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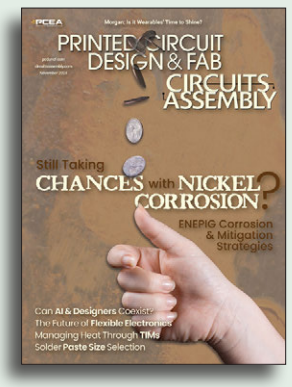

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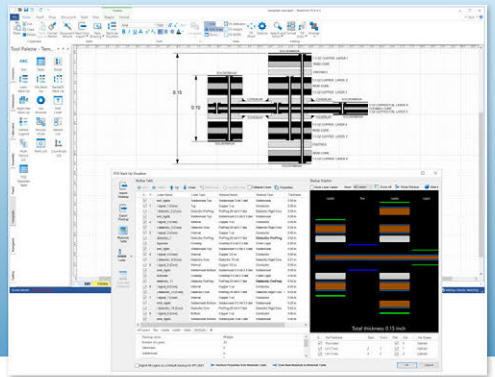

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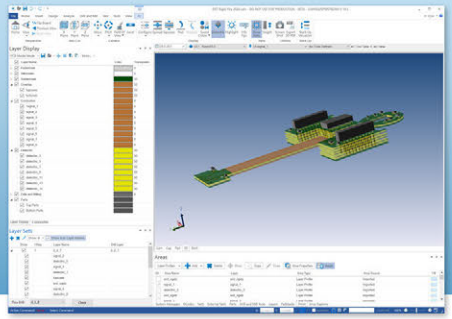
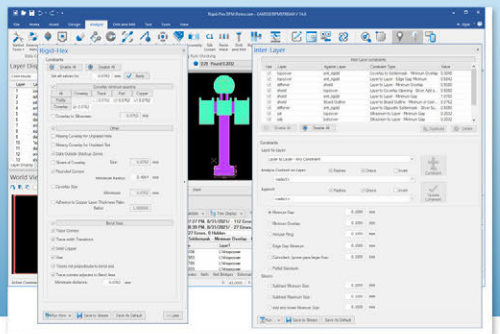


A rigid-flex design in 3D. Shown with layers spread to improve visualization of the layer stackup.



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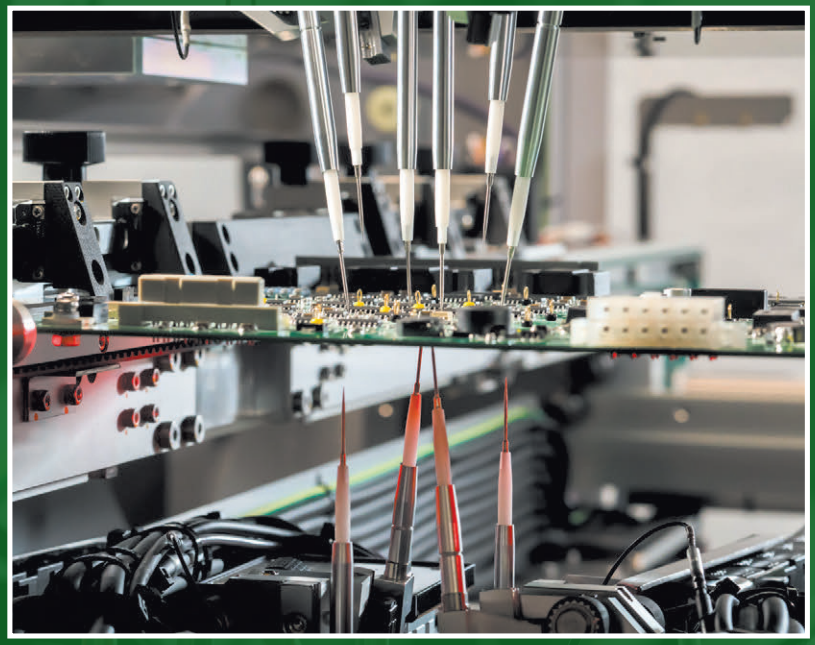

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Kicking the Gerber Habit

DUMB DATA WON'T die. And the blame rests squarely on users who resist upgrading to formats that are designed with today's boards and manufacturing methods in mind.

That's the message from the PCEA Portland (OR) Chapter at its meeting in late October. The sentiment was shared across a spectrum of users, from designers to fabricators to assemblers, including the host, Axiom Electronics.

We know the issues: Too often, fabricators and assemblers receive conflicting duplicate and erroneous design data files. More often than not the culprit is Gerber-based data packages, which almost always require modification prior to fabrication or assembly.

So while persistent errors from design to manufacturing are often due to manual entry miscues or otherwise obvious omissions such as a missing solder mask layer or discrepancies within the netlist, the industry by and large continues to put up with the pain instead of migrating to a new format.

The market use reflects the general ambivalence. According to Dana Korf, now senior director of technology, US for Victory Giant Technology and a veteran of years of work on data transfer standards, ODB++ makes up about 20% of the overall market, with IPC-2581 garnering a 5% share and Gerber dominating the rest. While the major board fabricator he previously worked for in China implemented IPC-2581 years ago, as have major OEMs such as Cisco and Apple, most haven't followed suit.

Axiom is an electronics manufacturing services company based in Portland, OR. According to Rob Rowland, director of engineering operations, the company encourages IPC-2581, and alternately, Siemens' ODB++, a position echoed by a major OEM present. Intelligent data files, Axiom says, reduce the amount of time spent on a job by several hours. If that's widely true, the labor costs alone would make the switch financially viable, without even considering the reduction in human-generated errors.

The fabricators present were more mixed, however, noting they are at the mercy of whichever format is sent by customers. Pushing back, it seems, might encourage customers to find other suppliers.

There are clear functional differences between IPC-2581 and ODB++. They have been noted elsewhere, so I won't elaborate here other than to point out that like Gerber, ODB++ is controlled by a company, not an association, and as such isn't a consensus standard. (Some will argue that's a feature, not a bug.)

Where agreement lies, however, is that the time to move from dumb data formats is now. Korf says his life's mission is to convince the industry to kick its Gerber habit. "We can completely eliminate netlists," he exclaims. "Think about

that!”

The chapter is conducting a pilot for creating a data transfer process that will help prepare users for future AI needs. Those interested in participating may contact Stephan Schmidt at sschmidt@pcea.net.

‘Labor’ Wants Experts

Readers know we publish the PCD&F PCB Designers Salary Survey each year as a means for professionals to benchmark job demands and compensation.

Our efforts apparently caught the attention of a nongovernmental organization called Occupational Information Network (O*NET), which for the past couple decades has conducted a data collection program on behalf of the US Department of Labor. O*NET is the primary source of occupational information used by job seekers, employers, workforce agencies, and others who use such information in their daily activities.

O*NET is assisting the Labor Department in gathering occupational information for approximately 1,000 occupations. They are looking for volunteers to participate in their latest survey on electronics engineers (except computer, which apparently merits its own segment), which involves completing a set of questionnaires about their work. (View a sample questionnaire here: https://onet.rti.org/pdf/index.cfm.)

The O*NET program serves employers, human resource professionals, job counselors and labor market analysts across the country who depend on occupational information to perform their work. Individuals who are exploring and planning careers also use O*NET information. Part of PCEA’s mission is to advance the careers of professional electronics engineers, and as such, we support efforts to ensure accurate, actionable data are available to our members.

O*NET has asked for our help in locating individuals willing to participate in the survey. These participants usually have five or more years of experience in the field, and may also have experience as a supervisor or educator as well as the expertise to rate the occupation on tasks, knowledge areas, work context factors, and work activities.

Any information provided is kept strictly private and will not be shared with anyone outside the O*NET organization. A random sample of those who volunteer will be invited to complete the questionnaires, and will receive a small monetary compensation and a certificate of appreciation from the US Department of Labor.

If you meet these criteria and are interested in participating, please contact Nicole Glass at RTI International, the O*NET data collection contractor, at nglass@onet.rti.org or 919-865-3440 ext. 108.

mike@pcea.net
@mikebuetow

P.S. See us this month at PCB Carolina. And visit pceatraining.net for the latest Certified Printed Circuit Designer training schedule.

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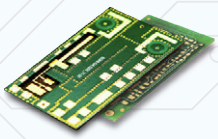
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Siemens Acquires Altair in $10B Deal

MUNICH – Siemens has signed an agreement to acquire Altair Engineering for $113 per share, representing an enterprise value of approximately $10 billion.

The acquisition of the simulation software provider will increase Siemens' digital business revenue by 8%, adding around EUR600 million ($651 million) to its revenue of EUR7.3 billion ($7.9 billion) in fiscal year 2023, the company said, and providing Altair full access to its global footprint and customer base should have a revenue impact of more than $500 million per year in the mid term and more than $1 billion per year in the long term.

"Acquiring Altair marks a significant milestone for Siemens," said Roland Busch, president and CEO, Siemens, said in a release announcing the acquisition. "This strategic investment aligns with our commitment to accelerate the digital and sustainability transformations of our customers by combining the real and digital worlds. The addition of Altair's capabilities in simulation, high performance computing, data science, and artificial intelligence together with Siemens Xcelerator will create the world's most complete AI-powered design and simulation portfolio."

"It is a logical next step: we have been building our leadership in industrial software for the last 15 years, most recently, democratizing the benefits of data and AI for entire industries," said Siemens CFO Ralf P. Thomas. "The acquisition of Altair is highly synergistic, underpinning Siemens' stringent capital allocation, balancing investments and shareholder returns on the basis of a strong balance sheet. The transaction is expected to be EPS accretive two years post-closing."

Based in Troy, MI, Altair has more than 3,500 employees and specializes in software and cloud solutions for simulation, IoT, high-performance computing, data analytics, and AI.

"This acquisition represents the culmination of nearly 40 years in which Altair has grown from a startup in Detroit to a world-class software and technology company," said James Scapa, Altair's founder and CEO. "We have added thousands of customers globally in manufacturing, life sciences, energy and financial services, and built an amazing workforce, and innovative culture. We believe this combination of two strongly complementary leaders in the engineering software space brings together Altair's broad portfolio in simulation, data science, and HPC with Siemens' strong position in mechanical and EDA design. Siemens' outstanding technology, strategic customer relationships, and honest, technical culture is an excellent fit for Altair to continue its journey driving innovation with computational intelligence."

Altair was reported to be seeking a sale after receiving acquisition interest earlier in October, with PTC and Cadence Design Systems reported as possible bidders in addition to Siemens.

The deal is expected to be completed in the second half of 2025, subject to customary conditions.

TTM Receives $30M from DoD to Fund Expansion

SYRACUSE, NY – TTM Technologies received a $30 million grant from the US Department of Defense to help fund an expansion of its PCB manufacturing capabilities.

The grant, facilitated through the Defense Production Act Purchases (DPAP) office, will enable TTM to acquire and install advanced manufacturing equipment and develop prototype designs for printed circuit boards. The project will begin at TTM's Centers of Excellence across the US and culminate in integration into its new Syracuse facility.

"The DoD requires state-of-the-art advanced printed circuit board manufacturing capability to support defense programs," said Dr. Laura Taylor-Kale, assistant secretary of defense for Industrial Base Policy. "This project provides domestic manufacturing capabilities to meet demand for current and future US systems."

"This $30 million investment will help enable TTM to build a new 200,000+ square foot facility, significantly increasing domestic production of ultra-high density printed circuit boards and bolstering supply chain resilience in line with the 2024 National Defense Industrial Strategy," added Anthony Di Stasio, director of the Manufacturing Capability Expansion and Investment Prioritization directorate.

Würth to Close PCB Plant After Drop in Orders

NIEDERNHALL, GERMANY – Würth Elektronik will close its PCB production plant in Schopfheim, Germany, citing a "dramatic decrease" in orders due to weakness in the European electronics industry. The closure affects more than 300 jobs at the facility.

The company said the region's economic crisis has reached historic proportions, particularly in the industrial electronics sector, leading to a sharp decline in European PCB manufacturers as orders shift to China and other countries. It said the situation is exacerbated by massive increases in energy and personnel costs, as well as geopolitical and economic uncertainty.

The demand from other industries that rely heavily on regional value creation is too low to permanently utilize the capacities of all Würth PCB production facilities, including medical technology and aerospace, the company said.

"Unfortunately, we currently see no alternative to ceasing production in Schopfheim," said Daniel Klein, managing director of Würth Elektronik Circuit Board Technology. "This measure is necessary to minimize losses and ensure the company's long-term competitiveness. The cost pressure is highest at our series and standard PCB plant in Schopfheim."

Future orders will be handled at other Würth Elektronik locations in Germany.

“The management and employee representatives began discussions on Oct. 4 about a reconciliation of interests and a social plan to cushion the necessary decision with socially acceptable solutions and to support the colleagues,” said Würth Elektronik managing director Andreas Gimmer. “Further meetings have been scheduled. There are no concrete results yet.”

Würth said its production sites in Niedernhall and Rot am See, Germany, will focus on industries and applications whose more complex and individual PCBs are manufactured in Europe. Comprehensive services around the PCB will be maintained to accompany customers from the product idea to the finished product.

Ventec Consolidates German Facilities

KIRCHHEIMBOLANDEN, GERMANY – Ventec in October announced plans to consolidate two facilities here into a single production and logistics center. The company said the project is scheduled to be completed in the fourth quarter of 2025.

Following the company’s acquisition of Holders Technology in October 2021, Ventec has two separate facilities in this southwestern Germany town, and the company said it plans to consolidate the two and upgrade a 13,500 sq. ft. campus with modern offices, fully equipped production halls and a new 1,800 sq. m. warehouse.

The enhanced facilities will include an enlarged prepreg cutting cleanroom, a new hall for cutting the company’s laminate materials and state-of-the-art drilling and milling machines. The facility will also include a modern dust-extraction system that meets the latest CO_2 reduction requirements, as well as solar power and heat pumps to ensure the buildings meet the latest eco guidelines.

Ventec said the production halls will separate the areas for handling varnish products from Taiyo, Ventec CCL and prepreg, and distribution release films and non-CCL materials, optimizing the layout for smooth process flows for volume and quickturn service.

“We are investing in our vision to take the EMEA business forward into the future, as we strive to continually improve services for customers, enhance delivery performance, raise quality, and ensure the best possible working environment for our people,” said Frank Lorentz, general manager, Ventec Central Europe.

“The investment in our European Production & Logistics Center is a testament to Ventec’s commitment to driving sustainable development across our global supply chain network,” said Mark Goodwin, COO, EMEA & Americas. “The increased footprint with enhanced volume and quick turn servicing capability and large warehousing facilities in a new centralized building is critical to the successful execution of our growth strategy. When completed, our new facilities will contribute towards further strengthening the global Ventec supply chain to meet the constantly evolving needs of the electronics manufacturing community throughout EMEA and worldwide.”

VVDN to Build PCB Plant in India

MANESAR, INDIA – VVDN Technologies plans to invest up to $200 million in a new PCB fabrication and connectors facility, part of a larger strategy for the ODM to ensure a steady supply chain for key components and lessen its imports from China.

The new plant is expected to come online within three to four years, said Vivek Bansel, president of VVDN, according to published reports.

VVDN is one of India's largest electronics ODMs.

Amber, Korea Circuit Form JV for PCB Production

GURUGRAM, INDIA – Amber Enterprises has signed a joint venture with Korea Circuit to manufacture advanced printed circuit boards in India.

Amber said the partnership is aimed at addressing India's growing demand for electronics, and through this collaboration, the companies plan to bring cutting-edge technology and manufacturing processes to the nation's market.

Amber and Korea Circuit will own 70% and 30% of the joint venture, respectively, which will focus on manufacturing high-density interconnect (HDI) PCBs, flexible PCBs, and semiconductor substrates.

AT&S Sells Korean Plant to Somacis

LEOBEN, AUSTRIA – AT&S in September completed the sale of AT&S Korea, including its PCB manufacturing plant in Ansan, South Korea, to Somacis for around €405 million ($452.8 million). The transaction is subject to regulatory approval and is expected to be completed in the next few months.

"With the sale of the plant in Ansan we aim to further sharpen the group's strategic profile," said AT&S CFO Petra Preining. "We strongly believe that with the Italian technology group Somacis as its new owner, the Ansan site will unleash its full potential and continue pursuing an attractive journey of strong growth."

"Ansan is an AT&S success story," said CEO Andreas Gerstenmayer. "When AT&S acquired the plant in 2006, all revenue was generated locally, and its performance was far below the expectations of AT&S. The development of new applications, strong investment in technology and capabilities, as well as the strong commitment of the responsible team resulted in strong revenue growth and a significant improvement in performance. Within only a few years, revenue quadrupled."

The Ansan plant focuses on producing flexible circuit boards for electronic systems across several industries.

“As flexible microelectronic applications are growing and will open up entirely new technological opportunities in the years to come, we were looking for a buyer who recognizes the full potential and that will purposefully lead the organization into the future,” said Peter Schneider, member of AT&S’ board and EVP of its Electronics Solutions business unit.

“We were highly impressed with the management team and technological capabilities of the Ansan plant and are very excited about its future potential. We plan to continue to serve its existing customer base with the highest reliability and strong technological competencies that Ansan is currently well-known for, while at the same time maintaining its proven track record of growth through strong additional investments in its existing team and technical capabilities,” added Giovanni Tridenti, CEO, Somacis.

Scanfil Acquires Asia-Pacific Manufacturer SRXGlobal

OULU, FINLAND – Scanfil in October announced the acquisition of SRXGlobal and its factories in Melbourne, Australia, and Johor Bahru, Malaysia, for €23.3 million ($26 million).

Between the two factories, SRX has eight total SMT lines and around 300 employees.

“The acquisition of SRX is a step in building our presence in Asia-Pacific region and the implementation of our strategy,” said Scanfil CEO Christophe Sut. “It creates synergies in procurement, improves geographic diversification and strengthens our customer portfolio. The acquisition brings us new customers and allows our existing customers to expand their operations with us in the new areas of the fast-growing Asia Pacific region.”

SRX specializes in complex, high-mix, low-to-medium volume production and has a diversified spread of customers, Scanfil said.

“We have a lot in common with Scanfil with our Medical and Industrial focus, complex manufacturing capabilities and, importantly, genuine pride in the people we employ – creating a team that can deliver world-class operational performance takes time and dedication,” said Paul Appleby, CEO, SRX. “For almost 30 years, SRX has provided exceptional service in Australia and Malaysia and developing meaningful relationships with our staff, customers, and suppliers. Culturally, we are very close to Scanfil and share similar values with high work ethic, professionalism in all things we do, and strong customer focus. I am thrilled that SRX is now part of the Scanfil family, and I look forward to seeing SRX grow stronger under the new ownership structure.”

Jabil Acquires Thermal Management OEM

ST. PETERSBURG, FL – Jabil in October announced the acquisition of Mikros Technologies, a manufacturer of liquid cooling solutions for thermal management.

Jabil said the continued adoption of AI, energy storage and electric vehicles is driving higher-power density systems, and liquid cooling has emerged as a more energy-efficient alternative to air cooling for many applications.

The company said the acquisition of Mikros will enable Jabil to help its customers manage the intense thermal requirements of their current and next-generation products while considering sustainability and cost considerations.

"We are thrilled to welcome Mikros Technologies to the Jabil team," said Ed Bailey, senior vice president and chief technology officer, Jabil. "The thermal management capabilities they bring will allow Jabil to extend the range of services we provide to cloud service providers, hardware OEMs, and liquid cooling solutions providers. In addition to the data center ecosystem, we see significant opportunities in other end-markets that require thermal management, including automated test equipment for semiconductors, batteries, energy storage systems, and electric vehicles."

Jabil said Mikros' microchannel cold plate designs enhance energy efficiency by effectively cooling over 1kW per square centimeter, and its technologies and capabilities will complement its portfolio of data center lifecycle solutions, semiconductor test equipment solutions and energy and transportation solutions.

"Joining Jabil is a tremendous path forward for Mikros Technologies. We can now scale our best-in-class liquid cooling capabilities to meet the thermal demands of the world's leading brands alongside a high-performing team of people we enjoy working with," said Drew Matter, CEO, Mikros Technologies.

Flex to Acquire Crown Technical Systems

AUSTIN, TX – Flex entered a definitive agreement to acquire Crown Technical Systems, a specialist in power distribution and protection systems, for $325 million.

Crown Technical Systems brings nearly three decades of power distribution and control experience, with capabilities in modular solutions, medium-voltage switchgear, and control and relay products. The company has customers in utilities, data centers and power generation, and has facilities in California, Texas, and Canada.

"The addition of Crown Technical Systems strengthens our position to help customers solve power, heat, and scale challenges in the data center space aligned with our long-term growth strategy," said Flex CEO Revathi Advaithi. "This acquisition reaffirms our commitment to differentiate our value through our EMS + Products + Services strategy that will deliver longer-term shareholder value."

"This deal brings together complementary products and teams, marking a superb outcome for Crown's employees and customers," said Norm Siddiqui, president, Crown Technical Systems. "We are excited to join the Flex team and accelerate growth through Flex's global reach and strong presence in markets such as data centers."

Flex said the acquisition increases its exposure to markets such as modular data centers and medium-voltage power distribution, while also extending its power portfolio and accelerating its growth in the US data center market.

Crown Technical Systems is expected to generate revenue of approximately $120 million, with the transaction expected to close no later than December 2024, subject to customary closing conditions.

Mycronic Buys German AOI Maker

TÄBY, SWEDEN – Mycronic has acquired Modus High-Tech Electronics, a German provider of automated optical inspection systems.

Modus specializes in automated optical inspection units for coating, soldering and components within printed circuit board assembly, and has also developed solutions for fuel cell inspection. The company was founded in 1999, has 18 employees and more than 1,650 scanners and 650 camera systems in service. Its net sales in 2023 amounted to €4 million ($4.3 million).

“Modus’ inspection systems are an integral part of conformal coating production lines, where Mycronic’s High Volume division is a global leader in electronics conformal coating solutions. Together we will be able to offer complete and optimized solutions to our respective customers,” said Ivan Li, senior vice president, high volume, Mycronic.

Aimtron Expands Operations After Public Listing

AHMEDABAD, INDIA – Aimtron Electronics announced an expansion of its domestic electronics assembly operations in India after a public listing earlier this year.

The company said the public listing marks a significant milestone in its journey, providing greater financial flexibility and an opportunity to accelerate its strategic initiatives.

“India holds tremendous potential in electronics manufacturing, and we aim to be a major contributor to that growth. Our goal is to ensure that a significant share of our production and innovation happens within the country,” said CEO Mukesh Vasani.

The company said it is aggressively increasing its Indian manufacturing capacity, aiming to locally produce sophisticated and high-quality electronic components that meet global standards. As part of the expansion, Aimtron is investing in new technologies such as advanced SMT lines with AI capabilities and automated assembly systems.

The company is also working to develop local talent, and with the launch of the Aimtron Foundation, it is providing extensive training and skill development programs for young engineers and technicians. Aimtron said the foundation is key in bridging the skills gap, equipping individuals with the expertise needed to thrive in the electronics manufacturing industry.

“Developing local talent is key to our strategy,” said Vasani. “Our vision is to create a skilled workforce that drives innovation from within India.”

Report: Jabil Looks to Expand India Investments

ST. PETERSBURG, FL – Jabil is looking to invest an additional $250 million to $275 million in India over the next few years for at least two more manufacturing units, the *Economic Times* reported.

The company currently has two units in Pune where it manufactures plastic casings for Apple's AirPods, and could be looking to make plastic casings for chargers, some older iPhone models, AirPods or components for Apple watches and Mac computers, according to ET's report.

As Apple continues to look to India as an alternative to China, 13 of its suppliers, including Zhen Ding Technology, TDK Corporation, Tata Electronics, Sunwoda Electronic Company, Shenzhen YUTO Packaging Technology, Jabil and Foxconn, have manufacturing and assembly facilities in the country.

PCD&F

All Flex Solutions installed an **Omron** VP9000 3-D solder paste inspection system and a VT-S1080 3-D AOI for its flexible circuit fabrication and assembly facility in Bloomington, MN.

Ascent Circuits will invest INR650 crore ($77 million) to build a PCB manufacturing facility in Hosur, India.

Dynamic Electronics joined **High Density Packaging User Group**.

