Batten Down the Crosshatches, pg. 20

UP Media Group

PRINTED CIRCUIT DESIGN & FAB

CIRCUITS ASSEMBLY

pcdandf.com
circuitsassembly.com
February 2021

Drawing Standards

Solder Joint Durability

Under-stencil Wipe Chemistry

Is the DESKTOP ECAD Market Broken?

(No, But Change is Coming)

$10 MILLION IN RECENT TECHNOLOGY CAPEX INVESTMENTS

NIST 800-171 COMPLIANT CYBERSECURITY PROCESSES

250,000 SQUARE FEET SUPPORTING ALL TECHNOLOGIES

4 STATE-OF-THE-ART NORTH AMERICAN FACILITIES

U.S. Partnership USPAE for Assured Electronics

SUMMIT INTERCONNECT

www.summit-pcb.com

Thin Lamination Board
TLB

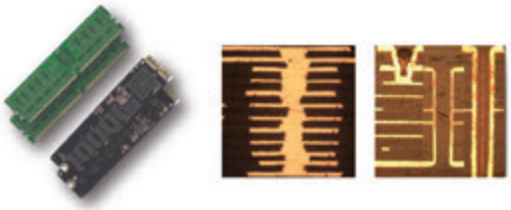
TLB, a global leader
in the 4th industrial revolution.

TRUST 2030

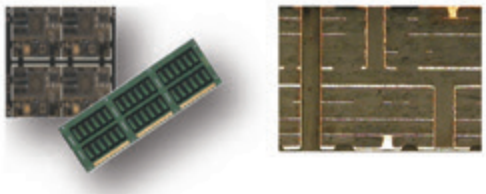
Good Company in 20 Years, Great Company in 30 Years.

TLB is specialized in manufacturing PCB for semiconductors. By joining World Class 300 in 2018, we have become a company specializing in materials and components leading the fourth industrial revolution. Based on technology and quality, we will establish ourselves as a material parts company that leads not only Korea PCB but also world PCB.

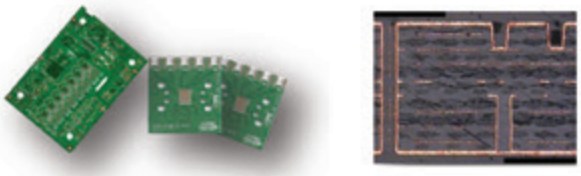
DRAM Module
/ SSD Module



IOT / Build-up Board



Semiconductor TEST B'd
& 5G Network System



TLB CO., LTD.

15602) 305, Sinwon-ro, Danwon-gu, Ansan-si, Gyeonggi-do, Republic of Korea Tel.82-31-8040-2096 Fax. 82-31-492-6623
Domestic Tel. 82-31-8040-2071, E-Mail. cmh@tlbpcb.com Offshore Tel. 82-31-8040-2060, E-Mail. will_shin@tlbpcb.com

PROTOTYPES
IN 4 DAYS FROM TAIWAN

No Tariffs!

Best Quality and Price!

Technology:

Up to 50 Layers
Any Layer HDI
Sequential Lamination
Blind / Buried Vias
Laser Drilling / Routing
Heavy Copper

Materials:

Fr4
Metal Core
Isola
Rogers
Polyimide - Flex
Magtron

Accutrace Inc. SINCE 1986

www.PCB4u.com sales@PCB4u.com Tel: (408) 748-9600

2986 Scott Blvd., Santa Clara, CA 95054

SAM & ITAR Registered UL E333047 ISO 9001 - 2015

FEBRUARY 2021 • VOL. 38 • NO. 2

PRINTED CIRCUIT DESIGN & FAB CIRCUITS ASSEMBLY

FIRST PERSON

MONEY MATTERS

TECH TALK

DEPARTMENTS

FEATURES

IN THE DIGITAL EDITION

ON PCB CHAT (pcbchat.com)

PCB Chat

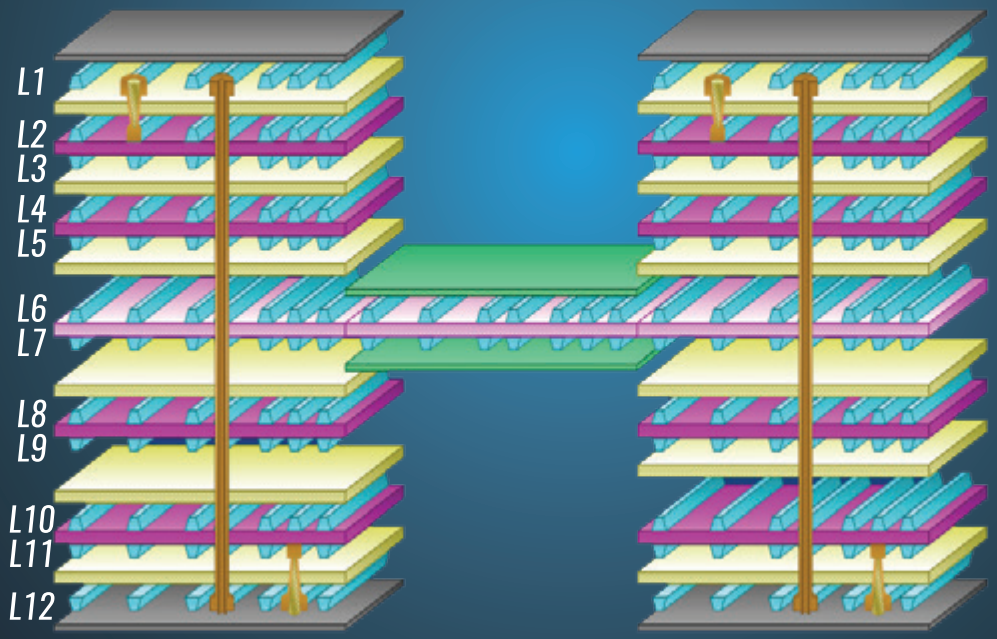
POSTMASTER: Send address changes to
PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY, PO Box 470, Canton, GA 30169

RUSHPCB

20 YEARS OF MANUFACTURING EXPERIENCE WITH BLIND AND BURIED VIAS, RIGID FLEX & FLEX PCB ELECTRONIC DESIGN, & QUICK TURN CIRCUIT BOARDS, ASSEMBLY & FULL TURNKEY

Multilayer PCB Stackup

12 Layer Flex Rigid, 0.030" Thick Rigid, 0.008" Thick Flex
Blind Via L1-L2 & L11-L12, 0.003" Hole, Resin Filled,
0.002"/0.002" Trace/Space, Controlled Impedance



Manufactured on August 2016

When you're in a rush call RUSH PCB

Affordable Pricing ★ Satisfaction Guarantee ★ Fast Response ★ Free Quote ★ Fast Shipping
HDI Boards ★ Stacked Micro Vias ★ 2 mil line & Space ★ Flex & Rigid Flex

Located in the Silicon Valley
PCB up to 12 Layers in 3 days
PCB Assembly Same Day Turn
Full Turnkey Service

Certified: ISO9001/ITAR/UL

www.rushpcb.com | Sales@rushpcb.com | 1 408 496 6013
Rush PCB Inc, 2149-20 O'Toole Ave, San Jose, CA 95131, U.S.A

PRINTED CIRCUIT DESIGN & FAB / CIRCUITS ASSEMBLY

pcdandf.com

circuitsassembly.com

PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY is distributed without charge to qualified subscribers. For others, annual Subscription Rates in U.S. funds are: $80 (U.S. and Canada), $145 (all other countries). Single copy price is $8.50. All subscription and single copy orders or inquiries should be directed to PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY, PO Box 470 Canton, GA 30169, email subscriptions@upmediagroup.com. Photocopies and issues on Microfilm/Microfiche (16mm, 33mm or 105mm) are available from University Microfilms International, 300 N. Zeeb Rd., Ann Arbor, MI 48106, Telephone 313-761-4600.

PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY is published monthly by UP Media Group Inc., PO Box 470 Canton, GA 30169. ISSN 1939-5442. GST 124513185/ Agreement #1419617.

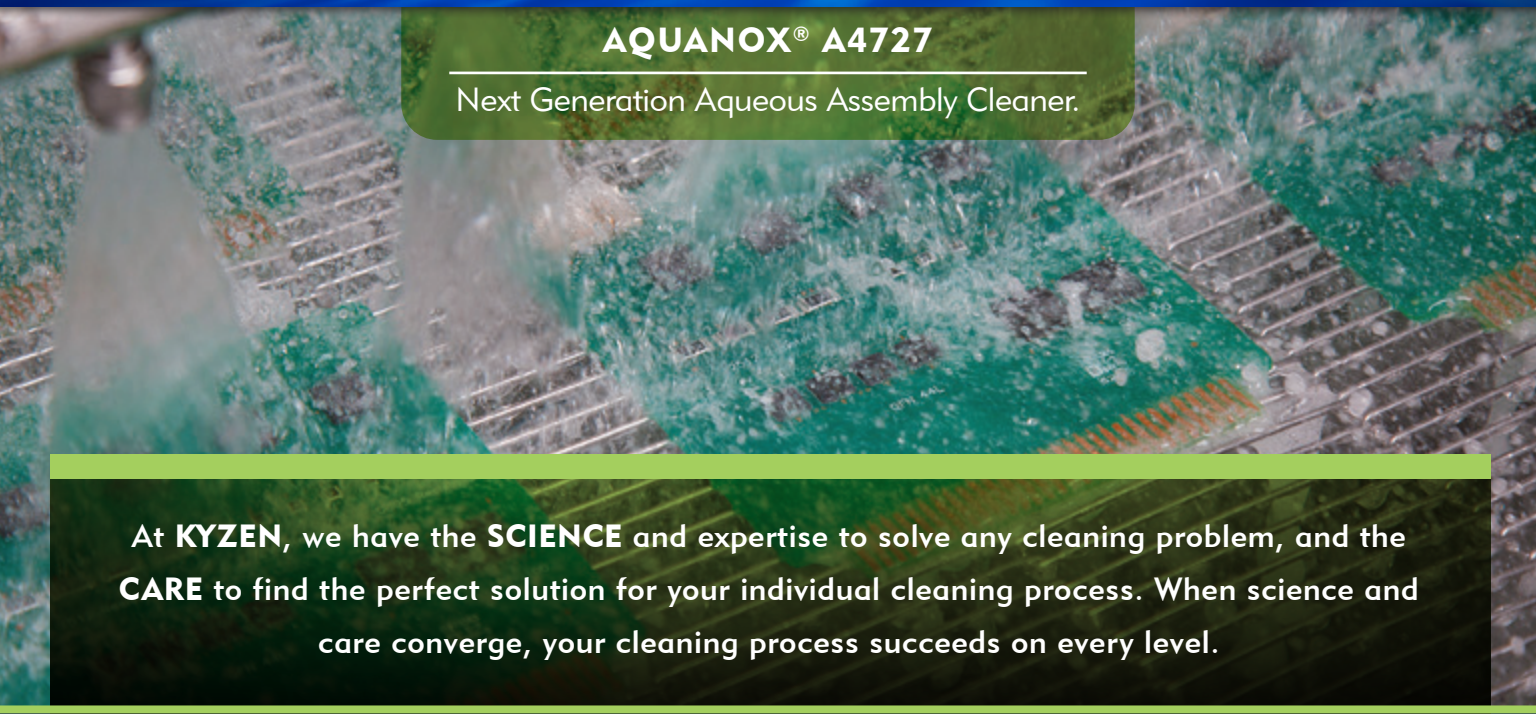
Periodicals postage paid at Canton/Ball Ground, GA, and additional mailing offices.

