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May 2023

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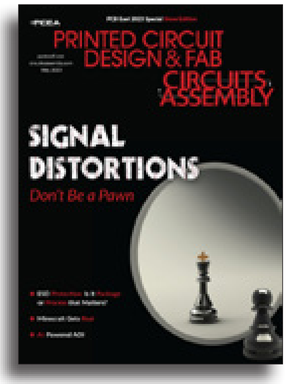

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A NewCo to Revive the Past

IT'S BEEN WELL established by now that North America, once neck-and-neck with Japan for the title of largest producer of printed circuit boards, has long since ceded that space to China.

But there was a moment, several years ago, at an industry meeting where market research was broadly disseminated and debated, where Taiwan was promoted – briefly – as the future.

Walt Custer, the charismatic pundit known for his informative and humorous presentations, was asked if North America was about to be eclipsed by the Pacific Rim. His reply was that he felt it was only a matter of time before Taiwan became the top-producing nation.

Dr. Hayao Nakahara, sitting in the audience, then stood and pointed out some basic facts:

- Taiwan had a population of around 23 million.
- China had a population of well over 1 billion.

I don't recall the entirety of the exchange, but Naka's point was that China would overwhelm its neighbors with abundant space for new campuses and a near-inexhaustible supply of lower-cost workers in what was then still very much a labor-intensive manufacturing operation. China, he correctly deduced, would surpass everyone: North America, Taiwan and Japan.

Fast forward to today. China is indeed the dominant player in bare boards, with roughly 60% of the world production taking place there. But Taiwan is No. 2, at $11.6 billion as of 2021. That's slightly more than the Americas, Europe and Africa and the Middle East combined. (For the full accounting, see Naka's annual NTI-100 list. https://www.pcdandf.com/pcdesign/index.php/editorial/menu-features/16699-the-unsinkable-unstoppable-pcb-market)

But why was Taiwan not only able to surpass the West in output, but maintain that lead through two decades? Why hasn't the island-nation succumbed to the economics of demographics (low population, an educated workforce that would have ample opportunities in non-manufacturing sectors, an average age that rose 24% between 2000 and 2018) coupled with a relative scarcity of natural resources, particularly available land?

I asked a few experts on Taiwan's bare board industry. The short answer: There's no consensus. One did point to Taiwan's government policies, which are conducive to maintaining key industries like semiconductors and PCBs. "Government is unified in supporting industry," he said. A few others said the levels of automation in Taiwan far exceed those of North America. But could those factors alone be enough to allow Taiwan to continue to beat – easily – the West on price even after the shipping and other logistical costs are accounted for?

And if so, there's a silver (or perhaps copper) lining.

Buoyed by government grants and the US Congress' newfound passion for building things at home, a group of US-based companies are looking at closing the technical gap.

Under the auspices of the US Partnership for Assured Electronics (USPAE), these companies are tackling the issue of how to build substrate-like PCBs for next-generation semiconductors. In short, what good is $50 billion of new semiconductor fabs if the bare die must be shipped to the Pac Rim to be packaged?

"The concern is the US can't do enabling technology," said Joe O'Neil. "We need a highly automated process, with operations performed in clean-room environments, capable of low-mix, high-volume production."

The short-term solution calls for setting up a service bureau to work with existing suppliers to produce the core technology, which would then be sent to a dedicated company (called NewCo) to make the buildup layers using a common process capable of 1/1 mil lines/spaces.

"That would get things started," says O'Neil, "but won't solve the industry base problem."

The longer-term goal, he says, is the creation of a Center of Excellence for domestic PCB training. The outfit would develop the recipes, prove them out, and transfer that technology to industry, and train the workforces of the participating members. The objectives call for settling on a single process in order to accelerate the learning curve, so less time is spent on R&D and more on training.

The actual training goals are fairly modest: about 12 engineers every six months. But it's the closest the US industry has come since the conception of the Interconnection Technology Research Institute to forming a manufacturing collaborative with an actual physical production space. (We say "conception," because ITRI never realized its own plant.)

We can't just wish a turnaround to happen. If North America wants to revive its past, it needs to invest in technology that will allow it to leapfrog its current trendline. Given the stakes, we applaud this effort to match ideas with action. □

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PCDF Briefs

AT&S said it will delay the start of production at its new plant in Malaysia to 2026-27 due to high market inventory and weak demand.

Fraunhofer-Gesellschaft purchased a **Nano Dimension** DragonFly IV 3-D printer.

Haier plans to invest Rs 1,500 crore ($184 million) over the next two years to set up a PCB manufacturing and injection molding plant at its Greater Noida industrial park.

Hushi Electronics began construction on a $280 million PCB factory and warehouse in Thailand.

Jianding has acquired a PCB factory from an undisclosed Japanese company in Dong Nai Province, Vietnam.

Notion Systems held a groundbreaking ceremony for its new company headquarters, which will feature 3,600 sq. m. of floor space.

Prototron Circuits named **Sourcing Specialists** representative in the Northeast US.

Pythos Technology Philippines is exploring six to seven business opportunities in Qatar in the fields of electronics, manufacturing, engineering and technical services.

Quanta Computer's board has approved a company plan for up to $50 million to set up a new plant in Vietnam.

Schweitzer Engineering Laboratories purchased two **Chemcut** wet processing systems for its PCB fabrication plant in Moscow, ID.

Summit Interconnect installed two new automatic wet processing machines and **MacDermid** Shadow lines and etchers.

Sunstone Circuits is strengthening its partnership with **Screaming Circuits** through more efficient and concise communication, unified team building and training, and a streamlined quote turnaround.

T-Works is building a multilayer PCB fabrication facility in India that can facilitate rapid fabrication of up to 12-layer boards.

Würth Elektronik officially opened its High-tech Innovation Center in Munich on Apr. 3.

Zhen Ding Huai'an's HDI/MSAP substrate plant will enter small-scale mass production in the second quarter.

CA Briefs

Cogiscan announced new distribution partnerships with **MacTech** for technical sales support and representation in Argentina.

Collins Aerospace plans to expand its electronics production facility in Cedar Rapids, IA,

Biden Invokes Defense Production Act for PCB Production

WASHINGTON, DC – President Joe Biden has authorized the use of the Defense Production Act to spur domestic and Canadian production of printed circuit boards, citing the technology's importance to national defense.

A presidential determination signed by Biden in April permits the Department of Defense to utilize its Defense Production Act Title III authorities to invest $50 million in advanced microelectronics capacity and ensure the production of state-of-the-art integrated circuits in the US.

"United States industry cannot reasonably be expected to provide the capability for the needed industrial resource, material, or critical technology item in a timely manner," Biden said in a memo released by the White House. "I find that action to expand the domestic production capability for printed circuit boards and advanced packaging is necessary to avert an industrial resource or critical technology item shortfall that would severely impair national defense capability."

The Defense Production Act ruling also calls for more "advanced packaging" that permits multiple devices to be packaged and mounted on a single electronic device, shrinking them and making power use more efficient.

"The rapid changes occurring within the microelectronics industry make it imperative for the Department of Defense to ensure that this critical sector can support the nation's defense needs. The Presidential Determination will allow the DoD to use additional tools to ensure the resilience of American microelectronics manufacturing," Anthony Di Stasio, director of the Manufacturing Capability Expansion and Investment Prioritization (MCEIP) office. "We are committed to working with our interagency partners to expand the microelectronics domestic industrial base in the United States."

Emerson to Acquire National Instruments

ST. LOUIS – Emerson Electric in April announced it will be acquiring National Instruments for $8.2 billion. The agreement comes after NI rejected multiple offers from Emerson, which initially offered $7 billion.

The transaction is expected to close in the first half of Emerson's fiscal 2024, subject to the completion of customary closing conditions, including regulatory approvals and approval by NI shareholders.

NI, which provides software-connected automated test and measurement systems, had $1.66 billion in 2022 revenue and operates in more than 40 countries, serving approximately 35,000 customers across semiconductor and electronics, transportation, and aerospace and defense markets.

"We are pleased to reach an agreement with NI, whose best-in-class test and measurement product and software offerings accelerate Emerson's progress toward a cohesive, higher growth and higher margin automation portfolio," said Lal Karsanbhai, president and CEO, Emerson. "With this expansion into test and measurement, Emerson will enhance its automation capabilities and gain a broader set of customers that relies on NI's solutions at critical points along the product development cycle.

"These capabilities provide Emerson industry diversification into attractive and growing discrete markets like semiconductor and electronics, transportation and electric vehicles, and aerospace and defense that are poised to benefit from secular growth trends. NI's business is well-aligned with our vision for automation and we look forward to working together to bring more comprehensive and innovative solutions to our customers, accelerate growth and position Emerson to deliver significant shareholder value."

"Over the past several months, we've been evaluating strategic options for the future of our business with the intent to maximize its value," said Eric Starkloff, CEO of NI. "We ran a robust and comprehensive process, considered a range of potential

to meet increasing demand.

Ducommun has entered into a definitive securities purchase agreement to acquire **BLR Aerospace.**

EMD Electronics will spend $300 million to expand its specialty gas production facility in eastern Pennsylvania in a step state officials hope will boost the area's appeal to the fast-growing semiconductor industry.

Foxconn may begin construction on a new mobile phone plant in Bengaluru, India, this month.

Hentec Industries/RPS Automation named **Production Automation** sales representative in the Upper Midwest US.

InSource Technologies purchased its second **Hentec Industries/RPS Automation** Vector 460 selective soldering system.

Kodiak Assembly purchased a **Mirtec** MV-6 OMNI AOI.

Mara Technologies held a ribbon-cutting ceremony for its US headquarters in Grand Blanc Township, MI.

Microsoft plans to build a $1 billion data center on a 315-acre plot in Mt. Pleasant, WI, currently owned by **Foxconn.**

NeoTech announced that it has purchased equipment to open a new SMT line at its facility in Westborough, MA.

Nidec installed a **Yamaha** line in its new factory in Mexico.

PDR named **SMTVYS Technology** manufacturers' representative in Mexico.

Pro-Active Engineering purchased a **Nikon** XT V 160 x-ray machine.

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

Sarcos signed a manufacturing services agreement with **Jabil** to advance production capabilities for its robotic systems.

Sure Grip Controls announced the acquisition of **Industrial Electronic Controls** of Rockford, IL.

Sypris Electronics recently received additional orders to manufacture and test electronics assemblies for an additional four systems to be supplied to a US DoD contractor.

Syrma SGS Technology is looking to double its SMT lines by using the proceeds of its IPO.

Tata Group is reportedly in the final stages of acquiring **Wistron's** iPhone manufacturing facility in India.

options, and believe this represents the best outcome for all NI stakeholders. This transaction is a strong testament to the improvements and initiatives we've implemented in recent years that have transformed NI into a software focused company with higher growth, better profitability and lower cyclicality. We're thrilled that Emerson recognizes the value we've created and we believe they will help us build on our momentum to further position NI as a leading provider of software-connected automated test and measurement systems."

IPC CTC Calls for IC Substrate Manufacturing Facility in US

BANNOCKBURN, IL – The establishment of a pilot facility in the US for manufacturing IC substrates is a first step towards re-establishing semiconductor packaging within the US, and the CHIPS and Science Act of 2022 can be used to jump start the effort, according to a white paper released by the IPC's Chief Technologist Council.

After decades of offshoring for the PCB and IC substrate industry, the experience base in implementing and executing the operational management of an IC substrate fabrication facility is nearly nonexistent in North America – for both the leadership skills required as well as the process engineering expertise which provides the backbone of these operations, the paper states. No real "surplus" of PCB manufacturing expertise is available to seed an IC substrate fabrication facility, and this is amplified by the fact that PCB companies are generally risk-averse.

While the CHIPS Act is meant to jump start the effort, the competition for funding has led to the proposed creation of complicated, highly centralized mechanisms that are likely to eat up funding while failing to address the underlying needs.

The CTC's recommendation for the funding is to build an IC substrate fabrication pilot line, which neither has to be, nor should be, state-of-the-art as its initial technology point. Rather, it should be set up to allow for capabilities to grow quickly, targeting state-of-the-art in the future without being held hostage to these eventual requirements in the short term. The committee also recommends that this facility be implemented as a US asset, following a consortium model like the High Density Packaging User Group, permitting any company to join, participate, contribute and realize the benefits of the effort.

The CTC says the facility should not be "squeezed" into a surplus building that is donated, but should instead be constructed with the end in mind. Plan for the next iteration/generation of equipment, acknowledging that more is required, and that more is both possible and required. The expansion space must be available at time zero, so that as version 1 is implemented, version 2 is already being planned and has available space. When version 2 is implemented, version 3 is planned for the space that the newly obsolete version 1 currently occupies. The model would be to continue to swap out the equipment, incrementing capability at a sustainable pace.

This facility would not only start to resolve the IC substrate manufacturing shortfall, but would also be geographically located to facilitate the other weaknesses that have been identified in the semiconductor packaging ecosystem, the paper says, and there should be a university presence nearby with an outstanding and recognized electronics curriculum, ideally staffed with highly experienced industry subject matter and operations experts. The curriculum can utilize this pilot facility as a sort of "Unit Ops Lab" specific to PCB or IC substrate fabrication.

Additionally, it should have easy access to semiconductor and outsourced semiconductor assembly and test (OSAT) facilities, the paper said, using the Center for Advanced Microelectronics Manufacturing (CAMM) advocated and administered by Binghamton University in New York as an example for the model of ecosystem that should be built.

Variosystems installed an **EKRA** Serio 4000.1 screen printer, **Parmi** 3-D SPI, **ASM** component level placement traceability, **Heller** reflow oven and **Parmi** 3-D AOI at its Southlake, TX, facility.

Variosystems announced the acquisition of **Kubeg,** a rapid prototyping and small series electronics solutions company based in Zizers, Switzerland.

VJ Electronix appointed **Uptech** to support its customers on the US West Coast.

Yageo plans to invest 205 million euros ($225 million) in the next decade to expand its component manufacturing operations in North Macedonia.

PCDF People

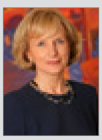
Westermo Network Technologies named **Ciro Blazevic** PCB layout engineer..

Rogers named **Michael Webb** senior vice president and chief administrative officer.

CA People

AIM Solder appointed **Demétrius Nunes Maciel** to technical support Brazil and **Jua Coates,** pictured, to customer service supervisor for AIM Solder Rhode Island.

Alert Tech SMT announced **Brian Laney's** promotion to the role of chief operating officer.

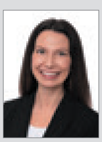


Bright Machines announced that **Gayle Sheppard** will transition from co-CEO to chief executive officer.



Green Circuits named **Richard Dutton,** left, CFO, appointed **Adam Szychowski,** middle, vice president, sales & marketing, and appointed **Jennie Tran,** right, to senior director of human resources.

Intervala named **Sara Fenimore** director of supply chain and welcomed **William Hibbs** and **Laura Bradbury** as purchasing managers.



MicroCare named **Rebecca Mahoney** senior quality control chemist.

Wild River Technology and Cadence Collaborate to Improve Simulation Measurement

HILLSBORO, OR – Wild River Technology and Cadence in April announced a collaboration to improve simulation to measurement correspondence using WRT's next-generation Channel Modeling Signal Integrity Platform.

Cadence chose WRT's CMP-50 Advanced Channel Modeling Platform for benchmarking its Clarity 3D Solver against the associated EM correlation across multiple workflows and is inclusive of WRT's 400-800 gigabit Ethernet simulation solution for designing critical interconnects for PCBs, IC packages and systems on IC (SoIC).

CMP-50 incorporates critical structures for material identification in 3-D for anisotropic materials, crosstalk analysis in the x-y and z directions, and a host of additional interconnect solutions that typically challenge EM solvers. This generation improves launch and via design methodology along with crosstalk analysis and changes the trajectory of traditional EDA development often conducted in a hardware- and measurement-less vacuum.

"The Wild River Technology team is well-known to be highly skilled and trusted signal integrity technologists," said Gary Lytle, product management director, multiphysics systems analysis technology, at Cadence. "As such, this collaboration allows us to not only prove out the accuracy of Clarity against known measurements but also allows mutual customers to better understand how to take accurate measurements and why that's important when simulation meets the real world."

"The Cadence team dug really deep, and we found the simulation-measurement correspondence to be excellent," said Al Neves, founder and chief technologist, Wild River Technology. "It's been very productive collaborating with Cadence and its savvy engineers. We were able to address fundamental problems of practical electromagnetics using both our CMP-50 platform and the Cadence Clarity 3D Solver."

Cadence is utilizing a host of advanced correspondence tools (S-parameters) and complementing time-domain transformed (TDR) impedance data along with proprietary tools being developed that corresponds S-parameters as vectors, such as the Modified Hausdorff Distance metrics and causal material models.

Altair Establishes $1M STEM Scholarship at Columbia University

TROY, MI – Altair has established a $1 million scholarship for students pursuing a four-year engineering or STEM-related undergraduate degree at Columbia University's School of Engineering and Applied Science.

The Altair #OnlyForward scholarship will award 10 students with $25,000 annually, which they will receive each year of their undergraduate studies until graduation.

"Sponsoring these life-changing scholarships is an honor for Altair," said James R. Scapa, founder and chief executive, Altair. "Throughout our history we have always prioritized diversity, as it is a foundational pillar of our culture and thereby our success. The Altair #OnlyForward Scholarship was established to celebrate and develop the next generation of diverse, world-class talent that will impact our world for years to come."

"This scholarship will empower our students to make remarkable achievements in the classroom and lab, in the community, and beyond," said Shih-Fu Chang, dean of Columbia Engineering. "We are extremely grateful to Altair for generously supporting education and opening doors for underrepresented students in engineering and applied science at Columbia."

The Altair scholarship is designed to assist incoming/first-year students pursuing an undergraduate degree in engineering and applied science, and who have demonstrated leadership in or support for the African American and/or Latino community. Additionally, the scholarship aims to support students who are socioeconomically disadvantaged, have worked or lived in diverse environments, and have demonstrated experience in or commitment to working with historically underserved, underrepresented, or underprivileged populations. Ideally, the scholarship will benefit first-generation college students.

Columbia Engineering will select and announce the first cohort of scholarship recipients in the fall of 2023.

APCT Acquires San Diego PCB

SANTA CLARA, CA – APCT has announced the acquisition of San Diego PCB, a printed circuit board design services company. Financial terms were not disclosed.

"We are delighted to partner with San Diego PCB to provide our customers with a complete PCB lifecycle solution from design and layout to prototyping and production," APCT CEO Steve Robinson said in a statement. "Over the past 20 years, San Diego PCB has built a strong reputation for quality, service and efficiency and is the perfect complement to APCT products. I am delighted to welcome everyone on the San Diego PCB team to the APCT family."

"We are tremendously excited to join the APCT platform," said Tony Bell, division manager of San Diego PCB. "APCT shares our dedication and commitment to putting the customer first and is an ideal partner for San Diego PCB. Through this combination, we'll continue to provide our customers with best-in-class PCB design services, and we're excited to leverage APCT's quick turn prototyping and production fabrication capabilities to serve even more of our customers' needs."

San Diego PCB merged in 2003 with Milwaukee Electronics.

Sunshine PCB Acquires Vision Industries

SHENZHEN, CHINA – Sunshine Global Circuits has announced the acquisition of Malaysian PCB manufacturer Vision Industries. Closing of the acquisition is subject to government and regulatory approval and is expected to be finalized in May.

The acquisition is meant to extend Sunshine's manufacturing capabilities into Southeast Asia and enhance Sunshine's product offerings in microwave and RF circuit boards, as well as further establish Sunshine Global Circuits as a premier international PCB manufacturer after the establishment of Sunshine USA in 2011 and the acquisition of Sunshine Germany in 2013, the company said in a release.

"This acquisition will allow Sunshine and Vision to integrate our capabilities and services to enable us to better serve our customers world-wide," said Mark Zhang, president and chairman of SGC. "With this acquisition as the starting point, Sunshine will gradually increase the technology and production capability in Penang. We will add HDI process, advanced automation, and quick turn prototyping to elevate the current capabilities while maintaining our high-mix, low-to-medium volume model. Sunshine will devote the necessary resources to scale the Penang facility to be the best manufacturer in Southeast Asia for Rigid and RF PCBs."

