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# PRINTED CIRCUIT DESIGN & FAB

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May 2021

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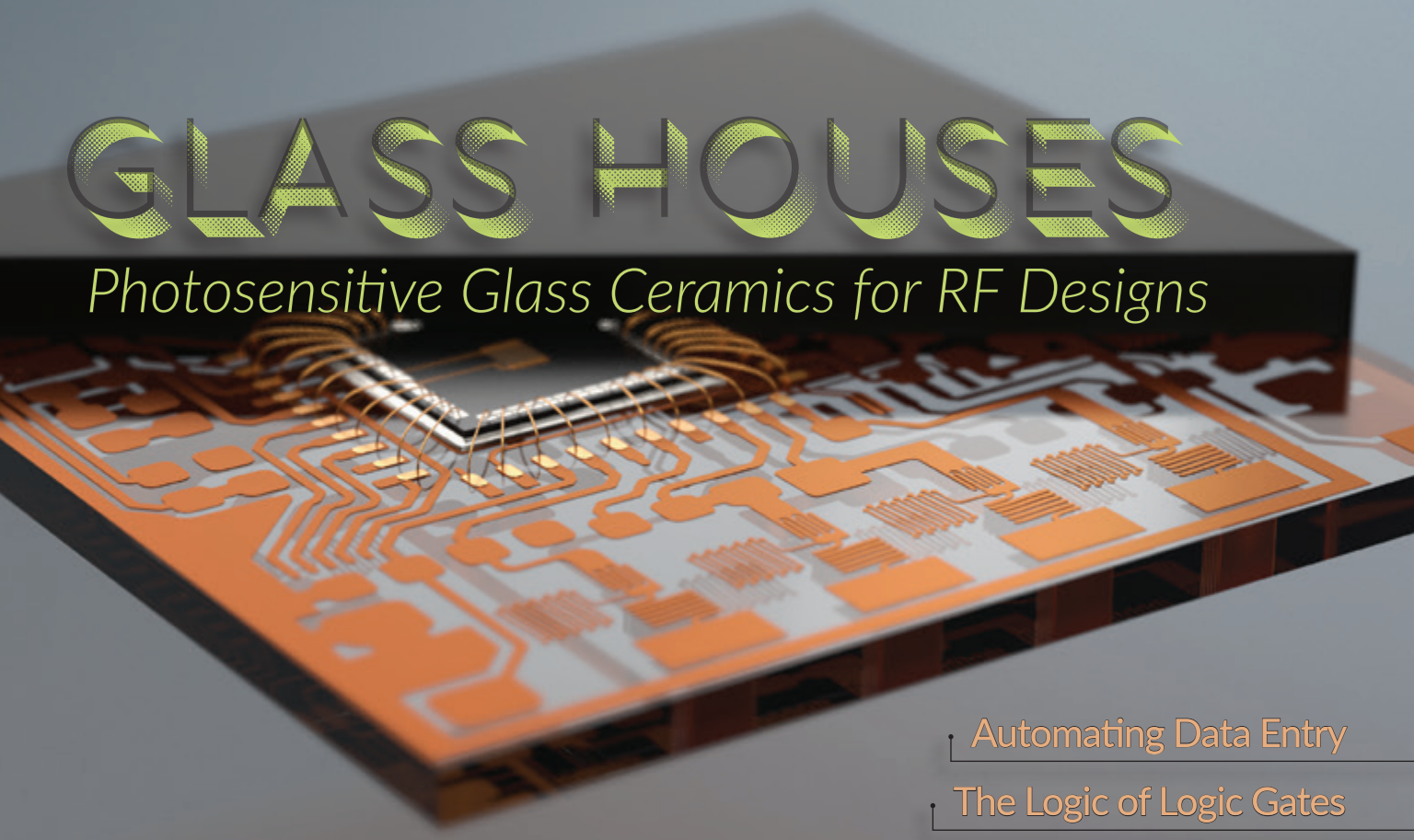
*Photosensitive Glass Ceramics for RF Designs*



- Automating Data Entry
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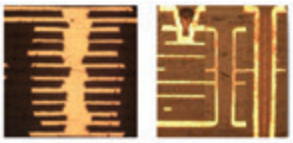
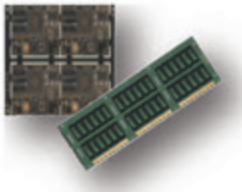
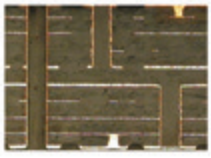
/ SSD Module

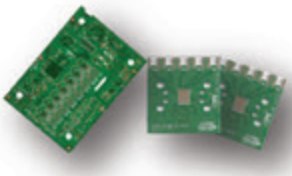


IOT / Build-up Board





Semiconductor TEST B'd
& 5G Network System



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# PRINTED CIRCUIT DESIGN & FAB CIRCUITS ASSEMBLY

## FIRST PERSON



## MONEY MATTERS



## TECH TALK



## DEPARTMENTS



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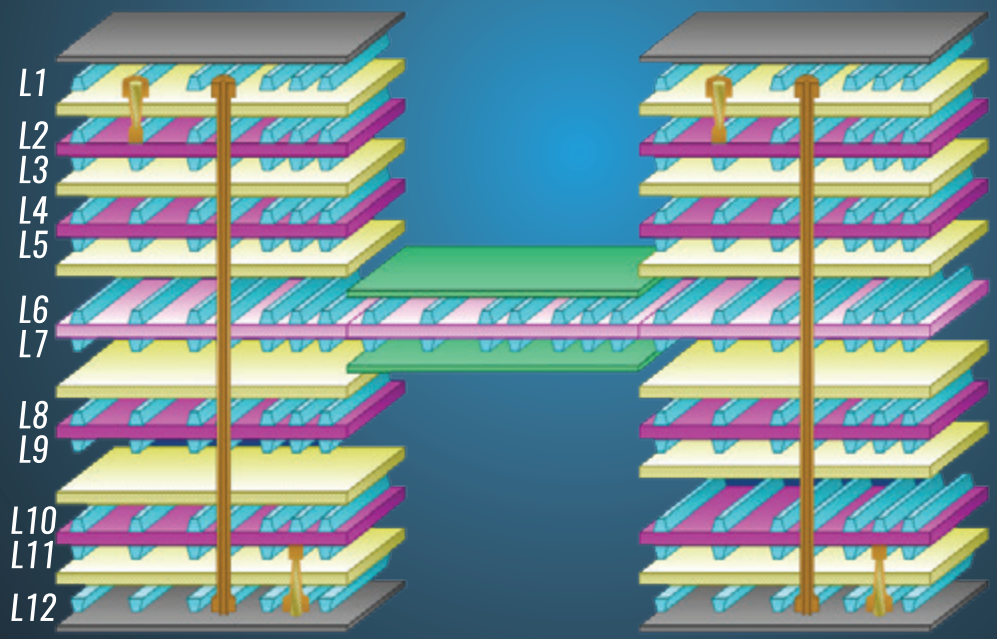


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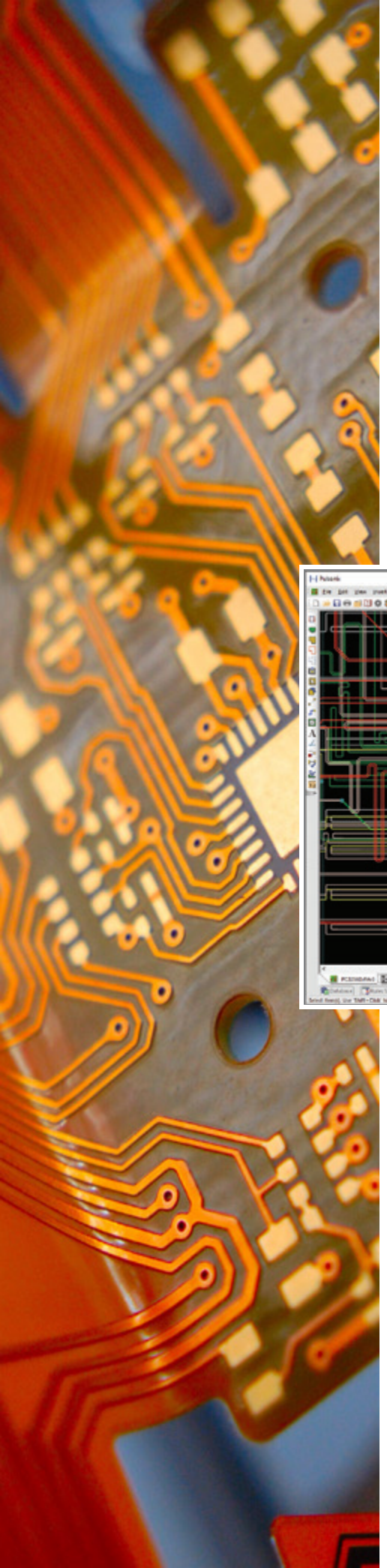

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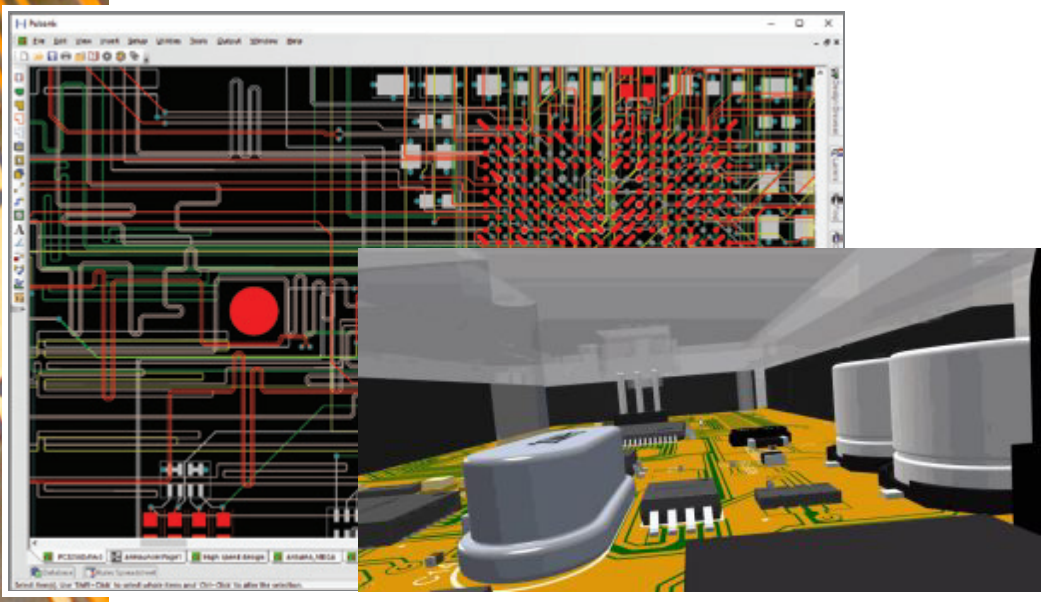

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MIKE BUETOW
**EDITOR-IN-CHIEF**

# Branding Citizenship

CONSUMER PRESSURE ON corporate behavior is cyclical and typically short-lived. Consider "dieselgate." Volkswagen for years rigged the emissions testing on certain vehicles to appear to meet state and national standards. Confronted with the discrepancies, VW management lied in what would be a futile attempt to cover up its wrongdoings. The transgressions cost the carmaker more than $30 billion in fines and penalties. At the time, it looked like a major hit to the company's reputation.

We are in an era where focused consumer pressure has the potential for immediate worldwide impact. Primed by social media, buyers have never held so much broad sway. Will this this newfound power to drive electronics industry decision-making?

The nongovernmental organization China Labor Watch routinely pummels Chinese-based manufacturers for mistreatment of workers and labor law violations. The leading media companies in the world pick up its investigations. Yet its efficacy in changing corporate behavior is murky.

As democracies and pseudo-democracies capitulate in places like India and Thailand, there will be pressure on multinationals to steer clear, lest they be seen as supportive of pariah regimes. But even if China's 20-year dominance over the electronics supply chain wanes, the next home for the industry will likely be equally complex. Thailand routinely jails citizens, including minors, for speaking out. Defaming the monarchy is punishable by up to 15 years in prison *per incident*. Under prime minister Narendra Modi, India's crackdowns on speech and the criminal justice system, not to mention minorities, is drawing increasingly vocal criticism in many foreign policy quarters.

Yet the odds this will stop factory migration are minimal, at best. The rush for new revenue is too important, and the consequences, if any, easily mitigated.

One thing many electronics multinationals have in common is membership in an official-sounding organization called the Responsible Business Alliance (RBA). Formerly the Electronics Industry Citizenship Coalition (EICC), RBA is a group of companies that "share a commitment to ensure working conditions in the electronics supply chain are safe, that workers are treated with respect and dignity, and that business operations are environmentally responsible."

Fancy words aside, the RBA is a crock. The companies that make up its membership include Apple, Amazon, Foxconn, Pegatron, Wistron and other OEMs and ODMs that are routinely singled out by NGOs in social media and the mainstream media for disregarding worker health and local labor laws. In my view, the RBA is used as a shield: listen to what we say; don't look at what we do.

I can't argue with the decision to locate factories where the labor is skilled and generally cheap. But, while I can't rationalize how any company with lofty corporate citizenship goals aligns itself with nations that routinely practice state-sponsored oppression, I fully recognize there's no stopping those decisions.

The heads of our industry are smart, analytical people. I have no doubt they are studying the impact of their decisions on their brand, much in the way US companies have contemplated, then stuck with China, despite sanctions intended to get them to reconsider.

And who can argue? At the time of dieselgate, VW was the world's second-largest automaker. Five years later, it was number one.

Foxconn's biggest threat. Next month we will roll out this year's CIRCUITS ASSEMBLY Top 50 list of the largest EMS companies. Expect few surprises. Instead, the real mystery is guessing how big Foxconn can get.

The answer, according to Foxconn, is really big. As it gets into electric vehicles, 5G markets and components, there's almost no ceiling to the potential. As it stands, Foxconn is approaching $200 billion in annual revenues. Not long ago – one generation, actually – the entire EMS industry was smaller than that.

Of course, Foxconn won't get there simply by making solder joints. So, if the question is can anything or anyone knock Foxconn from the top spot, the answer is yes: Foxconn. Some estimates have it reaching $300 billion in the next decade. To hit that mark it will increasingly make the jump from EMS to ODM to OEM. It is setting up a consortium to develop a common hardware and software platform for the electric vehicle industry. (Isn't that what Apple wants to do?) And what that means for Apple, HP, Dell and the many other blue-chip companies that rely on Foxconn to make those solder joints remains to be seen. Who will they turn to then? Because that company or companies will likely duke it out for the new number one.

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## PCDF People

**Cheryl Tulkoff** and **Greg Caswell** have published a book called *Design for Excellence in Electronics Manufacturing.*

Insulectro promoted **Paul Welter** to director of sales for DuPont chemistry.

Nano Dimension named **Zivi Nedivi** president.

Royal Flex Circuits named **Jorge Jauregui** director of manufacturing.

Trackwise named **Steve Hudson** chief operating officer. He has over 20 years' experience in automotive and aerospace with MG Rover, Bentley Motors and Rolls Royce Aerospace.

## PCDF Briefs

**Accurate Circuit Engineering** installed an **atg Luther & Maelzer** A5EO flying probe test system.

Citing higher metals costs, **Agfa** is raising prices more than 10% across its entire range of IdeaLine phototooling films for PCBs, and **Nanya Electronic Materials** told customers copper foil substrate prices are rising 15 to 20%.

**APCT** installed a **DIS** Rigid Flex Optical Registration system.

**EMA Design Automation** added **Parallel Systems** to its sales channel in the UK.

**Eternal Materials** plans to invest CNY90.5 million (US$13.8 million) to build a coating production line at its plant in Suzhou, according to reports. The new line is expected to be fully operational in the second half of 2022.

**FTG** installed an **Averatek** A-SAP line in its fabrication plant in Fredericksburg, VA.

**IMI Inc.** celebrates its 50th anniversary in May, making it one of the oldest circuit board fabricators in America.

**Jiangxi Zhiboxin Technology** broke ground in Jiangxi, China, on a 500,000 sq. m. PCB production facility for 5G communications products.

**SnapEDA** now integrates its CAD database directly into **DipTrace's** PCB design software. Also, SnapEDA and **Labcenter Electronics** have partnered to allow engineers to search and import SnapEDA's CAD models directly within Labcenter's Proteus Design Suite without leaving their design environment.

**TopLine** has been granted a US patent for lead-free solder columns for column grid array substrates.

## New Book Explains PCB Trace Heating and Cooling


**BOSTON** – A pair of experts on printed circuit board design have released a new book exploring the temperature of traces and vias and how to accommodate them in a design.

*PCB Design Guide to Via and Trace Currents and Temperatures* covers PCB materials (copper and dielectrics) and the role they play in the heating and cooling of traces. It details the curves found in IPC-2152, the equations that fit those curves and computer simulations that fit those curves and equations.

The 246-page book, authored by Doug Brooks, Ph.D., and Johannes Adam, Ph.D., presents sensitivity analyses that show what happens when environments are varied, including adjacent traces and planes, changing trace lengths, and thermal gradients; and explores via temperatures and what determines them, along with fusing issues and whether we can predict the fusing time of traces. Readers will learn how to measure the thermal conductivity of dielectrics and how to measure the resistivity of copper traces and why many prior attempts to do so have been doomed to failure.

For more information, visit artechhouse.com. (MB)

## Toppan Flex TFT Withstands 1M Bend Cycles

**TOKYO** – Toppan Printing has developed a flexible thin-film transistor that reportedly withstands a million bending cycles to a 1mm radius of curvature and demonstrates advantages for practical application, such as an on/off current ratio of at least 107, with carrier mobility of 10cm$^2$/Vs or more.

The TFT has the flexibility to be wound around a mechanical pencil lead, the durability of a flex circuit, and carrier mobility exceeding 10x that of amorphous silicon TFTs, the firm says.

Flex testing shows no variation in carrier mobility and other properties before and after a million bending cycles to a 1mm radius of curvature.

Toppan aims to advance manufacturing technology, enhance flexibility, durability, and carrier mobility, and target the development of flexible sensors. (CD)

## Service Excellence, NPI Award Winners Announced

**ATLANTA** – CIRCUITS ASSEMBLY and PCD&F in April announced the 2021 New Product Introduction Award winners for electronics assembly equipment, materials, software, and PCB fabrication. CIRCUITS ASSEMBLY also named the winners of the annual Service Excellence Awards.

The 14th annual NPI Awards recognize leading new products during the past 12 months. An independent panel of practicing industry engineers selected the recipients.

The winners are:

- Accu-Assembly: Component Storage (Accu-Stock)
- Accu-Assembly: Labeling Equipment (AccuID)
- Anda Technologies USA: Dispensing Equipment (iCoat-6)
- ASM Assembly Systems: Training Materials (ASM Academy Digital Training)
- Brady Corp.: Automation Tools (ALF19-XS Label Feeder)
- BTU: Soldering – Reflow (Health Check Services)
- ECD: Selective Soldering Tools and Accessories (SelectiveRIDER)
- Elsyca: Plating (Elsyca CuBE)
- EVS International: Soldering – Alternative (EVS 18KLF)
- Hanwha Techwin Automation Americas: Component Placement – High-Speed (Decan S1)

# Re-Engineering the EMS Partnership


At EDM, we do things differently by design. We start by listening to what our customers wish they had in a contract manufacturing relationship and then structure a solution that incorporates that. Variable demand? Our supply chain and production teams design a stocking program with finished goods Kanban that keeps deliveries on time even with changing forecasts. Is labor cost an issue? Our engineering team specializes in custom production automation that minimizes touch labor so well that we've brought projects back from China. Concerned about quality? So is every one of our employee owners on the production floor. Need a better product to beat the competition? Our engineering team has a track record of helping customers enhance their products over multiple generations.

In short, we've been the secret sauce for customers in industrial/instrumentation, transportation/public safety, specialty consumer, medical and telecom industries for more than three decades. If you are looking for a U.S. EMS provider capable of supporting your complete product lifecycle from design through post-manufacturing support or a subset of those services, give us a call at (434) 385-0046 ext. 8163 or visit us at www.edmva.com.

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The **US Air Force** enlisted **BotFactory** to develop a fully automated desktop machine for onsite, on-demand 3-D printing and assembly of PCBs for its AFWERX program.

**Zuken USA** is finalizing plans to take its annual Zuken Innovation World Americas conference to a fully virtual platform Aug. 4-5.

## CA People

Eutect named **Axel Wolff** sales representative. He has been a sales representative for various electronics machine manufacturers since 2000.

Kurtz Ersa named **Michael Wenzel, Ph.D.** managing director. During his 30-year career, he has served as managing director, consultant, and interim manager of well-known companies in mechanical and plant engineering, and automation.

Libra Industries named **Jeff Swenson** senior vice president of operations. He has 25 years' experience in contract manufacturing, and has run manufacturing operations in the US, Mexico and Asia. Libra also promoted **Cory McMaster** to senior director of operations at its Dallas facility.

MicroCare named **Kimberley Dilts, Ph.D.** global regulatory manager, responsible for ensuring the company's cleaning products comply with global chemical control legislation. She has a Ph.D. in chemistry and extensive knowledge of GHS classifications. Also, **Dylan Griswold** has joined as senior sourcing analyst, and **Brian Donnelly** is the new director of manufacturing. He has 20 year' experience in manufacturing.

Mirtec appointed **Rui Gésero** sales manager for Germany, Austria and Switzerland. He has a degree in business, management and marketing, and a background in all aspects of electronics manufacturing.

Optimas Solutions appointed **Daniel Harms** chief operating officer.

TestEquity appointed **Derrick Jones** vice president of sales.

Whizz Systems appointed **Dan Williams** director, sales & marketing. He has over 20 years of experience in EMS sales and marketing.

- Henkel: Thermal Interface Materials (Bergquist microTIM mTIM 1000)
- Indium: Cored Wire (CW-232)
- Juki: Soldering – Selective (iCube HighFlex)
- Koh Young America: Software – Process Control (KSMART)
- Kyzen: Cleaning Materials (Aquanox A4382 OA)
- MacDermid Alpha Electronics Solutions: Soldering Materials (Alpha OM-372)
- MIRTEC: Test and Inspection – AOI (MV-6Z Omni)
- Omron: Test and Inspection – SPI (CKD VP9000)
- SelecTech: ESD (FreeStyle ESD Plus)
- Viscom: Test and Inspection – AXI (iX7059)

The awards were presented during a virtual ceremony, which can be viewed here: https://vimeo.com/534113541.

"The competition was fierce, and the judges found some of the categories very difficult to decide," said Mike Buetow, editor-in-chief, PCD&F/CIRCUITS ASSEMBLY. "Clearly suppliers spent their year in Covid purgatory in a productive manner."

CIRCUITS ASSEMBLY also announced winners of its 29th Annual Service Excellence Awards (SEAs) for EMS providers and electronics assembly equipment, materials and software suppliers. The winners received the highest customer service ratings, as judged by their own customers.

In the EMS category, the overall winners were Kimball Electronics (sales over $500 million), Firstronic (sales of $101 million to $500 million), and XLR8 Services (sales under $20 million). There was a tie for top score in the sales of $20 million to $100 million category between Qualitel and Electronic Systems Inc.

The EMS companies with the highest scores in each of five individual service categories also received awards. (Overall winners were excluded from winning individual categories.)

In the small-company category, Silicon Forest Electronics won in all five categories. For companies with revenue between $20 million and $100 million, Spectrum Assembly also won all five individual categories.

For firms with revenue between $101 million and $500 million, Mack Technologies won in each of the individual categories, tying Vexos for dependability/timely delivery.

For EMS companies with revenue over $500 million, Creation Technologies took home all five awards.

"The SEAs are widely acknowledged as the most significant recognition program in the electronics assembly industry," said CIRCUITS ASSEMBLY editor-in-chief Mike Buetow. "Congratulations to all the entrants for their willingness to compete as part of their ongoing pursuit of excellence."

Electronics assembly supplier award winners were Europlacer Americas for pick-and-place; Speedprint Technology for screen printing; Kyzen for cleaning/processing materials; Koh Young America for test and inspection; Anda Technologies USA for dispensing; Heller Industries for soldering equipment; Aegis Industrial Software for automation/manufacturing software; Count On Tools for automation/handling equipment; Datest for test laboratories; and Air-Vac Engineering for rework and repair. (MB)

# Plexus Breaks Ground on First Thailand Plant

**BANGKOK** – Plexus broke ground in late March on a 400,000 sq. ft. manufacturing facility here, which the EMS company expects to be complete in the fiscal third quarter of 2022. The new plant, its first in Thailand, will include two levels of production and warehouse space and four levels of office space. Plexus did not initially disclose the price tag.

The facility will feature various energy-efficient and green building initiatives, as well as considerations for future enhancements as operations commence. The facility will also include an exterior green zone to ensure team members have a welcoming outdoor space to utilize and gather. Plexus expects to hire 1,800 workers to staff the plant.