Postmaster: Send address changes to PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY, PO Box 470 Canton, GA 30169.

The right solutions happen when you care enough to ask the right questions.

AQUANOX® A4727

Next Generation Aqueous Assembly Cleaner.



At **KYZEN**, we have the **SCIENCE** and expertise to solve any cleaning problem, and the **CARE** to find the perfect solution for your individual cleaning process. When science and care converge, your cleaning process succeeds on every level.

KYZEN means Continuous Improvement – AQUANOX A4727 is just one example!
For more information visit KYZENCleans.com

KYZEN
Where Science and Care Converge.

KYZEN.COM

WORLDWIDE ENVIRONMENTALLY RESPONSIBLE CLEANING TECHNOLOGIES

MIKE BUETOW
EDITOR-IN-CHIEF

Floating in the Mainstream

WE SPEAK SO often of the maturing ("graying") of the engineers and operators who work in the printed circuit industry, we sometimes overlook whether the same term applies to the companies that employ those individuals.

And yet that matzah ball is hanging out there, particularly when it comes to printed circuit design software.

The textbook definition of a mature market is when it has reached a "state of equilibrium." This is characterized by "an absence of significant growth or a lack of innovation."

It goes on: "In a mature market, companies have excess inventory or capacity, products become more homogenized (less differentiated), and there is pressure on prices and profits."

Can you think of anything in our corner of the world that applies to?

Bare board fabrication comes to mind. Even as the volume and frequency of electronics are exploding, growth at the manufacturing level is nominal, year in, year out. A relative handful of customers, such as Apple, Samsung and Intel, often dictate the winners and losers.

EMS is in the same vein. Its profit margins are lower than those of fabricators, and much of its future relies on extending its reach in each direction on the supply chain in pursuit of added revenue and higher margins.

Fabrication and assembly also share a vast inverted pyramid revenue shape, with thousands of smaller shops at the base dominated by a handful of billion-dollar players at the apex (and in the case of EMS, one overlord by the name of Foxconn. Maybe you've heard of them.).

Unlike their manufacturing cousins, the ECAD market from a revenue standpoint has for more than a decade been dominated by four major players, which alphabetically are Altium, Cadence, Siemens (Mentor) and Zuken. The latter three offer both mainstream (desktop) and enterprise tools, and Altium is racing to catch up in the enterprise space.

There is some dispute as to how much the ECAD industry is growing. Per the ESD Alliance data, the sector has grown year-over-year in 17 of the past 19 quarters. That's a healthy run. Less clear is which companies are truly driving that growth, and from which products, a picture made opaquer by Siemens' acquisition of Mentor a few years back. Altium's numbers shot up over a period of years, but recently even that company has fallen prey to the gravity of the market. So, when the major ECAD vendors started pulling in sales from their indirect channels, in many cases terminating longstanding relationships with distributors or VARs, that's a clue the revenue center of gravity is shifting.

ECAD is sticky. The tools are complicated enough to learn. But mastery may take a backseat to the parts libraries and IP blocks design engineers create and build up over time. Our big takeaway from scores of conversations with users over the years is they change flows because they must, not because they want to. A lot of things are (mostly) missing from (most) desktop tools: collaboration, thermal analysis, signal integrity analyzers and validation, chip-package-board routing, all the Df-whatevers. Yet designers still plug on.

So where is the growth coming from? Price increases, in some areas. Term-rental deals (although there's not much swapping going on). New technology, often pushed down from higher-end tools. The occasional unicorn, like a Tesla or an Amazon, that comes seemingly out of nowhere to become a major player in electronics design.

This month we offer insights of the leading ECAD vendors as to where they think the mainstream market is headed. (And yes, some enterprise thoughts are sprinkled in.) Not surprising, our panel sees plenty of runway for the market. But while all agree the current tools are good, they recognize they must continue to get easier for the occasional user, while more effectively linking to extended features in both native and external environments.

Is there room for new players in the desktop market? I wouldn't rule it out. Eagle, now owned by Autodesk, and Pulsonix trail the bigger guys in revenue, although there is clear brand loyalty by users, and both vendors are making investments in development.

The potential is greater than ever for new designers, because the demand for new products is high. Mainstream ECAD tools will become far more intuitive and automated. Whether that happens through efforts of the major vendors or through upstarts intent on disruption is a potentially billion-dollar question.

mbuetow@upmediagroup.com
@mikebuetow

P.S. We are heartened at the Covid-19 vaccine rollouts and keeping our fingers crossed for a return to "normal" soon. Be sure to register for the PCB East technical conference and exhibition, coming in June to the Boston area, at pcbeast.com.

Yamaha's Remote Doctor Makes House Calls!

You want to perform your best, in perfect health, and an occasional check-up helps keep you that way. Nobody knows you better than your own doctor.

It's the same with your YAMAHA SMT machines. That's why we're introducing new remote diagnostic tools that, like your doctor, analyze performance data already in your SMT machine and provide accurate feedback. No service call or interruption: it's a detailed report on your productivity, allowing you to optimize the operational efficiency (OEE) of your equipment.

This new service reviews and analyzes your data directly from your production line, letting you know about critical items that affect your overall productivity.

You get a rapid assessment of your line's real output over time, compared to its theoretical capability.

Want real time monitoring, diagnosing and optimization of your entire factory? Yamaha also offers a complete Factory Dashboard System.

Now you can make real-time, informed decisions:
You are in complete control.

To learn for about Yamaha's Factory Solutions, please visit
www.yamaha-motor-im.com/software-solutions

YAMAHA
Revs Your Heart

PCDF People

Aspocomp promoted deputy CEO **Antti Ojala** to chief operating officer. He joined Aspocomp in 2003. He succeeds Jari Isoaho, who joined the fabricator in 1989.

Crane Aerospace named **Dale Hanzelka** senior engineering designer.

Eagle Electronics named **Carl Schlemmer** quality assurance manager.

Hari Pillai has rejoined Sanmina as president of Components Technology, the company's printed circuit board and mechanical systems business unit. He previously spent 17 years with Sanmina in various leadership roles, including president and COO and executive vice president of its EMS division.

PCDF Briefs

CCI Eurolam, a distributor of PCB fabrication equipment and materials to EMEA, will acquire **Adeon Technologies,** a provider of fabrication equipment, for an undisclosed sum.

National University of Singapore researchers have invented a cobalt-complex-based super-hygroscopic material that might solve the problem of moisture-related electronics failures and help keep devices charged in the process.

Riverside Research and **Ohio State** engineers have launched a project using AI to produce an unknown circuit board's schematic.

Speedy Circuits will invest NT$180 million (US$6.32 million) in a new factory in Taoyuan as part of the government's "Invest in Taiwan" initiative.

The **US DoD's** new cyber security standards for defense contractors are creating significant costs and uncertainties for electronics manufacturers, but industry leaders are trying to make it work, according to participants in **IPC's** North American Executive Forum call on Jan. 6.

Ventec appointed **Sigma Component Design** sales representative in Canada.

Zero Defects International (ZDI) and **Skyla Technologies** announced measures to increase their PCB front-end engineering CAM service capabilities.

CA People

CalcuQuote named **Jani Leppälammi** VP of global sales and **Dirk Stender** responsible for business development in Central Europe.

GEN3 named **Chris Hunt, Ph.D.,** chief technology officer.

Elite Material to Buy Arlon EMD

TAOYUAN, HEISN, TAIWAN – Elite Material Co. will acquire a 100% equity interest in EMD Specialty Materials, further consolidating the printed circuit laminates and removing yet another US domestic owner of a critical material. Elite will pay $28.73 million in cash for the company.

In a regulatory filing, Elite said it sought to establish a North American manufacturing base and expand to the US to meet long-term market demand.

Rancho Cucamonga, CA-based EMD makes specialty laminates and prepregs for PCBs used in the aerospace, defense and semiconductor industries. Known also as Arlon EMD, it has been owned by Critical Point Capital since its purchase from Rogers in 2015. (MB)

Son of Founder Leads MBO of Circuits West

CHICAGO – A local consulting firm has partnered with Charles Anderson to acquire Circuits West for an undisclosed sum. Daniel P. O'Reilly and Co. will partner with Anderson, who is taking over for his father as CEO of Circuits West.

Circuits West designs and manufactures PCBs, specializing in the support and design of complex, dense and high-speed applications.

"I am excited to take over the company I've seen my father build over the past 25 years and lead it into the future," said Anderson. "This investment will help Circuits West grow, add capabilities and modernize as a PCB manufacturer, while continuing to provide our clients with a world-class product and unparalleled customer service."

DPO added, "We became intrigued by the bare board fab industry after learning that many of our private equity clients were investing in the space. When we dug into the industry and visited over a dozen board houses, it became clear there was a spectrum of quality, and that Circuits West was clearly near the top. Chuck did a great job of growing the company and continuing to invest in technology. With Charles' energy and experience inside and outside the industry, we think we can do something really special. We will differentiate based on speed, quality and customer centricity that we think will be unrivaled in the relatively sleepy PCB space." (CD)

PE Firm Acquires Ohmega Technologies

CULVER CITY, CA – A private equity firm with $1.5 billion of committed capital in January acquired Ohmega Technologies, a manufacturer of embedded thin-film resistive materials. No other terms were disclosed.

In a press release, Arcline Investment Management said, "The addition of Ohmega perfectly aligns with our specialty electronic components platform growth strategy to assemble a portfolio of companies with world-class products and customer service. We are excited to work with this talented team to accelerate Ohmega's growth, while maintaining the company's unique culture and customer-first mindset."

"We are very pleased with the acquisition of Ohmega by Arcline," said Bruce Mahler, VP and general manager of Ohmega. "Our commitment to the long-term supply of OhmegaPly to our customers is enhanced with this acquisition. We're also excited by the prospect of working with Arcline and Kevin Perhamus, the president of Arcline's specialty electronic components group, and know Arcline's commitment to investing in Ohmega and OhmegaPly will serve our customers well for many years to come." (CD)

US Congress Approves Funds for Pb-Free Electronics R&D

BANNOCKBURN, IL – The fiscal 2021 defense appropriations bill includes $10 million for research into the issues surrounding lead-free electronics in mission-critical appli-

cations. A number of trade groups including IPC had called for these funds to be included under the assertion that the high-rel sector has been slow to adopt lead-free materials, putting it at risk of falling behind best practices.

IPC said industry experts believe a five-year, $40 million investment in a public-private R&D program would yield more than $100 million in US defense savings per year and improve military readiness and overall innovation. Congress provided $5 million for such R&D in FY 2020.

Over the past 15 years, the commercial electronics industry has largely phased out its use of lead in electronic components and circuit board assemblies, driven by government regulations and concerns about lead's harmful effects on human health and the environment. However, the aerospace, defense and high-performance (ADHP) sectors have been reluctant to migrate to lead-free electronics because there are inadequate data on the reliability of lead-free components in ADHP applications.