Infinitum Gains PCB Fab Capability with Circuit Connect Acquisition

AUSTIN, TX – Electric motor OEM Infinitum has acquired Circuit Connect, a printed circuit board fabricator based in Nashua, NH, for an undisclosed amount.

In a press release, Infinitum said the acquisition of Circuit Connect supports its efforts to become more vertical and immediately permits a substantially higher production capacity of PCB stators. The acquisition of the 30-year-old PCB fabricator also provides a framework for continuous volume growth, which is critical to meeting the high demand for Infinitum's electric motor technology.

Circuit Connect has supplied Infinitum with PCB stators for more than five years and has been closely involved in developing the manufacturing process and quality product. The company has 21 employees who will join the Infinitum family, while continuing to service existing customers via the operation from Nashua.

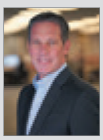
Infinitum's unique air core motor motors replace heavy iron found in traditional electric motors with a lightweight, printed circuit board (PCB) stator said to be more reliable and require fewer metals such as copper.

Mycronic appointed **Magnus Marthinsson** interim senior VP global technologies.

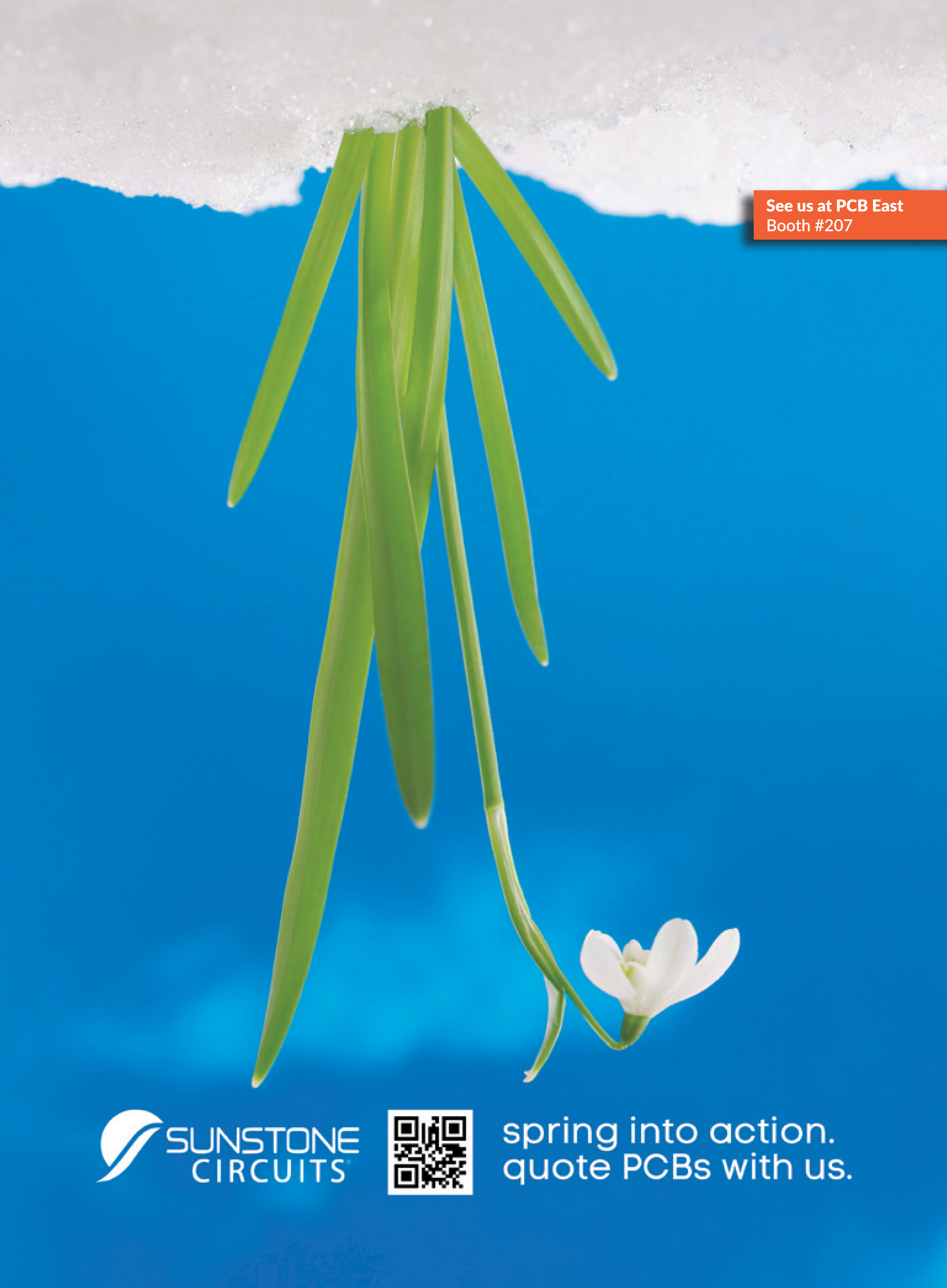
Namics named **Keith Araujo** director, sales & marketing.

Universal Instruments appointed **Brad Bennett,** pictured, as president, succeeding **Jean-Luc Pelissier,** the company's CEO and president for the past 16 years who will retire after a brief transition phase. Bennett has held various management roles at Universal, most recently as business unit general manager and VP.

Z-Axis hired **Carmen Sapp** as sales manager.



Zentech Manufacturing named **Michael Buseman,** pictured, president and CEO, succeeding **Steve Pudles,** who will remain with the company as an advisor and board member. Buseman has more than 30 years' experience in EMS and component distribution, most recently as chief operations officer of Benchmark Electronics.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"Our PCB stator is the heart of our sustainable electric motors and what allows us to deliver the efficiency and energy savings that is so important to our customers and the planet," said Ben Schuler, founder and CEO, Infinitum. "Circuit Connect has worked side by side with us advancing and improving how PCB stators are made. Their acquisition will help us ensure consistent delivery of quality stator components as we execute on our hypergrowth phase and scale up manufacturing to meet demand for our motors that can power the world with less energy and waste."

"As a leader in PCB fabrication in the US for more than three decades, Circuit Connect's dedication to customer success aligns well with Infinitum's mission to build motors with reliability and extended life," said Rick Clutz, founder, Circuit Connect. "We look forward to continuing to serve our customers and are excited about the next chapter as we ramp up production to help create motors that can have such a lasting and positive impact on the environment."

Wus Takes Over Majority of PCB JV with Schweizer

SCHRAMBERG, GERMANY – Wus Printed Circuits has approved the acquisition of a majority stake in Schweizer Electronic (Jiangsu), increasing its share of the printed circuit board fabricator to 70% from approximately 13%.

Wus also plans to carry out a capital increase of around EUR29 million at the joint venture in China, in which Schweizer Electronic AG will not participate. Schweizer will hold around 20% of the JV when the transactions are closed.

The JV will continue to operate under the name Schweizer Electronic. Under the new majority structure Schweizer Electronic will retain a seat on the board.

Schweizer, which generates almost 30% of its consolidated sales through its JV for high-frequency PCBs, has also agreed to significantly expand its cooperation with Wus. It retains its flagship printed circuit board fabrication plant in Schramberg, with a focus on ensuring high production volumes of chip embedding technology, while also having full access to the technologies of the other Wus plants. In addition to sites in Germany, Taiwan and China, the company plans to expand in Thailand.

"This enables Schweizer to address additional product and market segments and increases the opportunity for additional growth without the need for own high investments in production capacities," the company said in a press release.

Jabil Building Production Facility in Croatia

ST. PETERSBURG, FL – Jabil has announced the construction of a new production facility in the Croatian city of Osijek. Construction of the new facility is planned to be completed in 2024, and the factory will create more than 1,500 jobs for local workers, the company said in a press release.

The company said it is also planning to open a factory to produce medical prosthetic parts, plus printed circuit assemblies for the automotive industry.

Recruitment has begun and will continue through 2023.

Tempo Automation Announces Acquisition of Optimum Design Associates

SAN FRANCISCO – Tempo Automation announced that it has entered into a definitive agreement to acquire Optimum Design Associates, an electronic design services company with offices in the US and Australia.

By vertically integrating electronic design and manufacturing, Tempo expects to be able to engage with customers even earlier in their product design process, streamlining the hardware development journey and providing a more efficient and faster way to get electronic products to market, the company said in a release announcing the acquisition.

Tempo said the anticipated benefits of the acquisition include access to Optimum's experienced engineering team and cross-selling opportunities to expand the customer base. The transaction is expected to close in the second quarter of this year.

"This acquisition will be a significant step toward our vision of transforming the speed and quality of electronics prototyping," said Joy Weiss, CEO, Tempo Automation.

"Our proprietary design management tools and library services are natural extensions to Tempo's Accelerated Manufacturing Platform," said Nick Barbin, cofounder and president of Optimum. "The acquisition is an efficient way for us to accelerate our roadmap and offer PCB assembly services to our customers."

DoE Announces $50M in Smart Manufacturing Incentives

WASHINGTON, DC – The US Department of Energy has announced $50 million in funding from the Bipartisan Infrastructure Law for states to accelerate the use of Smart Manufacturing technologies through providing access to tools and assistance.

The State Manufacturing Leadership Program is meant to remove existing barriers that prevent innovative, data-driven tools and technologies from being used by small- and medium-sized manufacturers (SMMs). These tools will allow SMMs to increase production efficiency and play key roles in bolstering the domestic manufacturing base.

"Unlocking the potential for small- and medium-sized clean energy manufacturing facilities to use the same technologies as larger facilities will make us more competitive on a global scale," said US Secretary of Energy Jennifer M. Granholm. "This funding opportunity will ensure that the benefits of a clean energy economy are felt across the country."

The program will support all US states, including Washington DC and US territories, in accelerating the deployment

of smart manufacturing technologies by SMMs by providing financial assistance to SMMs to implement smart manufacturing technologies and practices and broaden access to high-performance computing resources.

With this funding, states and territories will be able to create new programming or build on existing programs that provide technical assistance to SMMs. Applicants are encouraged to submit proposals for funding that cover initiatives such as, but not limited to:

- Promoting the benefits of smart manufacturing technologies among SMMs based on national and regional economic development and supply chain priorities
- Identifying and providing financial assistance to facilitate SMMs' access to and implementation of smart manufacturing and high-performance computing resources and technologies
- Securing partnerships with labor unions and other stakeholders to expand and diversify the smart manufacturing talent pool and develop, promote, and scale adoption of smart manufacturing training.

Foxconn Plans $800M Investment in Southern Taiwan

TAIPEI – Foxconn is planning to invest T$25 billion ($820 million) in the next three years in new manufacturing facilities in southern Taiwan to support its electric vehicle ambitions, the company said in early April.

Foxconn, which is seeking to diversify its revenue base by expanding into the EV market, said the investments in Kaohsiung will include plants for making electric buses and batteries for EVs.

Ocutrx Acquires Spectrum AMT

IRVINE, CA – Medical manufacturing company Ocutrx Technologies has announced the acquisition of Spectrum Advanced Manufacturing Technologies, a Colorado-based electronics manufacturing and assembly company.

With the acquisition, the consolidated Ocutrx Spectrum company now has seven SMT lines, including ISO Optics Lab capabilities, to serve medical, commercial and government entities. Spectrum is known for providing high-relabiity hardware and NPI support to its customer base, with a history of more than 25 years for many defense, NASA and commercial space flight programs.

Ocutrx said the acquisition will fuel its efforts to repatriate its supply chain and leverage Spectrum's infrastructure to produce its medical headsets in compliance with FDA standards on US soil. The company will also work with Spectrum's clients like Lockheed-Martin, Raytheon, Honeywell, Northrop Grumman, Honeybee Robotics, Barber-Nichols and NASA to enable growth opportunities in new non-medical verticals including the aerospace, robotics, 5G, 5G-MEC, automotive, gaming and AR/XR defense markets.

"The acquisition of a revenue positive, EBITDA positive company is a huge milestone for us in controlling our growth and in healthcare generally. It is also a quantum leap to bring new 3-D visualization and AI tools for surgeons in the operating room," said Michael A. H. Freeman, CEO. "And, the fact that the DoD and Fortune 500 companies are looking more and more for AR/XR and AI solutions creates a unique opportunity out of this business combination integration."

Spectrum founder and CEO Jeff Riggs is staying on as a minority partner with Ocutrx and will remain CEO of Spectrum for several years to permit Ocutrx and Spectrum to fully integrate.

Note Acquires ATM Electronics

STOCKHOLM – Note has added a second plant in Eastern Europe through the acquisition of Bulgarian electronics manufacturer ATM Electronics.

In a release announcing the acquisition, Note said it expects that the demand for electronics manufacturing in Europe will continue to develop strongly in the coming years, and the SEK36 million ($3.5 million) purchase of ATM Electronics is meant to meet that growing demand. Note also plans to grow ATM's manufacturing while also increasing its offerings to customers to include complete PCBAs and turn-key products.

"Note continues to develop strongly. We are enthusiastic about this acquisition, which, in addition to adding another profitable plant to the group, also expands our manufacturing capacity in Eastern Europe," said Johannes Lind-Widestam, CEO and president, Note. "We see great value in the fact that we are now expanding the possibilities to offer our existing customers advanced electronics manufacturing in a very cost-effective part of Europe."

ATM Electronics currently has around 80 employees at its manufacturing facility in Sofia and at an assembly facility in Petrich, and its principal owner Sergej Shardin will continue in his role as CEO.

ISC Buys MX Electronics Plant in CA

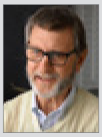
SANTA ANA, CA – Interconnect Solutions Company, a provider of electromechanical and interconnect solutions, announced on Apr. 20 that it has acquired the Santa Ana-based assets of MX Electronics Manufacturing.

In a statement announcing the acquisition, ISC said the addition of MX Electronics' assets adds capacity in many existing business lines, plus capability in printed circuit board assembly (PCBA) to better serve both existing and future customers. ISC is part of Tide Rock's manufacturing portfolio.

"We are thrilled to be able to continue serving customers of MX Electronics just up the road from where they're used to," said Mark Papp, president, Tide Rock YieldCo. "This acquisition is a natural fit for our company. It will add important capabilities to our shop and allow us to provide our customers with even greater value." □

National News

Conferences Task Group. The PCB West 2023 technical conference schedule is available this month at pcbwest.com. This year's conference features more than 125 hours of top-rank training from the leading names in electronics design and manufacturing. Visit pcbwest.com for details.



EMI seminar. Rick Hartley will present a special live two-day workshop on "Control of EMI, Noise and Signal Integrity in High-Speed Circuits and PCBs," coming June 20-21 to the Atlanta suburb of Alpharetta. As Hartley notes, EMI is a leading concern for electronics designers and a major cause of failures. The seminar has been updated to contain a fair amount of new information that was not taught in years past. Each attendee will receive a color PDF copy of the full slide deck. For details, visit pcb2day.com.

When time-varying energy travels in the transmission lines of a printed circuit board, state changing electric and magnetic fields are present. Not properly managed, these fields are the energy source of noise, EMI and signal integrity issues.

"Noise" is "intentional energy" that we fail to control and contain. Uncontrolled energy can generate many forms of interference. Some circuits are noisy, others are not. With the right training, the reasons and solutions are easily understood.

Compounding the issue are today's extremely fast ICs. A circuit with 100ps rise time IC outputs can generate very serious problems, whether clocked at 5MHz, 500MHz or 5GHz.

Knowing proper design of circuits and PCBs to contain E&H fields, as well as knowing how to mitigate the effects of high-speed devices, are the keys to successful design of low noise circuits. This two-day seminar is a crisp focus of the issues PCB designers / engineers must know to prevent EMI, signal integrity, crosstalk, ground bounce and grounding issues in high-speed digital and mixed-signal designs.

Chapter News

Ontario, Canada. We will hold an event in early May with Ata Syed of PFC Flexible Circuits presenting on flex design.

San Diego. We had booth at the Del Mar Electronics Show in San Diego on Apr. 26-27. More than 60 people attended our talks by Mike Konrad of Aqueous Technologies on cleaning no-clean solders and Dave Lackey of American Standard Circuits on flex design and manufacturing.

Seattle. We are looking at getting the Seattle Chapter back up and running. If anyone is interested in assisting with the chapter activities, please contact Tim Mullin at tim_mullin@comcast.net.

PCEA Partners with SCORE.org to Provide Business Mentoring

Mentorship is a key reason why PCEA exists, and to that end we are pleased to announce a new partnership with SCORE.org. What follows is from Phil Marcoux, a member of the PCEA Education Committee and a mentor at the Silicon Valley Chapter of SCORE.

PCEA is more than an international network of engineers, designers, fabricators, assemblers, and anyone related to printed circuit development. It also is a network of businesses employing all those involved in printed circuit development and assembly.

The mission of PCEA is to promote printed circuit engineering as a profession by encouraging and facilitating the exchange of information and the integration of new design concepts through education, certification, communications, seminars, and workshops. PCEA is also striving to help its member companies thrive and succeed.

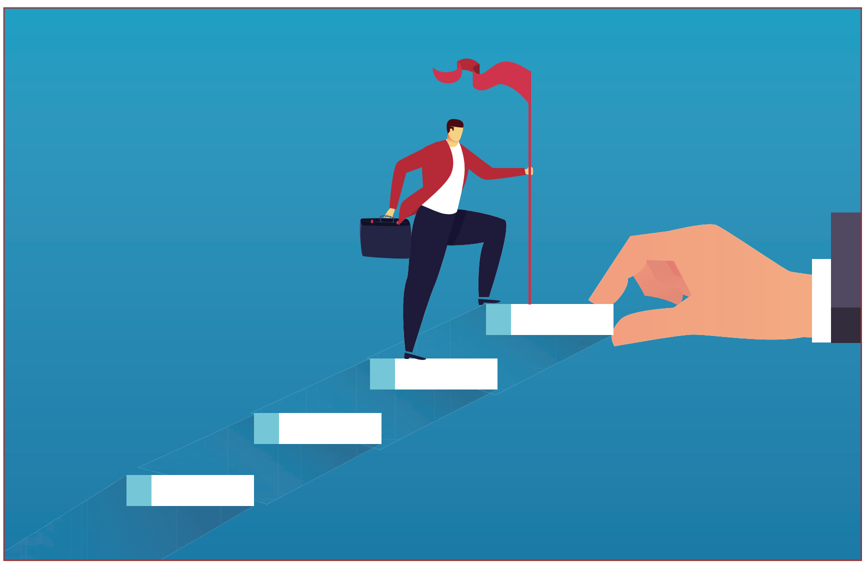
SCORE.org has the mission of fostering vibrant small business communities in the US through mentoring and education. SCORE was created in 1964 and is funded, in part, through a cooperative agreement with the US Small Business Administration. It is committed to help every person succeed in their small business!

SCORE is composed of over 12,000 volunteer mentors organized across more than 200 chapters. SCORE mentors know what it's like to be a small business owner since over 80% were involved in starting businesses. I have been a volunteer with the Silicon Valley chapter for the past four years. In 2022, the SV chapter mentored over 1,000 individuals who wanted help starting their own businesses. As of March 2023, we've already mentored over 600. Each chapter offers very low-cost classes (in-person and online) and free mentoring.

To access these classes and services, interested US PCEA members need only to register on the SCORE.org website. There you can see what classes are available either on-demand or upcoming at one of the chapters. There are numerous free business templates available to organize your ideas.

If you want to get specific help immediately, enter the keywords for the help you're looking for and you'll be presented with a list of available qualified mentors across the US. Once registered as a client, you may request a specific mentor or request recommendations for mentors from a local chapter.