Nano Dimension will acquire 3-D printer manufacturer **Markforged** for $115 million. The transaction is expected to close in the first quarter of 2025, subject to the satisfaction of customary closing conditions.

SpaceX expects its new facility in Austin, TX, to become the largest factory for printed circuit boards in the US, according to president Gwynne Shotwell.

Shenghong Technology will build a $260 million PCB plant in Vietnam.

Yuzhou Fine Chemical purchased land in Thailand's Prachinburi province to attract potential investors to the country and help strengthen the PCB manufacturing industry.

CA

Absolute EMS expanded its PCB assembly capabilities to meet the demands of the AI industry.

American Circuits opened a 37,000 sq. ft. production facility in Charlotte, NC.

Apple is set to move AirPod production to **Foxconn's** factory in Telangana, India.

Bransys installed two **Rehm** VisionXP+ Nitro 3850 Type 834 reflow ovens.

Cambodia is striving to promote the development of the automotive and electronics industries in the country to keep pace with global advancements.

Cisco opened its first manufacturing facility in Chennai, India, with **Flex** as its contract manufacturing partner.

Electronic Coating Technologies opened a new facility in Orlando, FL.

Éolane installed an advanced SMT line from **Yamaha Robotics SMT Section**.

Epack Durables will manufacture PCBA controllers and other components for **Panasonic Life Solutions'** air conditioners.

Incap installed a **Panasonic** NPM-GP/L stencil printer and AM100 placement machine at its facility in Newcastle-under-Lyme, UK.

Foxconn is considering a $1 billion investment to establish a smartphone display module assembly unit in Tamil Nadu, India, focusing on iPhones.

G&B Electronic Designs installed a **Koh Young** Zenith Alpha HS+ 3-D AOI.

Gen3 will offer **Zestron's** products and analytical services in the UK.

GPV in September opened an additional SMT line at its factory in Guadalajara, Mexico, after transferring it from its factory in Elva, Estonia. The EMS firm said much of the demand in America is moving toward Mexico, and the company is doubling its production area there in 2024, with the final layout expected to be completed in the first half of 2025.

Jabil expanded its advanced photonics packaging NPI capabilities at its site in Ottawa, Canada, opened a 48,000 sq. m. manufacturing facility in Osijek, Croatia, and is closing its facility in Florence, KY, in December, laying off 108 workers.

Konza Technopolis signed an MOU with the **Korea Electronic Association** to establish a $1.4 million electronics manufacturing support center in Kenya.

Kurtz Ersa opened a new production facility in Juárez, Mexico, and announced a partnership with **Interflux Singapore** to distribute its fluxing technologies.

L3Harris Technologies began production on its electronic warfare suite for F-16 fighter jets destined for six US partners.

Microsoft will invest $1.3 billion over the next three years to build up its infrastructure in Mexico for cloud computing and artificial intelligence.

Moldova's electronics sector is actively growing and evolving due to a robust legislative framework and infrastructural developments.

Molg announced $5.5 million in seed funding to scale its effort to tackle e-waste in electronics and component manufacturing through a robot-based circular manufacturing process.

NEOTech added an enhanced wire bonding manufacturing process for microelectronics circuit assemblies.

Niche Electronics opened an 11,000 sq. ft. production facility in Bedford, MA.

Noyce Kilby, an electronics manufacturer headquartered in Hong Kong, has started renovation of a manufacturing facility in Lithuania.

OKI received an order to produce units for satellites developed by **Astroscale Japan**.

RBB entered into a partnership with **LogiSync** to expand its in-house design capabilities.

Safran plans to build a defense electronics facility in India, its first factory to be built outside of France.

Saki signed a sales partnership agreement with **Blue Star Engineering & Electronics** for the Indian market.

Scanfil will assemble printed circuit boards for **Herma's** labeling machine.

Schott opened a new production facility in Kulim, Malaysia.

Syrma SGS Technology opened a 60,000 sq. ft. PCBA manufacturing facility near Pune, India.

Tata Group and **Analog Devices** announced a strategic alliance to explore cooperative manufacturing opportunities using Analog's products in Tata applications.

Tata Electronics plans to expand its workforce by hiring 20,000 additional employees at its iPhone assembly plant in Hosur, Tamil Nadu.

Vishay Intertechnology announced restructuring actions, including job cuts and the closing of factories in Shanghai, Germany, and Milwaukee, WI.

Z-Axis installed **Mycronic** MYPro series A40DX pick-and-place machines.

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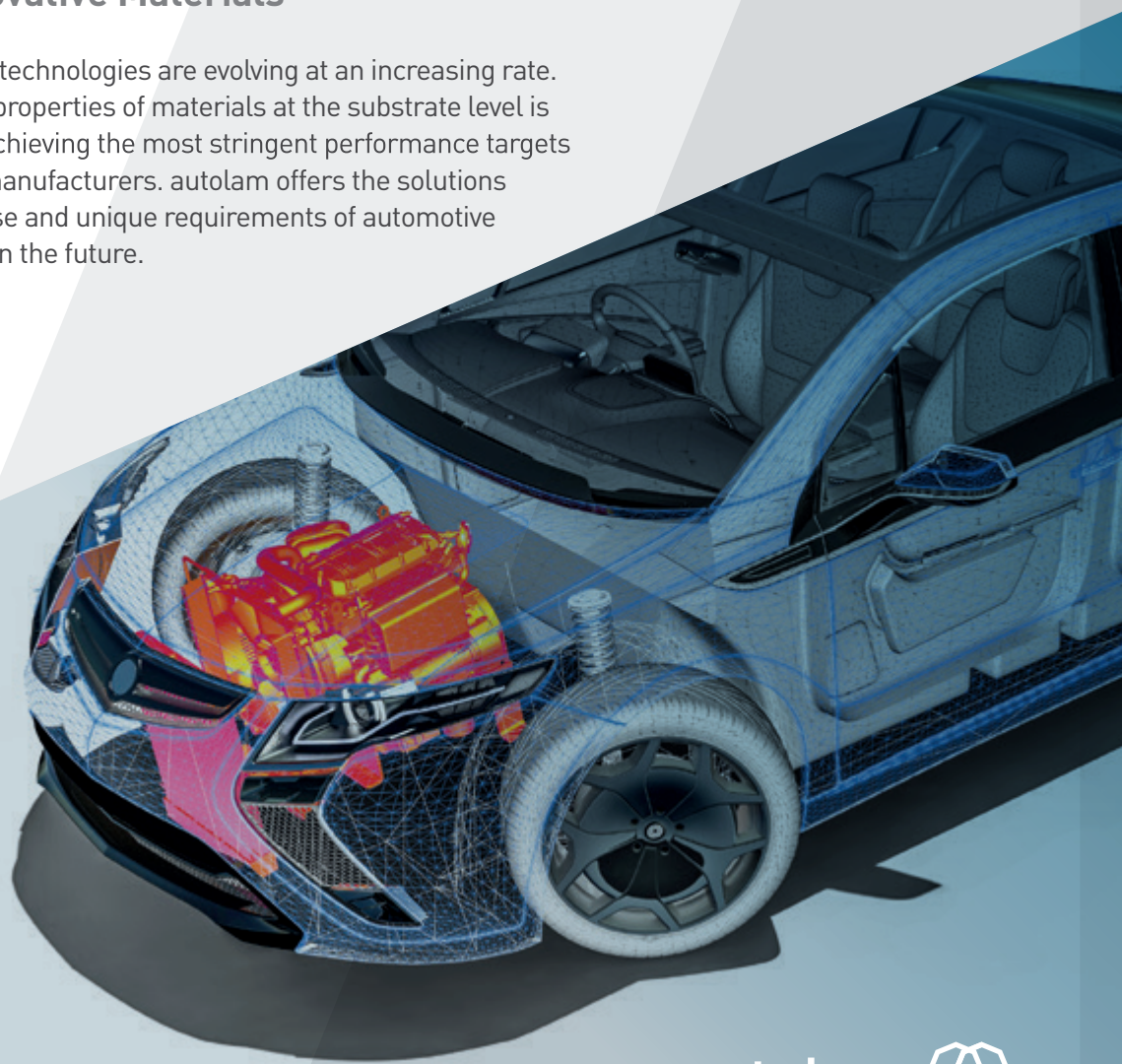

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PCDF


Dana Korf


Bill Wang

Dynamic Electronics named **Mike McMaster** engineering director.

Victory Giant named **Dana Korf** technical director, US.

Ventec promoted **Bill Wang** to group technical vice president.

CA


Ella Gwilliam


Dustan Carr


Bryan Schumaker


Chris Stori


Patrick Moody


Zoltán Dávid


Christoph Antener


Frank Mazzone


Mukesh Dulani


Mark Norris

Bill Hackett

Barb Koczera

Markus Nikles

Ganesh Shettigar

Roberto Ferraretto

Altus Group appointed **Ella Gwilliam** operations and planning assistant.

Austin American Technology added **Dustan Carr** to its service team.

Benchmark Electronics appointed **Bryan Schumaker** CFO.

Bright Machines appointed **Chris Stori** CEO.

Cirtronics appointed **Patrick Moody** president and CEO.

Danutek named **Zoltán Dávid** field service engineer.

Escatec appointed **Christoph Antener** chief procurement officer.

LinkSemi hired **Frank Mazzone** as head of sales and business development.

Milwaukee Electronics appointed **Mukesh Dulani** president.

Nordson Electronics Solutions promoted **Mark Norris** to vice president, strategic partnership accounts.

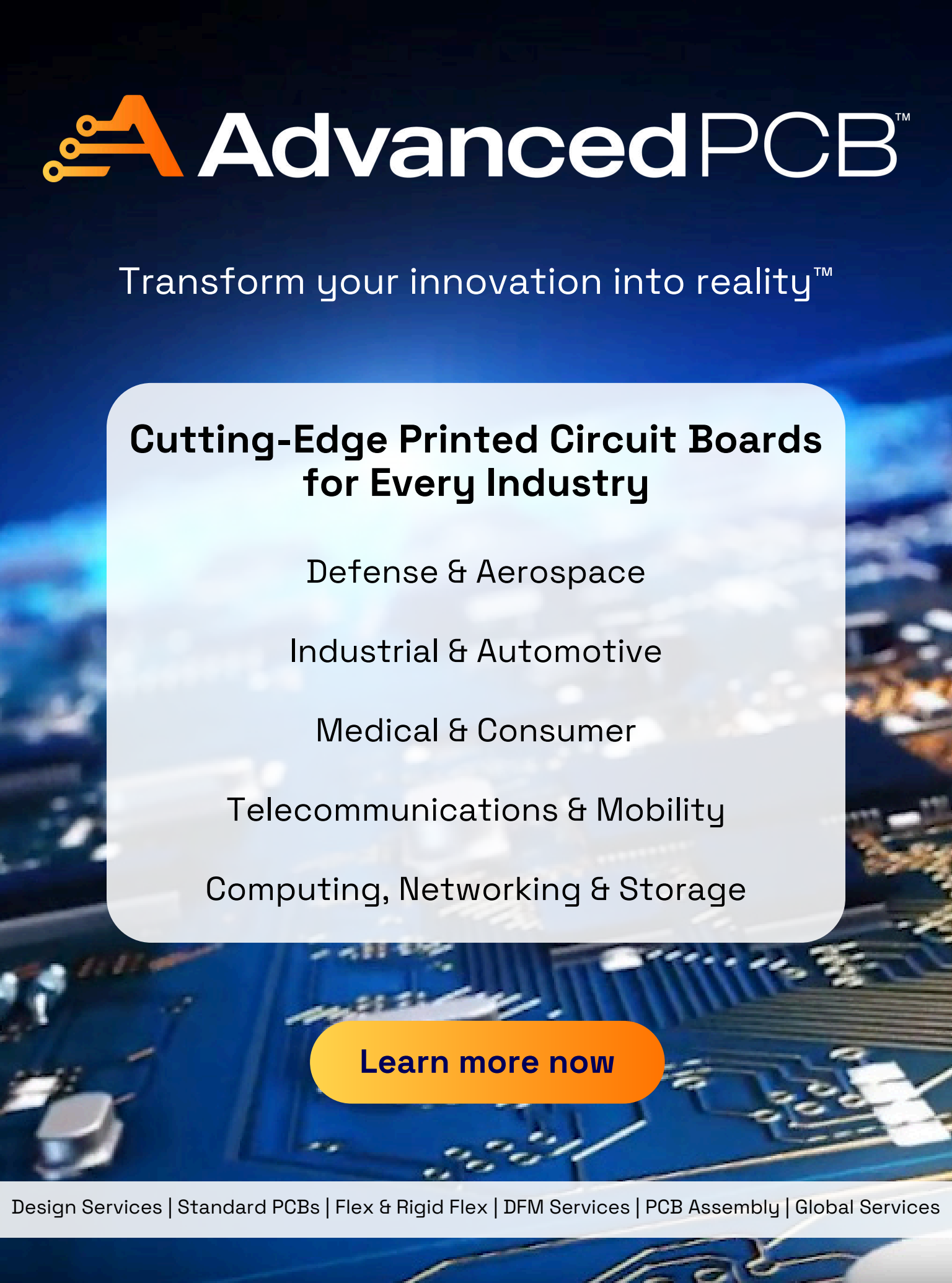
Surf-Tech appointed **Bill Hackett** of Advanced Technology Solutions manufacturer's representative.

TEXMAC Takaya named **Barb Koczera** outside sales representative.

Variosystems appointed **Markus Nikles** CFO.

VJ Electronix appointed **Ganesh Shettigar** to its sales team in India.

Yamaha Robotics SMT Section appointed **Roberto Ferraretto** area manager for Italy.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PCEA Names Webb, Schmidt Award Recipients

PEACHTREE CITY, GA – PCEA in October announced Susy Webb recipient of the third annual PCEA Leadership Award and Stephan Schmidt recipient of the third annual PCEA Membership Award. The announcements came at the PCEA annual meeting in conjunction with the PCB West conference and exhibition.

The Leadership Award recognizes members who have made significant, long-term contributions to the association and the industry. The Membership Award recognizes individuals for standout contributions to their local chapter.

Webb is vice chairman of the PCEA Executive Board and a member of the Education Committee and Conferences Task Group. She co-authored PCEA's Certified Printed Circuit Professional training and certification curriculum, and is a regular speaker at PCB East and PCB West, and international design conferences, and consults for individual companies and PCEA chapters. She is a former writer/columnist for PCD&F, a chapter writer for Clyde Coombs' *Printed Circuits Handbook,* and one of the judges for the annual Siemens TLA competition. A senior PCB designer with 40 years of experience, her career includes experience in coastal and oceanographic oil exploration and monitoring equipment, point-to-point microwave network systems, and CPCI and ATX computer motherboards.

"Name the job in the printed circuit industry, and Susy Webb has done it," said Stephen Chavez, chairman, PCEA, in announcing the award. "She has been one of the most popular presenters in the history of the PCB East and PCB West technical conferences, a significant contributor to the PCEA Training Design Certification curriculum, and a strong leadership voice and mentor across the organization.

"We can think of no one more deserving than Susy Webb for the 2024 PCEA Leadership Award," he added.

Schmidt is the leader of the Portland (OR) chapter, which meets each month and is now embarking on a review of intelligent data transfer processes. He is a global technology executive with over 20 years of experience in the laser and electronics industry, most recently as the North American President of LPKF Laser & Electronics, a leading provider of laser-based solutions.

"Stephan Schmidt has completely revitalized the Portland chapter, and it is now functioning as perhaps the most active group within PCEA," Chavez said in announcing the award.

"Moreover, his energy and thoughtfulness about ensuring local members have a range of presentations – from design to fabrication to assembly – make him an invaluable leader in our organization. It gives me great pleasure to recognize Stephan Schmidt with the 2024 PCEA Membership Award."

PCEA chairman Stephen Chavez (far left) and president Mike Buetow (far right), with 2024 PCEA award winners Susy Webb and Stephan Schmidt.

Members Vote to Relocate PCEA

PEACHTREE CITY, GA – PCEA members voted unanimously at the annual meeting in October to support a board of directors' recommendation to redomesticate the corporation to the state of Georgia.

The members also endorsed the slate of directors for 2025-27, including Jim Barnes, Stephen Chavez, Tomas Chester, Doug Dixon, Justin Fleming, Rick Hartley, Matthew Leary, Charlene McCauley, Anaya Vardya, Susy Webb and Eriko Yamato. PCEA president Mike Buetow rounds out the board.

The meeting was held during the PCB West conference and exhibition at the Santa Clara (CA) Convention Center.

PCEA was incorporated in California in March 2020. Following the acquisition of UP Media Group in January 2022, PCEA moved its headquarters to Georgia, where most of the new employees were based.

Missouri. The new Missouri chapter will sponsor a talk on DfA by Dale Lee, staff DfX process engineer at Plexus, in January. For details, visit https://attendee.gotowebinar.com/register/5063134528735616 92.

Portland, OR. We held a live meeting at Axiom Electronics in October. Featured speakers included Matt Stevenson of ASC Sunstone on design for fabrication, Rob Rowland of Axiom on design for assembly, and Dana Korf of Victory Giant on electronics data transfer. The next meeting takes place Nov. 21 via Zoom and features John Johnson of American Standard Circuits presenting on design guidelines for RF PCBs. Those interested should email stschmidt@pcea.net.

PCBs are complex products which demand a significant amount of time, knowledge and effort to become reliable. As it should be, because they are used in products that we all rely on in our daily life. And we expect them to work. But how do they become reliable? And what determines reliability? Is it the copper thickness, or the IPC Class that decides?

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Summer Doldrums Hit Japan's PCB Market

TOKYO – Japan's printed circuit board recovery remained mixed in August, as rigid board sales fell nearly 10% year-over-year on a nearly 13% drop in production output.

The data are compiled by the Japan Electronics Packaging and Circuits Association (JPCA) based on reporting from scores of domestic manufacturers.

Flex boards were nearly flat, growing 0.7% from a year ago in sales, while output was down about 7%. IC substrate sales were the outlier, rising 11% for the period despite a production drop of about 2%.

For the year, flex circuits sales are up 6.5% on a 1.3% rise in output. Rigid board sales are down 5.4% on a 13% drop in output, and IC substrates are down 11% in revenues despite a 10% increase in output.

Pass the Pie

Trends in the US electronics equipment market (shipments only)

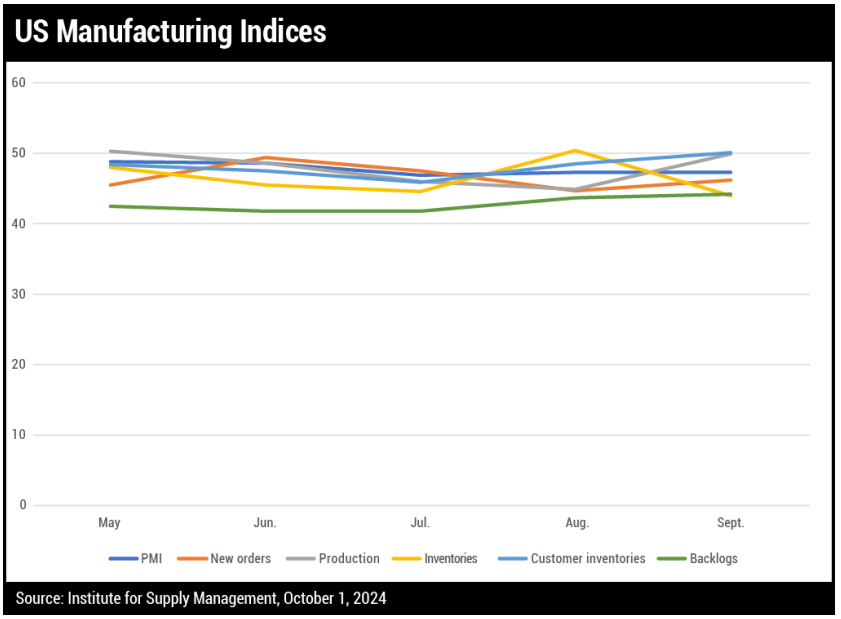
	% CHANGE			
	JUN.	JUL.[r]	AUG.[p]	YTD
Computers and electronics products	-0.4	0.2	-0.2	0.9
Computers	-2.3	2.3	-0.9	21.6
Storage devices	-6.0	7.4	-1.2	5.2
Other peripheral equipment	-3.0	0.6	3.8	6.7
Nondefense communications equipment	2.3	0.2	-1.1	0.2
Defense communications equipment	-2.5	-1.0	2.6	-3.0
A/V equipment	0.0	4.3	-1.4	-0.5
Components[1]	-2.0	-0.7	1.6	5.4
Nondefense search and navigation equipment	0.2	0.5	-0.5	2.3
Defense search and navigation equipment	-0.8	1.2	1.5	5.2
Electromedical, measurement and control	0.3	0.1	-1.4	-1.6

[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: US Department of Commerce Census Bureau, October 3, 2024

Key Components

	MAY	JUN.	JUL.	AUG.	SEPT.
EMS book-to-bill[1,3]	1.35	1.32	1.21	1.27	1.26
Semiconductors[2,3]	19.3%	18.3%	18.7%	20.6%	TBA
PCB book-to-bill[1,3]	0.96	0.95	0.99	0.99	1.08
Component sales sentiment[4]	112.3%	98.9%	103.4%	108.4%	98.8%

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



Hot Takes

Fourth-quarter memory prices will see a significant slowdown in growth, with conventional DRAM expected to increase 0-5%. (TrendForce)

Global **smartphone shipments** increased 4% year-over-year to 316.1 million units in the third quarter. (IDC)

North American EMS shipments in September were up 10.3% year-over-year and 2% sequentially. Bookings rose 19.6% from a year ago but fell 10.8% from the previous month. (IPC)

September **North American PCB shipments** plunged 24.1% year-over-year and 23.8% sequentially. Bookings slipped 4.4% from a year ago and 2.8% from the previous month. (IPC)

Global **semiconductor sales** hit $53.1 billion in August, the highest-ever total for the month and a year-over-year increase of 20.6%. (SIA)

Electronics industry sentiment declined significantly in September due to rising cost concerns and weakening demand. (IPC)

Singapore's electronics production slowed in September, growing 1.9% year-over-year compared with 50% in August, on slower demand for infocom and consumer electronics. (Singapore Economic Development Board)

The Philippines expects a 5% growth in **electronics exports** next year amid inventory correction and the expected entry of new investments. (SEIPI)

Mexico's Chihuahua state aims to develop supply chains related to chips and circuit boards to improve its competitiveness.

India is expected to limit **imports of laptops, tablets and personal computers** after January, a move to push companies such as Apple to increase domestic manufacturing. (Reuters)

Taiwanese **AI server supply-chain firms** are preparing for an anticipated surge in demand from major cloud service providers. (Quanta)

NAND contract prices will drop 10%+ in the fourth quarter and NAND wafer contract prices will slip 10-15%. (TrendForce)

Taiwan's **passive components supply chain** is anticipating a favorable market outlook for 2025, a result of the demand generated by AI device applications, according to industry sources. (DigiTimes)

Global TV shipments in September increased 15% compared with the same period last year, marking the eighth month of 2024 that shipments have achieved year-on-year growth. (Luotu Technology)

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The Costs of Complacency

With more supply chain crises brewing, be proactive in your preparations.

THE VARIOUS ISSUES that have beleaguered the supply chain, and those companies and individuals that rely on it, continue to baffle me. I fully understand that when Covid emerged on the scene, especially as quickly as it did a few years ago, the global supply chain, as well as so many other aspects of our "normal" life, came to a grinding halt. But that was then, and this is now, so I cannot stop thinking, "What does this all mean?"

That companies were forced to shut down, whether partially or completely, for lengthy periods of time while the pandemic was in full rage is understandable. Safety of employees and the fear of what might or could or is happening to public health have a way of moving to center stage in people's minds and habits, regardless of where they live or what they do for a living. It was understandable that shortages occurred with factories' production levels slashed for the health and safety of employees.

The tariffs being levied on everything imaginable – from both sides of the world – did not help. When it is economically more lucrative to sell into some countries and not others, the supply chain pivots to the more lucrative option. Couple that pivot with slashed production levels from factories across the globe, and the availability of the limited inventories gets further skewed, with some areas being relative winners while others are losing.

