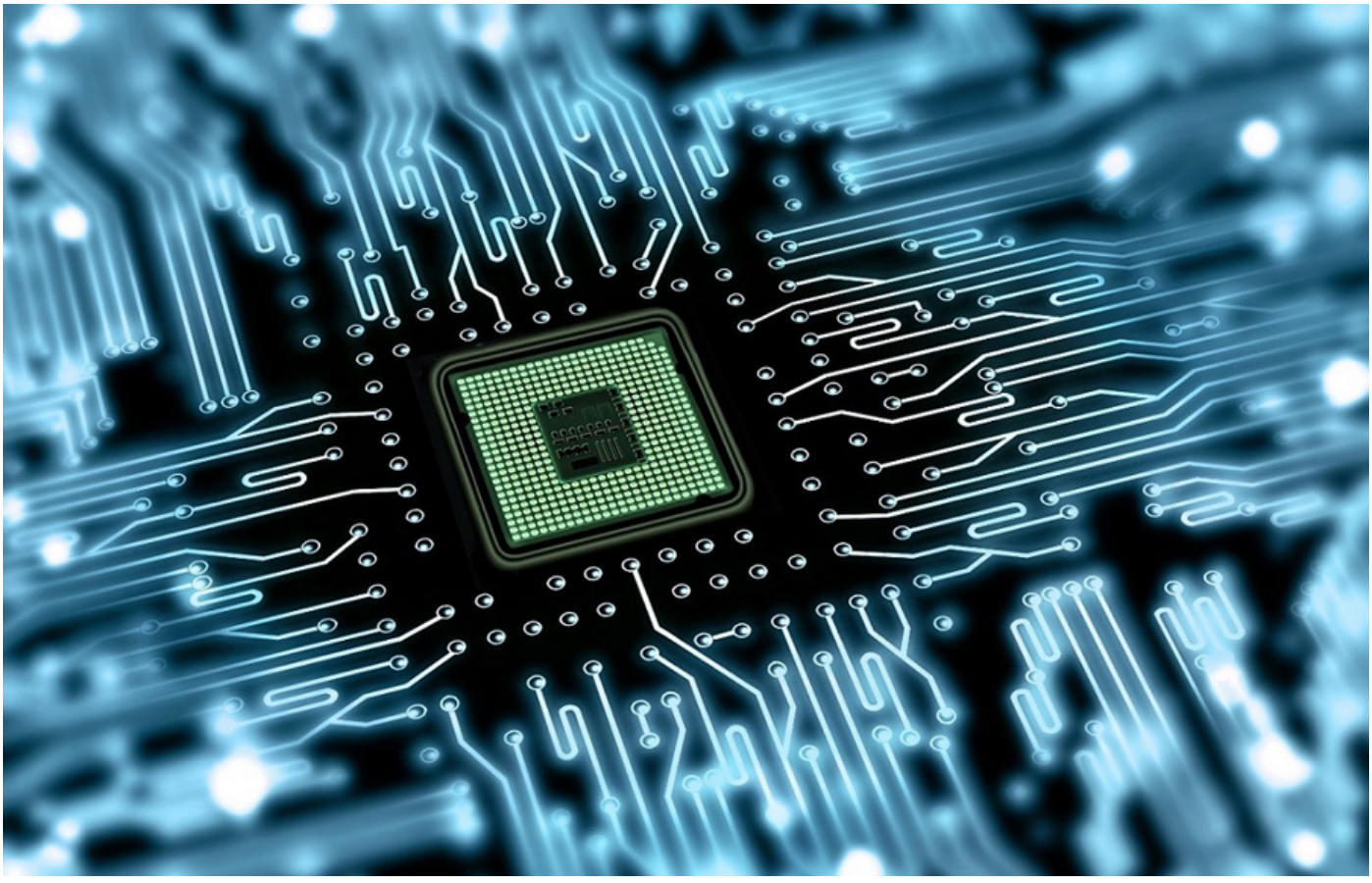


Figure 1. Server CPUs are driving new packages and material sets.

The update also examines substrate material shortages, including glass fiber for the core and bismaleimide triazine (BT) resin for a variety of substrate types. Underlying causes for shortages are discussed, along with alternatives for these materials.

An update on glass-core substrates examines progress and highlights challenges in developing the technology. A particular advantage of glass core is the potential for a thinner core than existing glass-cloth materials offer. Still, a core thickness of 1.0mm may be necessary to meet reliability requirements. High-performance applications will require 11 or more build-up layers, and to date, only three or four build-up layers on each side have been fabricated in test vehicles. Little reliability data have been published for glass-core substrates, and the cost compared to alternatives is unavailable.

TechSearch's annual survey on substrate design rules features coverage of laminate flip-chip BGA and CSP substrate suppliers worldwide. Design rules include body size, core thickness, via and pad diameter, minimum bump pitch supported and substrate finish.

Consumer Comeback

Trends in the US electronics equipment market (shipments only)

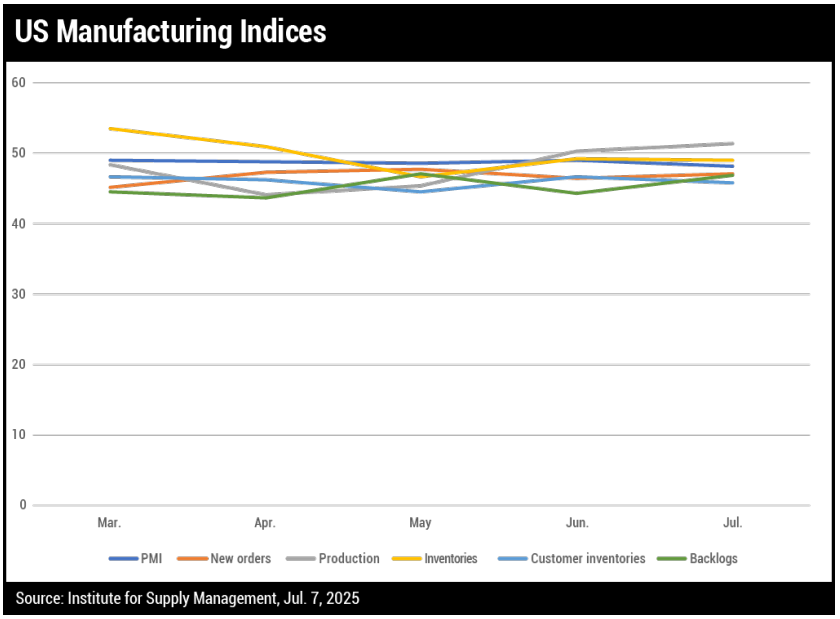
	% CHANGE			
	APR.	MAY[r]	JUN.[p]	YTD
Computers and electronics products	-0.2	0.8	0.3	4.8
Computers	-0.7	-2.2	-0.6	16.3
Storage devices	7.6	-1.3	-9.6	11.0
Other peripheral equipment	39.8	-3.6	5.5	7.3
Nondefense communications equipment	-2.6	3.2	0.7	7.4
Defense communications equipment	-7.8	2.2	1.3	1.2
A/V equipment	-0.2	3.3	-3.6	-3.7
Components[1]	-1.2	-0.1	2.7	4.1
Nondefense search and navigation equipment	3.9	0.7	0.7	5.0
Defense search and navigation equipment	0.1	0.5	0.5	3.2
Electromedical, measurement and control	-0.9	1.4	-0.3	4.0

[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: US Department of Commerce Census Bureau, Aug. 2, 2025

Key Components

	MAR.	APR.	MAY	JUN.	JUL.
EMS book-to-bill[1,3]	1.36	1.43	1.41	1.28	1.23
Semiconductors[2,3]	1.8%	22.7%	27.0%	19.6%	
PCB book-to-bill[1,3]	1.23	1.21	1.03	1.06	1.00
Component sales sentiment[4]	112.5%	94.7%	93.1%	121.5%	121.6%

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



Hot Takes

The DDR4 market is set to remain in a persistent state of undersupply and strong price growth through the second half of this year, and rigid server orders are crowding out supply for the PC and consumer markets, forcing PC OEMs to accelerate DDR5 adoption. (TrendForce)

Revenue among publicly listed **Taiwanese-based PCB fabricators** in July rose 8% year-over-year. (TPCA)

Some 88% of **US electronics supply chains** rely on foreign inputs, with significant upstream exposure to Chinese sub-components across allied trade routes. (Altana)

Global TV shipments reached 92.5 million units in the first half, up 2% year-over-year, driven by tariff-related uncertainties and China's "trade-in" subsidy program. (TrendForce)

Worldwide **tablet shipments** grew 13.1% year-over-year in the second quarter, totaling 38.3 million units. (IDC)

Only 26% of **job candidates trust AI** will fairly evaluate them, even though 52% candidates believe AI screens their application information. (Gartner)

Global **notebook shipments**, excluding detachable models, outperformed expectations in the second quarter, rising 11.8% quarter-on-quarter. (DigiTimes)

First-half **M&A deals among North American EMS and PCB companies** this year are tracking closely to 2024, with seven reported EMS deals, versus eight in 2024, and two PCB deals, same as a year ago. (GP Ventures)

OLED monitor shipments will reach 2.66 million units in 2025, an 86% year-over-year, driven by demand for new gaming devices. (TrendForce)

Worldwide **silicon wafer shipments** increased 9.6% year-on-year to 3.33 billion sq. in. (MSI) from the 3.04 billion MSI recorded during the same quarter of 2024. (SEMI)

The 90-day moving average **North American EMS shipments** in July fell 4.1% and shipments declined 5.1% sequentially. Bookings rose 7.9% from last year and increased 13.4% from June. Year-to-date shipments are down 0.6% and bookings are up 1.5%.(GEA)

In July **North American PCB shipments** rose 20.7% year-over-year and increased 11.3% sequentially. Bookings climbed 22.2% from a year ago and fell 5.5% from June. Year-to-date shipments are up 7.6% and orders are up 17.2%. (GEA)

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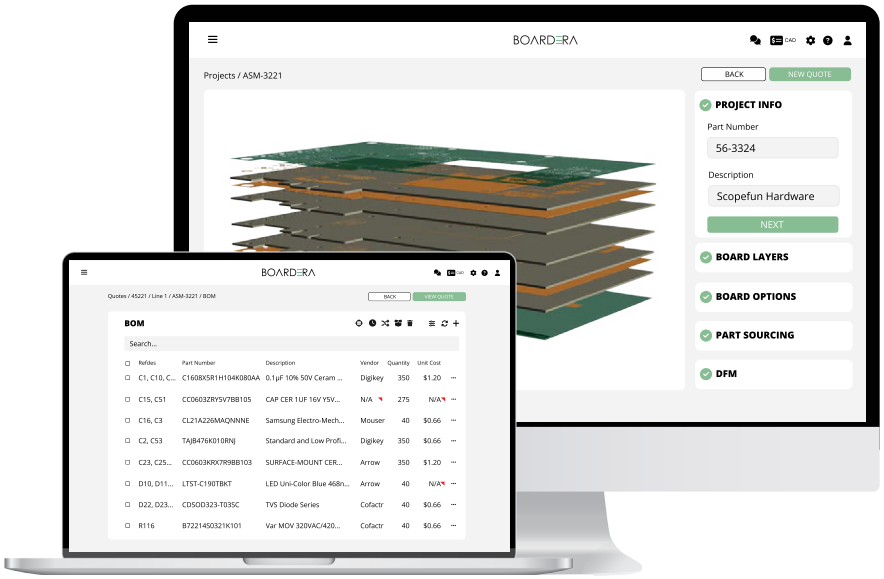

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- Geopolitical impact analysis
- Networking opportunities
- Exhibition access to PCB West (Oct. 1)

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- Al Block, National Instruments
- Chris Hunrath, Insulectro
- Dana Korf, Victory Giant Technology
- Kurt Palmer, Schmoll America
- Sean Patterson, CrossGen AI Community

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ROI

Navigating Variable Costs Amid Tariff Turbulence

Riding out tariff turmoil takes more than watching the balance sheet.

I TOOK A few economics courses in college, but I'm no Adam Smith. And I have predicted the future reasonably accurately, but no one would mistake me for a prophet. What I do understand, however, after nearly 50 years in manufacturing, most spent as a corporate president, is the impact of costs on profitability. More specifically, the impact of dramatic and unpredictable rising costs on a business's ability to thrive, survive or founder.

Cost accountants typically separate expenses into two overall buckets: fixed costs and variable costs. Fixed costs may include items such as insurance, occupancy, benefits and so on. Variable costs include materials, supplies, labor, etc. Within a couple of years in manufacturing, however, I realized that in the real world only a small portion of costs are fixed, and the majority are truly variable. While all costs must be watched, monitored and managed, variable costs are the ones that make or break a balance sheet and income statement.

Under "normal" conditions, managing costs in a business, especially in a manufacturing business, is challenging. Too much scrap adds to costs, just like better-than-expected yield helps reduce them. Unplanned maintenance or a vendor's larger-than-anticipated price hike can and do happen in "normal" times. The offset is to prudently increase pricing by balancing the need for solid margins and satisfying customers with good value and a good product.

But these are not normal times. Ongoing upheaval on the global stage, most notably the economic roller coaster of constantly announced, implemented, rescinded, modified and eventually implemented tariffs, has global trade, and especially manufacturing, confounded and ill at ease.

In electronics manufacturing and especially printed circuit boards, my "A" list of direct variable costs to watch included copper (used in laminate as well as foil and plating nuggets); film; backer foil; drill/route bits; and gold. For the companies I was with, except for gold, *all* these purchased items came from a foreign country.

In a typical year, each and every item would rise in cost. Historically, increases would be in the 3-8% range. Commodity markets drove copper and gold increases, so they saw more price fluctuation, but over time the increases were in line with overall inflation. Since Jan. 1, the trends are notably different, however. Through mid-August, the *pre-tariff* price of gold is up 30%+ and copper is up 20%. While gold may not be directly impacted by tariffs, other raw materials such as aluminum, steel, film and copper, are as of this writing, subject to tariffs ranging between 20% and 100%.

Now, if everyone could count on the most recently announced tariffs, making business decisions, especially ones related to maintaining some reasonable margin, would be relatively simple. That is not the case in the extraordinary world we are in, however. In particular, reading and understanding the tea leaves regarding what, if any, exemptions are allowed is an ongoing and exhaustive exercise.

Managing when virtually every variable cost is in flux is extremely challenging. Decisions must be made with little or inaccurate information. Mistakes, therefore, will be made by just about all businesses. Customers, while aware of the supply-chain pressures, will be fighting to minimize any price increases on *their* orders. And regrettably, some smaller companies, or companies with weak balance sheets, may not survive.

While none of us has prior experience with these tariff swings, in times of upheaval history has shown two actions are essential. First, keep clear, proactive and ongoing communication with all your customers *and* suppliers. Up-to-date knowledge is critical in times of dynamic change. The knowledge may not just be about costs and impacts on pricing. Is an alternative supply flow occurring that may mitigate some of the impact of tariffs but cause longer lead times, and or knowledge about potential material shortages that changing supply routes may cause. Any knowledge you can glean from either supplier or customer – and then pass on to the other – is true value-add and could prevent a costly assumption from exacerbating an already difficult situation.

Second, and equally important, maintain clear, proactive and ongoing communication with all your employees. The team needs to know what is going on, and what management is doing to protect the business and employees' jobs. In times of uncertainty, the rumor mill cranks up, especially when major news outlets are reporting different takes. Providing the workforce with the best available information will lower employee anxiety, helping to stave off mistakes that negatively impact yields.

Times are a-changing. Focus, patience and communication are needed now more than ever.

PETER BIGELOW has more than 30 years' experience as a PCB executive, most recently as president of FTG Circuits Haverhill; peterbigelow@msn.com. He is vice chair of the PCB Management Symposium: Navigating through Turbulent Times, taking place Sept. 30 at PCB West.

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Is Your Inventory Process Wrecking Your Company?

Lessons from a chaotic EMS warehouse.

MANY YEARS AGO, after punching out of a negative-culture electronics manufacturing services company, I interviewed with a smaller, family-run EMS. After numerous phone interviews, I flew to their facility and met with the president and the newly hired COO. After spending some time addressing a Q-and-A session in the president's office, we took a facility tour, starting in the warehouse.

We never made it to the SMT lines before things went off the rails. What happened?

In the warehouse, the team demonstrated a robust incoming inspection process. Well done! But it quickly became clear that chaos ruled the day once kits began to be pulled.

Figure 1. Inventory management makes all the difference in low-margin industries.

Too many partially "dropped kits" awaited parts or line time. Racks were staged among the stockroom aisles, in the walkway and in every corner of the expansive warehouse. Never have I seen so many kits waiting to be pulled into the manufacturing floor.

When asked about details behind their clear-to-build process, they proudly replied that the plan was to "drop $1 million worth of inventory (kits) a day, build $1 million worth of finished goods a day, and to ship $1 million worth of finished goods a day."

Having never heard such a simple edict implemented, all I saw in the warehouse were partial kits with parts missing, poor staging as jobs were stacked side by side awaiting parts or line time and unauthorized personnel walking around with clipboards looking for "their part" on shelves and – shockingly – in other, partial kits. One employee in a smock of a color not used by warehouse personnel actually removed parts from a staged kit and walked them to another.

Sound bad so far? It only gets worse.

As we moved from the warehouse into the SMT area, all I could see were staggered kits waiting line time. On one hand, most of the numerous SMT machines seemed to be in use, but everywhere I looked, all I could see was a "sea of green": racked PCBs.

The president proudly told me this was the beginning of the $1 million-a-day build process. I walked to one rack and found the tracker (back then, it was paper, not digital). It had been on the floor for more than a week.

I couldn't take it anymore. I asked the president if he understood this didn't count as WIP, and my "sea of green" comment didn't refer to green PCBs but rather his cash (dollar bills) idling on a manufacturing floor, as materials sat without a plan to convert them in a timely fashion to finished goods.

Oh, the fight was on. The response was defensive and indignant: I was "slick," and as a salesman, wasn't knowledgeable about industrial manufacturing.

The COO, who had been quietly taking this all in, told the president he would finish the tour with me. After the president huffed off, I asked the COO to walk me out so I could catch a plane home. Instead, he convinced me to finish the tour. Later, over lunch, the COO asked me to join him, as the family was about to be bought out of the business, and he wanted a partner experienced in both business development and in business.

The turnaround we executed will be told another day. My point is to show how a poorly run inventory process can demolish an EMS company. In fact, if we look back at all the failed EMS companies over the past 30 years, the root cause usually boils down to running out of cash and/or depleting new orders. In a low-margin business, cash is king. For businesses like EMS, inventory is by far the largest cash drain in the industry.