"This new advanced manufacturing facility will help ensure that we are properly

positioned to support robust future growth projections within the APAC region, particularly given Thailand's highly skilled workforce and established supply chain," said Steve Frisch, executive vice president and chief operating officer. "These attributes support Plexus' strong history of operational excellence, particularly in markets with highly complex products and demanding regulatory environments. We look forward to expanding our services and solutions in Thailand as we continue to fulfill our vision of creating the products that build a better world." (MB)

## MacDermid Alpha Opens Die Attach App Center in Taiwan

**TAOYUAN CITY, TAIWAN** – MacDermid Alpha Electronics Solutions opened its Greater China Die Attach Application Center here on Apr. 1. The advanced technology and application center will house technical service and lab personnel, equipped with die attach assembly and process equipment for high-volume process optimization and component designs using paste and film products.

"With MacDermid Alpha's unique role as a leading packaging materials supplier to all steps of the electronics manufacturing supply chain, this multimillion-dollar investment to build a leading-edge application center is an important next step in enabling our customers to meet their design goals," said Rick Frick, VP and GM of the Semiconductor Solutions division. (CD)

## CA Briefs

**1 Click SMT Technology** has opened a demo center in Suzhou to provide local support to the automotive and medical instrument industries.

**Absolute EMS** invested in a **Jaguar** N450 lead and lead-free wave soldering system.

A coalition of seven trade associations, including the **Telecommunications Industry Association, Information Technology Industry Council, Semiconductor Industry Association** and **National Association of Manufacturers,** has petitioned the US Trade Representative over concerns regarding India's mounting tariffs on information communications technology products and services.

**Argo EMS** named **Integral Sales** manufacturers' representatives in New England.

**Asteelflash** reportedly suffered a cyber attack by the REvil ransomware gang, which demanded a $24 million ransom.

**Axiom Manufacturing Services** revealed its annual revenue for 2019-2020 exceeded £62 million, and the UK-based EMS company is embarking on a hiring spree.

**Bharti Enterprises** has signed an agreement with **Dixon Technologies** to form a joint venture to build telecom equipment, including IoT devices, modems, routers and set-top boxes.

**BEST** installed an NAI PRO-X110 x-ray inspection system.

**BrandSafway** has acquired **JA Electronics Manufacturing.**

**Bright Machines** named **Murray Percival** manufacturers' representative.

**BSU** opened an EMS plant and headquarters in Austin, TX.

Cambodia has greenlit a pair of investments totaling nearly $5 million combined in new electronics assembly plants, according to the Council for the Development of Cambodia (CDC).

**Circuit Technology Center** installed a second robotic hot solder dip (RHSD) machine.

**CyberOptics** received a $1.2 million order for its MX3000 memory module inspection systems.

**Cypress Industries** has added additional PCB assembly lines and expanded its high-level assembly footprint in Mexico to handle additional volume.

**Elbit Systems** completed its previously announced acquisition of **Sparton's** sonobuoy unit from an affiliate of **Cerberus.**

**Enics** will reduce headcount at its EMS operations in Turgi, Switzerland, by up to 125 workers.

**Ericsson** inaugurated the first 5G circuit board production line in Latin America.

**Foxconn** has begun making servers and other 5G networking gear for a handful of clients, including **Cisco,** at its manufacturing complex in Wisconsin, according to multiple sources familiar with the matter.

Global efforts to develop national self-sufficiency in chip production are "economically unrealistic" and US-China trade tensions have contributed to the chip shortage, according to **TMSC** chairman Mark Liu.

**Intel** will greatly expand its advanced chip manufacturing capacity as its new chief executive announced plans to spend as much as $20 billion to build two factories in Arizona and open its factories to outside customers.

**Koh Young America** recognized sales partners **Technical Resources Corp.** and **Repstronics** for remarkable contributions.

**Kyzen** launched the *Cleaning Insights* e-newsletter.

**LG Electronics** will shutter its money-losing mobile communication business.

**Pace Electronics** will expand its electronics manufacturing plant in Sodus, NY, and add 15 jobs.

**Pegatron** will complete its factory site expansions in Vietnam and India in the second half of 2021 and begin an expansion at a plant in North America in 2021, according to CEO SJ Liao.

A new study from the **SIA** found that the global semiconductor supply chain has become increasingly vulnerable to natural disasters and geopolitical disruptions because suppliers have become more concentrated in distinct regions.

**Shenmao** established an independent testing laboratory in Taiwan called **Cheetah Inspection.**

**Solu-M** installed 22 **Mirtec** SMT AOI machines at its plant in Mexico.

**Specialty Coating Systems** acquired **Diamond-MT** for an undisclosed sum.

**Syrma Tech** is banking on e-vehicles and IoT for the next phase of the Indian EMS company's growth.

**Tech Etch** announced the grand opening of its Innovation Center, located at the company headquarters in Plymouth, MA.

**Test Research Inc.** opened an office in Bắc Ninh, Vietnam.

**Texas Instruments** awarded **Kulicke and Soffa** its 2020 Supplier Excellence Award.

**TMSC** plans to invest $100 billion in the next three years to expand its manufacturing capacity and support research and development.

**Wildtrax** installed a **Europlacer** iineo+ II pick-and-place machine, its second.

**XDry** announced an exclusive representative agreement with **T&S Associates** in the Southeastern US.

**Xiaomi** plans to invest about $10 billion over the next decade to make electric vehicles.

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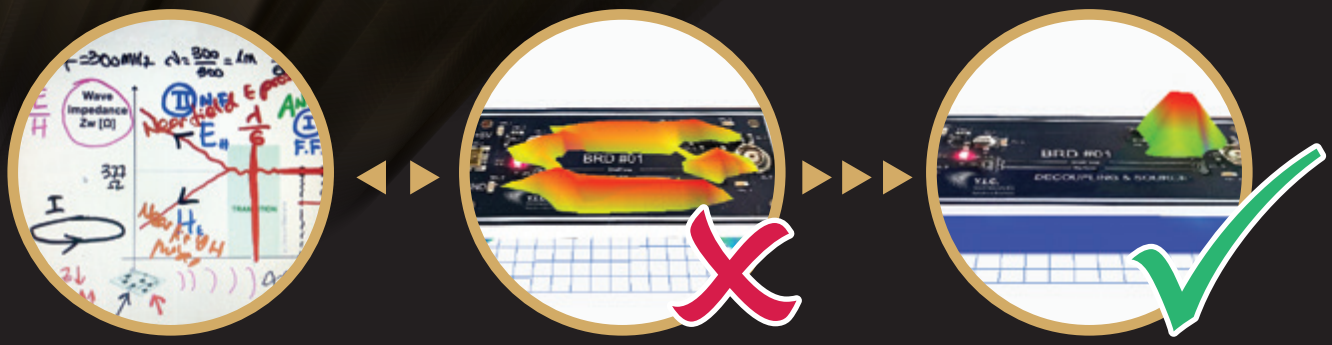

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## CALM BEFORE THE STORM

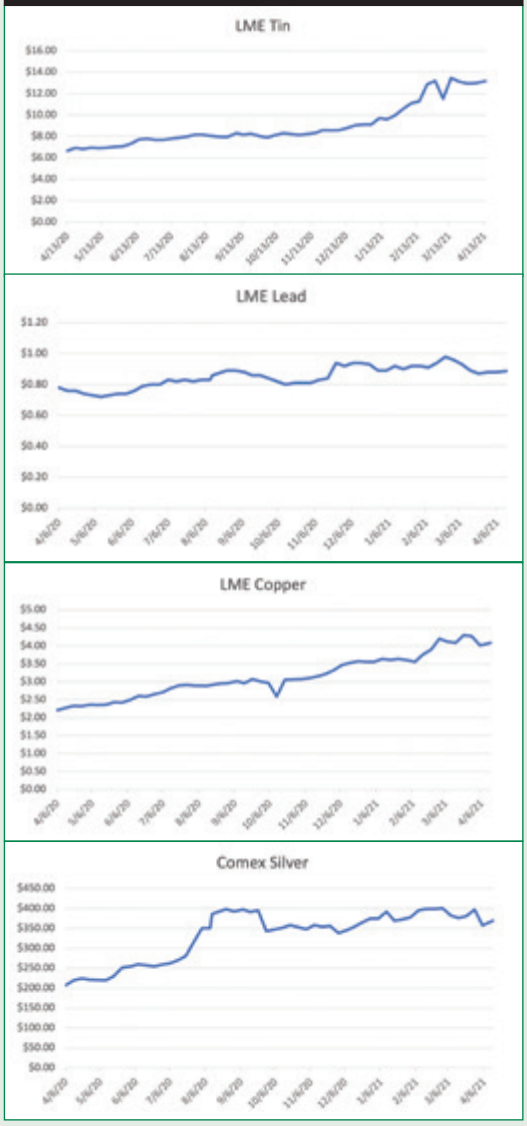
| Trends in the US electronics equipment market (shipments only) | % CHANGE DEC. | JAN. | FEB. | YTD% |
|---|---|---|---|---|
| Computers and electronics products | 0.8 | 1.2 | -0.4 | 8.1 |
| Computers | -2.4 | 6.5 | 2.3 | 3.5 |
| Storage devices | 1.4 | 20.4 | -4.7 | 28.7 |
| Other peripheral equipment | -3.8 | 9.9 | -3.5 | 19.9 |
| Nondefense communications equipment | 2.8 | -5.5 | -0.5 | 14.2 |
| Defense communications equipment | -11.3 | 4.5 | 2.9 | 9.8 |
| A/V equipment | -12.9 | 17.7 | 0.5 | 21.8 |
| Components[1] | -0.5 | 1.1 | -0.9 | 6.3 |
| Nondefense search and navigation equipment | -1.0 | 3.0 | -1.0 | -1.2 |
| Defense search and navigation equipment | 0.9 | 4.7 | -2.2 | 3.2 |
| Medical, measurement and control | 1.5 | 2.2 | -0.9 | 9.8 |

[r]Revised. *Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: U.S. Department of Commerce Census Bureau, Apr. 5, 2021

# Hot Takes

- **PCB and MCM design software** revenue fell 0.8% year-over-year to $292.9 million in the fourth quarter. (ESDA)
- **Sales at the top 50 EMS companies** accounted for $384 billion in revenue, up 4.6% year-over-year, largely due to the top 10 EMS firms. (MMI)
- **Shipments of smart home devices,** up 4.5% in 2020, will grow 12% per year over the next five years. (IDC)
- **North American electronics manufacturing orders** in February rose 21.5% year-over-year and 16.7% sequentially. Shipments were up 6.4% compared to 2020. (IPC)
- **The global semiconductor industry** is on track to register a rare three consecutive years of record highs in fab equipment spending, with a 16% increase in 2020, followed by forecast gains of 15.5% this year and 12% in 2022. (SEMI)
- **Substrate capacity remains tight** for both flip chip ball grid array (FC-BGA) substrates and laminate-based CSPs. (Techsearch International)
- **German PCB manufacturers** reported fourth quarter sales rose 1.7% from a year ago, bringing the full-year results to a loss of 9%. (ZVEI)
- **Exports of electronics goods by India** reached an all-time high in December, with mobile phones accounting for most of the gains. (ICEA)
- **Total semiconductor unit shipments,** including ICs and optoelectronics, sensor/actuator, and discretes, are forecast to rise 13% in 2021 to 1.13 trillion units, a new record. (IC Insights)
- **Worldwide IT spending** is projected to total $4.1 trillion in 2021, up 8.4% from 2020. (Gartner)
- **Total TV panel shipments** for 2021 will reach 269 million units, relatively unchanged compared to 2020 levels. (TrendForce)
- **Global shipments of traditional PCs,** including desktops, notebooks, and workstations, grew 55% year-over-year during the first quarter. (IDC)
- **Worldwide sales of semiconductor manufacturing equipment** surged 19% to an all-time high of $71.2 billion in 2020. (SEMI)

## METALS INDEX




## US MANUFACTURING INDICES

| | NOV. | DEC. | JAN. | FEB. | MAR. |
|---|---|---|---|---|---|
| PMI | 57.5 | 60.5 | 58.7 | 60.8 | 64.7 |
| New orders | 65.1 | 67.5 | 61.1 | 64.8 | 68.0 |
| Production | 60.8 | 64.7 | 60.7 | 63.2 | 68.1 |
| Inventories | 51.2 | 51.0 | 50.8 | 49.7 | 50.8 |
| Customer inventories | 36.3 | 37.9 | 33.1 | 32.5 | 29.9 |
| Backlogs | 56.9 | 59.1 | 59.7 | 64.0 | 67.5 |

Source: Institute for Supply Managemen, Apr. 1, 2021

## KEY COMPONENTS

| | OCT. | NOV. | DEC. | JAN. | FEB. |
|---|---|---|---|---|---|
| Semiconductor equipment billings[1] | 27.3% | 23.1% | 7.6% | 29.8%[r] | 32%[p] |
| Semiconductors[2] | 5.86% | 8.4% | 9.55% | 13.2%[r] | 14.7%[p] |
| PCBs[3] (North America) | 0.97 | 1.05 | 1.10 | 1.14 | 1.29 |
| Computers/electronic products[4] | 5.01 | 5.13 | 5.11 | 5.05[r] | 5.10[p] |

Sources: [1]SEMI, [2]SIA (3-month moving average growth), [3]IPC, [4]Census Bureau, [p]preliminary, [r]revised

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# IT Piracy

How much of your budget goes to protect you from the companies that are supposed to be protecting you?

OVER THE PAST several years I have heard, learned, discussed and agonized over cybersecurity more than I would have ever imagined in my wildest dreams a decade ago. And I have invested a massive amount of money in cyber and all other types of security during this time to be safe (hopefully). When I moan and groan about the staggering cost, cultural change to our operating environment, and considerable training all employees must undergo to relearn basic computer tasks, the response I hear – usually from vendors or some other third-party – is "that's the cost of being in business these days."

Yes, being in business has underlying fixed costs that may change but never decline. These days some of those costs are to harden IT infrastructure and put in place systems, equipment and procedures to primarily safeguard data, and sometimes maybe even employees. Several years ago, attempting to explain as simply as possible to employees the need to prepare for cyber attacks, I drew a comparison to the pirate attacks of lore. At the time, piracy was commonplace on the coast of Somalia. Some hacker, I suggested, from a nation/state was ready to kidnap a Captain Phillips, take his ship and plunder its cargo. Indeed, I know of companies held ransom for Bitcoin losing control and access to all their IT infrastructure and basically being unable to operate systems or even shopfloor equipment.

The threat is real, and we all need to do the due diligence and invest the time and money to put in place reasonable safeguards to eliminate or at least dramatically limit the potential of losing valued intellectual property, data files and critical code. The more I learn and invest to have a secure, safe and trusted business that customers, suppliers and employees have confidence in, however, the more I realize there is more than one type of pirate operating in the cybersecurity universe.

When you try to tackle the herculean task of hardening systems, servers and software to be robust and cybersecurity-safe, you realize that, for all intents and purposes, you must replace almost your entire IT infrastructure. With so many legacy software programs running on equipment from companies long out of business, it is logical to focus attention on that large potential black hole. In this particular instance, however, you quickly discover that what's old and functioning, even if from a defunct company, is just landscape. The journey you are on is supported by companies such as Microsoft, Amazon, and other behemoths in the "tech" world. And that's when you realize the other pirate is less Somalian terrorist and more like Captain Jack Sparrow from *The Pirates of the Caribbean.*

How could this be? Simple. An IT system relies on two basic things: software and internet, or more specifically, email. We take both for granted, especially as they are based on platforms from companies that support all industries on all types of hardware equipment globally. The problem is those companies know it. That's where the piracy begins. One part of the behemoth corporation decides to update its email software. Great! Then it crashes the operating system that runs the computer it resides on. So, you, or more specifically your "IT guy," gets the various patches and fixes it. You are back up and running, safe and secure as before. However, the next week a different part of the same behemoth corporation decides to update *its* operating system, which crashes the email service. Once again you – or more likely your "IT guy" – gets the patches going and fixes it.

This happens over and again, and regrettably is just as predictable as the antics of Jack Sparrow as he outwits the British navy while plundering bounties and charming innocent maidens. Corporations large and small have jumped on the cybersecurity bandwagon and have figured out that business will pay whatever it takes to protect themselves from a cyberattack. And with protocols being developed and launched such as CMMC certification to enable companies to prove they have the best defenses built into their IT and security infrastructure, the costs in time and treasure escalate. Much of the money you are spending is to "fix" what these companies muck up by not coordinating their own internal efforts and to pay someone else to certify what you already know.

I realized, then, that a decent percentage of my IT security budget goes toward efforts to protect myself from the companies that are supposed to be protecting me!

That is indeed the cost of business in our current world. No question we want safe IT infrastructure. No question that companies fallen victim to cyberattacks or bitcoin ransom experience devastating impacts to their business, profits and reputations. The frustration is that in our technologically fast-paced world, just when you think you are "there," an OS change is made on software used globally, and you have to start

*continued on pg. 19*

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


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# 3 Reasons PCB Buyers Pay Too Much

"We have used this vendor for years" is not a viable strategy.

AS THE PRICE of PCB materials continues to skyrocket, why are some circuit board buyers stuck firmly in the past, doing business as they always have? Why, even when paying more than they should, do they fear upsetting the apple cart?

Bare board buying can be competitive, but only if those overseeing their company's PCB supply chain are willing to occasionally buck a system put in place years ago. For circuit board buyers and procurement managers in particular, I see three ingrained habits that do damage to a firm's PCB purchasing program and its ability to get competitive pricing.

1. Buyers are untrained. One outdated practice in the PCB industry that always amazes me is the willingness to throw buyers into the deep end without giving them 21st century training on how to buy boards. Does management assume PCB buyers will gain all the knowledge they need on the job? Sometimes, they probably do. But often, they end up costing their companies a lot of money as they learn from their mistakes.

Too many OEM and EMS companies have a seat-of-the-pants approach to buying printed circuit boards. Sooner or later, their untrained buyers will hurt the bottom line, either through reduced profits or lost sales. PCBs will be quoted incorrectly, and buyers won't know how to leverage their spending power across the vendor base.

Why would assembly firms, *especially* those that tout ISO certification, not provide training in buying the commodity that is the foundation of their assembly processes and one of their largest expenses?

2. Buyers are overwhelmed. Buyers are now responsible for the acquisition of everything from HDI boards to cable assemblies to, sometimes, the office toilet paper. Keeping the vendor base on its toes is a core buyer responsibility, but it's the job of upper management to ensure buyers have the resources they need to focus on bringing prices down, both for new opportunities *and* existing business.

PCB buyers should regularly seek offers from other vendors, especially on business already in-house elsewhere. Things change, and buyers should be ready to pivot to less expensive solutions, even for customers that only want to consider domestic suppliers. Unfortunately, many OEMs and EMS companies make the process of moving PCB orders to new vendors too cumbersome, taxing the overwhelmed buyer even more.

The truth is adding qualified suppliers is not as hard as you may think. And being able to offer your customers a list of vetted suppliers – offshore or domestic – will demonstrate your company's commitment to seeking the best pricing.

Your purchasing team deserves a quick and seamless process for bringing on those new suppliers. Make sure they have it.

3. Buyers are too comfortable with the status quo. OEM and EMS companies sometimes say a customer will not allow them to move business from an existing vendor. In some cases that's true. But often, it's simply a way to politely turn away a PCB salesperson.

Is there something unique about the PCB that only a particular manufacturer can build it? Or is it out of fear that if the order were to move, there'd be a quality problem? This is an understandable concern, but PCB buyers should not be held hostage to one particular manufacturer. Many qualified vendors are out there.

Ask yourself: "Does my PCB vendor know I won't or can't move an order once it's placed?" If so, you as a PCB buyer have made a big mistake. Many vendors will take advantage of that knowledge, as their fear of losing business is diminished.

Board buyers must never leave vendors too comfortable about whether they'll get that next order. Vendors should be motivated to keep your business by holding pricing in check. Let them know all PCB jobs will be actively quoted, new orders and reorders.

The threat of losing business will help keep PCB vendors at the top of their game when it comes to pricing, customer service, and timely delivery. And PCB buyers should be wary of becoming complacent with their vendors. Buyers should leverage vendors, not the other way around.

In the post-pandemic PCB supply chain, companies that stick with the old approaches will have a much harder time remaining competitive. "We have used this vendor for years" is not a viable strategy.

But having a trained and confident buying team will boost your bottom line and help keep your customers happy. ❑

*Ed.:* The author will present a webinar on saving money on PCB purchases on May 19. See pcb2day.com for details.

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


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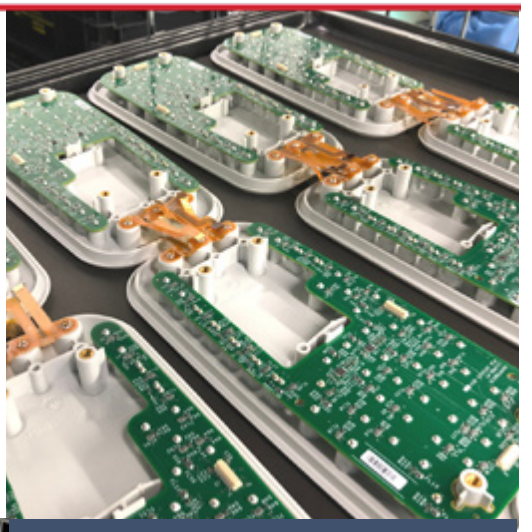

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# Unpacking Logic as it is Used on a Printed Circuit Board

You need a buffer zone.

THE TRUTH SHALL set you free. The truth table of a logic device determines the outcome of a logical operation. A handful of operations are described as gates. The gates are named for the function that applies. To start, two main ones are the AND gate and OR gate. Both usually have two inputs and one output.

You may have a hallway or stairwell light in your home with a light switch at either end. When both switches are in the down position, the light is on. When both are up, the light is also on. If one is up and the other down, the light is off. The truth table for those two switches is shown in **TABLE 1.**

We represent the binary logic states with a one or zero, although there are exceptions. The one can also be called high state, while the zero represents a low logical state. One or zero, high or low, voltage applied to the pin or not applied: all are ways to describe the situation. Low is not always synonymous with ground. It could be a negative voltage. Some devices have a tri-state output that uses negative and positive voltages with ground as the middle state.

**TABLE 1.** Binary Logic States

| SW1 | SW2 | Result |
|---|---|---|
| On | On | On |
| On | Off | Off |
| Off | On | Off |
| Off | Off | On |

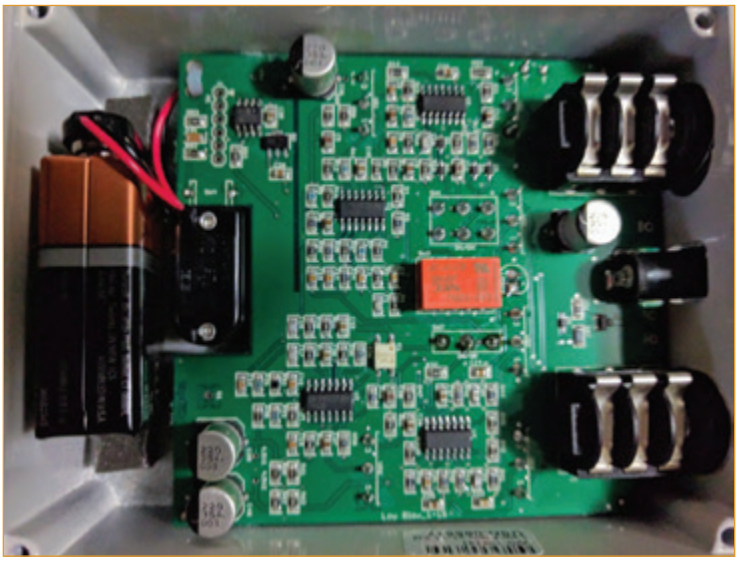

**FIGURE 1.** Guitar effects pedal small signal processing carried out with the help of basic logic devices.

**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.

Turning code into action. Setting that little wrinkle aside, machine language is a string of ones and zeros compiled from a list of logic statements in the software. Once compiled, the binary code can be applied to the logic gates to do something useful, or at least amusing, in terms of manipulating the input to drive an outcome.

To activate an AND gate, both input pins must have a voltage applied. An OR gate needs only one of the input pins to have a charge, but a positive outcome can be had with a nominal voltage applied to both input pins. If we don't want a high state when both pins of an OR gate are active, use an exclusive OR gate, also known as an XOR gate.

Further, we could flip the bit, so all the outcomes are reversed. Put an N on the front of the descriptor for a NAND and a NOR gate. The OR gate can be both exclusive and inverted, which we call an XNOR gate. The two light switches I mentioned resemble the EX-NOR circuit. They are also useful in memory devices.

Buffers and inverters. Fleshing out the other simple logic gates are the inverter and the buffer. These logic devices have one input pin and one output pin. As you'd expect, an inverter will flip the bit from one state to the other, depending on what comes in.