The combined result was that pandemic-level inventories of everything from household cleaners to automobiles were in short supply. People complained that the car they wanted was missing their desired tech thanks to the strained supply chain. It became glaringly obvious that certain items were only produced in a few countries – which were nowhere near the customers seeking those items.

So it is understandable why inventory levels were impacted over the past four years. Supply chains were disrupted and buying habits were altered, but why are supply chains and inventory levels not back at pre-pandemic levels? I fear it is because of complacency, possibly caused by exhaustion from all we have lived through over the past few years.

A feeling of exhaustion makes even thinking about the next challenge, well, exhausting. Yet by not focusing on what is needed next, some avoidable results can be averted.

As I write this, dockworkers along the US East and Gulf coasts have gone on strike. How long this work stoppage will go is unclear, but everyone knows it will disrupt the supply chain, and the likelihood of its occurrence was known well in advance – enough to have taken steps to minimize its impact. The same can be said about what has been happening in the Middle East. Tensions have been mounting for years, so a prudent executive should have a "Plan B,"

"C" and "D" in their hip pocket for not *if*, but *when*, hostilities escalate to a level that will impact supply chains.

Complacency can too easily cause critical situations, events and challenges to be easily ignored. And when ignored, they can simmer and grow into far more monumental circumstances, or as with Covid, crises that demand immediate and costly attention.

Yet another situation is the replacement of inventory being consumed by the wars in Europe and the Middle East. While the pictures of the destruction taking place certainly tug at the human heart, the equally brutal reality is that at some point the warehouses will be empty – and far sooner than anyone can imagine. Then what?

Under ideal conditions, industry will snap into action to fill the void of the inventories and materials being consumed at war, but will it? And could it do so as quickly as needed? At the moment, it certainly appears that complacency is glaringly apparent in the lack of sense of urgency to replace goods.

That brings me back to my rhetorical question, "What does this all mean?" Over the past four years, we all, individually and in our businesses, have been through so much. A pandemic that burst upon the globe pushed the global supply chain almost to its breaking point. Yet when looking at other events that could have an even greater disruptive effect, we are witnessing a sense of complacency in dealing with it.

So now as most in our industry commence with planning and budgeting for 2025, keep in mind that diligence, commitment and being proactive are the best ways to approach this important task. Complacency, on the other hand, appears a surefire way of enabling bad circumstances to get the upper hand and take control. When reflecting over the past several years, think about situations and problems that could have been avoided if a good, comprehensive plan had been in place. And think of the events that could not have been anticipated but would be better dealt with if a comprehensive – and flexible – business plan was developed and in place.

Learning from experiences, especially the extraordinary ones, should be part of the business planning process so the future flows smoothly, without trace of complacency.

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

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EMS Sales Teams: Digital Failures?

A comprehensive website is a salesperson's best friend. So why don't more EMS companies have one?

I READ AN article reposted on LinkedIn where a buy-side (pay-to-play) consulting group demeaned the EMS industry salesperson's communication skills and blamed them for the dysfunctions within our industry. The premise was that, because Covid prohibited face-to-face engagements, the business development person's lack of digital communications and their inability to redirect their sales efforts digitally were a root cause for woes in our industry today.

The EMS industry has been slow to embrace the digital world. But to assert that corporate digital dysfunction is an individual salesperson's issue implies that one's own accounts on LinkedIn, Facebook and X (Twitter) will drive enough deals to shore up a flat or declining EMS business. While I encourage my clients' sales teams to utilize these platforms for various communications, gaining industry knowledge, networking and infrequent lead generation, they make up a tiny element of what an EMS company should undertake to optimize its digital sales opportunities and boost a sales process that even now has somewhat limited face-to-face engagements. Does your EMS company suffer from elements of this discussion? Let's start a corrective action process.

First, consider your website. When was it last updated? I review many EMS websites, and when compared to their corporate company overviews, I often find conflicting or missing important elements on the sites. Your website should be your 24/7 salesperson. It doesn't close deals; humans still do that. But many OEM outsourcing searches start with a "silent review" of an EMS website. Many times, the EMS is unaware of that OEM "hit" and no sales follow-up occurs. Do you have analytics connected to your site's traffic and is there a process to follow up on relevant searches? Does your company optimize (SEO) the site so you show up early on a list of potential EMS companies from an OEM's search?

I still encounter EMS companies whose sites consist of a single landing page. That so little attention and investment has been placed here amazes me. Everyone in the industry should be exposing relevant facts about capabilities, markets served, core values, quality certifications and other important details that trigger an OEM to spend more time with you or determine whether your company is a fit for its outsourcing needs. It is especially important, albeit difficult, to define what differentiates your company from others in the industry. In an old industry presentation I have given from time to time, the first slide is a view of the earth from space with the title: EMS – We All Look Alike from Space. *How* do we differentiate ourselves from the thousands of EMS companies across the globe? Content.

When I find an EMS website lacking good technical, business, social and internal company content, I know it stands a

good chance of not getting a follow-up call from an OEM that viewed it early in a silent web search. Effective content is a mix of technical white papers, posts, opinions and videos espousing technical merits and competencies. Business issues affecting our industry are important to connect with, especially if you can tie that to a service offering that solves a specific business problem we all face, such as component availability or obsolescence. Are you helping your community with programs and volunteer activities? Are internal employees recognized for process improvements and promotions? A holistic approach for letting prospective OEM outsourcing teams know exactly what you are and what you are not should aid in proceeding past the silent search and moving to a more engaged mid-sales process.

How about virtual tours of your plant? Many OEMs have difficulty auditing an EMS plant in person. How do we support a formal virtual audit? This is not just a four-minute walkthrough of the factory, although that is an important video, too. You may want to consider where time has been spent in the past during face-to-face audits by world-class OEMs. Consider making detailed videos on each element of your business where time was invested in those in-person audits to be sure your processes are highlighted in great detail. I have spent a good portion of an in-person audit just on incoming raw material, verification/inspection, tracking, historical record-keeping for highly controlled industries, consigned versus purchased material, storage of like material so it is not mixed among clients, and kit dropping. How can a 30-second segment of a corporate-wide overview that brushes on raw material handling address an OEM's concerns?

The markets you serve should not be intuitive based only on the quality certifications obtained. For example, AS9100 is a critical element to chase A&D business. But what else sets you apart as the least risky choice for OEMs in this market? How do you address material obsolescence and component counterfeiting? How do you qualify a high *f* manufacturing PCB source if the OEM left that BoM item as an open source? Are you an experienced test house? How well do you perform SMT changeover, since these runs tend to be shorter than, say, telecom or consumer-based business? While different markets have some similarities of needs, there are key differences between the various markets you may want to serve. I always encourage clients to expand on their experiences so a prospect can easily see where they excel.

While EMS sales teams became effective in Zoom and Microsoft Teams during the pandemic and can conduct virtual meetings with aplomb, many have been left to fight a sales battle with little ammunition in their sales tool kit.

Poorly constructed corporate overviews are common in our business. Many are too long, listing details not needed in a general overview. Some are too short, missing critical elements every EMS overview should include. Some I have reviewed don't include the basic elements of their business that would trigger prospective OEMs to invest more time assessing them. A well-thought-out corporate overview, with massive backup slides of the numerous individual elements of the EMS company, is in order *if* you are supporting your sales team effectively.

If 50% to 75% of your monthly balance sheet costs are raw materials, why not have pages of slides detailing your robust materials organization processes, problem-solving methods and software tools? Isn't that a logical big risk to a prospective OEM as it is a huge part of its spend with an EMS? Think about detailing your DFx and manufacturing engineering capabilities; PM team operations; specific technologies you are good at manufacturing/testing (i.e., RF, power, optical, fine-line, box builds); a review of primary differentiators to those you often compete against; examples of a BoM (DFSC) scrub, DfM, DfT and DfA; detail if you can really offer quickturn assembly, and different corporate

overviews tailored to the specific industries you want to hunt and grow in. These are not expensive investments to make in support of your sales force. What about digitally supporting the HR department as it struggles to attract new and experienced talent? Why would an SMT engineer, or another in-demand position, want to work for you versus your competitors? You would not play a football game with nine players, so why not arm your sales force with a robust sales tool kit and give them all 11 players to compete with?

Then there's the digital tools your materials team needs to embrace. The materials planning and communications between an EMS and its OEM counterparts is more demanding than ever. It isn't just about the demand of some industries that pulls the global capacity of specific commodities and fluctuates lead times. Parts shortages and price fluctuations drive dysfunction, customer satisfaction and revenue capture much more than a salesperson with an inactive Twitter account.

A final critical element OEMs consider when all else seems equal in their final outsourcing decisions among EMS competitors is the NPI process. I am defining NPI as a validation build required to be given the green light to scale to production, or better stated, the first-article acceptance build. Many reading this may not feel their NPI process is robust, repeatable and well documented. Does every PM, at every site, for every new SKU being launched, go through identical NPI process steps with their materials, quality, manufacturing, test and planning organizations? I have seen hard-fought-for new clients lost at the NPI stage as the first-article builds were handled so poorly. I have seen OEMs never reach the scale of their intended outsourcing TAM with an EMS due to poor NPI execution. I have seen first articles pass and the EMS get bogged down on the first production run as problems surfaced that were not uncovered in the first-article build process. This topic deserves more time than given here, but ask yourself, is my NPI process a strength or weakness? If it is not a robust and repeatable process that every new SKU goes through, it may be time to rethink that process. Differentiate your company with a robust, repeatable and well-documented NPI process, and advertise it to as many prospective OEM clients as possible.

It's a given that EMS salespeople must interact on their individual social media platforms. But it is fly poop on dust when compared to the EMS company's obligations to invest in an overall digital strategy and the digital process and tools to support its sales team's communication and sales efforts. Let's put the focus of any dysfunction in the EMS company's marketing outreach where it belongs, because if we blame a salesperson's digital communications skills, the problem will never be resolved.

I have read that industry experts are prognosticating that a high percentage of all sales activity will continue to be digital even with the pandemic behind us, so this is a long-term benefit for those who invest properly.

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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Solder and Stencil Considerations for Double-Sided PCBs

Accounting for the assembly process will put your design on the fast track.

THOUGHT-PROVOKING QUESTIONS keep coming my way, and then it's down the old rabbit hole. So it goes something like this: "How do we integrate so many different parts in such a small PCB area?" The answer is a little deeper than the geometry of Tetris, but that's a good illustration of packing the available space. This, of course, starts with the CAD symbol library and manifests in the assembly yields at the factory. We have to connect those dots.

Once the PCB logic is sufficiently captured, placement studies can start. Pay attention to the spacing and orientation of components. The interrelationships of neighboring parts can affect the solderability of the overall PCB. The assemblers like to see a consistent rotation of the components and an even distribution across the board.

It's unlikely that every device on the board will be able to meet that preference. The electrical performance is going to take priority in several cases, particularly with analog designs. That said, you can still pick an orientation that suits most components. The similarity will inform the manufacturing engineer how the board should travel along the placement machinery and guide the soldering process.

Creating an A/B flip panel. Manufacturing may also drive the assembly subpanel geometry. They look at how most of the parts are rotated and send the board through the process so that most passive components go through broadside to the direction of travel. This means leads are soldered at the same time rather than sequentially. The effort helps reduce the infamous tombstoning defect.

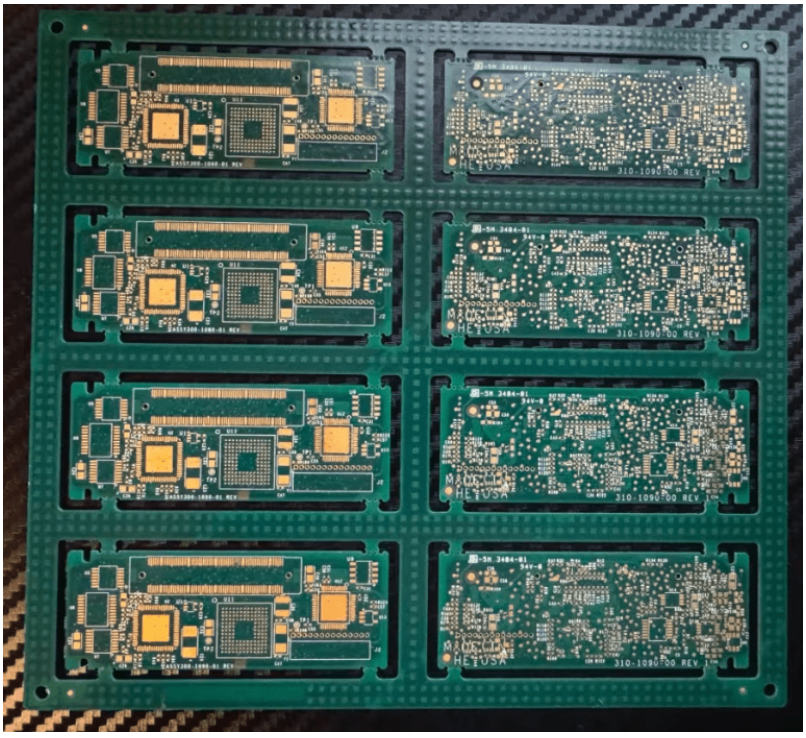

Figure 1. A four-up/four-down A/B flip panel for a 10Gb transponder daughtercard.

Double-sided circuit boards might be able to pass through the process using a single stencil. This is known as an A/B flip panel. Half the boards in the assembly subpanel are topside-up and the other half are upside-down and rotated 180°. The result is a panel that looks exactly the same no matter which side you start with.

One x-y pick and place file and one solder paste stencil suffice for both sides of the board in one go. Aside from saving on a stencil, the time it takes to populate one side of the panel is exactly the same as populating the other side. Often, a board ends up with more parts on one side than the other, creating an imbalance in the time it takes for each side. With half the boards "up" and the other half "down," the time and setup for each operation is the same.

One of the key parameters of an A/B flip subpanel is the weight of the components. Heavy parts are not so good at staying attached when they are on the underside. Glue can be used, but it's a cost and process subject to cosmetic issues. Ungluing can be a pain when it comes to rework. More likely, the heavy part will negate the option, so all boards will be empaneled with the same side up.

In any case, the subpanel supports assembly with tooling holes and fiducial marks on both sides. The discarded area of the subpanel may also have a test coupon or an arrow that shows which way to handle the panel in the fixture. Don't make operators guess.

Implementing solder mask-defined lands. A general rule of thumb is the paste stencil opening is equivalent to the copper area of the pad. That would generally be 2 mils smaller than the solder mask opening. That would hold true until the solder mask is all that's left to define the pad.

When the ambient copper floods over a pad, it becomes mask defined by definition. When this is the case, only the

paste stencil is left to represent the vestigial pad that was consumed by the copper flood. The solder mask has to shrink to the original pad size, matching the paste size for a repeatable solder joint.

One of the main reasons for solder mask-defined lands is accommodating fine-pitch devices. The must-have that defines the process is the minimum web that can be laid down between two pads. If the minimum web is wide enough to paint the entire gap between the pads, then it's clear that solder mask-defined lands must be used. The solder mask web is also relevant to the paste stencil in that a minimum width of material is required between stencil apertures.

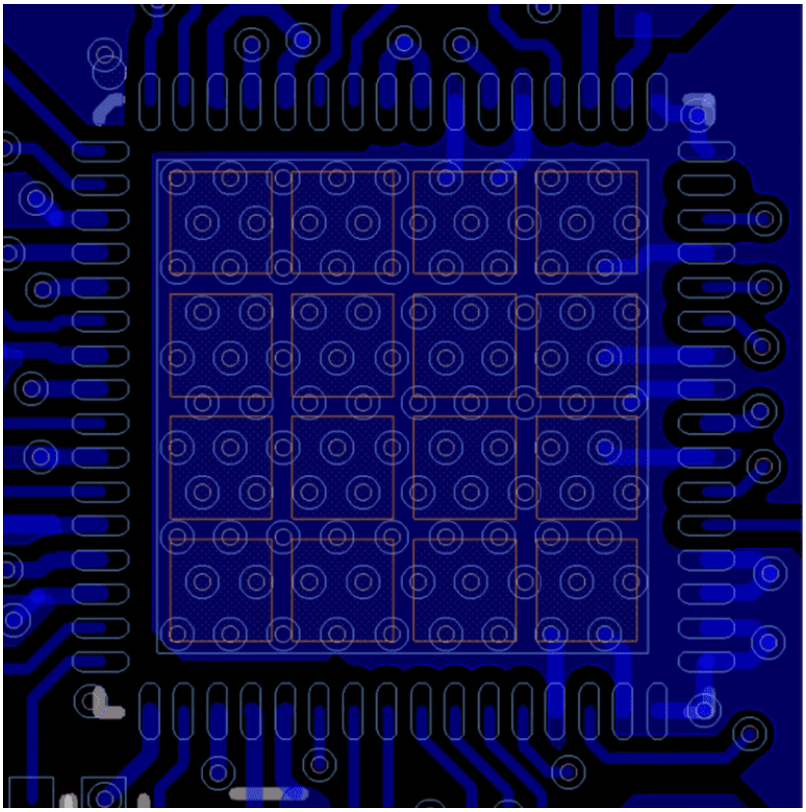

Figure 2. Fine-pitch devices may require solder mask-defined lands rather than non-solder mask-defined lands to get a proper laydown of mask between the pins. The GND paddle paste mask is broken into 16 squares to calibrate the amount of solder.

Gang relief is usually a last resort since the solder dam helps keep each solder joint in its own little world. When you don't have the mask between pads, the amount of paste has to be decreased to starve out the tendency for solder to create bridges from one pad to the next during reflow. An exception to that is where there are pins that do not get soldered. Edge connectors and press-fit connectors fit this profile.

The ever-shrinking footprints in the name of progress. As the package size shrinks, the integrity of the pad and the paste opening become critical parameters affecting assembly yields. The paste apertures, as well as the actual solderable land, may need to be more organic than the datasheet suggests. Rounding off the corners of the pad is becoming more common.

When it comes to the 01005-size passive components, the footprint could end up with D-shaped pads with a full arc around the toe filet. Further, it may be mandatory to fan out the pads with a specific width line that extends from the

center of the pad. The pad would have non-solder-mask-defined lands. A little extra mask would fill where the trace exits the pad to make that spot mask defined.

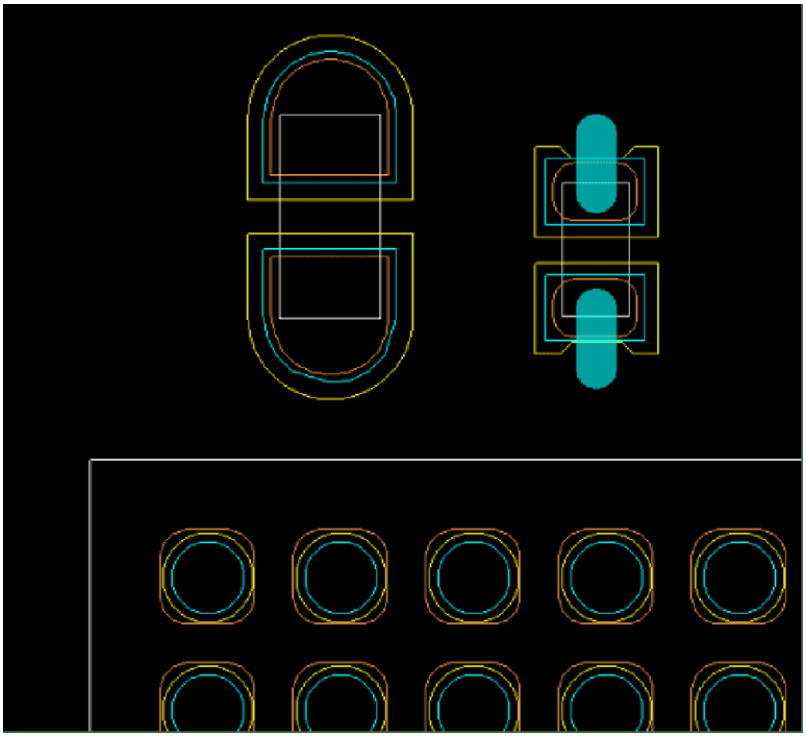

Figure 3. The differences between 0201 and 01005 can be profound. The footprint on the right is for an 0201 part while the left shows a suggested footprint for an 01005.

There are other potential ways that the paste stencil openings would not match the metal layer. The so-called home plate pad bevels the stencil to reduce the paste under the gap between the pads. Another approach rotates the five-sided home plate such that it points away from the center of the part. That one plays out more like the D-shaped pads mentioned above. It comes down to what type of solder defect is most prevalent.

Naturally, the finer pad pitch will dictate thinner stencil material than the typical 4-mil thickness. Lasers are used to create the leading-edge stencils. There are options to build up or carve out selected areas. The idea is to step up or step down different areas of the stencil so that you get more or less paste applied to different areas.

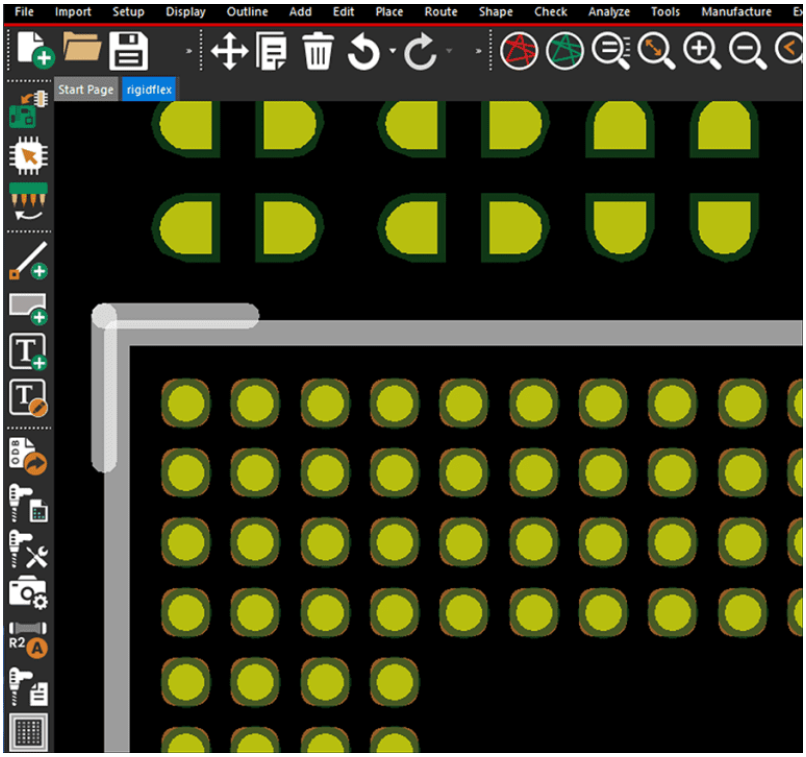

Figure 4. With yellow for metal, green for mask and gold for the stencil, this 0.4mm pitch BGA footprint is an example of over-printing the solder paste.

Time = money. My first ECAD job had us designers buying our paste stencils from the same local vendor. One day, our manager pulled me aside and asked why I paid $140 for a stencil when everyone else paid $175 for theirs. The difference was that I did not select the expedited schedule option.

The reason was that the PCB itself was going to be a four-day turn, so we didn't need a 24-hour spin on the stencil. Three days was sufficient to get it in my hands; I just had to order it right after commissioning the board (I'm not sure why my coworkers rushed their stencils but that soon changed). Those dollar figures and turnaround times are from the early '90s when life was different. We were literally launching the information age. Little did we know…

When the factory is down the stairs or in the next building, the tactical aspects of the PCB enablement shine brighter. In some cases, it's probably better to have a buffer between engineering and the actual production line. Engineering changes have to be vetted in some way before taking effect. When a solder defect is holding up progress, finding the root cause and delivering a workable solution should be a top concern in any case.

Price is often the key metric for consumer goods. That aspect really tilts the table toward offshore manufacturing, where the feedback loop is measured in time zones. We don't feel the pulse of a fab shop halfway around the world. This only sharpens the focus on the preproduction data from the assembly team. Make their problems your problems, and hopefully, there will be no further problems.

Reacting to unforeseen issues is a day in the life on the assembly line. Even with the best-laid plans, solder defects find their way into a board. We have preproduction cycles to help resolve these issues. There are telltale signs of too little or too much paste in the mix. Individual apertures can be modified to solve defects related to too much

solder. Typical clues for excess solder will be solder balls, bridging, dross or head-on-pillow defects. Insufficient solder will manifest in pinholes, non-wetting and disturbed solder joints.