How component deliveries are ordered and scheduled, how full kits are dropped (and I agree that a secondary process missing a component but that has a FedEX tracking number and can "catch up" to that kit as it travels through the initial manufacturing stages makes it an in-play kit drop) and how high overhead SMT lines are scheduled to start the manufacturing cycle should be considered if you want a robust inventory management system that optimizes cash

preservation.

While numerous other actions can be taken to conserve cash in the EMS space, this highlights a real-world issue encountered in one of the turnarounds I have been a part of. And, it can be a relatively easy process fix, provided you know what you are doing.

JAKE KULP is founder of JHK Technical Solutions, where he assists OEMs and EMS companies with optimizing demand creation offerings and deciding when and where to outsource manufacturing. He previously spent nearly 40 years in executive roles in sales and business development at MC Assembly, Suntron, FlexTek, EMS, and AMP Inc. He can be reached at jkulp@cox.net.

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DESIGNER'S **NOTEBOOK**

Power Circuits: An Island POV on PCB Design

Draw the map and make it happen.

AS THE SAYING goes, Rome wasn't built in a day.

That doesn't refer to the city-state as we know it, but rather the empire as it was back in the day for my hometown of Augsburg, Germany. Located where the Wertach River joins the Letch River on its way to the Danube, which flows from the Black Forest to the Black Sea. The Danube is a long river starting in Germany and ending at the border between Romania and Ukraine.

You might be wondering what all of this has to do with placing components on a PCB.

The global circulation of water is a little like the distribution of power on the board. There is a source and an endpoint, but it's a closed system. Tributaries may diverge or converge to provide access to cities and towns along the way. Those features are formed naturally by erosion. Similarly, we etch away the copper on a PCB using chemistry. The steering effect is the same in the end.

This is what I picture when looking at a board outline and a cluster of components arrayed on the outside, as in **Figure 1,** for instance. A connector on the board carries the current that drives all the various devices along a path the designer provides. In place of the four capital cities that populate the banks of the Danube, think of the processor, memory, WiFi and sensor(s) as towns linked by a flow of invisible energy.

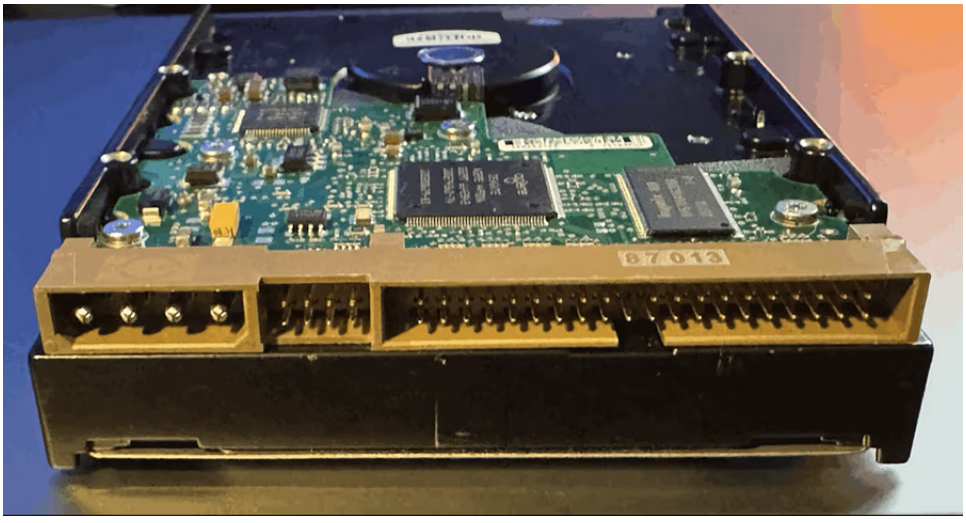

Figure 1. This disk drive shows how the four larger power pins are segregated from the signal pins using one application-specific connector. (Source: Author)

There is a whole different set of cases on the other side of the globe where a single ocean is the main feature. A quick aside: the Hawaiian people have two words to describe directions that make more sense than north, south, east and west. *Makua* refers to "toward the mountain," while *makai* points us to the sea. The chip is the mountain, and every pin must get down to the beach to float away on the current **(Figure 2)**.

Figure 2. The idea that everything flows to the sea is central to a good fan-out strategy. The nucleus of an atom is another good metaphor for the influence of a device on all the dependent components. (Thought you might like a pause on the windward coast.) (Source: Author)

Power: Where the PCB drama lives. Making power connections is a world unto itself. Power integrity has surpassed signal integrity in terms of the amount of detail to consider. It's assumed that the design will deliver on all the point-to-point routing involving the traces. You isolate the victims, especially from the aggressors. Since space is at a premium, it is a balancing act. Most islands don't have wide roads.

It's up to you to know when to use shepherd vias to maintain the sanctuary around the differential pairs and bus lanes. I'll pour the copper and go from there to "massage" the circuit layout to get those ground vias around the bus. Resolving timing budgets is assumed. These are the table stakes for the PCB designer in today's world.

This is for certain: Traces will be routed and then altered. That part was much harder when I started in this business. Now, we can be gentle with an existing trace. If we like it, we can hug it. If we need to make way for improvement, we can shove the existing trace out of the way.

Don't get me started on the dynamic copper that politely steps aside when you come routing through with a new connection. CAD tools have grown along with the complexity of the boards. There's no going back, so familiarity

with the latest features of the tools is useful. The shape-to-shape air gap constraint can be a safety requirement, particularly for higher voltage.

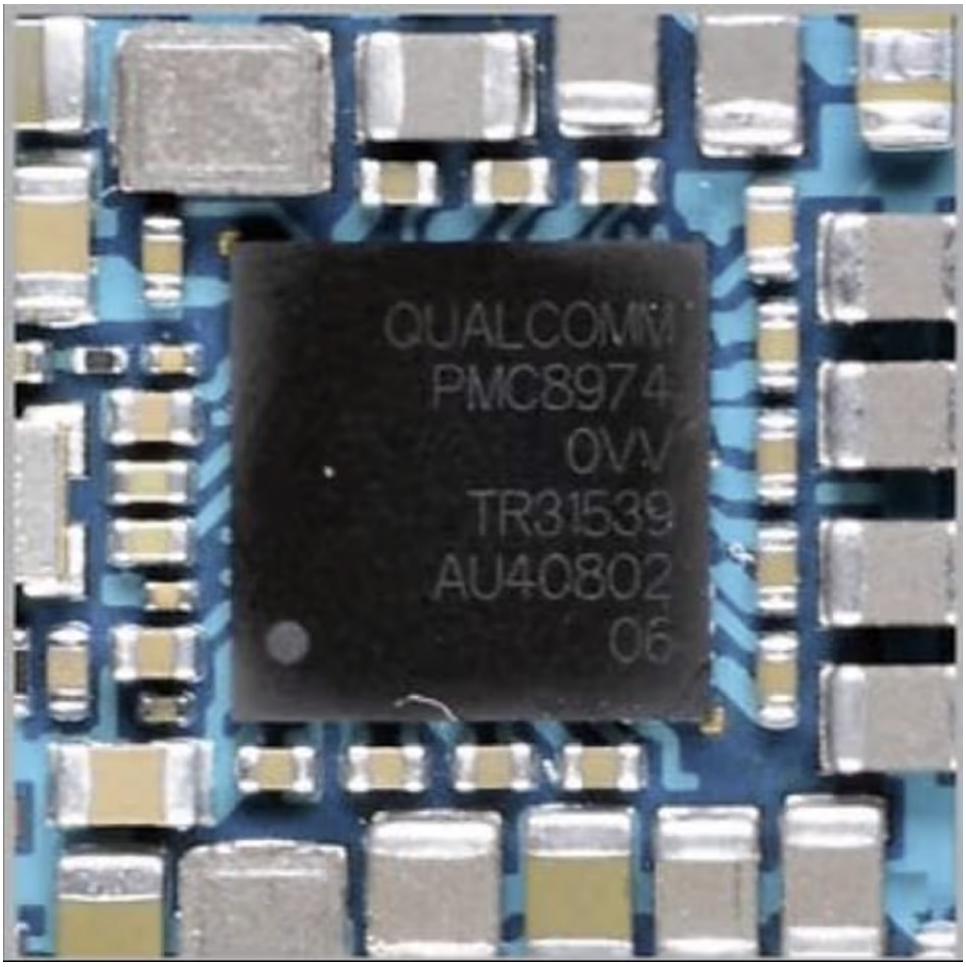

Figure 3. A Qualcomm PMIC with 12 switch-mode power supplies in one package. It appears that the caps are placed before the inductors, although the inductors are the main part of the noise suppression. The series L wants to be first, while the shunt caps can fit there, so you do what you can with what you have. (Source: eBay)

Power management ICs: An SoC's best friend. This is the routing strategy difference between microvias and through-hole vias. The farther into the rings of BGA pins you go, the deeper the vias have to reach in the z-axis to find a path away from the core of the device. The devices receive power from different voltages, and those voltages separate further by function. Numerous regulators are in play, some dialed into the same voltage, such as +3.3VDC. The same 3.3V domain won't be used for all the 3.3V pins. There's often a need for 2.5V, 1.8V and so on, including negative voltages. Splitting it is usually the job of a power management IC, or PMIC, which is a collection of regulators in one package. (More than one package may be needed to feed a SoC.)

Those who have used a switch-mode power supply know they depend on a sizable inductor that is often larger than the individual device. Those inductors more or less surround a PMIC. The inductors and obligatory capacitors make a pair that is always too big to situate adjacent to the output pins, which are always on the outer row of the BGA package.

Instead, they must be moved from the PMIC, forming a row which we connect to the output pins using fan shapes that radiate outward, getting thicker as they approach the inductors. We want them closer for noise abatement, but that's physically impossible. PMICs are a compromise every time.

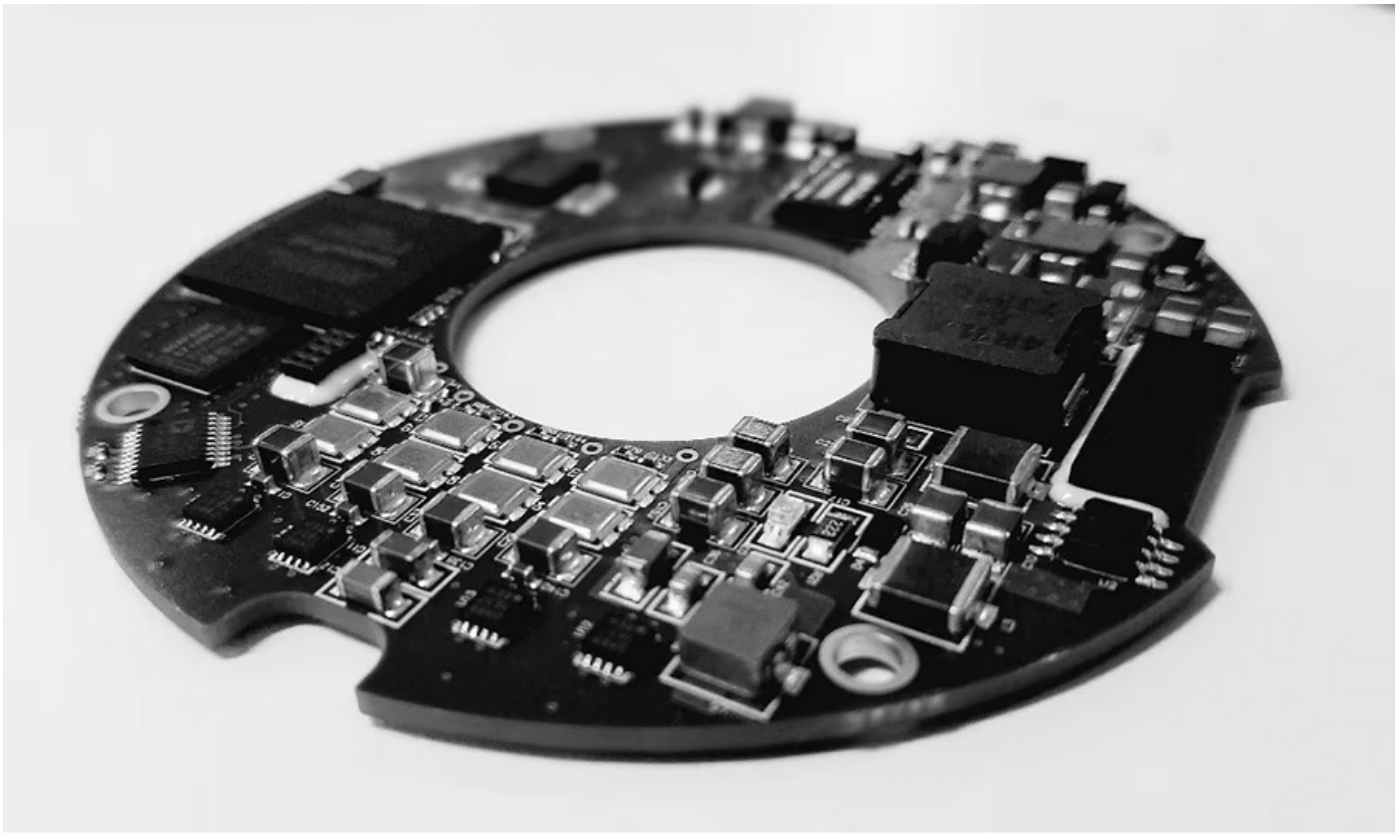

Figure 4. Power and control are on display. This PCBA is charged with rotating a LiDAR sensor 20 times per second while also powering up 32 lasers and 32 detectors for simultaneous location and mapping (SLAM) functionality. Robots, cars and mining equipment are all candidates for electronic spatial awareness. (Source: Author)

I write that power is king because so many things run on battery power, where efficiency is the key factor. It isn't just mobile devices, though. No electronic product wants to hog power. We want to be greener, of course. Doing a bang-up job on the power delivery network (PDN) and executing on the high-priority traces is the green solution all along.

More integration equals greater power demand. The higher integration on today's devices is one of the daunting challenges in PCB design. The processors of that bygone era had a pin-count in the upper four hundreds with a single core to feed. The spacing of the pins was more generous at 2.5mm down to 1mm, or perhaps 0.8mm at worst. We can only dream of working with that much space between pins.

Now, we're dealing with devices with half of that pitch. The struggle with 0.4mm pitch BGAs is real. An IC can still be an island, but now the SoC is doing so many different things, it looks more like a metropolis. A hierarchy of devices will be close to the SoC. Dynamic and static memory devices are first and second in line.

The remainder of the various parts must hope for a location "good enough" to do their thing. Generally, the power domains dominate the decisions. Then there are cases like USB connectors or antenna locations where the components are crowded into a specific part of the board. Those are the outlying islands where contact is limited,

maybe even discouraged.

Thermal considerations drive PDN decisions. Big power means big heat. Laying down a grid of power pins will not be effective without a similar number of vias associated with the ground domain. The ground patch can be the answer, but may also be augmented with a heatsink. The heatsink can be directly attached to the hot spot or a heat pipe can be used to transfer energy to an outboard heatsink. These are your rivers and reservoirs that carry away and contain the thermal exhaust of our hard-working chipsets.

Placement can be quite European with small domains clustered together. Still, each part of the power grid likes to be isolated from the others. The bridges and tunnels of New York provide a colorful map of all the boroughs with minimal interconnects. I tend to see each board as some kind of geography, whether a metropolis or a charming village. Those simulation games always need room for the utility companies, and likewise, the boards want their specific power structures. Draw the map and make it happen.

JOHN BURKHERT, JR. is a principle PCB designer in retirement. For the past several years, he has been sharing what he has learned for the sake of helping fresh and ambitious PCB designers. The knowledge is passed along through stories and lessons learned from three decades of design, including the most basic one-layer board up to the high-reliability rigid-flex HDI designs for aerospace and military applications. His well-earned free time is spent on a bike, or with a mic doing a karaoke jam.

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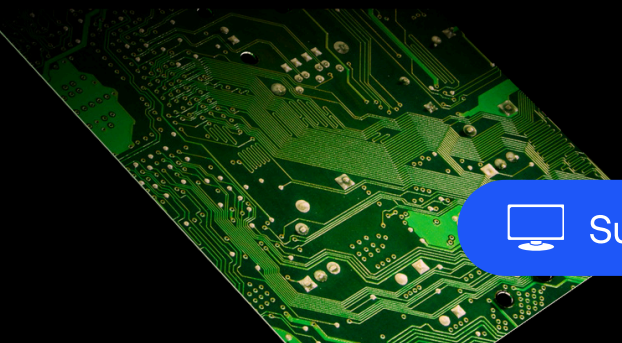

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Navigating Collaboration and Confidentiality in PCB Design

Securing PCB design collaboration through tiered access controls and secure cloud environments.

IN TODAY'S INTERCONNECTED world, engineering teams are increasingly global, collaborating across time zones and continents to bring complex products to market faster. This collaborative spirit, while driving innovation, introduces significant security challenges, particularly in sensitive fields like printed circuit board (PCB) design. Protecting intellectual property and customer data is paramount, demanding sophisticated solutions that balance accessibility with stringent security.

Let's explore the evolving landscape of security in PCB design, from common collaborative scenarios to the critical demands of high-stakes industries.

1. Scenario one: Global teams, one PCB design. Picture this: A single, complex PCB design being developed simultaneously by engineers in Bangalore and Phoenix. Using today's advanced technologies, the project assigns three PCB designers working simultaneously in this same design layout in one eight-hour shift. The advantage of this team approach is that the project gets 24 manhours of effort out of a single eight-hour shift. No one is required to work overtime, leading to a good work-life balance. Then, the team in Arizona hands off this same design to its international cohort: three designers located in a time zone 12.5 hours away.

Adding in their eight-hour shift provides an additional 24 manhours of effort. Then another handoff occurs, sending the in-process PCB design tasks back to the team in Arizona. This back-and-forth process (team effort) continues until the job is complete.

Let's look at this approach from a bird's eye view: In one working business day (a 24-hour period), the team produced a total of 48 manhours of effort on the PCB design layout. This same process is repeated for five straight business days. Now let's do the math.

Based on 48 manhours per day over five days, at the end of that business week the team produced 240 manhours of effort. This multiuser team approach thus produced six weeks (1.5 months) of man effort in one week (five business days). This is a significant reduction in design cycle time, and a game-changer approach to PCB design!

While this distributed model accelerates development cycles, it inherently multiplies security vulnerabilities. Data, including schematics, layouts and component libraries, must traverse international networks, each with varying security protocols and legal frameworks. The challenge lies in ensuring consistent data integrity, controlling access to sensitive design blocks, and preventing unauthorized duplication or modification across diverse geographical

locations and potentially different corporate networks. A single compromised endpoint or an insecure data transfer method could expose the entire design, leading to significant financial losses – or worse, ruined industry reputation.