Our community of experienced entrepreneurs, corporate managers, and executives is eager to help, either to start or grow an existing business. ❑



AT THE EDGE

Trends in the US electronics equipment market (shipments only)

	% CHANGE			
	DEC.	JAN.[r]	FEB.[p]	YTD
Computers and electronics products	-0.2	0.1	0.1	4.9
Computers	1.2	8.5	1.6	8.1
Storage devices	-1.8	4.4	-2.4	9.5
Other peripheral equipment	-1.2	2.9	-4.0	100.1
Nondefense communications equipment	-1.9	-0.7	1.7	-4.4
Defense communications equipment	0.9	0.9	0.5	6.1
A/V equipment	-5.2	8.4	-11.4	-14.7
Components[1]	-1.4	1.2	2.1	6.4
Nondefense search and navigation equipment	-0.2	-0.2	-0.1	2.7
Defense search and navigation equipment	1.3	-1.3	0.4	1.2
Electromedical, measurement and control	-1.0	-1.1	0.2	1.6

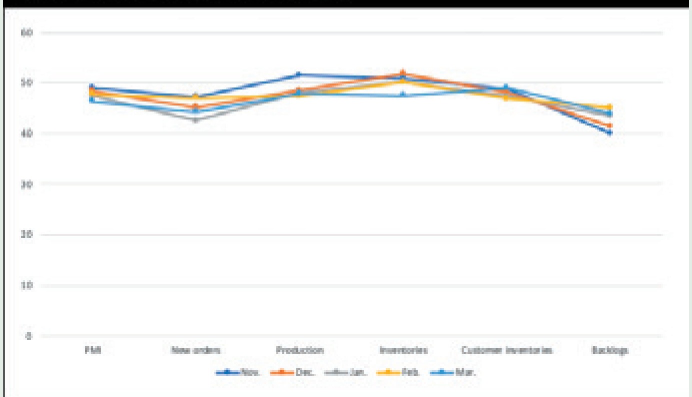
[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: US Department of Commerce Census Bureau, Apr. 4, 2023

KEY COMPONENTS

	OCT.	NOV.	DEC.	JAN.	FEB.
EMS book-to-bill[1,3]	1.30	1.38	1.36	1.36[r]	1.30
Semiconductors[2,3]	0.3%	2.9%	4.4%	-18.5%[r]	-4%[p]
PCB book-to-bill[1,3]	1.29	1.0	0.87	0.94	0.99
Component sales sentiment[4]	75.6	58.1	65.8	82.2	90.6

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

US MANUFACTURING INDICES



Source: Institute for Supply Management, Apr. 3, 2023

Report: PCB Industry in Midst of Down Cycle

COLD SPRING HARBOR, NY – Global PCB sales will fall this year before recovering in 2024, according to new market research from Prismark Partners. Industry sales will be $78.4 billion, down 4.1% from last year, and the average annual compound growth rate will be 3.8% from 2023 to 2027, the firm says.

The firm expects a slowdown this year in each of the major PCB categories: rigid, flex circuits, HDI, and IC substrates. The downturn could be short-lived, however, with demand recovering by later this year.

The data are skewed, says the Taiwan Printed Circuit Board Association (TPCA), due to rapid growth of the substrate segment over the past few years. Lower demand in 2023 will result in a "significant decline" this year for BT and ABF substrates.

The trade group said anecdotal reports indicate some optimism for a positive year after bottoming out in the current quarter, provided demand in the second half recovers to typical levels.

Japanese PCB Output Continues Slide

TOKYO – Japan's PCB production continued to shrink in January and recorded the largest decrease in more than six years, with flexible circuit production falling for the third consecutive month, according to the latest statistics released by the Japan Electronics Packaging Circuits Association.

Japanese output of printed circuit boards in January fell by 11.7% from the same month last year to 80.4 million sq. m., with output decreasing 10.7% to 49 billion yen ($375 million).

The output of rigid PCBs in the country fell 8.3% from the same month last year to 679,000 sq. m. in January, shrinking for the 11th consecutive month; the output value fell 11.4% to 29.3 billion yen ($224 million), decreasing for the fifth consecutive month.

Flexible circuit production fell 17.7% to 89,000 sq. m., shrinking for the first time in five months, while output value shrank for the third straight month, decreasing 8.3% to 2.07 billion yen ($15.8 million).

The output of module substrates dropped 42% to 35,000 sq. m., showing a decline for the eighth consecutive month, with output falling 9.8% to 17.7 billion yen ($135 million), the second decrease in three months.

Hot Takes

- Global **notebook shipments** reached 33.9 million units in the first quarter, down 13% sequentially and 39% year-over-year. (TrendForce)
- **Worldwide IT spending** is projected to total $4.6 trillion in 2023, an increase of 5.5% from 2022. (Gartner)
- Shipments of **traditional PCs** fell 29% year-over-year to 56.9 million. (IDC)
- **Fan-out packaging revenue** was $1.86 billion in 2022, and will grow at a CAGR of 12.5% through 2028, reaching $3.8 billion. (Yole Intelligence)
- The **hardcopy equipment market** fell 8.9% year-over-year in the fourth quarter. (IDC)

The Thrill of the Journey

Remember to sell the excitement of the industry.

AS FINDING AND hiring talent has become so difficult over the past several years, it seems in every conversation I have, especially when younger people are involved, the subject turns to the need for talent in the world of manufacturing. With the baby boomers retiring in record numbers and the millennial generation showing so little knowledge of, or interest in, manufacturing, while appearing to prefer a "gig" type of employment (read: it's just a temporary job), my mantra of talking about the needs of industry for new talent at times seems like a broken record.

Recently a millennial asked me a simple question: "Why do you like manufacturing so much?" The question caught me off guard, for two reasons. First, I assume that everyone knows why I like manufacturing and our industry so much. Second, it's exactly what needs to be asked, but is typically missing from discussions when seeking and finding new talent! We discuss the need to hire, but rarely do we discuss the excitement, opportunity and personal satisfaction that can be had in manufacturing. Here's what makes manufacturing, electronics and our industry such an exciting place to be.

Manufacturing means building a tangible product. I like the satisfaction of being part of a team that is making – building – *something,* something that can be seen, used, and results in a productive object. In retail, you may meet many people, but you did not create anything. In the service sector, you may solve a problem, but not by creating an elegant device. In manufacturing you get to work with people while solving a problem – by building something that can be seen and held!

Technology, and all that goes into building it, is nothing less than exciting. Technology is always changing. More than almost any other industry, electronics catalyzes the latest capability and enables manufactured items to function faster and better than could have been imagined. During my career I have seen technology transform manufacturing. Long gone are the mainframe computers of the early 1970s. Thanks to technology and electronics, those mainframe computers morphed to mini-computers, then to "personal" computers, then to laptops and tablets, then to smartphones. Consider the evolution! All those devices were manufactured, and none would have been possible without the technologies enabled by electronics.

Printed circuit boards – their fabrication and assembly – represent the perfect marriage of process discipline and on-the-fly creativity. Nowhere in the spectrum of electronics or manufacturing is that more evident. Our industry produces the chassis, the backbone of innovation.

Think about all that goes into fabricating a simple (not!) printed circuit board. To produce one requires several mutually exclusive processes that, together, produce an inclusive technological marvel. Manufacturing commences with vastly differing processes including lithography, CNC machining, plating and etching, laminate (the physics of pressing materials together), and the final verification and validation of all those processes to produce a high-quality and relatively economical platform on which additional components are added and the manufacturing process continues.

Equally impressive is all that goes into the assembly of printed circuit boards. The EMS community takes one circuit board and populates it with hundreds, if not more, small, often fragile components with pinpoint precision. And all these components must fit precisely within minimal real estate, processed with a combination of automated equipment with some possible handwork requiring the skill and dexterity of highly proficient people.

The fact is that, throughout manufacturing, especially in our industry, skilled people make the difference. It's exciting to me how two companies with the same machinery and equipment can produce vastly different product, while two companies with completely different machinery and equipment can produce the same product. These are some of the things that excite me most about our industry. The creativity necessary to build product. The discipline to follow proven processes to produce product. The ever-changing technological demands and tools available that require continual mental retooling and constant learning. All these make our industry an exciting one to be in.

Most of all, it's the pride that comes from knowing that you contributed to producing something. Producing a technologically advanced item while utilizing so many varied processes that, together, create imaginative, quality, cost-effective solutions that are in demand by virtually every industry. It's that sizzle we often forget to talk up when discussing our industry, especially when recruiting and interviewing prospective employees. It is the "excitement" and "what if" and "just imagine" we too often forget to communicate to young people looking for a place to earn money and begin their employment journey.

Everyone in our industry is in need of talent: the next-generation employee. Thanks to a simple question, I have retooled my elevator pitch from one of "need" to one of "exciting opportunity." Hopefully I am not alone. □

PETER BIGELOW
is president and CEO of IMI, Inc. (imipcb.com); pbigelow@imipcb.com. His column appears monthly.

There is No Such Thing as a Bad EQ

Proper fab specs can prevent a deluge of engineering questions.

I HAVE BEEN selling bare printed circuit boards for over 30 years to a variety of customers who order a wide selection of PCBs. The most common complaint I hear from board buyers is about the number of engineering questions (EQs) asked whenever a new order is placed, or when a part number is moved from one supplier to another.

"Why can't you build the boards without all these questions?" they ask. "We sent you the working files!"

To many buyers, the inevitable EQs that come along with moving a PCB order to a more cost-effective supplier seem daunting. Sure, the new pricing may be great, but many PCB buyers will delay switching to a new supplier because they don't want to deal with engineering questions from the new fabricator.

I hate EQs just as much as the next sales guy. Who wants to bring up a problem or concern to possibly scare a customer or delay an order over what might seem a minor issue? But it is business malpractice when buyers are knowingly leaving money on the table because they don't have the time or knowledge to properly order PCBs from better suppliers just because of potential EQs.

And sometimes it's not just wasted money; the quality performance of the incumbent vendor is permitted to slide, again because buyers are hesitant about facing those pesky questions from a new vendor.

Purchasing and engineering personnel need training to be able to properly relay all the information required to properly build a PCB.

Some board buyers would rather a PCB vendor make assumptions about an order and not bother the customer with questions about changes or modifications. Could a PCB vendor make a buyer's life easier this way? Sure. But should they?

How much leeway or license should a buyer grant to a vendor to make assumptive changes to the customer-supplied artwork? I understand the delivery clock is ticking and the customer wants the order as soon as possible. But who wants to populate boards with expensive components only to have them fail at the end of the assembly line?

PCB vendors want to build orders correctly. Their questions help protect their interests *and* those of their customers. It's worth it to take the time to answer all questions completely.

Here are some tips for buyers on how to minimize EQs after the order is placed to help speed orders through the manufacturing process:

- Although not all buyers have the expertise to do this, files need to be checked before being sent to fabricators to ensure orders have all required information *and* that they fall within industry (and possibly company) manufacturing standards.
- Many old fabrication drawings need to be updated. Often, companies lack a documented PCB fabrication specification that manufacturers can reference when they receive information that is incomplete or needs clarifying.
- If documentation is lacking, nothing beats an actual sample of the PCB that was built before. Plenty of information can be gleaned just by looking at the actual board. And yes, an emailed photo(s) works wonders too!
- "Print states: Build to IPC Class 2. Is that IPC-A-600 or IPC-6012?" This simple question means a world of difference when it comes to the amount of testing and paperwork required – which means a much higher price. The customer might require all that additional paperwork to confirm the assembly meets its needs. If the proper paperwork isn't with the boards at delivery, the assembled product might be useless. Be sure to answer this question. By the way, "Just build commercial" is not an acceptable answer, as both IPC-600 and IPC-6012 are commercial specifications.
- "Are X-outs allowed?" To save on PCB costs, some assembly operations can accommodate PCBs that are provided in array or panel format with X-outs – nonfunctional boards – while other assemblers cannot or will not accept X-outs. A corporate PCB fabrication specification spelling out customer preferences addresses this issue and saves time.

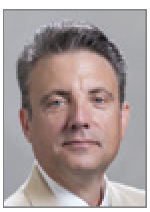
Surprisingly, many companies, including some well-known OEMs and plenty of EMS firms, do not have a corporate PCB fabrication specification that is unique to their operation or assembly needs.

This document can be as concise as a few pages. It should outline everything from acceptable material types to desired metal finishes to final packaging and storage requirements. It should also include panelization instructions.

Corporate fabrication specs should answer most EQs. You might get specific queries about dealing with artwork tolerances, for example, or the need for a stackup variance to permit controlled impedance. Those questions would have to be answered individually.

continued on pg. 36

GREG PAPANDREW has more than 25 years' experience selling PCBs directly for various fabricators and as founder of a leading distributor. He is cofounder of DirectPCB and can be reached at greg@directpcb.com.



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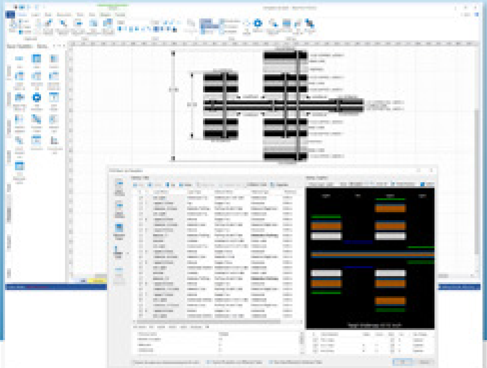
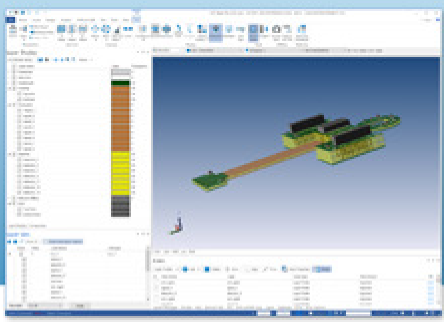
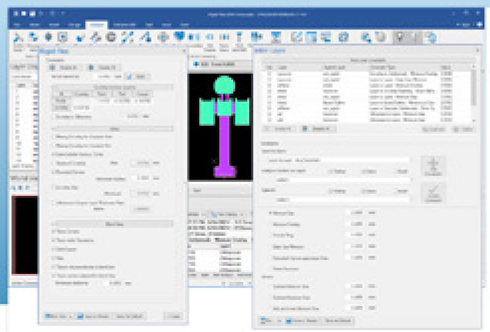
- Manage Variable Stackup Zones for Rigid-Flex Designs
- Easily Create Custom Flex or Rigid-Flex Fabrication and Assembly Documentation
- Use DFM analysis to analyze a flex or rigid-flex design for potential fabrication or bend related defects



Use Stack Up Visualizer and Blueprint's Rigid-Flex Stackup template to easily manage and document rigid-flex stackups.



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



Use Rigid-Flex and Inter-layer DFM analysis to analyze flex and rigid-flex designs.

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PCB Design in a Chip Company: Some Significant Particulars

To land the job you want, it pays to be grounded and groomable.

STARTING A NEW job is a big deal even if you're not leaving your current company. It's a commitment to learn the ropes while being humble and deferring to those in the know. In the field of PCB layout, a lateral move is often as good as moving up if the move expands your skill set in a way that helps your long-term goals.

Long-term goals should be about more than money. What is your dream company? What is the role that would keep you engaged or become a step toward the top rung of your personal career ladder? My niche is in wireless. Once that die was cast, the industry kept pulling me back into its orbit. It is nearly always that the employer initiates the contact for a new opportunity.

GoPro is no exception, with lots of analog work in capturing audio and video from the physical world while streaming geo-located image data over Wi-Fi. Meanwhile, the in-house graphics chip is as complex as anything I've seen on VR/AR headsets, laptops or smartphones.

Like most other handheld products, size, performance and battery life are the competing interests. The company wisely gives us cameras and encourages us to put them through their paces. It gets packed along for my morning walk out by the bay. Then, when something isn't responding as it should, I can raise the issue with the development team.

Google did the same thing with its products but gave us the goods well before they were launched. That could be the main difference between a small company and a mega-corp. It had to help that the marketing department could carry the company on its own with all the R&D you can imagine. The hard part is spending that much money wisely.

The "G-Chips" team sure gave me a lot of IC package footprints for fan-out studies. After enough of them, you get a feel for what type of stack-up it would take based on pin pitch and quantity. A lot of PCB technology is driven by the available devices. Chip companies compete to fill the socket and their top factors are aligned with the OEMs in size, performance and power efficiency.

Setting up your career path by focusing your résumé. Whatever you are doing now should reflect what you want to be doing down the line. After a little self-examination, rewrite your résumé with a focus on what you want to do next rather than including every major accomplishment. Be especially vigilant to minimize anything major you don't really want to keep doing. Whatever you mention has a chance of attracting a recruiter who wants to fill a spot. By saying exactly what you've done, you're asking for more of the same.

People who write job descriptions are throwing out a common list of buzzwords. You can expect high-speed digital or high-frequency analog to be among the requirements. Those technologies will be implemented differently depending on the specific application.

Thick telecom backplanes are a different world to consumer goods, where back-drilling is unlikely. Whatever skill is common to the industry will be on the list. List the things you want to do in hopes of finding an outfit that wants you to do just that. The hiring manager wants the designer to fit the description like a key in a lock. For better or worse, your résumé buzzwords are that key.

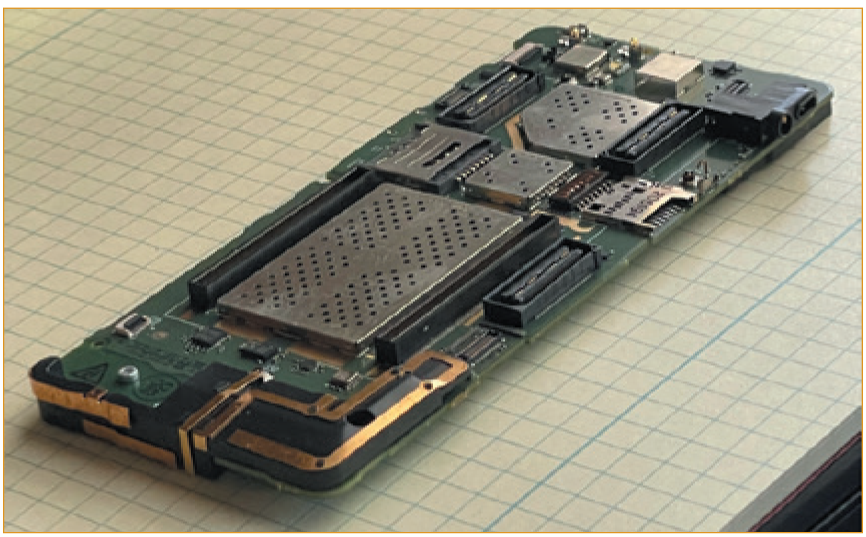
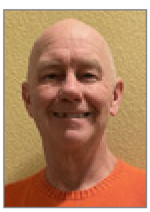


FIGURE 1. Various devices share a board with shielding separating functions to improve coexistence.

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.



Chip companies come in two sizes, tiny and internationally known market leaders in their particular segment. Getting started in a startup is risky. It can take months after tape-out to get the first silicon back from the foundry. The ceramic substrates take about the same lead time. The company's funding isn't going to be enough for a second spin, so the first pass is a moonshot. "Do, or do not. There is no 'try.' "

While the venture might not work out financially, you get to keep everything you learned there. Numerous segments specialize in different core functions. When looking for talent, they place a premium on skills that fit their niche. A generalist PCB designer can walk right into most situations, but the hiring team has to be convinced it is a low-risk choice with at least some crossover between their requirements and your accomplishments.

In a tight labor market, that effort can expand to finding a groomable candidate in an adjacent field. I didn't know anything about 40GB/s optical transponders, but I was well grounded in RF and had worked with lasers in the past, so a startup took a flier on me. I packed up my one-person service bureau and hopped on the dot-com boom.

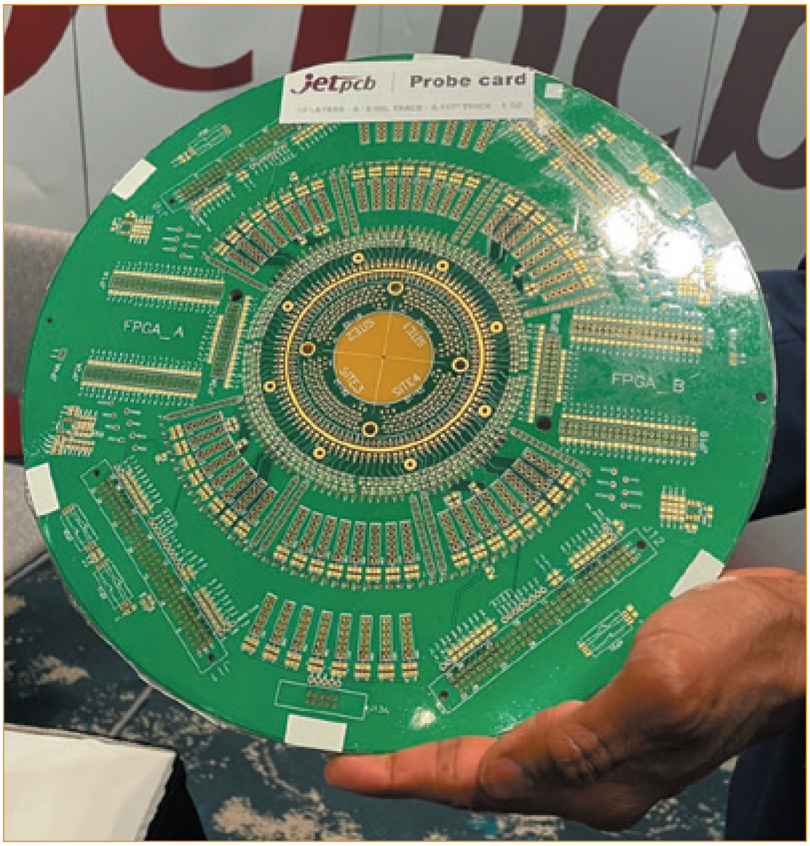


FIGURE 2. Probe cards may be the ultimate fan-out exercise. You better like round boards if you want to be happy working with a chip team.