Assembly yields from the above defects should be analyzed at the first opportunity. Often, a global edit to the offending padstack is the most effective remedy. When it's too late for that, look at the thickness of the stencil and the geometry of the openings. The volume of the solder can be increased by over-printing beyond the existing pads. It can also be decreased with a smaller opening or by creating a windowpane of four separate openings for a large copper pad. Figure 2 details an array of 16 windows as a jumping-off point.

Solder paste can be procured in large containers for mass production but also comes in applicators similar to a syringe or turkey baster for depositing it by hand. Scaling up and gaining the precision necessary for fine-pitch devices can also be done with refrigerator-sized machines that apply the paste robotically.

Robots must be programmed to do each type of board, and they cost big money. Wait for them to be synthesized on a pad-by-pad basis using the AI with the right set of prompts. With enough equipment, you might get away from using paste stencils altogether.

In the factory, dispensing solder paste is not as fast as using a stencil. On the plus side, dispensing is more adaptable to updates when the board gets a minor placement revision. It's a capital cost that would allow the manufacturer to put a few people into better positions.

Reflow temperatures will vary with different solder paste formulas. The paste itself can be more or less granular in composition. The finer grain will get into the smaller openings better. More than likely, there are RoHS agreements in place. That will narrow the field a little. You start with the normal formula for SAC 305 solder and make adjustments if there are trending solder defects. This is one of the reasons we have pilot programs.

The board is a fixed cost that is usually a fair portion of the overall bill of materials all by itself. Add in all of the bits and pieces of the assembly and note that you are now deeper into the schedule as well as the production cost curve. This is why knowing the intricacies of the assembly process is one more key to delivering a profitable program.

JOHN BURKHERT JR. is a career PCB designer experienced in military, telecom, consumer hardware and, lately, the automotive industry. Originally, he was an RF specialist but is compelled to flip the bit now and then to fill the need for high-speed digital design. He enjoys playing bass and racing bikes when he's not writing about or performing PCB layout. His column is produced by Cadence Design Systems and runs monthly.

ENGINEERING *TOMORROW'S* ELECTRONICS

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Where are the Wearables?

The smartwatch has lived up to the hype. Can other wearable technologies follow its lead?

WILL WEARABLE TECHNOLOGY ever realize its potential? Exciting technical innovations that should succeed often disappoint commercially, failing to take off for reasons that can be difficult to define.

Some forecasters would already have us walking around in clothing made from smart textiles that can monitor vital signs such as respiration and body temperature, track sports performance or fatigue levels, or assist treatment such as posture correction or physiotherapy. On the other hand, we could be routinely interacting with the world through AR glasses that overlay everything we need to know, wherever we are, minute by minute, and record our experiences wherever we go. And perhaps our wearables should be battery-free, powered by energy-harvesting technologies that can turn movement, daylight, or even the difference between hot and cold, into enough electrical energy to keep us connected all the way to the furthest extremities of the grid.

While these all have their place in the modern world – augmented reality is making inroads in industrial scenarios such as on production lines and in vehicle maintenance, and controls powered by ambient energy have been commercialized for smart-building applications – the massive, all-pervading adoption within consumer markets has not come about.

Smartwatches, however, represent a segment of the wearables market that is now delivering on its promise and living up to the hype; perhaps the one single wearable product category that has become truly successful in the consumer domain. The category has taken off largely by providing accurate, convenient health and fitness tracking. People love gadgets that can make them healthier and fitter, and a smartwatch on the wrist is in an optimal place to capture reliable and extensive data about movements, activities and signals such as heart rate and temperature. By connecting to the user's smartphone, that data also become easy to access and visualize.

Previous technological generations have given us gadgets like pedometers that could be easily carried in the pocket to provide basic step counting, from which distances walked can be calculated reasonably accurately and easily. Similarly, heart rate monitors became fashionable with the creation of ECG chest straps that are simple enough for consumers to figure out and convenient to wear. Subsequently, optical pulse counting using photoplethysmography has taken simplified, non-invasive heart rate monitoring to a new level.

Even those pedometers and HRMs, however, are relatively niche accessories; HRMs, in particular, remain the preserve of serious or semi-serious athletes. The secret of smartwatches' success lies in the arrival and coalescence of

multiple constituent technologies: tiny, robust MEMS inertial sensors, satellite positioning, Bluetooth personal area networking leading to the low-energy technology that connects our devices today, as well as the smartphone. Or perhaps I should say the smartphone app, the concept that provides the dashboard for so many essential activities of modern living: banking, social media, shopping, traveling and car parking. And – connected to the smartwatch as the data-gathering device – fitness activity tracking.

This is a revolution that has spread to give us hybrid watches that combine connected functionalities with traditional styles, while on the other hand enabling the extension of specialized equipment such as dive watches. These have evolved to provide far more than traditional time and depth monitoring when underwater. Not only adding typical smartwatch features, the latest models go much further by providing hundreds of customizable sports modes that can tailor the watch behavior for diverse pursuits from mountain biking, trail running and mountaineering, to weight training and yoga. And, of course, diving, with modes for freediving and scuba diving. There is also help with recovery after training, and with this kind of built-in expertise, it's easy to see an opportunity to introduce AI into the mix and take things further. We could soon all have access to Olympic-level coaching to help us toward our goals.

With next-generation biosensors now emerging, which can manage multiple channels of body signals, the continuing trend of converging advanced technologies in the smartwatch could create many more new avenues for development. In the future, these devices could give us accurate early warnings of disease or mental health indications that could empower us to seek help sooner, and perhaps even find a suitable counselor nearby and arrange a consultation through the Internet.

This once geeky accessory, the smartwatch, has become a $30 billion market with unit sales of 150 million per year. The market continues to grow at about 10% CAGR, with the greatest revenues coming from North America and Europe and the fastest growth in Asia and the Far East. To see what's coming next in wearable tech, we could look to the emerging markets for smart rings. Integrating more or less the same technologies as smartwatches, they can offer advantages such as ruggedness and extended battery life for applications such as heart monitoring, sleep tracking and payments.

On the other hand, could some of those untapped technologies like smart fabrics show us that they have simply been waiting for the right complementary technologies to create a new and unimagined market? We may only find out when, or if, it happens.

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PRINTED **ELECTRONICS**

The Future is Thin, Flat and Flexible

What's ahead for antennas, heaters and inks.

by MICHAEL LEFEBVRE

In the 39 years I've been in the printed electronics industry, I've had the privilege of witnessing, influencing and playing a part in life-changing innovations such as the SonoCine ultrasonic breast imaging device and printed wearable therapeutics. As brilliant as these breakthroughs were back in the day, however, they don't hold a candle to today's conductive transparent thin films that are enabling limitless design and engineering possibilities.

The following is a synopsis of some of the leading-edge technologies and their applications. After reading about the following examples based on my current experience, I think you'll agree that the future of our industry is exciting indeed!

Aesthetic and Green

Transparent, flexible antennas. Today's 5G frequencies don't penetrate buildings well, and the need for more antennas to facilitate 5G speed is growing exponentially. The problem is that consumers don't want unsightly features (read: antennas) attached to their products or visible anywhere within their environments.

A new class of antenna is emerging to solve that problem. Transparent antennas, made with flexible, conductive hybrid films offering performance equivalents to leading low-loss, ceramic-based PCB laminates, work as well as traditional nontransparent printed antennas. They can be leveraged for automotive, cellular, NFC, Wi-Fi/Bluetooth, LPWAN and GNSS/satellite use, to name a few.

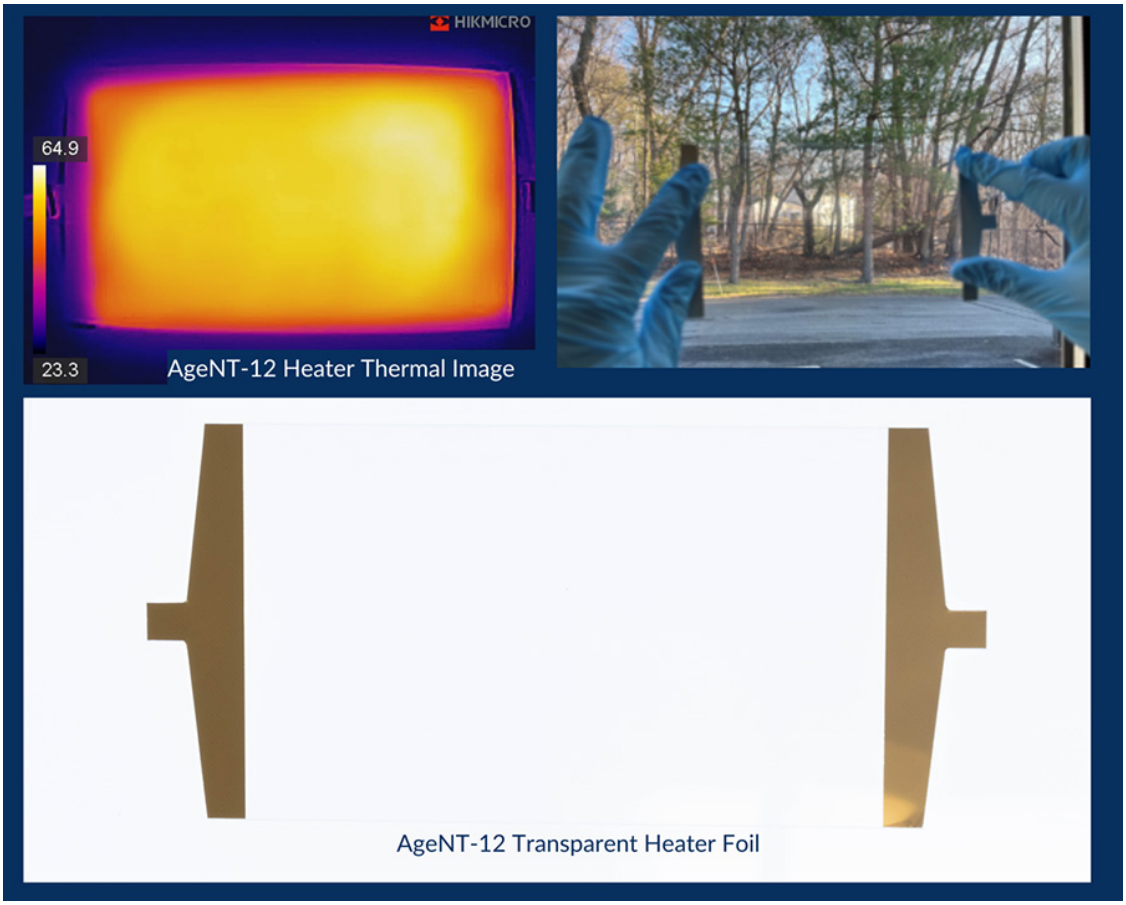

Figure 1. Transparent antennas can be used in automotive, cellular, NFC, Wi-Fi/Bluetooth, LPWAN and GNSS/satellite applications while removing unsightly traditional antennas.

Chasm Advanced Materials believes high-performance transparent antennas have the potential to overcome connectivity challenges in a variety of fields, including automotive, enterprise IoT and smart cities. These antennas can be easily integrated with glass or windows, providing a level of freedom that is hard to match. With peel-and-stick options, users can upgrade their connectivity setups without drilling holes or risk of damage to their assets. Furthermore, this technology can be integrated using various methods, such as optical clear adhesive (OCA) lamination and film insert molding processes.

Transparent heaters. Our industry has long leveraged IME to carry electronic signals for heaters. At DuraTech, for example, we manufacture resistive heating elements to de-ice polycarbonate snowplow headlights. This is done by inserting a functional thin-film printed with conductive silver ink into an injection molding tool so it bonds with the resin of the molded lens. As a result, snowplow headlights illuminated with low heat-producing LEDs stay free of snow and ice.

Companies like Chasm are taking that technology further. For example, optical cameras, LiDAR and radar sensors in advanced driving assistance systems (ADAS) don't perform well in fog, rain, snow and cold conditions. Yet solutions like embedded microwires or indium tin oxide films can result in energy loss or distortion, thermal gradient issues or are easily cracked. Chasm's AgeNT heaters are compatible with camera, lidar and radar sensors, delivering rapid and uniform heating over the entire camera lens, lidome or radome surfaces **(Figure 2)**. The heaters are transparent, with no visible wires, and are stable during temperature, humidity and UV aging tests. Moreover, they are compatible with

standard automotive voltage (12V), making them easily integrated into existing vehicle systems. In comparison, other emerging technologies struggle to provide enough power density at 12V. AgeNT heaters can be mass produced at low cost, making them an attractive solution for automotive manufacturers and suppliers.

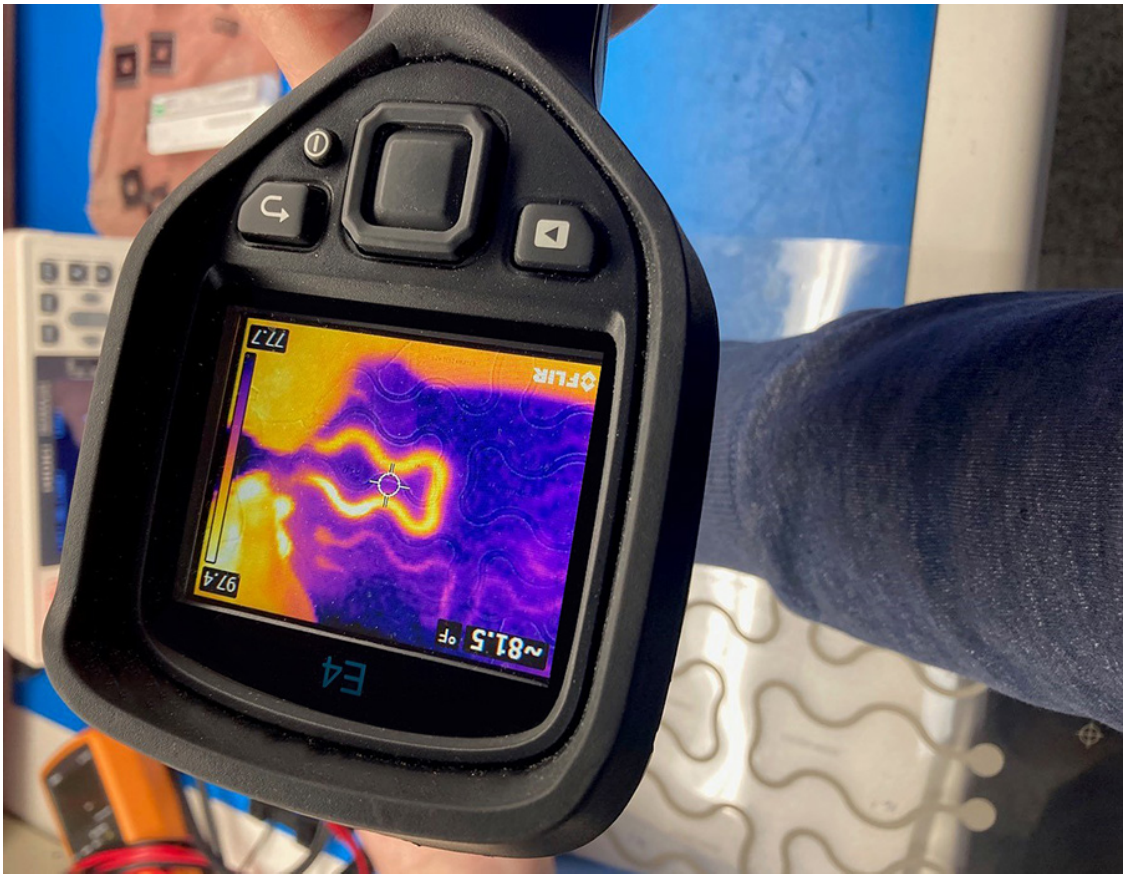

Figure 2. Chasm's transparent heaters provide even heating of a surface, with no visible wires.

The next step in transparent heater technology extends to road management systems. An example in development includes printed spherical heaters inserted into the compound curves of a toll system's glass fisheye lenses. Sensors within these lenses must be able to operate in all weather conditions to identify vehicle size – from motorbikes to semi-trailers – to determine what toll rate applies to each vehicle. Another example is heaters for solar-powered cameras placed at fixed road junctions to help municipalities and snow removal companies gauge road conditions. Armed with accurate information supplied by snow-, ice- and fog-free cameras, they can then determine how to mix the appropriate brine solutions and where to put them to keep roads safe for driving.

Cavitated inks. For most users, cavitation implies powerfully destructive liquid microjets and shock waves that will pit the hardest metals or ceramics. These are caused by significant pressure changes that form vacuum bubbles, which collapse when the pressure is greater on the outside of the bubbles. One example is when a propeller turns in the water to decrease pressure, thus forming the vacuum bubbles that ultimately collapse and pit the metal propeller. Today, however, cavitation is being leveraged in an entirely different way that's rocking our industry.

ACI Materials has developed a controlled cavitation process that produces functional inks with nanoparticle dispersion to less than 0.1µm. Essentially, the process forms vacuum bubbles within the material and then fractures the bubbles to release the energy. This energy is released in the form of liquid microjets and shock waves, creating the

ultimate dispersion of the product mix and achieving near primary particle size (elimination of large agglomerates). Cavitation does not alter the morphology of malleable particles, although layered structures like graphite and nanoclays will exfoliate, forming high aspect ratio particles. The cavitation process creates ink with superior conductivity and mechanical performance, permitting printers with a squeegee and a flood bar to be used where we could never have imagined; markets like power management, for example, that were were formerly off limits due to ink limitations.

ACI Materials has developed and currently produces the world's only cavitated functional inks. These specially formulated inks enable the solderability of silver-based additively manufactured printed circuits, permitting high-throughput, low-cost component attach in FHE applications. When this process is combined with a substrate such as PET, which is very low-cost, printers can work toward a cost-comparative way to additively manufacture circuits – a benefit for them and the environment.

Cavitation also makes the ultra-fine dispersion of carbon nanomaterials possible **(Figure 3)**. This matters in the manufacturing of stretchable fixed-resistance heaters, for instance. Functional fillers, including carbon, must be fully dispersed to consistently print a trace with a target resistance. If not fully dispersed, the shearing forces of screen printing can continue to disperse the carbon fillers during the print run. This changes the resistance of each print throughout the print run. Achieving full dispersion of carbon fillers is extremely difficult. Through cavitation, carbon is fully dispersed before it ever goes on the screen, resulting in consistently even output temperatures from fixed-resistance heaters, even in print runs of thousands of heaters.

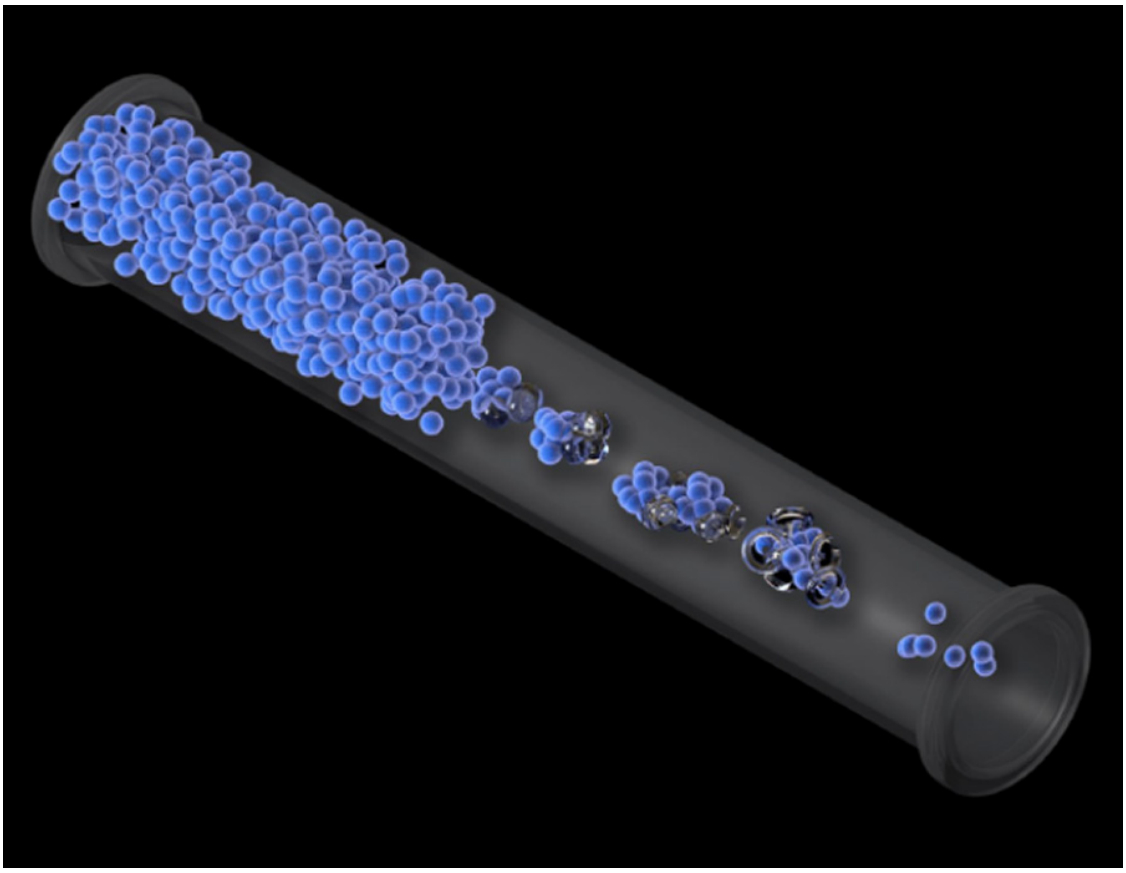

Figure 3. ACI's cavitation process improves material performance, enabling new applications in stretchable/wearable technology and flexible hybrid electronics.

Ultimately, cavitated inks could make a tremendous difference to our personal carbon footprint. Cavitated ink, for example, can be used on stretchable material, enabling the creation of wearable heaters that conform to the human body – and withstand wash cycling and drying. So, if we can make a four-foot scarf with a printed heater that measures just 18" for the part of the scarf that wraps around your neck, how likely are you to turn up the heat in your home? Not very. It's thin, flat, flexible, convenient and extremely power-efficient in more ways than one.

Finally, cavitation itself is a green manufacturing process. Because it takes place in a closed stainless-steel environment, no VOCs are released (which also results in yields of nearly 100%).

More and more, OEMs are mandating designers prove we're not contributing to the waste stream. If we can't bring two or three environmentally sustainable options to the table that our customers can take to their boards of directors, we'll lose the business. Medical manufacturing is a prime example, and this is where cavitation can also be a game-changer.

Take glucose monitoring systems; millions of which are used daily. With cavitation, we can print those monitors using a tenth of a gram less silver per sheet to achieve the same signal strength. Not only does less silver end up in landfills when those monitors are discarded, the monitors themselves cost providers less. When you're quoting the printing of 300 million glucose monitors in a year, we're talking about significant cost savings and substantially less silver ending up in the waste stream.

Photobiomodulation. Wearable photobiomodulation (PBM) therapy is another new frontier for printed functional electronics. Previously known as low-level laser therapy, PBM is a medical treatment that applies low-level lasers or LEDs to the surface of a person's body to relieve pain and accelerate the healing process. It's a proven alternative to traditional treatments, such as opioids, for pain and inflammation. New applications promise benefits beyond tissue healing and pain reduction and include cosmetic applications for acne treatment and wrinkle reduction.

Not only do PBM wearable patches offer convenient, effective treatment for numerous medical conditions, they are also non-invasive, making them safer for the patient than other medical treatments **(Figure 4)**. They also don't use harsh chemicals that can irritate skin like many acne treatments, and they come with very little packaging – no bottles, caps or boxes that go directly into the waste stream.

Figure 4. Wearable photobiomodulation patches offer a noninvasive alternative for several medical treatments.

Carewear's Light Therapy system is a wireless, wearable, over-the-counter, FDA-cleared, CE MDD class IIa medical device for the management of pain and treatment of soft tissue injury, wrinkles and acne. It is paired with a digital health infrastructure, allowing clinicians to select treatment parameters and outcome indicators, monitor utilization and report in real time through the cloud.