When it comes to a buffer, the idea is to refresh the signal without altering the state, so we can send it on its way. The buffer may be useful as a means to revive the voltage to its full specification, while removing any other signal integrity issues. The schematic symbol for the buffer is like the inverter, except there is no little circle on the

output pin. As you can see, the circle is common to all the gates that invert the outcome.

**The evolution of logic.** Over the course of time, the working voltage for logic gates has gone down. The smaller voltage swings happen faster with less switching noise. When I started out, we had TTL (transistor-transistor logic), which ran on +/-5V. Along came CMOS architecture, and three is the new five. It keeps on progressing. The data rate jumps while the voltage goes down. That progress means the threshold between a zero and a one state is a little more difficult to read if there is significant voltage drop over a length of trace or wire.

That's where those buffers come in. You could also create a buffer by chaining two inverters together in a series. The output is refreshed while the double switch puts the logic in the original state. Since inverters typically come with six or more gates in a standard package, there may be a few empty slots somewhere to use for that purpose. You can be creative with these building blocks.

These primitives are themselves made of a small number of transistors and passive elements. The AND gate is not restricted to two input pins. It could take three or four input pins registering a 1 for the output pin to follow suit. Other circuits combine functions into more integrated features. You may have heard of a flip-flop (not the shoe), a level shifter or a comparator, for instance. These are conveniently packaged groups of logic gates for specific purposes, of which there are many.

**Gate swapping. (Because nobody is perfect at schematic capture.)** The first iteration of the schematic is unlikely to result in a totally smooth flow, especially when we allow the system to randomly assign the individual gates to their packages. Even when we try to plan ahead, the PCB layout may have areas where reassigning the logic gates is beneficial. That might be done by revisiting the schematic.

Another way is to optimize the connections while in the layout using a gate-swapping routine. First, you have to be sure gate swapping is, in fact, allowed. Then you have to back-annotate the schematic to align with the layout. Your approach will depend on your normal tool-flow and the complexity/flexibility of the circuit.

These humble circuits have become cobbled together with others to form massive colonies with billions of transistor-level residents. It all begins with statements written in software compiled into binary code that drives the whole process. The super massive system on a chip is no more complex than this. It's just that there is a lot of it all in one location. Have fun trying to keep up with our digital future. ▫

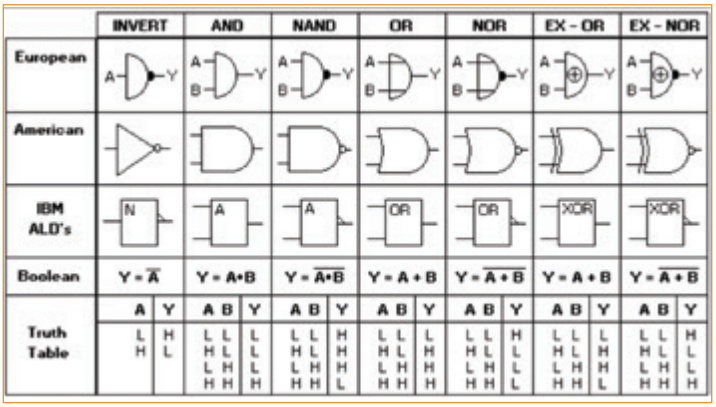


**FIGURE 2.** A visual of the schematic symbols and truth tables of typical logic gates. Credit: IBM.

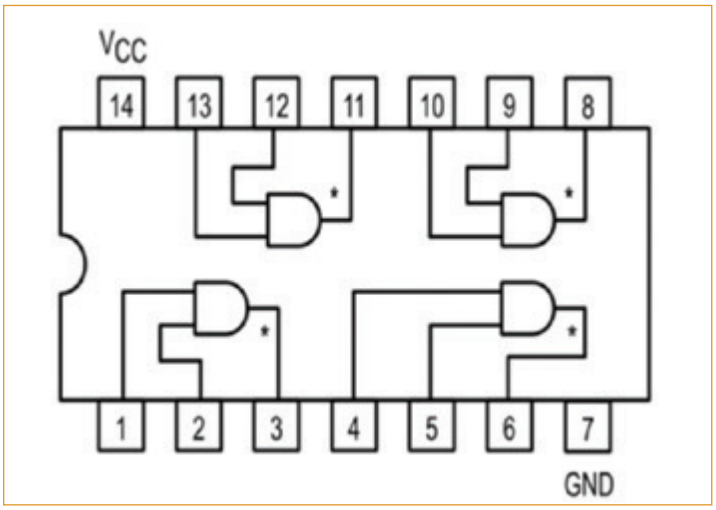


**FIGURE 3.** 4LS09 QUAD AND GATE typical configuration in a 14-pin package has four logic gates, or six in the case of inverters or buffers. Credit: *Circuit Digest.*

*ROI, continued from pg. 16*

the process over.

As more industries realize the potential vulnerability their IP and that of their customers is exposed to by antiquated computers, servers and software, the cybersecurity mantra, and the costs associated with it, will certainly be there. It would be helpful, however, if some of the big suppliers of software, systems and platforms eliminated the dumb actions that make them often appear more pirate than defender.

Then again, maybe I am wishing for too much! It certainly was simpler and less costly way back when all you had to do was bolt down the typewriter and lock the file cabinet. ▫

# Cleaning Up

Help navigating career decisions is part of the value of PCEA.

IN THIS MONTH'S column, I extend an overview of two recently held PCEA chapter meetings and give a nod to two interesting presenters who gave their time to cover relevant topics. Next, I hand it off to PCEA chairman Steph Chavez who relates a recent personal career "crossroads" experience and shares what gave him the hope and confidence to carry on. This month, I am excited to provide our readers with a growing list of events coming in 2021.

## Chapter Updates

The Michigan Chapter held a highly anticipated kickoff meeting on Feb. 24. Chapter chairman Dugan Karnazes welcomed an international online audience to the meeting and spoke about the excitement and anticipation of bringing local area printed circuit engineers together to learn alongside a greater audience. The featured speaker for the event was Terry Munson, owner of Foresite, who presented The Forensics of Dendrite Shorting. Munson offered his definition of cleanliness, then described no less than 16 sources of contamination that cause dendritic shorts on PCBAs and offered mitigation techniques **(FIGURE 1)**.

Attendees were captivated throughout the presentation, which included explanations for a variety of PCB residue factors and sources that contribute to underlying causes for failure. Process malefactors include a disregard for bare board and component cleanliness, incomplete heat-activation of no-clean fluxes, poor cleaning system performance, flux and/or cleaning agent entrapment under low-standoff component packages, and outside contamination. There were many follow-up questions for Munson, validating the audience's interest. The meeting concluded with a raffle for $200 in prizes from our generous PCEA sponsors.

A Feb. 25 Silicon Valley Chapter meeting was hosted online with featured speaker Joe Bevan, product manager of lamination for Insulectro, on PCB materials and their applications **(FIGURE 2)**. Chapter chairman Bob McCreight welcomed the attendees to the crowded Zoom presentation meeting hall. McCreight gave a brief history of the longstanding Silicon Valley chapter before introducing Bevan, who was supported by PCEA's own Mike Creeden, technical director of design and education for Insulectro, to relay the many questions that streamed in during the presentation. Bevan covered many valuable topics, including an overview of copper foil categories, production methods, the mSAP process and a discussion on the rewriting of IPC-4562, "Metal Foil for Printed Board Applications."

During the business portions of each of these back-to-back meetings, chairman Steph Chavez was delighted to take an opportunity to showcase two new PCEA chapters in attendance whose leadership

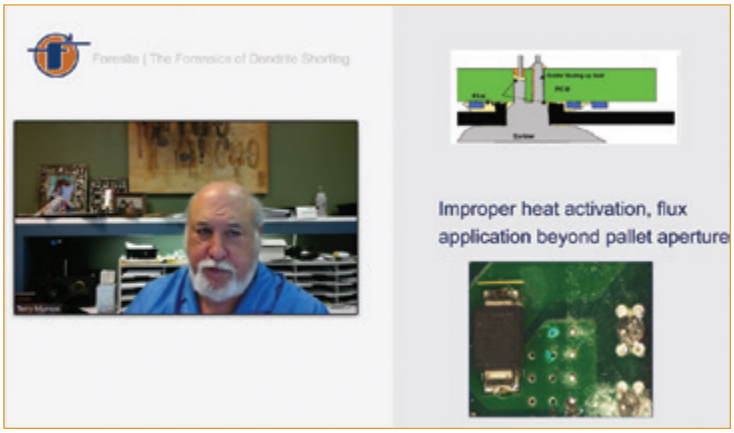


**FIGURE 1.** Terry Munson discussed causes of dendritic shorts with the Michigan chapter.


**FIGURE 2.** Joe Bevan describes substrate materials at the Silicon Valley chapter meeting.

**KELLY DACK, CIT, CID+,** is the communication officer for the Printed Circuit Engineering Association (PCEA). Read past columns or contact Dack; kelly.dack.pcea@gmail.com.

was present to help support both events. He first welcomed Luis Saracho, chairman of the Monterrey, MX, chapter **(FIGURE 3)**. Next, Chavez welcomed Zachariah Peterson, who recently started the Portland, OR, chapter **(FIGURE 4)**.


**FIGURE 3.** Luis Saracho of the Monterrey, MX, chapter.


**FIGURE 4.** Zach Peterson of the Portland, OR, chapter.

## Message from the Chairman

*by Stephen Chavez, MIT, CID+*

For this month's "Message from the Chairman," I am reflecting on the essence of PCEA and the benefits of membership within the PCEA collective. Specifically, are you experiencing the value of giving and receiving as a PCEA member? I do this by sharing a recent personal experience many can relate to. It brings a spotlight to the true value of PCEA membership.

"Collaborate, Educate and Inspire" is the core mission of PCEA. As we come off a tough year within our industry, 2021 has many companies adjusting, adapting, and making tough decisions: to survive, to move forward, and to be successful. This calls for changes that may be good or bad, depending on what side of the decision line you fall on.

Like most of you, I have a day job. I bring my "A game" every time I strap myself into my "cockpit" here in my office, where I conduct business as a printed circuit engineer. Lord knows, I am always confident and have no hesitation when wielding my CAD system to either design complex PCB circuits solo or while integrating and collaborating on many global engineering teams. My 30-plus years of industry experience provides me a certain level of confidence, allowing me to walk with a swagger. Yet, I am by no means invincible. Like everyone else, I am not impervious to changes or tough decisions beyond my control.

Recently, I came into a situation where I found myself contemplating the direction of my future and needed to make decisions that could seriously impact the trajectory of my career path, where each option had potential pros and cons. I am sure many of you can relate to what I am talking about. Those readers who are early in their career and have not yet experienced this will at some point come to a similar crossroads in your career.

As I evaluated my situation and contemplated my options, in hopes I was seeing things from every angle, I realized that with all my experience I could benefit from advice and a support network where I could discuss ideas and seek advice from others like me. So, what did I do? I immediately tapped into my PCEA network. My immediate PCEA network consists of many industry veterans and professionals who have been at these similar crossroads. As I worked the situation alongside my established network, I realized they have become lifelong personal friends as well. They stood alongside me while listening to me vent and provided me with solid advice as we worked the problem together. I was not alone! More important, I had the horsepower of the PCEA collective there to support me! The core PCEA mission was in full effect … Collaborate, Educate, and Inspire. I collaborated with other members to work the situation. I was educated by members who have been at these crossroads and could provide me with solid advice. Last, I was inspired by my longtime mentors who were counseling me, while at the same time I was inspiring others around me on how I handled myself and how I was addressing the situation as an industry professional.

The best thing was I had others to reach out to who put me at ease, knowing that through PCEA I had a safety net on which to rely.

Many in the industry may be in a similar situation. Some have no idea what to do or which direction to go, or worse, no one to reach out to for advice. This I know: When I think about what I just went through, as well as the early years of my career when I came out of the Marine Corps in 1995 with no civilian industry experience and no support network to tap, I had no choice but to go down the road of "hard knocks." That was a tough and long road indeed. Many readers can relate.

Knowing what I know now, and what PCEA offers as an industry association, is simply awesome! Collaborate, Educate, and Inspire: Those three words say it all. I wish I had something like PCEA early on in my career path. I hope those who have not yet become PCEA members join and tap into this awesome professional trade association. For those who are already members, take advantage of the PCEA. Join a chapter

for awesome professional development and great professional networking.

Refer to our column and the PCEA website to stay up to date with the upcoming industry events. Many free webinars are available, so take advantage of these opportunities. If you have not yet joined PCEA, I highly encourage you to do so by visiting pce-a.org.

I continue to wish everyone and their family health and safety. Best of success to all as 2021 unfolds.

Warmest regards,
Steph

## Next Month

How do you hone your printed circuit engineering skills? Are your skills measureable? The PCEA has much in store for our readers regarding career training and certification you will not want to miss.

## Upcoming Events

Below is a newly seeded list of upcoming events to get our readers excited about traveling again. It is up to every one of us to do the best we can to follow CDC guidelines and take the precautionary measures to squash the spread of Covid-19 and its variants, including handwashing, masking and vaccination if possible. We're still in this together!

### PCB East 2021
Jun. 15-17, 2021
Marlborough, MA
www.pcbeast.com

### Zuken Innovation World 2021
Aug. 4-5, 2021
online
https://ziw.zukenusa.com/

### DesignCon 2021
Aug. 16-18, 2021
San Jose, CA
www.designcon.com

### PCB West
Oct. 5-8, 2021
Santa Clara, CA
www.pcbwest.com

### SMTA International 2021
Nov. 1-4, 2021
Minneapolis, MN
www.smta.org/smtai

### PCB Carolina 2021
Nov. 10, 2021
Raleigh, NC
www.pcbcarolina.com

### Productronica
Nov. 16-19, 2021
Munich, Germany
https://productronica.com

Spread the word. If you have a significant electronics industry event that you would like to announce, please send me the details at kelly.dack.pcea@gmail.com, and we will consider adding it to the list.

Refer to our column and the PCEA website to stay up to date with the upcoming industry events. If you have not yet joined the PCEA, please visit our website pce-a.org to find out how to become a PCEA member.

## Conclusion

Sometimes we can find ourselves at the crossroads of several career unknowns. During a time such as this, we need confidence things will work out regardless of the path followed. Thankfully, we have networks of peers who can help us pivot if the road starts to spiral into a downgrade. Belonging to any or many of the electronics industry's meaningful trade organizations can help us to chart our paths onto the road for success through communication and collaboration, which can lead to opportunities to be educated, then to educate – to be inspired and then to inspire. □

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# Applying Principles of Industrial Automation in Healthcare Can Deliver Better Services for All

How AI and lab-on-a-chip pave the way for economical solutions.

WE COULD BE moving into the end game with the Covid-19 pandemic, at least as far as the severest effects are concerned. Clearly, the virus and its mutations are here to stay, and the future will be about protecting us through immunization and developing better treatments. The fact that effective vaccinations have become available only a year after the pandemic was recognized is remarkable. It's partly due to the speed with which researchers have been able to do the data crunching needed to model and understand how best to attack the virus.

In the past, the computations involved in sequencing the virus DNA would have taken vast quantities of computer time and prolonged development of the vaccine. Cloud computing using AI accelerators has dramatically shortened the time to complete the technical work involved in creating the vaccines now being rolled out.

It would be great if we could harness our technologies to create an early warning system when clusters of unusual diseases or events occur anywhere in the world. That's exactly what organizations like BlueDot are doing right now. Indeed, BlueDot says it spotted the cluster of unusual pneumonia cases in Wuhan in December 2019 that we now know was the coronavirus. To monitor the spread of infectious diseases around the world, it analyzes a huge number of variables, not only official public health data but also climate information, international travel patterns, animal and insect population data, and others. This relies on the ability of AI to detect patterns, and exceptions to those patterns, hidden within the enormous body of information. By sifting through the reports and data points collected every few minutes, 24 hours a day, from sources around the world, using techniques like machine learning and natural language processing, BlueDot brings a small number of cases to the attention of experts for further investigation. Only with AI do we have a hope of finding those cases.

While AI empowers us to monitor the effects of variables such as climate and movement of people, and disease carriers such as insects, with greater precision than ever before, capturing raw data that accurately describe the condition of patients calls for large numbers of sensors that are easy to use and inexpensive. The University of Bath in the UK is leading a project to tackle an emerging diabetes epidemic in Turkey, for which it has developed children-friendly patches for painless glucose quantification. The patches are designed to be economical because typical noninvasive sensors that do not require finger pricking are simply too expensive for large-scale studies in developing countries. They contain an array of hydrogel microneedles that painlessly capture subcutaneous interstitial fluid to be tested using a μTAS (Micro Total Analysis System) sensor platform fabricated on a flexible printed circuit, using special substrate materials for the carrier for the lab-on-a-chip components. Optimizing the properties depends not only on the right amount of flexibility but also biocompatibility.

"AI SOMETIMES GETS THE **RIGHT ANSWERS** FOR THE **WRONG REASONS** WHEN TRAINING, WHICH COULD **PRODUCE MACHINES** THAT MAKE **INCORRECT INFERENCES.**"

In the industrial world, cost savings are achieved through intensively automating processes to reduce the cost of labor and increase output. Accuracy and precision are also improved. Automation can bring these advantages to healthcare, too, enabling more people to benefit from better services and enjoy better patient outcomes. We have seen how human-guided surgical robots have improved on the fine-motor skills and visual acuity of human surgeons. Research-

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ers have also successfully used augmented reality in surgery to overlay images such as CT scans in the field-of-view that show the locations of items such as bones and blood vessels to help direct procedures such as reconstructive surgery or neurosurgery. In addition, we are seeing precision optical technology from the PCB inspection business now being applied in the medical domain to help increase the precision of brain surgery, permitting smaller incisions that minimize trauma and enable faster recovery times.

Full automation is now a promising next step. I'm involved with a group that fundraises for cataract surgery in India. India has high instances of "avoidable blindness" simply because many people are too poor to afford cataract surgery. The undersupply of qualified surgeons and costs of training are key challenges we face. We are optimistic automated laser surgery can help address these issues by reducing reliance on training and increasing the number of procedures that can be carried out per day.

Historically, laser surgery has been seen as the premium option, offering lower risk and better outcomes for the few. With greater automation, there is hope the benefits could ensure affordability for many and increase the number of operations per year. Likewise, I see full automation as the way forward for many surgical procedures, most likely using single-purpose machines. It could be a few generations before a general-purpose diagnosis and surgical station like the MedPod 720i imagined in the movie *Prometheus* becomes not only technically feasible but affordable.

There may, of course, be fears for the future. I think both human surgeons and surgical machines will be needed for a long time to come, due to generally high demand. Moreover, human expertise will be essential to direct services and oversee individual cases. As AIX-COVNET, a project developing machine learning to analyze lung x-rays from Covid-19 patients, noted, AIs will sometimes get the right answers for the wrong reasons when training, which could produce machines that make incorrect inferences. We need not only data scientists, but also domain experts, to create the machines that will provide these much needed services.

# The Case of the Unresponsive PDN

Chip caps help only if the conduction in the path is sufficient to deliver the right charge.

MUCH OF THE talk in the simulation world lately is focused on power. Even SI experts are starting to see how power has a material impact on their high-speed data transfer success. With power on the forefront, what effect will that have on the additional design demands of low-frequency supplies? Why should you consider power throughout your design process?

Signal integrity, at its basic core, studies and describes the effects physical structures have on a signal, as it is transmitted from a source (transmitter) to a destination (receiver), but makes no mention of where the energy for the signal originates, or where it goes once received. Although a bit of oversimplification, the transmitting IC pulls energy from its power supply, bundles it as a bitstream and transmits data to a receiving IC, where the energy is dumped onto the ground and eventually returns to the power supply, ready to repeat. Admittedly, today's high-speed signals are largely differential and draw from multiple power rails, so we aren't describing the exact current flow. What we are describing is the notion that reliable data transmission involves both a clean path from driver to receiver in addition to a well-designed plan to deliver and return needed power.

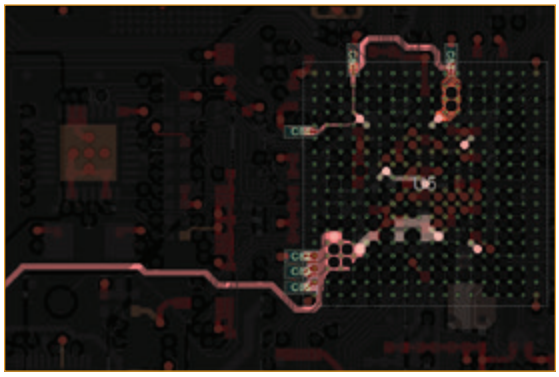

**FIGURE 1.** Routing power has become increasingly complex.

In our previous column related to power distribution (PCD&F, April 2021), we discussed capacity. Specifically, we focused on the increasing current demands associated with most new designs and showed the need to ensure our conductors (pins, planes, vias, and etch) were up to the challenge. Today we add another requirement: responsiveness. Even an IC with ample current supply could experience "power shortage" if the energy needed to transmit the data bitstream isn't available in time.

The CAP to the rescue. Fortunately, capacitors have solved this problem. Capacitors provide the PCB engineer with the ability to distribute "quick response, power reserves" at selected locations around the board. While the power supply is still responsible for the energy needed to transmit the bitstream, the capacitors provide localized supplemental boosts where needed, subsequently refilling (charging) from the supply. The result is a power distribution network (PDN) capable of supplying each device sufficient current and ensuring delivery is timely enough to support the instantaneous needs of each IC.

Meeting these power boost requirements across the entire design gets increasingly complex with multiple power requirements at differing voltages becoming the norm due to the unique requirements of chips within the design **(FIGURE 1)**. Determining the quantity, size and location of these power substations (caps) is not that different from the task faced by a city planner. For example, a well-placed substation has little value if it isn't directly connected to the population it serves, be it a municipal service or PCB power. For PCB and packaging purposes, ICs access their power source through the very structures we deal in every day: connectors, vias, etch, and planes. In fact, when we began our series (PCD&F, March 2021), we explored the use of simple modeling to reliably evaluate a power system's capacity. Resistors (really resistance) representing the power loss devices experience as they are farther from the supply would enable us to generate graphical depictions of the electrical behavior. Frequently, the necessary corrective action could be readily deduced from the graphical depiction alone. With capacity concerns in check, the focus shifts to responsiveness. Can the needed charge be delivered on time?

Deducting inductance. To answer that, we must add a means to evaluate the power system's responsiveness. When addressing the instantaneous needs of high-speed ICs, capacitors provide surplus charge, with a level of portability. This enables these reserves to be in closer proximity to the devices that draw from them, as the location and means of attachment control their effectiveness. Adding capacitors of any size, to any location, will yield little benefit if the conduction in the path is insufficient to deliver the charge the capacitors

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hold to the pins of the chip in need. Therefore, it makes sense to address the connectivity of each intended capacitor footprint and ensure the best device is selected for each location.

We used resistive loss in our power path to evaluate our DC performance and ensure our PDN would achieve needed DC capacity. In a similar way, we can look to inductance to evaluate our PDN's responsiveness. In its very definition, inductance is described as "an opposition to a change in current flow," the identical *opposition to change in current* that would restrict a PDN's responsiveness. In short, where responsiveness is a concern, inductance is directly indicative of "good" vs "bad" PDN routing. Fortunately, via the wonders of physics, inductance is quite predictable when we know the materials and the geometry of our conductors, the items we deal with daily in both packaging and PCB domains. Similar to our DC experience, resistive losses accumulate as the distance from the source increases. The inductance also accumulates over length to degrade responsiveness. Not surprisingly, things we do to improve capacity (reduction of cumulative resistance) generally also improve responsiveness (reduction of cumulative inductance).