2. Scenario two: Interdependent PCBs, varying security clearances. Consider a complex system, such as an autonomous vehicle or a sophisticated industrial control unit, comprising multiple PCBs. One team might be designing the powertrain control board, another the sensor fusion module, and a third the human-machine interface (HMI). Each of these PCBs, while part of the same system, may have different levels of design sensitivity or require engineers with specific security clearances. The powertrain board, for instance, might contain highly proprietary algorithms, while the HMI board might be less critical. The challenge here is to enable seamless collaboration on the overall system integration while strictly enforcing granular access control. Think back to scenario #1, a team consisting of US and international personnel, which is not uncommon today. How do you allow an engineer to see the interface specifications for a connected board without granting full access to its highly confidential internal design? Today's advanced EDA tools can assign respective team members to specific project roles and grant access to specific security levels and content. When it comes to addressing and controlling International Traffic in Arms Regulations (ITAR) content and access to specific systems, this is crucial and must be carefully addressed. A breach or compromise of data subject to ITAR can lead to serious consequences, including both civil and criminal penalties, depending on the severity and nature of the violation.

3. Aerospace/military challenges: The gravity of a security breach. For industries like aerospace and defense, the stakes are exponentially higher. A security breach in PCB design for a fighter jet, a satellite or a missile defense system isn't just about intellectual property theft; it can directly compromise national security, endanger lives and erode public trust. Unauthorized access could lead to:

- Theft of critical design specifications, giving adversaries a direct pathway to replicate or counter advanced technologies.
- Introduction of malicious code or design flaws that could lead to system failures, backdoors or performance degradation during critical operations.
- Operational compromise. Exposure of vulnerabilities that could be exploited in real-world scenarios, impacting mission success and personnel safety.

The consequences are catastrophic, making robust security not merely a best practice, but an absolute imperative.

Protecting customer data in a collaborative world. Beyond specific scenarios as discussed in the scenarios above, the overarching question for any organization is: how do you protect customer data and your IP despite the undeniable need for collaborative work? The traditional approach of isolated design environments hinders efficiency, while open collaboration risks exposure. The key is to find a balance where data are accessible only to those who need it, when they need it, and under controlled conditions. This requires a shift from perimeter-based security to a data-centric approach, where the focus is on protecting the data, regardless of their location or the user accessing them. Trust, compliance and reputation are all on the line.

The answer lies in implementing a comprehensive security framework built around two core pillars: a tiered/restricted access and a secured cloud-based environment.

Tiered/restricted access (role-based access control). RBAC involves defining precise roles and permissions for every user within the design environment. Instead of an all-or-nothing approach, access is granted based on the principle of least privilege.

- **Granular permissions.** An engineer might have "read-only" access to a specific sub-circuit, "edit" access to their assigned design block, and "no access" to highly sensitive sections.
- **Version control integration.** Access controls are tied to specific design versions, ensuring that only authorized personnel can make changes or revert to previous states.
- **Audit trails.** Every action is logged, providing a clear, immutable record of who accessed what, when and what changes were made, crucial for compliance and forensic analysis.

Secured cloud-based environment. Moving PCB design collaboration to a purpose-built, secure cloud platform offers significant advantages over traditional on-premises or ad-hoc solutions.

- **Centralized data management.** All design data resides in a single, secure repository, eliminating fragmented data across multiple local drives.
- **Robust encryption.** Data are encrypted both in transit (e.g., via TLS/SSL) and at rest (e.g., AES-256), protecting them from interception or unauthorized access.
- **Scalable security infrastructure.** Cloud providers invest heavily in cutting-edge security measures, including firewalls, intrusion detection systems and regular vulnerability assessments, often exceeding what individual companies can maintain.
- **Compliance certifications.** Reputable cloud platforms adhere to industry-specific compliance standards (e.g., ISO 27001, SOC 2, ITAR for defense), providing a certified secure environment.
- **Multi-factor authentication (MFA).** Adds an essential layer of security, requiring users to verify their identity through multiple methods.
- **Disaster recovery and business continuity.** Cloud platforms offer built-in redundancy and backup solutions, ensuring data availability even in the event of unforeseen disruptions.

Combining granular access controls with the inherent security benefits of a dedicated cloud platform fosters seamless global collaboration while maintaining the highest levels of data integrity and confidentiality. This strategic approach not only protects invaluable intellectual property but also builds customer trust and ensures compliance in an increasingly complex and interconnected engineering landscape.

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

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Materials Innovation Beneath the Surface

Everything is changing in high-performance substrates, from materials technology to engineering priorities.

MATERIALS SCIENCE IS a quiet contributor to high-performance electronics, playing a huge yet mostly unseen role, enabling everything from smartphones and automotive systems to 5G radio access, communication infrastructures and high-performance computing systems. That conventional-looking circuit board, which the user may never see or think about, is anything but ordinary underneath. While ICs sit serenely on the surface, the processes going on inside couldn't happen without the engineering that created the substrate beneath. Demand for improvement is ever-present, and many avenues may be explored in search of a solution.

At microwave and RF frequencies, managing signal energy is a critical imperative that directs substrate-engineering choices. Signal propagation repeatedly realigns the dielectric's molecular dipoles, converting a proportion of the energy into heat that dissipates into the ambient environment. The effect is small, and general-purpose resins that tend to have a large dipole moment cause minimal losses at low frequencies. At GHz frequencies, however, the losses are significant and must be addressed.

Materials science has produced more suitable resins, engineered for low polarization to preserve energy within the signal. Ultimately, PTFE – which has effectively zero dipole moment – has the lowest loss of the materials currently available. Moreover, introducing extra materials to the resin, such as ceramic fillers, gives extra control over properties like thermal performance. Care is needed to ensure particles are of consistent size and evenly distributed throughout the material, however.

As the industry develops extremely low-loss resins, signal integrity degradation due to the glass-fiber reinforcement within the substrate becomes more significant and demands attention. In particular, the feature sizes of high-speed circuits have become comparable to the dimensions of the glass weave in the X-Y plane. Changing the conventional weave to a symmetrical square pattern gives a valuable improvement in signal integrity. An alternative is to remove the glass content altogether, which is driving the development of advanced film materials that can deliver even better high-frequency performance.

Successfully reducing substrate-related losses then shifts attention to the copper traces and – at high signal frequencies – the skin effect that concentrates signal propagation into a small area at the perimeter. Effectively shrinking the conductor's cross-sectional area increases the impedance and, therefore, also signals energy loss. At frequencies above 1GHz, the effective skin depth becomes less than 2.1µm. Adding to the challenge here, the typical surface roughness of the copper traces is by tradition intentionally up to about 6µm to assist adhesion to the prepregs. Because the skin

depth is less than the roughness, high-frequency signals experience scattering as well as high impedance.

To deal with this, the barrier layer – applied to protect and preserve the copper traces in the factory and the field – is the next aspect of the stackup to undergo scrutiny. Dealing with signal issues calls for a smoother, flatter profile than can be achieved through conventional tinning applied using processes like hot-air surface-leveling (HASL) or roller tinning. Gold plating can provide excellent smoothness and ensure solderability, but is expensive due to gold's relative scarcity. Hybrid electroless nickel/immersion gold (ENIG) introduces a nickel barrier about 4-7µm thick, which is needed to prevent the gold from diffusing into the copper, and permits a thinner gold layer. The immersion-gold process results in a deposit thickness of about 0.05-0.2µm, lowering the cost premium. An additional electroless palladium layer may also be deposited (ENEPIG), which permits the gold layer to be thinner still at about 0.03-0.05µm. The palladium brings further advantages, such as increased solder joint strength and preventing the black-pad effect that can result from nickel's phosphorous content.

At microwave frequencies, however, nickel's magnetic properties become problematic and can interfere with circuit function. We could consider thicker gold plating, albeit at a price premium. Nanotechnology may be the answer, as research has shown some success depositing a nano-organic layer to prevent diffusion. The gold plating can also be just a few nanometers thick, deposited using a cyanide-free process.

In the search for the performance improvements needed to build multi-GHz systems, advanced materials science is transforming the board's composition. We will likely need to rely even more heavily on this know-how in the future as we seek solutions that fulfill sustainability goals in addition to satisfying the established design triangle of solvability, manufacturability and performance. Sustainability is the new fourth dimension, squaring that triangle and demanding consideration for the long-term environmental impact of everything we produce. The question for engineers is no longer simply whether we *can* make it, but whether we *should* make it, and how long it can last without harming the future. Investors and innovation funds demand strong answers.

We will find them by improving the constituent materials and production processes, and through proper consideration for end-of-life, including disposal and recyclability, to avoid simply adding to the pile of waste. In the quest to overcome the technical challenges, it's increasingly important to steer away from rare materials or materials that are difficult to recycle. Finding elegant solutions that meet requirements, including preserving our well-being and avoiding negative impacts from production, use and disposal, holds the key to successful innovation in this field.

As we address these issues, we can anticipate future generations of products made possible with advanced PCBs enabled by cutting-edge materials science. Superficially standard, but very far from mundane in every way.

ALUN MORGAN is technology ambassador at Ventec International Group (venteclaminates.com); alun.morgan@ventec-europe.com. His column runs monthly.

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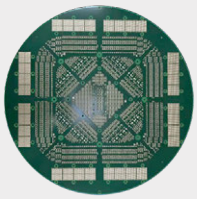

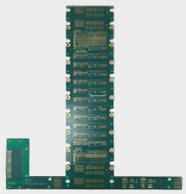

TECHNICAL FEATURES

Max. Layer Count: 46
Max. Panel Size: 620*710mm (24.4*28'')
Max. Board Thickness: 6mm
HDI: 3+N+3, Anylayer
Back Drilling
Max. Through Hole Aspect Ratio: 32:1
Max. Laser Via Aspect Ratio: 1:1
Min. Line Width / Spacing: 30/40 μm
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NTI-100

Tracking Giants: Inside the World's Top PCB Fabricators

From Shenzhen to Southeast Asia: The changing map of PCB production.

by DR. HAYAO NAKAHARA

Accurately investigating the revenues of the world's largest PCB fabricators is confounding: Each year is filled with mergers and acquisitions, and no public records exist for a number of fabricators because they are either privately owned or part of large corporations which do not disclose the revenues of their PCB operations. As years go by, more "estimates" creep in. As a result, the author's confidence in the data diminishes each year. Nevertheless, the NTI-100 continues to reflect the status of the global PCB industry; its size and market trends can be deduced from the fabricators listed.

For clarification, while ranked lists often refer to the 100 largest, in this case, "100" refers to companies with printed circuit board manufacturing revenues over $100 million. A record 159 companies reached that mark in 2024, versus 134 companies in 2023.

As usual, many organizations and companies contributed to this year's rankings, directly and indirectly. The author would like to thank them. The author is entirely responsible for any errors – there are doubtlessly many, unfortunately.

To determine year-over-year growth rates, the revenue of each fabricator in 2023 is converted to US dollars using 2024 exchange rates **(Table 1)**. As a result, most 2024 figures are slightly smaller than the corresponding ones from 2023. For instance, Japanese fabricators experienced pronounced changes due to the severe devaluation of the yen against the dollar. The yen stood at about 110:$1 from 2018 to 2021. If the yen remained in that range, the ranks of Japanese fabricators would be much higher. At the time of this writing, it is oscillating at around 146:1.

Table 1. Average Exchange Rate: Local Currency vs. US Dollar

Currency	2018	2019	2020	2021	2022	2023	2024
China yuan (RMB)	6.615	6.910	6.903	6.402	6.732	7.072	7.196
Japan yen	110.44	109.01	106.77	108.98	131.43	141.70	151.53
Taiwan NTD	30.16	30.93	29.47	27.64	28.98	31.15	31.31
S. Korea won	1,100.80	1,165.70	1,180	1,136	1,292	1,306	1,364
Thai baht	32.320	31.03	31.27	31.76	35.06	34.77	35.29
Singapore dollar	1.349	1.364	1.38	1.333	1.379	1.343	1.336
Malaysia ringgit	4.035	4.12	4.203	4.11	4.40	4.56	4.58
Vietnam dong	23,001.08	23.202.59	23.20	22,879	23,121	23,815	25,060
Philippine peso	52.700	50.82	49.62	49.94	54.52	55.61	51.30
Indonesia rupiah	14,236.00	13,798.61	14,559.25	14,195.00	14,851.00	15,238.00	15,861
Canada dollar	1.296	1.327	1.34	1.224	1.302	1.35	1.37
Indian rupee	68.430	70.39	71.12	73.36	78.01	82.57	83.68
Mexico peso	19	19.25	21.50	20.13	20.12	17.74	18.30
Russia ruble	62.78	64.69	72.412	73.12	76.495	85.31	85.82
Switzerland franc	1.002	0.99	1.38	0.967	0.99	0.90	0.88
UK pound	0.75	0.78	0.78	0.721	0.812	0.805	0.782
Euro	0.844	0.894	0.868	0.839	0.952	0.924	0.924

NTI summary from exchangerates.com as of Jan. 1, 2024

Table 2 shows the 30 largest fabricators in 2024. Some companies achieved very high growth, such as Shennan, WUS, BH Flex, Victory Giant, Gold Circuit, Nitto Denko and Hongxin Electronics. Only two non-Asian fabricators are in the Top 30: TTM Technologies and AT&S. With their new plants, they will gain in the rankings, although most Asian fabricators in this list have invested heavily in new plants in Southeast Asia, which began to bear fruit gradually in 2025.

Table 2. NTI-100 2024, 1-30

Rank	Company	Local Name	Nationality	2023	2024	% Change
1	Zhen Ding Technology	臻鼎科技	Taiwan	4,893	5,483	11.3%
2	Unimicron	欣興電子	Taiwan	3,323	3,685	10.9%
3	DSBJ	東山精密	China	3,232	3,446	5.6%
4	Shennan Circuits	深南電路	China	1,880	2,488	32.4%
5	Mektec	メクテック	Japan	2,379	2,448	3.1%
6	TTM Technologies	TTM Technologies	US	2,232	2,443	10.9%
7	Compeq	華通電脳	Taiwan	2,142	2,314	8.0%
8	Tripod	健鼎科技	Taiwan	1,880	2,102	12.3%
9	WUS Group (TW+CN)	楠梓電子(滬士電子)	Taiwan	1,370	1,956	42.8%
10	Kyocera	京セラ	Japan	2,076	1,920	-7.5%
11	Kinwong	景旺電子	China	1,495	1,759	17.7%
12	AT&S	AT&S	Austria	1,671	1,721	3.0%
13	BH Flex	베에이치플렉스	S. Korea	1171	1579	34.8%
14	Kingboard PCB	建滔集団	China	1,458	1,534	5.2%
15	SEMCO	삼성전기	S. Korea	1,259	1,492	18.5%
16	Victory Giant	勝宏科技	China	1,102	1,491	35.3%
17	Meiko	メイコー	Japan	1,185	1,365	15.2%
18	HannStar Board	瀚宇博徳	Taiwan	1,372	1,330	-3.1%
19	Ibiden	イビデン	Japan	1,260	1,301	3.3%
20	Gold Circuit (GCE)	金像電子	Taiwan	960	1,239	29.0%
21	Young Poong Group	영풍그룹	S. Korea	1,424	1,123	-21.1%
22	AKM Meadville	安捷利美維	China	1,013	1,100	8.7%
23	Nanya PCB	南亜電路	Taiwan	1,349	1,031	-23.6%
24	Kinsus	景碩科技	Taiwan	857	975	13.8%
25	Simmtech	심텍	S. Korea	764	903	-1.9%
26	Nitto Denko	日東電工	Japan	690	895	29.7%
27	Suntak	崇達科技	China	802	872	8.8%
28	Flexium Technology	台群科技	Taiwan	1,046	844	-19.3%
29	Hongxin Electronics	厦門弘信電子科技	China	483	816	58.9%
30	Shinko Electric Industries	新光電気工業	Japan	843	810	-4.0%
	Top 30 Total			**47,611**	**52,465**	**10.2%**

In US$ millions.

Source: N.T. Information Ltd., July 2025

Tables 3 to **7** show the remainder of the 159 fabricators with revenues of $100 million or more in 2024.