Future Needs

The examples we've looked at here are indicative of the central role functional printed electronics will have not only in the development of exciting new products that will improve our living standards, but also by eliminating waste and scrap and allowing resource-efficient material choices.

To sustain our momentum, it is imperative that the industry actively promotes science, technology, engineering and mathematics (STEM) education at every level and at every opportunity. The printed electronics industry isn't alone in the search for skilled workers, and competition continues to increase as technology permeates a growing number of employment sectors. In fact, the International Monetary Fund reports that by 2030, there will be a global shortage of more than 85 million tech workers, representing $8.5 trillion in lost annual revenue.

We are up to the challenge, though. The future of our industry is so exciting that it's easy to share our enthusiasm. On a personal level, many of us are involved in local programs to promote STEM. Let's keep that going; who knows where it can lead us next?

Ed: This article was originally published in TechBlick and is reprinted here with permission of the publisher and author.

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Rocking and Rolling at ZIW

The annual user event was tuned into AI, but that's not the only melody being played.

by TYLER HANES

Zuken welcomed customers and partners to Cleveland in September for the electronics design software company's annual users event, providing an opportunity for networking and a backstage pass to the company's most recent software updates and future innovations.

Zuken Innovation World Americas, colocated with Vitech's Integrate24, opened with comments from Kent McLeroth and Enrique Krajmalnik, the chief executives of Zuken USA and Vitech, respectively, and a keynote address befitting its location in the supposed birthplace of rock and roll with Mark Schulman, drummer for such artists as P!NK, Billy Idol, Foreigner and Cher.

Schulman shared his musical journey and some of the lessons learned from rock's legends, as well as his own methods to change his perspective and enter a "rock star" state of mind – whether on the stage or in daily life.

Rock drummer and motivational speaker Mark Schulman shared his tips for achieving the "rock star" state of mind at ZIW's keynote address.

Overall, the Americas version of ZIW – the company runs similar events in Europe and Asia each year – featured more than 50 technical sessions, including one focused on AI collaboration in PCB design by Kyle Miller, Zuken's technology research and strategy manager spearheading the company's foray into AI-based design.

Miller said the company's current AI integration is intended to serve as a copilot for ECAD designers, offering routing suggestions or initial suggestions for parameters, which users can implement or ignore. User feedback is then used to train the AI for the future, tuning the model's response to the actual designer's own knowledge and preferences.

Zuken launched AIPR (Autonomous Intelligent Place and Route) as an add-on for its CR-8000 PCB design software last year, allowing AI-based placement and routing as part of the first of three phases of AI development. The first phase, Basic Brain, is where the company currently is on its roadmap and uses Zuken's library of designs to enable smart autorouting.

For the next phase, Dynamic Brain, Zuken plans to allow customers to integrate their own designs into its AI algorithms to accelerate the design process and improve productivity. With its final phase, Autonomous Brain, the company aims to develop an AI model that can continuously learn and improve its own capabilities.

Over the coming years, Zuken will refine its AI collaborative tool and consider user feedback while developing the next phases, which will continue to learn from design examples and take a more active role in design to improve productivity and allow designers to focus on higher-level design concepts, Miller said.

A session by solutions architect Lance Wang focused on the importance of power integrity screening in high-speed designs. With electronics getting smaller and faster, power delivery is becoming a more critical aspect of a design, and PI screening will speed up the design process, he said.

Conceptual issues that can derail a design from the start, such as poorly designed planes, bottlenecks and violations of impedance limits, can be quickly found with the CR-8000 design software's EMC Adviser screening capabilities, which allows corrective action before digging into the detailed analysis for the finer issues that may occur, Wang said.

Electromagnetic compatibility was the focus of another presentation by technical account manager and senior applications engineer Andy Buja, who discussed the inefficiencies in a typical design process that doesn't verify EMC compliance until the testing phase. Through use of design rules and constraints in EMC Adviser, the program can catch any EMI issues in the placement and routing phase, allowing designers to make corrections earlier in the workflow to speed up the design process, he said.

For those using CR-8000, the event also featured several instructional sessions that examined techniques for improving productivity. Zuken's manager of engineering operations, Steve Watt, outlined recent updates to the software, including the addition of new autorouting features, while application engineer Chuck Bassett shared some tips automating certain processes in Design Force and Design Gateway – CR-8000's programs for designing single and multi-die packages and logical circuit design and verification, respectively.

Aside from the technical sessions, ZIW also featured an exhibition with several of its partners, including KSD Technologies, MID, Cetec ERP, Harness Works and ECAD-Port. Also returning was the popular Genius Bar, which allowed users of CR-8000 ECAD, E3.series wiring harness software, and other Zuken products to speak directly with company experts to get answers to questions or solve issues they may be having.

With around 150 attendees at the conference, including Zuken staff, the event offered opportunities for a deeper understanding of the company's offerings, as well as the ability to network with their peers and some of the leaders in the industry, said Amy Clements, director of marketing communications.

"One of the main objectives was to empower participants with the knowledge and tools they need to drive innovation within their own organizations," she said. "This is an exciting time for Zuken, and we're looking forward to building on the momentum."

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PLATING

ENEPIG Corrosion Mechanisms

Different types of nickel corrosion and potential mitigation strategies.

by PATRICK VALENTINE

Electroless nickel immersion gold (ENIG) chemistries were introduced in the mid-1990s to replace electrolytic nickel and gold for high-density circuits. In the mid-1990s, nickel corrosion, soon to be known as the ubiquitous "black pad," was discovered. Chemical suppliers and board manufacturers took steps to reduce the occurrence of black pad. To that end, in 2002, IPC released IPC-4552, "Performance Specification for Electroless Nickel/Immersion Gold (ENIG) Plating for Printed Boards."

In the late 1990s, electroless nickel electroless palladium immersion gold (ENEPIG) chemistries were introduced as a universal finish for gold, aluminum and copper wire bonding, with perceived protection from black pad. In 2013, IPC released IPC-4556, "Specification for Electroless Nickel/Electroless Palladium/Immersion Gold (ENEPIG) Plating for Printed Boards." Today, black pad is still a reality with ENIG and ENEPIG plating.

Electroless Nickel Deposition

The most common electroless nickel baths for printed circuit boards (PCBs) use a phosphorous-containing reducing agent, typically incorporating ≤10% phosphorous, by weight, in the nickel deposit. The nickel phosphorous (Ni-P) deposit is amorphous and has an isotropic surface energy. This produces a Ni-P deposit with hemispherical nodules that look like soap bubbles **(Figure 1)**.

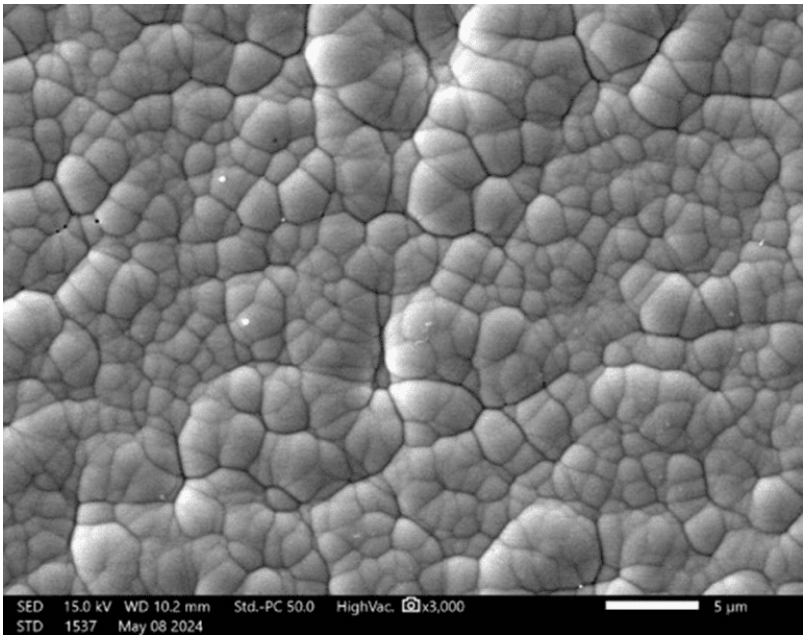

Figure 1. Hemispherical Ni-P nodules.

Nickel nodule growth conditions vary from nodule to nodule, so we see nodules of various sizes, as seen in Figure 1. As plating thickness increases, the nickel nodule hemispheres contact each other, forming cusps. Any two given nickel nodule nuclei are separated from each other by a distance of (D) units. Each nickel nodule has a given radius (r) for its size **(Figure 2)**.

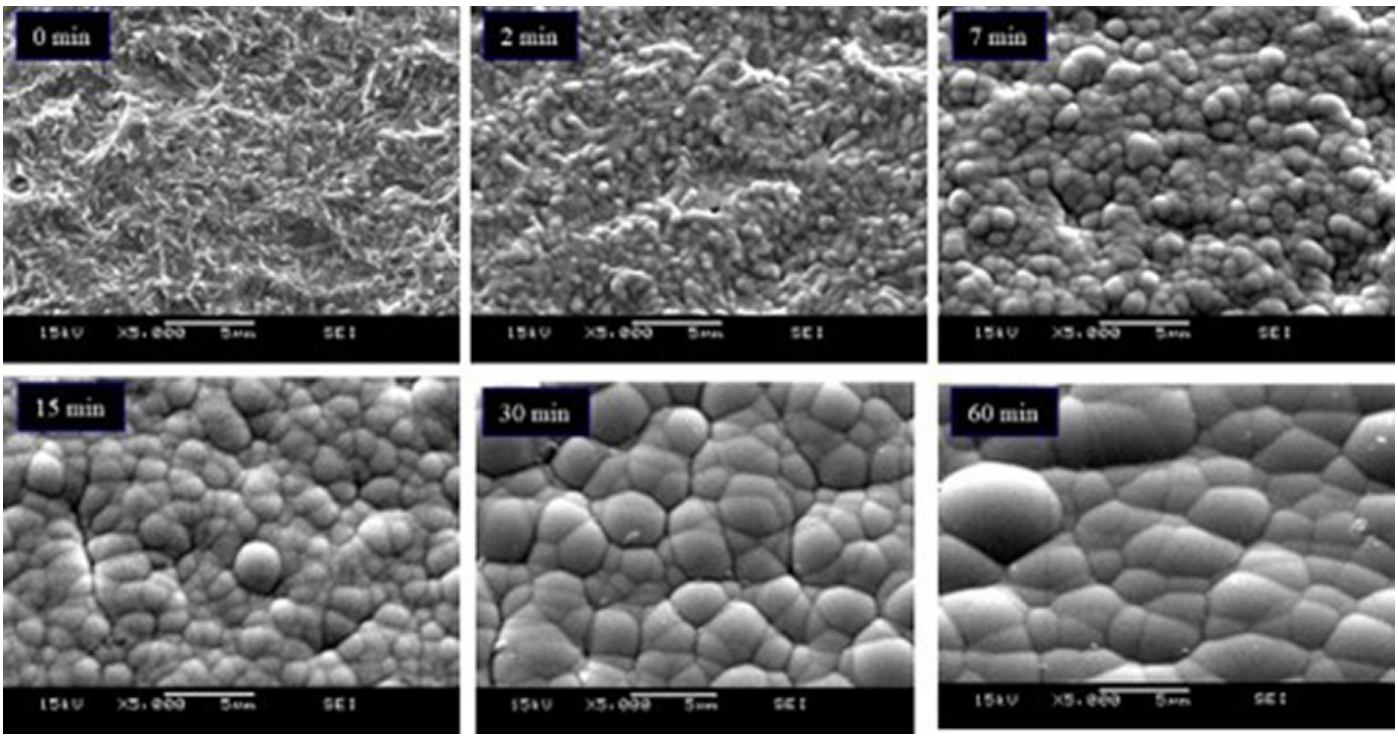

Figure 2. Nickel nodule hemisphere growth versus plating time.

There are inherent stresses at the cusp for any given two nickel nodules in contact with each other. The smaller the radii, the higher the stress. As plating thickness increases, the cusp stress at the two nodules decreases, and the propensity for boundary corrosion is reduced. The Cartesian coordinate system can model the distribution of cusp

stresses.[1]

The ratio of r/D is critical.[1] As the r/D ratio is increased, cusp stress is reduced, and boundary corrosion is suppressed. There are two ways to increase the r/D ratio: 1) increasing the thickness of the nickel deposit, which increases the radius (r) of the nickel nodules, and 2) increasing the number of nucleation sites by optimizing the cleaner micro-etch activator, and nickel initiation, which decreases the distance (D) between two given nickel nodule nuclei.

Nickel and Palladium Corrosion Mechanisms

The primary types of corrosion with ENEPIG deposits are catastrophic horizontal, nodule pits and boundary pits. All three types are galvanic corrosion. Galvanic, or bimetallic corrosion, is an electrochemical process in which one metal preferentially corrodes when in electrical contact with another in the presence of an electrolyte. Both nickel and palladium are subject to galvanic corrosion by gold. Stoichiometrically, this is shown in Equation 1 and Equation 2.

$$Ni^{0} + 2Au^{-1} \rightarrow Ni^{+2} + 2Au^{0}$$

Eq. 1. Nickel, gold stoichiometry.

$$Pd^{0} + 2Au^{-1} \rightarrow Pd^{+2} + 2Au^{0}$$

Eq. 2. Palladium, gold stoichiometry.

The explanation for nickel corrosion is that the nickel readily gives up electrons if there is an accepting species, in this case, gold. If gold is unavailable, as in the deep nodule boundaries, the hydrogen (H^{+}) ions pick up the electrons and permit the nickel to corrode without gold deposition. In the case of ENEPIG, the difference in voltage in the electromotive force (EMF) series determines the driving force for the displacement reaction to proceed **(Table 1)**.

Table 1. EMF Series

Metal	Volts
Nickel	-0.25
Palladium	0.83
Gold	1.4

The driving force for the gold/nickel displacement is equal to +1.4 to -0.25 = 1.65V, while the driving force for the gold/palladium displacement is equal to +1.4 to +0.83 = 0.57V. Nickel is approximately three times more easily displaced than palladium. If pores are in the palladium layer, the gold will preferentially exchange with the underlying nickel, causing nickel corrosion at the palladium-nickel interface.

Catastrophic horizontal corrosion. The primary drivers for catastrophic horizontal corrosion are poor adhesion between the nickel and palladium layers, macro-cracks in the palladium deposit, or a thin/porous palladium deposit.[2] **Figure 3a** shows horizontal corrosion with a 2µin palladium deposit and an exaggerated immersion gold time of 30 min., and **Figures 3b** and **3c** show the effects of palladium macro-cracking. Milad found that 6-9µin of palladium was needed to negate nickel corrosion due to a thin/porous palladium deposit when coupled with exaggerated immersion gold times.[2] The thicker palladium deposit likely reduces the palladium cusp stresses, too, but only to a certain point.

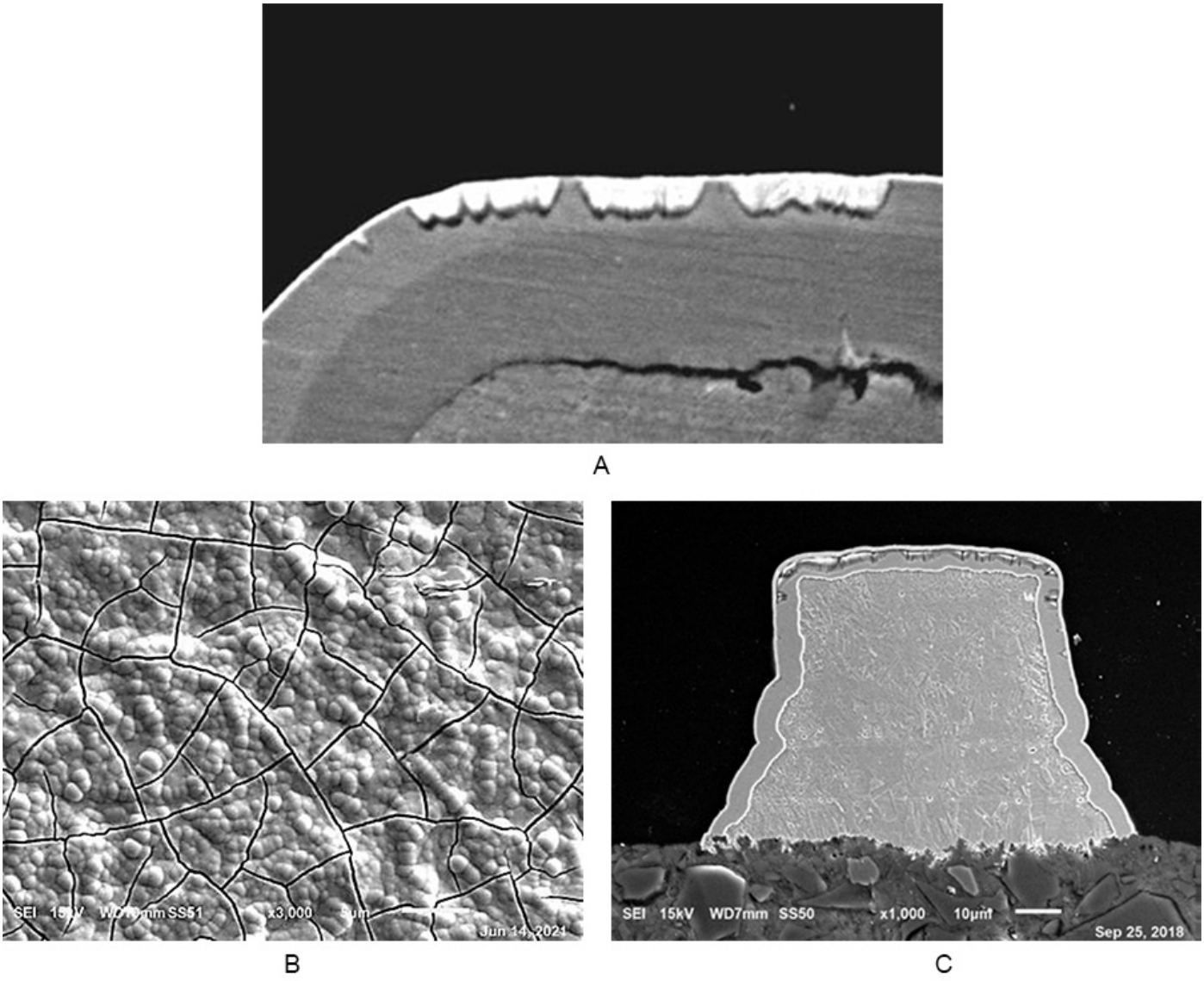

Figure 3. Various horizontal corrosions. (a) 30-min. gold time, (b) palladium cracks, (c) palladium crack corrosion.

Nodule and boundary pit corrosions. There are three primary drivers for pit corrosion: a thin/porous palladium deposit,[2] micro-cracks in the palladium deposit, and hydrolyzed nickel species ($NiOH^{+1}$) formation on the plated nickel deposit.[3] Micro-cracks can form in the palladium deposit due to hydrogen embrittlement during the palladium plating. Hydrolyzed nickel species can form on the nickel nodules or at nickel nodule boundaries due to excessive nickel drip times and poor-quality rinsing. The hydrolyzed nickel species result in particles and nickel oxidation. When these particles form, there are increased stresses at the cusp for any given two palladium nodules in contact.

In general, the same nickel r/D ratio criticality also applies to the palladium deposit. The r/D ratio may be increased two ways: 1) increasing the thickness of the palladium deposit, which increases the radius (r) of the palladium nodules and reduces cusp stress, but only to a certain point, and 2) increasing the number of nucleation sites by optimizing the nickel bath parameters, drip time, rinsing and palladium initiation, which decreases the distance (D) between two given palladium nodule nuclei.

Pit corrosion can occur within or at a nickel nodule boundary. **Figure 4a** shows pit corrosion, and **Figure 4b** shows the seam in the palladium deposit providing a path to the nickel deposit, resulting in the corroded nickel area (bright white area).

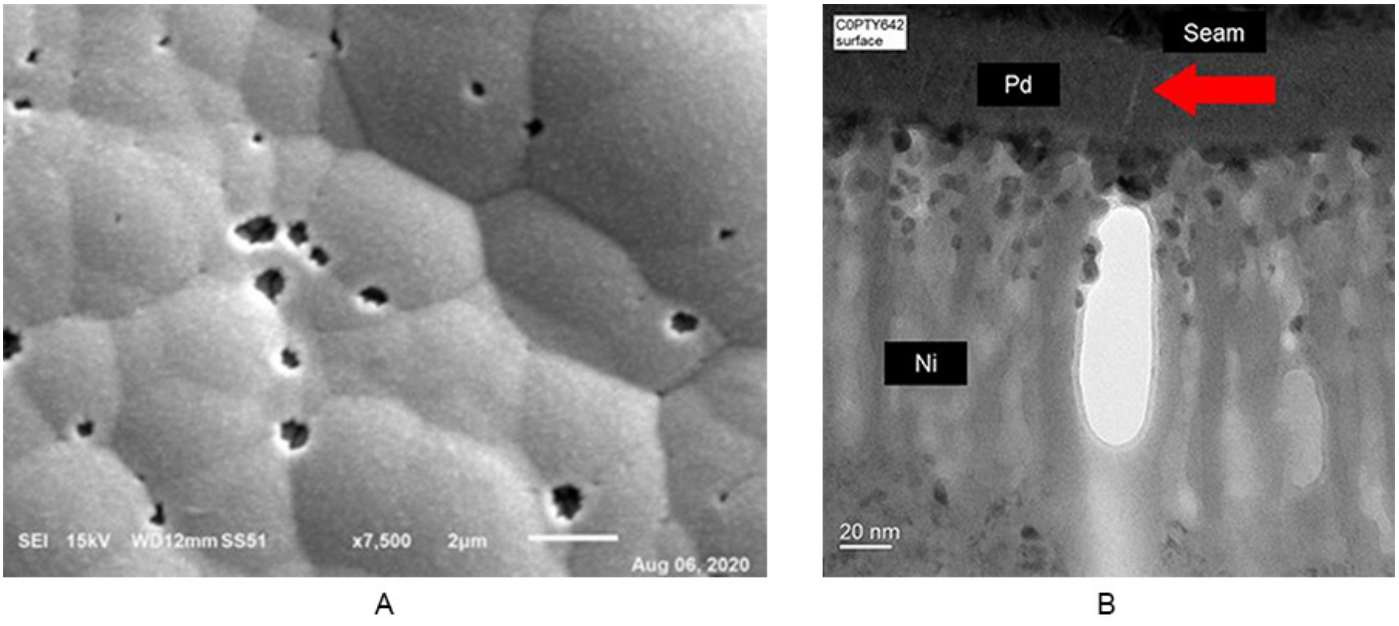

Figure 4. Nickel pit corrosion. (a) top-down view of pits, (b) palladium seam corrosion.

Energy-dispersive x-ray spectroscopy (EDS) was used to analyze the pit corrosion site in Figure 4b. There is clear evidence of the gold (Au) breaching through the palladium (Pd) and corroding the nickel (Ni). In the corrosion's wake is the enrichment of oxygen (O) and phosphorous (P) **(Figure 5).** This can lead to solderability and wire bonding issues.