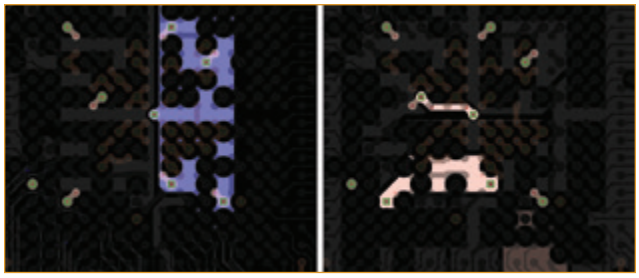

**FIGURE 2.** Intuition can fail you. Inductance won't.

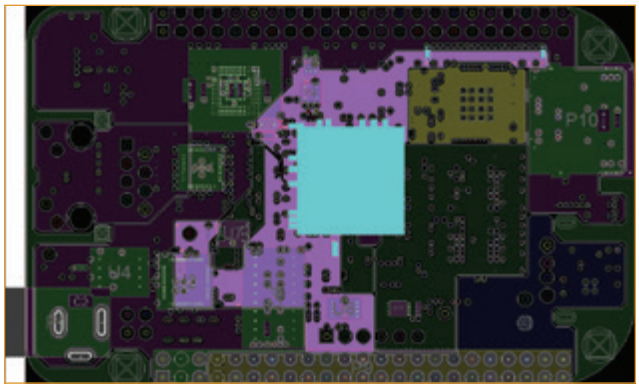

**FIGURE 3.** Decoupling strategies are evolving.

**With inductance, when things go wrong, they go wrong fast.** There is, however, a noteworthy difference in the extent to which these factors influence a product's performance. The resistive losses we associate with a PDN's capacity do degrade the output. This compromise is generally observed gradually over a large distance and is regulated by the cumulative *current* demands of all chips sharing power. By contrast, inductive loss, which can quickly defeat a power source's responsiveness, can be observed at surprisingly small distances (**FIGURE 2**). These losses, influenced much more by *frequency*, as opposed to current, represent an increasingly challenging dilemma every time the data rate ticks up. As PCB engineers now routinely see interfaces with transfer rates well into the gigahertz range, even 50GHz in a few, the demands on the PDN aren't likely to lessen. Meeting those demands, as we'll explore in our next column, is readily achievable. However, it does require a multi-level approach. Today's power delivery networks depend on contribution, not just from the source, but include regulators, DC-to-DC converters, large "bulk" capacitors, and the familiar 0402 and 0603 ceramics that decorate every PCB produced. These workhorses generally outnumber the others by orders of magnitude, and connecting them typically accounts for a significant portion of the power/ground routing. Capacitance from the laminate layers of the PCB, "in-package" and "on-die" capacitance, all become part of the system PDN equation. With schematic and stackup typically fixed, what we can control at the time of layout is inductance. We've long been accustomed to impedance-controlled etch and understand its relationship to the geometric construction (i.e., thickness and width). In fact, tools from several vendors accurately predict trace geometry that would result in impedances outside specified requirements. Controlled inductance isn't as familiar, but there are options that can predict pin-to-pin inductance. Perhaps the most controllable aspect of PDN design, outside of part selection, would be the inductance from power pin to neighboring capacitor and the inductance from supply to the power pins.

Ultimately the most significant "influencer" in terms of supply responsiveness, is the way we connect supply to power pin and capacitor to power pin. Different from most simulation objectives, tools are used to provide guidance in suspected problem areas. These simulators make quick work of discerning the good connections from the bad and can be used to optimize capacitor device selection, effectively fine-tuning even the most complex systems.

**Becoming an inductance sleuth.** While inductance is predictable, it's not intuitive, and the challenge is in identifying inductance issues (**FIGURE 3**). For example, planes can often become so perforated with vias, etc., their performance is diminished. Even adding vias to an array used to facilitate high-current-layer changes can reduce capacity if the drills obstruct the inner vias. While each of these complexities makes sense, it is only intuitive once our attention is focused on the problematic area.

Without responsive power availability, designs will fail and will often fail inconsistently, making them hard to debug in the lab. With a proper understanding of PDN responsiveness and inductance, design teams can account for these issues upfront to build the effective and responsive PDNs modern devices demand. ▫

# The OCR Solution to Data Entry

A top-down approach for reducing error-prone and time-intensive manual operations.

LAST MONTH WE talked about the often ambiguous, unstructured design data packages running rampant in the PCB industry, which drive non-value-add administrative tasks across all phases of our data exchange and processes, and we underscored the urgency to integrate "smart engineering" data-driven processes, as becoming more efficient as an industry in reducing cost and NPI cycles should be a critical objective to all organizations. What exactly do we mean when we talk about smart engineering or data-driven processes? Buzzwords and acronyms are all around us, such as digital transformation, RPA (repetitive or robotic process automation), BPM (business process management), SaaS (software as a service), etc. All encompass a similar objective: optimizing our processes throughout the enterprise.

In the PCB manufacturing facility, some classic examples of duplicated data entry when receiving a new design package are in the front-end engineering process steps **(FIGURE 1)**. Several generic steps occur across the industry, and all of these must occur, with the sequence varying based on the company or manufacturing facility. In many cases, each of these process steps are completely segregated software applications, which in essence results in non-value-added administrative tasks.

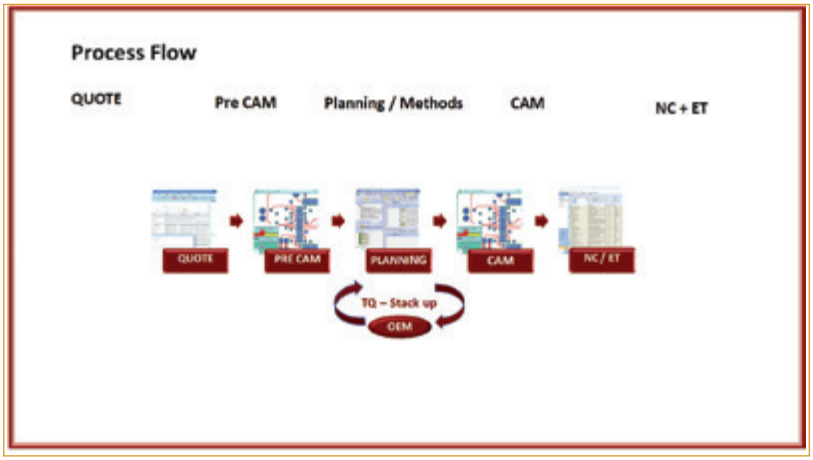


**FIGURE 1.** Most PCB operations have redundant manual data entry processes.

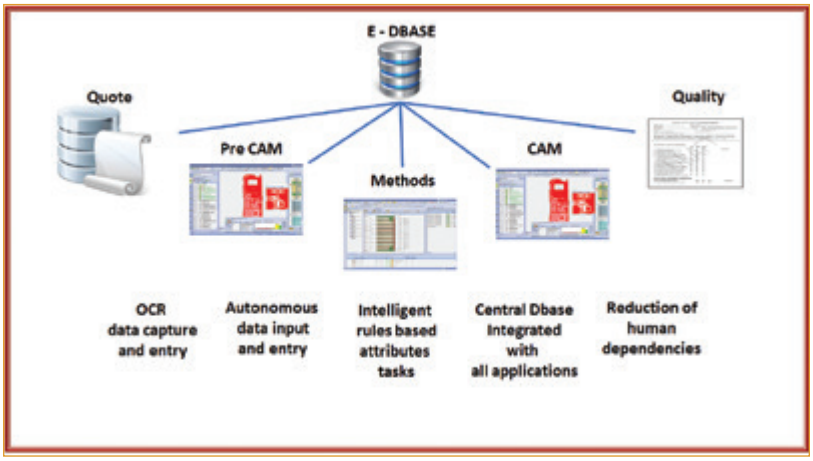


**FIGURE 2.** By entering all information into a central master database, downstream processes acquire their required data autonomously.

All the software applications we use today, from quote to engineering and CAM, require some form of data entry to complete a process step. An engineer must read the fabrication drawings, specifications (industry and customer), and manually populate the applicable defined fields. Examples are surface finish, solder mask type and color, drill and tolerances, product dimensions, materials and thickness, impedance and SI requirements, and inspection criteria, along with many other product attributes. In a typical scenario, these manual steps occur in quote, then are duplicated in engineering/planning upon order receipt, and in many instances occur once again in CAM. Multiple personnel read the same documentation and manually enter the same information into their respective software applications. The inefficiency of all this could not be more evident.

Data entry is tedious and error-prone, so how can we enter data one time only, or even make it semiautonomous? A solution is getting this information entered once at the entry point into the operation and into a central

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master database. All other related applications downstream in the process then acquire their required information autonomously (FIGURE 2). Reading the fabrication drawing is certainly still a necessity, but we eliminate manual and duplicated data entry, and simple validation checks replace the monotonous administrative data entry tasks.

Another fascinating approach I have researched the past few years provides the methodology for semiautonomous data entry. The data package arrives to the designated portal; the fabrication drawing(s) is extracted and downloaded into an optical character recognition (OCR) application; and within minutes all critical product descriptions and attributes are extracted with a quick validation by an engineer, exported into an XML file, uploaded to a central master database, and are easily accessible to all software applications in the operation.

OCR has been around for years, and frankly I was reluctant when initially investigating. It exceeded my expectations, and the results amazed me. All data package documentation, specifications (industry and customer), purchase orders and beyond would no longer require an engineer to read, interpret and manually enter in another application. Many companies in multiple industries are adopting this technology to drive efficiency and reduce costs. The potential for utilizing this in electronics industry processes is real and attainable. My next column will provide real-world examples of how this works and its benefits.

The industry as a whole must become more efficient. While we wait patiently for structured data packages to be widely adopted, there are opportunities within our operational environments to drive productivity and improve quality. Taking the first step toward smart engineering is often the most difficult, but the rewards can be bountiful. ❑

"OCR EXCEEDED MY EXPECTATIONS, AND THE RESULTS AMAZED ME."


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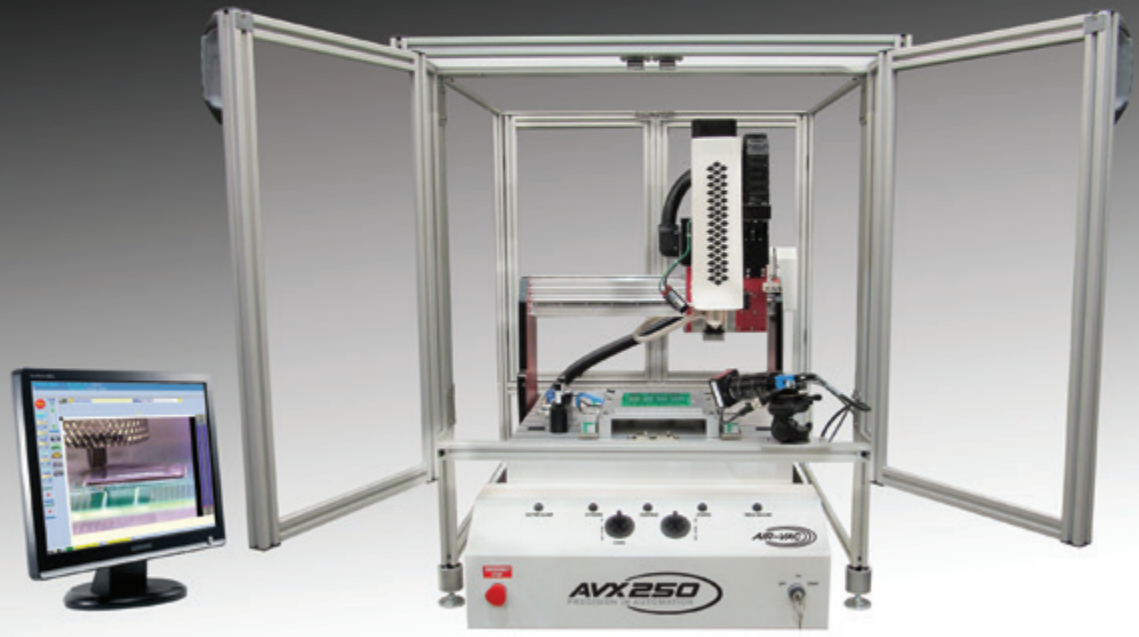


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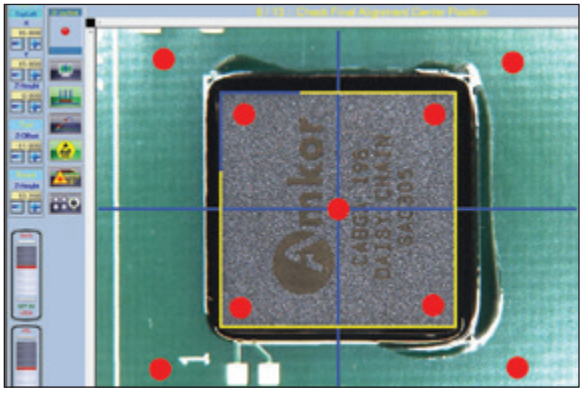
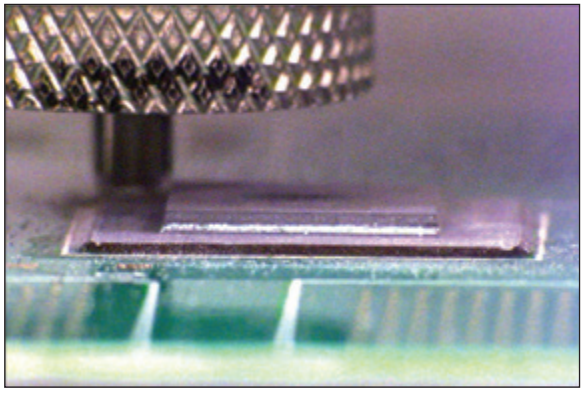
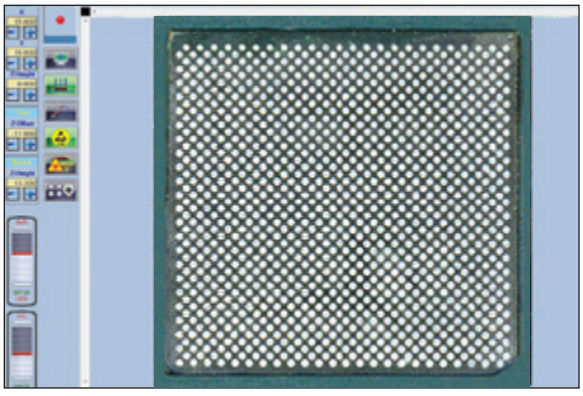


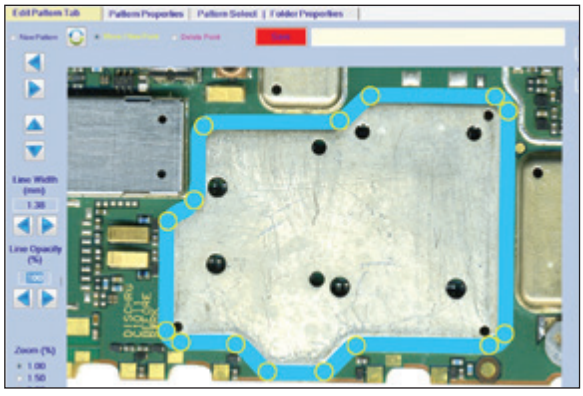
Laser Measurement



High Precision Milling



Milled Site



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*"Celebrating 30 years of business is an incredible milestone, we are so grateful for not only our customers who have placed their trust in us, but our amazing employees we refer to as our family and TEAM! We certainly could not have done it without their talent an dedication." - Curt Couch, Vice President, Count On Tools, Inc.*

"When I was brand new to the industry I had to have a custom nozzle made. Count On Tools walked me through the process and delivered a product that worked exactly as it should have. The right tool can make all the difference in the world and save hours of labor time. Count On Tools has always been responsive on quoting with fair pricing and amazing with delivery. They met and beat all expectations I had of them." - **Mary Ann, REDCOM Laboratories, Inc**

"They have gone above and beyond to help us with everything we have purchased. Any time I have contacted them, they have responded within an hour. Nozzles work just as well as brand name for a fraction of the cost." - **Clint, Syncro Corporation**

"COT is really responsive and knows our customer comes first and when we need something expedited they are on it. They are quick and friendly on any communications between us. Great customer service and everthing I order is correct and on time or early." - **Corey, Hybrid Design Associates, LLC.**

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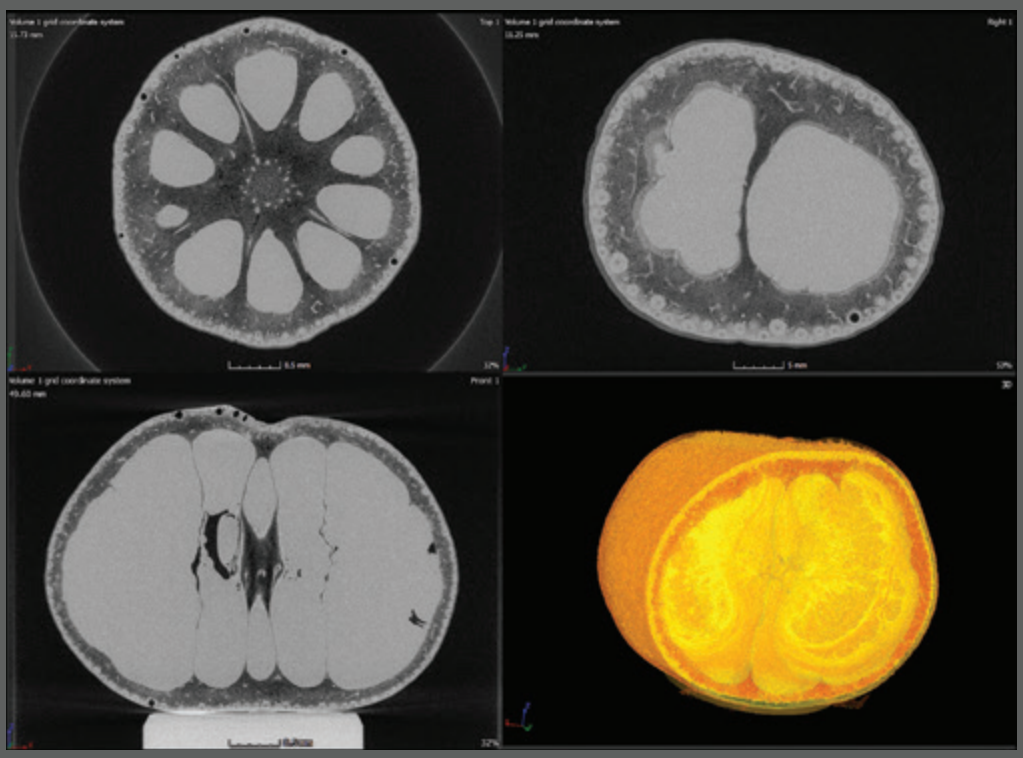

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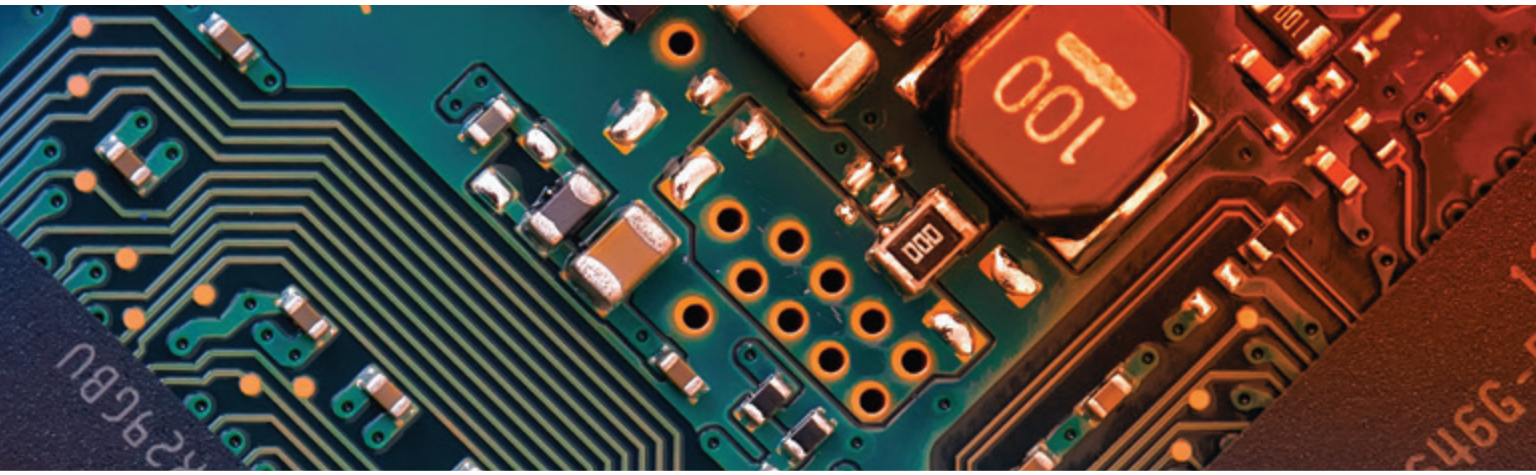

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WOSB (Woman Owned Small Business)


# Dispensing Equipment

## (iCoat-6 High Precision Selective Conformal Coating Machine)


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*Congratulations from*
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# iCoat-6

WINNER!
2021 NPI Award,
Conformal Coating:
**iCoat-6 Precision Selective Conformal Coating System**

The iCoat-6 is a highly precise, selective conformal coating machine offers closed-loop fluid heating that provides a constant fluid viscosity, even in machine suspension. The recirculating fluid delivery system offers stable fluid pressure and temperature, even under varying production and incoming air pressure conditions.

For thin-film applications, a laser film width sensor provides a closed-loop automatic adjustment of thin-film coating parameters. A dual head configuration with fixed valve separation is standard for the iCoat-6.

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**47639 Lakeview Boulevard**
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**www.anda.us**


# Soldering - Reflow

## (Health Check Service)

*The Service Team thanks you for the recognition of BTU's Health Check and of what we believe is the best customer service in the industry!*


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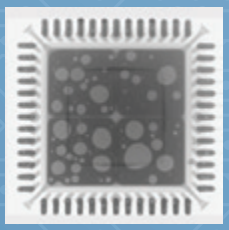
# Pyramax Technology to Eliminate Solder Voids

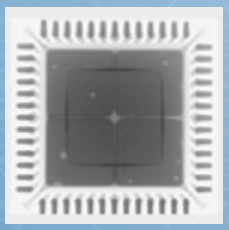
Pyramax Vacuum


Vacuum reflow is a proven solution for PCB assemblies or products that require low solder voiding for critical performance applications. Pyramax Vacuum has been designed with the requirements of large EMS, OEMs and high-volume automotive segments in mind. The system features controlled heating within the vacuum chamber enabling industry leading thermal uniformity and the tightest control of liquidus time. Processing temperatures of up to 350°C can be achieved with vacuum levels lower than 20 Torr. Integrated controls and fully automatic vacuum operation are achieved via BTU's proprietary WINCON™ control system.



**Traditional Reflow**

Voiding occurs when flux or solder paste oxidation is entrapped in the solder joint. Shown here is an MFL processed with and without vacuum reflow. BTU's vacuum reflow solution is designed to reduce voiding to <5% (process dependent).



**Vacuum Reflow**

Pyramax™
**The global standard of solder reflow**

For additional voiding data scan the code to download the paper
**Operation of a Vacuum Reflow Oven**

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# Plating

## (Elsyca CuBE)

Elsyca CuBE

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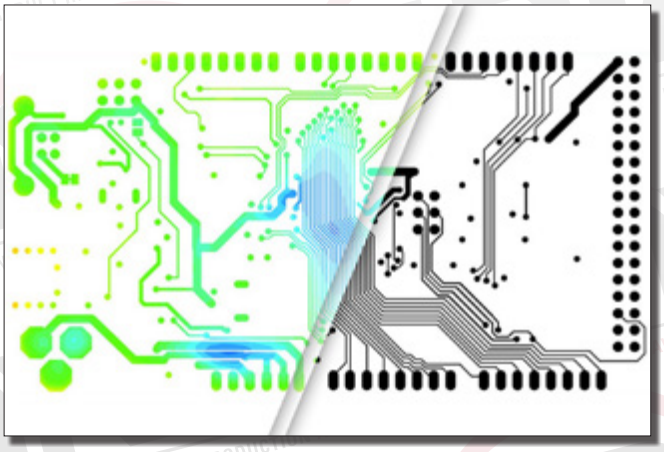

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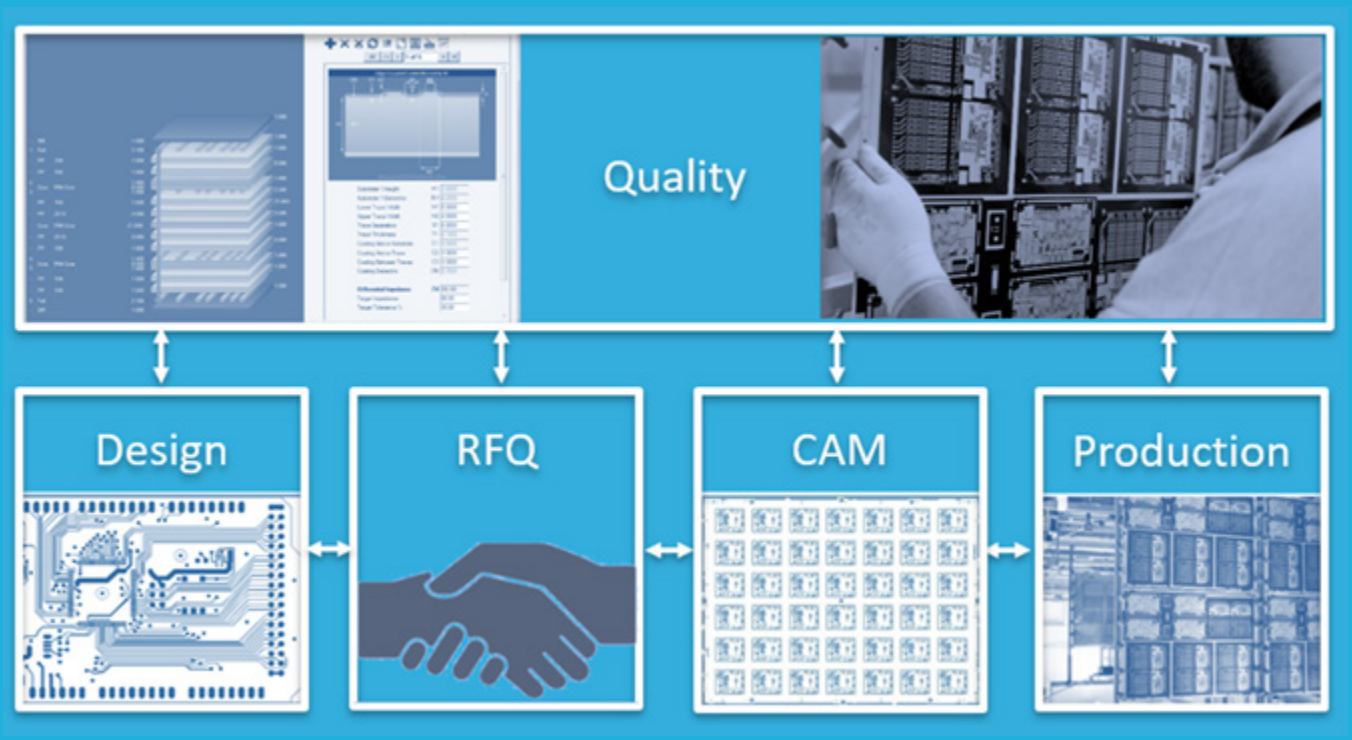
Congratulations from PRINTED CIRCUIT DESIGN & FAB

www.elsyca-pcb.com

# Our simulation technology makes the difference!




**Short lead times, correct pricing, maximizing production capacity and quality. It all requires fact-based decisions ideally based on upfront, comprehensive, objective, consistent and expert independent data.**

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WINNER

# Component Placement - High-Speed

(Decan S1 Fast & Flexible Mounter)

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# Soldering - Selective

## (iCube HighFlex)

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JUKI | LOWEST COST OF OWNERSHIP


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## SELECTIVE SOLDERING

# iCube


Some selective soldering machines have only small localized spot preheaters for the bottom. Preheating is a critical stage of the process in selective soldering, especially with Pb free alloys and thermally challenging PCBs. For this reason, the iCube comes standard with a full-size IR bottom-side preheater and optional dual top-side IR or convection preheaters that will ensure proper flux activation and perfect top-side fill even on the most challenging products.