The gap between commercial and defense electronics is growing wider as lead-free becomes more established in commercial technologies, and as governments – particularly in Europe – have implemented more stringent rules on the use of lead. Today's defense electronics are now 15 to 20 years behind the commercial market in terms of the underlying materials used, undermining supply chain resiliency and technological superiority.

"This vote is a win for US taxpayers, defense readiness, and the electronics industry supply chain," said Chris Mitchell, IPC vice president of global government relations.

"The migration of the commercial industry to lead-free electronics has created supply-chain concerns for the ADHP sectors that can only be overcome through public-private R&D," he added. "These funds will support a collaborative research effort that will help ensure that mission-critical systems have full access to cutting-edge electronics from a robust global supply chain.

"Together with our partners in the Pb-Free Electronics Risk Management (PERM) Council, IPC will continue to advocate for a proactive, long-term approach to this issue," Mitchell added. (IPC)

HIG Capital to Pay $171M for SMTC

TORONTO – SMTC has entered into a definitive agreement with an affiliate of H.I.G. Capital in which H.I.G. will acquire all outstanding shares of SMTC's common stock for about $170.5 million.

SMTC's board of directors has unanimously approved the acquisition and recommends stockholders adopt the agreement.

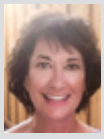
"Over the past three years, the team at SMTC has done an excellent job of transforming the company into a global leader among midsize providers of end-to-end electronics manufacturing services by offering superior supply chain management and proactive services and solu-

Inova named **Reinaldo Drago** industrial and supply chain manager.

Kurtz Ersa named **Joe Pellot** to its service team. His experience includes small engines mechanic.

MaRC Technologies hired **Sandy Chew** for sales in Northern California and Northern Nevada. She has a bachelor's in mechanical engineering.

Naprotek promoted **Daniel Radler** to director of engineering and named **Peg Fordney** director of business development. Radler has a degree in engineering from San Jose State and was process engineer at Solectron before joining Naprotek. Fordney was program manager at Natsteel, a strategic account manager at Flextronics and sales director at Jabil, and held roles in manufacturing and operations at Juniper and Cisco, among others.



Neways Electronics appointed **Steven Soederhuizen** chief operating officer. He has held senior management positions at Stork Industrial Components, VDL Industrial Modules, Fokker Aero Structures and GKN Aerospace.

Zollner Elektronik CEO **Johann Weber** retired on Jan. 1 but will remain a member of the supervisory board. **Ludwig Zollner,** the eldest son of the company's founder, will take over as board spokesman.

CA Briefs

Absolute EMS has invested in three **Hanwha Techwin Automation** HM520 modular mounters and a nitrogen oven.

ACC Electronix installed two **CyberOptics** SQ3000 3-D SPI/AOIs.

Akyumen Industries will invest $100 million in a new facility to make 5G smartphones in Gary, IN.

Apple suspended new business to **Wistron** in Narasapur, India, in the wake of worker riots in late December. Up to NT$200 million (US$7.1 million) in damage was caused. In response, Wistron fired the head of the factory.

Apple plans to produce up to 96 million iPhones for the first half of 2021, a nearly 30% year-on-year increase, but industry-wide shortages of key components could threaten that target.

tions to an expanding base of customers," said Ed Smith, president and CEO, SMTC. "Partnering with H.I.G. will enable us to accelerate our growth through continued investment in our customers, capabilities, and footprint.

"In addition to delivering immediate value to our stockholders, this investment provides SMTC with a long-term partner with an extensive track record of supporting its portfolio companies with operational expertise, technology and financial management experience. Together, we believe we can capitalize on strategic growth opportunities, while continuing to meet the needs of our customers by delivering high-quality, innovative solutions and services."

"We are pleased to partner with Eddie Smith and his team," said Phillip Wood-Smith, managing director of H.I.G. "They have done an outstanding job over the past three years serving some of the most attractive end EMS markets, including aerospace and defense, industrial IoT, 5G, and medical and safety. With its industry-leading solutions and strong customer relationships, we believe there is significant opportunity to invest in SMTC's customers and capabilities to further expand the company's leadership position. We look forward to partnering with SMTC's talented management team and employees to serve its customers with best-in-class solutions, build upon its existing capability excellence, and help SMTC achieve its full potential."

The transaction, which is subject to the receipt of approval from SMTC's stockholders, antitrust clearance, and other customary closing conditions, is expected to close by the second quarter of 2021. (CD)

PE Firm Behind Spartronics Acquires Primus

WILLIAMSPORT, PA – New York-based One Equity Partners, a middle market private equity firm, has purchased Primus Technologies, an EMS firm based in Williamsport, PA, with annual revenues over $100 million. Financial terms of the transaction were not disclosed.

Last July, OEP bought the EMS assets of Sparton Corp., which has since been renamed Spartronics. The combined companies will have annual revenues of around $420 million, a source with knowledge of the transaction told CIRCUITS ASSEMBLY.

Primus primarily supplies the military, aerospace, medical, industrial and transportation sectors. Key customers have included Raytheon, General Dynamics and Kaman.

Spartronics has eight locations in the US and one in Vietnam. The sites perform a variety of design, assembly and aftermarket services, primarily for the high-end reliability sector.

"Primus Technologies has established itself as a leader in the electronics manufacturing services space, particularly among key aerospace and defense customers," said Paul Fraipont, president and CEO, Spartronics. "Our investment in Primus demonstrates our ability to acquire great businesses with complementary strengths. We look

ASE, Chunghwa Telecom and **Qualcomm** unveiled a 5G smart factory in Taiwan.

Baidu, the Chinese search giant, is reportedly considering making its own electric vehicles and has held talks with automakers about the possibility.

Suppliers are reporting downstream customers are stockpiling chips. **Honda** will cut auto production due to a shortage of semiconductors used in its vehicle control system, and a source says the shortage could "impact tens of thousands of vehicles during the March quarter on the domestic side alone."

Cogiscan expanded its strategic partnership with **ASM Assembly Systems** to include new machine connectivity solutions to support Industry 4.0 initiatives.

CyberOptics received orders valued at $4.2 million for its 3-D MX3000 memory module inspection systems for multiple subcontractors of a large memory manufacturer.

DigiProcess installed **Aegis's** FactoryLogix Solution.

Dover Corp. awarded **Mack Technologies** with its 2020 Supplier Recognition Award for the North American region.

forward to working together with the proven team at Primus to grow Spartronics with an expanded footprint and broader capabilities. The Primus campus in Williamsport is well-suited to accommodate our growing company. We plan to relocate our headquarters from Watertown, SD, to Williamsport in the near future." (MB)

AEM Holdings Proposes Acquisition of CEI for $75M

SINGAPORE – Electronics manufacturing company AEM Holdings has launched a S$99.7 million (US$75.2 million) bid for contract manufacturer CEI. AEM plans to delist CEI from the Singapore Exchange and take it private.

AEM is offering S$1.15 in cash, or a mix of cash and new AEM shares, for each ordinary share in mainboard-listed CEI.

CEI shareholders can opt to accept the offer for either 85% cash and 15% new shares, or 70% cash and 30% new shares at an issue price of S$3.55 for each new share in AEM.

Founded in 1999, CEI has annual revenues of about $100 million primarily from customers in the industrial equipment market. It operates sites in Singapore, Indonesia and Vietnam. (CD)

Intervala to Expand at New Site in PA

PITTSBURGH – Intervala has signed a long-term lease finalizing the relocation of its corporate headquarters and EMS manufacturing operation in Westmoreland County, PA.

With the relocation, the company continues to reside in the Greater Pittsburgh area and gains more square footage in anticipation of future growth. Intervala finalized the five-year lease for the 217,000 sq. ft. space, including several extension options.

The site incorporates line-of-sight manufacturing and engineering, manufacturing and inspection technologies, as well as ESD and environmental controls. The build-out of the new production floor, office and collaboration spaces, employee facilities and a customer welcome area are underway.

"We are thrilled with the many opportunities our new location provides, including the ability to design the best possible manufacturing experience for our customers and work environment for our employees," said Teresa Huber, president and CEO of Intervala. "In addition, the site provides significant room for expansion, as our business providing full-service manufacturing of complex, high-performance printed circuit board assemblies, electromechanical systems, and cable and harness assemblies continues to grow.

"We also are grateful to RIDC for its support in meeting the needs of Intervala's business in helping us identify and create a professional and comfortable space that will appeal to our customers and employees, and reflect positively on our organization." (CD)

European Circuits purchased a **Mirtec** MV-3 Omni 3-D AOI.

Foxconn plans to invest around $200 million in **Byton,** with mass production of the M-Byte electric SUV planned for 2022.

More than 200 workers at **Google** and other **Alphabet** units in January formed a labor union for US and Canadian offices, building on years of protests over working conditions and business practices.

Huawei committed 200 million euros toward a new mobile phone network equipment factory in east France, pressing ahead with the rollout despite French curbs on firms using its 5G gear.

i-Med Technology and **Neways Electronics** entered a partnership to produce the Head Mounted Digital Loupe (HMDL) and the 3-D viewer based on the technology.

Intelligent Manufacturing Solutions (IMS) installed a **Dage** Assure x-ray component counter.

IPC has debuted IPC-CFX Self-Validation and Equipment Qualification System, a cloud-based test bed for equipment vendors and manufacturing facilities to self-validate CFX messaging.

Logitech said that by the end of 2021, more than half the mice and keyboards produced within the company's largest product portfolio will be made from post-consumer resin.

Micron Technologies will set up a Centre of Excellence with the government of India.

Microsoft is working on in-house processor designs for use in server computers that run the company's cloud services, adding to an industrywide effort to reduce reliance on **Intel's** chip technology.

Mirac is opening a second EMS facility in Ohio and is hiring 20 to 40 new assembly workers.

EMS firm **Naprotek** has been purchased by **Edgewater Capital Partners** for an undisclosed sum.

The National Defense Authorization Act of 2021 (NDAA) includes provisions supporters hope will lead to a resurgence in chip manufacturing in the US.

NovaCentrix appointed **Bentec** manufacturers' representative in the UK, Europe and Asia.

Plasmatreat Schweiz has been founded in Switzerland to serve the local market. The company named Klaus Kresser manager.

Rohde & Schwarz and **IHP** have performed the first full 2-D/3-D antenna characterization of transceiver modules operating in the D-Band.

Salcomp acquired a 30,000 sq. m. electronics manufacturing facility in India from **Jabil.**

Scanfil will close its Hamburg, Germany, EMS factory.

SEC Co. said it has sold more than 1,500 industrial x-ray inspection machines since its launch in October.

Teledyne Technologies will acquire **FLIR Systems** in a cash and stock transaction valued at approximately $8 billion.

Thermaltronics named **Southwest Systems Technology** manufacturing representative in Texas, Oklahoma, Arkansas and Louisiana.

ViTrox Technologies named as sales channel partners **Suzhou Jetoptech Electronics** in China and **MTSC** in Thailand.