High-performance substrates: AlN and LTCC. I landed a job in a company with in-house chips and they cut me loose with the IC package design software. It is not hard to learn if you already know the PCB tools. The real learning curve came in the form of the details around the LTCC (low-temperature co-fired ceramic) materials. There was no room for negotiation. Until then, I considered 25.4µm and 25µm to be essentially the same thing.

It all starts with the ceramic in the form of tape in the so-called green state – prior to firing. During the green state, holes are punched into the tape, which are then filled with a metallic paste. Then, the circuit pattern is applied prior to going into the kiln. While being fired in the kiln, the parts shrink by a controlled percentage, about 15% in the z-axis, a bit less in the x and y dimensions.

The via fill material doesn't shrink by that same percentage. For that reason, we limit the number of layers that a via could traverse before sidestepping with a pair of vias on one layer to hand off the signal to continue on its vertical path. The bottom line here is that a complete stack of "microvias" through the entire LTCC stack of, let's say, 21 layers would lead to a defect they call posting. It would not lead to a flat surface, which is useful for a seal ring or a solder joint.

This via-posting avoidance technique is one of many quirks involved with providing a carrier for the silicon. I use the word "silicon" to describe the chip, but other materials will come into play, some of them seriously toxic. A lot goes on that you don't get to see in a chip company unless you put on a "bunny suit" that covers you and your tiny dust particles. I can already tell I wouldn't want a job inside the foundry.

The ebb and flow of a chip provider. Supporting a chip team can be somewhat seasonal where a pulse of work is followed by some downtime. Your life will revolve around the chip tape-out period. Everything that could be anticipated is covered in the initial printed circuit board revision. The team must be able to measure performance so it can be fine-tuned.

The second revision is informed by the reality of the situation. There can be flaws among the nearly uncountable transistor gates on a device. Imagine doing a revision on a board without moving a via or adding or removing one. We can sometimes revise the chip on a shorter lead time if it is just a metal spin done that way at the device level.

Often, there is no easy fix on the die, so our job is to find patches for those bugs and make the device whole before it goes out into the world. We can spin out a PCB quicker than a new chip even if the original punch sequence is reused. This is all-hands-on-deck time. Be a hero. Save the product launch. Save the company in some cases. In any case, look forward to a successful landing. That's what matters in the chip game. ❑

WHO'S EXHIBITING

Accurate Circuit Engineering
AGC Multi Material America, Inc.
All Flex Solutions
Allfavor Technology, Inc.
American Standard Circuits, Inc.
APCT
Archer Circuits
Arlon EMD
Bay Area Circuits, Inc.
Bittele Electronics Inc.
Cadence Design Systems
Cicor Group
Copperdot (Robert Bosch GmbH)
DownStream Technologies, Inc.
DuraTech Industries
EM Solutions Inc.
EMA Design Automation
Fischer Technology, Inc.
Finest Printed Circuit Board Limited
Flexible Circuit Technologies
GS Swiss PCB AG
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IDENTCO
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IPC-2581 Consortium
Ironwood Electronics
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MFS Technology (S) Pte Ltd.
MVINIX Corporation
Notion Systems GmbH
Oak-Mitsui Technologies
Optiprint AG
PCB Technologies – USA
Polar Instruments, Inc.
Printed Circuit Engineering Association (PCEA)
Quantic Ohmega/Quantic Ticer
Rogers Corporation
San-ei Kagaku Co., Ltd.
Screaming Circuits
SEP Co., Ltd.
Shenzhen Danyu Electronics Co. Ltd.
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Sierra Circuits
Siemens
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SVTronics, Inc.
Taiyo America Inc.
Trilogy-Net Inc.
Trylene Inc.
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Ventec International Group
Veritiv Corporation
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Victory Giant Technology
XDry Corporation
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The 5 Pillars of PCB Design Best Practices

Our newest column shares tips and tricks and lessons learned over 30 years in PCB design.

WITH TODAY'S COMPLEX printed circuit board (PCB) designs challenging us at almost every stage of the design process, along with shortened project schedules and shrinking budgets, achieving success is no easy feat. Smaller component packages, faster signal edge rates or rise times, and increased design for manufacturing (DfM) challenges all make it difficult to achieve success and get product to market on time and under budget. The foundation for achieving success is understanding PCB design (the *full* design process) and mastering the power of today's EDA tools.

Even so, design teams can lose valuable time on unproductive tasks. Designers need a collaborative approach to electronic systems design that keeps them connected through all engineering disciplines and gives them best-in-class solutions to handle complexity across the entire PCB design process.

More specifically, we are experiencing heightened complexity in four key areas.

- **Product complexity,** including advanced packaging technologies, transmission speeds, multi-discipline co-design, component count and density, form-factor, and material technologies.
- **Organizational complexity,** including collaboration across engineering disciplines, collaboration across geographies, knowledge management, and workforce productivity and efficiency.
- **Process complexity,** including user-experience, integrated verification, heterogenous tool chains, system engineering, system decomposition and verification, and streamlined design to manufacturing.
- **Supply chain complexity,** including global supply shortages, contractor management and assessment, alternate supply, pricing volatility, risk assessment, and sourcing visibility and knowledge.

If you're a PCB designer, an electrical engineer, or someone else involved with printed circuit engineering looking to optimize the tools and processes you use throughout the full PCB design flow, you will want to follow this column series on PCB design best practices.

Why am I sharing PCB design best practices? My objective is to share with you what I've learned over the past 30 years: tips and tricks and lessons learned regarding printed circuit design. I'll do that by breaking down PCB design best practices into five categories, or what I refer to as the five pillars.

1. **Digitally integrated and optimized:** Under this pillar, I'll cover electromechanical co-design, design and manufacturing, library and data management, work-in-progress data management, and PLM integration.
2. **Engineering productivity and efficiency:** Under this pillar, I'll cover automation (placement, route, and outputs), analog/digital/RF co-design, concurrent design (schematic and layout), design reuse, constraint driven design, and advanced design for both rigid-flex and high-density interconnect (HDI).
3. **Digital-prototype driven verification:** Under this pillar, I'll cover shift-left approaches, specifically regarding the analysis and domain specialists.
4. **System-level model-based engineering:** Under this pillar, I'll cover multi-board design, FPGA/PCB optimization, and IC/package/PCB co-design.
5. **Supply chain resilience:** Under this pillar, I'll cover design for resilience, which really became a major issue to deal with as the pandemic caused significant negative impacts worldwide.

These pillars cover the full spectrum of printed circuit engineering and printed circuit board design,

continued on pg. 36

FIGURE 1. The foundation for success in PCB design involves both understanding the full design process and mastering the CAD tools.

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

Pervasive Virtual Reality, Driven by Gamers, Could Bring Exciting Opportunities for Professionals

Is the next generation of designers honing its skills on Minecraft?

ALAN MORGAN is technology ambassador at Ventec International Group (ventec-group.com); alun.morgan@ventec-europe.com.

IF THERE WERE a record for the longest wait for a technology to take off (longest gestation period for a new technology), then virtual reality must surely be a top candidate for the honor. As long ago as 1990, the movie *Total Recall* gave mainstream audiences a dystopian view of the way life could be. The intervening three decades have cemented the image of the headset-wearing gamer in our minds – totally immersed in the experience yet oblivious to all around. And still it has failed to gain a large-scale following. Until now, perhaps.

With equipment sales currently rising at about 14% per annum according to research by IDC, all the big consumer technology brands are planning major new product launches in the coming months. Growth should accelerate to more than 30% in the next five years.

Of course, it's all about computing performance, power and cost: the computing to deliver lifelike experiences at lifelike speed, within a lightweight, wearable form factor, and at an affordable price. Finally, all three criteria appear to be satisfied and the marketers feel that gamers are now ready to take their passion to the next level.

The gaming market should drive economies-of-scale that will make the technology affordable for commercial-use cases. Previously in this column, I've discussed how augmented reality can assist manufacturing and help enhance productivity and quality, as well as reducing training overhead. Now, the same immersive qualities that make such a great case for gamers is creating exciting opportunities for VR as a design aid.

Manufacturing companies have had 3-D modeling tools for some time now and have used them to drastically shorten the time to market as well as reduce development costs. Although the software renders 3-D images, however, users have been forced to view these images on a two-dimensional screen. It has remained for the designers' minds to connect those images with the finished article and visualize interactions with other parts in the system and with the world around. Assisted by VR, designers can build digital twins of their creations and see them come to life, treating them almost as physical objects. More than ever, designers can inhabit a simulation. It's important to note here another property of the latest VR solutions from leading vendors, which mixes elements of the real world into the experience to help users exist in their virtual worlds for longer periods; it not only fuels gamers' addiction but also helps designers become more productive.

This could save enormous cost and time in the nuclear industry, for example, and effectively allow access to competitively priced low-emission energy. As we all know, the nuclear industry is highly regulated. These regulations include compulsory validation of any new power station design, which can demand multiple expensive iterations. If design changes are found to be necessary, the validation must be repeated. Assisted by VR, designers can inhabit the installation virtually, walk around, and simulate every detail of running the power station. They can even quickly change and optimize the positions of specific buttons on the control panels, and the locations of important amenities, and practice emergency or safety procedures. Thus, every aspect can be properly addressed before committing to the physical validation, including any non-safety-related issues that may in the past have been noticed but deemed too expensive or time-consuming – and unnecessary – to fix.

We can also see this bringing great value to automotive design and maintenance; in particular for electric vehicles. Siemens and Porsche have described how they developed augmented reality software that uses design data from the carmaker's Taycan EV project to assist maintenance at service centers anywhere in the world. There's an important safety angle here for technicians working with today's most powerful EVs. The AR software lets them see the complete power system including charging, battery, and electrical connections within the vehicle. It also shows the high-current paths and displays how the energy is flowing, allowing them to see exactly where they need to take extra care. The electrical energy onboard the vehicle, at a potential of several hundred volts, demands respect and understanding, so it's good to see that all of us involved with this technology – from manufacturers of power semiconductors and high-performance PCB materials to end-product manufacturers and their partners – are making the changes needed to ensure safety and reliability at operating voltages now approaching 1kV.

The widespread availability of immersive VR at consumer prices will also increase the value of remote collaborative working. Many of us are working from home much more these days, although current tools can be somewhat restrictive. With VR in the home, designers can meet *in* a space to interact with objects,

continued on pg. 36

collaborate, and visualize the effects of their design changes quickly.

It's been a long time coming, but the age of pervasive AR/VR could finally be about to dawn. The gaming market will continue to be a powerful force driving the performance gains and economies-of-scale needed for the technology to become ubiquitous and affordable for mass adoption. On the other hand, many of those gamers could be the same people stepping into virtual design studios and collaborative spaces to do their day jobs. They will be completely at home in either environment. ❑

Board Buying, continued from pg. 26

Companies can save a great deal of time and get fewer questions by creating fab specs and then ensuring they are fully understood within the firm and among the vendor's engineering personnel.

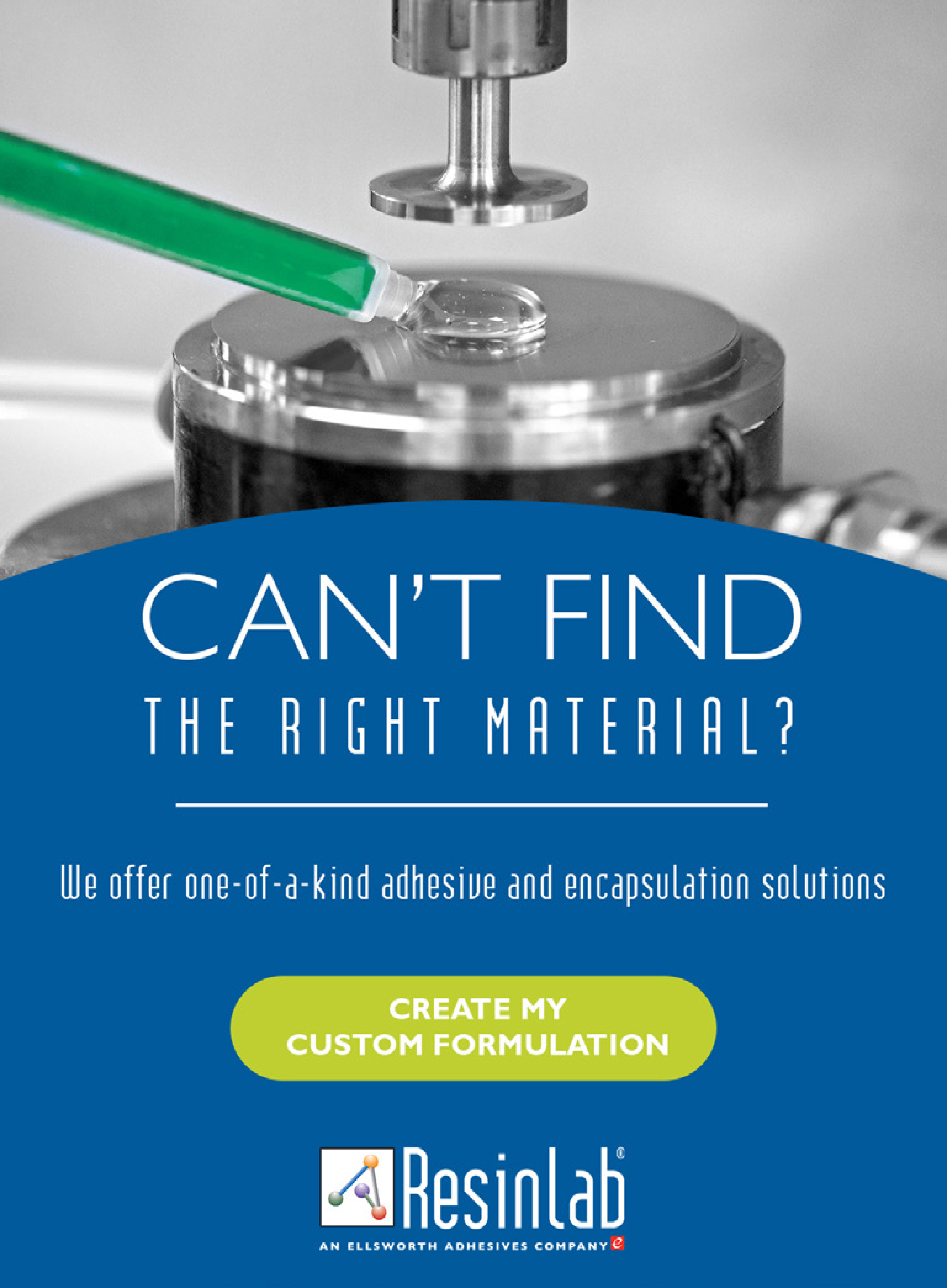
The bottom line is PCB buyers should be thankful for engineering questions. There is a direct correlation between the number of questions asked and the quality of product received, and those questions will save your company money (and many headaches) in the long run. ❑

Design Best Practices, continued from pg. 32

and as I cover each of them in this series month to month, you'll gain a better insight into the approaches to PCB design and the roadblocks and resistance to change from existing processes and methodologies – from how a specific task is best accomplished, to when a specific task or tasks should be completed in the PCB design process. I'll also discuss what tasks in the design cycle can and should be optimized and which tasks you shouldn't skip as you look for ways to reduce engineering design time in getting your product to market, along with reducing project costs. My hope is that you get a better insight and understanding of PCB design best practices, along with gaining some unique insights from what we'll share in these five pillars. Understanding, knowing and implementing industry best practices will enable your success.

Full disclosure: I have used several EDA tools at one point or another, with the most success coming from using the Siemens platform of EDA tools throughout my career. I'm naturally biased. The best practices I'll share can be applied to most design tools, but since I'm now at Siemens, most of the illustrations I use will be with those tools.

Follow along to learn PCB design best practices! We have also created a PCB design best practices video series that you can view on our YouTube playlist. ❑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Reflections from DISCONTINUITIES

Models for predicting the effects of signal-destroying reflections.

by YURIY SHLEPNEV

An ideal digital interconnect is a lossless transmission line with characteristic impedance and phase delay flat over the signal bandwidth and termination resistors equal to the characteristic impedance. In such interconnect, bits generated by a transmitter would flow seamlessly into the receiver with no limits on the bit rate. Such a utopian transmission line exists only in our imagination – and in textbooks. The physics of our world prohibits that. One way to describe "what happens to the signal on the way to a receiver" is to use the balance of power that can be written for the passive interconnect as follows:

P_out = P_in - P_absorbed - P_reflected - P_leaked + P_coupled

This is in frequency domain over the bandwidth of the signal as defined in Shlepnev.[1] P_out is the power delivered to the receiver and P_in is the power delivered by transmitter to the interconnect. All other terms in the balance of power equation describe the signal distortion. The formula above expresses all we need to know about the interconnects (it should be "cast in granite"). As they say, "a formula is worth a thousand words," almost literally in this case. To understand it, just imagine the interconnect system as a multiport with the transmitter at port 1, receiver at port 2 and multiple other ports for links coupled to the link connecting port 1 and 2 and terminations to real impedance (not necessarily identical at all ports). In short, something like **FIGURE 1** together with the definition of waves and scattering parameters (or S-parameters).

The Harringon's concept of "loaded scatterers" allows us to turn any interconnect system (even malfunctioning as an antenna) into a multiport and describe it with the waves and scattering parameters, as in Figure 1. Furthermore, the choice of real Zo for all ports makes those waves the "power waves." Now we can define the powers in the balance of power equation through the multiport waves a and b as follows:

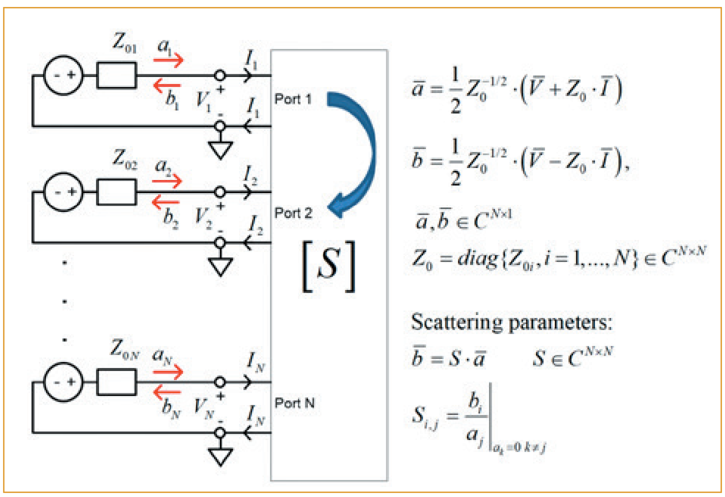

FIGURE 1. Interconnect system as a multiport.