An optional closed-loop pyrometer can ensure the required temperatures are reached before releasing the PCB to the soldering process and maintain the heat on the PCB during the soldering process. High quality, flexibility and reliability offered in a complete all-in-one package is what you get with the inline iCube Selective Soldering System.

**www.jukiamericas.com**


# Software - Process Control

## (KSMART)

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*Koh Young pioneered True3D measurement-based inspection 20 years ago to create a zero-defect future. Today, AI-powered KSMART leverages data to deliver process insights and reduce costs.*

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True 3D Smart Factory Solutions, Powered by AI

# KSMART

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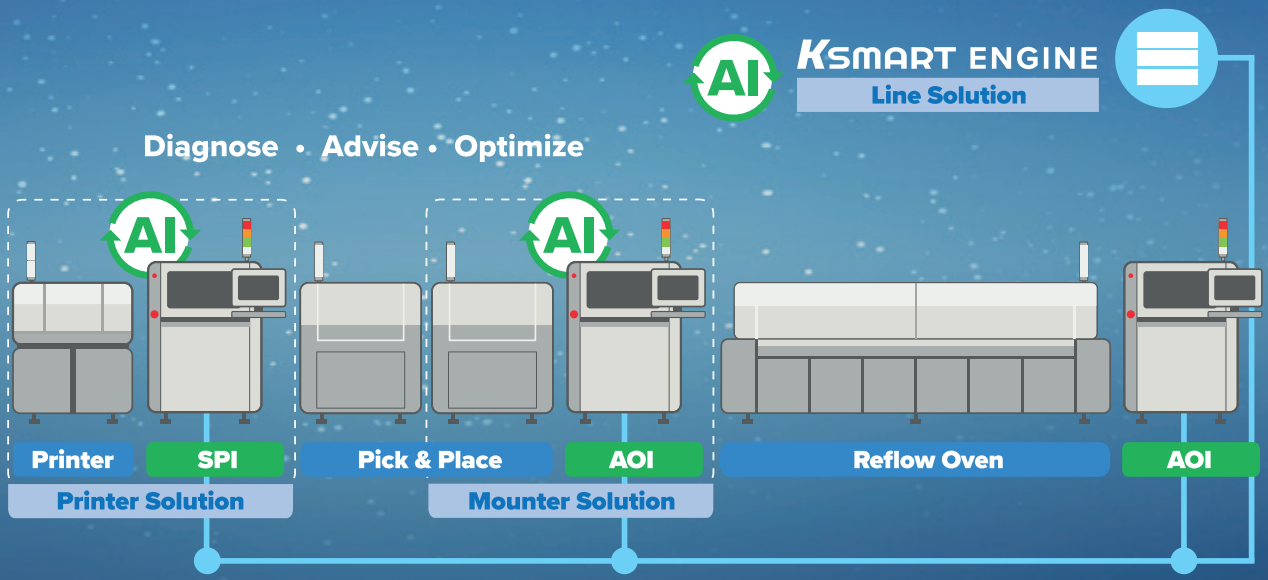


We pioneered True 3D inspection 20-years ago for a zero-defect future. Today, AI-powered KSMART leverages data and connectivity to create a smart factory.


NEW PRODUCT INTRODUCTION
**WINNER**
BEST PROCESS CONTROL SOFTWARE


# Cleaning Materials

## (Aquanox A4382 OA Flux Residue Cleaning Chemistry)

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# Soldering Materials

## (ALPHA OM-372 Solder Paste)

MacDermid Alpha ELECTRONICS SOLUTIONS

*ALPHA OM-372 is a result of MacDermid Alpha's continual commitment to further advancing the electronics industry by enabling more complex PCB designs and enhancing electrochemical reliability.*


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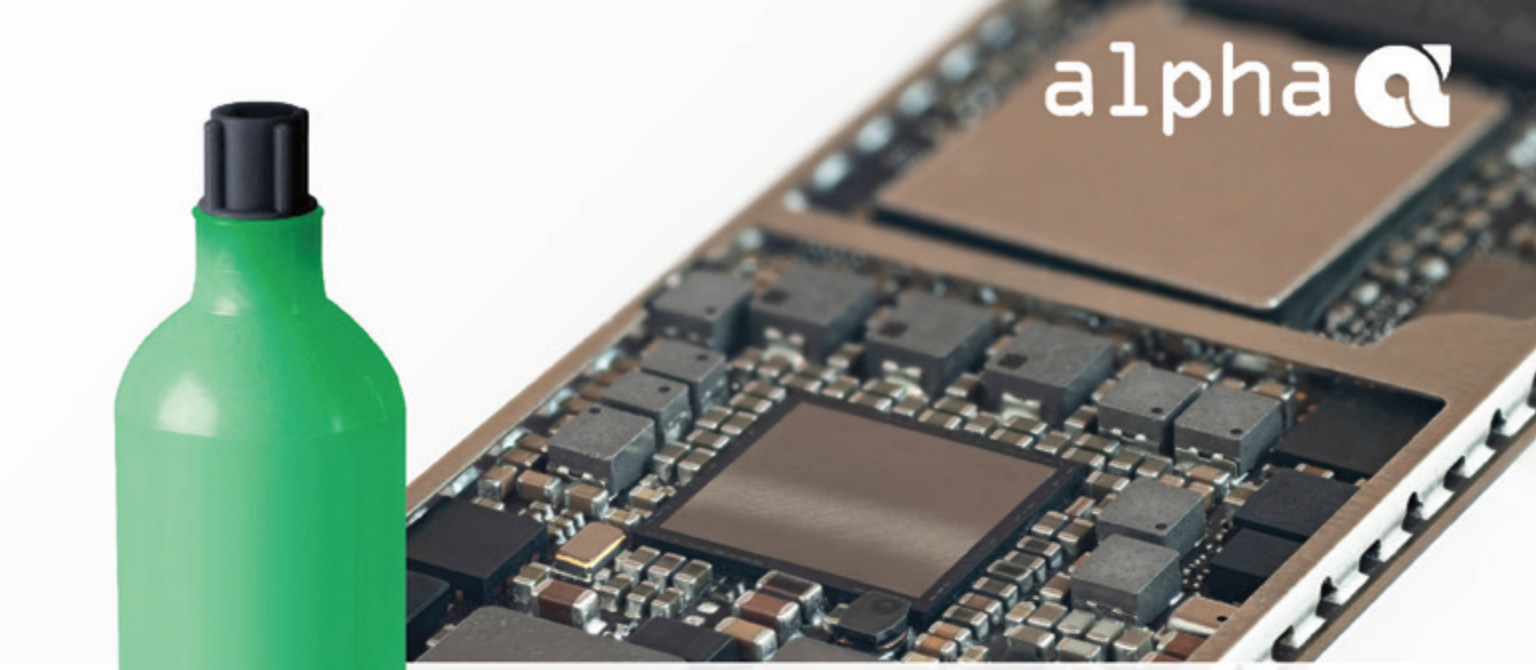

# ALPHA® OM-372

## High electromechanical reliability, ultra-fine feature, no-clean solder paste


**ALPHA OM-372** is designed for superior performance on assemblies with ultra-fine pitch components requiring excellent stencil transfer efficiency and high electrical reliability, such as those found in mobile and wearables, computing, and medical assemblies.

ALPHA OM-372 Key Features:

- Best-in-class electrochemical reliability on fine pitched low standoff packages.
- Ultra-fine feature printing and reflow capability down to 008004 components.
- Minimum post reflow residue provides high reliability performance for fine pitch, high density designs when flux is entrapped under devices
- Excellent HiP/NWO Performance on high I/O count packages.
- No-Clean, Zero-Halogen

MacDermid Alpha ELECTRONICS SOLUTIONS

www.macdermidalpha.com


# Test and Inspection – AOI

## (MV-6Z Omni 3D AOI)

MIRTEC

*On behalf of MIRTEC's talented engineering team, it is an honor to accept CIRCUITS ASSEMBLY's 2021 NPI Award for our MV-6Z OMNI 3D AOI machine.*

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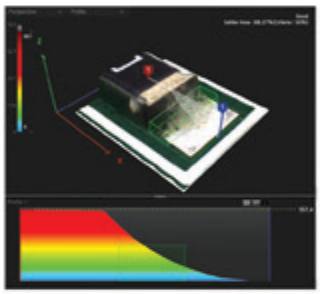
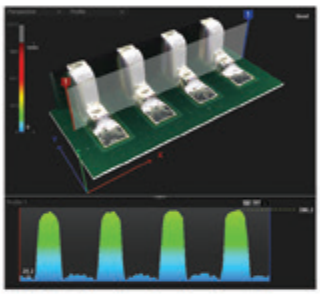
# MIRTEC


"VIRTEX is a trusted technology partner providing Electronics Manufacturing Services (EMS) to customers in the high-reliability aerospace and defense, government, medical, and industrial markets. With eight facilities located strategically throughout the US and Mexico, we are able to serve our customers on a local/regional level. In order to meet our stringent quality standards, we need equipment to guarantee that what we do, we do well! MIRTEC has been an ideal partner providing us with outstanding inspection equipment and super responsive technical support. MIRTEC's MV-6 OMNI machine provides real time data collection and reporting ensuring that the superior execution and quality that VIRTEX stands for is evidenced in the products we deliver to our customers, every time, every day!" Brad Heath - CEO and Founder of VIRTEX



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# Test and Inspection - SPI

## (Omron/CKD VP9000 3D SPI)

OMRON

SPI AOI AXI

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OMRON SPI | AOI | AXI

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# VP9000 3D SPI

- True yield and process improvements
- Innovative and advanced features
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CKD


# Test and Inspection - AXI

## (iX7059 Heavy Duty Inspection System)

VISCOM
vision technology

*Full Production in Place: Viscom's executive officers Peter Krippner and Carsten Salewski at the production site of the NPI Award-winning iX7059 Heavy Duty Inspection and other iX7059 inline X-ray inspection systems.*

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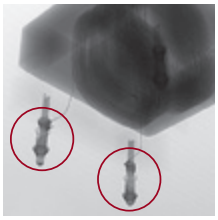
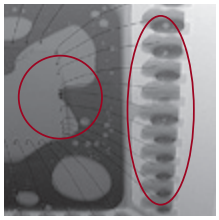
# Innovation is in our DNA:

## Future-ready inline X-ray inspection of power electronics for EV









**Large, heavy, and solid assemblies – encased or as complete models – require a 100% quality assurance.** As a result, perfect-fit inline X-ray inspection in 2D, 2.5D, or 3D is the first choice for high current and high voltage electronics. With its iX7059 Heavy Duty Inspection solution, Viscom is setting a new standard for fast, high-precision inline X-ray inspection. The special transport system enables seamless handling of inspection objects on workpiece carriers or in soldering frames with a weight of up to 40 kg – a unique feature that offers huge advantages for trending segments such as e-mobility, new energies, and telecommunications.

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WINNER

3D SPI | 3D AOI | 3D AXI | 3D MXI | 3D Bond | CCI

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# PCB ENGINEER EDUCATION:
## And Then There Were 2

New (and different) industry programs fill (wide) gaps of academia. **by CHELSEY DRYSDALE**

In the 2020s, receiving an undergraduate – or even a graduate – degree in one's chosen area of expertise is no longer enough to start a career, let alone sustain one. We must all be lifelong learners to keep abreast of new information, technology, and processes to flourish. Continuing education is not an option; it is a must. The PCB design occupation is no exception. Cue scores of passionate subject matter experts, eager to impart decades of knowledge gleaned from on-the-job training, higher education, face-to-face interaction, and teaching in a time when the industry struggles to replace veterans who are retiring at a rapid pace.

In March, PCD&F reached out to the creators of emerging online programs available to those interested in perfecting design and layout of printed circuit boards. First, PCD&F spoke with Michael Creeden, CID+, and Rick Hartley, BSEE, CID, via Zoom about their new self-published manual, *Printed Circuit Engineering Professional,* and the instructor-led program that accompanies it: Printed Circuit Engineering Designer (PCED), available from a national training center.

Creeden and Hartley, who coauthored the 400+ page A-to-Z reference guide with Gary Ferrari, CID+, Susy Webb, CID, and Stephen Chavez, CID+, are directors of the nascent Printed Circuit Engineering Association. PCEA is offering those who complete the program a new certification, Certified Printed Circuit Designer (CPCD).

We also spoke with EPTAC, the training center that is promoting and offering the new program, to discuss its role in the PCED program.

Finally, we turned to IPC, which is updating its Certified Interconnect Designer (CID) program, moving it to an online course. (Disclosure: UP Media Group president Pete Waddell and editor-in-chief Mike Buetow helped develop the original CID program, and Buetow is a director of PCEA.)

PCD&F inquired about the origins and impetus for the program, goals and learning objectives, as well as how it compares to other educational training currently available. The transcript is edited for length:

PCD&F: What was the original rationale? Why did you want to create this program?

Creeden: That's a wonderful question. Statistics and our personal experiences indicate there's a critical shortage of trained professionals to accomplish this circuit layout, and industry really has failed at replacing designers. The BSEEs graduating from universities are being conscripted to accomplish their own layouts, and very few, if any, have formal education to be successful in laying out boards.

Hartley: That is the bottom line. We realized we had to come up with a way to train these people to do printed circuit design and engineering because they weren't going to learn it in college.

PCD&F: What are your goals for the program?

Creeden: We had to figure out who the target audience was for this course, and the answer was actually broad and singular, meaning anyone involved in printed circuit engineering – from schematic to layout to fab or assembly – but specifically, anyone required to accomplish printed circuit engineering layout. That could include a college graduate, or a seasoned designer seeking to gain high-end signal integrity applications and solving some dense place and route of high-speed design or RF circuitry. At the same time, they want to understand some of the manufacturing relevance for both high yield and high reliability.

Hartley: Most of us [who developed the PCED] have decades of experience, and we wanted to impart that knowledge to the newcomers, so they would have the opportunity for success fairly early on in their careers and not have to wait three decades to figure out what they're doing.

Creeden: The curriculum is called the *Printed Circuit Engineering Professional*. It's meant to be much more encompassing than just how to do layout. A lot of other curricula exist,

and often they are targeted. A lot of CAD software vendors put up content with the hopes to sell their software. CID and CID+ are wonderful programs, and I still teach those. What they did was they took an existing designer and taught them about manufacturing and standards, which is wonderful. Our course attempts to do all of that and so much more. It truly covers everything from manufacturing to schematic and circuit development, primarily focusing on the layout, making the actual tooling, putting that circuit into a tooling that can be built – and that it can be built for test compliance, usage … so many things. You have to teach both the standards and the manufacturing content.

PCD&F: What will the engineer learn?

Creeden: They're going to learn what we call an A to Z for the profession. Very few engineers graduate saying, "I want to be a designer." But what they find is doing the layout is what is truly what they need to do. So, when they take this curriculum, they will be highly employable. If I'm at a Fortune 100 company, and I'm trying to hire two engineers, I'm going to hire the person who understands engineering circuitry but also can put that into a layout. This curriculum is what we call CAD tool neutral because CAD is always evolving, and the depth of functionality that CAD tools have is incredible, but there's a whole learning to that, and what we found is learning a CAD tool is kind of equivalent to learning to use a socket set. It does not make you a mechanic. This is a science of the mechanics of printed circuit engineering.

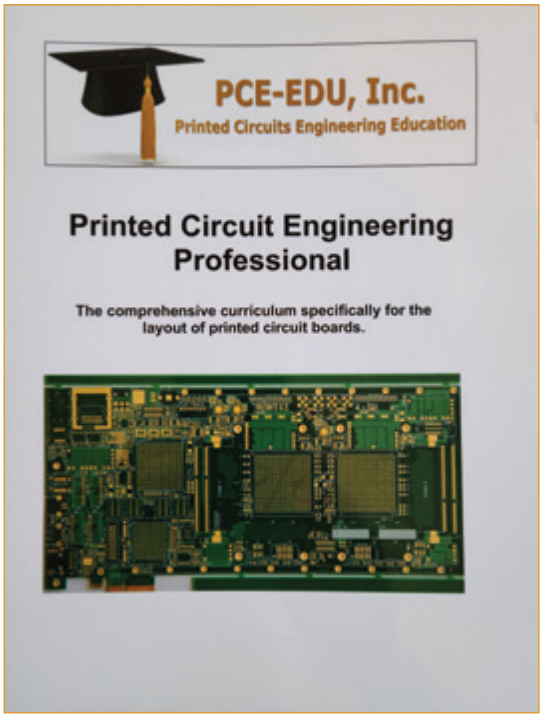



**FIGURE 1.** The new 400-page *Printed Circuit Engineering Professional* manual was released this spring.

Hartley: I was in one of Lee Ritchey's classes probably 20 years ago, and someone asked, "Lee, what in your opinion is the best CAD tool?" He said, "My father was a master carpenter, and he used to make cabinetry and things that were just magnificent. When I tried to repeat what he had done, I made boxes that didn't have good joints, that fell apart, and just had problems. When my dad bought power tools to make his job go faster, I used power tools and simply made junky stuff faster. That's the way CAD tools are. Having a CAD tool doesn't mean you can do the job. It means you can do it faster once you learn the tool."

[Lee] said, "There is no one CAD tool, in my opinion, that's better than the other. The one that feels best in your hands is the one you should use."

You have to learn the art and the craft of printed circuit design. That's the key.

Creeden: I get asked that question a lot. To me, the best CAD tool is the person sitting behind it. There really are no prerequisites to this course. It's truly geared to support someone coming into the profession and also someone who has been in it for years.

PCD&F: How does this program improve on what's already in the market? What differentiates it?

Creeden: It was our intention to make something very contemporary. This truly addresses changes occurring today and tomorrow in the industry. Several curricula were written decades ago, and therefore don't reflect many current challenges with today's circuitry and technologies. Many of them approach it from what I would call a "focused" perspective, whether it's standards, manufacturing, CAD tool, or just solving layout – or maybe it's just signal integrity or power delivery. We attempted to do it all, and we did it in a flow basis [reflecting how] you actually perform the task.

Many curricula give what I would call an exposure. Let me take you through *one* circuit, and I'm going to teach it to you on a CAD tool. If that's not my CAD tool, then I'm a little disadvantaged taking your course. It just exposes you to one circuit. And one thing we've learned in printed circuit engineering is, for example, a 5Ω line to a high-speed digital engineer is so different than a 50Ω line to an RF engineer. So, what's the difference? Read the book. You're going to find out a lot. We call it the nuance of design engineering.

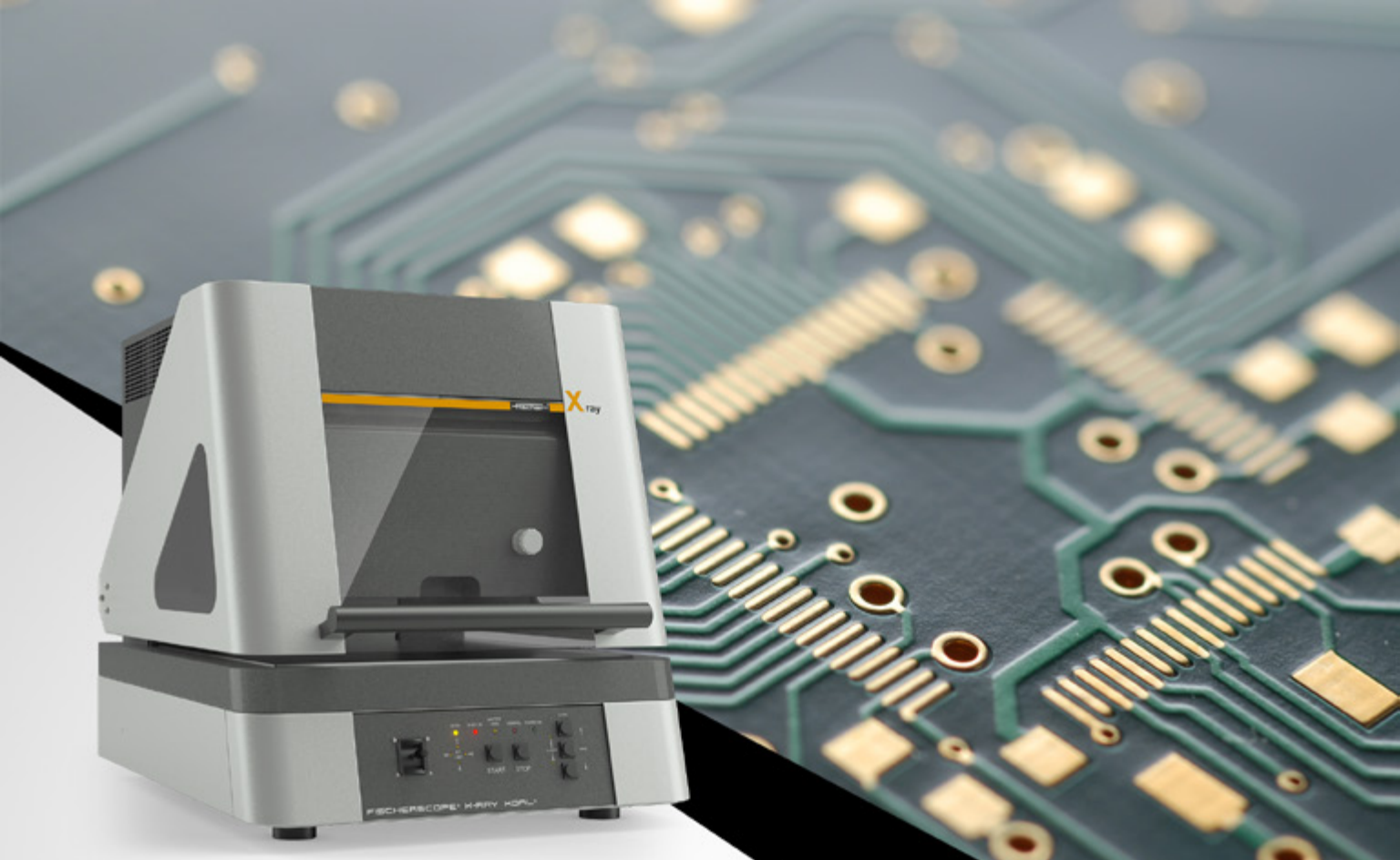
[*Printed Circuit Engineering Professional*] is a lifelong reference book. It includes some 400 pages, supplemented by 800 PowerPoint slides.

PCD&F: Who's teaching the course?

Creeden: The course is licensed exclusively to EPTAC in North America. We have 10 seasoned instructors who are all members of the PCEA.

PCD&F: Are they offering it already?