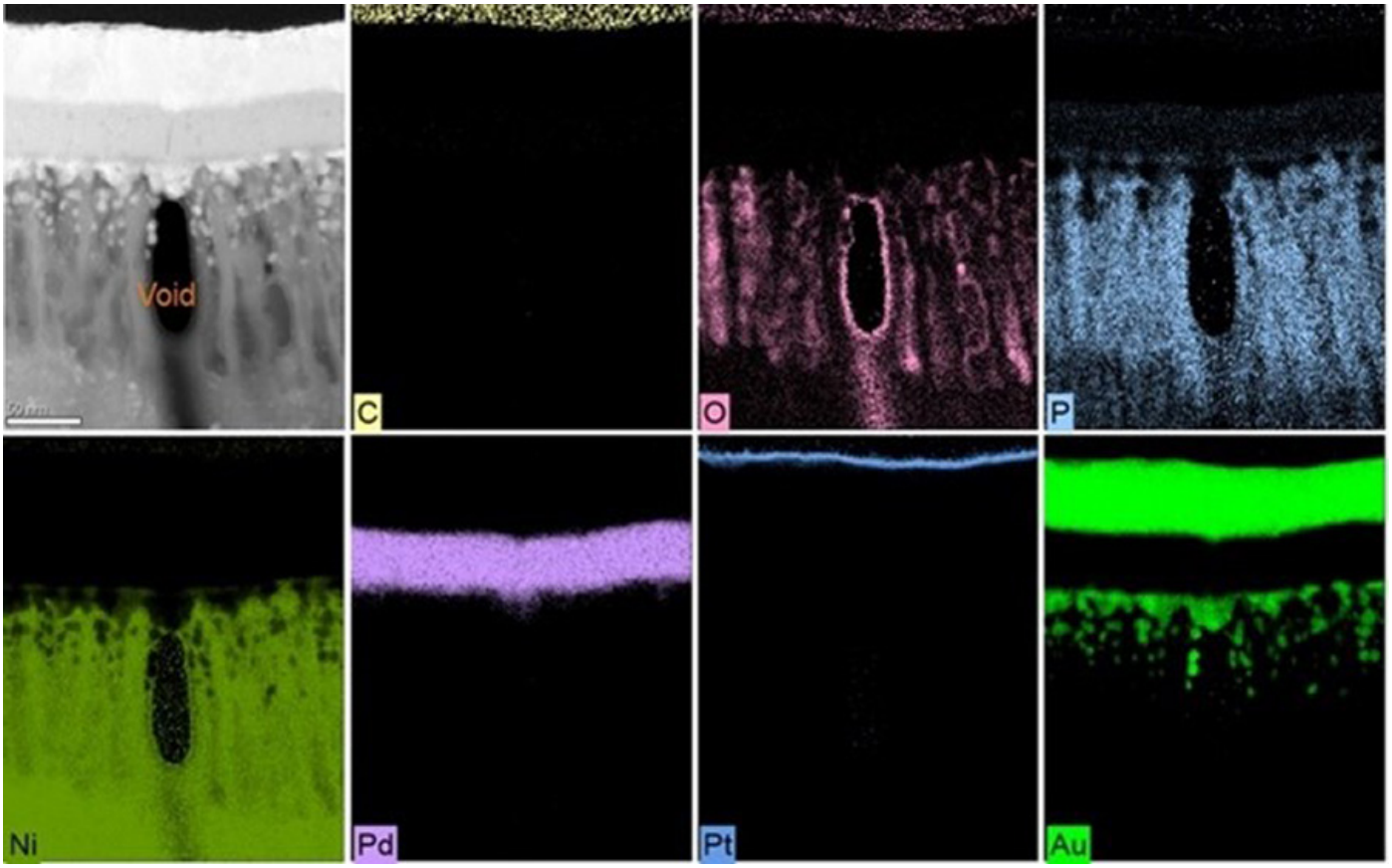

Figure 5. EDS of the pit corrosion.

Nickel seam corrosion. Pit corrosion can be traced back to hydrolyzed nickel species ($NiOH^{+1}$) formation on the plated nickel deposit. Nickel seam corrosion is a specific type of boundary pit corrosion with a different origin. Instead of particles originating on top of the nickel deposit, particles originate at the bottom of the nickel deposit, in essence, on the base copper. These particles then create excessive stress at the nickel nodule boundary cusps, increasing the propensity for corrosion. The increased nickel cusp stresses transfer to the palladium deposit, completing the seam pathway. Particles that lead to nickel seam corrosion are due to poor copper surface preparation and insufficient surface cleaning; in some cases, over-aggressive micro-etching roughness can lead to nickel cusp stresses. **Figure 6** is a focused ion beam (FIB) milling of a nickel seam corrosion pit.

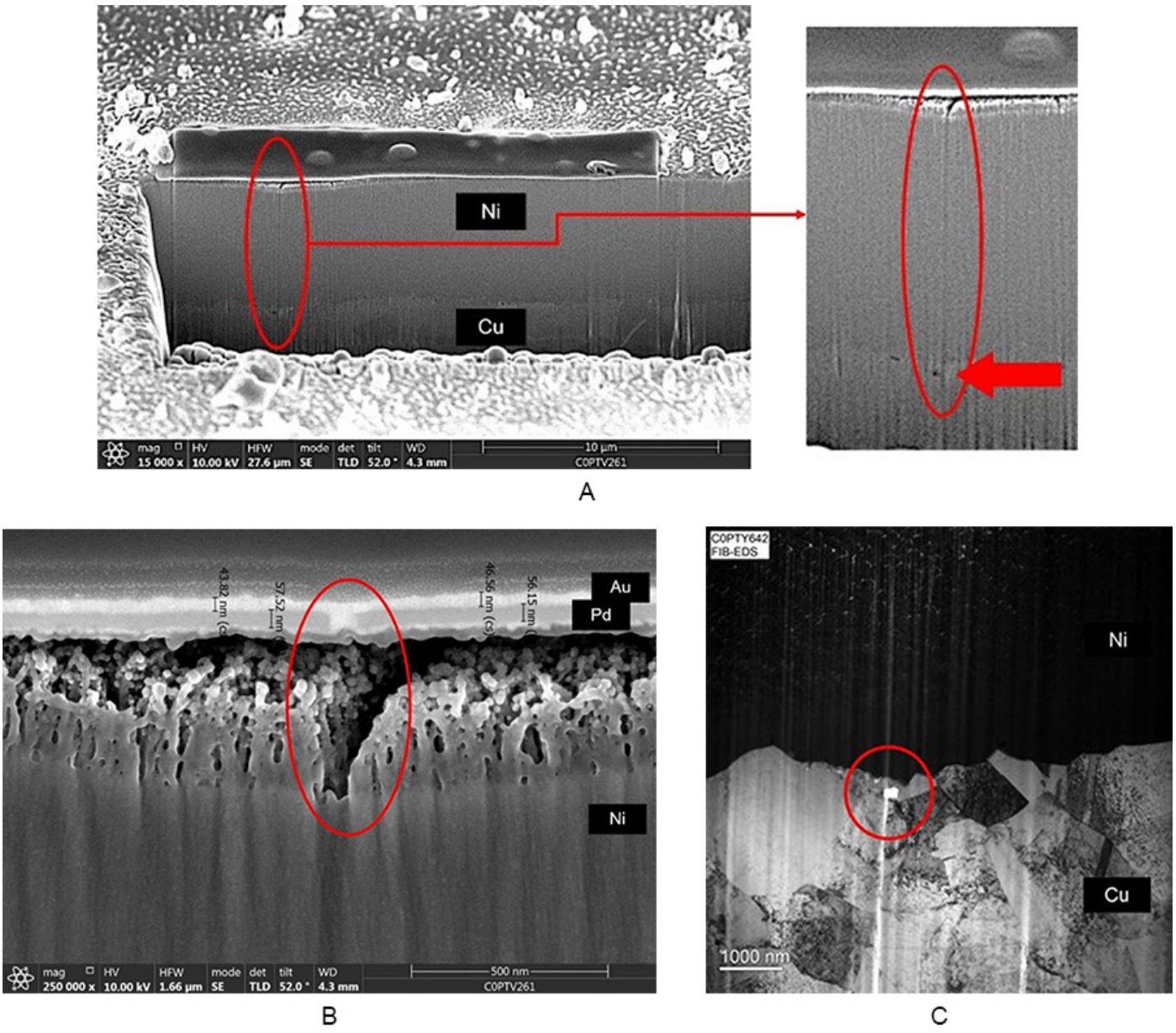

Figure 6. Nickel seam corrosion. (a) nickel seam, (b) high magnification of the nickel seam, (c) copper surface particle.

The so-called "curtain effect" occurs during FIB milling due to surface roughness and shadowing effects. This effect resembles the formation of vertical stripy, rippled patterns across the milling surface (see Figures 6a, 6b, and 6c). The curtain effect occurs during the ion attack of the milling surface and has to do with the roughening of the milling and diffusion, which smooths the surface. To minimize this issue, a protective platinum metal layer is deposited along the region of interest before the initial milling, reducing the rough surface layer and allowing the clean surface for the ion beam to mill.[4]

Energy-dispersive x-ray spectroscopy (EDS) was used to analyze the particle site in Figure 6c. Evidence is clear of carbon (C), oxygen (O), nickel (Ni) and phosphorous (P), along with empty space **(Figure 7)**. The seam pathway is now set for the immersion gold to corrode the nickel deposit.

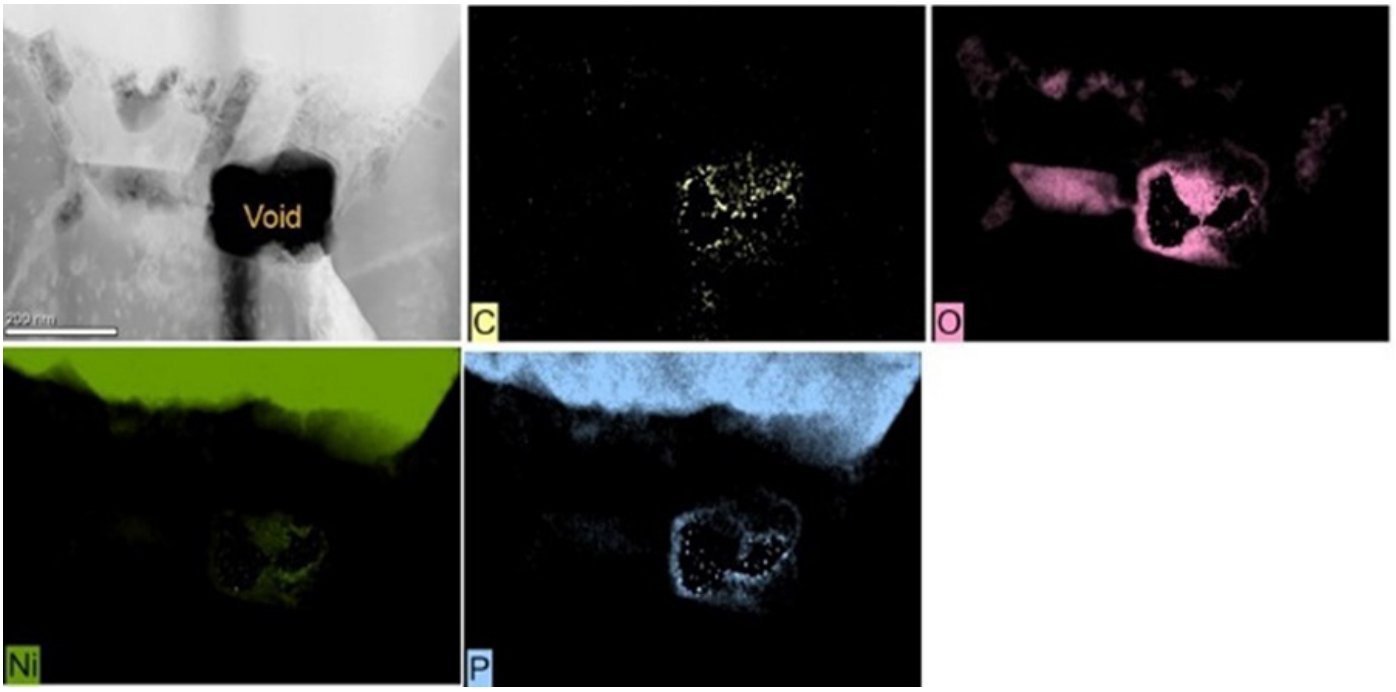

Figure 7. Nickel seam particle from Figure 6c.

RAIG Corrosion Mitigation

Conventional immersion gold electrolytes function strictly by galvanic corrosion. A mixed reaction occurs in a reduction-assisted immersion gold (RAIG) electrolyte: an initial galvanic corrosion reaction followed by an autocatalytic reaction induced by a reducing agent. This permits the RAIG electrolyte to minimize galvanic corrosion while permitting higher gold thickness capabilities than conventional immersion gold electrolytes.

RAIG electrolyte produces a uniform deposit for ENIG and ENEPIG applications with a low coefficient of variation. Wire bonding and solder joint reliability have been demonstrated to be excellent. Taking advantage of the benefits of the RAIG process enables world-class quality "on target with minimal variation."[5]

Conclusions

Common electroless nickel baths for printed circuit boards typically incorporate ≤10% phosphorous, by weight, in the nickel deposit. The nickel deposit structures have hemispherical nodules that look like soap bubbles. With the electroless nickel deposit, the r/D ratio is critical and determines the cusp stresses and propensity for boundary corrosion. Electromotive force (EMF) analysis reveals nickel is approximately three times more easily displaced than palladium. If pores are in the palladium layer, the gold will preferentially exchange with the underlying nickel, causing nickel corrosion at the palladium-nickel interface. There are three primary types of corrosion with ENEPIG deposits: catastrophic horizontal, nodule pits and boundary pits. Nickel seam corrosion is a specific type of boundary pit corrosion that stems from a different origin. Process optimization through designed experiments, process management by statistical process control, and reduction-assisted immersion gold are the best ways to mitigate ENEPIG corrosion mechanisms.

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Royalty Flush

A noted solutions architect offers an audacious plan for AI acceptance. It just might work.

by TYLER HANES

The talk of AI-based printed circuit design – and the idea that artificial intelligence could theoretically design a board faster and more efficiently than a human – has inevitably led to the fear that designers will be replaced by their algorithmic counterparts.

Rather than stoke those fears, a proposed process for AI implementation presented by a leading ECAD architect at PCB West in October focused on the new opportunities that could come for designers as AI implementation begins to take place.

That proposal, offered up in the keynote address by Charles Pfeil, was the precursor to several panels and conference sessions at this year's conference, apropos as AI and its impact on PCB designers is front and center on the minds of many in the industry as AI continues to grow.

Figure 1. Charles Pfeil discusses a roadmap for AI in PCB design during his keynote address at PCB West.

The annual return of PCB West, the largest conference and exhibition for printed circuit board design, fabrication and assembly in Silicon Valley, saw attendees with a renewed air of excitement and energy – marked by the expo's highest attendance since before the Covid-19 pandemic and four days of packed sessions taught by many of the industry's leading minds.

In addition to the more than 125 hours of conference presentations and panels covering topics from signal integrity and DfM to thermal and rigid-flex design were several timely sessions on AI in electronics.

Pay to Play

Before AI can take a leading role in the design process, however, the artificial designers still need lots of training – with current autorouting and autoplacement programs serving as an example of the work that needs to be done.

Many designers say it takes more time to go back and fix those programs' mistakes than just doing the job themselves, especially when dealing with complicated boards that have multiple factors to consider, Pfeil said.

"The AI needs to learn how to balance multiple competing objectives and make effective tradeoffs," he said. "This is what the designer does."

Figure 2. Screaming Circuits business development manager Vitaly Michalchuk explains the EMS company's service offerings.

For the AI models to improve their design capabilities, EDA companies will need access to known-good designs for training, but getting those designs could prove challenging as many companies are hesitant to give up their IP, he said.

To solve that problem, EDA companies will likely need to develop compensation plans to convince customers to give up their copyrighted materials for training, but getting access to those designs is only the first piece of the puzzle.

Simply adding designs into a database will not fully train an AI to design a board, as there are multiple methods to solve design problems, with some methods working in certain situations but not others, Pfeil noted.

He said training AI to know what methods to use and when to use them will require expert designers to put their thought processes on paper through the development of decision trees that the AI can follow to determine what to prioritize at each step of the design process.

Like the method for encouraging companies to use their design for training, Pfeil proposed a similar compensation track for designers, who may feel alienated or like they're being pushed out of the industry by the continued advances in AI design.

He said that rather than telling designers that AI will replace them, employers should encourage their teams to take an active role in developing the AI models.

To incentivize them to do so, those companies could create new positions for designers and put them in charge of training AI models or offer royalties to designers whose designs and concepts are used for training and later used in new AI-generated designs.

Looking to the future, as AI takes a more leading role in the design process, today's designers could have long-term opportunities to oversee or improve AI learning at their current employer or EDA companies, or they could transition into AI-assisted design consultants or managers, Pfeil said.

Figure 3. Ventec's Chad Wood (left) speaks to a PCB West exhibition attendee.

To encourage that transition, companies would need to offer new compensation packages that reflect the long-term savings that would come from the advances in AI-based design, he said.

“I believe designers who help train AI should be substantially compensated,” he said. “Because what they’re doing for that company is creating an environment where they can get their boards faster and more effectively.”

‘Eager to Learn’

For PCB West’s one-day exhibition, the floor was the liveliest it has been in years, with registration and attendance rising to their highest numbers since 2019 – before the Covid-19 pandemic threw a wrench into the works of live events.

The energy of exhibition attendees was reciprocated by the more than 100 exhibiting companies and the staff members staffing their booths.

“This has been a great turnout,” said Jill Oxnam, product manager at Screaming Circuits.

The Oregon-based electronics manufacturer is a regular exhibitor at both PCB West and PCB East, and this year’s show provided some good conversations and some excellent leads, she said.

Summit Interconnect senior account manager Allison Herrera shared the same sentiment, saying the show provides an opportunity for face-to-face time with both those they know and those they would like to meet.

“We’ve had a lot of visits from existing customers and some potential new customers,” she said. “We’ve seen a lot of industry friends, and we’ve had a lot of activity from people wanting to know about what we offer.”

Figure 4. JITX chief of staff Kenneth Chang applauded the mix of designers and engineers.

The PCB manufacturer is another regular PCB West exhibitor, with this year marking the eighth time that Herrera had personally been to the show, and she said the 2024 crowd was the best she had seen in recent years.

“Post-Covid, this is the best show I’ve seen,” she said.

Mike Peterseim, representing Canadian PCB manufacturer PFC Flexible Circuits, said he had some great conversations throughout the day, and he thought this year’s attendees were more engaged when they were visiting booths.

“I think this is one of the better years,” he said. “I feel like the people walking the show are more project-specific and actually have projects they’re working on and not just looking for contacts,” he said.

For KiCad, the provider of open-source design software, this year marked the first time the company was represented as an exhibitor, but project lead Seth Hillbrand said he was pleasantly surprised at the growth he saw.

“It’s a fantastic show,” he said. “I haven’t been to PCB West in about a decade, and it’s nice to see how it’s grown.”

Hillbrand said the crowd featured a good mix of attendees, including designers and businesses looking for more information, and the show permitted the company to share some of its lesser-known offerings directly with those businesses.

“We haven’t done trade shows before, but we were getting a lot of people saying they didn’t know we offered business services,” he said. “We figured that it would probably be a good idea to go to where we can interact with the businesses and get the message out there.”

For first-time exhibitor Founder PCB, a Chinese PCB manufacturer that has expanded with a new US sales team, PCB West was better than anticipated, with representatives from some of the bigger Silicon Valley companies stopping by their booth for a chat, said director of North American sales Marvin Gaines.

“It’s a better turnout than I expected, both in the number of people and the quality of the crowd,” he said.

Figure 5. Breadboard's Olivia Holman speaks with a PCB West visitor.

While this year's crowd grew in number, it also brought in some of the younger demographic, which is a good sign for an industry that is seeing many workers entering retirement age, said Igor Luvishis, president of Elgris Technologies, a provider of translators to exchange data among EDA platforms.

"I can tell you that at this show, there are more people," he said. "And I can tell you there are younger people, which is good news."

PCB West also offers an opportunity for smaller or lesser-known companies to represent themselves and make new connections, said Tony Torres of Israeli fabricator and assembler PCB Technologies.

"I think it's been very, very successful," he said. "We've had a lot of people coming through and I'm sure we're going to do it again next year."

Canadian electronics manufacturer Trilogy-Net is another regular exhibitor, but it was the first time in a few years for president Trevor Pullishy, who pointed out that the show is seeing new companies and new attendees as more aspects of the industry are represented.

"It's been three years since I attended, and the crowd's definitely changed in those three years," he said. "There's a lot more diversification."

Another of the newer companies in attendance, JITX, a startup developing a method for code-based PCB design, saw big crowds at its booth throughout the day and hosted a design community meetup and generative AI panel to encourage more networking after the show.

Chief of staff Kenneth Chang seconded the diversity of the audience and said companies like Cofactr operating in the

GenAI space may have drawn non-typical PCB designers as supply chain management takes a more central role in the industry.

He also pointed out that despite the size of the event, PCB West still provides an intimate experience for exhibitors and attendees to get to know each other.

“Quality engagement with customers and vendors was nonstop from the get-go,” he said.

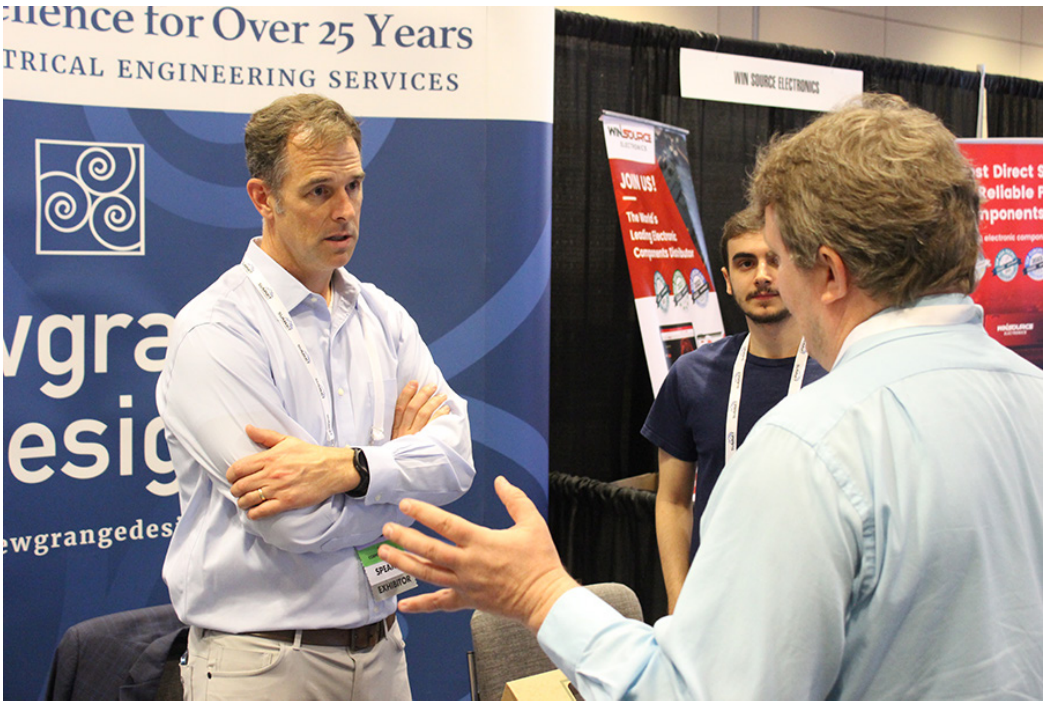

Figure 6. Newgrange Design president Matthew Leary (left) speaks to an attendee of PCB West.

With AI a hot topic among the conference sessions and panels, a few AI-focused companies also exhibited at the show, including Cofactr, a specialist in supply chain management that uses AI to enhance its component selection and procurement software.

“This year felt like a room eager to learn and explore,” said chief strategy officer and cofounder Phil Gulley, who also participated in the PCEA-JITX GenAI panel. “It’s inspiring to see startups, innovative organizations, leading manufacturers, established enterprises and everything in between sharing ideas and digging into the topics we’re all passionate about.”