Table 3. NTI-100 2024, 31-60

Rank	Company	Local Name	Nationality	2023	2024	% Change
31	Shenzhen Fastprint	深圳興森快捷電路	China	745	808	5.8%
32	Olympic	世運電路科技	China	628	704	11.1%
33	Sumitomo Elect Ind.	住友電気工業	Japan	610	702	15.1%
34	LG Innotek	LG이노텍	S. Korea	851	695	-18.3%
35	Fujikura	フジクラ	Japan	566	683	20.7%
36	Daeduck Electronics	대덕전자	S. Korea	667	654	-1.9%
37	Shengyi Electronics	生益電子	China	455	651	43.2%
38	Mutara Manufacturing	村田製作所	Japan	598	645	7.5%
39	Aoshikan (ASK PCB)	奥士康	China	602	634	5.5%
40	CMK	日本シーエムケー	Japan	598	630	4.9%
41	ISU Petasys	이수페타시스	S. Korea	495	614	24.0%
42	Unitech	燿華電子	Taiwan	478	592	23.8%
43	Taiwan Techvest (TPT)	志超科技	Taiwan	605	566	-6.5%
44	Dynamic Electronics	定穎電子	Taiwan	502	566	12.6%
45	SI Flex	에스아이플렉스	S. Korea	507	548	8.1%
46	Sun & Lynn	深聯電路	China	404	537	11.0%
47	Chin Poon	敬鵬工業	Taiwan	535	522	-2.4%
48	Delton Technology	広州広合科技	China	372	519	39.4%
49	Ellington	依頓電子	China	441	487	10.4%
50	Kingshine	広東科翔電子	China	412	472	14.6%
51	Founder PCB	方正印刷電路	China	420	470	11.9%
52	Bomin Electronics	博敏電子	China	405	454	12.1%
53	China Eagle (CEE)	中京電子	China	365	407	11.8%
54	Apex International	泰鼎電路	Taiwan	403	398	-1.2%
55	CCTC	汕頭超声印製板	China	355	386	8.8%
56	Sanmina	Sanmina	US	340	380	11.8%
57	KCE	KCE Electronics	Thailand	411	376	-8.5%
58	Red Board	紅板	China	327	375	15.0%
59	DAP	디에이피	S. Korea	295	358	21.5%
60	Wuzhu	五株科技	China	357	340	-5.0%
	Total			**14,749**	**16,173**	**9.7%**

Source: N.T. Information Ltd., July 2025

Table 4. NTI-100 2024, 61-90

Rank	Company	Local Name	Nationality	2023	2024	% Change
61	Guangdong Junya	広東駿亜電子	China	337	326	-3.3%
62	Gul Technology	Gul Technology	Singapore	377	322	-11.9%
63	Ichia Technology	毅嘉科技	Taiwan	274	304	11.3%
64	Lincstech	リンクステック	Japan	264	304	15.2%
65	Transtech	江蘇伝芸科技	China	293	293	0.0%
66	Guangdong XD Group	広東興達(佳康集団)	China	285	285	0.0%
67	Maruwa	マルワ	Japan	244	285	16.8%
68	Summit Interconnect	Summit Interconnet	US	240	280	16.7%
69	ASE	日月光	Taiwan	260	260	0.0%
70	Somacis	Somacis	Italy	241	257	6.3%
71	ACCESS	珠海越亜半導体	China	238	250	5.2%
72	AdvancedPCB	AdvancedPCB	US	200	250	25.0%
73	Onpress	安柏電路	China	204	239	17.2%
74	Career Technoogy	嘉聯益科技	Taiwan	314	232	-26.1%
75	Toppan Printing	凸版印刷	Japan	218	224	2.8%
76	Camelot PCB	金湶電路科技	China	185	222	20.2%
77	FICT	エフアイシーティー	Japan	195	218	11.8%
78	Shenzhen Sunshine	深圳明陽電路	China	225	217	-3.7%
79	Würth Elektronik	Würth Elektronik	Germany	140	215	-3.6%
80	Kyoden	キョウデン	Japan	213	211	-0.9%
81	Amphenol PCB	Amphenol PCB	US	190	210	10.5%
82	SZ Jove Enterprize	深圳中富電路	China	172	202	17.2%
83	Shihui Fushi	四会富仕電子科技	China	183	196	7.5%
84	Taihong Circuit Industry	台豊印刷電路工業	Taiwan	217	194	-10.6%
85	Shirai Denshi	シライ電子	Japan	190	193	1.6%
86	Jiangxi Union Gain	江西聯益電子科技	China	178	189	6.0%
87	Forewin FPC	福菜盈電子	China	126	182	44.6%
88	Jia Li Chuang	先進電子(珠海)	China	180	180	0.0%
89	Changzhou Auhong	常州澳弘電子	China	150	180	20.0%
90	Top Reach	深圳至誠合電子	China	179	179	0.0%
Total				**6,712**	**7,099**	**5.8%**

Source: N.T. Information Ltd., July 2025

Table 5. NTI-100 2024, 91-120

Rank	Company	Local Name	Nationality	2023	2024	% Change
91	Minzhenhong	広東明正宏電子	China	147	179	21.6%
92	Leader-Tech	上達電子	China	163	178	9.4%
93	Ji'An Munkan	吉安満坤科技	China	169	176	4.2%
94	Kyosha	京写	Japan	162	173	6.8%
95	Palwonn	競華電子	Taiwan	113	167	47.8%
96	Aikokiki	愛工機器	Japan	148	166	12.5%
97	NBC	エヌビーシー	Japan	153	165	7.8%
98	Glorysky	恵州市特創電子	China	153	164	7.1%
99	APCB	競国実業	Taiwan	191	164	-13.9%
100	Sete Potevio Sei	中電科学普天(旧杰謇)	China	167	160	-4.1%
101	STEMCO	스템코	S. Korea	201	158	-21.3%
102	Tianjin Pulin	天津普林	China	90	157	74.6%
103	SZ Konka PCB	深圳康佳電路	China	152	156	2.2%
104	Schweizer Electronics	Schweizer Electronics	Germany	151	156	3.3%
105	Sichuan Ruijienxin	四川省杰鑫電子	China	119	154	29.9%
106	Synopex		S. Korea	172	154	-10.3%
107	Kunshan Huanxing Grp	昆山華新電子集団	China	147	153	3.8%
108	Jiangxi ZLE	江西中絡電子	China	147	151	3.1%
109	Hyunwoo	현우	S. Korea	174	151	-13.1%
110	PCB Technology	PCB Technology	Israel	130	150	15.4%
111	Longteng Electronics	湖北龍騰電子	China	109	149	36.5%
112	Forewin FPC	福菜盈電子	China	194	149	-23.4%
113	Haesung DS	해성디에스	S. Korea	179	147	-17.7%
114	KS Wangyuangtong	昆山万源通電子	China	137	145	6.0%
115	Daisho Dennshi	大昌電子	Japan	160	145	-10.0%
116	Jinagsu Difeida	江蘇迪飛達電子	China	152	144	-4.9%
117	SZ Xinyu Tengye	深圳新宇騰跌電子	China	137	144	5.5%
118	Jinagxi Xushen Electronics	江西旭昇電子	China	135	144	6.5%
119	Fuchangfa	信豊福昌発電子	China	124	143	15.1%
120	Welgao	江西威尔高電子	China	114	142	24.2%
Total				**4,490**	**4,684**	**4.3%**

Source: N.T. Information Ltd., July 2025

Table 6. NTI-100 2024, 121-150

Rank	Company	Local Name	Nationality	2023	2024	% Change
121	Yongxinglong Electronics	黄石永興隆電子	China	118	142	20.3%
122	Xusheng Electronics	江西旭昇電子	China	137	140	2.2%
123	Brain Power	欣強科技	Taiwan	173	139	-19.7%
124	First Hi-Tech	高技企業	Taiwan	132	138	4.5%
125	Zejiang Leuchtek	浙江羅奇泰克科技	China	107	137	28.0%
126	Liang Dar	良達科技	Taiwan	155	134	-13.5%
127	Song Shan Electronics	松山電子	Taiwan	139	133	-4.3%
128	NTK	日本特殊陶業	Japan	144	129	-10.4%
129	Ronghui Group	江西栄暉電子	China	84	133	58.3%
130	New Flex	뉴플렉스	S. Korea	126	132	4.8%
131	Dongguang Hongyuen	東莞康源電子	China	114	131	14.9%
132	Meizhou Ding Tai	梅州鼎泰電路板	China	126	128	1.6%
133	Xiehe Electronics	江蘇協和電子	China	104	128	23.1%
134	Stariver (Galaxy)	深圳市星河電路	China	124	127	2.4%
135	TLB	티엘비는	S. Korea	130	125	-3.8%
136	Jiangsu Suhhang	江蘇蘇杭電子集団	China	130	125	-3.8%
137	Shenzhen QD Circuit	深圳強達電路	China	92	124	34.8%
138	SDG Precision	三德冠精密	China	113	123	8.8%
139	Longyu PCB	龍宇電子(梅州)	China	110	123	11.8%
140	Linangjinchen	聯錦成科技	China	111	123	10.8%
141	Trustech	深圳全成信電子	China	102	123	20.6%
142	Gangzhou Kingshun	贛州金順科技	China	133	119	-10.5%
143	FTG	Firan Technology	Canada	99	118	19.2%
144	Jiangxi Asurung	江西愛升精密電路	China	92	115	25.0%
145	Xingzhinguang Circuit	恵州市星之光科技	China	113	115	1.8%
146	Xiamen Guangpu Elec.	光苒電子股份	China	111	113	1.8%
147	CHPT	中華精測科技	Taiwan	99	110	11.1%
148	Oki Printed Circuit	沖PCB	Japan	97	110	13.4%
149	HT Circuit	永捷電子	China	95	110	15.8%
150	SZ Jing Cheng Da	深圳精誠達電路科技	China	93	110	18.3%
	Total			**3,503**	**3,757**	**7.3%**

Source: N.T. Information Ltd., July 2025

Table 7. NTI-100 2024, 151-159

Rank	Company	Local Name	Nationality	2023	2024	% Change
151	Gangzhou Beyond PCB	贛州超跌	China	101	109	7.9%
152	Lienchuang Electronics	深圳市聯創電子	China	74	108	45.9%
153	Tonglin Anbo Circuit	銅陵安博電路板	China	98	109	11.2%
154	Kunshan Huaxing	昆山華新電子	China	98	102	4.1%
155	Inno Circuits Ltd.	四川英創力電子	China	97	102	5.2%
156	Sichuan Intronics	四川英創電子	China	96	102	6.3%
157	Theme Int'l Holdings	栄暉集団	China	110	102	-7.3%
158	Dingcheng Electronics	深圳鼎成億鑫電子	China	77	103	33.8%
159	Concord Electronics	江蘇協和電子	China	84	101	20.2%
Total				**835**	**938**	**12.3%**

Source: N.T. Information Ltd., July 2025

Table 8 consolidates the NTI-100 fabricators' production by region. These data are summarized to show the relative "strength" of each region, which in most cases means "country." One aside: China treats Taiwan as one of its provinces. Whether it is an independent country or a region, for this list, Taiwan is tabulated separately.

Table 8. NTI-100 2024 List Summary by Region

Region	No. Entry	2023 Output	2024 Output	2024/2023	Share
China	83	26,320	30,077	24.3%	35.3%
Taiwan	26	23,732	25,588	7.8%	30.0%
Japan	22	12,997	13,763	5.7%	16.2%
S. Korea	15	8,429	8,837	4.9%	10.4%
N. America	6	3,301	3,681	11.5%	4.3%
Europe	4	2,203	2,349	6.6%	2.8%
S.E.A.	2	788	698	-11.4%	0.8%
Middle East	1	130	150	15.7%	0.2%
Total	**159**	**77,900**	**85,143**	**9.3%**	**100.0%**

In US$ million

Note: Total of China, Taiwan, Japan and S. Korea amounts to 92% of 8 regions.

Source: N.T. Information Ltd., July 2025

Since these figures reflect the leading fabricators, the percentage share closely represents the production value created by the top fabricators in their own country *and* abroad.

Global PCB Output and 'Country' Shares

China's PCB output was about $56.4 billion in 2024 **(Table 9)**, of which approximately $16.7 billion was produced by Taiwan fabricators. The output in China by other foreign fabricators is estimated to be about $5 billion (major contributors include TTM Technologies, AT&S, Mektec, Meiko, CMK, Gul Technology, etc.). That leaves about $34.7 billion made in China in 2024 by domestic companies.

Table 9. World PCB Production by Region

Region	2023	2024E	2025F	2024 Share
N. & S. America	3,210	3,340	3,600	3.5%
Europe	1,980	1,985	2,000	2.1%
Middle East & Africa	200	240	260	0.2%
Russia*	250	260	270	0.2%
West Total	**5,640**	**5,825**	**6,130**	**6.1%**
China	54,000	56,400	61,470	59.1%
Taiwan	7,650	8,075	8,700	8.5%
Japan	7,785	8,220	8,460	8.6%
S. Korea	7,760	8,090	8,560	8.5%
Thailand	3,050	3,600	4,820	3.8%
Vietnam	2,900	3,300	3,960	3.5%
Other Asia	1,150	1,320	1,580	1.4%
India	560	580	620	60.0%
Asia Total	**84,855**	**89,585**	**98,170**	**93.9%**
World Total	**90,495**	**95,410**	**104,300**	**100.0%**

*Wild guess

$8.5B to $9B from PCBA & EMS by PCB fabricators

In US$M at 2024 exchange rates

Source: N.T. Information Ltd., July 2025

China is "renting" places for foreign transplants. PCB output in Southeast Asia will grow by leaps and bounds over the next several years, mostly from foreign transplants.

Table 10. 2024 PCB Output by Nation

Nation	2024 Output (US$B)	Share
China	34,700	36.4%
Taiwan	26,650	27.9%
Japan	14,780	15.5%
S. Korea	10,120	10.6%
US	4,200	4.4%
Austria	1,840	1.9%
ROW	3,120	3.3%
Total	95,410	100.0%

Source: N.T. Information Ltd., July 2025

After six months of work, very intensive in June and July, the author is tired of looking at these tables. One mistake means rebuilding all the tables. It's nerve-racking. Readers can probably understand the feeling, since the first NTI-100 article was produced in 1999, with subsequent lists every year for a quarter century.

The primary reason for investigating the world's top PCB fabricators is to estimate global PCB production. By analyzing data and understanding the nationality of the fabricators, it was thought that a reasonable assessment of

global production and production by country could be made, given the author's (decent) knowledge of the locations of the world's top PCB fabricators. This study of global PCB production began in the mid-1980s with the IPC TMRC, headed by Ray Pritchard, then IPC's executive director.

As the years went by, the list of top fabricators grew, as did the production locations. As a result, it is harder every year to collect accurate data. The most valuable source of data comes from the Taiwan Printed Circuit Association (TPCA) and China Printed Circuit Association (CPCA), coupled with the author's connections. When the World Electronic Circuits Council (WECC) data are considered, however, the author feels that CPCA reflects about 75% of China's actual production. China is, of course, the largest national producer (59% share) in the world. In CPCA's defense, it is nearly impossible to get data from the 1,500 fabricators operating in China, including foreign-owned companies.

Of the estimated $56.4 billion PCB production in China, domestic Chinese companies made up $34.7 billion (62%), meaning foreign-invested fabricators' share in China is substantial (38%). In the 1990s and through the 2000s, many foreign fabricators built plants in China and employed residents. These transplants became a valuable source of PCB technologies in China. Many prominent Chinese PCB fabricators were launched using knowledge obtained from these foreign transplants, leveraging expertise not only in technology and manufacturing but also in management.

Glorious China, yes, but a dichotomy is taking place there. Shenzhen once had more than 400 PCB fabricators. Today, that number is probably less than half. Recent news indicates that more than 20 PCB bankruptcies have occurred in China in recent months, including Wuzhu Technology's Dongguan plant, which Wuzhu Shenzhen purchased from bankrupt Taiwan fabricator Yashin and renamed Wushu Dongguan. PCB fabricators with financial muscle and technology built plants outside Shenzhen, many in Jiangxi Province. Towns where these new plants were built were inconvenient to reach from Shenzhen or Hong Kong. Ji'An, for example, where Kinwong, Red Board, Shengyi Electronics and many more have large plants, was hard to reach. The nearby town of Jingangshan had the only regional airport accessible from Shenzhen, a once-daily flight. Now, high-speed trains take passengers from Shenzhen to Ji'An in two hours. (Jingangshan is the city where Mao Zedong started the infamous "Long March.")

China became the manufacturing hub of the world. That means, the most important supply chain was built there, and the global firms dependent on this supply chain started to worry about this one-sided dependence. This concern applied not only to end-products but also extended to a large portion of the components needed to build these products, including PCBs, which are supplied from China. The Covid pandemic stranded the Chinese supply chain – badly. Then, firms that were previously dependent on China began to pressure their suppliers to relocate elsewhere. The PCB industry is particularly keen on this strategy.

Still, relocation talks date back as far as the early 2000s. "Chindia," meaning from China to India, was a term created by journalists who knew the strain of overreliance on China. Realizing India was too immature to absorb vast manufacturing operations from China, "Chindia" became "China+1." The "+1" can be anywhere, India included. From the viewpoint of the PCB industry, Southeast Asia became the favorite "+1" location since India's PCB infrastructure remains poor: essential equipment and materials must still be imported, with no local supply capability in sight.

In the past two years, more than 60 PCB fabricators, mostly from Taiwan and China, have built or are building plants in Thailand, Malaysia and Vietnam, causing a bit of a problem in recruiting local workers and engineers. The quick

solution is to relocate workers and engineers from their home countries, perhaps temporarily, until the plants run smoothly. The same situation occurred in China in the 1900s and 2000s.

But while that practice is being followed, the Thai government is responding to cap it. It enacted a law that prohibits these transplants from hiring more than 30% of "management" from their home countries. The definition of "management" is loose, however, and it seems this is mostly a government effort to encourage foreign investors to hire more local managers, whatever "managers" means. Thailand lacks a sufficient domestic workforce knowledgeable in PCB manufacturing and the country is going to be a battleground for Taiwanese and Chinese fabricators looking to secure experienced locals. Because of this situation, the cost of PCB production in Thailand seems to be higher than in China for the same product and quantity (for the time being, anyway).

Infrastructure is being built rapidly in Thailand. Major copper-clad laminate (CCL) fabricators from Taiwan, ITEQ and TUC, built plants near their customers. Kingboard Chemical added a new CCL plant, as did Shengyi Technology. Elite Material (EMC) chose Malaysia, in front of TTM Technologies' Penang plant. MKS-Atotech is building a chemicals plant. Topoint built a drill bit manufacturing plant within a stone's throw of Gold Circuit Electronics in an industrial park in Pranchinburi, home to many PCB fabricators, including CMK, Dynamic, STARTeam, Founder (iFound), with more coming. ITEQ's CCL plant is in Rojana Industrial Park, also in Prachinburi Province, 10 minutes from Gold Circuit.

In Thailand, the only substantial domestic PCB fabricator is KCE Electronics. Provided everything goes well, Thailand will produce more than $10 billion worth of PCB yearly in five to seven years, nearly all by transplants. A similar situation exists in Vietnam.

Vietnam has been dominated by Japanese and South Korean fabricators, now joined by a few Taiwanese (Tripod and T.P.T) and Chinese (Victory Giant). Malaysia has a few local PCB fabricators, but its strength is nowhere near that of the newcomers: TTM Technologies, AT&S, GBM, Simmtech, Sunshine, etc. Singapore has three PCB fabricators: Sanmina, Lincstech (now part of GBM) and one local, Additive Circuits. Toppan Electronics is building a new IC package substrate plant in Singapore with Broadcom's participation, investing about $350 million. The only large PCB operation in the Philippines is Ibiden Philippines. Other small fabricators in the Philippines are essentially all Japanese-owned.

What the author suggests is that Southeast Asia will produce $18 billion to $20 billion worth of PCBs, maybe by 2030-32. Chinese PCB fabricators are still investing in China. Taiwanese fabricators' investment is concentrated in Thailand, however. As such, their growth will come from Thailand. The only growth in Japan and South Korea is coming from IC package substrate investments. On a global level, North America and Europe seem to be falling further behind, although some individual fabricators are striving, such as TTM Technologies and AT&S.

The 2030 rankings will be interesting (assuming the NTI-100 series is still published then). One thing is certain: Taiwan and China will continue to dominate PCB production, and despite continued bankruptcies, more names will appear in future NTI-100 lists.

DR. HAYAO NAKAHARA is president of N.T. Information and a contributing editor to PCD&F/CIRCUITS ASSEMBLY; nakanti@yahoo.com. He is the world's foremost authority on the worldwide printed circuit board market.


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SOLDERING

Cold Solder Joints

Why they occur, and what to do about them.

by AKBER ROY

Soldering, the process of joining two or more metals through the application of heat, has been around for millennia, and is the primary means of making physical and electrical connections between the leads of electronic components and the metal pads on a printed circuit board. To make the connection, the solder must be molten so that it can wet the metal surfaces that need to be connected. When solder cools enough to solidify, it forms a joint, making the connection. Reaching a specific temperature (the precise temperature varies depending on the alloy used) is essential, however, because unless the solder melts to its liquidous form, it cannot wet to the mating surfaces. Solder that doesn't melt, even if present, is referred to as "cold." Even if the solder joint appears fine visually, it lacks the strength and integrity of a proper joint and could fail.