P_in is power delivered into the interconnect by transmitter: P_in = |a1|^2 [Wt], |a1| is magnitude of the incident wave at the transmitter end or port 1;

P_out is power delivered to the receiver: P_out = |b2|^2 [Wt], |b2| is magnitude of the transmitted wave at the receiver end port 2 assuming that |a1| != 0 and no incident waves on the other ports |ak| = 0 for all k != 1;

P_absorbed is power absorbed or dissipated by dielectrics and conductors and possibly by absorbing boundary conditions in interconnect models (more on that below);

P_reflected is power reflected back to the transmitter: P_reflected = |b1|^2 [Wt], |b1| is magnitude of reflected wave at the transmitter end, assuming that no incident waves on the other ports|ak|=0 for all k != 1;

P_leaked is power leaked into the other coupled interconnects, modes and, possibly, into power distribution network (PDN – another type of interconnects) and into free space (radiated): P_leaked = sum(|bk|^2 [Wt], k != 1,2; |bk| are waves transmitted to the ports of the coupled interconnects, |ak| = 0 for all k != 1;

P_coupled is power gained from the other coupled interconnects, modes, PDN and free space: P_coupled = |b1|^2+|b2|^2 [Wt], a1 = 0, a2 = 0, ak != 0 for all other k;

FIGURE 2 is a summary for defining elements in the interconnect balance of power. Let's examine those terms further. First, let's assume that the link is localized somehow – no coupling or P_leaked = P_coupled = 0 (the coupling will be a subject for another article). It is hard to do it for the real life "open waveguiding systems" such as a printed circuit board or packaging interconnects, but is close to reality for properly designed interconnect systems. The remaining balance of power is:

P_out = P_in - P_absorbed - P_reflected

What can we learn from this simple expression? P_out characterizes the transmitted signal and includes signal distortions from absorption or dissipation[2] as well as from all kinds of reflections. This is important to know. If more power is reflected or absorbed, then less power is delivered to the receiver – and that means more signal degradation or distortion. It is a little more complicated with the complex termination impedances. So, let's stay with the real termination impedances; it is not a simplification or approximation because all reactive parts of the termination impedance can be easily embedded into S-parameters – the "black box" can take everything in.

$$P\_in = |a_1|^2,\ a_2 = 0$$

$$P\_out = |b_2|^2\ a_1 \neq 0;\ a_k = 0,\ k \neq 1$$

$$P\_reflected = |b_1|^2\ a_1 \neq 0;\ a_k = 0,\ k \neq 1$$

$$P\_leaked = \sum_{k \neq 1,2} |b_k|^2\ a_1 \neq 0;\ a_k = 0,\ k \neq 1$$

$$P\_coupled = \sum_{k=1,2} |b_k|^2\ a_{1,2} = 0;\ a_k \neq 0,\ k \neq 1,2$$

$$P\_absorbed = |a_1|^2 - \sum_k |b_k|^2\ a_1 \neq 0;\ a_k = 0,\ k \neq 1$$

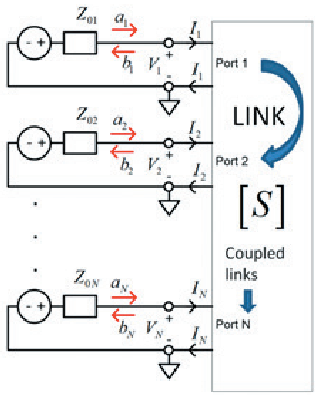

FIGURE 2. Definition of elements in the interconnect balance of power.

P_out can be expressed as insertion loss (IL, a positive number) in dB as:

IL = 10*log(P_in/P_out) [dB]

This is by definition. We can rewrite it with the magnitudes of the multiport waves as:

IL = 10*log(|a1|^2/|b2|^2) = 20*log(|a1|/|b2|) = -20*log(|b2|/|a1|) = -20*log(|S21|)

S21 is the transmission parameter – transmission from port 1 to port 2. The insertion loss is just negative magnitude of the transmission parameter S21 in dB.

P_absorbed characterizes all power losses to heat the materials (the inevitable contribution to the increase of entropy) or dissipated by absorbing boundary conditions in interconnect models. It can be expressed as (no coupling):

P_absorbed = P_in – P_out – P_reflected = |a1|^2 - |b2|^2 - |b1|^2 [Wt]

This is a useful formula in case you want to evaluate the absorbed or leaked (if leaks are modeled with the absorbing boundary conditions for instance).

P_reflected characterizes just the reflections and can be expressed as the return loss (RL, a positive number) in dB as:

RL = 10*log(P_in/P_reflected) [dB]

Again, this is by definition. We can also rewrite it with the magnitudes of the multiport waves as:

RL = 10*log(|a1|^2/|b1|^2) = 20*log(|a1|/|b1|) = -20*log(|b1|/|a1|) -20*log(|S11|)

Here S11 is the reflection parameter – reflection at port 1. The return loss is just the negative magnitude of the reflection parameter S11 in dB.

$$\frac{P\_out}{P\_in} = |S_{2,1}|^2 \Rightarrow IL = 10 \cdot \log\left(\frac{P\_in}{P\_out}\right) = -20 \cdot \log|S_{2,1}|$$

$$\frac{P\_reflected}{P\_in} = |S_{1,1}|^2 \Rightarrow RL = 10 \cdot \log\left(\frac{P\_in}{P\_reflected}\right) = -20 \cdot \log|S_{1,1}|$$

FIGURE 3. Expressions for insertion and reflection loss through power.

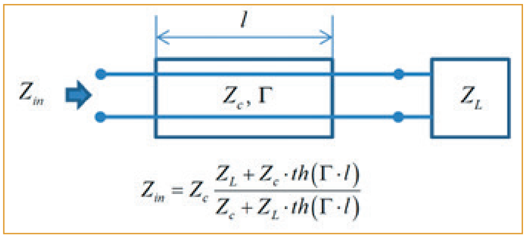

FIGURE 4. Input impedance of a transmission line segment loaded with *ZL* impedance.

FIGURE 3 shows the expressions for insertion and reflection loss through power:

The absorption or dissipation losses in dielectrics and conductors were discussed in Shlepnev.[2] Such losses are inevitable, but can be effectively mitigated at the stackup planning stage – the selection of dielectric and conductor materials and stackup geometry defines the maximal possible communication distance for a particular data rate and power required to transmit the signal.

Considering the reflections, they can be further separated into the following categories:

1. Reflections from mismatch of transmission line impedance and terminations[3]
2. Reflections from single discontinuities – transitions, vias, AC caps, length compensation structures, gaps in reference plane, ...
3. Reflections from periodic discontinuities – fencing vias and cut outs, fiber-weave effect….

Item 1 is discussed in Shlepnev.[3] The most important thing for understanding the reflection from that is the formula for reflection parameter from a segment of transmission line with complex propagation constant (Gamma), characteristic impedance (*Zc*) and length (*l*) terminated with *Zo:*

$$S_{1,1} = \left(Z_c^2 - Z_0^2\right) / \left(Z_c^2 + Z_0^2 + 2 \cdot Z_c \cdot Z_0 \cdot cth(\Gamma \cdot l)\right)$$

The reflection reaches the maximal values at frequencies where the transmission line length is the quarter of wavelength in line (Lambda) or Lambda/4+n*Lambda/2 in line (see definitions in Shlepnev[3]):

$$\max(S_{1,1}) = \left(Z_c^2 - Z_0^2\right) / \left(Z_c^2 + Z_0^2 + 2 \cdot Z_c \cdot Z_0 \cdot th(\alpha \cdot l)\right)$$
$$\max(S_{1,1}) = \left(Z_c^2 - Z_0^2\right) / \left(Z_c^2 + Z_0^2\right),\ if\ \alpha = 0$$

Here alpha is the attenuation constant that increases with the frequency.[2] This is another remarkable formula – the reflections are smaller for lines with more losses (greater alpha) and at higher frequencies.[3] The last part is valid only if there are no discontinuities. It makes everything perfectly clear with the choice of characteristic impedance: the closer Zc to the termination impedance Zo, the lower the reflections. A link with Zc=Zo would be the best link, if it were possible to design and build it like that. What prevent us from doing it are all kinds of transitions. In reality, just some parts of interconnects look like, and can be modeled as, the transmission lines. There are also transitions between the transmission lines: packages, connectors, vias, length compensation structures, AC coupling capacitors, transitions between the transmission lines of different types or with different cross-sections. Accurate analysis of a complete link with the discontinuities usually requires validated software with 3-D electromagnetic analysis capabilities. Before providing examples of such numerical analysis, let's write a couple of practical formulas for qualitative and quantitative analysis of the reflections from the discontinuities. The first formula is for the input impedance of a transmission line segment loaded with *ZL* impedance (**FIGURE 4**).

It can be easily derived starting with the exponential expansion[3] by setting the boundary conditions on the right side. The formula for the impedance can be used recursively starting from the receiver by including discontinuities in a transmission line that have expressions for the impedance – capacitances, inductances or combinations, stubs and so on. All you need to know is how to connect the complex impedances in parallel and in series. As soon as we know the input impedance of the link at the transmitter side, the reflection parameter can be computed as:

$$S_{1,1} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0}$$

Note that this is exactly the value as the reflection coefficient that is usually designated with Gamma.[4] There are no differences in this context. The formula can be also inverted, to compute Zin from the reflection parameter.

Now, let's examine a few cases. First, if *ZL* = *Zc* then *Zin* = *Zc* and the reflection parameter is *S11=(Zc-Zo)/(Zc+Zo)* – this is reflection from the ideally terminated transmission line segment or from the infinite transmission line. It correlates well with the S11 provided earlier for the transmission line segment with the infinite length (cth is the unit in this case). Another limit case is *ZL=infinity* – this is open-circuited segment of transmission line. In this case Zin is particularly simple:

$$Z_{in} = Z_c \cdot cth(\Gamma \cdot l)$$

What can we learn from that in the context of interconnects? It can be used to model and explain the effect of stubs. The first order approximation for a via-hole discontinuity is a transmission line model. If via is going through all stackup layers, but connects only one surface layer with an interior layer for instance, the remaining part of the via is a stub connected in parallel to the link. If stub length is a quarter of wavelength in corresponding equivalent transmission line model, we have input impedance of the stub as follows:

$$Z_{in} = Z_c \cdot th(\alpha \cdot l)$$

It is zero if alpha or attenuation is zero; that means it short-circuits the link. With zero Zin, the reflection is S11 = -1. It does not matter what the other parts of the link look like. Never let it happen at the frequencies close to the Nyquist frequency! So, it is all the transmission line trigonometry – though hyperbolic in this case, literally.

After having some fun with the formulas and the limit cases, let's analyze a couple of ideal discontinuities. The analysis can be done with the formulas as well (a good exercise), but it is much easier to do it with the software – Simbeor in this case. A 0.1pF capacitor connected in parallel into a segment of an ideal 50Ω transmission line (yes, ideal transmission lines exist in the software as well) will have magnitude of reflection (left graph, left axis, red line) and phase of reflection (left graph, right axis, brown line), as shown in **FIGURE 5.**

Time-domain reflectometry (TDR) is also shown on the right plot. It is much easier to recognize the capacitance on

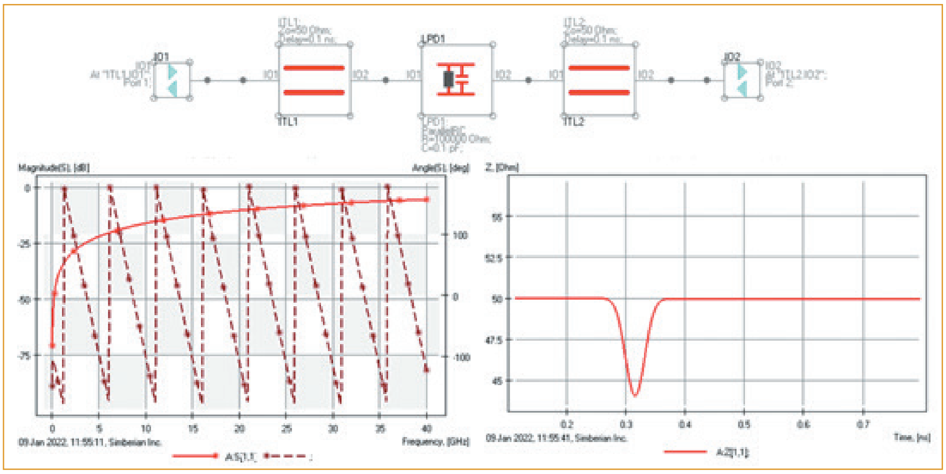

FIGURE 5. A 0.1pF capacitor connected in parallel into segment of ideal 50Ω transmission line showing magnitude of reflection (left graph, left axis, red line) and phase of reflection (left graph, right axis, brown line).

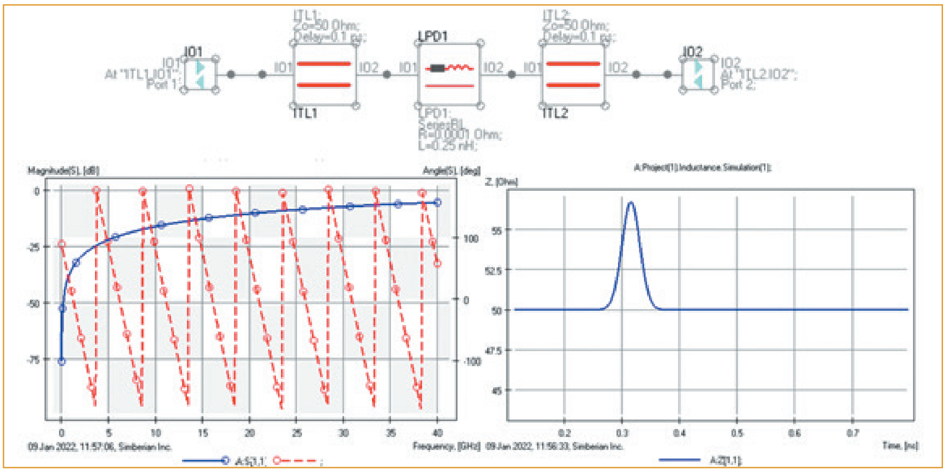

FIGURE 6. 0.25nH inductance connected in series into the same ideal 50Ω transmission line segment.

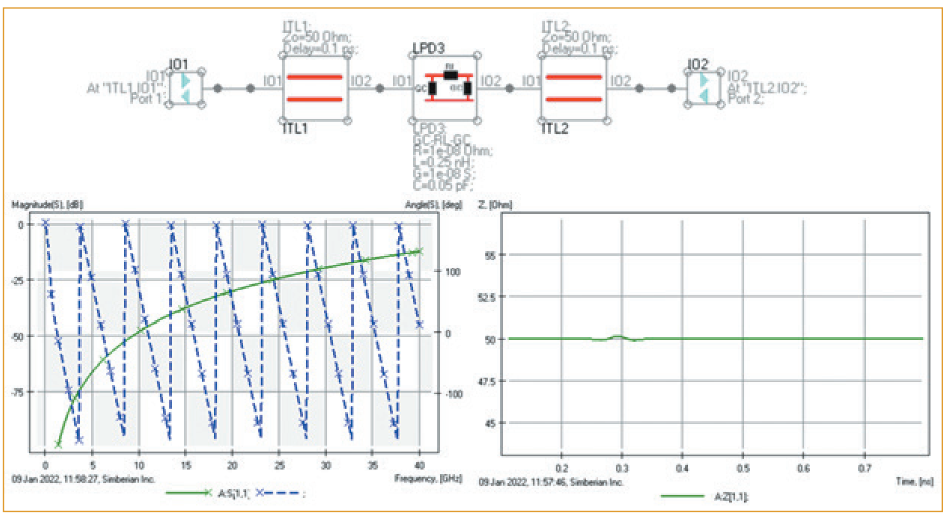

FIGURE 7. 0.1pF capacitance and 0.25nH inductance combined as C/2-L-C/2 circuit.

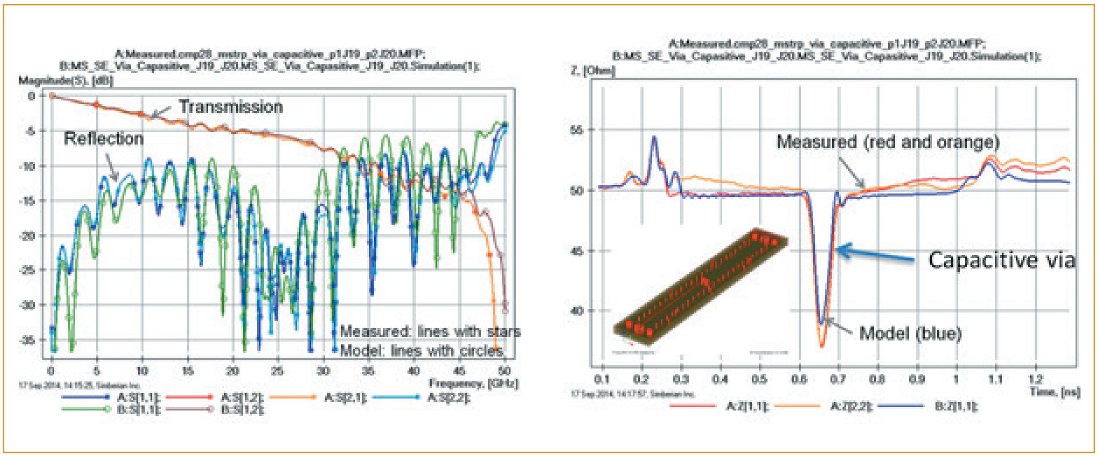

FIGURE 8. Capacitive via from the CMP-28 validation platform.

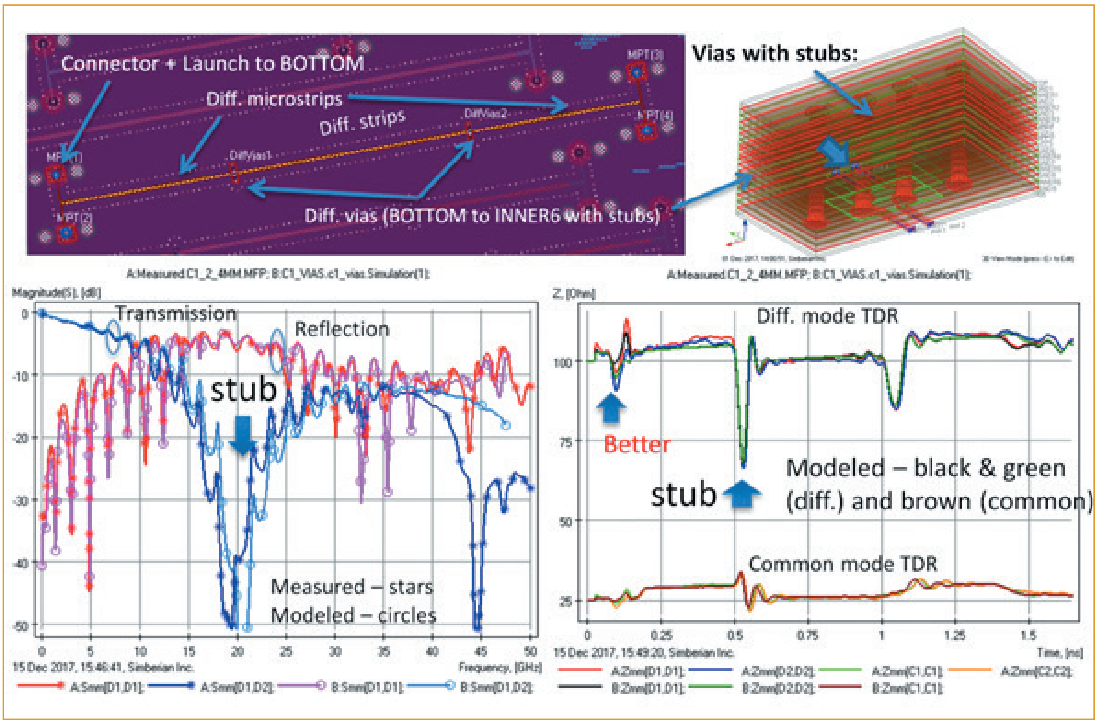

FIGURE 9. Modeled and measured magnitudes of the differential reflection and transmission parameters and differential and common-mode TDRs for a differential link with two vias from BOTTOM to INNTER6 layers with stubs.

the TDR plot as the "capacitive" dip. The TDR is computed here directly from the frequency-domain response with 40ps Gaussian step function.

Next, let's look at 0.25nH inductance connected in series into the same ideal 50Ω transmission line segment shown in FIGURE 6. The frequency-domain reflection magnitude shown in blue on the left graph is exactly as the reflection from the capacitance (the values are intentionally selected to have it like that). However, the phase is different (though it is difficult to conclude something from it) and the TDR shows a clear "inductive" bump.