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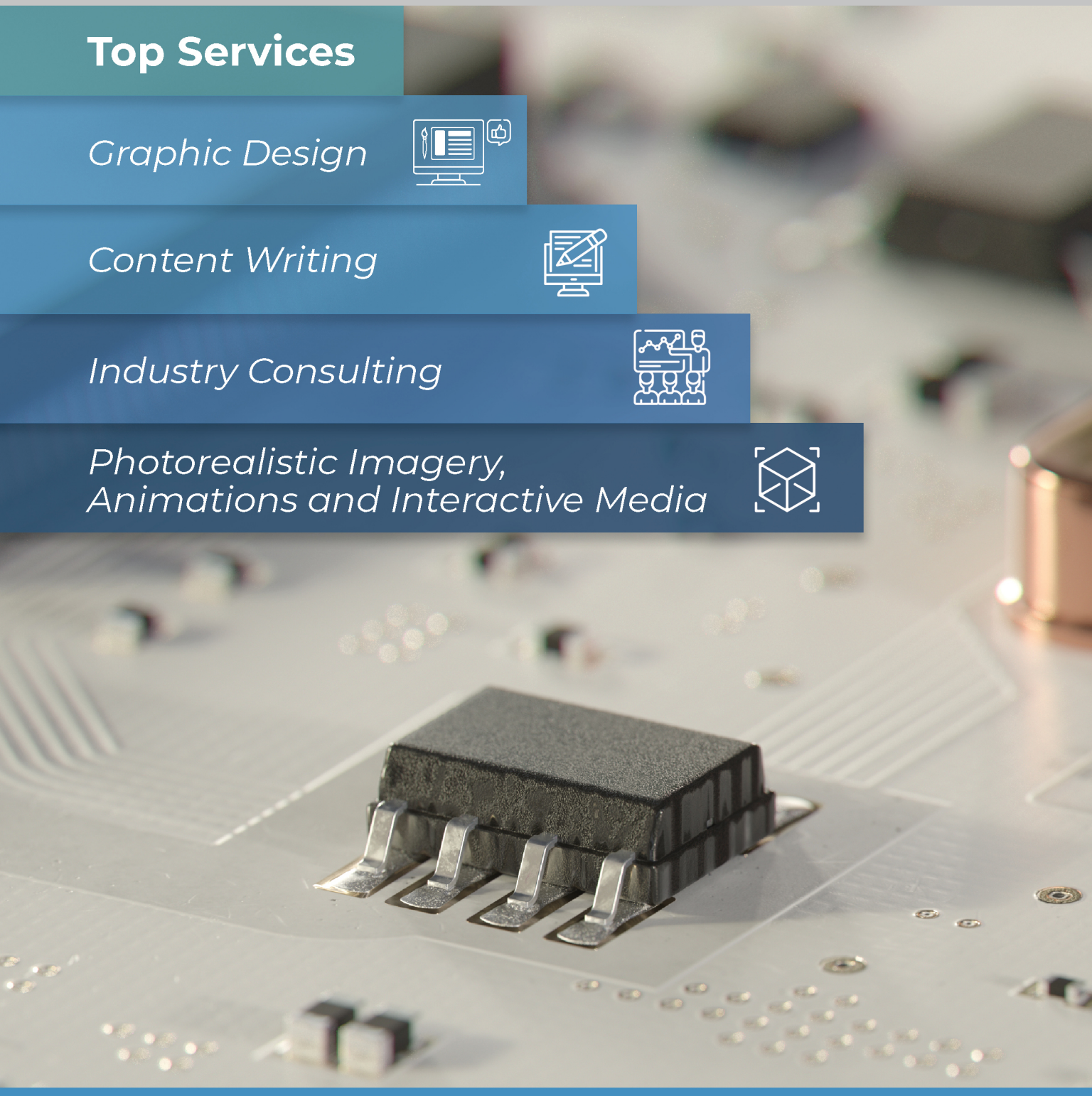

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SOLDER PERFORMANCE

When to Downsize Solder Paste Powders

Smaller components do not always need a smaller paste.

by GAYLE TOWELL

As components shrink in size, the demand for finer solder pastes increases. But the selection of solder paste is not just about matching component size; it's also about optimizing printing and reflow processes to prevent defects and ensure reliability.

Here we explore the significance of solder paste powder size, particularly when and why manufacturers should consider downsizing from standard types to finer alternatives.

The exact method for creating solder powder, and ultimately solder paste, can vary significantly from one manufacturer to another. These differences in production methods can lead to very different outcomes when printing with a particular paste size.

In other words, you can end up with entirely different results when using a Type 5 paste from one manufacturer compared to another. Moreover, the inherent variation within a given solder powder production process will have a greater influence on the paste's performance the smaller the particle size gets.

IPC standardizes particle size classification, but it still permits significant variation. IPC standards specify that only 80% of particles for a given type must fall within the nominal range **(Table 1)**. This leaves room for differences in particle size distribution among manufacturers, which can significantly affect solder paste performance, including printability, reflow behavior and reliability.

Table 1. Particle Distribution Limits Per IPC J-STD-005A

Type	Less than 0.5% larger than	Less than 10% between	At least 80% between	Less than 10% smaller than
Type 3	60µm	45-60µm	25-45µm	25µm
Type 4	50µm	38-50µm	20-38µm	20µm
Type 5	40µm	25-40µm	15-25µm	15µm
Type 6	25µm	15-25µm	5-15µm	5µm
Type 7	15µm	11-15µm	2-11µm	2µm

When considering whether to downsize solder paste, consider the size and spacing of components, the production environment and settings and the potential challenges that can come with smaller powders.

In general, the smaller the paste, the more challenging the process. Because of this, the ultimate success of the process becomes increasingly dependent on all the variations in solder paste production methods described above.

The 5-Ball Rule and Its Implications

A common heuristic used to determine what powder size to use is the so-called "5-ball rule." The 5-ball rule suggests that the smallest stencil aperture should be at least five times the diameter of the solder paste's largest particles **(Table 2)**.

Table 2. Lower Limits for Stencil Aperture Diameters

Type	Lower limit of stencil aperture diameter per 5-ball rule
Type 3	225µm
Type 4	190µm
Type 5	125µm
Type 6	75µm
Type 7	55µm

For instance, with Type 4 solder paste, where particles range up to 38µm, the smallest printable aperture would be around 190µm/0.004". As assemblers move to to finer powders like Type 6, with particles as small as 5-15µm, however, the practical applicability of the 5-ball rule becomes uncertain. This is because the extremely small particle sizes and tighter spaces have not been thoroughly tested, thus the rule might not hold true or require adaptation for these advanced types.

Let's Get Small?

Downsizing to a smaller powder comes with tradeoffs, especially at the smallest powder sizes, namely:

- Smaller powders are more difficult to produce and come with a higher price.
- Smaller powders have a greater surface area to mass ratio and more potential for oxidation. This shortens shelf life and makes them more sensitive to process parameters, with requirements for nitrogen reflow for Type 6 and smaller.
- Manufacturing methods differ from one supplier to the next, so there can be substantial variation in the quality of a particular powder size in terms of sphericity of particles and particle size distribution. These variations can lead to unanticipated issues and defects.
- Stencil design adaptations might be needed for finer powders to avoid issues like stencil clogging or insufficient paste release. This involves considering stencil thickness, aperture size and wall smoothness.
- In general, the smaller the powder, the smaller the process window, which means settings such as squeegee pressure and speed must be carefully dialed in.

Bigger is Better

Because of the significant tradeoffs from downsizing, if an application is near the threshold suggested by the 5-ball rule, it may be prudent to stick with the larger size. In fact, at AIM, we have had several situations where our Type 4 paste outperformed Type 5 paste in situations that were borderline when it came to the downsizing decision.

As an example, suppose the boards to print contain 01005 components. IPC-recommended stencil apertures for these components are 175 x 250µm, which may be outside of what Type 4 paste should be able to print (≥190µm).

With a little ingenuity, however, it's also possible to use a rounded square aperture design with a side length of 190µm or slightly larger for these components. This aperture shape maximizes volume while improving transfer efficiency.

In this scenario, transfer efficiency can be further maximized by using a nanocoated 4-mil or even 3-mil stencil. Hence, if 01005s are the smallest components on a given board, Type 4 paste can work with few unintended side effects.

Half-Size Solder Pastes

Some pastes are labeled Type 4.5 or Type 5.5, begging the question whether it might be a good idea to switch to a half size if their components are right on the edge, such as the case described above.

No IPC specifications define what these half types are, however. While it may be expected that a paste labeled Type 4.5 has a particle size range between that of Type 4 and Type 5, in fact it could be larger, smaller or simply broader – as would happen were Type 4 and Type 5 powder mixed together.

When considering a half-size paste, get a clear indication from the manufacturer as to the particle size distribution before proceeding.

Conclusion and Recommendations

Selecting the appropriate solder paste type is crucial for achieving optimal assembly outcomes. The 5-ball rule offers a foundational guideline for this choice, but it's essential to consider the broader context of your manufacturing processes and component requirements.

Before downsizing solder paste, assess the potential benefits against the associated challenges, such as increased oxidation or reflow issues. Optimization of existing processes with the current paste type may alleviate the need for downsizing, maintaining production efficiency and product quality.

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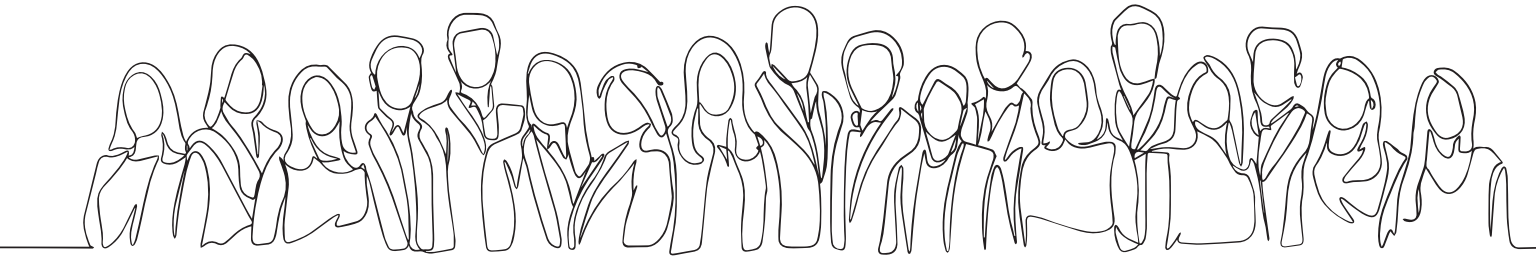

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TIMS

Keeping Electronics Cool

Types of TIMs and their application methods.

by NATHAN PRESLAN

As demand for high-performance electronic devices continues to grow, managing heat dissipation effectively has become a critical challenge. Thermal interface materials (TIMs) are pivotal in ensuring efficient thermal management by facilitating heat transfer between heat-generating components and heat-dissipating devices. Here, we examine the various types of TIMs and their application methods, including insights into modern dispensers and the advantages and disadvantages of these methods in electronics manufacturing.

In the electronics industry, thermal interface materials are integral to various applications, including processors and GPUs, power electronics, memory modules, automotive electronics and telecommunications. For example, TIMs are used between processors or GPUs and their heatsinks to ensure efficient heat transfer, preventing thermal throttling and enhancing performance. This issue has been magnified by the recent surge in AI-related hardware, which often requires significantly more processing power and generates more heat that must be managed effectively.

Other high-power components, like power transistors and LEDs, also generate significant heat, and TIMs help maintain optimal operating temperatures, prolonging the lifespan and reliability of these components. Memory chips, especially those in high-performance applications, benefit from TIMs as they manage heat dissipation and maintain thermal stability.

In automotive applications, TIMs are used in electronic control units (ECUs) and other high-power components to ensure reliable performance under extreme conditions. TIMs are also used to manage the heat generated by high-power amplifiers and similar devices in base stations and other telecommunication systems. These materials are a critical element in ensuring efficient thermal management, which helps maintain the performance and longevity of the equipment.

TIM Types

Thermal interface materials come in several forms, each tailored to specific applications and performance requirements. The primary types of TIMs include thermal adhesives, thermal gap fillers such as greases and pastes, as well as thermal pads, phase change materials (PCMs) and thermal tapes.

Thermal greases and pastes are highly viscous compounds that fill microscopic air gaps between surfaces, enhancing thermal conductivity. They are widely used due to their performance and ease of application.

Thermal pads are solid, compressible materials typically made from silicone or other polymers infused with thermally conductive fillers. They are user-friendly and ideal for applications where rework and reusability are important. Thermal adhesives serve a dual function: They provide thermal conductivity while also acting as adhesives, bonding components together. Such adhesives are commonly used in applications where mechanical fastening is impractical.

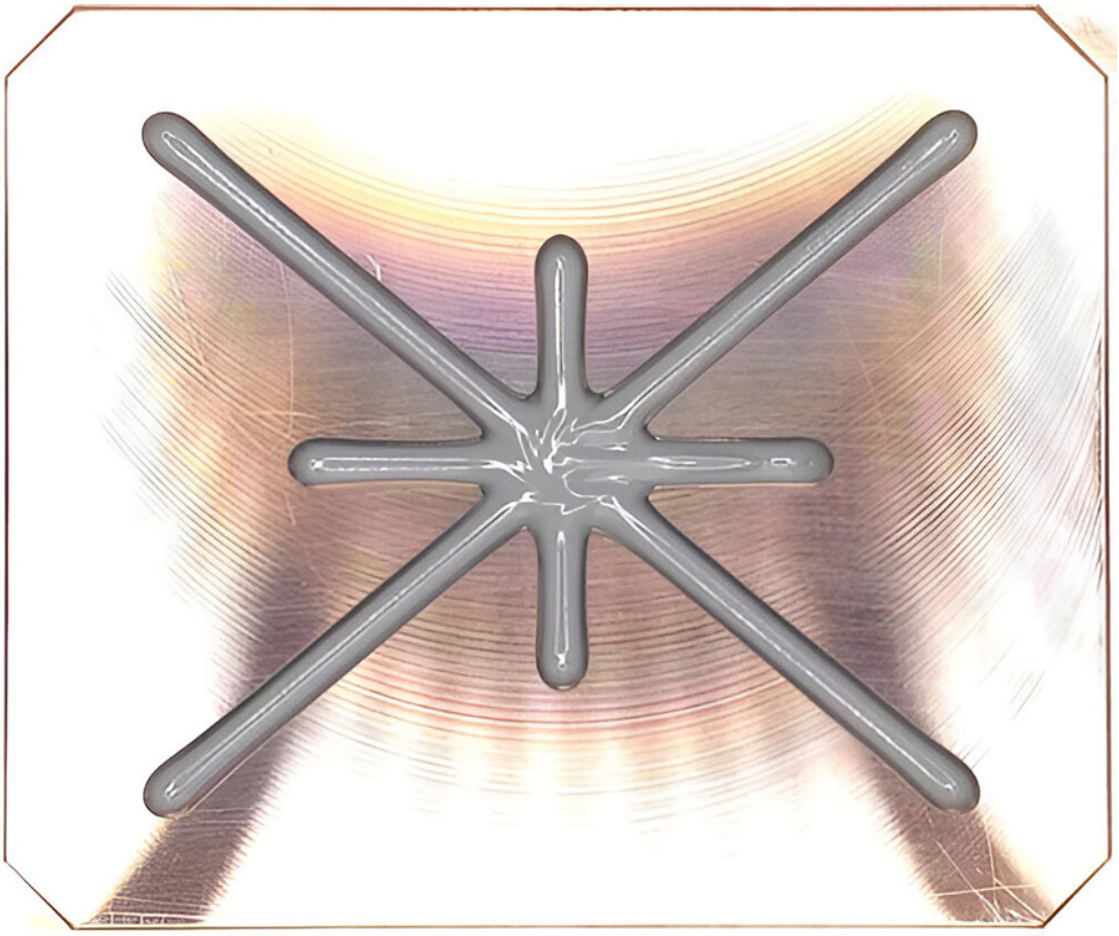

Figure 1. Thermal interface materials come in various forms tailored to specific applications and performance requirements.

Thermal tapes are double-sided tapes with thermally conductive properties, offering both adhesion and thermal management. They are suitable for lightweight components and applications requiring quick assembly.

Phase change materials (PCMs) are a more recent concept for electronic systems cooling. PCMs are used to absorb peak energy loads, such as during power-on operation, and then reject that heat load at another time, which can be useful for applications requiring repeated thermal cycling.

Application Methods

The effectiveness of a TIM depends not only on its material properties but also on the application method. Common application methods include manual application, automated dispensers, stencil printing and the use of thermal pads and tapes.

Manual application of TIMs does not require specialized equipment, making it a low-cost and flexible option. It is suitable only for small-scale operations and prototype volumes since it is labor-intensive. This method also has an increased likelihood of human error and uneven distribution, which can negatively affect the thermal performance of a system.

Automated dispensers are programmed to apply specific amounts of TIM in precise locations. This significantly reduces application time and aids precise, repeatable and consistent application of TIMs, which is critical for high-performance and high-volume manufacturing. These systems do require an investment in equipment and maintenance and typically involve programming and regular calibration, which can be challenging for small operations.

Traditional screen printing uses a stencil to apply a specific amount of thermal paste or adhesive. This method ensures consistent thickness and coverage to achieve the desired thermal conductivity. It is suitable for high-volume production with minimal waste but requires precise alignment and setup, which can be time-consuming. It is also limited to specific designs with no height variance, and any adaptation or change requires an entirely new custom-made stencil, making it significantly less flexible.

Thermal pads, tapes or PCMs cannot be dispensed, which typically makes them more difficult to work with, especially in a high-volume environment. They can, however, be easily repositioned or replaced, making them well-suited for rework and repair. These materials generally have lower thermal conductivity compared to greases and pastes and require consistent pressure to maintain effective thermal contact.

Automated Dispensers

Modern dispensing systems have updated the precision and efficiency of applying of thermal interface materials. These systems utilize advanced technologies to cater to the stringent requirements of the electronics industry. Highly accurate positioning systems ensure the accurate movement of the dispensing head, while pressure sensors and feedback loops monitor the material flow, adjusting parameters in real time to maintain consistency.

TIMs, especially thermal greases and pastes, often have high viscosity, posing challenges for consistent dispensing. They often have a consistency of caulk or something even resembling Play-Doh. Silicone greases, for instance, are inherently thixotropic, which means they can become less viscous under applied pressure. Advanced dispensers are equipped with features to handle these materials effectively. Heated dispensers, for example, maintain the TIM at an optimal temperature to reduce viscosity, ensuring smooth flow and accurate application. Additionally, high-pressure systems with precision auger pumps that regulate the flow rate and volume of the material can dispense viscous materials without clogging or interruptions, maintaining a steady and reliable application process.

TIMs are often abrasive and can contain aluminum oxide or even ground diamond. Automated dispensers need to be robust and well-engineered to minimize wear and tear while constantly delivering precise amounts of TIM with high repeatability.

One of the key features of advanced dispensers is their capability to apply the TIM in specific patterns and quantities

tailored to the unique requirements of each application. This level of customization is particularly beneficial in high-volume manufacturing in areas such as artificial intelligence, 5G telecommunications and electric vehicles, where different components may require varying amounts of TIM. Software interfaces allow operators to create and store multiple dispensing profiles, ensuring quick changeovers and minimal downtime.

TIMs are essential for managing heat in electronic devices, ensuring their reliability, performance and longevity. As electronic components continue to shrink in size while increasing in power and complexity, effective thermal management becomes even more critical. Selecting the right TIM and application method requires consideration of various factors, including thermal conductivity, ease of application and cost.

The application of TIMs is increasingly reliant on automated state-of-the-art dispensers due to their ability to deliver precise, consistent and repeatable results. These systems are vital for high-volume electronics manufacturing, where the accuracy and uniformity of TIM application can significantly affect device performance and yield rates while reducing waste and minimizing the risk of human error. As the demand for high-performance electronics grows, the role of TIMs in thermal management will remain crucial, driving innovations in both materials and application technologies.

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Evaluating Equipment Tradeoffs

Do multiple single-spray-nozzle conformal coaters outperform a three-nozzle machine for volume builds?

ELECTRONICS MANUFACTURING SERVICES (EMS) providers often have to evaluate equipment selection tradeoffs on more stringent standards than original equipment manufacturers due to their needs for flexible capacity across multiple clients.

In one recent example, the engineering team at SigmaTron International's Chihuahua, Mexico, facility needed to evaluate whether multiple single-spray-nozzle automated conformal coating machines would be a better choice for a high-volume project than a single machine customized with three spray nozzles.

The argument in favor of multiple single-nozzle machines was the flexibility they could provide in addressing the needs of other projects, plus the redundancy they provided should one machine have unanticipated downtime. Customizing a single machine with three nozzles cost less than three machines, took up less space on the factory floor and reduced setup and cleanup time. The potential negative to the single machine option, in addition to the lack of redundancy for unanticipated downtime, was that most other projects would require only a single nozzle, utilizing only a third of the custom machine's capacity.

The choice was made to customize one machine with three nozzles. Six Sigma core tools were used to evaluate the best choice for nozzle type, assumptions related to takt time with three nozzles, accuracy of spray, optimum spray pattern and repeatability of the process.

Two coating types, four coverage options and two nozzle types were tested over 10 board sample sets, evaluating the area covered, coating time, curing time, material use, capacity required, pallets required and unit cost.

Once the conformal coating choice was approved, a CPK study verified conformal coating thickness. The sample size was 20 printed circuit board assemblies (PCBAs), and a PosiTector 6000 was used for measurements. The results were in line with expectations.

A measurement systems analysis (MSA) study was performed on the selected coating to verify that the required coating thicknesses could be achieved using the planned equipment configuration. Ten PCBAs were coated and measured three times by three different appraisers using a PosiTector 6000. The study included a gage repeatability & reproducibility study (R&R) that tested repeatability against equipment variation, reproducibility against appraiser variation, R&R, part variation and total variation. The results showed detectable variation was within statistical process control limits.

An additional MSA used the optical inspection system to determine the percentage of coverage. The sample size was nine PCBAs with three appraisers and three trials. Results showed detectable variation within statistical process control limits.

The results of these detailed studies were shared with the OEM to determine the preferred coating and nozzle type. By utilizing Six Sigma core tools to evaluate the results of variations and validate assumptions about key characteristics, the OEM could see the impact of various choices.

A production part approval process (PPAP) and validation run of 100 pieces were performed, following OEM confirmation of machine configuration and coating choices.

The results validated that the single machine with three nozzles would meet cost, capacity and quality requirements. From a Lean perspective, the single machine choice reduces the non-value-added setup and cleanup time. It also uses less energy. The operation's footprint is minimized on the factory floor. The studies related to coating options, pattern choice and nozzle type helped reduce the overall takt time of the operation. The process as currently designed requires 18 seconds per unit application time plus load and transition time into the machine. The coating is applied to three units at a time. Two operators are required: one to load PCBAs on pallets and one to inspect for correct application at the end of the line. The engineering team is currently evaluating a conveyor option that would turn and return the coated units to the first operator to eliminate the need for the second.

While this option was best for a long-term, high-volume program, it might not have been ideal for an EMS provider engaged in higher-mix production, particularly if PCBA sizes have significant variance among different projects. Utilizing Lean philosophy to consider the most efficient process and Six Sigma core tools to analyze best equipment configuration assumptions helps teams make the best choice for their production environment. This approach also helps drive continuous improvement over time as opportunities are identified.

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The PCB Podcast

SEEING IS BELIEVING

Profiles in Delusion

Unreasonable demands warrant blunt responses.

A YOUNG MAN called me. He didn't want to call me. It was Friday. Friday is for vanishing, not confrontation. He persisted throughout the preceding week in sending emails, hoping someone on our end would engage. No one did. Not our customer service manager. Not our operations manager. Not our business/office manager. Without exception, all directed the young man to me.

Options reduced to one, he finally capitulated and called me. He was audibly nervous. He talked fast. When I was allowed the (rare) opportunity to reply, he cut me off and talked over my answer. The ensuing word jumble accomplished nothing. In exasperation, I finally admonished him, "You know, studies show that a conversation works optimally when the first party speaks and the second listens, after which the roles reverse. Can we try that as an experiment in achieving better communication?" He seemed reluctant. He kept on speaking nervously. Clearly, he did not appear comfortable with the message he was assigned to deliver.

That message was this: He wanted more time to pay us. More accurately, Higher Authority was dictating more time. Blame one customer: They wanted payment terms extended from the conventional net 30 to their requested net 90. Ominously, the request stated that their customer was expecting uniform acquiescence to their grand idea from all suppliers to "maintain this growing partnership …."

Partnership. Growing.

As in bank account. Better their interest earned than ours, goes the mindset.

Bowdlerize (transitive verb): to modify by abridging, simplifying, or distorting in style or content.

Like distorting the content or style of conduct in a business relationship by hanging support and partnership on a flimsy dependency on extortionate credit terms. Boeing did that to its suppliers. That worked out well.

The irony is that the company's owner, a billionaire, has ample assets at his disposal. Times are irrefutably not tight, cash flow-wise, for the OEM. The proprietor simply wants to hold on to his money, as much as he can, for as long as he can, because he can. Net worth confers a license to bowdlerize.