Here, we focus on understanding cold solder joints, what causes them, and design and manufacturing practices to prevent them.

Solder is simply an alloy, composed usually of tin with other metals, depending on the desired properties, melting point or other characteristics. It can contain copper, silver, lead, antimony, indium, bismuth or other metals. Regardless of the attachment process used – surface mount technology (SMT) or through-hole technology (THT) – soldering is integral to the assembly process.

PCB assemblers use various methods to apply solder to the board, including wave soldering, reflow soldering, selective soldering and hand soldering. Despite the utilized method, the formation of cold solder joints is a common issue and can significantly impact the performance and integrity of the PCB and increase assembly costs, in part through the need for rework.

A cold solder joint occurs when the solder fails to melt properly and bond with the components as intended. This can result in weak or unreliable connections that may break or cause malfunctions in the electronic device. Cold solder joints typically have a dull, grainy appearance instead of the shiny, smooth finish of a well-formed solder joint **(Figure 1)**.

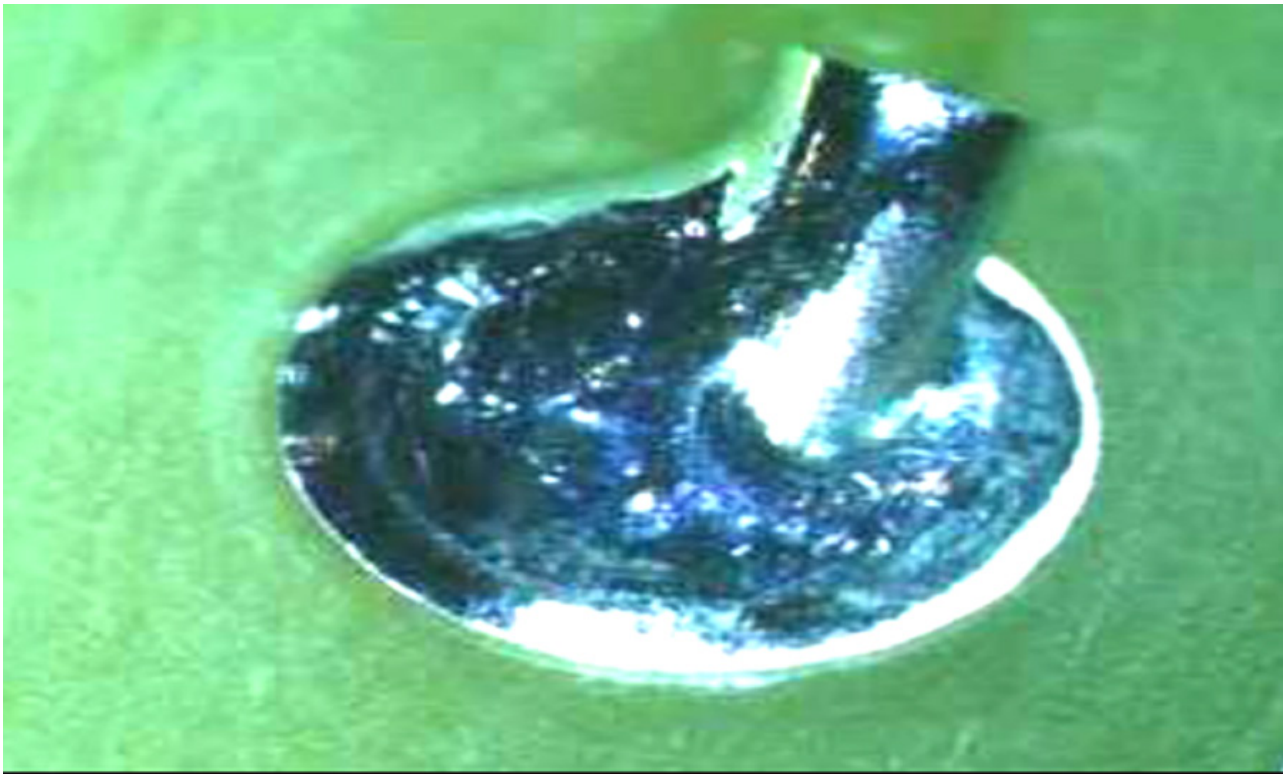

Figure 1. Cold solder joints tend to look dull and grainy instead of shiny and smooth.

Many perfectly good solder joints are not necessarily shiny, depending on the solder alloy used. With a cold solder joint, the solder does not completely melt, or it does not flow sufficiently to cover the component lead and PCB pad. The connection will not be as strong and conductive as necessary for reliable circuit operation.

Causes of cold solder joints. Cold solder joints form for a number of reasons during the soldering process:

- **Insufficient heat.** If the PCB is not preheated sufficiently, the components and PCB pads may be unable to reach an adequate temperature for soldering. This can hinder solder from flowing correctly, leading to cold solder joints. The temperature in the preheating zone must be precisely regulated.
- **Inconsistent solder wave height.** The flow and height of the solder wave in a wave soldering machine should be uniform for effective soldering. A low wave height can prevent solder from making good contact with all component leads, resulting in cold joints or insufficiencies or "starved" joints. A stable wave height ensures that all leads are equally coated with molten solder.
- **Excessive soldering speed.** If the PCB travels through the solder wave too rapidly, the solder will not have sufficient time to flow and adhere to the component leads. Excessive soldering speeds can cause insufficient solder joints.
- **Oxidized or dirty pads/leads.** Dust, oil or oxidation on the component leads or PCB pads can hinder solder from sticking or wetting. Cleaning the pads and leads thoroughly before soldering is necessary to form strong joints.
- **PCB design error.** Without anticipating the impact, PCB designers often use a direct connection when electrically connecting the PTH component holes with large copper shapes on inner layers. During wave

soldering, molten solder rises in hole barrels, during which time the heat of the molten solder repeatedly dissipates into the inner layers. A direct connection **(Figure 2)** increases the rate of heat dissipation that limits the rise of molten solder paste in the PTH barrel and ultimately results in a cold and weak solder joint.

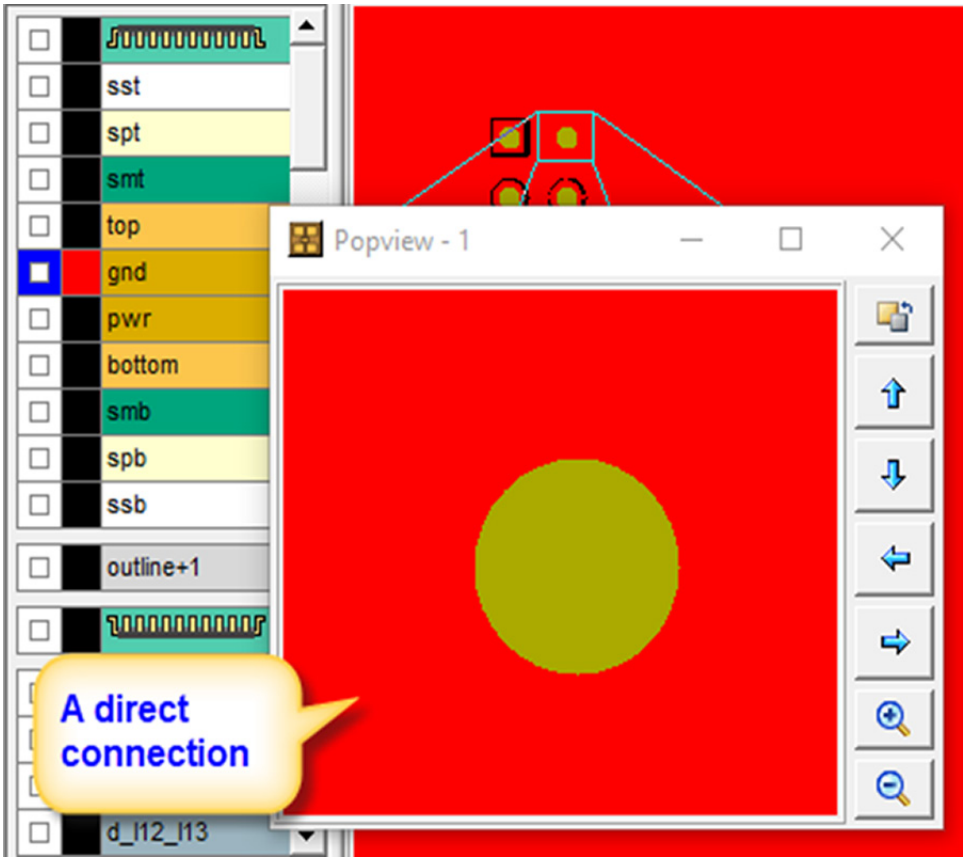

Figure 2. A direct connection from the PTH component holes on innerlayers increases the heat dissipation rate and causes cold joints.

Preventive Measures

Cold solder joint prevention during wave soldering involves paying close attention to detail throughout the process, from designing the PCB through post-soldering inspection. To mitigate these issues, several preventive measures can be implemented to ensure optimal soldering results:

- **Optimize preheating.** Ensure the preheating area is adjusted to the right temperature and there's time to enable the PCB for heating to the ideal soldering temperature. This reduces thermal shock and enables the solder to flow with ease.
- **Ensure consistent solder wave height.** Check the solder's wave height regularly and maintain it appropriately. The wave height should be calibrated so that component leads are fully submerged in the molten solder and do not result in splashing or bridging.
- **Control soldering speed.** Adjust the conveyor speed as the PCB travels through the solder wave to ensure components have sufficient time to develop good contact with the solder. Excessive speed may cause an inadequate solder connection, while a pace too slow can result in too much solder deposition and problems

with component placement.

- **Use high-quality solder and flux.** Use the highest-quality solder with a suitable flux so that the solder melts evenly and forms reliable bonds. Poor-quality solder or dirty flux can prevent good soldering and result in poor connections.
- **Best design practices.** During PCB design, when connecting PTH component holes with copper shapes of GND or power layers, always use a thermal connection **(Figure 3)**. A thermal connection reduces the rate of heat dissipation in plane layers during wave soldering, enabling the solder to remain molten for a longer time while soldering. This permits molten solder sufficient time to flow throughout the hole barrel, from the top of the hole to the bottom, creating a strong and solid solder joint.

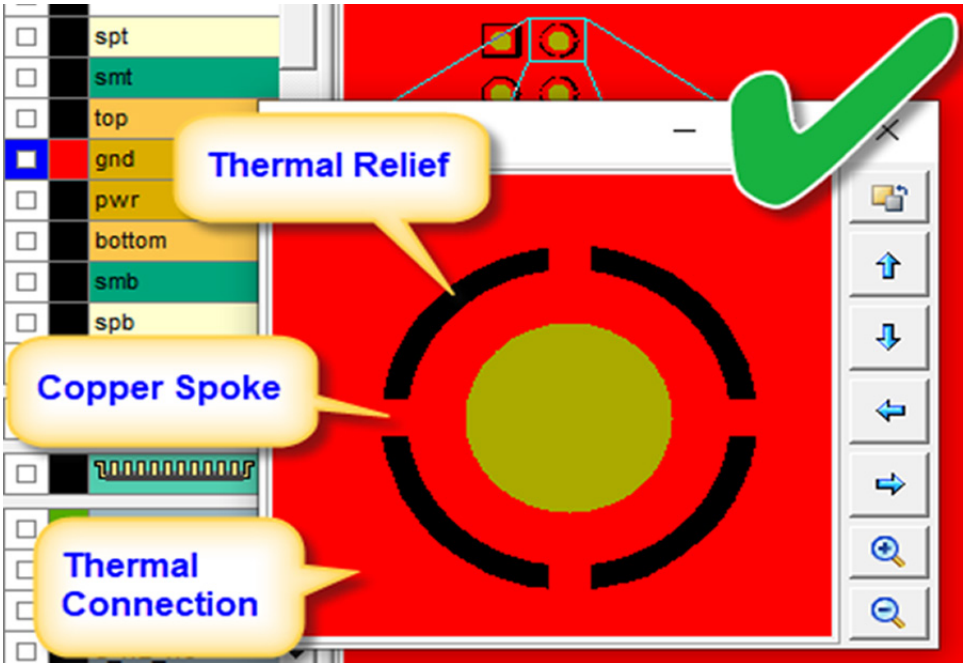

Figure 3. A thermal connection reduces the heat dissipation rate in plane layers during wave soldering, permitting solder to flow completely through the barrel.

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PARTS **SOURCING**

Where Market Intelligence Meets Distribution

Component Dynamics is showing how independent distributors can guide their customers in tricky times.

by MIKE BUETOW

It's well-established that the Covid component crisis forced the electronics manufacturers to rethink how they managed their supply chains.

The lesser-told story, however, is how it also reoriented distributors, pushing them to reposition their linecards and services to adapt to the changing market.

Those lessons were not lost on Component Dynamics, an independent supplier focused on supplying high-quality electronic component solutions for obsolete and hard-to-find parts. But while the company might scour the globe on behalf of a customer in need of a handful of tantalum capacitors, it also provides valuable market intel, boosting those firms' predictive capabilities.

Figure 1. The Component Dynamics management team includes US account manager Matt Whitaker (left) and managing directors Torsten Schwanbeck (center) and Marc Schwanbeck (right).

Component Dynamics' customer base comes largely from industries that use legacy components, such as medical, military and aerospace, and telcos, which are constantly shifting yet have products that could last years or longer in the field. Still, as managing partner Marc Schwanbeck explains, customers come to Component Dynamics to meet a need.

"Our customers know to contact us when they're looking for hard to find product or having trouble with their normal supply channel; they're looking for a reliable source with more service and support than they would otherwise receive from the manufacturer or their traditional supply chain in some cases. Or they might be looking for actionable market trend data."

Adds managing partner Torsten Schwanbeck: "What they want to know from us is whether there is product out there and above all else will the quality meet their expectations. For that we have developed an exceptional quality program that our customers have grown to rely on."

"Customers often hedge their bets," Marc says. "They'll go with the supply-chain solution they have in place, but knowing how things can go, they'll want to have a backup plan in place, which we're happy to deliver when they're ready to execute."

To the latter point, Marc points to DDR4 memory, which, at the time of our visit, was undergoing supply volatility. When Component Dynamics saw announcements that DDR4 end-of-life notices were about to start, it leveraged its experience to develop strategies for its customers based on the particular ODM's practices.

"It seems some people aren't going to be receiving their deliveries. What do we do? We check in with our top customers. We ask how they're doing with their supply on those products, and make sure that the data they're getting from their normal supply chain is accurate. And then we provide a backup solution if something goes awry."

Checks and Balances

Component Dynamics maintains an approved vendor list, which its software system strictly monitors. The list includes original component manufacturers, franchised distributors, and third parties, including factories willing to leverage their excess inventories. Purchases are made only from qualified vendors that have no history of quality issues and maintain on-time deliveries across multiple shipments with the company.

Figure 2. Quality control manager Emily Fabian runs the test lab.

Traceability, of course, is always a key, and an area of differentiation.

Explains Marc: “We search our network and quote our customers accordingly. If we maintain the known chain of custody back to the original manufacturer, we note that and pass it on to our customer at the time of quotation. If it’s one level removed, or from an independent distributor, we share full transparency with them at time of quotation. When we don’t maintain traceability, we’ll go the extra mile to make sure all components are of original quality. If we need to test – for automotive, aerospace, or medical end-applications, for instance – product will be inspected at an approved third-party laboratory in addition to our in-house inspection.

An Entrepreneurship 30 Years in the Making

Torsten Schwanbeck started in the electronics distribution industry in 1996. Of his early days, he recalls, “As I learned more about electronic components, I realized it was an industry that was growing fast, and an interesting one, and I found my match. I was good about retaining information, part numbers, market pricing and developed customer relationships built on integrity, reliability, and trust.”

His son Marc attended Bentley University in the Boston suburbs, graduating with a degree in economics and finance. A stint in a finance role at a Fortune 500 distributor taught him how a large wholesale electrical distributor works.

It set the foundation for what Component Dynamics is doing today, albeit on a much smaller level. “We’re serving a role the same way that any distributor would serve a customer. You’re looking for a way to solve their problems.”

Matt Whitaker, the US account manager, also went to school in Boston, majoring in economics and finance at Boston

College, followed by an MBA from Boston University. After 13 years running the North American tax and oversight division for a major investment group, he had "aspirations that were more entrepreneurial."

As Whitaker tells it, "Our paths crossed, and being involved with OEMs that have these cutting-edge products was more interesting to me than tax code.

Whitaker began in OEM sales, later expanding to relationship development and management. He also aids in expanding the company's market opportunities.

"The [business] cycle is going to go up and down, [or] there's going to be stability in the market, like there is now. So where can we add value? We look at other things, like excess inventory management cost savings. Can we find pricing that's below your franchise distribution pricing? That's been our focus in a non-shortage environment."

While based in Portsmouth, NH, a seaport city about an hour north of Boston, Component Dynamics now maintains offices in Germany, China and Hong Kong. Having boots on the ground in key regions allows local staff to verify market intelligence and perform inspections.

When Component Dynamics started, there was no Covid. Once the pandemic occurred, however, the parts allocation environment helped spur the company's ascent. In 10 years, the team feels it has gained a lifetime's worth of supply-chain experience.

According to Marc, "You start to recognize when those situations occur, so you can let your customer know, 'I see something coming.' The purchaser might not have experience in a shortage situation, and you're there to guide them and say, "Look at your annual demand. What does it look like if you can only get half of it? Does that stop your company in its tracks? Do you have a way to pivot? Do you want us to provide a backup plan?"

Onsite Test Labs

One advantage Component Dynamics has is onsite test labs. The AS9120B and ISO 9001-registered Portsmouth facility features, among others, a Glenbrook Technologies x-ray, Hitachi EA 1000 XRF, Leica DVM6 digital microscopes, and an AMAC vacuum packing machine. Traceability includes a full quality control report, including the moisture sensitivity level.

The 5,000 sq. ft. warehouse is climate-controlled and houses thousands of parts packaged on tape, trays and reels.

Germany and China also have warehouses and labs, albeit with slightly different equipment (Germany has a decapsulation machine, for instance), and follow the same inspection protocols.

Figure 3. The onsite warehouse helps Component Dynamics manage its customers' excess material.

An internal quality management system follows an industry-standard sampling plan aimed at counterfeit avoidance.

Higher-lead count testing is performed offsite, and Component Dynamics has established longstanding relationships with outside test labs, which enables it to receive favorable pricing and turnaround times.

"We can do that globally; it doesn't necessarily have to be in the United States," says Marc Schwanbeck. "If product needs to be sent to Asia, they have facilities there, or vice versa; if something must be done in Europe, we can utilize the test lab there. And then we have our supply chain network adjust accordingly."