What if we combine 0.1pF capacitance and 0.25nH inductance as a C/2-L-C/2 circuit? The reflection will go down, as shown in FIGURE 7. That explains how the transmission line works: t-line has both capacitance and inductance with the ratio equal to the characteristic impedance; Zo = sqrt(L/C) = 50Ω, as in this case. The reflections in the frequency domain are small, but not zero. This is because of the model uses lumped L and C in the middle of continuous transmission line segment and it behaves as the t-line only at lower frequencies. A TDR with a 40ps rise time is almost flat, however, and does not resolve such lumped discontinuity in this case.

Finally, we show a few practical examples of the electromagnetic discontinuity analysis with validation as used in our DesignCon 2020 tutorial.[5] The first example is the capacitive via from CMP-28 validation platform designed by Wild River Technology (FIGURE 8).

Modeled and measured magnitudes of the transmission and reflection parameters are shown on the left graph and corresponding TDRs are on the right. The link includes coaxial connectors and launches (inductive bumps at the beginning and end). The reflections in this case are not show-stoppers: the link is short and the added capacitance is not so big. It was intentionally capacitive. (More analysis to measurement correlation examples from the CMP-28 platform are in Shlepnev.[6])

Another two practical examples with the analysis to measurement correlation are from the EvR-1 project[7] (see also app notes #2018_01, 2018_07 and webinar #8 at simberian.com). **FIGURE 9** shows the modeled and measured magnitudes of the differential reflection and transmission parameters and differential and common-mode TDRs for a differential link with two vias from BOTTOM to INNTER6 layers with stubs (structure EvR1-C1).

The via stubs almost short-circuited the link at about 20GHz; the reflection parameter (reddish lines with circles) went up and the transmission parameters (bluish lines with stars) went down around the stub resonance frequency. With the transmission below -30dB, the signal harmonics at those frequencies will not go through. Corresponding differential TDR shows a large capacitive dip at the via location, although it is difficult to conclude from TDR at which frequency the via would destroy the signal. Note that the correlation between the model and measurements is as good as it usually gets; this is because of the "sink or swim" approach used in Marin and Shlepnev.[7]

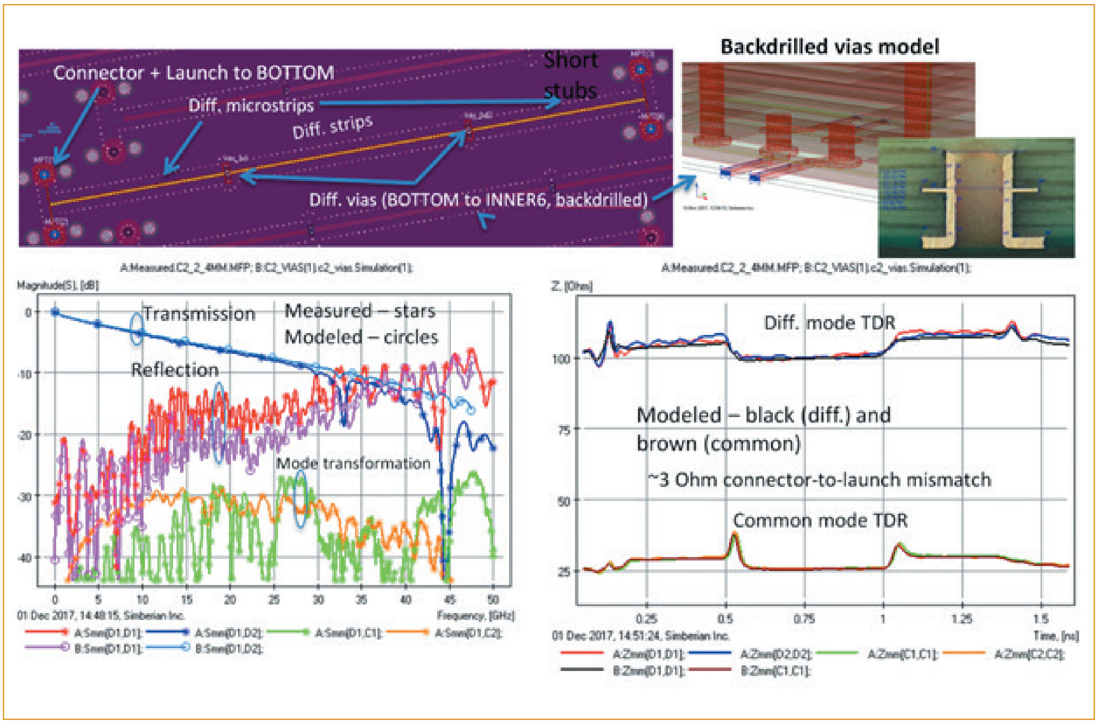

FIGURE 10. EvR1-C2 with back-drilled and optimized vias for the transition between the same layers.

What can be done to avoid such harmful reflections? Via back-drilling and optimization – below is structure EvR1-C2 with the back-drilled and optimized vias for the transition between the same layers (**FIGURE 10**).

The reflection is below -10dB up to 30GHz and no bumps at the location of the vias – the link is as good as it can be for all practical purpose. Note that the correlation of smaller reflections is more difficult to achieve because of the manufacturing variations that were also investigated for this particular board in Marin and Shlepnev.[7]

The bottom line is that reflections – even from a single discontinuity – can destroy your signal, although the effect of major discontinuities can be predicted with validated models before the board design (pre-layout analysis) and must be predicted after the board is designed and before it goes into manufacturing (post-layout analysis). Examples of discontinuity analysis and optimization for typical PCB links with Simbeor electromagnetic signal integrity software are provided in the demo-video section at simberian.com/ScreenCasts.php?view=list. □

REFERENCES

1. Y. Shlepnev, "How Interconnects Work: Bandwidth for Modeling and Measurements," Simberian App Note #2021_09, Nov. 8, 2021.
2. Y. Shlepnev, "How Interconnects Work: Absorption, Dissipation and Dispersion," Simberian App Note #2021_10, Nov. 26, 2021.
3. Y. Shlepnev, "How Interconnects Work: Impedance and Reflections," Simberian App Note #2021_1, Dec. 22, 2021.
4. Wikipedia, Reflection of Signal on Conducting Lines, https://en.wikipedia.org/wiki/Reflections_of_signals_on_conducting_lines.
5. Y. Shlepnev and V. Heyfitch, "Design Insights from Electromagnetic Analysis & Measurements of PCB & Packaging Interconnects Operating at 6- to 112-Gbps & Beyond," DesignCon 2020 Proceedings, January 2020.
6. Y. Shlepnev, "Guide to CMP-28/32 Simbeor Kit," CMP-28 Rev. 4, September 2014.
7. M. Marin and Y. Shlepnev, "40 GHz PCB Interconnect Validation: Expectation vs. Reality," DesignCon 2018 Proceedings, January 2018.

Ed: To review figures showing 1) the interconnect balance of power expressed through S-parameters and 2) insertion loss, return loss, coupling and leaks, see the Appendix in the online or digital version.

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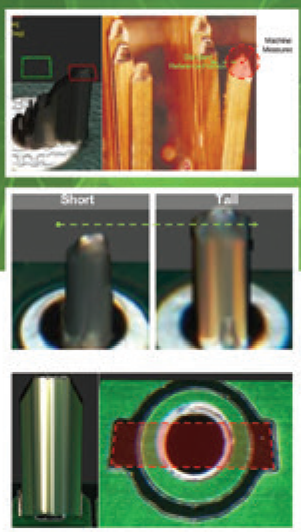
Koh Young Technology

True 3D AOI Technology with AI-powered Algorithms for Through-Hole and SMT inspection



Koh Young is delivering solutions to increase production efficiency with measurement-based inspection for boards with a mix of component types. The Zenith and KY-P3 product offerings provide automated back-end solutions that combine advanced optics and innovative AI-powered vision algorithms for through-hole leads and pins, as well as traditional surface mount components on the same assembly.

Typically, manufacturers required two separate machines for surface mount and through-hole inspection, but the updates to our best-in-class Zenith and KY-P3 machines afford mixed technology capabilities that reduces capital investments by delivering machines capable of both surface mount components and through-hole leads and pins.

The traditional surface mount components and through-hole leads and pins are inspected with our multi-projection Moiré interferometry system. With proprietary, AI-powered algorithms for blow or pin holes, solder volume, bridging, insufficient, excessive, solder balls, and solder fillet, missing or offset pin, pin height, polarity, plus foreign material, the machines are more powerful than ever. When considering pin inspection challenges, the KY-P3 addresses single, array, press-fit, and fork arrangements, as well as pins within a connector shroud, inner and outer wall distances, fork pin separation, and paste height measurement to help manufacturers increase yields.

Incorporating the world's first True3D™ quad-projection probe, the systems deliver shadow-free measurement with low false calls. Additionally, the "Stop-and-Go" probe movement allows it to capture 3D measurement data without system vibration, image stitching, or data interpolation. The machines deliver True3D™ measurement capabilities for automotive electronic control units (ECMs), industrial products, and computer boards, as well as backplane and connector assemblies. Its quantitative True3D™ measurement-based approach delivers best-in-class accuracy and repeatability for electronics manufacturers.

- Algorithms for Blow or Pin Holes, Bridging, Insufficient, Excessive, Volume, Solder Balls, and Solder Fillet, Missing or Offset Pin, Pin Height, Volume, Polarity, plus Foreign Material and Debris
- Suitable for Pin in Paste, wave, and selective
- Dual Side Inspection with Integrated Flipper
- 70mm extended clearance
- Versatile substrate and carrier handling systems
- Automated back-end THT inspection solution

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kohyoungamerica.com

SELECTIVE SOLDERING: A Need for Innovation and Development

Improving nozzle wettability will permit more challenging joints to be tackled.

by SAMUEL J. MCMASTER, ANDREW COBLEY, JOHN E. GRAVES and NIGEL MONK

Selective soldering utilizes a nozzle to apply solder to components on the underside of printed circuit boards (PCBs). This nozzle can be moved to either perform dips (depositing solder to a single component) or draws (applying solder to several components in a single movement). The selective soldering methodology thereby permits the process to be tailored to specific joints and permits multiple nozzle types to be used if required on the circuit board.

Nozzles can vary by size (internal diameter) and shape (making them suitable for different process types). This is all dictated by board design and process requirements. Selection of the nozzle type depends on the product to be soldered and the desired cycle time. Examples of different nozzle types are shown at pillarhouse.co.uk.

Hand-load selective systems must be programmed with the parameters for multiple solder joints. Many inline systems are designed to be modular, however. This modularity permits multiple solder stations with different conditions/nozzles to achieve low cycle times. **FIGURE 1** shows the two distinct types of selective soldering systems offered by Pillarhouse International Ltd.

Selective soldering provides many other benefits compared to wave and hand soldering, such as:

- Minimal thermal shock
- Lower running costs than wave soldering
- Operation under an inert environment to minimize soldering defects, reduce dross production and improve wetting performance (more details below)
- Applicability to low- and high-volume production
- Repeatability in the process and solder joints
- Fewer operators required.

Key attributes of nozzles. To ensure controlled application of the solder is maintained throughout the process, the solder must wet (adhere) to the nozzle. Wettability is the study of the adhesion of liquids to solids because of the interaction between the surface energy of the solid and the surface tension of the liquid. Surface energy (known as surface tension when referring to liquids) is a result of the relative bond strength of the material and the level of unbalanced forces at the surface. Multiple methods exist to characterize surface energy, depending on the components of the surface interaction that can be measured; however, the most common is measuring the contact angle of a stationary (sessile) droplet.

When no other forces act upon a liquid droplet (i.e., no contact with other surfaces and no air resistance due to movement), it will form a sphere as its own surface tension pulls it into that shape, as it is the minimum energy shape it can be. When in contact with a solid, the droplet will deform

FIGURE 1. Examples of different Pillarhouse International selective soldering systems: left, Jade MKII hand-load system; right, Orissa Synchrodex Pro modular inline system.

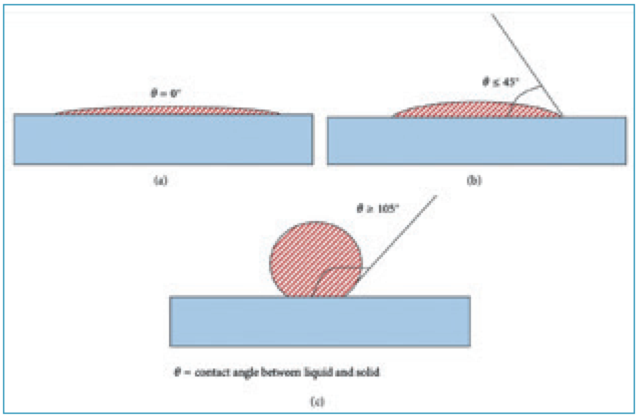

FIGURE 2. Examples of different contact angles between a droplet (stripped red) and solid (blue): a) contact angle of 0° demonstrating perfect wetting; b) contact angle less than 90° for a wetting surface; c) contact angle greater than 90° for a hydrophobic surface.

FIGURE 3. An example of a wetted nozzle.

FIGURE 4. An example of a non-wetting nozzle.

and spread. The amount of spreading and the angle of the interface between the liquid and solid is a product of the relation between the surface tension of the liquid and the surface energy of the solid. FIGURE 2 demonstrates scenarios with various levels of wetting. When the surface energy of the solid is greater than the surface tension of the liquid, the droplet will spread more and have a lower contact angle. Figure 2a and 2b are examples of this.

Typically, a static system would be preferred for wettability studies, but we are dealing with a dynamic process in the case of a nozzle. In this instance, the wetting of the solder to the tip of the nozzle maintains a stable radial wave and achieves control during the soldering process by maintaining a stable dome shape to deposit solder.

FIGURE 3 shows a well-wetted nozzle in which the solder is adhered to the entire outer surface of the nozzle and therefore has a stable radial wave. This permits good control during the selective soldering process. The static wettability for this nozzle would be akin to Figure 2a or 2b.

In the case of a material to which solder does not readily wet (non-wetting), the surface energy of the nozzle (or other material being wetted) is not enough to overcome the surface energy of the solder and therefore the solder will maintain a single stream, as shown in FIGURE 4. The static wettability of this nozzle would produce a large contact angle such as in Figure 2c.

Wetting between the liquid solder and nozzle requires a clean interface with minimal surface oxides on the nozzle. The presence of oxides on the surface interferes with wetting of the solder to the surface by acting as a barrier; additionally, the surface energy of oxides is too low for wetting to occur. Flux is used to remove oxides and generate/maintain this clean interface before and during operation. After cleaning, a chemical reaction between the solder and nozzle determines the extent of the wetting, but this interaction also limits the lifetime of the nozzle. It causes nozzle wear, and metal is leached into the solder bath. Exposure to the solder and the subsequent reaction alone does not cause significant wear. The contribution of liquid flow increases wear in a synergistic effect which suggests that the underlying mechanism is complex corrosion-erosion.

Therefore, a good nozzle must have good wettability to solder, ensuring that control can be maintained during the selective soldering process, in addition to a balance between the corrosion and wetting. The materials composition must be chosen carefully to achieve this. For example, extremely wettable materials such as copper have a high dissolution rate and will therefore be completely leached into the bath within hours, demonstrating the link between the wear process and wetting.

The need for development. Currently, the selective soldering industry sees innovation with the production of new machines, pump types and nozzle cleaning. The study of materials for nozzles has seen only minor development, however. A new nozzle material will reduce operation and maintenance costs for manufacturers by reducing the number of nozzles required overall and reducing downtime caused by nozzle failure. Improving the wettability of nozzles will permit more challenging joints to be tackled using the selective method. The current nozzles have a lifetime of approximately 200 hrs. (smaller nozzles wear faster, however, as they are smaller). This project has been undertaken in response to customer requests to increase nozzle lifetime and reduce maintenance.

Other players in the selective soldering industry have developed new nozzles with similar structures based on commonly applied electroless nickel-immersion gold coatings, but this approach uses materials already known to work in the industry. It is well known that the electronics industry is conservative in many regards and rightly so: "Why fix what isn't broken," especially when reliability is paramount? There has been a distinct lack of research in nozzle development. Each selective soldering manufacturer is highly secretive surrounding the materials used for their nozzles but there has been some noted development in nitriding as a surface engineering technique to extend the lifespan of wave soldering apparatus.

This groundbreaking research project is partly funded by Innovate UK and Pillarhouse International Ltd., in partnership with Coventry University through a knowledge transfer partnership scheme. The aim is to develop a new, longer-lasting nozzle with excellent wetting properties. By applying the studies of tribology and materials science, fundamental work looking at different materials and surface engineering techniques has selected a number of potential candidates that show improved performance.

Prototype testing has been used to confirm compatibility with existing solders and fluxes. The new AP Master Nozzle will be available in June 2023. ❑

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Programming-Free, AI-POWERED Visual Quality Inspection (VQI)

New advances permit defect detection in a fraction of the time.

by SHELDON FERNANDEZ

Despite the prevalence of automated optical inspection (AOI) systems for PCBA manufacturing processes, many organizations still rely on manual inspection for the post-SMT stage of production.

However, three overlapping trends – 1) the industry's well-documented labor shortage that's poised to worsen; 2) the projected 15% year-over-year growth in PCB manufacturing; 3) the migration of sensitive electronics manufacturing work back to North America – are obliging organizations to examine automated solutions for manual aspects of their workflow.

To this end, the latest advances in artificial intelligence (AI) – the "second wave" of AI characterized by machine learning and deep learning technologies – means that manufacturers can finally reap the rewards of reliable and high-performance automated inspection for the post-SMT and final assembly stages of production.

What AI Means for Assembly

Deep learning is a ubiquitous technology that excels at image identification tasks, and the state-of-the-art has enabled the creation of high-performance models that remain computationally efficient. But, at the risk of sounding flippant, so what?

In the book *Prediction Machines*,[1] three eminent economists recast the rise of AI as a drop in the cost of prediction: that is, of taking a set of inputs and producing a highly accurate output.

In the context of electronics manufacturing, one application of this technology is to ingest a set of high-resolution digital images of a PCB/PCBA and to output a prediction as to whether the board meets specific quality criteria.

As you'll see, this permits organizations to augment human eyeballs with cameras and artificial intelligence to realize certain productivity gains.

Moving from concept to reality, artificial intelligence enables the creation of automated visual quality inspection (VQI) systems at the back-end/final-assembly portions of the PCBA process that:

- Can identify defects more accurately than human operators
- Can identify defects in a fraction of the time vs. human operators
- Perform consistently and improve over time
- Can be programmed for new products in minutes
- Contribute to Industry 4.0 initiatives such as digitization.

The primary benefits of the system include higher production throughput, reduced demands for personnel, significant reductions in scrap, and an overall decrease in the cost of poor quality (COPQ).

At the same time, the data captured and generated by VQI systems unlocks second-order benefits, such as digitization and predictive analytics that are of interest to many technology executives.

Today's AI-based systems are versatile enough to handle high-mix PCBs and can be installed practically anywhere in a production line, including the post-SMT stage. Such flexibility permits manufacturers to implement VQIs at multiple inspection points, to improve both overall inspection performance, and to gain comprehensive digital records that extend through the entire PCB production lifecycle.

DarwinAI has developed a new complete, purpose-built solution, called the Automated Mixed-Assembly Inspection (AMI) system, in partnership with leading OEMs and electronics manufacturing services (EMS) companies. Within the PCB production environment, the hardware can be deployed as:

- **Inline** systems (**FIGURE 1**), typically located either at the end of SMT, or pre- or post-solder
- **Standalone** systems ideal for high-mix, low-volume environments where boards are being placed manually, or at repair stations where the system performs inspection once repairs are complete
- **Benchtop** systems, which retain the same performance level as the standalone model, but are designed with mobility in mind and thus have a smaller footprint.

To gather quality images of the board under inspection – the product can handle board sizes up to 24" x 24" – the system's optics incorporate a 20MP colored camera with a global shutter, a 25mm focal lens and polarizers, and a strobing white ring light. The field of view is 5" x 5", and the system can accommodate boards up to 25" x 25" by taking multiple images. The operator interacts with the AMI system via an integrated 19.5" P-CAP Premio touch monitor.