Wisconsin and **Foxconn** appear to be nearing an agreement on amendments to the company's now three-year-old contract, which could result in Foxconn receiving fewer state tax credits than originally agreed upon.

Zollner Elektronik has become part of the Technological Institute for Applied Artificial Intelligence to drive the digital transformation of its corporate processes.

INVENTORY TIGHTENS

Trends in the US electronics equipment market (shipments only)	% CHANGE SEP.	OCT.	NOV.	YTD%
Computers and electronics products	1.6	2.3	-1.4	4.0
Computers	4.3	1.7	0.7	-6.8
Storage devices	-5.2	17.7	-3.1	29.2
Other peripheral equipment	-7.9	2.1	3.9	10.3
Nondefense communications equipment	2.8	10.7	-7.0	12.4
Defense communications equipment	-5.1	0.0	2.2	7.1
A/V equipment	4.0	1.4	-0.3	-2.0
Components[1]	0.3	1.5	1.4	10.4
Nondefense search and navigation equipment	0.0	2.4	-1.0	-5.2
Defense search and navigation equipment	2.9	0.7	-2.1	2.5
Medical, measurement and control	1.1	1.7	-0.9	-0.5

[r]Revised. *Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: U.S. Department of Commerce Census Bureau, Jan. 6, 2021

US MANUFACTURING INDICES

	AUG.	SEP.	OCT.	NOV.	DEC.
PMI	56.0	55.4	59.3	57.5	60.7
New orders	67.6	60.2	67.9	65.1	67.9
Production	63.3	61.0	63.0	60.8	64.8
Inventories	44.4	47.1	51.9	51.2	51.6
Customer inventories	38.1	37.9	36.7	36.3	37.9
Backlogs	54.6	55.2	55.7	56.9	59.1

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

KEY COMPONENTS

	JUL.	AUG.	SEP.	OCT.	NOV.
Semiconductor equipment billings[1]	26.7%	32.5%	40.0%	27.3%[r]	23.1%[p]
Semiconductors[2]	4.23%	4.94%	5.79%	5.86%[r]	6.95%[p]
PCBs[3] (North America)	1.00	0.94	0.93	0.97	1.05
Computers/electronic products[4]	5.28	5.22	5.15	5.01[r]	5.12[p]

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

METALS INDEX

Hot Takes

- **Global smartphone production in 2021** is forecast to increase 9% to 1.36 billion units. (TrendForce)
- **German area PCB manufacturers'** third quarter sales declined 15% year-over-year, but were flat sequentially. (ZVEI)
- **Third quarter output value of PCB fabricators** across the Taiwan Strait was NT$185.9 billion (US$6.6 billion), flat year-over-year. (TPCA)
- **Fourth quarter PC shipments** rose 26% year-over-year to 91.6 million units. (IDC)
- **The global TV market** grew 1.2% growth in 2020 to 233 million shipments. Revenues are forecast to decline 1% to $83.7 billion. (Futuresource Consulting)
- **EMS market revenue** is expected to reach $581.3 billion by 2024, a CAGR of 5.6% over 2019. Communications (6.9%) and medical (6.4%) are expected to outperform the segments, while consumer will inch up 0.9% over the forecast period. IoT is expected to reach $3 billion in 2024, up 400% over the forecast period. (Lincoln International)
- **The December forecast for overall component sales** registered at 113.9, down from 136.9 in November. (ECIA)
- **The automotive electronics market** is estimated to reach $382.16 billion by 2025. (Allied Market Research)
- **Brazil's electrical and electronics industry** is expected to end 2020 at BRL 173.4 billion ($33.7 billion), up 1% year-over-year after inflation is accounted for. (Brazilian Electrical and Electronic Industry Association)
- **Global notebook shipments** will grow 8.6% year-over-year to 217 million units in 2021. (TrendForce)
- **The ATV electronics system market** is poised to grow by $117 million between 2020 and 2024, a CAGR of over 3%. (Technavio)

Is Covid Stagnating Your Workplace? Here's What to Do

Dealing with the emotional toll of the pandemic.

STAGNATION IS A devastating condition for any business. No enterprise chooses to be stagnant, and rarely does anyone within notice when inertia begins. Still, the effect can launch a downward spiral that can cripple companies, even in the most dynamic industries.

Stagnation has many causes, which can take a long time to do damage. Most common are simple things, such as when a company slows or stops development of new products or capabilities, or when it takes existing customers for granted while not working to develop new ones. Most common is when management stops investing in needed equipment or workers to make the bottom line look better, quarter after quarter. Each of these decisions are made, consciously or not, by management. And while the intentions may have been good, over time they become the root cause of stagnation and can bring a vibrant company to its knees.

Yet stagnation can occur despite management's best efforts to maintain a focused, engaged and vibrant business. Sometimes external events create an environment that must be dealt with. In the meantime, corporate progress falls by the wayside. Covid-19 is just such an event.

Covid-19 began to wreak havoc on the globe about a year ago. The pandemic has thoroughly changed how people go about their day, at work and home. People everywhere had to adjust from relatively carefree lifestyles to an era of social distancing, face masks, hand sanitizer, and the loss of face-to-face interaction, all while hearing about those who became extremely ill or died from the disease. Few of us don't know someone personally affected by the pandemic.

While there finally appears to be some light ahead in the form of vaccines that, at some point over the next year should be distributed to enough of the population to stop the spread, we have a long, long way to go. As we approach the second year of the pandemic, however, many are experiencing another phenomenon: Covid fatigue. Coping with this may present the biggest challenge for all. Employees, exhausted by the changes to their lives and routines, might not function at optimal levels at work. Worse, management also experiences Covid fatigue and is unable to rally the troops.

Over the next several months, possibly the top managerial challenge for most executives will be how to operate when employees are fatigued and the novelty of working remotely, social distancing and interacting with coworkers only via Zoom or WebEx wears thin. While many, if not most, have seen the advantages of harnessing technology to function while socially distanced, everyone yearns to get back to "normal" and reconnect with people, without donning masks and sanitizer and the stress of a Covid infection.

How businesses deal with this next stage is critical. Companies diligently made necessary changes and pivoted to ensure the physical safety of employees. They now need to focus on the emotional state of those same workers to prevent further Covid fallout.

Simple acts of kindness matter. This includes abundant patience and offering sincere thanks to all the employees who have endured so much over the past year. We must remain diligent and careful to avoid contracting the disease, of course. But we equally need to keep our senses of humor and show concern for each other. For company leadership, when developing and communicating new initiatives to move the team in a positive direction, remember to focus on the person as much as the goal. When frustration erupts, it could just be ongoing fatigue that needs to be released.

Let employees know the emotional toll they have endured is shared throughout the organization. Embrace this realization. Do not ignore it. For some, open acknowledgment of the difficulties and challenges of these times can offer relief.

Knowing that fatigue is setting in also creates an opportunity. Open discussion of lessons learned during the pandemic, and employee recommendations on how to make their lives easier, can bring stress relief and valuable input.

But possibly the most tangible way to both deal with Covid fatigue and prevent it from stagnating your workplace is to discuss the future. Engage employees in the aspects of the changes that might fit the post-pandemic work environment. Start a dialogue about how effective – or restrictive – trends such as working remotely or interactively have been, and what mix of in-person vs. virtual would work best. How has staggering or splitting shifts really worked for the company and employee? Engage all levels of employees and managers in conversations on how to utilize the benefits that have been realized. Finally, focus on moving forward so the enterprise does not stagnate. □

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

Sales and Marketing in the Transition to Post-Covid-19 Normal

Traditional materials such as whitepapers and articles are solid lead generators.

WHAT A DIFFERENCE a year makes. As I write this, three Covid-19 vaccines are approved and are in distribution to healthcare workers and nursing homes. By the time this is printed, it's likely the next tier of eligible recipients will be able to get a shot at a pharmacy or their doctor. The speed of development, manufacturing, testing and deployment is unparalleled. The teams involved in this have set the stage for a return to normalcy. Yet it is likely Covid-19 will have a global impact on business travel and selling processes for most of 2021, because it will take time for herd immunity to develop. So, what should sales and marketing teams in the electronics manufacturing services (EMS) industry expect as we transition back to normal?

The need for speed. OEMs discovered some EMS companies could cut new product introduction (NPI) time significantly during 2020. The bar will likely stay raised, both because it provides competitive advantage and because unanticipated variations in demand require it. Companies able to exploit their success in this area will likely see additional new business.

Demand will be more variable than usual. While parts of the economy have been almost normal for months, some regions experienced shutdowns. There is also pent-up demand for products such as appliances that experienced shortages in 2020. Consumer lifestyles changed in 2020 and are likely to impact buying patterns in 2021. A telecommunications technology shift is in play with 5G, and potentially political incentives for alternative energy products. From a sales perspective that translates to new opportunities in markets that may not have been as attractive in prior years.

Virtual audits will continue. Virtual audits are becoming popular enough that companies are now planning them as carefully as in-person factory tours. Many EMS companies have new customers who have not yet visited their factory in-person. Initially this trend will continue as a way to mitigate Covid-19 spread. When a practice continues for six to 12 months, however, people can get comfortable with it, especially if it saves time and money. As a result, I suspect some OEMs will incorporate virtual audits permanently in their early supplier identification efforts. From a sales perspective that has both upsides and downsides. On the positive side, it is easy for the entire OEM decision team to watch a virtual audit, and, when it is interactive, it provides the ability to build relationships with a larger group at the customer. On the negative side, virtual audits eliminate relationship-building activities such as lunch or dinner with the program team post-audit. They will typically have a shorter timeframe than a normal plant tour and, if format is completely dictated by the customer, may have limited opportunity for differentiation.

From a sales and marketing perspective, then, it becomes important to do four things:

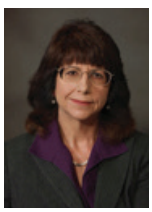
- Identify alternative methods for building relationships with key decision-makers. This could include follow-up with informational material, one-on-one calls with internal technical experts discussing solutions to key project challenges, or a BoM scrub with the initial quote.
- Create show-and-tell segments in the plant tour that differentiate. This might be a tour of engineering success stories, a short presentation on the NPI process or short presentation on a relevant technical capability.
- Incorporate storytelling in any plant tour. Most EMS companies in a given size class look alike. Don't just show equipment. Tell stories about challenging projects and the solutions provided in that area.
- Ask questions during the audit. While a decision-maker may be cagey during a sales call, they are often less guarded during a good plant tour. Use the opportunity to ask about decision team members, challenges they'd like to solve that aren't currently being addressed, and related projects that might be bundled for a better total price.

Marketing will continue to have challenges. Trade shows are being scheduled in 2021. However, I see two potential problems. First, I haven't talked to a salesperson who is enthusiastic about manning a booth right now. Second, most companies I know have banned discretionary travel. Shows may be held, but traffic is likely to be light for most of the year. And, while shows were flexible about cancellations in 2020, this year many are enforcing contract terms. Cancellation clauses typically permit cancellation without penalty only if the show changes dates or locations. So, trade shows are likely a marketing tool to shelve until 2022.