Creeden: Yes, in the second quarter we'll hold our first



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## Building on Legacy Design Training

*IPC launched the Certified Interconnect Designer program in 1995. At the time, it was met with some skepticism, as many veteran designers felt it took decades of trial by fire to perfect their craft.*

*Today, hundreds of designers have passed the CID exam, which now includes an advanced version, called CID+. PCD&F contacted IPC about its design training program, available at https://training.ipc.org/design-training-programs. Carlos Plaza, senior director of education, IPC responded to our questions via email.*

**PCD&F: Discuss the goals and rationale of the IPC PCB Design curriculum.**

**Plaza:** The IPC PCB Design curriculum provides training for new and current PCB designers at any stage in their career. The programs cover the techniques, methodologies and standards necessary to be successful in the design and development of printed circuit boards and assemblies for product applications across different sectors of the industry.

These focused, hands-on courses are especially important today because many of the current experts in the field are retiring and thus unable to pass on their knowledge and skills. No less important, the courses also provide a practical understanding of how to apply IPC standards to meet customer design requirements. The live online format allows veteran IPC instructors with decades of experience in the field to explain the nuances and interconnections between the many different design, fabrication, and material standards.

**PCD&F: What's in it for the design engineer?**

**Plaza:** The IPC courses allow participants to tap into the valuable insights that our instructors have garnered over a career spanning several decades and different sectors of the electronics industry. IPC training and certification courses also carry the weight of an organization dedicated to the advancement of members of the electronics industry since the inception of the modern printed circuit board itself. Employers know and rely on the training and certification programs to help their staff acquire the knowledge and skills required to effectively produce quality products to industry and customer specifications.

**PCD&F: How does it improve on what's already in the market?**

**Plaza:** Over the last three decades, IPC standards and certification programs such as CID and CID+ have played a critical role in protecting public safety and promoting excellence by ensuring the quality, reliability, and consistency of electronic products. However, the electronics industry recognizes they are only part of the solution. Surveys, interviews, and meetings with industry members revealed the need for the theoretical knowledge and practical skills required for both new and experienced designers to produce quality boards to customer specifications. In response, IPC worked with industry experts and instructional specialists to identify and impart the specific competencies that companies require of their designers to remain competitive.

These courses provide the practical knowledge and skills that designers need to do their jobs today.

The courses combine the experience of expert designers and instructors with job-specific exercises and projects to facilitate mastery of the key concepts required by circuit board designers. Weekly live online sessions allow participants to ask questions, clarify doubts, and address any issues that participants may have when they apply concepts to the actual design and layout of a board built to industry standards. This translates to applicability. Unlike other offerings on the market, past participants often echo one recent student when he observed that he "was able to directly apply lessons to things that I am currently working on at my job."

**PCD&F: Who is teaching it?**

**Plaza:** Kristopher Moyer, C.I.D.+, an IPC-certified industry expert with 25+ years of industry experience in many areas of board design, including high-precision low-voltage, sensor and signal conditioning, industrial controls and automation, and military and commercial aerospace.

**PCD&F: What background should someone have before sitting for the workshop?**

**Plaza:** It depends on the course. For example, those taking PCB Design need only have a basic understanding of electrical engineering concepts, while those taking more advanced courses such as PCB Design for Rigid-Flex Boards should be familiar with concepts such as schematic generation and signal integrity. Visit the course product page on training.ipc.org for a complete description and suggested prerequisites for each PCB design course.

**PCD&F: Does it require knowledge of any certain CAD program(s)?**

**Plaza:** A working understanding of any CAD program used to design PCBs is helpful but not necessary for introductory courses.

**PCD&F: Are any specific CAD tools used to teach the workshop?**

**Plaza:** The course is taught using the Altium Designer platform, and IPC provides a license for all students to use it during the course. However, it is not necessary to use Altium for the course, and the students may use any CAD tool they prefer for the projects in the class.

**PCD&F: What does this mean for the CID designation?**

**Plaza:** These courses are excellent preparation for the CID/CID+ certification exams. After completing these courses, participants will have the skills necessary to feel confident taking the CID/CID+ certification exams.

**PCD&F: Will those who pass the CID or CID+ exams have to periodically recertify?**

**Plaza:** Right now there are no recertification requirements for CID and CID+. – *CD*

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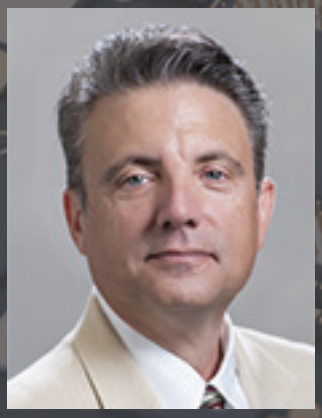

## Greg Papandrew

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classes. You can go to eptac.com/etrainings/printed-circuit-engineering-designer-online-program. You'll find the online courses there. It is also being made available to universities, not two-year colleges. This is for four-year colleges – essentially a matriculated student in a four-year degree program. The book is not available commercially. Our goal is to make better layout engineers. We feel [the book's] effectivity is brought through this training program.

The curriculum is also supported with an optional, industry-recognized certification. You do not have to obtain the certification if you don't want. Some just want the education. Some want the industry recognition. I would encourage you to do so because many employers really take note of this.

People pursue professional development because they want recognition, and they want education. How much value do you want to bring to your employer and to your own career?

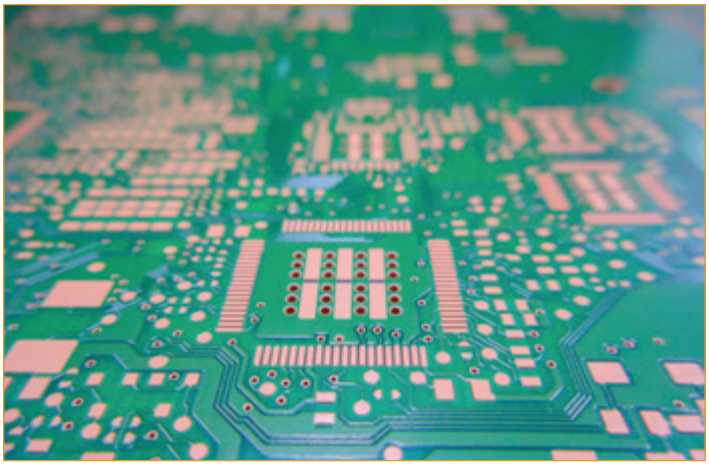

**FIGURE 2.** Backed by the PCEA, the new PCED curriculum is CAD tool neutral and focuses on the science of printed circuit engineering.

PCD&F: What does this mean for the CID designation?

Creeden: I think both are of value. This course is more contemporary. It is geared more toward empowering someone to perform engineering layout and all the associated relevance: standards, manufacturing, signal integrity applications. It's truly to perform the profession of engineering layout. I think CID, in its intentions, was to empower an existing designer to comprehend standards and manufacturing. CID and CID+ were written to take an existing designer and empower them with understanding standards of how their boards are built.

PCD&F: What background should someone have before taking this workshop?

Creeden: There are no prerequisites. It's appropriate to a beginner entering the profession. It is appropriate for a college graduate (a BSEE), and it is equally appropriate to a seasoned veteran who wants to understand many advanced packaging skills and high-end signal integrity applications and power delivery.

Rick has written a bonus seventh chapter to our book, and it is part of Rick Hartley's magic. It is essentially a very good overview of a lot of signal integrity, both theory and application. This is equivalent, in my perspective, to a master's program body of knowledge. I would call the rest of the curriculum approximately a fourth year of college. Most of the universities we've talked to are going to target this to a fourth year in a BSEE program.

PCD&F: Are any specific CAD tools used while teaching the workshop?

Creeden: No. We've created lab sections, whereby you can take the labs and apply them on your CAD tool. The reason is CAD vendors update their software as often as quarterly. So, we want to leave it to [students] to go to [software companies] for CAD software usage. They're the best ones to get that from.

However, we do teach in the book many ancillary things. It's not just about circuit design. We teach about program management. We teach about industry conventions. We teach about CAD tool utilization and proficiency. So, we talk about how to master your CAD tool, but we do it in a broad sense, so you can apply it to your specific tool. We talk quite a bit about tool efficiency, understanding conventions, and how to make procedures.

PCD&F: You mentioned the PCEA as the certifying body. Could you elaborate?

Alden Lewis and Mark Pilkington, EPTAC: EPTAC was approached by the PCEA informing us they had created a new printed circuit design program titled Printed Circuit Engineering Designer (PCED). This professional development program teaches the profession of layout engineering from A to Z and is written completely from a designer's perspective, encompassing the disciplines of PCB fabrication, assembly, testing and repair. It includes the latest technologies, materials, components, manufacturing equipment, and testing equipment and procedures.

Creeden: There are three entities: PCE-EDU is a curriculum development company. We have licensed this training program to EPTAC. Therefore, EPTAC is the one that's presenting this curriculum to the industry. PCEA is the certifying body.

When we created this curriculum, we approached many people in the industry. We approached other trade associations: IPC, SMTA. We approached the CAD companies, and eventually we settled on the PCEA. They were the last ones we asked because this has been a couple years in development, and they're new as of 2020.

You sign up at EPTAC. You will be sent the book, and then you have one to two months to read it, and then we will gather for a lectured review. The lectured review is live regionally when we come out of the Covid era, but the course is also available online, and it will be taught with a one-week commitment – a

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**PCD&F: Will EPTAC continue to offer the CID and CID+ programs?**

**Lewis and Pilkington:** EPTAC will continue to offer both the CID Designer and CID+ Advanced Designer programs, as there are organizations and individuals who want the IPC certification and to be taught a design course from the perspective of the fabricators, with an emphasis on the IPC standards associated with circuit design.

**PCD&F: Will EPTAC offer the new IPC PCB design certification of completion programs as well?**

**Lewis and Pilkington:** IPC's PCB Design series of courses are only offered directly through IPC and are part of IPC's Education series.

**PCD&F: How is the new PCED program priced?**

**Lewis and Pilkington:** Priced competitively, the PCED program is a 40-hour program that includes the PCED training manual, which is designed to be kept and utilized as a permanent reference resource for the design of electronic circuits. EPTAC offers both individual enrollment pricing, as well as pricing for dedicated group classes. □

**FIGURE 3.** The PCED program is ECAD tool agnostic.

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# Enabling HIGH-PERFORMANCE RF DEVICES with Photosensitive Glass Ceramics

A lower cost, highly accurate way to integrate passive devices.

by JEB FLEMMING

Photosensitive glass was invented in November 1937 by Dr. Donald Stookey of the Corning Glass Works. It was made public 10 years later, on June 1, 1947, and patented in 1950. Most will know glass ceramics from their glass stove top or the iPhone 12 Corning Ceramic Shield screen.

Glass is amorphous, meaning it has no crystalline structure. It's just a random assortment of molecules in a solid matrix. Ceramics, on the other hand, are crystalline structures of various types and compositions. Glass ceramics can exist in both the amorphous glassy phase and the crystalline ceramic phase. Glass ceramics are used in either one of those two states: 100% glass or 100% ceramic. For example, a Brown stove top is 100% ceramic, and the Samsung Gorilla Glass screen is 100% glass.

Photosensitive glass ceramics are a small subset, where microscopic regions of glass are converted into the ceramic phase. We call this a "dual-phase" or "two-phase" ceramic/glass structure, mostly glass with little bits of ceramic in them.

## 3-D Passives

Passive components have a rather boring name, which undervalues their role in electronics. In fact, passives are an essential part of any RF circuitry. One way to think of them is as the circulation system of RF chips. Historically there have been two major paths for manufacturing passive components.

The first path is discrete surface mount technology, in which a manufacturer will make a chip inductor and chip capacitor, and then assemble those on a PCB.

The second path, called integrated passive devices (IPDs), is where an inductor and capacitor are combined in a manufacturing process into a single device, not attached individually on a substrate such as FR-4. The value in this approach is due to the shorter connections between components, and the elimination of solder and solder pads, which cause significant system losses. And with IPDs, efficiencies go up and power consumption goes down. Both historical processes are planar and two-dimensional, which limits the quality factor, called Q (higher quality factor means lower loss), especially in an inductor.

The 3-D IPD (three-dimensional integrated passive device) offers the best performance of all. The integration of inductors, capacitors and resistors embedded into a single chip results in low system losses **(FIGURE 1)**. 3-D inductors provide larger inductance value per given surface area and higher Q due to enhanced magnetic storage. Reduced parasitic capacitance increases the self-resonant frequency (SRF), permitting higher operating frequencies. An added benefit is precision 3-D control of distance between inductor coil windings. This improves the tolerance of inductance and SRF, both essential to higher-frequency applications.

PSG (photosensitive glass-ceramic), the backbone of 3-D IPDs from 3D Glass Solutions, has exceedingly small through-holes (vias) down to 10µm that are used for electrical redistribution through the glass. This is done to spread out the inductor windings to both the top and bottom of the PSG to enhance the magnetic storage without increasing the surface area. Alternately, for a given inductance and surface area, the inductor turns could be spaced farther apart, reducing the parasitic capacitance between turns to boost the SRF. Benefits of PSG for electrical devices include getting the RF prop-

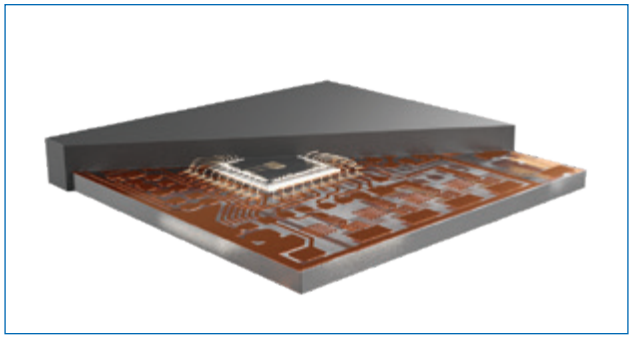

**FIGURE 1.** SIP with integrated passives and wire-bonded IC for fully functional system-in-package.

erties of glass with the strength of ceramics, and a low-cost, high-precision batch manufacturing process to produce the vias in glass. Additionally, PSGs have an intermediate thermal expansion, so vias can be filled with copper to make low-loss connections between the top and bottom of the device.

Being able to perform additional processing adds flexibility. For example, an inductor may be integrated by making a cavity and filling it with a magnetic material. These are second, third and fourth degrees of freedom that aren't available with other types of materials or processes. PSG enables these types of additional features (cavities and filling with magnetics) that can't be done at scale with ceramic boards, PCBs, or low-temperature co-fired ceramic (LTCC). PSG materials enable additional mask, etch and metal filling manufacturing steps, permitting these second, third and fourth degrees of freedom.

Another benefit of PSG is the cost. The cost is the same to make one hole or a million holes. Competitive technologies that make through-holes in glass rely on lasers, literally lasering every single hole individually.

In the novel technology, holes are not drilled. Instead, they are formed using ultraviolet (UV) light and a mask to start a chain reaction in the glass **(FIGURES 2 to 6)**. In this chain reaction certain molecules accept a photon and donate an electron to a different molecule. This creates a chemical change at the nanometer scale. Baking, the next phase of the process, converts the exposed regions into a ceramic micro-pattern. In the final phase, acid is used to preferentially eat away the ceramic phase, while not touching the glass phase.

The ability to create exceedingly small and precise vias enables much higher density interconnects compared with the traditional PCB process. Density can be increased by stacking several glass layers. Also, the ability to create cavities with ease presents a unique opportunity to tune the properties of the substrate, which is not practical when working with traditional substrates.

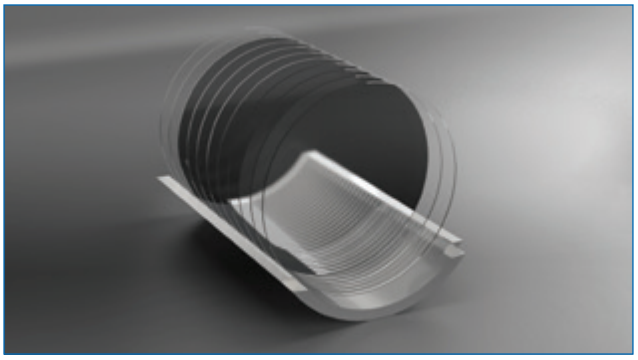

**FIGURE 2.** PSG wafers used in assembly of the novel processes.

## Repeatable Manufacturing

It all goes back to chemistry 101. The two fundamental principles are accuracy and precision, and they're very different. Both are necessary when manufacturing high-performance devices.

On one end of the spectrum is a very precise, repeatable manufacturing process that can make a single through-hole or a million, all going at the same 50µm size. The precision of the novel technology is tight, less than 1µm, compared to other technologies that might achieve +/-7 to 10µm. Building devices with precision ensures that if a million are built, they all behave the same. Such repeatability leads to high part yields and cost savings.

The other manufacturing principle, accuracy, means hitting the bullseye on the dartboard every time. The accuracy is possible by utilizing standard lithographic techniques used in the semiconductor industry. This level of manufacturing accuracy, when coupled with accurate 3-D electromagnetic (EM) simulation, leads to fewer design iterations and shorter time to production.

With precision and accuracy, systems can be designed to meet real world requirements. That means RF designs can be manufactured to accurately meet the requirements of a wide array of frequencies, from 400MHz to 300GHz.

## Applications Everywhere

Potential applications for 3-D IPD technology span a variety of fields, from 5G/6G wireless, optical transceivers in data centers, wi-fi, internet of things (IoT), ADAS radar sensors for autonomous driving, to gesture recognition, healthcare diagnostics, and much more.

Almost too many potential applications exist for this technology. Recently, we have focused on applications within the biggest markets, as well as some of the most challenging applications. Recently, most requests are around 3GHz to 7GHz because that is where a lot of market demand is. The high millimeter wave (mmWave) frequency, around 70GHz or higher, is another area of focus. They are sweet spots because it is difficult for other technology to create devices that perform well at these frequencies.

## The Design Process

With the onset of 5G and other advanced technology requirements, designers are faced with the daunting task of creating circuit designs that operate anywhere from <1GHz to the extremely high frequency mmWave spectrum above 100GHz, sometimes simultaneously, for signal coexistence.

Designs include lumped component IPDs in the sub-6GHz band, ranging in complexity from basic inductors and capacitors to low/high/band-pass filters, diplexers, baluns, couplers,

**FIGURE 3.** Mask, bake and etch PSG for vias, slots or other shapes to form 3-D structures.

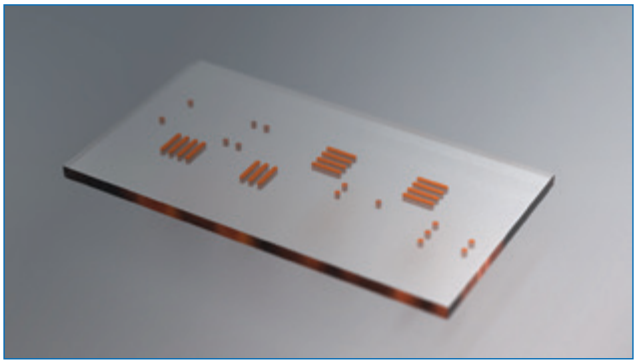

**FIGURE 4.** Plate and fill cavities with copper.

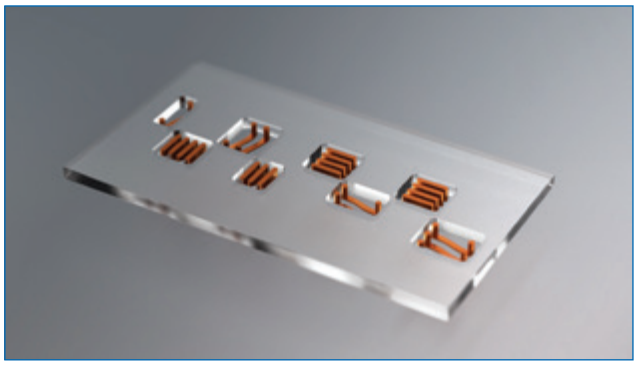

**FIGURE 5.** Plating of front and backside interconnections.

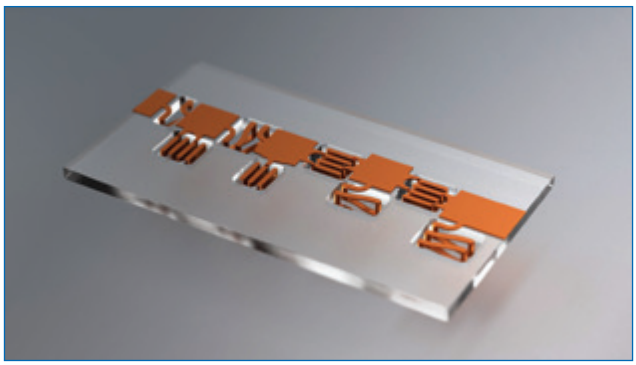

**FIGURE 6.** Create IPD by means of metal sputtering.

and to complex integrated designs in mmWave frequencies going all the way up above 100GHz.

The novel substrate technology is amenable across this entire range of frequencies. Like any substrate technology, it comes with its own set of process rules that need to be followed to yield reliably manufactured parts.

3D Glass Solutions (3DGS) decided early on to provide designers with resources on how to use the technology. The company built a robust set of design rules and published these to the broader market, so design engineers would have all the information needed to successfully utilize the technology.

Then, 3DGS embarked on a one-year strategic project with Cadence AWR Software to move these design rules to full software-based Product Development Kits (PDKs). PDKs exist for a variety of applications, allowing customers to accelerate their designs without having to spend a lot of time learning the design rules.

Multiple 3DGS PDKs in AWR enable designers to rapidly build up full 3-D EM circuits in the technology, and provide a quick design turn-time. Designers spend less time learning the individual process rules and building parameterized models from scratch. 3-D models of various types of inductors, capacitors and transmission lines are available for drop-in placement in the circuit. Also, the in-built circuit models permit easy

*continued on pg. 76*

## Invested in Technology

3D Glass Solutions chose to tackle the issue of scaling manufacturing within its own facility and with factory partnerships. That way the technology can be scaled up in terms of volume and in terms of location or geography.

3D Glass Solutions is located in Albuquerque, NM. Not every product can be made there, however. In some cases, overseas production is required. A global supply chain is being created that has flexible, elastic capacity, adjusting to demand where needed.

Two of the main investors in 3D Glass Solutions, Murata and Lockheed Martin, are strategic partners. Coincidentally, they are on fundamentally different ends of the spectrum as far as what is needed from the relationship.

Murata is the world's leading producer of RF devices, making billions of inductors and capacitors each day. 3D Glass Solutions works with Murata on the next generation of these simple devices.

At the other end of the spectrum is Lockheed Martin in the aerospace industry. Lockheed is principally concerned with size, weight and performance (SWaP) and needs to take evolutionary leaps for its customers, around 5% per year for the next 30 years. 3D Glass Solutions works with Lockheed Martin on systems-level integration to build complete systems with 3-D IPDs, cavities, and embedded transistors, with five to eight layers of glass bonded together. This system-on-a-chip (SoC) approach significantly reduces the footprint and weight of the device, as well as cost.

# Facilitating Continuous Improvement with IT Tools

How an app approach to data analysis cut initial data formatting time and sped defect resolution.

A KEY TENET of Lean manufacturing is to reduce variation through process standardization and control. To that end, most companies develop a control plan and monitor various steps of the process. The data collected in those monitoring activities are also useful in facilitating continuous improvement activities. This is particularly true as automated data collection technology has evolved and made it easier to share across multiple platforms.

For example, SigmaTron's team in its Suzhou facility uses a combination of enhanced inspection equipment, a proprietary manufacturing execution system (MES) and a newly created IT tool to drive continuous improvement efforts.

These efforts build on a Lean manufacturing approach that includes design for manufacturability (DfM) recommendations made to eliminate defect opportunities prior to the new product introduction (NPI) process and use of a production part approval process (PPAP) methodology during the NPI process.

Since the facility's focus is predominately higher volume production, its SMT lines are optimized to include a higher level of in-process inspection, utilizing 3-D solder paste inspection (SPI) following paste or glue deposition and automated optical inspection (AOI) both pre- and post-reflow. The MES collects yield data at those points and during in-circuit and functional test. The MES also tracks assemblies through each production step in the routing to support traceability requirements.

The thoroughness of this approach provides the facility's quality team with trends data needed to drive a robust continuous improvement process. The company's Taiwan-based IT team has built a trends analysis database app, known as the PDCA tool. Built around Edward Deming's Plan, Do, Check, Act framework, the tool supports trends analysis, continuous improvement activities and corrective and preventive action (CAPA) tracking. It tracks first-pass yield (FPY) by customer, group or model number. It also tracks major defect by process, and its raw data enable tracking of defects by part type. It sends emails to relevant team members when a defect exceeds the control plan limits to signal the need to open a PDCA project. Its summary section can provide FPY information by week, month or year.

In initiating corrective action, the team starts in the Plan phase, performing failure analysis, planning for the corrective action and setting a goal to achieve. In the Do phase, the team implements the corrective action plan. In the Check phase, the team reviews process data such as first-pass yield to determine if the corrective action reduced the identified defect and if any new defects have appeared. In the Act phase, the team documents the corrective action to ensure the process change is standardized across all relevant processes. The PDCA tool tracks this activity and provides dashboards that incorporate yield trends and defect pareto analysis.