The system also contains all the computing resources (e.g., actuator and strobing controllers, computational capacity) necessary to control the hardware and power the software, which itself includes a few notable components:

- Component detection system: a deep learning model that examines images of PCBs and automatically isolates individual components
- Defect identification system: a deep learning model that examines images of components and identifies an array of defects
- Explainable AI (XAI) module: understands the visual regions and factors that influenced the defect identification system's inspection conclusions; essential to providing transparency and building operator trust
- Inspection UI: a straightforward interface used both to configure the AMI system and to conduct inspections.

Addressing the Data Problem with Generative AI

One key obstacle to applying general vision AI systems to PCBA inspection is the dependence on training data, along with the associated overhead and effort needed to collate the large, labeled datasets that machine learning systems require. Manufacturing contexts are especially challenged by this impediment, as images of component defects are scarce.

In our experience, about half of manufacturers have the data, but it's rarely in a format conducive to building an AI system; whereas the other half lack the hardware imaging capabilities to obtain data of sufficient quality for AI applications. Taken together, these observations suggest that very few manufacturers are equipped to develop an AI-based inspection system in-house or to train a purpose-specific AI system in a timeframe conducive to economic payback.

FIGURE 1. Inline production deployment of a DarwinAI AMI system.

The AMI system eliminates this problem in two key ways.

First, the system is pre-trained on an extensive dataset of labeled PCB images. In practical terms, the system already knows how to interpret PCB images, recognize individual board components, and identify:

- SMT defects: missing component, wrong component, wrong resistor value, wrong polarity, skewed components, tombstoning, bent IC pins, cracks and chips; and
- Through-hole (THT) defects: missing component, wrong polarity.

Second, is a piece of IP our organization developed regarding a technology that's becoming increasingly ubiquitous called generative AI.

As the name suggests, generative AI involves the generation of novel and useful artifacts by an artificial intelligence system. ChatGPT, the renowned tool from OpenAI, utilizes the technology in key ways to generate language that human beings find convincing.

How is this technology used for something as different as PCB analysis? Recall that AI requires data in order to learn.

In our industry, it needs examples of component defects that are valuable to identify in a PCBA context (missing components, bad orientations, tombstones). Given that many manufacturing organizations already run efficient processes, such anomalies – what is sometimes termed "negative data" – can be difficult to obtain.

To this end, our research team was able to exploit the principles of generative AI to produce "synthetic data" for PCBs and defects, which was in turn used to train the AMI system to produce quality results. Moreover, whereas a user cannot necessarily trust the output of ChatGPT, an operator can trust the results of our AMI system by asking it to "explain" how it reached a particular conclusion by way of the aforementioned XAI module.

As a result of these technologies, the only information the AMI system requires to begin operation is a reference image of each model (i.e., a golden board). As such, configuring a new board model for inspection takes less than five minutes – a stark departure from many AOI systems.

5-Minute System Configuration

Configuring the AMI system doesn't require any rules-based or code-based programming. Instead, to create a new board profile, a quality engineer enters the model number and the physical dimensions of the board and places a golden board in the inspection/imaging chamber. From there[2]:

1. The AMI system captures images of the board.
2. The system automatically detects all board components, classifies them accordingly, and presents a map to the quality engineer.
3. The quality engineer reviews the classification (FIGURE 2), overrides any misclassified components, and approves the board profile.

At this point, the model's board profile is complete and the system can be used for production inspections.

Given material and component shortages, a manufacturer will sometimes stipulate that alternative components may be used on a given product (e.g., an alternate resistor).

To this end, an alternate component feature allows for the "union" of multiple golden boards, with the AI detecting automatically if a new component is an acceptable alternative to the reference standard. Such flexibility permits the AMI system to adapt to manufacturing realities including board refinements and component swaps, without incurring downtime or other complications.

The Inspection Process

Inspections are conducted within a human-in-the-loop (HITL) process **(FIGURE 3)** that begins with an operator selecting the appropriate board profile. From there[2]:

1. The PCB to be inspected is passed into the AMI's inspection chamber.
2. The imaging system captures multiple images of the PCB under inspection.
3. The component detection system identifies and extracts images of individual components.
4. Component images are passed through the defect identification system, which classifies components as defective, possibly defective, or non-defective.
5. The inspection UI presents the findings to an operator **(FIGURE 4)**, offering a side-by-side view of the entire board under inspection and the reference golden board; powered by the explainable AI module, the interface visually shows the reason why a particular anomaly was classified as a defect.
6. The operator reviews the findings (and is free to zoom in to examine and compare in detail, as needed), validating the AI's decision or overriding it.

By way of this process, the human operator and the AMI system work together to reach levels of performance effectiveness and efficiency that neither could achieve alone. Each inspection outcome further tunes the defect identification system to higher levels of inspection accuracy, creating a feedback loop that enables the overall AMI system to rapidly catch up to the inspection capabilities of a skilled operator, before surpassing – for the entire life of the production line – the limits of human expertise.

Real-World Outcomes

The novel system is in use today at a number of leading OEMs and EMS organizations, each of which has experienced a quick return on investment. This rapid ROI is primarily attributable to significant improvements in several key areas, including (as a composite average):

- 10% more throughput, attributable to less rework time
- 80% less labor required, due to the high degree of automation
- 50% less scrap, as defects are caught earlier.

Perhaps the strongest validation of the AMI system is that most manufacturers that have piloted the solution have either already expanded their deployment or are planning to do so in the near term, based entirely on first-order benefits.

However, the full benefits extend well beyond improve-

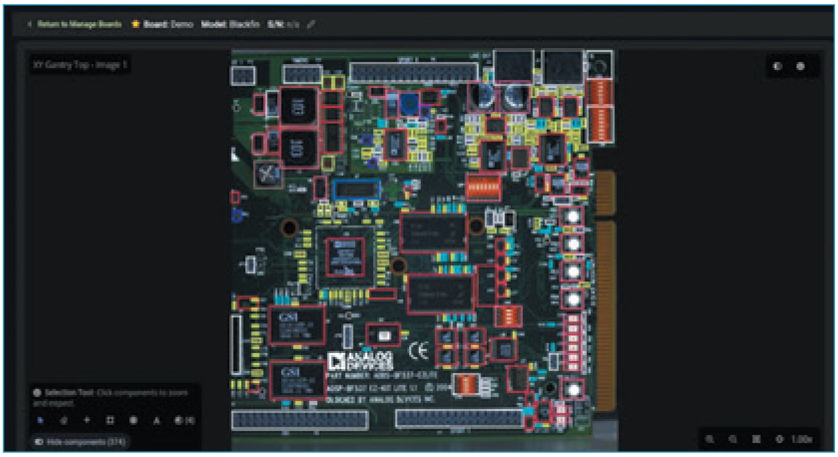

FIGURE 2. During the configuration process, the inspection UI shows the board components to the operator, with different components bounded by different colors; quality engineers can customize the interface to show different colors.

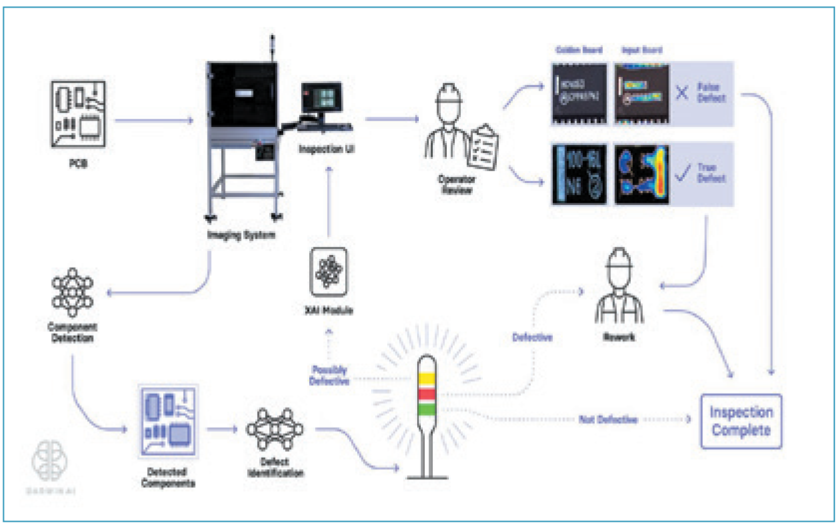

FIGURE 3. The AMI operates within a human-in-the-loop system that permits faster and more accurate defect identification than either operators or AI-only systems.

FIGURE 4. The Inspection UI identifies many component and defect types simultaneously, and clearly presents the findings to the operator, who can approve or override the AI's conclusions.

ments to the testing process, including second-order benefits that become apparent over a longer timescale. Every inspection produces a complete digital record – including images and metadata – the exportation, aggregation and analysis of which better equips manufacturers to:

- Locate and eliminate the root cause of defects
- Maximize line performance and yield
- Uphold quality standards across the supply chain
- Proactively recognize emerging issues (e.g., component drift as a result of minute changes in placement)
- Perform detailed audits.

Finally, our research team is developing new IP with the intent of tackling some of the "harder" problems in the space. For example, we are still in the early days of exploiting our Second Order Explainability technology that we revealed at MIT last year.[3] Process engineers and others interested in learning more about this subject can consult the SolderNet paper we authored in collaboration with the University of Waterloo's Vision and Image Processing Research Group and Moog Aerospace based in Buffalo, NY.[4]

Conclusion

Although the benefits of a reliable, automated inspection system are self-evident, deploying new systems in production environments is often a tall order – and manufacturers that have had poor experiences with other technologies may be hesitant to introduce an AI-powered system out of concern that performance will not match the promises.

From our experience working with leading manufacturers around the globe, we recommend an incremental approach that focuses on initial quick wins, perhaps even limited to a single inspection point on a single production line. Executing pilot programs to address known pain points can demonstrate the economic benefits of a new solution while also building familiarity and trust.

Equipped with data demonstrating clear ROI, quality and process engineers can secure wider organizational buy-in as they look to broaden the solution's applications.

This phased approach also gives an organization time to understand and accommodate any new requirements around data practices before scaling up to automate inspection at multiple points and on multiple lines.

After years of promise – and, yes, a few false starts – AI is transforming production workflows in concrete ways and delivering meaningful ROI. Automated visual quality inspection is proving its ability to not only help PCBA manufacturers mitigate palpable risks in the short term but also its potential to help manufacturers be strongly positioned to leverage transformational technologies in the future. ☐

REFERENCES

1. Ajay Agrawal, Joshua Gans and Avi Goldfarb, *Prediction Machines: The Simple Economics of Artificial Intelligence*, Boston: Harvard Business Review Press, 2018.
2. DarwinAI, AMI demonstration, https://www.youtube.com/watch?v=ge625Vw2Ahs.
3. Sheldon Fernandez, MIT Technology Review EmTech Digital Conference, March 2022, https://www.youtube.com/watch?v=7zditABaGgM.
4. Hayden Gunraj, Paul Guerrier, Sheldon Fernandez and Alexander Wong, "SolderNet: Towards Trustworthy Visual Inspection of Solder Joints in Electronics Manufacturing Using Explainable Artificial Intelligence," arXiv Forum, November 2022, https://arxiv.org/abs/2211.10274.

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VVDN Goes VERTICAL

India's largest ODM is looking to add PCB fabrication to complete its end-to-end mix.

by MIKE BUETOW

VVDN is perhaps best known as a provider of end-to-end engineering and manufacturing of hardware, mechanical and electronics assemblies, and embedded software, among others. Founded in 2007, it now has 11 product engineering centers worldwide, plus seven manufacturing plants across India, where its capabilities include SMT injection molding, tooling, die casting and metal stamping among others.

VVDN builds products for a range of end-markets, including cameras for surveillance and security communications products such as 5G radio units and 4G and 5G antenna; consumer products like wearables and Wi-Fi-based access points; computing products like HPCs and telecom servers, laptops and tablets; and automotive electronics such as automotive vision systems, ADAS, EV chargers, infotainment systems and more.

The company, which says it is India's largest ODM, in February announced plans to invest $100 million over the next five years in a new 100-acre factory in Tamil Nadu. That plant will add PCB fabrication capability, rounding out the firm's vertical integration strategy.

We spoke in late March with cofounder and president of engineering Vivek Bansal on the PCB Chat podcast. The following has been edited for clarity and length.

Mike Buetow: VVDN is probably not well-known to many in our audience, but your backstory is a familiar one. VVDN stands for voice, video, data, and network. You and your partners were Silicon Valley engineers who cofounded your company in 2007. What can you tell us about your original goals?

Vivek Bansal: When we started this company, we were working for different companies. I worked for Hughes and my colleagues were working for companies like Cisco, and back then the whole electronics product development was conducted in a manner where the electronics were done in Taiwan. Taiwan was big at that time, and China was coming up. And all the software development was happening out of India. There was literally no one company that would do the full electronics and software. We thought that was a big opportunity for VVDN and we thought we could be a one-stop solution providing end-to-end capabilities in terms of electronics.

With that idea in mind, we started this company and early on we were able to excite a lot of customers in North America, to engage with us to do both hardware and software. This whole model turned out to be very successful. We started as a design house; for the first few years we were working as a design company and eventually we got into manufacturing.

MB: Even though you started with the software side, the plan all along was to add manufacturing.

VB: That is correct. We always knew that ultimately that's a huge potential for VVDN and, being in India, we really thought that we would stand out and be one of the market leaders if we not just do design but also manufacturing.

MB: As you know, in that time frame, the supply chain was very segmented, with design, manufacturing and assembly and test all spread out among different companies and the vertical integration model that HP, IBM, Digital Equipment and a lot of the Japanese OEMs had developed was really getting taken apart.

What caught my eye was a company announcement in February regarding a new factory in Tamil Nadu. The factory calls for a $100 million, 100-acre manufacturing plant to be built over the next five years. Now, as part of that, you

plan more SMT capacity, correct?

VB: That's right.

MB: And its expansion will include printed circuit fabrication, meaning VVDN will truly become vertically integrated. What prompted that decision to add bare board fabrication?

VB: VVDN has been continuously investing internally to do as much backwards integration as possible. We started literally doing SMT in-house and gradually added mechanical tooling, injection molding, die casting … all of that.

Now the next natural expansion was to do our own printed circuit boards. Today we go outside. A lot of our vendors are in China. What happens is, any time we do a new design, doing a PCB for the first time takes about six weeks or slightly longer. Literally we are waiting just for the boards to come and that's quite a long period. We thought: Why don't we bring in this process internally in the company, as we will shorten our lead times. And looking at the scale that we have, the kind of volumes we are doing right now, we almost buy millions of quantities of these PCBs on a year-on-year basis. And the volumes are increasing. We thought, it's best to bring in that capability internally as it will shorten our lead time and reduce the logistics pain. With all that in mind, we decided to set up internally in the company. The work has just started and in the next 12 months we will have a state-of-the-art facility in Tamil Nadu which will start producing printed circuit boards.

MB: That's a remarkable development, in my opinion. A lead time of six weeks for a company that does so much engineering – and a really high number of designs and NPI work – I could see that being very restrictive to have to wait that long.

India's bare board fabrication infrastructure is still in the early stages. Nearly all laminate equipment and chemicals must be imported. Are you taking any steps to ensure a consistent supply base prior to actually coming online?

VB: All that will definitely happen as we get into this process. We will have to take all the necessary steps to make sure the supply chain and chemicals are available on time. And we will keep enough inventory on our side. Like I said, our volumes are quite significant. To cater to those volumes, we will have to maintain a decent supply chain on our side.

MB: Will you take orders just for bare boards from customers, or will all the fabrication be used as part of your vertical integration strategy?

VB: That's going to happen. The way we run our manufacturing, each of the units has its own P&L. They run as independent operations. While this unit will manufacture for VVDN, it would continue to function as an independent unit to support any other customer, not just in India, but globally. This will do PCB manufacturing for customers across the globe.

FIGURE 1. IoT is a key end-market for VVDN, along with 5G and data centers, cloud computing and apps, networking, and vision systems such as camera sensors and video.

MB: The best data I have suggest that the domestic Indian PCB production is about $350 million per year, of which about 50% is exported. Meanwhile, India imports about $1.2 billion worth of PCBs each year, so that suggests a robust market opportunity in front of you.

VB: That's right. And another thing, at this moment, the kind of PCB fabrication we do in the country is literally lower-end PCBs, up to four layers, some impedance-controlled. It's a slightly lower end on the scale, which is why you see more imports, because all the complex PCBs are coming from outside. This fabrication unit should be able to produce PCBs for data center servers, [those type of] complex boards. It should be able to do a 28- to 30-layer PCB. Also, very complex, dense PCBs with buried vias and all that.

MB: On the basis of the end-products that you buy, I was thinking about the types of boards that would be required and they would absolutely have to be HDI, very high-layer-count boards. You would instantly become one of the most sophisticated bare board fabricators in the country.

VB: That is right. My vision for the scale and level and quality we want to produce would be to cater to the top customers in the world. We really want to set up something that will be top of the line.

MB: VVDN employs more than 10,000 workers, and I've heard you have plans to hire some 25,000 more in the next five years. Is that correct?

VB: That's correct. You know, VVDN is doing phenomenal. Things are going very well for us, and there is this huge business opportunity out there. The kind of products and solutions that we are doing already, quite a few of them are in production today, but many more designs are going on at this moment which will soon get into production, and the scales and volumes are significantly very high. I'm assuming to take care of all those requirements, we will have to hire the number of people that you just mentioned. We will have to do that for sure.

MB: Does that imply that you expect that most of the employees you hire will be on the manufacturing side? Or are you going to staff up on the engineering side as well?

VB: We are going to staff up on the engineering side as well. The way VVDN is, we are an engineering-led manufacturing company. We have deep engineering capabilities combined with manufacturing capabilities. We have almost 5,000 engineers in the company and we are continuously ramping up. We are hiring more people, so absolutely we're going to be investing more and more on the engineering side.

MB: Do you have plans for expansion offshore or will that staffing be more or less dedicated to India.

VB: India, of course, is our current focus at this moment. But we are looking for global expansion. We opened an engineering office in Vietnam. We are staffing our US office with more engineers, solution architects, technology evangelists. We are also exploring a manufacturing facility overseas; it could be in Mexico to begin with, and there could be another in Europe, but those are the long-term, next one to two years plan. We have to do that eventually. Looking at all our customer demands, we will have to be in those places. To answer your question, we are looking to ramp up overseas as well.

TABLE 1. VVDN at a Glance

Engineering	Manufacturing	Services
Ashmedabad	Manesar (6 sites)	Product engineering
Bangalore	Pollachi	PCB design
Bhubaneswar		SMT assembly
Chennai		Box build
Gurugram (2 sites)		Test
Kochi		Injection molding
Manesar		Metal stamping
Noida		Mechanical tooling
Puni		Die casting
Pollachi		Product certification
		PWB fabrication*

*Coming

MB: Some notable Indian electronics manufacturing companies have gone public recently: Dixon Technologies, Syrma and Avalon, among others. VVDN is privately held. Do you have any plans for a public offering?

VB: We do have plans for public offering in the next couple of years. Certainly, we plan to go public. Looking at how VVDN is growing, we want to pass on the benefit to all our employees and our shareholders. We do plan to go public in the next three to four years, depending on the market situation.

MB: The Indian government has placed a concerted emphasis on building up its manufacturing sector. At this time has that translated to improvements in the supply chain, logistics and market access?

VB: Definitely, Mike, there is a huge improvement. The Indian government has come up with something called PLI schemes, which is "production linked incentive," and VVDN is one of the big beneficiaries of those schemes. As a result, it's encouraging a lot of local design and manufacturing. All the chip companies have a deep focus in the country. They are making their chips more available here. There's huge improvement. The government additionally is improving the large stakes, infrastructure imports and exports. With the current government there is huge focus and a lot of action on the ground. We see improvements on a day-to-day basis.

MB: When you think about all your different customers, what does the ideal customer look like to you? What kind of company is the best fit to use VVDN?

VB: This is a little tricky. We are going after quite a different variety of customers at this moment. We work with large customers, in billions of dollars in terms of revenue. We work with a lot of mid-sized companies as well, and we like to work with several startups. We feel proud that a lot of startups have grown with us and today a few of them have billion-dollar valuations. We like to work with all of them.

MB: So despite your relative size and the breadth of capabilities you offer, you feel emerging companies also could find a home inside VVDN?