Marketing material is more important. In a virtual world, marketing material becomes a primary engagement tool. That said, it must be beneficial to the

continued on pg. 44

SUSAN MUCHA is president of Powell-Mucha Consulting Inc. (powell-muchaconsulting.com), a consulting firm providing strategic planning, training and market positioning support to EMS companies and author *of Find It. Book It. Grow It. A Robust Process for Account Acquisition in Electronics Manufacturing Services*; smucha@powell-muchaconsulting.com.



Why Do We Have to Follow Drawing Standards?

They play an outsized role in continuous improvement.

TIME WAS CREATING drawings meant using paper and a pencil. Can you imagine? The main variable was the type of so-called lead in the pencil. Even in those primitive times, it was necessary to agree on an overall language. The particulars that allowed the community to get its message across were determined by standards. Standards, in turn, were driven by the requirements of the equipment that archived and reproduced the drawings.

One of those pieces of equipment was microfilm. You might recall microfilm stores many drawings in a small space. Bringing those tiny pictures back to human-readable sizes would lose some of the sharpness of the data. Standards were set up so we could still make out the images and data with no doubt about what we saw.

Drafters would pencil-in the linework and run the pencil over the object lines again and again to ensure it was certain to come back from the photographic shrinkage. Text sizes and, importantly, space between characters, were a function of the size of the drawing. Smaller A and B size documents could use 0.125" minimum text height, while C-size formats and above required 0.140" letters and numbers. Minimum spacing between rows is half of the text height, so taller lettering gets more space.

FIGURE 1. Pencil work was a job in itself. (Source: AutoGuide)

Text size is one example of typical drawing requirements. Department of Defense work has a huge ecosystem of standards. One document will reference several others. Those documents, in turn, expand to other relevant documents. It seems the entire Library of Congress is in play by the time all the interlinked specifications are on the table.

Government sets the bar for its vendors and sends auditors with calipers to measure the size of the text and other aspects of the documentation. Its rules are enforced by the authority to stop shipments if the overall document package fails to meet expectations. In a way, they're not even concerned with the product itself. Their primary concern is the entire program can be resurrected from the microfilm records if the company itself were somehow removed from the face of the earth.

A custom carries forward out of momentum. Bureaucracy in the commercial sector is trying hard to catch up and move forward at the same time. ISO, ANSI, IPC and other organizations are looking to replicate the process control without quite so much emphasis on reliability, traceability and excruciating completeness. Businesses that do not work on government contracts are free to adopt whatever methodology they choose, including making their own.

No legal mechanism exists to hold consumer product documents to any standards. Telecom and other large outfits that work both sides of the fence are likely to keep subcontractors in line with prevailing practices. Supplier guidance is a valid strategy when you're flying by the seat of your pants. You will have to grow into a system eventually. It's how we keep the wheels turning.

For the most part, IPC and other standards organizations took the governmental regulations as a template. From there, they could strip away the unnecessary mumbo-jumbo and add in the particulars for enterprise. For example, we still categorize PCBs for toys as Class 1, while business machines are Class 2, and high reliability is Class 3. The entire build scheme of a hardware product is based on those three buckets.

General principles of documentation. These seven points are the essence of documentation:

- Everything should be traceable to a standard definition.
- Document everything once, then refer to the controlling document for the characteristic.

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.

WEBINAR

PCB2DAY

SPONSORED BY

EMA Design Automation®

February 23, 2021

Part One:

10:00 am – 1:00 pm EST

Part Two:

2:00 pm – 6:00 pm EST

A Guide to Engineering PCB Design

Susy Webb, CID

$150

Limited seating, register today!

pcb2day.com

Professional Development Certificate included!

- A drawing is a what-is document.
- A procedure is a how-to document.
- Continuous improvement: Don't allow success to slow the march of progress.
- Maintain a tight logistics loop, including revision control and traceability of inventory.
- These and other measures apply to the entire supply chain.

Traceability, in a document sense, means somewhere is a source of the information, and that source is in a secure location. We can retrieve that data any time they are needed. As far as physical inventory, the dynamic includes not only the part number and revision but the time, place and purpose for which the item was procured in the first place.

Documenting everything once dovetails with traceability in that a second source of information that contradicts the first needs to be avoided. The top document in that case is the laws of the locality, followed by the contract, the purchase order, then the particular drawings, and finally the standards called out to fill in the gaps. In a smaller sense, it applies to the application of dimensions so there is only one way to interpret the physical minimum and maximums.

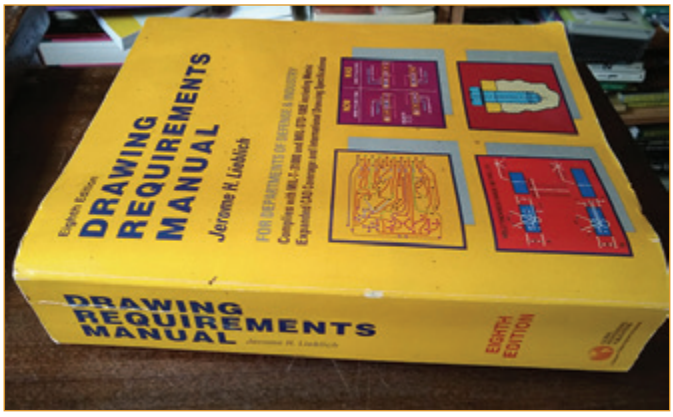


FIGURE 2. A phone book-size style guide where "shall" means something very specific. New 11th edition copies are priced near $900. (Source: eBay)

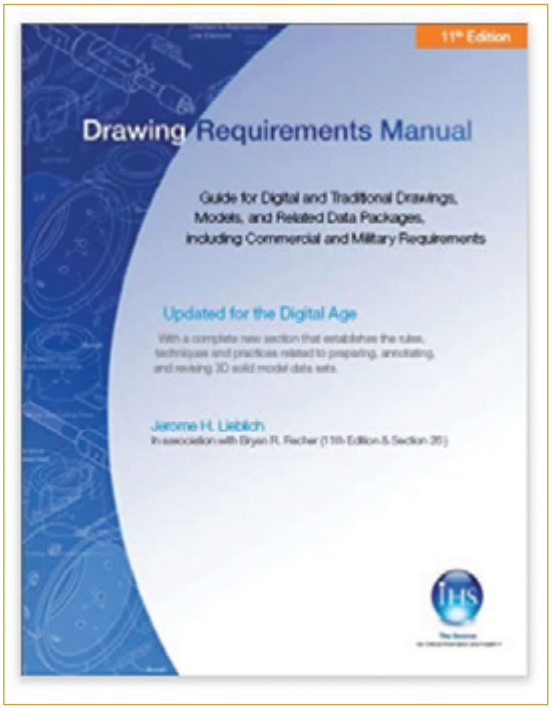


FIGURE 3. Jerome Lieblich has made a life's work of documenting the documentation process.

Fabrication and assembly drawings are considered inspection documents that depict a completed unit. While exploded-view images can be generated, they're best used as an illustration in a process document. The main difference is a procedure is limited to letter-size paper, while drawings make up the larger paper sizes.

That may seem like nonsense in a world where a PDF file can be any size we like. Still, there's more to it than keeping the drafters out of the loop of the factory flow documentation. A binder with the relevant specs is more practical than a drawing that covers the whole desk. Rework instructions and test procedures also fit the small format mold. Some of this is clearly a holdover from a time when computer monitors were not sitting on every desk in the factory.

Continuous improvement is a key principle. It is why we have the revision block. We are expected to stress-test product to the breaking point. Whatever broke is strengthened, and the product torture starts over. Extending beyond the reliability lab, we strive to improve all aspects of engineering execution in pursuit of a prosperous product lifecycle.

Getting everyone in the organization on board is a horizontal approach. A big part of continuous improvement is extending it through the entire vertical. The prime contractor is responsible to the customer but also must be a conduit to the subcontractors to ensure they are in compliance and passing it down to their vendors. Doing all this with a complete paper trail is costly.

Much of the commercial sector is not obliged to take it to that extent. The automotive industry comes to mind as a place where definitive quality control is a must. If a defective component is an issue down the road, all instances of that component must be replaced through a recall.

Managing inventory so they have provenance of every part helps ensure they do not have to replace every example if the failure is contained to a certain lot or date code. Pushing the requirement down through the supply chain strengthens the awareness of quality, while enabling the factory to pinpoint problem parts.

Creating documents that convey the design requirements is the essential deliverable of our job. We can call it artwork, but it is also very technical work that helps determine outcomes. While the reason for some documentation procedures seems from another time, they serve the continuity that allows us to communicate our goals. As an organization grows, so does the formality of its documents. All we have to do is improve it a little every day. □

Oh, That Radical PCB Engineering Conspiracy Theory

Applying sound science to circuit board design through test.

IN THIS MONTH'S column, I share a few terms I've been contemplating lately, which I have been trying to put in the context of the role of the PCEA within the electronics industry. Next, I hand it off to PCEA Chairman Steph Chavez for some inspiration for the fresh start of the year. And finally, I provide a list of coming events.

PCEA Updates

You may have noticed the use of three concepts mentioned extensively in 2020: "believe the science and data," "speak truth to power," and consider "systemic" causes for problems.

These concepts were associated with some particularly challenging, if not nasty, displays of societal failure in 2020. It has been easy for us to see how, in an agitated and perhaps desperate social climate, a time-consuming, methodical approach to collecting data and applying them to science can give way to convenient conspiracy theory. Speaking truth to power got some people fired overnight. The term systemic was used to point to long-term causes for some particularly blatant failures of a society to prepare people for success.

Will society's negative issues be addressed? Will any good come through lessons learned from science, speaking truth to power and examining systemic causes for our problems? I hope so.

As 2021 begins, my thoughts are on these concepts. How can an organization like the PCEA help the electronics industry see positive movement in our industry? Our organization can do much to inspire our membership in the long run.

Where would our printed circuit engineering technology be without science? Our leaders within the PCEA are actively engaged in partnering and promoting the science and research data of the many electronics Ph.D.s whose work continues to advance PCB designs in the areas of layout, materials, processing and overall performance. The goal of the PCEA educational committee is to pull industry stakeholders away from "conspiracy theories" like:

- An EE degree automatically makes one an experienced PCB engineer.
- Just because the finish spec for copper says 2 oz., the supplier is plating up to a full two ounces.
- Your electronic components app notes are 100% correct for all applications.

They want to expose our members to science that can be leveraged to improve PCB design, manufacturing, test and procurement. The PCEA educational committee is tasked with teaching solid, scientifically sound, core PCB engineering concepts. The concept here is to give members the education and confidence to speak the truth about design, manufacturing, test and procurement to fellow stakeholders, project managers, and even CEOs or legal representation during the most agitated and chaotic times of a project development cycle.

Rejecting radical PCB engineering conspiracy theory, embracing science and becoming educated enough to speak truth to powerful management and customer contacts are keys to overcoming systemic PCB engineering failure. Systemic success models include proliferation of relevant, real-time data to be accessed and rightly used to promote the well-being of one's fellow PCB engineering stakeholders and their individual responsibilities. A customer must truly define their needs. A program manager must understand those needs, select project stakeholders and work to gather data and feed them truth. PCB design, manufacturing and test engineers must be enabled to work within a corporate culture that promotes frontloading projects with a healthy respect for science, data and educated stakeholder feedback.