Torsten adds, "The way some companies perceive an independent distributor is an expensive alternative to solve component shortages they might have. We want to change this perception and to be a full-service partner. In times of shortages, we want to provide excellent service, quality and product to the customer for reasonable pricing.

"In the event our customers have overstock on product, we actively search to see if there are any potential buyers in the market and match part numbers through our database to potential customers to maximize returns. We will always remain active in the market and in any market cycle as a full-service independent distributor for these OEMs.

"We want our customers to think of us as an extension of their internal procurement team."

To that point, Marc ticks off several scenarios.

"In today's environment many of our clients are looking to move material out and free up shelf space and liquidity. They might move their excess material to our site, and have us market it under a formal inventory program We bring them opportunities when we match demand from other contract manufacturers and original equipment

manufacturers to offer them the best recovery scenario versus pennies on the dollar.

"Or perhaps they have contracts with a distributor and want to cancel an order. The disty said, 'No, it's already here. You have to take the product.' In these scenarios we say, 'OK, you've got too much product. We can help you with that.'"

Regional Impact

One advantage of having facilities in three regions is the impact on local customers. Each entity is a standalone company, under common ownership, with the businesses in Germany and China operating under the name CCI Europe and CCI Asia, and Component Dynamics operating in the US.

While independent, they all utilize the same ERP system and have visibility into decades worth of demand and market data. Access to that history is particularly useful when, as Torsten puts it, " leverage our market data and history to locate hard find product and approach the right sources in the right regions and industry where we have history on specific products or product groups."

Product is moved around the companies as it makes sense, to reduce the impact of tariffs, for instance.

While onboarding a recent new customer, for example, the needed stock was in the US, but for compliance reasons and ease of doing business, the customer wanted a German-speaking vendor in the same time zone. While the order originated from US offices, Component Dynamics assigned a staffer in Germany as the point of contact. "We try to make it easy for the customer to do business with us," Marc says.

That collegial dynamic has been noted. As Whitaker says, "The exciting thing for me is being involved with this cutting-edge technology, and watching it grow and it's a family business. I grew up in a family business, so it's something I'm comfortable with and excited to be part of."

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

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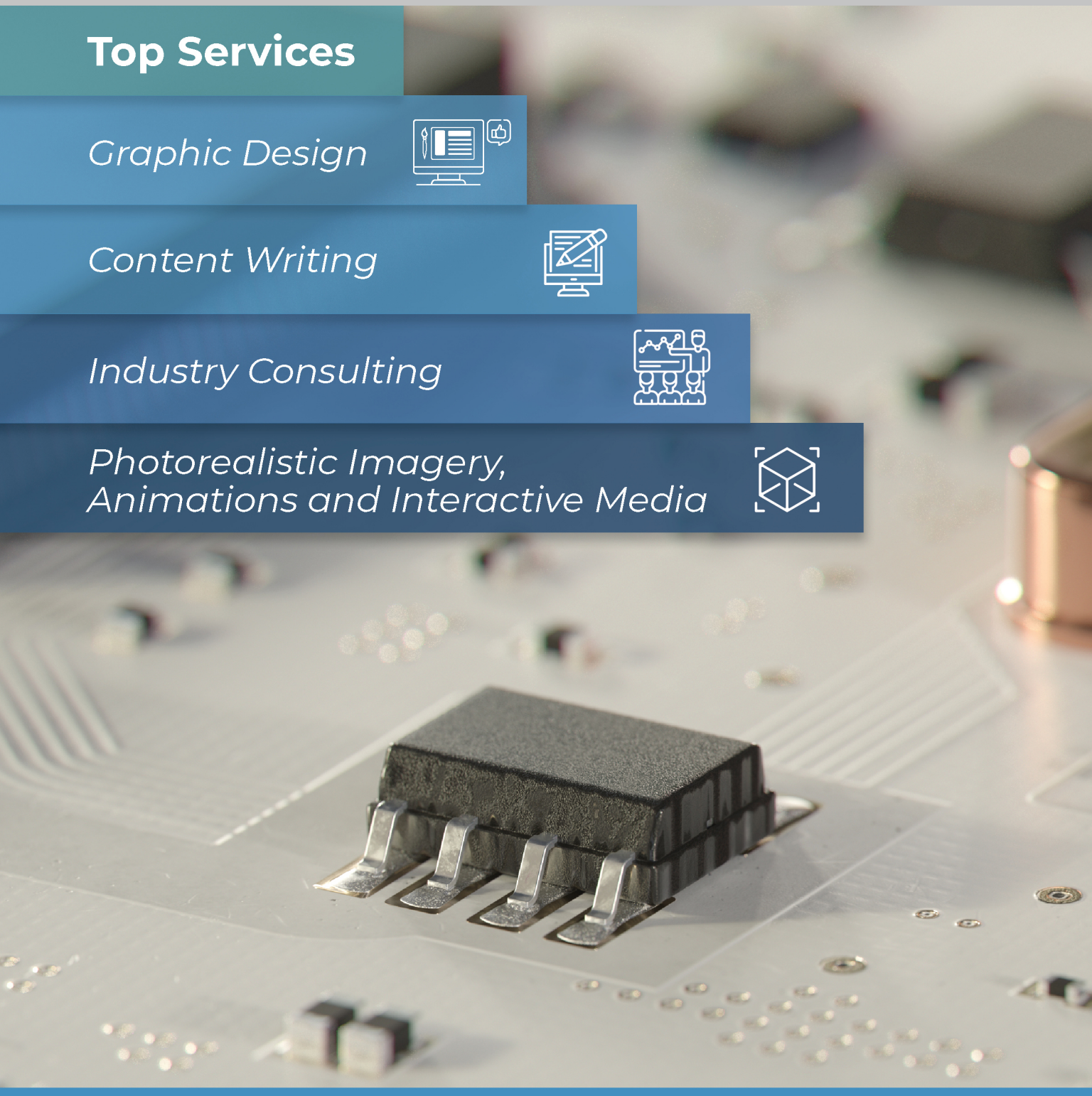

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LIGHTS-OUT MANUFACTURING

Smart Factory Evolution: Innovations in Automated Production

Maintaining stable production through error and predictive detection.

by AKIHIRO SENGA

As industry shifts from the Internet of things, entailing machine-to-machine (M2M) and person-to-person communication, to the Internet of everything, enabling communication between people and things on a global scale, it is necessary to build more advanced systems by integrating items beyond just things, that include people, processes, and data. For example, changes in automotives and the use of VR and AI are revealing new possibilities.

Smarter factories require production systems with integrated data linkage and automation **(Figure 1)**. Systems that permit devices to share data and automatically solve problems are being put to practical use as productivity-enhancing measures. Considering this, Fuji Smart Factory's smart solutions are taking the lead toward this level of automation.

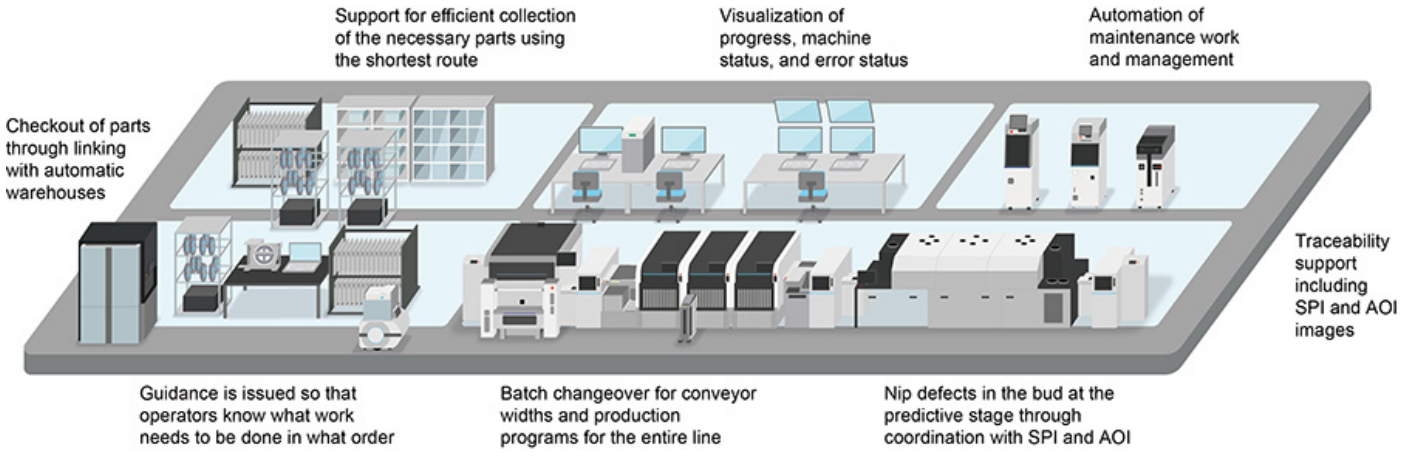

Figure 1. Smart factories require production systems that "talk" to each other without human intervention.

As expressed by Fuji's head of Robotic Solutions, Takeshi Sato, "Fuji is exceeding placement limits under the 'Target Zero' concept, aiming for the ideal SMT production site. This concept encompasses 'Zero placement defects', 'Zero machine operators', and 'Zero machine stops,' leading to the newly defined goal of 'Zero placement limits.' Each of these contributes directly to achieving high quality, automation, stabilization of production, and enhancement of the ability to handle complex placements, and is an important pillar supporting the next generation of manufacturing.

"Fuji has worked to achieve the first three zeros by developing equipment that does not permit placement defects, creating a production environment in which lines do not stop, and automating standard operations, all while sincerely addressing the problems faced on the production floor. Now, in response to the rapid changes in technology

and markets, we have expanded our focus to 'Zero placement limits,' with the belief that there is no placement Fuji cannot achieve.

"In addition to state-of-the-art equipment capabilities, the integration of advanced technologies such as AI, data utilization, and automated conveyance with AMR alleviates issues such as manpower shortages and dependency on manual labor, enabling human resources to be focused on more creative work."

Smart Factory Roadmap

In 2017, the FUJI Smart Factory project was launched to develop work guidance functions and units that automate manual tasks **(Figure 2)**. Starting at around the same time, Fuji also formed alliances with other equipment manufacturers that make up the SMT line to expand M2M functions that lead to improvements in overall equipment effectiveness (OEE).

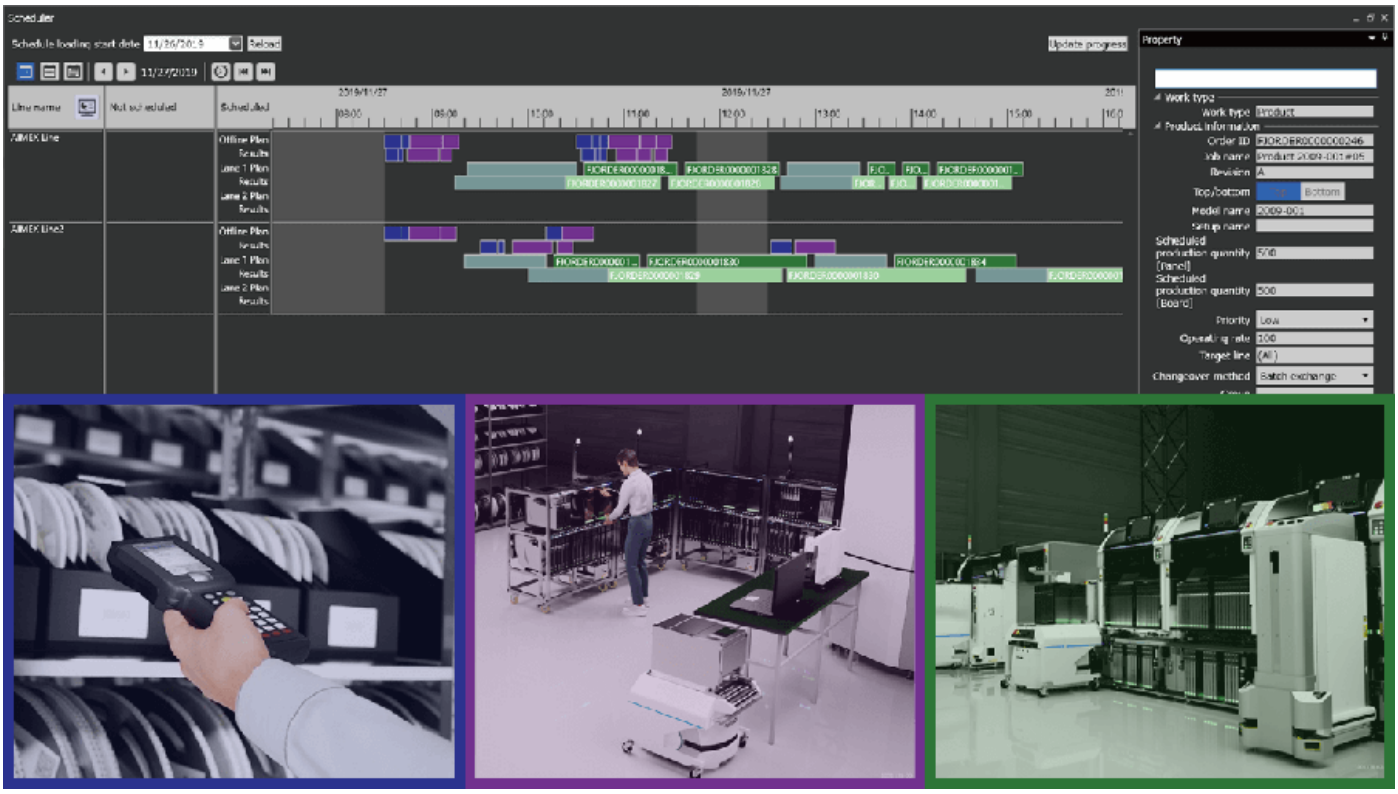

Figure 2. The Fuji Smart Factory includes alliances with SMT equipment OEMs aimed at improving OEE.

The roadmap for FUJI Smart Factory (FSF) is broken into three steps:

- In FSF 1.0the systems and machines that configure the production line are linked together, and some traditional manual work is automated;
- In FSF 2.0, the current stage of smart factory support provided to customers, automation and linkage extend beyond individual lines to the entire production floor;
- And in FSF 3.0, the planned next step in automation, the 5M+E data contained within the factory is consolidated to realize a factory that continues to operate through feedback cycles and analysis of differences

between planned and actual production.

Improved Placement Efficiency

FSF 2.0 includes the following features for automation of the entire production floor. Collectively, these features lead to increased efficiency, reduced production times, improved utilization rates, drastically reduced potential for errors, enhanced flexibility, higher quality in output and improvements in inventory management.

Production schedules. As shown in **Figure 3,** Fuji's Scheduler tool automatically creates the optimal production schedule that includes the optimal conditions for production, taking into account multiple factors, including panel widths and reflow temperatures.

Figure 3. Location management expedites parts picking.

Parts allocation (reservation) prevents repetition of tasks due to a lack of the necessary parts after production preparation has begun.

Parts picking. The system guides parts that must be collected at each storage location by utilizing parts location management for efficient collection of the necessary parts using the shortest route.

The host system transmits information on necessary parts to the automated warehouse, enabling reliable checkout of parts.

Offline changeover. The system provides changeover guidance, so operators know what work they need to do and in what order to ensure that the necessary parts are supplied to the placement line without delay. LED lighting patterns provide a visual indication of whether it is possible to use a feeder **(Figure 4)**.

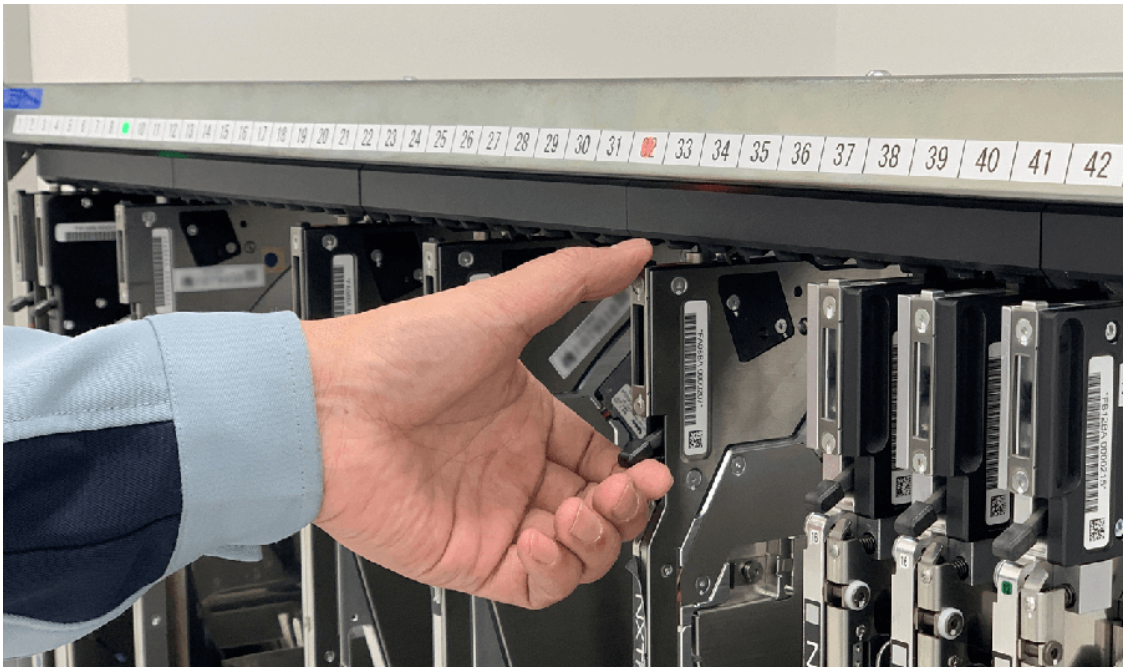

Figure 4. Automatic work orders inform offline changeover.

Floor logistics. Autonomous mobile robots (AMRs) automatically transport the necessary feeders, printing materials and panels to load and unload these items to and from the line.

Figure 5. AMRs move materials and equipment.

Production lines. By scanning either the kanban ID or panel ID code, production programs can be changed from the current production to the next for all machines that configure the line. Upon receiving inspection results from SPI and AOI, the necessary actions are performed automatically inline with any trends that indicate status changes **(Figure 6)**.