And screw the rest of us.

Our reluctant emissary cleared his throat like a nervous tic. He coughed a lot (email is so much easier and more

impersonal), discomforted by his desire to deliver the message in hit-and-run fashion, obtain assent without protest and begin his weekend, secure in the knowledge he could run up his "Mission Accomplished" banner to his customer in time for Monday morning coffee, claim his Attaboy, stabilize his blood pressure and go on living.

Between throat clearings, his argument for 90-day terms rested on some imagined industry standard (a preemptive search of IPC standards revealed no such thing). To confirm, we weren't looking at – and he wasn't citing – the wrong set of standards. We also checked subclauses of AS9100, section 8.4.1, in which supplier risks must be managed, such as the risk of default. A cursory review confirmed the relevant sections of AS9100 say nothing about payment terms.

Finally absolved of his burdens, we had the message, and it was our turn to respond. So I did, quite simply, restating that our terms are net 30. There was silence at the other end, then a renewed attempt to argue that they were merely adhering to something euphemistically called "industry standards" (knowledge of which, evidently, remained hidden prior to its mandate from their customer). I requested he present evidence of those standards. No answer. I reiterated in as professional a tone as I could muster that we believed net 30 was reasonable and customary, that we paid our suppliers in 30 days, and that we stood by those terms. He countered by arguing we were the only supplier to reject his proposal. I added we were comfortable being a party of one, and that numbers massed to one side of an issue did not always correlate with its correctness.

Our discussion clearly over, his mission unsuccessful, my interlocutor's coughing intensified. This was not going according to plan. He promised to pass our response on to his customer. I acknowledged that I assumed he would do so and wished him a good weekend.

And a nice life.

Imagine an employer telling her employees, in peremptory fashion, that because of competitive pressures, industry standards were changing and paydays would now occur only once every 90 days. Imagine. Then ask this: why is delaying payment of one's obligations considered by some to be "good business" and "standard?" Whose ethics prevail in the minds of those who agree with that statement?

Philosophical ruminations aside, four months later, they're still paying us in 30 days.

Another young man recently asked me to review his business plan and whether his company's wares would be worth presenting in a technical forum. He and his startup want to get "more involved" with the industry, given the general prevalence of AI and his startup company's specific niche. Never mind his questionable judgment (more dubious "good business") in cozying up to pseudo-luminaries like me.

His deference was flattering just the same. Each of us has their price.

His wares are soft: His algorithm, as best I understand it, monitors shop floor activities using data feeds from closed-circuit cameras, comparing the observed data with "standards" (that name again) to ascertain if employees are working "efficiently" (says who?) and alert management if they are not. Another peel of the AI onion to illustrate how wonderful it is as a technology.

Enmeshed in our everyday lives. How special.

The idea is to provide "game-time" video so that management can review and identify individual inefficiencies in behavior and movement by shop floor personnel, and somehow correct them. The cameras, and the AI they feed, focus exclusively on personnel. No thought of machines. Or their linkages. Or process design. Or appropriateness of materials to the task. Or the interconnectedness of all factors. Or the psychological state of those doing the work. Just personnel efficiency, as the algorithm's programmer, at the behest of management and the brilliance of my friend's IP, define it. Product literature boasts that this "Operations Digital Twin" addresses activity objectively, thus enabling swift root cause evaluation and resolution through focused management interventions. All data-driven. All from a distance, with no one-on-one contact. All very clinical; antiseptic, even. What you measure, you manage.

Eternal vigilance is the price we pay for …?

Taylorism?

"Taylorism, also known as Scientific Management: A theory of management that analyzes and synthesizes workflows. Its main objective is improving economic efficiency, especially labor productivity. It was one of the earliest attempts to apply science to the engineering of processes to management. Its name derives from that of its pioneer, Frederick Winslow Taylor. Tools include the use of time and motion study to standardize repetitive manufacturing practices." (Thanks, Wikipedia.)

Digital Taylorism.

"Digital Taylorism is based on maximizing efficiency by standardizing and routinizing the tools and techniques for completing each task involved with a given job. Digital Taylorism involves management's use of technology to monitor workers and make sure they are employing these tools and techniques at a satisfactory level …. Another example of Digital Taylorism being used in the workplace is found in organizations who use surveillance systems to monitor workers and make sure they are on task at all times; the percentage of surveillance being used in the workplace is continually growing." (Thanks again, Wikipedia.)

That's what this guy is offering: Production Nirvana in a split screen. In stereotypically amoral, libertarian Silicon Valley style, he's gung-ho for the coolness, with no consideration for those pesky ethical side effects.

He thinks this is a good thing.

Who provides the objective standards to program the algorithm? Isn't that decision in itself subjective?

If process automation, a la Industry 4.0, remains the distant goal, aren't human technicians evolving in their job responsibilities to machine and process maintainers rather than operators? And if that supposition is true, what's the point of monitoring them? Wouldn't the data from the machines – designed to regurgitate data upwards and outwards – be sufficient to gauge process efficiency, set KPIs, monitor them and adjust accordingly?

Finally, nothing conveys trust, from management to the workforce, more than a factory floor infested with digital

eyeballs, whose expressed purpose is to ensure workers are working up to an unseen, unknown, "objective" standard defined by those looking down through the cameras with a god's eye view. Lots of negative metaphors to filter through. Sounds like a place to avoid. Unless you're a union organizer.

So what did I tell him? Present his paper. We live, work and thrive in a marketplace of ideas. Let the audience judge. They'll tell you what they think. They have standards.

Just brace for the answer.

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

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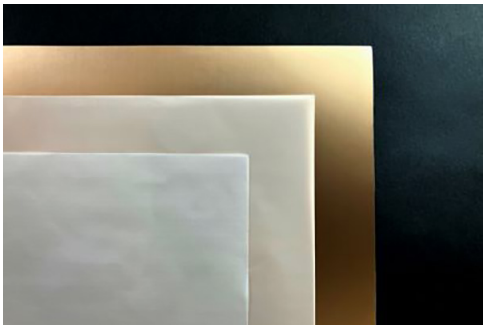

AGC METEORWAVE ELL PCB MATERIALS

Meteorwave ELL multilayer PCB materials are said to achieve low transmission loss and high thermal resistance. Contribute to higher capacity, higher transfer rates and lower power consumption of data communication, with reliability in high-temperature environments and UL-94 V0 certification. Come in a variety of prepregs and constructions and are for use in applications such as telecommunications, core routers, high speed switching/ routing systems, cloud storage, aerospace, automotive, radar and AI.

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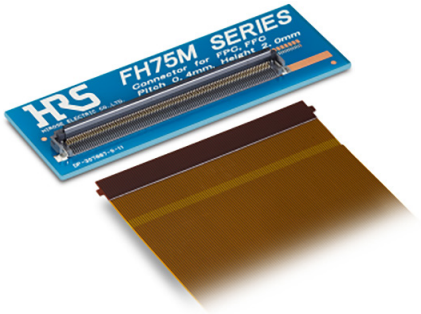


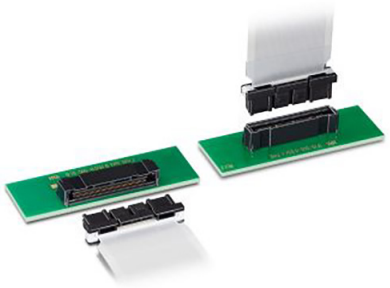
HIROSE FH75M FPC/FFC CONNECTOR

FH75M series flexible printed circuit/flat flexible connector supports MIPI D-PHY (1.5Gbps) and eDP1.3 (5.4Gbps) specifications in a miniature footprint. Features a 0.4mm pitch and 2mm height and uses a two-point contact design with two independent springs that provide a wiping action to prevent contact failure from dust, dirt and other contaminants. Operating temperature of up to 125°C. Meets automotive requirements for shock and vibration

resistance, hydrogen and sulfur gases, humidity and corrosion. Uses a flip lock with FPC tab and housing side catches that offer a retention force of 51.4N and delivers easy FPC insertion while emitting a clear tactile click to confirm complete locking. User-friendly design has wide tapers that provide smooth FPC insertion, and comes in 100-position version that is halogen-free and RoHS compliant.

Hirose Electric

hirose.com



HIROSE TF70 FPC/FFC CONNECTOR

TF70 two-piece FPC/FFC-to-board connector is designed for harsh environment applications including automotive. Features a center lock design that permits one-handed insertion and removal and a locking strength of more than 40N. Includes guide key to prevent misinsertion and a clear tactile click to indicate complete and proper mating. Pitch is 0.5mm and design reduces size and weight of end-products. Operating temperature is -40° to +105°C, and comes in right angle and straight angle connection methods.

Hirose Electric

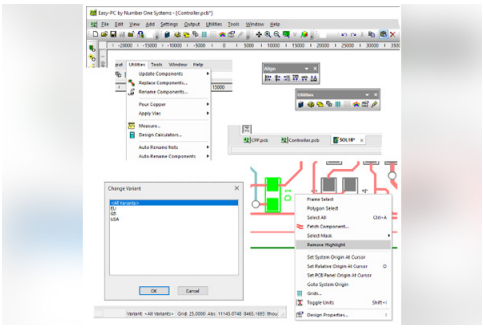
hirose.com

INSTADEEP DEEPPCB PRO ECAD

DeepPCB Pro PCB design tool uses AI to automate, optimize and accelerate the design process from start to finish. AI automation is said to simplify complex PCB design tasks, such as placement and routing, using reinforcement learning techniques. Enhances design cycles to allow faster product development and quicker time to market. Is built on Google Cloud.

InstaDeep

instadeep.com



NUMBER ONE SYSTEMS EASY-PC V.28 ECAD

Easy-PC v.28 PCB design tool features more than 40 new enhancements. New features include an updated user interface that includes a “flat” look, improved toolbars and a utilities menu to simplify the design experience, plus enhanced tools for library creation and editing that now include support for .epl format files, improved symbol editing and access to over 15 million components. Other new features are flip vertical mode, rotate around center, and text cutout creation for copper layers, and upgraded geometry checks and a reorganized DRC dialog to for more accurate and stable designs. New tools for drill ident creation, automatic plot generation and enhanced via handling.

Number One Systems

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PULSONIX 13.0 CAD

Pulsonix v.13.0 PCB design tool features improved ECAD/MCAD process along with other new features. Introduces bidirectional IDX collaboration interface said to enable seamless data exchange from ECAD to MCAD to provide incremental design exchange and eliminate the need for large design transfers each time a change is made. Allows changes to be tracked and reviewed with each action accepted or rejected. Enhanced 3-D engine provides photorealistic render of PCB design and enables additional parameters when designing rigid-flex boards. Dynamically calculates trace width based on impedance.

Pulsonix

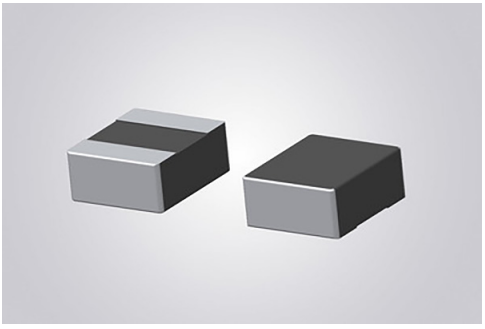
pulsonix.com

TTM XINGER UWB BALUN TRANSFORMERS

XMB0220K1-50100G (0.18-1.9GHz) and XMB0465Z1-50100G (0.4-6.5GHz) balun transformers offer common-mode rejection ratio, for efficient signal conversion. XMB0220K1-50100G is for test and measurement, telecom and COTS mil-aero applications. Enables single-ended signals to be applied to differential ports on analog-to-digital and digital-to-analog converters and integrated RF chipsets used in radar to IoT sensors. XMB0465Z1-50100G is an 1008-sized, low-profile balun, for high-level integrations for 5G, LTE and aero radar, as well as L-, S- and C-Band in communications and mil-aero markets. Also enables single-ended signals to be applied to differential ports on integrated RF chipsets.

TTM Technologies

ttm.com

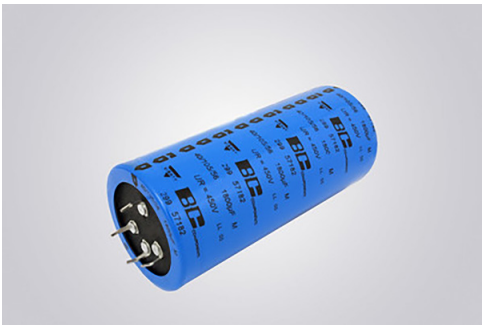


VISHAY HIGH-REL POWER INDUCTORS

Commercial IHLL-1008AB-1Z and automotive-grade IHLP-1008ABEZ-5A inductors come in 2.5mm x 2mm x 1.2mm 1008 case size. Offer higher operating temperatures up to +165°C, a range of inductance values and lower DCR. IHLL-1008AB-1Z features terminals plated on the bottom only, enabling a smaller land patter, and offer inductance values from 0.33µH to 4.7µH. IHLP-1008ABEZ-5A features terminals plated on the bottom and sides, permitting formation of a solder fillet with strength against high mechanical shock while simplifying inspection. AEC-Q200 qualified, typical DCR as low as 12.0mΩ.

Vishay Intertechnology

vishay.com



VISHAY 299 PHL-4TSI CAPACITOR

299 PHL-4TSI series of snap-in, four-terminal aluminum electrolytic capacitors now features 350V, 500V, 550V and 600V rated capacitors. Feature cylindrical aluminum case with pressure relief, insulated with a blue sleeve, for ripple current ratings from 1.9A to 7.6A. Have a 105°C temperature capability and useful life of >5000 hr. Can replace banks of large screw terminal capacitors connected by a busbar with smaller parts connected by a PCB, lowering construction costs and enabling soldering processing instead of manual mounting. Also limit the number of components required with larger can sizes than standard two-terminal snap-in capacitors – ranging from 35mm x 50mm to 45mm x 100mm.

Vishay Intertechnology

vishay.com

CA

CHECKSUM ILS-X2 MULTI-TESTER

ILS-X2 dual panel automated test system is said to effectively double parallel test output by supporting the handling and testing of two panels simultaneously. Enables more tests to be performed in parallel, integrating ICT, ISP and parallel functional tests like LIN, CAN, BIST, current, voltage and others.

CheckSum

checksum.com

EMIL OTTO EO-B-016 FLUXES

EO-B-016 flux series now includes versions with different solids content. EO-B-016A features 2% solids, EO-B-016B has 3% solids and EO-B-016C has 4% solids. Are all high-efficiency no-clean fluxes based on alcohol with di-carboxylic acid activator complex and synthetic resin, and can be used in wave, selective and hand soldering processes as well as in dip soldering and strand tinning. Applicable using all standard application methods except foaming and are said to be versatile and OPS-compatible.

Emil Otto

emilotto.com

INSPECTIS EXTENDED REACH BGA-XL STAND

BGA-XL stand allows inspection of ultra-low clearance BGAs, and optional new XM lenses provide up to 285X screen magnification. Is designed for small standoffs, e.g., 200µm, and very small ball arrays. When coupled with new extended reach BGA-XL stand for larger boards, provides greater reach, power and capability. Consists of a lens (standard or XM) plus a probe tip (standard or small), and new XM higher power lens is compatible with standard and small probe tip, which features a 27% smaller footprint. Side-view BGA inspection system comes with built-in high-power lighting and high-resolution 90° viewing angle. Mechanical improvements to BGA camera stand make the platform more stable and improve the mechanism that reduces risk of prism damage.

Inspectis

inspect-is.com

ITW EAE CENTURION REFLOW HEAVY BOARD OPTION

Vitronics Soltec Centurion 1240 reflow soldering oven now includes new heavy board options. Enhance CT 1240's capabilities by handling of heavier boards while boosting throughput of dense and heavy assemblies. Meet stringent industry requirements without increasing footprint, rather than extending oven length.

ITW EAE
itweae.com

MACROFAB FABIQ QUOTING TOOL

FabIQ quoting tool provides accurate quotes in real time and automatically suggests engineer-reviewed alternates for unavailable parts. Is said to instantly price over 95% of assemblies with no human interaction and identify process changes and tooling that can save customers thousands of dollars automatically. Supports custom stackups up to 32 layers, various copper weights and surface finishes.

MacroFab
macrofab.com

MASTER BOND EP3HT-LO EPOXY

EP3HT-LO is a single-component, non-premixed and frozen, heat-cured epoxy with an unlimited working life at room

temperature. Passes ASTM E595 tests for NASA low outgassing. Features a lap shear strength of 1,600-1,800psi, a tensile strength of 5,000-6,000psi and a tensile modulus of 250,000-300,000psi. Withstands 1000 hr. of 85°C/85% RH exposure and features a Dk of 3.9 at 60Hz and a volume resistivity of greater than 10^{14}Ω-cm at room temperature. Withstands a variety of chemicals such as water, oils, fuels, acids and bases and is serviceable from -60° to +400°F (-51° to 204°C). Cures with heat, polymerizing in as few as 5-10 min. at 300°F (~150°C), and is said to bond to metals, glass, composites, ceramics and many plastics.

Master Bond

masterbond.com

METCAL MIRCROFINE SOLDERING PRODUCTS

MicroFine product line includes soldering handpieces and cartridge tips for use under microscopes. Come with soldering and tweezer handpiece configurations and are compatible with the Metcal MX Series and Connection Validation Series soldering systems. Offer fixed temperature process control featured in Metcal's SmartHeat products, but in significantly smaller, lighter formfactors.

Metcal

metcal.com

MRSI-175AG EPOXY DISPENSER

MRSI-175Ag epoxy dispenser is an ultra-high-speed, flexible solution with multiple dispensing methods and

materials. Can dispense silver-filled epoxies, conformal coating, sintering paste, thermal grease and UV adhesive, among others. Is said to be configurable for complex applications, such as microwave modules, optical modules, hybrid circuits, multichip modules, advanced packaging and semiconductor packaging. Also offers process control and is 35% more energy efficient than previous systems.

MRSI Mycronic

mrsisystems.com

SHENMAO PF719-P250A SOLDER PASTE

PF719-P250A high-reliability lead-free alloy is said to provide anti-thermal fatigue performance. Is halogen-free (ROL0) with no halogen intentionally added, for compliance with RoHS, RoHS 2.0 and REACH regulations. Also reportedly offers voiding performance and resistance to multiple reflows while maintaining solderability and printability.

Shenmao

shenmao.com

TRI TR7700QC SII AOI

TR7700QC SII 3-D AOI features user-friendly programming for easy setup, flexible IPC-A-610 inspection algorithms and optional AI-powered solutions. Also features a 12MP high-speed camera and offers four factory-setting configurations ranging from 10µm to 15µm. Can inspect THT components, and interactive 3-D models help review detected defects such as lifted BGA components, IC leads, connectors, switches and other mounted devices. Inspects tall (up to 40mm) and short components during same inspection. Supports IPC-CFX and Hermes.

Test Research, Inc

tri.com.tw

In Case You Missed It

3-D Printing

"Iterative Printing of Bulk Metal and Polymer for Additive Manufacturing of Multi-Layer Electronic Circuits"

Authors: Zeba Khan, *et. al.*

Abstract: In pursuing advancing additive manufacturing (AM) techniques for 3-D objects, this study combines AM techniques for bulk metal and polymer on a single platform for one-stop printing of multilayer 3-D electronic circuits with two novel aspects. The first innovation involves the embedded integration of electronic circuits by printing low-resistance electrical traces from bulk metal into polymer channels. Cross-section grinding results reveal (92±5)% occupancy of electrically conductive traces in polymer channels despite the different thermal properties of the two materials. The second aspect encompasses the possibility of printing vertical bulk metal vias up to 10mm in height with the potential for expansion, interconnecting electrically conductive traces embedded in different layers of the 3-D object. The work provides comprehensive 3-D printing design guidelines for successfully integrating fully embedded electrically conductive traces and the interconnecting vertical bulk metal vias. A smooth and continuous workflow is also introduced, enabling a single-run print of functional multilayer embedded 3-D electronics. The design rules and the workflow facilitate the iterative printing of two distinct materials, each defined by unique printing temperatures and techniques. Observations indicate that conductive traces using molten metal microdroplets show a 12-fold reduction in resistance compared to nanoparticle ink-based methods, meaning this technique greatly complements multi-material additive manufacturing (MM-AM). The work presents insights into the behavior of molten metal microdroplets on a polymer substrate when printed through the MM-AM process. It explores their characteristics in two scenarios: deposited side-by-side to form conductive traces and deposited out-of-plane to create vertical bulk metal vias. The innovative application of MM-AM to produce multilayer embedded 3-D electronics with bulk metal and polymer demonstrates significant potential for realizing the fabrication of free-form 3-D electronics.
(*npj Advanced Manufacturing*, August 2024, https://doi.org/10.1038/s44334-024-00001-0)

Flexible Electronics

"Stretchable Arduinos Embedded in Soft Robots"

Authors: Stephanie J. Woodman, *et al.*

Abstract: To achieve real-world functionality, robots must be able to carry out decision-making computations. Soft robots stretch, however, and therefore need a solution other than rigid computers. Examples of embedding computing capacity into soft robots currently include appending rigid printed circuit boards to the robot, integrating soft logic gates, and exploiting material responses for material-embedded computation. Although promising, these approaches introduce limitations such as rigidity, tethers or low logic gate density. The field of stretchable electronics has sought to solve these challenges, but a complete pipeline for direct integration of single-board computers, microcontrollers, and other complex circuitry into soft robots has remained elusive. The authors present a generalized method to translate any complex two-layer circuit into a soft, stretchable form. This enabled the creation of stretchable single-board microcontrollers (including Arduinos) and other commercial circuits (including SparkFun circuits), without design simplifications. As demonstrations of the method's utility, the authors embedded highly stretchable (>300% strain) Arduino Pro Minis into the bodies of multiple soft robots. This makes use of otherwise inert structural material, fulfilling the promise of the stretchable electronic field to integrate state-of-the-art computational power into robust, stretchable systems during active use. (*Science Robotics*, September 2024, https://doi.org/10.1126/scirobotics.adn6844)

Quality Assurance

"PCB Plug-In Solder Joint Defect Detection Method Based on Coordinated Attention-Guided Information Fusion"

Authors: Wenbin Chen, *et. al.*

Abstract: Printed circuit boards (PCBs) are the foundational component of electronic devices, and the detection of PCB defects is essential for ensuring the quality control of electronics products. Aiming at the problem that existing PCB plug-in solder defect detection algorithms cannot meet the requirements of high precision, low false alarm rate and high speed at the same time, this work proposes a method based on spatial convolution pooling and information fusion. First, on the basis of YOLOv3, an attention-guided pyramid structure is used to fuse context information, and multiple convolutions of different sizes are used to explore richer high-level semantic information. Second, a coordinated attention network structure is introduced to calibrate the fused pyramidal feature information, highlighting the important feature channels, and reducing the adverse impact of redundant parameters generated by feature fusion. Finally, the ASPP (atrous spatial pyramid pooling) structure is implemented in the original Darknet53 backbone feature extraction network to acquire multi-scale feature information of the detection targets. With these improvements, the average detection accuracy of the enhanced network has been elevated to 96.43% from 94.45%. This experiment shows that the improved network is more suitable for PCB plug-in solder defect detection applications. (*Scientific Reports*, August 2024, https://doi.org/10.1038/s41598-024-70100-7)

Signal Integrity

“High-Speed Signal Optimization at Differential Vias in Multilayer Printed Circuit Boards”

Authors: Wen-Jie Xu, *et. al.*

Abstract: The number of printed circuit board layers increases with increases in data transmission rates, and the signal integrity (SI) of high-speed digital systems cannot be ignored. Introducing vertical interconnect accesses (vias) in PCBs can realize the electrical connection between the top layer and innerlayers, however, vias represent one of the most important reasons for discontinuity between PCBs and package. In this work, a new optimization scheme for a differential via stub is proposed, with 3-D full-wave numerical simulation used for modeling and simulation. Results show that this scheme optimizes the return loss and insertion loss while making the signal eye diagram more ideal, which can improve the transmission effect of high-speed signals. (*Electronics*, August 2024, https://doi.org/10.3390/electronics13173377)