Message from the Chairman

by Stephen Chavez, MIT, CID+

Happy New Year! 2021 is finally here. Thank goodness 2020 is behind us! We view 2021 as open to much potential and great opportunities. Many people set New Year's resolutions each January. For many, these consist of a handful of new resolutions mixed with some of the same old ones. These "carryovers" may or may not get filed or accomplished, yet remain on the annual list, year after year. Long ago, I would write down New Year's resolutions. I no longer make them. Is this a good or bad thing? I guess it's up to how each of us perceives this annual setting of goals or "good intentions" to promote change or improvement in our respective lives. Everyone handles the beginning of a new year a bit differently when it comes to resolutions or goals.

During my end-of-the-year holiday break/vacation, I take some personal time to do deep-level self-assessments and evaluations. I think about how the previous year unfolded, and how I adapted. I review my successes, failures, opportunities taken, and opportunities missed or which I simply did not take advantage of. Then I ask myself several questions, such as, "When looking into a mirror, are you truly happy with

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.

who is looking back? Did you do better than the year before? Did you honestly try your hardest and give your best each and every time? Did you practice what you preach? What do you think you could've done better? Did you learn from any failures or shortcomings? Did you treat others as you would like to be treated? Did you live each and every day outside your comfort zone?" Here is a big one I started asking myself about 10 years ago: "Did you make a positive difference in someone's life?"

After this deep self-assessment and self-evaluation, I identify areas to improve or evolve. Then I go after them, continuing to tell myself, "Steph, you can do better, so much better! There is always room for improvements! Attack each day as if it's your last and have no regrets as this year unfolds! Positive attitude is everything, even when things don't go as planned or expected! Remember Steph, don't be afraid to fail because fear itself is a self-induced mental roadblock to success."

For PCEA, 2020 was year we will never forget for many reasons. It was our birth year. It was a year that unfolded with many challenges, especially with adapting, evolving into and incorporating our virtual existence in today's industry due to Covid-19. Like many, PCEA adapted to these challenges and overcame them. As our momentum continues into 2021, we review how PCEA came about, where we started from, where we want to be, what it will take to get there, and what we will to do to make it happen. It's similar to my self-assessment. As a collective, we agree to strive to be and do better in all aspects of what PCEA stands for. Collaborate, inspire and educate are at the core of our values and mission. PCEA will do this even better for the good of the industry in 2021. We are eager to attack and do so much more, from years of lessons learned and feedback from many within our industry. So, are these a form of New Year's resolutions? Are these goals? You decide. I challenge you to do your own self-assessment going into 2021. I also challenge you to stay outside your comfort zone for personal growth, and do whatever it takes to be better and do better, as you chase your own definition of success.

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

Warmest regards,

Steph

Next Month

It looked like some new live printed circuit engineering events would be coming. Not so fast. 2021 continues to require we submit an ounce of prevention to pound out the cure for new electronics jobs and technology. Help is on the way! PCEA is traveling at warp speed to feed our diverse electronics industry data in hopes this may lead us to mutate our thought process or at least provide us with antibodies to help ward off career stagnation.

Upcoming Events

Below is a list of upcoming events that may lead you to mutate your thought process or at least provide you antibodies to help you ward off career stagnation:

- Mar. 8-12: IPC Apex Expo (online)
- Apr. 13-15: DesignCon (San Jose, CA)
- May 11-13: IPC High-Reliability Forum 2021 (Baltimore, MD)
- Jun. 7-10: Zuken Innovation World (Scottsdale, AZ)
- Jun. 8-10: PCB East (Marlborough, MA)
- Aug. 31-Sept. 3: PCB West (Santa Clara, CA)
- Nov. 1-4: SMTAI (Minneapolis, MN)
- Nov. 10: PCB Carolina (Raleigh, NC)

Spread the word. If you have a significant electronics industry event 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 upcoming industry events. If you have not yet joined PCEA, visit pce-a.org and find out how to become a member.

Conclusion

The most productive, long-term changes within a society come not from negative agitation but through education, science and truth. In our PCB engineering culture, we are occasionally affected by "disruptive technology." True disruptive technology can wipe out an entire industry. Think of the troubles LEDs caused the incandescent lightbulb industry. But we might consider this an example of technologists inciting "good trouble" – a significant change in technology based on the long-term benefit of the entire society considered. Long-term benefits for all.

PCEA doesn't want to help educate our industry stakeholders so we can all speak truth to power and get fired the next day by management or customers who can't handle what we say. Our organizational goal involves collaborating to help create and inspire an entire industry of informed people who have their industry's long-term best interests and success for all in mind.

See you next month or sooner! □

Zero-Emission Aviation Promises Better Services and Cleaner Skies

Are low-loss flex circuit materials an enabler?

SAAB MAY HAVE been first to bring aerospace technologies overtly into the automotive world when it introduced the aerodynamically styled 92 in 1948. The idea proved popular and effective, setting a trend that has made technologies such as infrared vision, radar and heads-up displays common features in today's vehicles.

The flow of technology and know-how may soon be seen in reverse, as the aviation industry seeks to clean up its environmental credentials. In my last column, I mentioned Airbus' recent flying achievements with fully electric planes. The company is also experimenting with hybrid platforms powered by a combination of lithium-ion batteries and a range-extending combustion engine, and recently unveiled several new hydrogen-powered concepts.

We can expect technological progress toward larger planes capable of longer flights; the ultimate goal, obviously, is zero-emission planes operating commercially viable services. Key challenges facing battery-powered electric aircraft include compensating for the extra weight of large Li-ion batteries. There are also demands for charging infrastructure and safe solutions to minimize recharging times so operators can turn services around quickly. The automotive industry has experience dealing with these issues and could provide solutions.

In addition, some intriguing innovations could help with weight loss. Last month I mentioned highly integrated motor stators made from lightweight PCB materials. Further opportunities include the potential for flexible printed circuit (FPC) interconnects to replace traditional – and heavy – wiring looms. FPC itself is not new, of course, and is heavily used in commercial products such as smartphones, cameras, printers and hard-disk drives. The breakthrough in FPC, which lets the aerospace sector benefit from this technology, lies in the industrial processes developed for producing FPCs up to extreme lengths capable of spanning the wing of a large aircraft.

Today's airliners can contain over 100km of wiring, weighing several thousand kilograms. Although this is only 1 to 2% of the plane's overall weight, significantly reducing the wiring – in conjunction with other savings throughout the airframe – can help offset the large batteries needed to replace conventional fuel. While about 30% of the infrastructure could go wireless, FPC comprising power and signal connections can now be made in lengths over 20m. As we in the PCB industry know, replacing wires with FPC, using low-loss substrate materials, can increase reliability and improve electrical performance by permitting superior control over impedances and spacing between conductors.

The main alternative to batteries, liquid hydrogen (LH2), has 200 times the energy density of a Li-ion battery and could provide a more effective route to achieving the range needed for commercial flying. Aircraft manufacturers are working on two approaches, either using the hydrogen in fuel cells that power electric motors or directly in hydrogen combustion engines. In either case the main exhaust is water vapor, which significantly reduces aviation-related greenhouse gas emissions. Clearly, however, using LH2 brings challenges. On-board cryogenic cooling is needed to maintain the temperature below -253°C, and low-carbon energy is needed for hydrogen production using processes such as electrolysis.

High-end know-how from the defense and aerospace industries continues to filter into commercial applications, as it has for many generations. A current example is the birth of the civilian drone sector, leveraging communications and airframe-design knowledge conceived for unmanned military surveillance. Today, small drones are increasingly used in applications such as surveying, mapping, photography and parcel delivery, as needed legislation evolves to facilitate and govern their use.

Demand from logistics companies already promises to drive the concept in intriguing new directions such as large unmanned cargo aircraft (LUCA). This could result in valuable new applications and faster, more cost-effective freight services. About two years ago, Chinese developers announced the first flight of the Feihong-98 (FH-98), claimed to be the world's largest unmanned transport drone. With a maximum payload of up to 1.5 tons, the FH-98 resembles a small turboprop plane and can fly at about 15,000' and 180km/h.

Several US companies are working on prototype cargo drones. Among them, California-based Nautilus suggests large autonomous drones can help reduce global air freight costs by 50%, as well as boost cross-border commerce and assist the development of low-infrastructure regions.

These technologies promise us all a better life and a cleaner environment. At this early stage, however, the performance in terms of flying range and carrying capacity falls short of requirements for commercial use. Yet technology moves quickly, as we know. The

continued on pg. 44

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

PCB EAST 2021
Conference & Exhibition

The **ORIGINAL** Conference and Exhibition for
Printed Circuit Board Design, Fabrication and Assembly on the **EAST COAST**.

NEW DATES:

Conference: June 15 - 17
Exhibition: Wednesday, June 16

Best Western Royal
Plaza Hotel & Trade Center
Marlborough, MA

PCBEAST.COM

WHO'S ON BOARD?

ACE Accurate Circuit Engineering
all flex Flexible Circuits • Heaters • Assemblies
cicor
DownStream Technologies
EMA Design Automation
GS SWISS pcb technologies
MECADTRON
MINCO
Polar
SEF
SVT SVTRONICS, INC.
TRILOGY-NET INC.™
ZUKEN

Why Do Some Flex Circuits Have Hatch Patterns in the Plane Layers?

Crosshatches help meet target impedance values and improve flexibility.

A CROSSHATCH OR mesh pattern is often seen in the copper plane of a flex circuit. It will look something like **FIGURE 1.**

The most common hatch pattern is a simple mesh of conductors perpendicular to each other and rotated 45° relative to the signal pattern. Some use elongated diamond shapes or circular openings. Each accomplishes the same thing. Keep in mind most impedance tools model only the perpendicular square opening pattern.

Why is this done? Several reasons are involved, as well as some tradeoffs. Solid planes provide complete EMI shielding and an efficient return path with maximum current carrying. Solid planes make a part stiffer, however. That's not an issue for the typical rigid PCB, but is certainly a consideration for a flex circuit. Solid planes also impact impedance design and performance.

Some use a hatch plane to reduce total copper content on select layers, which can increase flexibility. Less copper makes a part more flexible. In some cases, a designer may take a hybrid approach and use a solid plane, and then selectively cross-hatch in the region they want the part to bend. This provides the maximum shielding and return path for most of the part, with crosshatches only in limited locations. It can also keep the part flatter in areas where a bend is not desired.

Lately, the primary reason for using a crosshatch pattern is to help manage impedance. Using a hatch pattern as a return path for impedance signals can really boost impedance.

Typically in a rigid PCB, to get higher impedance means reducing signal line width or increasing dielectric thickness, or selecting a lower dielectric constant material.

It isn't that easy with flex circuits. Options for standard flex materials are limited. Therefore, only certain dielectrics are available. Flex material dielectric constants are quite low, which is offset by being very thin. Increasing the dielectric thickness can be done up to a point but comes at a steep cost of reduced flexibility. As a practical matter, it is hard to get much more than 0.005" separation from the signals to the plane with flex. That leaves the option of reducing the line width. This is an option, but keep in mind wider traces can withstand more bending. For mechanical reasons, keep traces as wide as possible to maximize robustness.

This brings us back to crosshatch. Let's look at a couple examples.