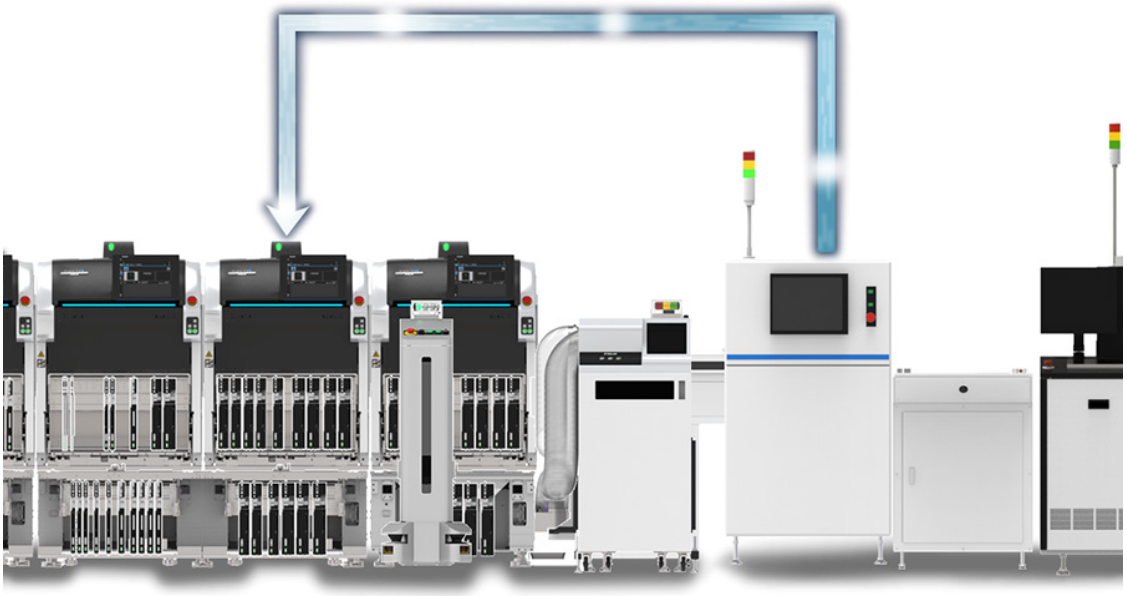

Figure 6. Inspection machines automatically communicate changes upstream.

Maintenance. Automatic maintenance units clean feeders, nozzles and heads, and check the performance of these after cleaning. Through system linking, maintenance history is recorded and guidance for when to perform maintenance is issued automatically.

Management. The system presents visual information necessary for management, including the progress status of the entire production floor, the state of production lines and equipment, and the occurrence of pickup errors **(Figure 7)**. Using the board ID or panel ID as a key, traceability data, including SPI and AOI inspection images, is provided immediately.

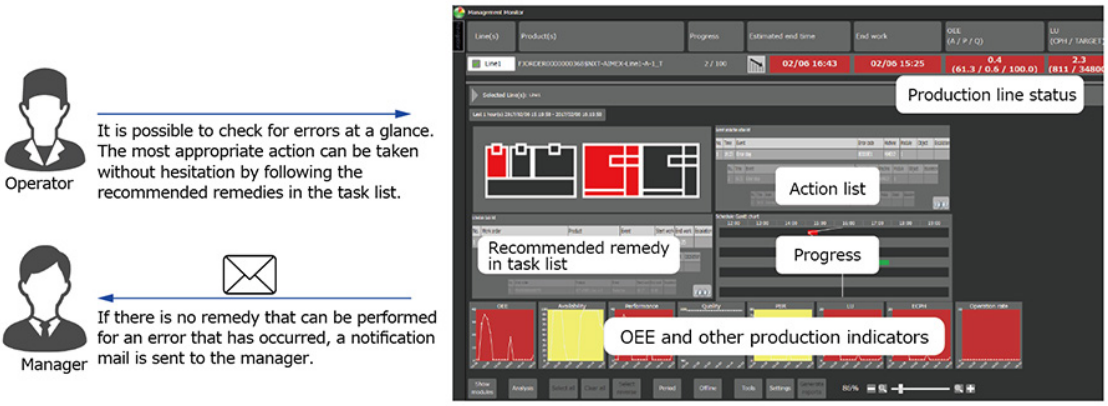

Figure 7. A dashboard conveys critical production status information.

Workload Reduction

The introduction of FSF2.0 will reduce the workload of operators and enable production with fewer workers. Some events require operator intervention to prevent productivity loss and defects due to equipment malfunctions, however. FSF 2.0 provides tools to alert workers when an event occurs that should be handled by operators or when

signs of such an event are detected.

- **IPQC Expert** can be used to note status changes based on short-term trends, and prompt action at the stage before defects occur.
- **FSF Mobile Conductor** sends machine error and warning notifications to mobile terminals held by operators.

These tools can be used in tandem to minimize the occurrence of defects, to minimize losses caused by errors and to maintain productivity.

Through aggregation of data from the production floor, analysis, predictive forecasting, autonomous control and self-diagnosis, Fuji is pursuing production process optimization. Fuji believes that this placement technology advancement will not only improve manufacturing sites but will also play a role in shaping the future of manufacturing.

AKIHIRO SENGA is engineering planning department manager at Fuji Corp. (fuji.co.jp); ak.senga@fuji.co.jp.

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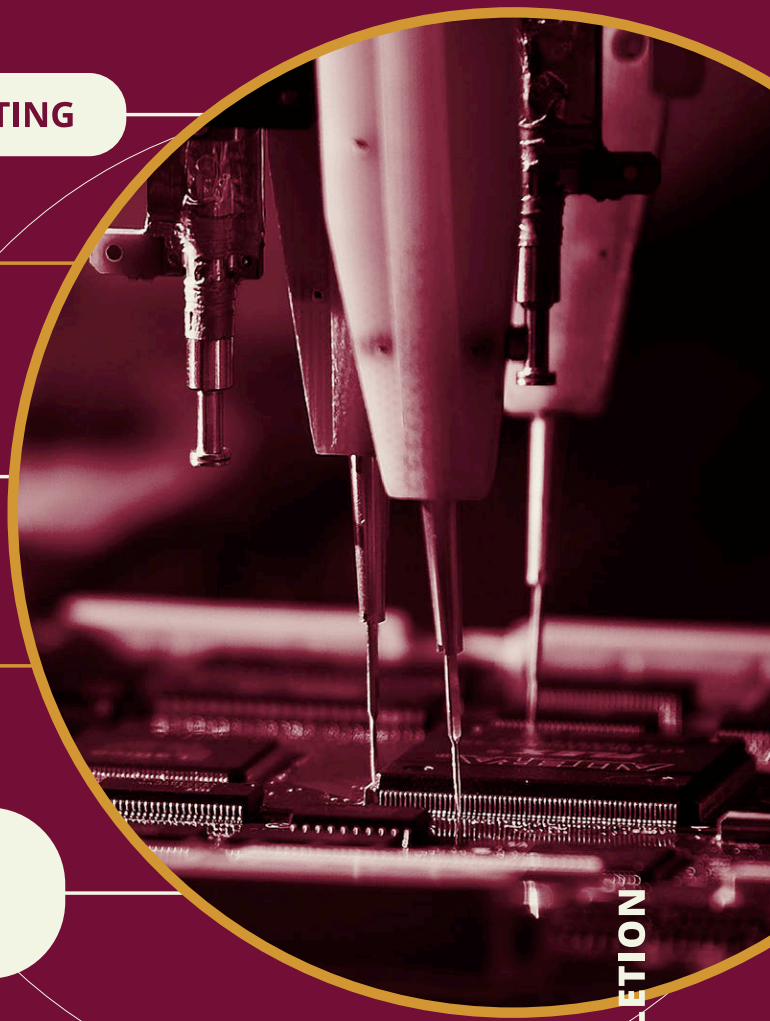

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The Growing Importance of DfX in AI Hardware

SMTAI Women's Leadership Program highlights how technology shifts lead to greater opportunities for those with specialized skills.

by PRIYANKA DOBRIYAL, PH.D.

The need to develop new technologies to meet the demands of artificial intelligence (AI) is increasingly urgent. The manufacturing of the necessary hardware at scale presents its own set of significant challenges, however, including highly skilled labor, specialized equipment requirements, automating complex tasks, supply chain disruptions and quality control issues. Given these manufacturing challenges, applying the principles of design for excellence (DfX) from the beginning of the design process is essential.

To illustrate, consider a specific example: the development of new interconnects, which are crucial for connecting the various components of an AI system. Interconnects are an example of the biggest bottleneck for AI performance. As electrical solutions near their physical limits, silicon photonics offer an opportunity to break through those limits by replacing traditional electrical interconnects with light. This permits significantly higher bandwidth, lower power consumption, reduced latency and improved thermal management, as photons inherently generate less heat and can transmit more data than electrons.

For advanced silicon photonics, the DfX challenges are particularly complex. The tight integration of optical and electronic components inside a single package, or even on a single chip, introduces a multitude of new variables for designers to consider. Design for manufacturing (DfM), for instance, must account for the precision needed to fabricate waveguides, modulators and photodetectors alongside traditional CMOS transistors, without disrupting the highly tuned CMOS manufacturing flow. This involves new processes, materials and devices, leading to challenges in design for test (DfT) as well, as traditional electrical tests may not be sufficient to verify both the optical and electrical performance, instead requiring the development of advanced photonics and electro-optic wafer-level testing. Furthermore, design for assembly (DfA) becomes more complicated due to the precise micron-scale fiber-to-chip coupling required for signal input and output – far more precise than electrical contacts – which can be sensitive to environmental factors and mechanical stress, driving the adoption of higher-accuracy assembly tools and precision manufacturing flows. These factors collectively increase the complexity of the entire design and manufacturing workflow.

Despite these challenges and progress toward solutions, technology is not static. The drive toward increasing bandwidth density and power efficiency drives new generations of technology, and with each new technology, we must address its unique DfX issues. For example, the industry is already moving beyond the limitations of traditional pluggable optical transceivers to more advanced architectures such as the 2-D co-packaged optics (CPO), 3-D CPO

and 3-D photonics interposer to address the shoreline problem (the I/O interface being limited to the edge of the chip). In particular, sophisticated 3-D photonics interposer architectures such as Passage are emerging as a pivotal solution, offering an unprecedented ability to scale communication bandwidth for the most demanding AI workloads. This architectural shift, which spreads the I/O interfaces across the entire surface area of the chip, necessitates a further re-evaluation of DfX principles to ensure manufacturability, testability, reliability and yield as complex PICs and ASICs are combined more closely into a single package. The assembly flow and test points must be carefully designed upstream to optimize the yield of the final solution, and to enable high-throughput assembly and testability at every stage, such as wafer and package-level photonics testing via detachable fiber connectors (primary bottlenecks being fiber attach methods and optical testing from wafer to package level). These assembly and test complexities contribute to increasing cost pressure on the back end of semiconductor commercialization, namely, packaging assembly and test, as depicted in **Figure 1,** compared to the earlier dominance of front-end silicon costs.

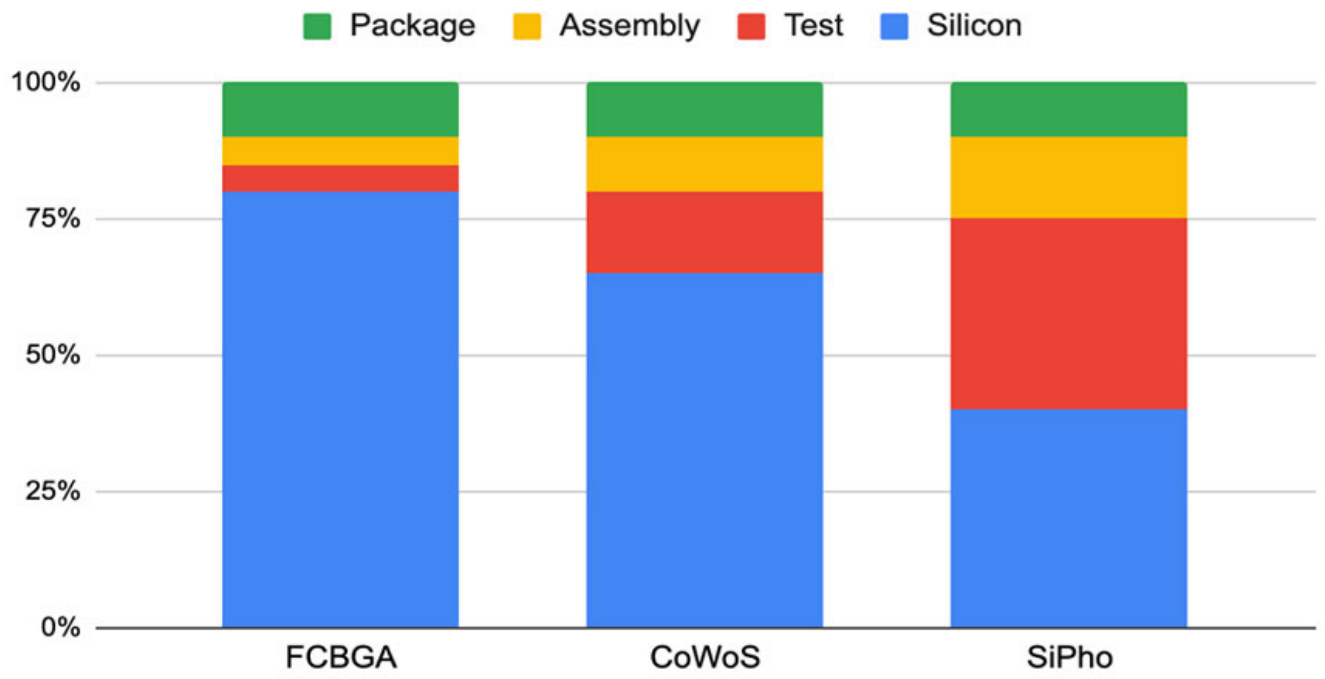

Figure 1. Silicon photonics illustrative cost breakdown: silicon, packaging, assembly and test (graph for illustration purposes only). FCBGA: flip-chip ball-grid-array. CoWoS: Chip on wafer on substrate. SiPho: silicon photonics. (Source: Sandeep Sane, Peter Carson, Lightmatter; for illustration purpose only)

The changing DfX landscape, exemplified by this transition in networking technologies, necessitates highly specialized skillsets and adaptable engineers. Historically, women have faced barriers in traditional manufacturing roles (workplace conditions and culture, flexibility, work life balance); however, increasing demand for specialized skills during technology transitions such as the shift to silicon photonics leads to greater opportunities for women by rewarding deep technological and cross-functional engagement, as well as leveling the playing field in the absence of a sufficient existing talent pool. Work accommodations that emerged due to the Covid pandemic have established a new standard for flexible working hours and improved work-life balance, making this a perfect storm to rebalance the technology workforce from top to bottom for the benefit of women.

The Surface Mount Technology Association (SMTA) Women's Leadership Program, to be held on October 20 in

Rosemont, IL, is designed to address these very inflection points in technology and workforce development. Now in its 14th year at SMTA International (SMTAI), the program serves as a platform where technical innovation and leadership development intersect. Under this year's theme, "Grab Your DFX Umbrella – It's Pouring Possibilities," the program explores real-world challenges and innovative solutions across electronics manufacturing. Through invited keynote presentations from women leaders in electronics and AI, attendees will gain perspectives on how to navigate emerging fields like silicon photonics, quantum computing, sustainability and advanced assembly. These sessions are complemented by roundtable discussions where participants can engage directly with industry experts and peers, tackling topics such as cleaning, harsh environments, PCB fabrication and assembly, repairability and test and failure analysis.

Just as DfX principles help us rethink manufacturability and reliability in next-generation technologies, the Women's Leadership Program helps us rethink how to build a more diverse and inclusive industry that harnesses the full potential of its workforce. The challenges of tomorrow – whether silicon photonics interconnects for AI or entirely new architectures we have yet to imagine – will demand collaborative problem-solving and the widest possible range of perspectives.

By attending, you'll not only expand your technical insight but also contribute to shaping a more inclusive future for engineering and manufacturing.

Learn more and register today: smtai.org/wlp.

PRIYANKA DOBRIYAL, PH.D., is engineering operations director at Lightmatter and a member of the SMTA board of directors; priyanka@lightmatter.co.

Figure 2. SMTAI WLP 2025 program.


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Optimizing SMT: GMP, SMED and TPM in Action

Focusing on fundamentals to drive world-class quality and throughput.

MOST ELECTRONIC PRODUCTS incorporate surface mount technology (SMT). Consequently, it is a critical process to monitor in terms of quality and cost. Lean manufacturing principles provide a solid foundation for eliminating the variation that can create defect opportunities as well as methodologies for improving throughput. Lean manufacturing-related philosophies in SigmaTron International's facility in Tijuana, Mexico, include good manufacturing practices (GMPs), the single-minute exchange of die (SMED) methodology and total productive maintenance (TPM).

GMP in SMT: The basis of quality. GMPs are a set of guidelines that ensure products are manufactured and controlled consistently, following quality standards. In the context of SMT, GMP areas of focus include:

- **Incoming control and component handling.** Ensure that all components meet specifications before entering the line. This includes visual inspection, moisture verification (for moisture-sensitive components) and proper handling to avoid electrostatic discharge (ESD) damage.
- **Inventory and warehousing management.** Maintain strict control over component inventory, including FIFO rotation (first in, first out) and storage in controlled environmental conditions to prevent degradation of materials, especially solder paste and sensitive components.
- **Regular cleaning and maintenance.** SMT machines are precise and fast. Regular cleaning of nozzles, feeders, stencils and ovens, as well as preventive maintenance according to the manufacturer's specifications, is crucial to avoid defects and prolong equipment life.
- **Staff training.** Staff must be fully trained in equipment operation, soldering process, visual inspection and troubleshooting. A well-trained workforce reduces errors and improves process efficiency.
- **Documentation and traceability.** Maintain detailed records of component batches, process parameters (programs, libraries, load sheets and oven profiles), inspection results and any incidents or concerns that arise. This enables complete product traceability and facilitates immediate problem identification and correction.
- **Solder paste control.** Solder paste is a critical material. GMPs require controlled handling, storage, preparation and application to ensure shelf life and optimal solder properties for improved paste print quality.

SMED: Reducing model changeover times in SMT. SMED is a methodology developed by Shigeo Shingo to drastically reduce the time required to change a process from one product to another. In the SMT process, this translates into minimizing downtime between the production of different printed circuit board assemblies (PCBAs).

The key principles of SMED for the SMT area are:

- **Separate internal from external.** Identify and move as many setup operations as possible outside of machine downtime (external operations). For example, set up feeders, stencils, squeegees, pallets and programs for the next model while the machine is still producing the current model.
- **Turning internal into external.** Look for ways to transform internal operations (which require the machine to stop) into external operations. This could involve using preset templates or interchangeable feeder carriages.
- **Simplify internal operations.** If an operation must be internal, simplify it as much as possible. This includes the use of quick-release fasteners, single-turn screws and standardized tools or fixtures.
- **Organization and standardization.** Have all the necessary resources, tools and components available and within reach. Standardize changeover procedures to make them repeatable and efficient.

Implementing SMED methodology in the SMT area reduces changeover times, enabling smaller batch sizes, greater flexibility in scheduling and planning, and a faster response to changes in demand.