VB: Yes, absolutely, absolutely. It's almost been 15 years since we started this company. We want to support the world with innovative products coming out of India and, within the country, we want to innovate, create new products, generate a lot of jobs and support the country as much as possible. ❑

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ESD Protection and Packaging/Unpackaging

A DoE reveals the packaging type matters less than the process used.

THE NEED FOR electrostatic discharge (ESD) protection is drilled into production workers from day one in most electronics manufacturing facilities. Most facilities have multiple layers of protection including floor tiles or conductive coating, smocks, individual grounding devices, ESD mats on workstations, and ionizing blowers throughout the production process. There are also multiple layers of protection from conductive totes to metalized bags for product as it ships out. There is a tendency to believe more protection is always better. Given that the seven wastes include both defects and overprocessing, however, from a Lean manufacturing standpoint there is value in analyzing how much protection is required for shipped products. Considering whether multiple layers of protection create a false sense of security with operators involved in pack/unpack operations also has value.

The team at SigmaTron's facility in Chihuahua, Mexico, recently studied what types of packaging and processes provide the most value in terms of ESD protection during the pack/unpack process. The primary goal was to understand if packaging or processing deficiencies were creating defect opportunities in either the packing process at the EMS facility or the unpack process at an OEM's facility, and implement appropriate corrective action. A secondary goal was to utilize the design of experiments (DoE) data to optimize packaging decisions so that products were appropriately protected by the right level of ESD protection.

The team started by designing a packaging DoE to analyze protection provided by cardboard, conductive cardboard and antistatic bags for products during packaging, in transit and unpacking.

Four different products and associated packaging were tested:

- Product A is a printed circuit board assembly (PCBA) in a plastic housing packed in a regular cardboard container
- Product B is a PCBA in a plastic housing inserted in an antistatic bag and then in a regular cardboard container
- Product C is a PCBA packed in black conductive ESD cardboard with dividers
- Product D is a PCBA packed in black conductive ESD cardboard with a tray.

A Model 8154 ESD Field Meter providing readings in kilovolts (KV) and a Megger Model PRS-801 impedance meter providing readings in ohms were used under an ASTM D257 measurement methodology.

Samples were measured under three different conditions in a work area that included an ionized air blower:

- Samples were measured before packaging at the final inspection table under ionized air, using the field meter to confirm existence of electrostatic charges. These measurements were made on two locations on the sample
- Samples were measured again inside the box prior to closing the lids
- Boxes were handled for 10 min. and then the measurements were repeated.

Gage R&R studies were conducted and a measurement systems evaluation (MSE) ranges chart and averages chart were developed to establish statistical process control (SPC) limits.

The results of the tests showed:

- Adding ionizer blowers helped to reduce or eliminate electrostatic charges when opening boxes in all scenarios
- Antistatic bags did not make a difference on the charges measured for Product B
- Black conductive ESD cardboard did not show a significant difference on charge generation for product C
- Handling material in trays through the process maintained close to zero electrostatic charges in Product D
- Use of shielded bags and correct location of ionizers kept charges at zero.

A test of regular cardboard for conductivity found the material to be dissipative. TABLE 1 shows the results.

TABLE 1. Results of the Cardboard Test for Conductivity

Conductive Range:	less than 1 x 10^5
Dissipative Range:	1 x 10^5 to 1 x 10^{11}
Insulative Range:	more than 1 x 10^{11}

The most significant conclusion was that correct positioning of ionizer blowers and the operator's correct use of trays and grounding devices had the most impact on minimizing or eliminating charges. This underscores the need for pack/unpack operators to be well trained in following procedures related to ESD workspace compliance, regardless of the packaging used. Conductive cardboard and antistatic bags did not perform significantly better than

continued on pg. 58

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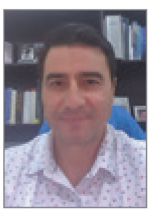

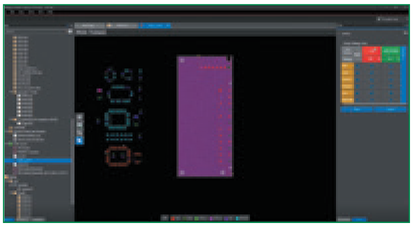

CADENCE ALLEGRO X AI ECAD

Allegro X Artificial Intelligence (AI) design software automates placement, metal pouring and critical net routing, and is integrated with fast SI/PI analysis. Using generative AI capabilities, streamlines system design process, achieving a 10X or more reduction in PCB design turnaround time. Enables feasibility analysis in early phases of design.

Cadence Design Systems
cadence.com/go/allegroxai

KICAD 7.0.1 ECAD

KiCad 7.0.1 fixes various bugs, improves print quality when using custom fonts, fixes CADStar importer memory leaks, handle dielectric sub-layers in STEP export, and more.

KiCad
kicad.org

HIROSE IT14 SERIES CONNECTOR

IT14 Series stackable BGA mezzanine connector is for high-speed and high-density server applications. Features self-mating design to eliminate need for additional mating parts. Supports data transmission rates exceeding 56Gbps NRZ/112Gbps PAM4. Ethernet OAM specified, and utilizes a high-density design (172DPs/in^2). Stubless two-point contact design for reliability, and protective housing encapsulates contact tips to prevent warping during mating.

Hirose Electric
hirose.com

NUMERICAL INNOVATIONS ACE 2D/3D TRANSLATOR V. 8.3.0

ACE 2D/3D Translator version 8.3.0 includes improvements to 3-D Step Export: optimized curves detection to minimize outputted STEP file size; and new options for IPC-2581 export and SVG files. Includes full support for flex and rigid-flex designs by including new layer subtypes, stackup zones and more.

Numerical Innovations
numericalinnovations.com

TIMES MICROWAVE INSTABEND 141

InstaBend 141 high-performance microwave assembly is for inside-the-box and between-box connections in applications including space flight, thermal vacuum, microwave test, and other commercial and military applications. Diameter of 0.163"/4.14mm enables lower loss for applications with stringent requirements in a form that is lighter weight than traditional semi-rigid cables, and small bend radius and flexibility enable low-profile installation, easier routing, and tool-free bending compared to semi-rigid cables, with a maximum frequency of 27GHz.

Times Microwave Systems
timesmicrowave.com

TIMES MICROWAVE XTENDEDFLEX 178 COAXIAL CABLE

XtendedFlex 178 continuous flex coaxial cable is for plastic cable drag chains. Features innovative design and unique material composition, including a stranded silver-plated copper-clad steel center conductor, FEP dielectric, tin-plated copper braid, and a rubber jacket, to deliver optimal bend movement and consistent electrical performance during continuous flexure.

Times Microwave Systems
timesmicrowave.com

VISHAY RCS0805 E3 RESISTOR

RCS0805 e3 anti-surge thick film resistor now includes a higher power rating of 0.5W. Can now be used in place of four standard parallel resistors in 0805 case size; two parallel devices in the larger 1206 case size; or one resistor in the 1210 case size. AEC-Q200 qualified and features resistance range of 1Ω to 10MΩ – and 0Ω jumper – with tolerances of ±0.5%, ±1%, and ±5%, and TCR of ±100ppm/K and ±200ppm/K.

Vishay
vishay.com

AEGIS FACTORYLOGIX MES

FactoryLogix 2023.1 and 2023.2 releases deliver enhancements across the entire platform. PLC Gateway simplifies and enables real-time connection and data transformation into standards-based IIoT between PLC equipment and any software system. Upgraded composable UI designer enables customers to craft a unique interface per operator station using a vast library of ready-to-use applets. Integrates with Arena PLM. Enhanced Limit Rework Attempts capability eliminates costly rework and repair actions by limiting rework events by inspection code and reference location.

Aegis Software
aiscorp.com

ARCH SYSTEMS ACTION MANAGER

Arch FX Action Manager automates responses to alerts using real-time data and built-in industry knowledge. Combines direct-to-machine connectors, globally scalable data brokers, cloud-based analytics, and action monitoring capabilities for an end-to-end solution that improves speed from project conception to analytics-driven actions.

Arch Systems
archsys.io

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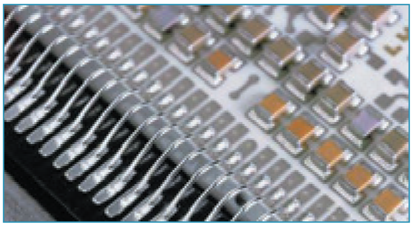


temperatures. Features room temperature stability for six months, is composed of high temperature thermoplastic instead of thermoset – making it more tolerant to thermal cycling and offering enhanced flexibility, plus has no need for ice packs/dry ice. Bend test capability of up to 10mm with minimal electrical property change.

Heraeus Electronics
heraeus-electronics.com

INOVAXE LS350 SMART RACK

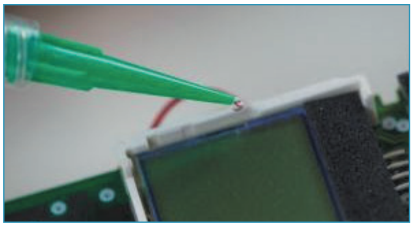
LS350 smart rack features four rows of 7" reel storage for a maximum capacity of 192, 7", 8mm reels in less than 1.6 sq. ft. of floor space. Includes integrated display running the standard InoAuto software, with additional features optimized for lineside usage, as well as an integrated 1D/2D barcode scanner. Operates as standalone storage, or as part of a complete system. Interfaces directly with pick-and-place machines and MES systems to automate production operations.

Inovaxe
inovaxe.com

MACDERMID ALPHA ARGOMAX 2148 PASTE

Argomax 2148 paste is for sintering large packages or components on gold or silver substrates. Is said to exhibit bond line thickness and adhesion utilizing a pure silver bond line, and provides superior performance and reliability for inverters in extreme temperature swings. Is suitable for a variety of applications and provides high thermal and electrical conductivity, and low sintering pressure required also permits use on components where pressure is critical. Dispensable.

MacDermid Alpha Electronics Solutions
macdermidalpha.com



MASTER BOND LED415DC90 ADHESIVE

LED415DC90 one-component adhesive cures rapidly without oxygen inhibition under exposure to a 405nm wavelength LED light source. Adheres well to similar and dissimilar substrates. Thixotropic index of 5.53 at room temperature, and a tensile strength of 5,500-6,500psi, tensile modulus of 450,000-550,000psi, and lap shear strength for aluminum to aluminum of more than 1,000psi.

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Shenmao America
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TOMPKINS ROBOTICS PICKPAL ROBOT SERIES

PickPal product series is a line of pick assist autonomous mobile robots. Standard PickPal model can carry 60kg of orders; PickPal+ handles up to 100kg of orders. Easy to implement and low operating cost.

Tompkins Robotics
tompkinsrobotics.com

VITROX TR1000S+I VISION HANDLER

TR1000S+i is for 360° inspection of BGA, QFP, QFN, CSP, TSSOP, MSOP, and SOP packages handled in tray-to-tape inspections. Features improved PP3 design with an added nozzle, and inspection speed is greatly improved to translate to an average UPH increase of 24%. Includes a built-in detaping module that reduces conversion time with movable linear guide.

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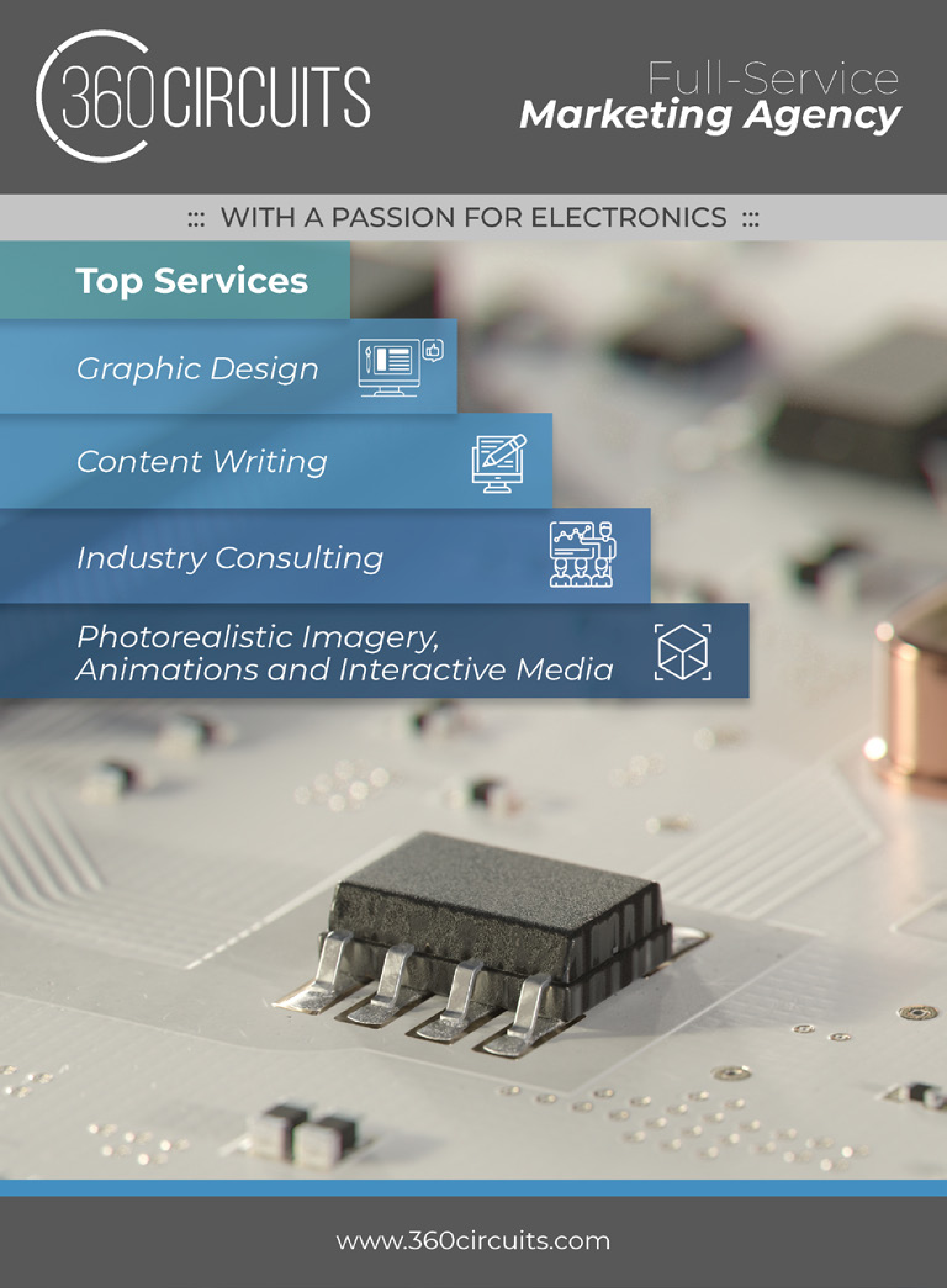

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In Case You Missed It

Electrochemical Migration

"Effects of Concentration of Adipic Acid on the Electrochemical Migration of Tin for Printed Circuit Board Assembly"

Author: Yi Sing Goh, *et al.*

Abstract: The continuous advancement in innovative electronic applications leads to closer interconnection spacing and higher electric field density, thus increasing the risk of electrochemical migration (ECM)-related failures. The ECM of tin (Sn) attracts great interest due to the wide use of Sn on the surface of the printed circuit board assembly. In this work, the authors investigated the effects of adipic acid (1ppm – saturated concentration) on the ECM of Sn using the water drop test (WDT) at 5V. In situ observation and ex situ characterization of ECM products were carried out using optical and electrochemical techniques. Results show that the electrochemical migration failure probability is higher at intermediate adipic acid concentrations (10ppm, 100ppm and 1000ppm). The major ECM reactions include anodic corrosion and the formation of dendrites, precipitates and gas bubbles. ECM failure does not occur at higher adipic acid concentrations (≥5000ppm), although the anodic corrosion becomes more severe. The complexation of Sn with adipic acid to form Sn adipate complex is suggested as the main factor suppressing ECM failure at higher concentrations (≥5000ppm) by retarding ion transport. The electrochemical parameters (Ecorr and Icorr) do not correlate with ECM failure probability. They affect the anodic dissolution stage, but not the subsequent stages in the ECM mechanism. In this study, the ion transport stage plays a more significant role in determining the ECM failure probability. (*Journal of Electronic Materials,* January 2023; https://link.springer.com/article/10.1007/s11664-022-10155-2)

MBSE

"Adoption of Model-Based Systems Engineering in Traditional DoD Systems"

Authors: Capt. Patrick Assef, USAF, and Lt. Col. Jeremy Geiger, USAF

Abstract: The transition to digital engineering has become a major objective within the US Department of Defense (DoD). One such method is model-based systems engineering (MBSE), or the use of models to facilitate systems engineering. Most new US DoD programs are being built from the ground up using MBSE. The question of whether MBSE should be incorporated into existing systems lingers, however. Little research currently exists on the efforts required to transition existing systems to MBSE. In this article, the authors measure the effort required to transition an existing system of systems (SoS), which primarily relied on document-centric methods, to MBSE. Time efforts were measured to develop the model for the SoS, as well as the subsystems and components it contains. Additionally, existing MBSE resources that are part of the cost of transitioning to MBSE were also compiled. The research is intended to serve as a guide for program managers throughout the DoD to roughly estimate the time and costs they will incur to transition their programs to MBSE. (*Defense Acquisition Journal,* March 2023; https://doi.org/10.22594/dau.22-892.30.01)

RF Design

"How to Select the Best Power Solution for RF Signal Chain Phase Noise Performance"

Authors: Mitchell Sternberg, Erkan Acar, David Ng and Sydney Wells

Abstract: Today's radio frequency (RF) systems are becoming more complex. This added complexity requires the best performance across all system metrics such as stringent link and noise budgets. Ensuring the proper design of the entire RF signal chain is critical. An often-overlooked section of this signal chain is DC power. It plays an important role in the system, but it can also introduce unwanted effects. One important measurement for RF systems is phase noise, a metric that can be degraded depending upon the choice of power solution. This paper investigates the effect that power designs have on the phase noise of RF amplifiers. According to the authors' data, selecting the right power modules is essential for improving the performance of the RF signal chain and can reduce phase noise by up to 10dB. (*TechOnline,* March 2023; www.techonline.com/tech-papers/how-to-select-best-power-solution-for-phase-noise)

Solder Joint Evaluation

"Development of Solder Joint Void Metrology to Monitor Solder Joint Quality in Printed Circuit Board Assemblies"

Authors: Thaer Alghoul, Ph.D., Pubudu Goonetilleke and Chris Alvarez

Abstract: Solder joint reliability is determined by multiple factors, one of which is voiding. The formation of voids in solder joints is caused by entrapped air during the reflow process and could be challenging to eliminate entirely. When voiding exceeds a certain level, it may lead to joint failure and is therefore important to quantify. X-ray inspection is a nondestructive method that can be used to measure voiding, but currently available x-ray equipment has limitations. Automated x-ray inspection tools (AXI)

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

Getting Lean, continued from pg. 58

regular cardboard.

Based on the study's data, the OEM determined that the packaging choices made for specific products provided acceptable levels of protection and that more focus needed to be placed on positioning of ionizing blowers in the unpacking operation.

While the study is not being used to suggest that OEMs eliminate the levels of packaging they have specified for their products, it is being used to provide OEMs considering a packaging change with an assessment of the effectiveness of different types of packaging under controlled conditions. Given that different classes of components have different levels of sensitivity to ESD, all packaging options should be considered. That said, this study enables OEMs to do a more detailed cost/benefit analysis when considering which levels of protection make best sense for their products. ❑

are fast but lack accuracy, whereas 2-D x-ray tools are accurate but slow and cannot be used in a production environment. The authors show a new method they developed using deep learning (DL) to improve the speed of void measurement with a 2-D x-ray tool while still maintaining accuracy. The DL method is a two-phase approach. The initial phase involves detection of solder ball area and then segmentation to detect the boundaries of the solder ball. The second phase involves segmentation to detect voids. The authors have achieved 99.9% solder ball detection and area segmentation, and 99.5% void segmentation. The capability of the deep learning method used is then determined using measurement capability analysis. (SMTA International 2022, https://smta.org/global_engine/download.aspx?fileid=8AC9B66B-BA7E-4730-9500-2AEFC52E470B&ext=pdf)