If we have a differential pair of 0.006" lines with a 0.006" space between them in 0.5oz. copper on a 0.003" substrate, we will get 88Ω in a microstrip with a solid plane. That does not meet our 100Ω goal. With a crosshatch mesh pattern of 0.006" lines on a 0.020" pitch, however, the impedance jumps to 100Ω.

Similarly, with a stripline differential pair of 0.006" lines with a 0.006" space between them in 0.5oz. copper on a 0.003" substrate, we will get 72Ω with a solid plane. Again, that does not meet our 100Ω goal. With a crosshatch mesh pattern of 0.006" lines on a 0.020" pitch, the impedance jumps to 82Ω. If we adjust the signal line width to 0.0045" and a 0.009" space, we achieve 100Ω. Alternately, we could leave the signal pair at a 0.006" line and space and adjust the hatch pattern to a 0.006" line and 0.040" pitch to achieve 100Ω.

When employing a hatch pattern, keep in mind other tradeoffs. First, a hatched pattern does not provide the same EMI shielding that a solid plane does. Depending on the expected frequencies in the operating environment, however, the hatch pattern can be designed to block the wavelengths of concern.

Hatch patterns can also increase losses related to the signal. This is due to the pattern itself causing the return path to be altered. In many cases the extra loss is well within budget, but it should be accounted for in cases that are very sensitive to losses.

Hatch patterns typically permit use of wider traces,

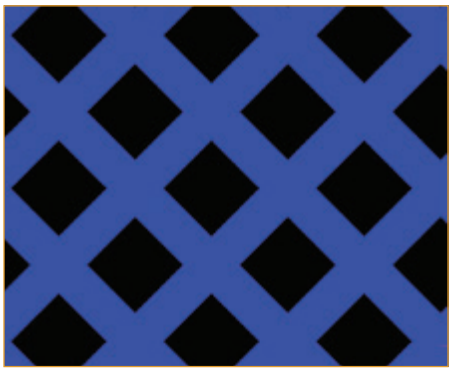


FIGURE 1. A crosshatch or mesh pattern in the copper plane of a flex circuit.

FIGURE 2. Symmetrically routed pairs help prevent skew.

NICK KOOP is director of flex technology at TTM Technologies (ttm.com), vice chairman of the IPC Flexible Circuits Committee and co-chair of the IPC-6013 Qualification and Performance Specification for Flexible Printed Boards Subcommittee; nick.koop@ttmtech.com. He and co-"Flexpert" **MARK FINSTAD** (mark.finstad@flexiblecircuit.com) welcome your suggestions.

which reduce losses related to the conductor. They also permit thinner dielectrics, which help meet flexibility needs.

When using hatch patterns, route pairs symmetrically on the hatch pattern to prevent skew. If one conductor in a pair is offset from the hatch pattern, the return path will be different for that conductor than for its partner. The pair in the middle of **FIGURE 2** is well-centered on the hatch pattern.

Depending on the design, the hatch pattern may only exist in the flex section, or it may extend all the way through the rigid section to achieve desired impedance values with the materials selected.

Crosshatch patterns are common and can be employed with very good results to improve flexibility. In cases where impedance is required, it can be the most important tool to meet target impedance values, while still being flexible enough to be installed. ▫

"A HATCHED PATTERN DOES NOT PROVIDE THE SAME **EMI SHIELDING** OF A SOLID PLANE, BUT **CAN BE DESIGNED** TO BLOCK THE WAVELENGTHS OF CONCERN."

DESKTOP TOOLS to Remain a Fixture

Despite channel changes, the major EDA vendors say user demand makes mainstream tools worth their continued support.

by MIKE BUETOW

What is the future of the mainstream PCB CAD market? As printed circuit boards get denser, with ever more parts, models, nets, and materials to use and track, and organizations emphasize collaboration across locations and technical domains, can standard tools keep pace? Do the vendors have the pockets and desire to continue developing multiple solutions to common problems? Or will the market dissect into open-source and enterprise platforms with a vacancy in the middle?

In pursuit of an answer to these and other questions, PCD&F in January reached out by email and phone to the top vendors of ECAD tools. We heard back from all but one. Their perspectives are aggregated here, with some edits for length and clarity.

First, what constitutes mainstream ECAD? For the purposes of this review, we characterized those tools as ones typically used primarily by individual users, not necessarily in collaboration within the organization. We also considered the breadth of features and functionality and perceived ease of use. Such tools typically have limited or no functionality for IC packaging, DfM, or data or library management. These are sometimes also known as shrink-wrap or desktop tools, although some developers might see those references as simplistic or even pejorative.

Software that fits this bill includes Altium Designer, Autodesk Eagle, Cadence OrCAD, Siemens (Mentor) Pads, WestDev Pulsonix, and Zuken Cadstar.

Our panel is clearly in agreement that layout software needs to be easier to use and to interface with other ECAD and MCAD platforms. And they concur that collaboration and other "enterprise" features are headed to the desktop. But while they consistently agree the desktop tools have a place in tomorrow's design cycle, they espoused differing views on how mature the market is, and the potential for its disruption.

PCD&F: The mainstream PCB CAD market has seen its fair share of changes over the past three years. There is a trend by most (not all) vendors to bring in-house sales from VARs/external distribution channels. What is driving this trend?

Benjamin Jordan

Benjamin Jordan, senior product manager, Autodesk: Downward pressure on license costs, plus a trend toward subscription-based licensing. To a lesser extent, the software becoming easier to use as well. In the past, channel partnerships offered the benefit of domain expertise and technical support in exchange for higher license costs. This was necessary because CAD was harder to use and required a lot of educating. More users now require less handholding, and at the same time don't want to pay high license fees because software development is a lot easier than it used to be.

AJ Incorvaia

AJ Incorvaia, executive vice president, Siemens Electronic Board Systems: We are constantly looking at the way we go to market with our products. We will continue to have a mix of direct channel and indirect channel [sales], and a lot of it has to do with the needs of the customers and how we can best service those customers. I don't think it's a particular trend, and it varies by geography and even country.

Kent McLeroth

Kent McLeroth, president and CEO, Zuken USA: Our industry is moving to an online sales process, much like other industries. Mainstream market product discovery, education, demonstration, and ultimately, a purchase is mostly made online or virtually. Several factors are driving this migration: The online tools available today in terms of webinars, cloud-based evaluations, on-demand training, instructor-led web training, and user

communities all allow vendors to centralize their sales and support interactions through the website. Also, the price point of a mainstream PCB tool makes it difficult to support a VAR channel.

Manny Marcano

Manny Marcano, president, EMA Design Automation: The needs of the market are changing. On one hand, the high-end market demands a more personalized, specialized salesmanship and application engineering support, whereas the single-seat, multitasking, multi-talented engineers are looking for a comprehensive tool that helps them achieve first-pass success. Having both in-house sales and external distribution channels helps meet the unique needs of each type of client, making this type of model essential. The Cadence VAR channel manages customer relationships with technical prowess and advanced data management solutions. We have a scalable product that serves the basic needs of an engineer all the way to the sophisticated demands of signal integrity and chip packaging. I think other vendors have been bringing sales in-house because their channel wasn't as strong as what Cadence has put together, nor did they have the breadth of product to support a multitude of customer needs. If you look at other adjacent CAD markets – mechanical CAD, multi-physics analysis – the channel is an integral part of these companies and a primary part of their go-to market strategies.

Lawrence Romine

Lawrence Romine, vice president of marketing, Altium: This is something we have been pursuing quite aggressively for the better part of seven years, and the overwhelming majority of our business is handled directly. We reasoned that it allows us to control the quality of the engagement with the customer, and in most cases at Altium, that is, the actual design engineer. Having a channel naturally creates channel conflict and internal competition. Unfortunately, this conflict usually comes at the expense of the customer experience. We believe that maintaining a direct relationship with users gives us a significant competitive advantage.

Bob Williams

Bob Williams, managing director, Pulsonix: Almost certainly cost. I know players are consolidating their sales teams because they are so well known, and the thinking is (customers) will buy from them regardless. We choose distribution because it's personal. We choose the distributors very carefully based on their skillsets and knowledge base, because they train the customers how to use the tool. You can centralize (support in one place), but when you have a wide customer base, you need to have people who can speak the local language.

Incorvaia: The other thing you'll see coming up in the near future is selling over the web, using a storefront where customers can go directly online and purchase services that augment their toolset. I think you'll see this combination; it's going to be a little different, depending on which region you are in, but I don't see us going away from that combination of channels.

PCD&F: In your estimation, is the mainstream PCB CAD market growing?

Marcano: Defining mainstream growth is a bit difficult, as what is mainstream has also been changing. I would say mainstream design is very alive, and it is happening across all types of customers big and small. The traditional customer pyramid really doesn't exist anymore. Almost all large allegedly "captive" accounts have many competitive tools driven by project requirements and are doing a combination of mainstream and high-end designs.

The mainstream market is growing because electronics are required to turn concepts into reality. For example, IoT devices are dependent on sensors and circuitry to work. These types of technology aren't going anywhere, and with constantly evolving technology, the need is only going to increase.

Romine: Data suggest the North American industry is growing, and there is plenty of market research that corroborates this. Typical estimations show a PCB CAD CAGR of 4 to 5%. We have seen growth in all our major markets worldwide, with Europe and the US being the most significant growth regions for us.

McLeroth: It's growing in North America. In response to this trend, Zuken has recently introduced a next-generation mainstream PCB tool called eCADSTAR, built on a state-of-the-art software platform to maximize 2-D/3-D performance with a modern look and feel.

Jordan: I don't think that it's changing significantly over the past few years because PCB design is still an unusual career choice, despite the demand for good designers. Some of the growth is population-based, but I think the upside is more electrical engineers are designing PCB hardware – a trend that has been going on for some time.

Williams: We see growth all around the world. A lot of start-ups and existing companies. There definitely is more sales and money in the market. But no (vendor) publishes the number of seats they've actually sold.

Incorvaia: We are starting to see electronics show up in all kinds of places. Everyone knows about the growth in automotive around autonomous or electrical vehicles, and the oncoming 5G, high-performance computing is seeing a lot of growth. But it's also in areas we may not have historically seen a lot

of electronics embedded, such as white goods and consumer devices. While the very high end of the market is growing nicely, we are also seeing growth in industrial, medical and consumer. There are companies in each of these segments using mainstream and enterprise tools.

Incorvaia: We see rapid growth in Asia, particularly driven by China. Japan on the mainstream side is a little soft; growth there is more on the enterprise side. Europe is like North America; growth is across the board, varying by country. Central Europe is growing faster than Southern Europe.

Romine: IoT is playing out disproportionately in the mainstream engineering market.

PCD&F: What effect, if any, has the appearance of relatively young but highly visible companies such as Amazon, Tesla, SpaceX and BlueOrigin changed outlook for mainstream PCB CAD tools? Are fast-growing startups starting and sticking with mainstream tools, or are they looking for higher functionality/feature-rich software?