In a controlled process, the root cause of drops in yields can often be difficult to identify. A recent project illustrates the benefits of the PDCA process in rapidly identifying these issues. The cumulative FPY failure rate on an SMT printed circuit board assembly (PCBA) had climbed to 1.23%. The team opened PDCAs on the top two defects: misaligned components and lifted parts. Their analysis determined the root cause of the misaligned components was an issue with a pick-and-place machine. A smooth part package was not being uniformly placed because the nozzle pressure was insufficient to hold it in place, and placement speed was contributing to the problem. The pressure and placement speed were adjusted, and yield improved. That process change was documented to be incorporated in future production activities involving that part. In the case of the lifted parts, analysis showed the part was not performing to specification under reflow. The vendor was contacted. It appeared to be a transitory issue, as it did not show up in other production lots. The result of both corrective actions was combined FPY failure rates dropped to 0.61%. The team is now analyzing a new top defect list to achieve further improvement.

This type of app approach to data analysis automates much of the initial data formatting, so quality and production personnel can quickly get the data they need. This simplifies the process of eliminating defect opportunities and is a necessary part of the journey to zero defects. ▫

**HOM-MING CHANG** is vice president China operations at SigmaTron (sigmatronintl.com); homming.chang@sigmatronintl.com.

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# When Life Goes Off Script

An out-of-body experience leads to introspection.

BY THE TIME you read this, I'll be having an anniversary of sorts. Commemorating, not celebrating.

Your life can change in an instant. Let me explain.

Two years ago, at the end of May 2019, our team exhibited a new CT scanning machine at an aerospace trade show in Southern California. Nothing newsworthy there. Display the machine, a kind of entry-level CT scanning system; answer questions from any and all; harmlessly scan a few souvenir water bottles to interactively show the novelty of nondestructive 3-D imaging. Do the usual glad-handing and manufactured sincerity that comes with the show gig. Expectantly snag a few promising leads over three tedious days. Inspire somebody to part with their cash. Show team solidarity around our maypole of a machine by memorializing the moment with a group photo. Say kumbaya, crate it up and dodge forklifts while prepping for shipment back north to our facility. There the system will go into working display as a demo unit. Goodbye, crate. Mission accomplished, take the rest of the week off and enjoy the sights and sounds of Southern California, rekindling my youth and visiting friends, savoring the week's success over cocktails with broiled fish in Seal Beach. Life is good.

That was Thursday.

Then came Tuesday.

The truck arrived at our back door at 7:30 the morning of Tuesday following Memorial Day. May 28, 2019. A nice, sunny Spring day. What could possibly go wrong?

The driver came alone. No helpers to move a 1550 kg (3417 lb.) load. Warning sign. He asked us for help. *Do we have a forklift?* No. *Do we have a pallet jack?* Yes, rated for 2500 kg. *Could he use it?* Yes. *Could we help him?* Yes.

Bad decision. One of our technicians jumped up on the liftgate of the truck to help. Not enough. I was out back, watching. I volunteered myself without hesitation. Or thinking. Guy needs help, you help him. Too bad actions have consequences. I jumped on the liftgate and pulled on the crate/pallet jack while our technician and the driver pushed. It wouldn't budge. One wheel of the pallet jack was wedged in the panel demarcating the two sides of the folding liftgate. Pushing and pulling by three strong male individuals wouldn't release it.

Until it did.

Force equals mass times velocity squared.

What happened next remains quite blurry. I remember something massive rushing toward me, then impact, then darkness. Nothing much after that until I woke up in an ambulance, with a paramedic's face 5" from mine, screaming my name. Frantically trying to get any possible recognition. Or cognition.

I'm told a lot happened during the blurry part. I know this from two eyewitness accounts, the fire department's report, and the intake report at the trauma center.

Force equals mass times velocity squared.

I'm told the crate abruptly freed itself from its captivity, but my back was partially turned, so I didn't have time to turn, react, and jump clear of its lurching forward movement over the edge of the liftgate. Where I was standing. Until the impact knocked me over the edge of the liftgate and to the ground. The crate followed in pursuit. Eight feet high by six feet wide by four feet deep, 3400 lb. gross weight, crate plus machine enclosed. Special delivery.

Witnesses say the crate and its contents then pitched over the edge of the ramp and did a half-cartwheel, with one corner of the crate striking the asphalt first, deadening its energy, before falling on top of me. This probably saved my life the first time. However, this then created a predicament, in that I was pinned on my side beneath it, unable to breathe. One of our employees rushed out of the building to find my (barely visible) exposed skin turning an unflattering shade of blue. Thinking quickly, this employee noticed and beckoned the warehouse manager of a neighbor company, whom he knew had a forklift. Our neighbor hurriedly fired up his forklift, drove across the driveway separating our two companies, and used the tines of the forklift to raise the crate off my side, just enough to loosen pressure on my diaphragm and enable breathing. This probably saved my life the second time.

Everybody's entitled to a bad day once in a while.

According to their report, six fire department units, with 13 personnel, responded to the incident. Plus the police. They found "… an estimated 60-yo-male who was trapped under an estimated 3500 pound piece of mechanical equipment … laying on the victim's hip, lateral chest, and head. Numerous pieces of block cribbing, flat cribbing, airbags, and chocks were used to support the machinery. The airbags were inflated and lifted the machinery an estimated 6", which provided enough room to remove the victim to a safe location."

Another portion of the report referred to me as "an elderly male." Crushed literally, then figuratively.

The report said biohazard material was also present on the pavement. That's an elegant term for blood.

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

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All this qualified me for an ambulance ride (not free) to the nearest trauma center, about eight miles from the back door of our office. There, in the ultimate karmic irony, my entire body – virtually every cubic inch – was CT scanned.

Scanning revealed the following (taken from admitting diagnosis report):

1. Crush injury to face and neck
2. Right 9 through 12 rib fractures
3. Left third rib fracture
4. Left sacral ala fracture
5. Bilateral superior inferior rami fractures
6. Left iliac wing fracture
7. Right SI joint diastasis
8. Right T12 through L4 transverse process fractures
9. Left L5 transverse process fracture
10. Left subacute DVT (deep vein thrombosis – blood clot) of popliteal vein, left lower extremity.

Other than that, I was fit to take the field and play rugby.

Next came surgery, which evidently I signed for, between bouts of delirium (pain does that). The surgeon's report states matter-of-factly that they discussed surgical options with me, prior to putting me under. I simply don't recall the details of that pleasant chat, nor if beverages and scones were served, accompanied by soothing ambient music. What I do know is that a 90mm titanium screw now makes its home embedded in my left pelvis. A TSA conversation starter should words fail at the security checkpoint.

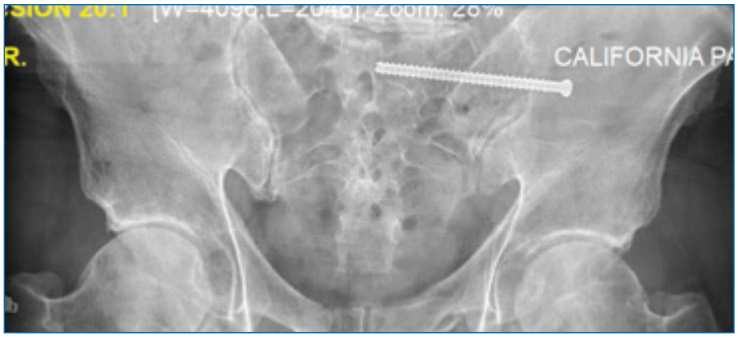



**FIGURE 1.** Failure analysis of author's midsection, held together by a 90mm screw. We have long-term reliability concerns.

Those were the preliminaries. The next 48 hours were sheer hell in Room 122, bed 1. The human body has a decisive way of telling its inhabitant that movement following injury is prohibited. Nerve endings react in cascading fashion, inducing spasms with every cough, sneeze, hiccup, turn of head, muscle twitch, or blink of an eye. Even bad dreams induce spasms. Each time, I was eager to disclose name, rank, serial number, and all pertinents of who shot JFK from the grassy knoll, what happened to Jimmy Hoffa, Judge Crater, and whether there really is a God – and what she has to say about us (a lot, and she resembles a paramedic). Absolutely nothing was worth hiding under such pain. Nothing. The only relief at certain moments was opioids (yes, them). The best one is called dilaudid (hydromorphone), administered intravenously. The journey from barbed wire to nirvana lasts about 45 sec. I took oxycodone and oxycontin for a while, too, until the pain became bearable, and I could swear it off and not have to stay awake through the night counting spiderwebs. I understand now why some can't swear it off. I was fortunate, but that's another story.

Speaking of no mercy, next came the physical therapists. Introduction to their tender mercies begins on Day 2. They demand you get moving right away, spasms or not. They love their work. They don't call it torture. Physical therapists smile sardonically for some reason. Like their trade was learned in some secret, undisclosed location, under government auspices. They smirk. For some reason, their sense of humor is not infectious.

Medical insurance companies have no sympathy either when it comes to deflecting payment responsibility. After three days, our carrier felt that I, the proud owner of 14 fractures, deserved discharge. I was ready to run marathons, and at my own expense, in their opinion. My doctors felt otherwise, and, fortunately, won the argument, considering at that point I was unable to put any weight at all on my left leg.

Eleven days in a rehab center followed nine days in the trauma unit. I was the youngest patient in a care facility otherwise populated largely by Alzheimer's cases. This made for interesting entertainment around the dinner hour each evening as some of my floor neighbors drifted into my room for a postprandial stare. Posting a large STOP sign on the entrance to my room put an end to uninvited incursions. Even dementia patients obey the rules of the road.

Nurses and technicians are unsung heroes. God bless 'em. They aren't paid nearly enough for what they must put up with from the likes of me. As we have all learned these past 15 months.

Home rehab lasted an additional three months. Another humbling experience: using a walker at 60 years of age. Also selling the physical therapists on my ability to negotiate the stairs *in my own house, as a prequalification to resume living there.* Three months' home sidelining drew the ultimate punishment: being voted onto the board of directors of my favorite trade association. Serves me right for not jumping off that ramp. Next time I'll look up.

My wife, the ultimate angel in this episode, would like that. She's lived the vows we gave each other nearly 38 years ago, notably the sickness-and-health clause. Especially since May 28, 2019. This column is a miniscule down payment on a big debt of gratitude.

So, why did I write about this, you ask? Partly for therapy, and partly because your life can change in an instant, when your back is turned, for a split second. Oh, and it involves CT scanning machines, before, during and after the event.

I knew about big life changes in theory. Now I've faced them in practice.

Spoken as an older and wiser fool. ▫

# 01005 Built-in Short

AOI during fabrication will catch most pad shorts caused by etching.

**BOB WILLIS** is a process engineering consultant; bob@bobwillis.co.uk. His column appears monthly.

THIS MONTH WE look at etching faults on PCBs. This is no ordinary set of pads. They are for an 01005 chip capacitor, the second-smallest chip component available. (Yes, there is an even-smaller size.) The 01005 component package is approximately 0.016" by 0.008" or 0.4mm by 0.2mm and small enough for most members of your staff.

Unfortunately, we found small copper shorts between the two mounting pads on one of our test boards that were not picked up during fabrication. The defective boards were spotted during printing trials. The nickel and gold plating are also present. As with many copper shorts, this is related to bare board etching and imaging, but they should have been picked up earlier.

It is not uncommon for bare board prototypes to miss standard AOI stages in fabrication. This was the reason in this case, as the author was in a hurry to start assembly trials. They printed and soldered fine, but the x-ray was a bit of a giveaway!

Find out how you can share a new series of Defect of the Month videos to explain dos and don'ts with your customers via PCD&F/CIRCUITS ASSEMBLY (https://bit.ly/3mfunlF).

We have presented live process defect clinics at exhibitions all over the world. Many of our Defect of the Month videos are available online at youtube.com/user/mrbobwillis. ▫

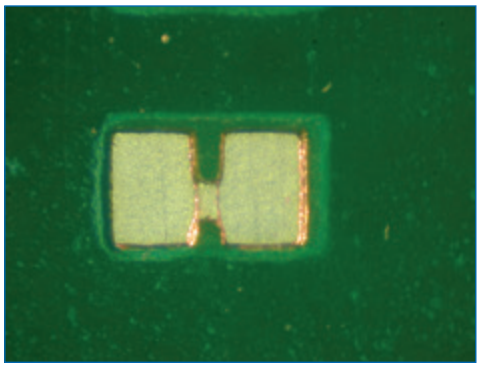


**FIGURE 1.** 01005 pad short.

*Packaging, continued from pg. 72*

tuning of layout parameters. For instance, an inductor could be tuned by modifying its trace width, core width, number of turns, spacing and via diameter, to generate a custom component that fits holistically with the end-requirements; e.g., low-loss, small-size, high SRF or power handling. The PDK also contains quasi-static component models that provide EM-like performance estimates at a fraction of the time and CPU resources needed for a full 3D E-M simulation.

Measured vs. 3-D EM simulated results of manufactured designs have shown exceptionally good correlation between the two.

## Conclusion

Simple chemistry and physics expanding on standard semiconductor processes permit next-generation RF devices to perform well. Applying physics to the known chemistry of photosensitive glass has changed the microstructure. This fundamental change permits precision RF designs in glass substrates, improving the performance of high-frequency devices, reducing parasitic losses, and driving miniaturization advancements into electronics. ▫

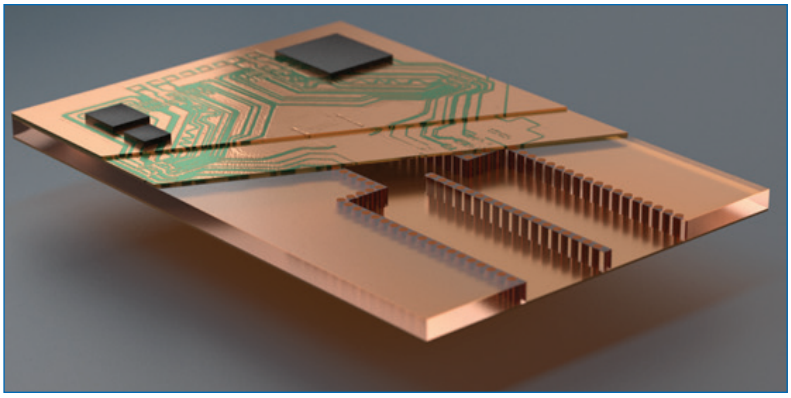


**FIGURE 7.** Antenna-in-package (AiP) with transmit and receive chips mounted directly to the novel integrated substrate.

**JEB H. FLEMMING** is chief technology officer and founder of 3D Glass Solutions (3DGS) (3dgsinc.com); jeb.flemming@3dgsinc.com. While at Sandia National Laboratories, he was principal developer of micropost technology, which won a 2007 R&D 100 award. He is inventor or coinventor on more than 30 patent applications.

# State-of-the-Art Technology Flashes

Updates in silicon and electronics technology.

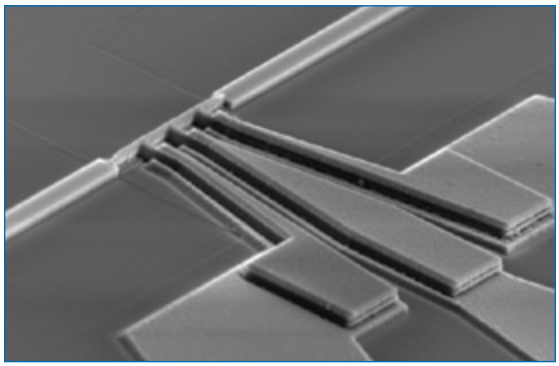
*Ed.:* This is a special feature courtesy of Binghamton University.

**GARY MILLER** is technology analyst at IEEC, Binghamton University. He has over 40 years' experience in electronic packaging. He previously was the chief mechanical engineer at Lockheed Martin; gmiller@binghamton.edu.

The **INTEGRATED ELECTRONICS ENGINEERING CENTER (IEEC)** at Binghamton University is a New York Center of Advanced Technology (CAT) responsible for the advancement of electronics packaging. Its mission is to provide research into electronics packaging to enhance our partners' products, improve reliability and understand why parts fail. Research thrusts are in 2.5/3-D packaging, automotive and harsh environments, bioelectronics, flexible and additive electronics, materials for packaging and energy storage, MEMS, photonics, power electronics, sensors, embedded electronics, and thermal challenges in electronic packaging. More information is available at binghamton.edu/ieec.

**IMEC and Intel researchers develop spintronic logic device.** Spintronics is a budding path in the quest for a future beyond CMOS. Devices use much less power than their CMOS counterparts and keep their data unpowered. IMEC and Intel researchers have created a spintronic logic device that can be fully controlled with electric current rather than magnetic fields. An electron's spin generates a magnetic moment, and when many electrons with identical spins are close together, their magnetic moments can align and join forces to form a larger magnetic field. Such a region is called a magnetic domain, and the boundaries between domains are called domain walls. A material can consist of many such domains and domain walls, assembled like a magnetized mosaic. *(IEEC file #12091, Semiconductor Digest, 1/21/21)*

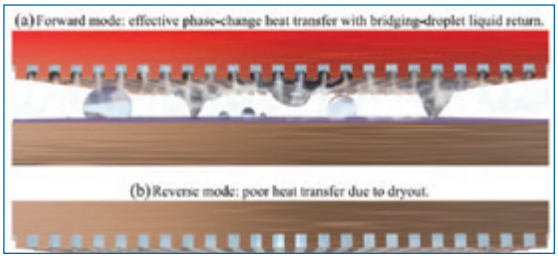
**Plasmonics: A new way to link processors with light.** Plasmonic transceivers transfer large amounts of data between processors. Fiberoptic links are the main method of slinging data between computers in data centers. Silicon photonics components are large in comparison to their electronic counterparts because optical wavelengths are much larger than transistors and copper interconnects. University of Toronto and Arm researchers have developed new silicon transceiver components that rely on plasmonics instead of photonics. The results have transceivers capable of at least double the bandwidth, while consuming 33% of the energy and 20% of the area, and could be built atop the processor. *(IEEC file #12097, IEEE Spectrum, 1/21/21)*



**Possibilities for new transparent materials that conduct electricity.** University of Minnesota researchers have made a discovery that provides the best qualities for touchscreens and smart windows: transparency and conductivity. The researchers are first to observe metallic lines in a perovskite crystal. The finding was made using advanced transmission electron microscopy (TEM), a technique that can form images with magnifications of up to 10 million. The conductive nature and preferential direction of these metallic line defects mean they can make a material that is transparent like glass and at the same time be directionally conductive like a metal. *(IEEC file #12095, Printed Electronics World, 1/26/21)*

**Researchers create novel photonic chip.** George Washington University researchers have developed a photonic digital-to-analog converter without leaving the optical domain. These converters can advance next-generation data processing hardware with high usage for data centers, 6G networks, and artificial intelligence. Current optical networks require a digital-to-analog conversion, which links digital systems synergistically to analog components. Using a silicon photonic chip platform, the researchers developed a digital-to-analog converter that does not require the signal to be converted in the electrical domain. This leads to high data-processing capabilities of optical data, interfacing to digital systems, and performing in a compact footprint. *(IEEC file #12099, Science Daily, 2/2/21)*

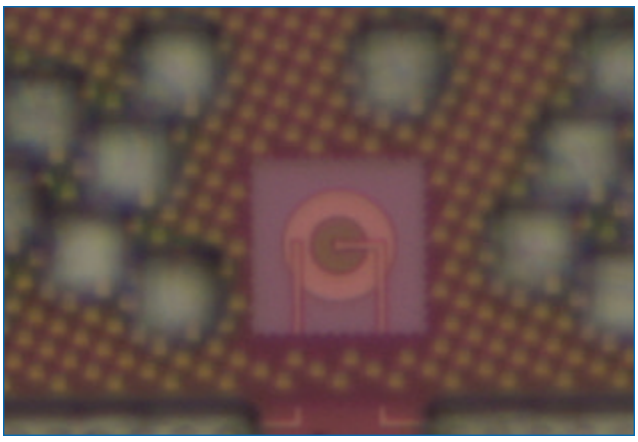
**Passive thermal diode restricts direction of heat flow.** Virginia Tech researchers have developed a thermal diode for aircraft thermal management technology that is adaptable to other areas, including electronic component and package cooling. Their approach uses two parallel copper plates separated by an insulating gasket micrometers thick; one plate contains a superhydrophilic wick structure, while the other is smooth and hydrophobic. The surface of the first plate has a wick-like structure consisting of micropillars that hold and conduct water, while the second parallel plate is smooth and coated with a hydrophobic water-repelling layer. *(IEEC file #12100, Electronic Design, 1/26/21)*



**Breakthrough in quantum photonics promises a new era in optical circuits.** University of Southern California researchers have demonstrated that single photons can be emitted in a uniform way from quantum dots arranged in a precise pattern. The team used this to create single-quantum dots with their remarkable single-photon emission characteristics. To create the precise layout of quantum dots for the circuits, the team used a method called SESRE (substrate-encoded size-reducing epitaxy). The team fabricated regular arrays of nanometer-sized mesas with a defined edge orientation, shape on a flat semiconductor substrate (GaAs), with quantum dots created on top of the mesas. The ability to precisely align uniformly emitting quantum dots will enable the production of optical circuits with advancements in quantum computing and communications. *(IEEC file #12113, Science Daily, 2/5/21)*

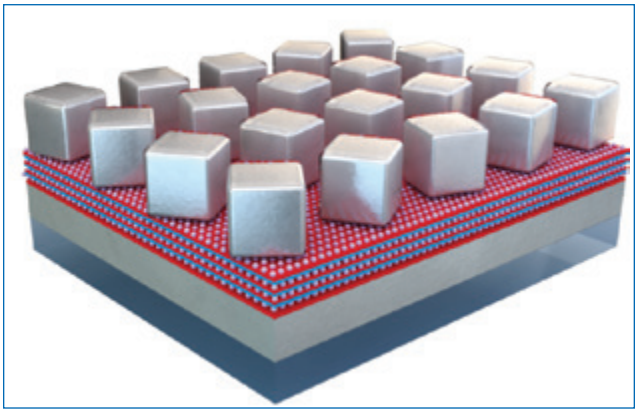
**Graphene "Nano-Origami" creates tiniest microchips yet.** University of Sussex researchers have developed microchips made from graphene and other 2-D materials, using a form of "nano-origami." By creating kinks in the structure of graphene, the nanomaterial behaves like a transistor, which is around 100 times smaller than conventional microchips. Using these nanomaterials will make computer chips smaller and faster. Ultimately, this will make computers and phones thousands of times faster. This technology, called "straintronics," using nanomaterials as opposed to electronics, permits space for more chips inside any device. *(IEEC file #12135, Printed Electronics World, 2/17/21)*

**LED can be integrated directly into computer chips.** MIT researchers have fabricated a silicon chip with fully integrated LEDs bright enough to enable state-of-the-art sensor and communication technologies. The advance could lead to not only streamlined manufacturing, but also better performance for nanoscale electronics. In addition to cheaper manufacturing, the advance could also improve LED performance and efficiency as electronics shrink to ever smaller scales. At microscopic scale, III-V semiconductors have nonideal surfaces, riddled with "dangling bonds" that permit energy to be lost as heat rather than as light. In contrast, silicon forms a cleaner crystal surface. *(IEEC file #12112, NASA Tech Briefs, 2/4/21)*



**Reconfigurable electronics based on multiferroics and nanomagnetism.** Virginia Polytechnic Institute researchers are developing new materials with large magnetoelectric (ME) coupling for next-generation multifunctional devices, including multi-state (neuromorphic-like) circuits, and E-field tunable microwave resonators for secure communications. Combining polarization and magnetization in the same solid controls the fundamental nature of electromagnetism in matter. Their research focuses on achieving the disruptive potential of emerging multifunctional magnetoelectrics, and in so doing lays the foundations for their use as a materials platform that would benefit future applications. *(IEEC file #12133, Aerospace & Defense, 2/1/21)*

**Capturing free-space optical light for high-speed Wi-Fi.** Visible and infrared light can carry more data than radio waves but has always been confined to a fiberoptic cable. Duke University researchers have made a major advance toward eliminating the fiber in fiberoptics. While working to create a free-space optical communication system for high-speed wireless internet, they showed speed and efficiency properties previously demonstrated on tiny plasmonic antennas can also be achieved on larger, centimeter-scale devices. The design uses silver nanocubes 60nm wide, spaced 200nm apart, covering 17% of the device's surface. These nanocubes sit above a thin layer of silver, spaced by a coating of polymer with four layers of fluorescent dye. The nanocubes enhance the photonic capabilities of the fluorescent dye, causing a 910-fold increase in the overall fluorescence and a 133-fold emission rate enhancement. *(IEEC file #12121, Science Daily, 2/11/22)*