TPM: Maximizing equipment availability. TPM is a comprehensive approach that seeks to maximize equipment efficiency throughout its lifecycle. It goes beyond traditional maintenance by involving all employees in the process and focusing on prevention. The pillars of TPM applicable to SMT include:

- **Autonomous maintenance (*Jishu Hozen*).** Empower and assist operators with clear, simple visual aids to perform basic maintenance tasks such as cleaning, lubrication and inspection. This increases equipment ownership and permits problem identification before it has a major impact.
- **Planned maintenance (*Keikaku Hozen*).** Develop a preventive maintenance program based on time, usage and equipment condition or characteristics. This includes scheduled inspections, parts replacement and calibration, if necessary.
- **Quality maintenance (*Hinshitsu Hozen*).** Focus on preventing equipment-related defects. This involves analyzing defect patterns and adjusting maintenance or processes to control or eliminate them.
- **Early team management (*Shoki Kanri*).** Incorporate lessons learned from maintenance into the design and selection of new equipment to ensure maintainability and reliability from the start.
- **Education and training (*Kyoiku Kunren*).** Continuously train operators and technicians in the skills necessary to operate and maintain equipment effectively and dynamically.
- **Safety, health and environment (*Anzen Eisei Kankyo*).** Ensure a safe and healthy working environment and comply with environmental regulations.

Adopting TPM in the SMT area helps reduce machine downtime, improve product quality and extend the lifespan of its most valuable assets.

The combined implementation of GMPs, the SMED methodology and TPM represents a powerful strategy for

optimizing operations in the SMT area. It improves quality and reduces costs, and it increases flexibility, responsiveness and competitiveness in a constantly evolving market.

OSWALDO ARGUELLES is a process engineer in SigmaTron International's (sigmatronintl.com) facility in Tijuana, Mexico.

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SEEING IS BELIEVING

What We Talk About When We Talk About Drones

Or how to follow the No Outburst in the Face of Idiocy rule.

THE DEARLY BELOVED, firm believers and associated hangers-on were reverently assembled to begin a Teams meeting or, rather, an inquisition.

Amid forced pleasantries, while we captives killed time awaiting latecomers, they appeared. Like viruses. One after the other, after the other: The Swarm. Blackened screens with names, resembling any college lecture, with the students doing their utmost to remain inconspicuous. Except the disembodied names on the screens concealed adults, not camera-shy undergrads. One said Ted's AI Notetaker. The second said Claire's AI Notetaker. Then Evan's. Then Irene's. And Muhammad's. Plus Sanjay's. And Chin's. Then Dylan's. Always a Dylan in 2025. We live in accursed times.

All that the Swarm lacked was a soundtrack blaring "Flight of the Valkyries."

Claire, Ted, Irene, Evan, Muhammad, Sanjay, Chin and Dylan were nowhere to be found. They're important; that's why they're absent. Performing essential tasks elsewhere. But consequential enough for their drones to stand in for them at our meeting, capturing, without prejudice, everything spoken during the proceedings. Every. Solitary. Word. For the archive and for posterity.

One imagines a fantasy world where Claire, Ted, Irene, Evan, Muhammad, Sanjay, Chin and Dylan, now at ease, seated and pensive around the post-meeting campfire, cocktails in hand, in multicultural harmony, huddled around a replay of the dialogue of today's gathering, captivated by every word. As any reasonable person would do. Every time. Such diligence, and marketing, built this country.

It has come down to this. In an overburdened, hyper-stimulated, perpetually shorthanded and ad-hocritized workaday world, all that is said in meetings is deemed worth recording but not necessarily hearing in person. The first draft of history, minus the drafters, was captured by digital indentured servants. To maintain witnesses and evidence in the unlikely event of something going wrong nine years hence, when complete traceability and avoidance of deniability might be important to organizations with paranoid management structures.

About that inquisition: The recording Valkyries memorialized eight EMS test engineers and programmers (their guys) interrogating two test service test engineers and their manufacturer's representative (our guys) about the details of flying probe test operations and services. And costs: relentlessly. Three real people, eight interlocutors and eight

drones taking digital notes for upper caste people too important to add their number to the black screens.

Curiously, the chief meeting organizer (CMO) and Head Hollywood Square Occupant (HHSO) of this particular get-together had visited our facility two weeks previously, to survey our capabilities. CMO's company was bidding for a new OEM engagement, with our company slating to perform a supporting role – at the OEM's insistence – providing flying probe test services. This was virgin territory for this EMS company; CMO was nervous enough to ask the same questions twice: once in person at our facility, then again before colleagues on video two weeks later, recorded for posterity by the Valkyries.

Why was he asking the same questions – reading from the same prepared script – as he did in person? Was he doing so for the benefit of Claire, Ted, Muhammad, Evan, Sanjay, Irene, Chin and Dylan? Was it performance art? Performed for whom? An audience of drones? Or an audience of the drone-masters, seeking accountability? And for what? To fill personnel records?

Not unlike an unplanned visit to the emergency room in which the admitting nurse, the charge nurse, the x-ray technician, intern, resident and attending physician all recite the same questions from the same checklist to the patient, hoping for consistent correct answers, consistent lies or sufficiently consistent ambiguity to establish direction and course of treatment, or not. In sextuplicate.

Today's video clinical process resembled a star chamber trial in reverse: the party in the dock (us) was found guilty of being undesirable outsiders, and evidence was now accumulating to justify the verdict. This group began from the premise (prejudice?) that no outsourcing was possible, OEM requirements notwithstanding. The agenda was clear: find evidence that party (again: us), by virtue of inconsistent responses, couldn't be trusted. Outsiders, to their way of thinking, couldn't be trusted. Outsiders reveal secrets better left hidden. We were outsiders. What was needed was evidence of untrustworthiness. The purpose of this video visit was to build the case to deny their customer its wishes. Because that's not how they do things. The panel arrayed against us on video this day, accompanied by drones, attested to their goal. Clearly, a striking lesson in belief by one EMS company that the customer isn't always right. In government this is called the Deep State. They know.

For the CMO and his audience of firm believers, performance was clearly politics. Like they had an audience of one whose title was CEO. One sensed unspoken agendas on the EMS company's side, none favorable to us. The questions to us were repetitive and tiresome and adversarial. Like a trial, designed to provoke. But we were resolute and didn't rise to the bait, resisting overt shows of emotion, calmly sticking to technical facts and yes/no answers. The No Outburst in the Face of Idiocy Rule was in force and strictly observed. Don't give them ammunition beyond their predetermined verdict.

Yet still they came, bending but not breaking our patience. All planned. All deflected.

"Please explain your cost structure."

"Why do programs cost so much?"

"Do you perform rework on failed boards? What does rework cost?"

"Why do you need a carrier?"

"How do you perform debug?"

"How do you handle ECOs? What is the cost, if any, of implementing ECOs?"

"Will you implement ECOs for free?"

"Why do you have minimum lot charges?"

"How long have you operated flying probe systems? Why do you operate the specific make and model you operate? How does it compare with other makes and models on the market?"

"If you find a repetitive problem – say, a missing or wrong-value capacitor – on an entire lot of 100 boards, do you test the entire lot and charge us for it, or do you stop and contact us early in the process and inform us so that we may decide whether to take corrective action and/or rework steps?"

"Describe your ESD control process. Does it meet or is it certified to ANSI 20.20?"

"What is typical test coverage on a board that is tested using flying probe technology?"

"Can you perform coverage analysis of a board prior to taking on the job? What does it cost? Will you do it for us for free?"

"What are your typical lead times? Can you shorten the lead time? Can you perform expedites at no extra charge?"

Give me your tired, your poor, your huddled masses yearning to breathe free. But don't give me any instructions to outsource. It's simply not done by our organization. We live by a higher law.

So, it seemed the fix was in. What is the sound of eyes rolling?

Our response, synopsized:

"Gentlemen (all live bodies on the call were men): In order, the answers to your questions are as follows:

Cost structure is time-based; because our time is worth it; no, you do the rework; free (see previous answer); because you need to hold the board in place and square on the machine in order to test it; carefully; ECOs imply time, which implies money; ECO cost depends upon the ECO; no; because CMMC and tariffs and other impositions need to be paid for (you don't have minimums?); 22 years; because in our opinion it's the best series of systems on the market; see previous answer; we stop and contact you; strict ESD control procedures are observed and documented; yes; coverage depends on the board; no; a lot; nice try; five to 10 working days; sure, if you're willing to pay for the expedite; nope."

As the journey through Tedium Mountain mercifully concluded, we felt pride at metaphorically keeping our arms and hands inside until the ride came to a complete stop. We felt more pride at swatting away a thinly disguised bid for free engineering. “Free” was an adjective freely employed from the EMS company side in our discussion. The CMO’s company had their own flying probe; it became clear as the interrogation proceeded that they were having trouble running it efficiently for lack of skilled personnel (like all good advocates, we knew this in advance, having done our homework about this customer by means of well-informed and connected industry colleagues). They wished to pick our brains and use the (free) information thus obtained to employ in-house, secure their position, justify their representation of competence to management, and reinforce their case to stay home, in direct contravention to the OEM’s wishes. Again, nice try.

All the proceedings were recorded for the edification of Claire, Ted, Muhammad, Irene, Evan, Sanjay, Dylan and Chin, and their entire C suite. The Swarm worked. The conspiracies of the engineering anthill are in the books forever. Our conscience is clear. We stood our ground. The recordings will clearly show that their bid for free stuff failed. Whether they want to do business with us and pay for it is their decision. Of course, since this is their customer’s wish, it is likely they have no choice. Justice.

And the product to be tested? A military jamming system to render drones useless.

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

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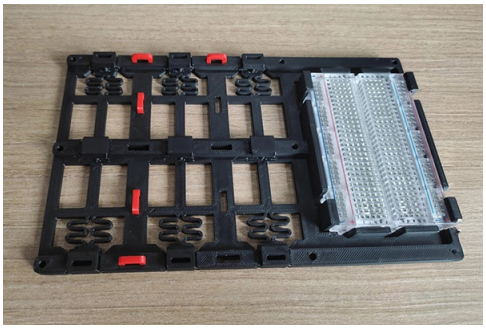

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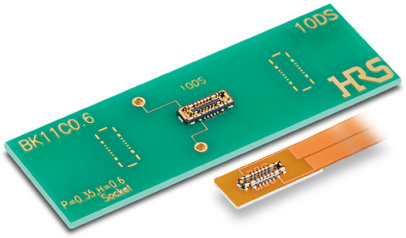

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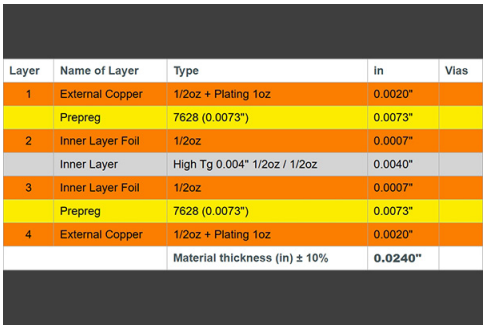

Layer	Name of Layer	Type	in	Vias
1	External Copper	1/2oz + Plating 1oz	0.0020"	
	Prepreg	7628 (0.0073")	0.0073"	
2	Inner Layer Foil	1/2oz	0.0007"	
	Inner Layer	High Tg 0.004" 1/2oz / 1/2oz	0.0040"	
3	Inner Layer Foil	1/2oz	0.0007"	
	Prepreg	7628 (0.0073")	0.0073"	
4	External Copper	1/2oz + Plating 1oz	0.0020"	
		Material thickness (in) ± 10%	0.0240"	

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PCB Stackup Calculator is an online tool for designing and visualizing multilayer PCB stackups from 4 to 14 layers. Users can select copper weights, dielectric materials and via options. Offers view of layer-by-layer breakdown aligned with IPC-6012. Enables flexibility in layer counts, provides standard copper foil and prepreg thicknesses and supports blind and buried vias. Clear stackup tables offer instant visualization for review and manufacturability.

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Indium Corp.

indium.com

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SCS G4 SPIN COATER

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Specialty Coating Systems

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"Structure Light Measurement for a BGA Packaged Chip with High-Precision and Large Field-of-View"

Authors: Jianfeng Zheng, *et al.*

Abstract: Ball grid array (BGA) packaging is one of the mainstream chip packaging modes. The deviation of solder ball height can significantly affect the safety and reliability of packaged chips and may even lead to chip failure. To efficiently and accurately measure the height of solder balls on large-sized square BGA chips, a large field-of-view (FOV) and high-precision structured light measurement system is constructed in this paper. The influence of fringes with different contrast and gamma nonlinearity on three-dimensional (3-D) reconstruction height is simulated to determine the boundary conditions of fringe quality. Based on these boundary conditions, the projection clarity and spot shape of the oblique projection lens are optimized according to the Scheimpflug principle. This effectively solves the problems of an unbiased axis and low utilization of projection in traditional structured light projection lenses and enables high-precision fringe projection on large-sized square BGA chips. Aiming at the abnormal height measurement problems caused by the high reflectivity and occlusion of the solder ball, an improved fusion algorithm is proposed, which can accurately fuse height data from multi-directional 3-D reconstruction data. The measurement system has an FOV of 95mm x 95mm, a measurement accuracy of 1.4μm for a standard plane, and 4.7μm for BGA solder balls. The results show that this system can perform high-precision detection of the height of solder balls on BGA chips, especially large-sized square chips. *(Applied Optics,* August 2025, https://www.researchgate.net/publication/393886013_Structure_light_measurement_for_a_BGA_packaged_chip_with_high-precision_and_large_field-of-view)

Plasma Jet Printing

"Low-Temperature Deposition of Gold Patterns with Improved Adhesion and Conductivity Characteristics for Printed Electronic Applications"

Authors: Lakshmi Prakasan, *et al.*

Abstract: Development of efficient metal deposition methods for patterning and depositing metal structures is crucial for advancing electronics manufacturing. Existing multistep processes that require separate equipment for each step hinder the progress of scalable and rapid metal deposition techniques. Plasma jet printing (PJP) is an advanced printing technique that has the capability to deposit plasma-assisted sintered metal traces with improved adhesion

with the help of a dielectric discharge plasma. In this work, the authors conducted a comprehensive study of the effect of plasma parameters on improving the surface properties of the substrate and electrical performance. The findings demonstrate a 6x improvement in the adhesion strength and a resistivity of $1.75 \times 10^{-6}\Omega$m achieved through low-temperature plasma sintering, making it suitable for depositing conductive traces on low-temperature substrates. The authors also demonstrate the heating-assisted plasma sintering to sinter metal nanoparticle inks containing PVP efficiently, significantly reducing the thermal budget while maintaining a single-step process. These results highlight PJP as a promising alternative to conventional metal deposition methods, offering a streamlined approach to high-performance electronic applications. *(ACS Applied Materials & Interfaces,* vol. 17, no. 32, Jul. 29, 2025, https://pubs.acs.org/doi/10.1021/acsami.5c10083)

Solder Joint Reliability

"A Machine Learning Framework with Shapley's Additive Explanations to Assess Solder Joint Reliability for Electronic Packaging"

Authors: Qais Qasaimeh, Haoran Li, Saad Hamasha and Jia Liu

Abstract: Assessing the reliability of solder joints is a significant challenge in electronics manufacturing, as numerous factors affect integrity and performance. Traditionally, accelerated life tests (ALTs) are used for evaluating solder joint reliability, and survival analysis models such as Weibull and the Cox proportional hazards model (Cox-PHM) are widely used to develop life prediction models based on ALT data. The rise of machine learning (ML) models, including random survival forest, extreme gradient boosting (XGB), and survival support vector machines (SSVMs), offers promising data-driven alternatives, especially given their potential for higher predictive accuracy. However, their interpretability remains a concern for the electronics manufacturing community. In this study, the authors conducted systematic research to integrate multiple ML algorithms and Shapley's additive explanation (SHAP) techniques to model solder joint reliability in thermal cycling tests from various impacting factors and to extract knowledge from the ML models for interpretability. The ML approaches demonstrate superior predictive performance compared to traditional survival analysis models. For instance, XGB achieves the highest c-index of 0.88 on the testing dataset, indicating strong discriminative power. Similarly, the KSSVM model yields the lowest test MAPE of 15.26%, reflecting excellent accuracy in predicting cycles to failure. The GB model also performs well, with a c-index of 0.88 and test MAPE of 15.31%, highlighting the reliability of boosting-based approaches. While traditional models like Cox-PHM and Weibull yield c-indices around 0.87 and 0.85, respectively, they fall short in prediction error, with MAPEs exceeding 20%. These findings confirm the advantages of advanced ML models in capturing complex patterns in reliability data. Furthermore, SHAP analysis enhances model transparency by revealing how critical features – such as component type, solder material and aging duration – interact to drive failure predictions, offering insight beyond what conventional models can provide. *(Journal of Electronic Materials,* Jul. 10, 2025, https://link.springer.com/article/10.1007/s11664-025-12101-4)

Sustainability

"DissolvPCB: Fully Recyclable 3D-Printed Electronics with Liquid Metal Conductors and PVA Substrates"

Authors: Zeyu Yan, Su Hwan Hong, Josiah Hester, Tingyu Chen and Huaishu Peng

Abstract: DissolvPCB is a novel 3-D printing-based method to fabricate fully recyclable electronic circuits. The technique combines polyvinyl alcohol (PVA) substrates and eutectic gallium–indium (EGaIn) liquid metal to create printed circuit board assemblies (PCBAs) that can be easily dissolved and reassembled, significantly reducing electronic waste.

Unlike traditional FR-4-based PCBs, which are difficult to recycle and typically require industrial-scale processes to reclaim materials, the novel circuits can be immersed in water to separate components, reclaim liquid metal, and regenerate PVA filament. This approach enables makerspaces and prototyping labs to close the loop on small-batch electronics manufacturing.

The novel approach relies on FDM 3-D printing with PVA filament to form circuit substrates containing hollow channels for EGaIn injection. The researchers developed a FreeCAD plugin that automatically converts KiCad PCB designs into 3-D-printable models with integrated sockets for through-hole and surface-mounted components. The additive process supports 3-D circuit topologies and shape-changing devices using Joule heating, as demonstrated with a self-bending gripper. The circuits demonstrated reliable performance, supporting currents up to 5A and high-frequency signals up to 10MHz, making them suitable for a range of prototyping applications. In testing, component recovery rates were up to 99.4% for PVA and 98.6% for liquid metal, and PVA was successfully re-extruded into new filament after dissolution. A lifecycle assessment (LCA) showed that DissolvPCB substantially outperformed traditional CNC-milled FR-4 boards across eight environmental metrics, including global warming potential, acidification potential and resource depletion. (UIST 2025 Proceedings, September 2025, https://uist.acm.org/2025/)