## Market Trends

**Optical sensor market is projected to reach $30 billion by 2026.** The global optical sensor market is estimated to exceed $30 billion by 2026. The flourishing consumer electronics industry in developing countries is expected to boost optical sensor demand in the forthcoming years. The appliance and consumer electronics industry in India was valued at $10.9 billion in 2019 and is estimated to reach nearly $21.1 billion by 2025. Optical sensors are broadly utilized in consumer

electronic devices for the detection of events, changes or input signals, and pass the information to other components. Increasing adoption of optical sensor for biometric recognition, high-speed detection, device authentication, and other security application in consumer electronic systems such as laptops, wearable electronics and smartphones will augment industry expansion. *(IEEC file #12104, Semiconductor Digest, 1/22/21)*

**New electric car battery can charge in five minutes.** A new electric car battery that can be fully charged in five minutes has been manufactured for the first time on a normal production line in China, based on designs by Israeli company StoreDot. The breakthrough could address a significant concern for electric car drivers: the fear of running out of power during a journey. The batteries are designed differently to standard Li-ion, replacing the graphite with semiconductor nanoparticles based on germanium. This battery design could have a significant impact on the adoption of electric vehicles, which are facing a bottleneck in countries such as the UK that have limited numbers of charging stations. *(IEEC file #1210, Sky News, 1/19/21)*

**Hyundai EV includes optional rooftop solar panel.** The most intriguing exterior feature on the new Hyundai Ioniq 5 fully electric, mid-size CUV (crossover SUV) is found on its roof: solar panels. You won't be able to rely on the sun to fully recharge the 58kWh standard range or 72.6kWh long-range battery inside the Ioniq 5, with it acting as a complementary charging source that can help extend range. Hyundai says the solar panels can add up to 2,000km per year. *(IEEC file #12146, ASME, 2/24/21)*

**General Motors plans to phase out gas, diesel cars by 2035.** General Motors plans to be carbon-neutral by 2040 and phase out gasoline and diesel cars by 2035. GM said by mid-decade it would offer 30 all-electric models, and by the end of 2025 40% of the company's models will be battery electric vehicles. The company said it is investing $27 billion in electric and autonomous vehicles in the next five years. President Biden said he planned to replace the government's fleet of cars and trucks with electric vehicles assembled in the US and signed several executive orders to address climate change, including establishing climate change as a national security priority. *(IEEC file #12107, The Street, 1/28/21)*

**What to expect in 2021 from the MEMS industry.** MEMS has brought a sensing revolution to consumer markets. MEMS microphones in every smartphone and tablet, together with CMOS image sensors, allow people to see and hear each other everywhere in the world. Global MEMS sensor revenue was $11.5 billion in 2019, and is set to reach $17.7 billion in 2025, at a 7.4% CAGR over this period. The market continues to be driven in 2021 with various trends and applications increasingly gaining momentum. For instance, MEMS-based environmental hubs and gas sensors are becoming ever more sought after, since people's perceptions of their immediate environment has changed. The population cares more about the air they breathe, both inside houses but also outside due to pollution. *(IEEC file #12129, Fierce Sensors, 2/10/21)*

**Surround sound from lightweight roll-to-roll printed loudspeaker paper.** Chemnitz University of Technology researchers have developed loudspeakers as thin as paper with impressive sound. Previously the sonorous paper loudspeakers were manufactured in a semiautomatic single-sheet production process. In this process, ordinary paper or foils are printed with two layers of a conductive organic polymer as electrodes. A piezoelectric layer is sandwiched between them as the active element, which causes the paper to vibrate. Since this was only possible in individual sheets in limited formats, the efficiency of this manufacturing process is very low. Their latest project, roll-to-roll printed speaker paper using inline process monitoring, converts sheet production into roll production. *(IEEC file #12125, Printed Electronics World, 2/4/21)*

## Recent Patents

**Metal additive structures on printed circuit boards (assignee: Microsoft Tech.) pub. no. US10881037.** PCBs include conductive metallic paths, such as vias, traces and pads. One or more metal additive structures are additively manufactured onto the PCBs in a manner that forms a con-

tinuous weld with at least one of the conductive metallic paths. As a result, the metal additive structures are continuous with the printed circuit board and do not require separate attachment mechanisms (e.g., soldering or mechanical fastening). The metal additive structures may include shield cans, frames, antennas or heatsinks for the printed circuit board.

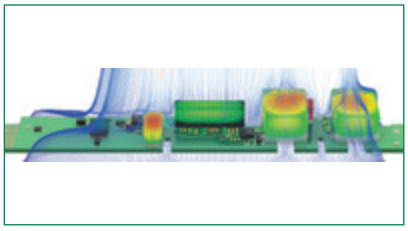
Cooling system for a data center (assignee: Beijing Baidu Netcom Science & Tech.) pub. no. US10888033. A cooling system for a data center includes at least one liquid-cooling heat exchanger disposed above each of the integrated circuit boards to dissipate heat from a first heat source disposed on the integrated circuit board through an internal circulation coolant in the liquid-cooling heat exchanger; a liquid-cooling distributing device comprising a first pipeline in communication with the liquid-cooling heat exchanger; a second pipeline in communication with a first cooling tower; a heat exchanger configured to cool the internal circulation coolant from the liquid-cooling heat exchanger to a first temperature through an external circulation coolant from the first cooling tower; and the first cooling tower configured to cool the external circulation coolant supplied via the second pipeline to the second temperature.

Semiconductor package including stacked semiconductor chips (assignee: SK Hynix Inc.) patent no. 16/709786. Disclosed is a semiconductor package. The semiconductor package includes a substrate including an opening, a first semiconductor chip, disposed on the substrate, including a plurality of first chip pads exposed through the opening; a second semiconductor chip, disposed on the first semiconductor chip to partially overlap with the first semiconductor chip, including a plurality of second chip pads, aligned with the opening; and a redistribution layer formed on a surface on which the second chip pads of the second semiconductor chip are disposed. One or more of the second chip pads overlaps the first semiconductor chip and is covered by the first semiconductor chip, with the remaining pads of the second chip pads exposed through the opening.

Double-sided cooled molded semiconductor package (assignee: Infineon Technologies) patent no. 16/924851. A method of producing a molded semiconductor package includes attaching a first load terminal at a first side of a semiconductor die to a leadframe, the semiconductor die having a second load terminal at a second side opposite the first side and a control terminal at the first side or the second side; and encapsulating the semiconductor die in a laser-activatable mold compound so the leadframe is at least partly exposed from the laser-activatable mold compound at a first side of the molded semiconductor package, and the second load terminal is at least partly exposed from the laser-activatable mold compound at a second side of the molded semiconductor package.

Wafer-level stack chip package (assignee: Amkor Technology) patent no. 17/028329. A semiconductor product in the form of a stack chip package and a method of manufacturing the same, where a plurality of semiconductor chips are stacked one on another to enable the exchange of electrical signals between the semiconductor chips, and where a conductive layer is included for inputting and outputting signals to and from individual chips. A stack chip package having a compact size, a second semiconductor chip having a smaller surface area by means of interconnection structures to enable the exchange of electrical signals between the first and second semiconductor chips, and by using a conductive layer for inputting and outputting signals.

Optical device including buried optical waveguides and output couplers (assignee: Intel Corp.) pub. no. EP3767351. Embodiments of the present disclosure are directed toward techniques and configurations for an optical coupler, including an optical waveguide to guide light to an optical fiber. In embodiments, the optical waveguide includes a tapered segment to propagate the received light to the optical fiber. In embodiments, the tapered segment is buried below a surface of a semiconductor substrate to transition the received light within the semiconductor substrate from a first optical mode to a second optical mode to reduce a loss of light during propagation of the received light from the optical waveguide to the optical fiber. In embodiments, the surface of the semiconductor substrate comprises a bottom planar surface of a silicon photonic chip that includes at least one or more passive or active photonic components. ▫



## ALTAIR SIMULATION 2021

Simulation 2021 accelerates simulation of real-world product performance and expands simulation-driven design for manufacturing functionality. Simulates 5G connectivity, electronic board-level performance, and manufacturing processes. Provides efficient PCB design review, verification, analysis, and manufacture for design of motors, sensors, and actuators with simulation. Updates include improved simulation and optimization of wireless connectivity, including 5G and EM compatibility.

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PCBflow cloud-based software extends Xcelerator portfolio with secure environment for PCB design teams to interact with manufacturers. Performs DfM analyses in the context of each manufacturer's process capabilities. Powered by Valor NPI software engine. Performs more than 1,000 DfM checks. Scalable to any company size.

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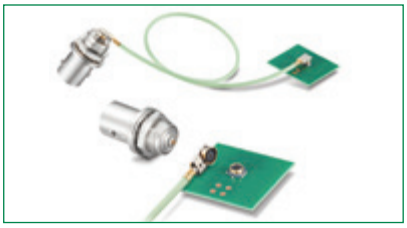

## HIROSE D.FL75

D.FL75 75Ω, 4K/UHD transmission coaxial connector supports 12G-SDI standard and SMPTE ST 2082-1. Requires 4 x 4mm PCB mounting space. Mating height of 2.7mm. For A/V equipment, portable medical devices, security cameras and video screens. Eliminates PCB traces and is reflow-solderable.

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## OTHERS OF NOTE

### ULTRA LIBRARIAN, TDK DC-DC MULTIMODULE

µPOL embedded DC-DC converters now include a 5W to 40W DC-DC multimodule reference design that reportedly enables concept to design in fewer than 15 min. Come in eight CAD formats. For crafting DC-DC power solutions between and around FPGAs, ASICs, memory, and under heat sinks on top or bottom of PCBs or daughtercards.

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### VISHAY BCCOMPONENTS 190 RTL

BCcomponents 190 RTL series low-impedance, automotive-grade miniature aluminum electrolytic capacitors combine ripple currents up to 3.36A with high-temperature operation to +125°C and useful life of 6,000hr. at 125°C. Offer lower impedance and 10% to 15% higher ripple current.

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### INVENTHUB PROJECT MANAGEMENT SUITE

PCB design project management tool suite provides single centralized, secure cloud database updated with every change. Supports visualization on formats such as Altium Designer, EagleCad and KiCad. Organization access controls enable team-based collaboration and sharing latest version of document. Smart BoM creates, edits and maintains bill of materials.

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### ROHM CSL1501RW

CSL1501RW side-emitting IR LED has peak wavelength of 860nm in 1 x 0.55mm sideview design. Emits light parallel to mounting surface. Serves as light source for eye tracking. Is ultra-miniature and side-firing. For compact mobile devices and wearables.

| Rohm Semiconductor |
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| rohmsemiconductor.com |

### AMPHENOL MINI-FAKRA

Mini-Fakra connectors support up to 20Gbps data transmission. Reportedly reduce installation requirements up to 80% compared to previous Farkra products. Color-coded housings. Mechanically keyed to prevent mismating. Come in type A right angle PCB and cable mount configuration.

| Amphenol RF |
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| amphenolrf.com |

### BEYSCHLAG NCW 0612 AT

NCW 0612 AT wide-terminal thin-film chip resistors for power electronics come in 0612 package size. Power dissipation up to 1W and resistance values down to 0.10Ω. AEC-Q200 qualified. Provide operating temp. up to +175°C, sulfur resistance as verified according to ASTM B 809, and moisture resistivity at 85°C and 85% RH.

| Vishay |
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| vishay.com |

## JUKI ICUBE HIGHFLEX

iCube HighFlex selective solder machine offers all-in-one package. New fluxer cleaner permits reduced maintenance of fluxer head. Flux residues and other contamination are dissolved and automatically cleaned from flux head at user-defined interval. All existing iCube features and options available.

| Juki |
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| jukiamericas.com |

## SAKI Z-AXIS

Z-Axis for 3Di AOI inspects tall components, press-fit components and PCBAs in jigs. Achieves max. height-measurement range in 3-D mode to 40mm. Max. focus height in 2-D is also increased to 40mm. Can inspect low-profile components and refocus on identification and polarity markings of tall components such as large electrolytic capacitors. Composite image enables accurate defect detection and optical character recognition. Enables accurate height measurement when inspecting pins of press-fit connectors.

| Saki Corp. |
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| sakicorp.com/en/ |

## EUROPLACER II-A1

ii-A1 flexible placement machine features single Tornado turret head. Placement speeds up to 15,000cph. 164 x 8mm feeder positions and two different types of internal matrix trays with up to 5 Jedec capacity, for devices up to 99mm x 99mm. Intelligent conveyor with board stops under full software control. Handles boards over 1m in length.

| Europlacer |
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| europlacer.com |

## OTHERS OF NOTE

### YINCAE SMT 158D8

SMT 158D8 conductive underfill is a diamond-filled, reworkable liquid epoxy. Thermal conductivity of >6W/mK. High salt-moisture resistance. Flows into small gaps without phase separation. Drop test reportedly two orders of magnitude better than solder paste.

| Yincae Advanced Materials |
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| yincae.com |

### ITW MPM EDISON

MPM Edison printer now comes with SECS/GEM communication package that collects and logs process data. Printer has print process capability greater than 2 Cpk for metric 2021 components. Has built-in ±8µm machine alignment and ±15µm wet print accuracy (≥2 Cpk @ 6 sigma). Features OpenApps, an open application interface with development kit that allows customers to develop custom interfaces in support of Industry 4.0 initiatives. Package provides readymade interface.

| ITW EAE |
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| itweae.com |

### ASM FACTORY EQUIPMENT CENTER

Factory Equipment Center software is for company-wide asset and maintenance management. Browser-driven tool plans, controls, executes, supports and documents maintenance and repairs of ASM and non-ASM machines, feeders, production tools and placement heads, including equipment in areas that are not part of SMT production. Check machine status.

| ASM |
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| asm-smt.com/en/ |

### NIHON SUPERIOR TEMPSAVE

TempSave B58 eutectic SnBi alloy has a melting point of 139°C. TempSave B37 ductile hypoeutectic SnBi alloy contains no Ag; reportedly has outstanding drop performance. TempSave B37 P610 solder paste can be reflowed with peak temp. of 190°C. Comes in solid wire form.

| Nihon Superior |
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| nihonsuperior.co.jp/English |

### KEYSIGHT I7090

i7090 massively parallel board test system performs tests in parallel on multiple PCB assemblies. Supports up to 20 cores in parallel with PCI eXtensions for instrumentation-based ICT capability. Core configuration is variable and not confined to fixed number of rows. Keysight OpenTAP support enables open platforms for integration of hardware. 600mm width. Provides unpowered and vectorless test extended performance technologies.

| Keysight Technologies |
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| keysight.com |

### MASTER BOND EP77M-FMED

EP77M-FMed two-part epoxy adhesive and sealant is for medical device assembly. Meets ISO 10993-5 requirements and is not considered to have a cytotoxic effect. Silver-filled system has volume resistivity of $10^{-3}$ ohm-cm and thermal conductivity of 1.44-1.73 W/(m•K). RoHS compliant.

| Master Bond |
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| masterbond.com |

# In Case You Missed It

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

## Electronic Materials

"Highly Stretchable Multilayer Electronic Circuits Using Biphasic Gallium-Indium"

*Authors:* Shanliangzi Liu, Dylan S. Shah and Rebecca Kramer-Bottiglio

*Abstract:* Development of sophisticated stretchable circuits requires new materials with stable conductivity over large strains, and low-resistance interfaces between soft and conventional (rigid) electronic components. To address this, the authors introduce biphasic Ga-In, a printable conductor with high conductivity ($2.06 \times 10^6 S m^{-1}$), extreme stretchability (>1,000%), negligible resistance change when strained, cyclic stability (consistent performance over 1,500 cycles) and a reliable interface with rigid electronics. A scalable transfer-printing process is employed to create various stretchable PCB assemblies that maintain their performance when stretched, including a multilayer LED display, an amplifier circuit and a signal conditioning board for wearable sensing applications. The compatibility of biphasic Ga-In with scalable manufacturing methods, robust interfaces with off-the-shelf electronic components and electrical/mechanical cyclic stability enable direct conversion of established circuit board assemblies to soft and stretchable forms. (*Nature Materials,* Feb. 18, 2021)

## Fabrication Processes

"Periodic Pulse Plating of Mid-Aspect Ratio Printed Circuit Boards for Enhanced Productivity"

*Author:* Carmichael Gugliotti, Rich Bellemare, Andy Oh and Ron Blake

*Abstract:* Pulse plating of copper has typically found use in the plating of difficult high-aspect-ratio printed circuit boards. Its ability to provide throwing power deep within through-holes with aspect ratios as high as 30:1 is well-established. This technology has long been thought of as a high-technology, high-cost, specialty process applicable only to high-end products. This paper discusses the advantages that pulse plating offers over conventional DC copper plating in high-volume production applications for panels with aspect ratios of up to 12:1. These advantages are reduced plating time, increased throughput, and reduced plated copper thickness on the panel surface, while meeting minimum in-hole copper thickness requirements. (SMTA *Journal of Surface Mount Technology,* vol. 33, no. 2, June 2020)

## Printed Circuit Design

"Analysis of Crosstalk in High Speed and High Frequency Printed Circuit Board"

*Authors:* Avali Ghosh, Sisir Kumar Das and Annapurna Das

*Abstract:* Numerical analysis of crosstalk between two traces in a printed circuit board is presented using the method of moments (MoM). In the high-frequency range, the attenuation constant is neglected in the theory for its very small values. The width of the trace is accurately determined for the trace impedance of 50 ohm from the charge distribution on the traces without using an approximated empirical formula. Line capacitances are determined from the total charge on the conductors and the line potentials. The coupling capacitance and inductance are determined from in-phase and out-of-phase excitations between the traces. Crosstalk interference is calculated from these coupling parameters. Results of crosstalk obtained from the above technique are verified by comparing with those obtained from four other methods: 1) Ansoft HFSS software, 2) even mode and odd mode analysis, 3) empirical formulae of parasitic elements, and 4) measurements using a vector network analyzer. All the results agreed well. The results obtained by using the method of moment technique are more stable, reliable and accurate among all the described different methods. This paper shows that the analytical method using MoM is a useful tool for predicting crosstalk interference in PCB without using expensive simulation software. (*International Journal of Electronics,* Jan. 19, 2021)

## Solder Joint Reliability

"An Investigation on Function of Current Type on Solder Joint Degradation in Electronic Packages"

*Authors:* Wenhui Cai, Fei Huang, Kai Liu and Mohammed Alaazim

*Abstract:* In real applications, several alternating currents (AC) may be injected into electronic devices. This study aims to analyze their effects on the lifetime of the solder joints and, consequently, shed light on these effects at the design phase. The authors investigated current waveform shapes on the performance and reliability of the solder joints in an electronic package. Three common and extensively used current shapes in several simulations and experiments were selected to study their effects on the solder joint performance. The results demonstrate a severe thermal swing and stress fluctuation in the solder joint induced in the case of triangle current type because the critical states lack any relaxation time. In fact, the stress intensification in the solder under application of the triangle current type has been shown to contribute to increasing brittle intermetallic compounds. An accelerated increase of on-state voltage of power semiconductor was also observed in the under application of the triangle current type. (*Soldering & Surface Mount Technology,* Sept. 23, 2020)

# PCB WEST 2021

Conference & Exhibition

30 YEARS

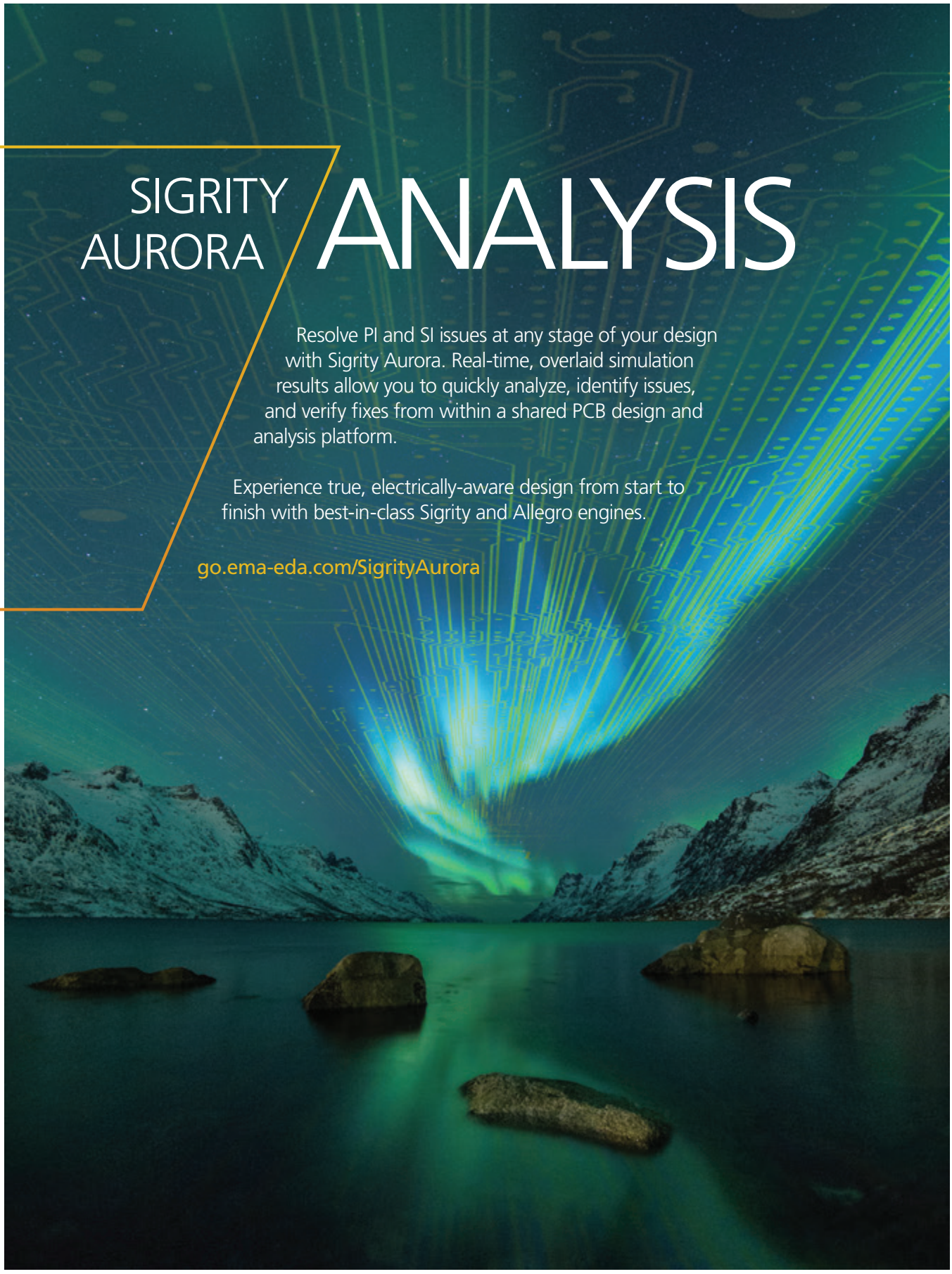
## Conference: October 5 – 8, 2021
## Exhibition: Wednesday, October 6, 2021

SANTA CLARA CONVENTION CENTER, CA

# WHO'S EXHIBITING

Accurate Circuit Engineering
Advanced Assembly
AGC Nelco America Inc.
All Flex Flexible Circuits & Heaters
American Standard Circuits, Inc.
APCT
Arlon EMD Specialty
Bay Area Circuits, Inc.
Bowman XRF
Cicor Group
DownStream Technologies, Inc.
DYCONEX AG
Dynamic Electronics Co., Ltd.
Elgris Technologies, Inc.
Elsyca
EM Solutions Inc.
EMA Design Automation
Emerald EMS
ExactCAD
Firan Technology Group - FTG
Fischer Technology, Inc.
Flexible Circuit Technologies
Fujipoly America
Goal Searchers Co., LTD Zhuhai
GS Swiss PCB AG
GTS Flexible Materials Ltd.
HSIO/Ironwood
Imagineering, Inc.
InnoLas Solutions GmbH
IPC-2581 Consortium
JetPCB USA
Leader Tech, Inc.
Mecadtron GmbH
MicroConnex
Minco Products, Inc.
MVINIX Corporation
Oak-Mitsui Technologies LLC
Ohmega Technologies, Inc.
Oki Printed Circuits Co., Ltd.
Optiprint AG
PCB Power
PFC Flexible Circuits Limited
Polar Instruments, Inc.
Polyonics
Printed Circuits
Pulsonix PCB Design Software
Quality Circuits, Inc.
Rogers Corporation
Royal Circuits
San Diego PCB Design
San-ei Kagaku Co., Ltd.
Screaming Circuits
SEP Co., Ltd.
Shenzhen Danyu Electronics Co. Ltd.
Shin Yi PCB Co., Ltd.
Siemens EDA
Somacis Inc.
Summit Interconnect
Sunshine Global Circuits
Sunstone Circuits
SVTronics, Inc.
Taiyo America Inc.
Ticer Technologies
Trilogy-Net Inc.
Ultra Librarian
Varioprint AG
Vayo Technology
Ventec International Group
Victory Giant Technology (Huizhou) Co., Ltd.
Xiamen Bolion Tech. Co., Ltd.
Zuken USA Inc.

pcbwest.com

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