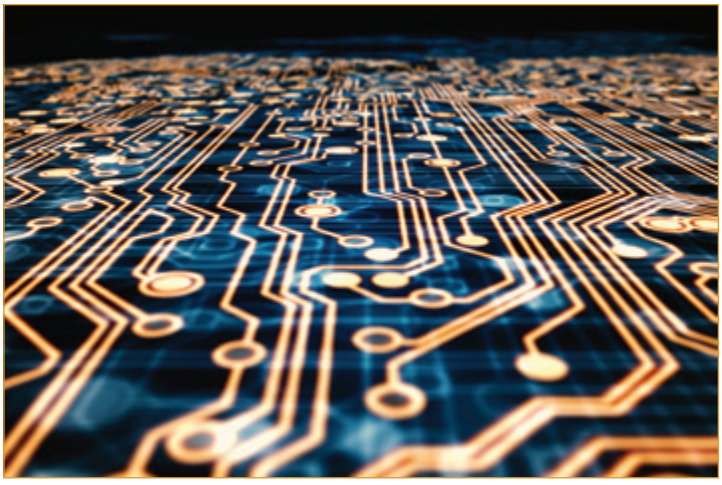


FIGURE 1. The mainstream market is characterized by single-seat place-and-route tools.

Williams: It's everything, isn't it? There are different levels of startups. Amazon and Tesla rocked from startup to functional very quickly. They have budgets for more complex tools. They are looking for tools that are functional all the time. They aren't typical of startups. There are magnitudes of scale.

We also see startups that are developing new technology at universities and spinning off their new tech. Also, there are startups that the likes of a Bill Gates would drop $10 million in, and that has quite an impact, because they have the budget to afford the tools. With some startups, they already have foresight in the future, and are looking ahead to their next level set of designs, and looking at the functionality they will need ahead. But they aren't looking at enterprise tools because the jump is quite big. A shrinkwrap product can do most of the functionality. I'm not sure what extra you get with the enterprise products; most CAD products can do most things.

Marcano: The focus of these companies is on process and design methodology. While there are certainly features required for them to accomplish their design goals, the ability to scale and solve process problems is more important. As these companies grow and their needs evolve, the key is to enable a design environment that can scale seamlessly to meet those design challenges. This allows these organizations to deploy a consistent, repeatable design process and methodology, while also being able to leverage the right level of technology based on design needs. At the pace these companies are innovating, they cannot afford a tool change or methodology disruption. They need a process built to grow with them.

Romine: I believe that both can and are true, at least as it pertains to Altium. [We believe] the most capable tools should be available to everyone. As we've democratized or created technological advances in the industry, we do not discriminate as to who can access them. If you have a subscription, you get it.

Incorvaia: There are a couple of attributes to these "new players" that are good for the marketplace. They tend to be very fast-moving companies, and because they tend to be new to the electronics industry, they aren't stuck on doing things the "old way." They are innovative and willing to break the mold. It is good for the industry because it continues to push the edge of the envelope and drive us forward.

The other benefit they bring to the market is, in many cases, they have pretty deep pockets. Not only are they willing to try new and innovative things, but they have the dollars to back it up and invest to try those things.

They are in the category of what I call the "fail fast" companies, where they try something, and if it doesn't work, they are quick to move on to something else. It keeps us vendors on our toes to provide them with the technologies and capabilities they need, and they are open to new ideas and trying new ways to do things. They typically start off with mainstream tools as a way to get into electronics design. They might start by outsourcing design, then bringing it in house.

McLeroth: The selection between an enterprise solution vs. a mainstream tool is driven by the specific needs of the company. Some factors driving an enterprise purchase from a high-volume/global market producer might include process customization, sophisticated variant data management, and DfT/DfM capabilities that do not fall into mainstream market capabilities. For instance, if an engineering manager requests a where-used list for version 4.6.1 of a reuse block, this task is beyond the capabilities of a mainstream PCB tool. A company, independent of size, with lesser manufacturing or data

PCB WEST 2021

Conference & Exhibition

30 YEARS

Conference: August 31 - September 3

Exhibition: Wednesday, September 1

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.
Bittele Electronics Inc.
Bowman XRF
Cicor Group
DownStream Technologies, Inc.
DYCONEX AG
Dynamic Electronics Co., Ltd.
Elgris Technologies, Inc.
Elsyca
EM Solutions Inc.
EMA Design Automation
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.
MV Circuit Technology Co., Ltd.
MVINIX Corporation
Oak-Mitsui Technologies LLC
Ohmega Technologies, Inc.
Oki Printed Circuits Co., Ltd.
Optiprint AG
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
Sierra Circuits, Inc.
Somacis Inc.
Summit Interconnect
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

management considerations, may find a mainstream PCB tool a perfect solution.

Jordan: Companies like these have experts who know and love the tools they use. One of the superpowers that PCB designers have is a proficiency with the tools they choose. So, for the most part, these high-profile companies will probably stick mostly with the tools they grow with. They have benefited some mainstream vendors tremendously in terms of credibility. At the same time, some applications are simply too complex for mainstream tools to handle, and as companies grow, a trend I have observed is small pockets of users who are tasked with the most demanding designs will begrudgingly use one or two "high-end" tools: tools that have terrible user experience but at least can handle large and complex designs.

Incorvaia: It's not necessarily because the mainstream tools can't handle the product complexity. The problem is the mainstream tools struggle when you get them in the large organization, and [the tools] struggle with the organizational complexity of having multiple people work on a design at the same time, having to develop standardized pieces of IP, whether they be libraries or reuse blocks, and also integrating the mechanical and electrical. When you get into all these issues, plus getting into "how am I going to get this into manufacturing?", the mainstream portfolio they have is insufficient, and they move to a more enterprise environment.

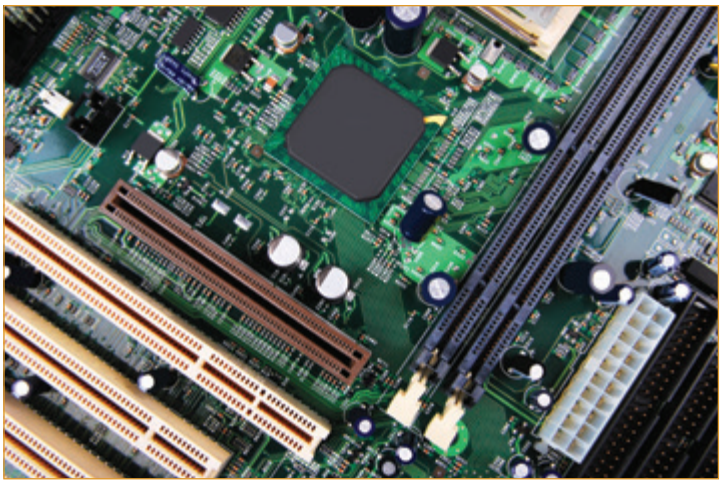


FIGURE 2. Design complexity goes beyond layer count or netlist size.

PCD&F: As engineers take over a predominant share of board layout and placement responsibilities, do you expect they will be more or less predisposed to using mainstream tools?

Marcano: Tool adoption should be determined based on the time-to-market demands. You can certainly muscle through a design with any level tool, but to achieve release-to-manufacturing deadlines, an engineering manager must consider efficiency and quality of the design tool. Mitigating risk early in the design process with a professional-grade tool and methodology is the key. As more EEs take on placement and routing, it is just a natural fit for them to have access to analysis tools in their design environments to solve problems in real-time. When looking at what goes into some of these "mainstream" designs these days, not having this kind of functionality is a real risk.

Incorvaia: Scalability means being able to move seamlessly into an enterprise tool, and be sure the data are compatible and the IP can be reused whether it be libraries or reuse blocks, making sure the processors you have in place and other tools you have with you around the design flow can be carried with you so you aren't starting from scratch.

What you will see over time is a lot of capabilities we thought of as enterprise capabilities will make their way throughout. The difference is going to be how customized do you want to make those capabilities, and how deep do you need to go with those capabilities?

I don't think the need for specialists will go away, but will focus more and more on the really difficult problems that require their level of expertise. We have to make sure our tools are more intuitive to use and easier to be managed by an occasional user.

McLeroth: As more electronics appear in products such as dishwashers and refrigerators, the electronics are commoditized, with engineers using more reference designs, reuse modules and off-the-shelf single-board computers. Some companies are standardizing on "platforms," so a common hardware core exists in all their products, offering numerous cost- and time-to-market benefits. Engineers in these types of markets become "occasional" users of the PCB tools and are a great fit for mainstream tools.

Romine: Engineers are pragmatists, which means they will use the tool that most efficiently gets the job done. We have always considered balancing the development of capabilities that engineers and designers request with what we see as the "next thing" that will transform the industry. When I joined Altium in 2005 as a salesperson, the cutting-edge feature in our release that year was the ability to flip the board and edit the bottom side. People loved that. I sold a lot of software with that feature! About six months later, we introduced native 3-D support in our PCB editor. General sentiments were that it was a gimmick. Looking back, which one of these features changed the industry? So, in a sentence, we feel this balanced development, coupled with ease-of-use and a fair pricing model, is attractive to these engineers getting into PCB design.

Williams: Absolutely more. For an engineer, they have the breadboarding, the firmware, the layout, the test … how much time do they actually spend using the CAD tool – up to 50%?

I'm doing the PCB design for two months and the rest of the time doing the process, the firmware, and so on. I wouldn't think an engineer who is doing everything would be using the bigger tools. They are too difficult to learn and too much money.

Jordan: I believe they will almost always use mainstream tools for a couple reasons. First, the majority of PCB assemblies designed in this world are still fewer than eight layers (or even six) and can be done quickly and easily in the hands of a designer who knows a mainstream ECAD tool. Second, "mainstream" tools by nature are the most well-known, and new users typically start with what's popular already because it's just so much easier to buy, learn, and get help with. They usually are working with a colleague who already knows one and shows them how to use it, or start with it when they're an undergrad at school.

McLeroth: The other end of the spectrum is where the hardware offers a competitive advantage and may involve extreme miniaturization or custom IC pin optimization for signal fidelity. This class of product typically requires the capabilities of the enterprise class solution.

PCD&F: In your estimation, is the general trend toward lower-layer-count boards or higher-end (highly dense, very-high-speed, and high-layer-count) boards? What about reuse of IP blocks?

Romine: Yes, yes, and yes! Arguments can support that all of these are trending, as electronics have become so ubiquitous in our world today. As you know, the technology trends correlate directly to specific applications and economic trends.

Incorvaia: It varies across the board. Certain market segments have different types of designs they focus on. If you look at networking, telecom, some automotive, certainly HPC, you see very sophisticated designs, high layer counts, larger form factors. Some of the other market segments see miniaturization with very dense designs. It's not necessarily specific to the size of the company.

McLeroth: The general trend is toward lower-layer, less dense boards based on the proliferation of electronics in all types of products where the hardware does not provide a competitive advantage. It is not that the need for enterprise class tools is declining, but that the commodity hardware market is growing.

Marcano: It depends on where in the market they fall; the market is bifurcating. Just because the layer count is low does not mean the complexity isn't there. The complexity can be in keeping the layer count down. As far as IP, I think reuse is still in its early stages in the mainstream. The tools support it to some extent, but it takes a defined process and methodology around the tools to successfully manage and share this IP across the organization. I expect this to be a strong area of growth. Access to design content and IP reuse – both internal and external, like reference designs – are areas that can be leveraged to help meet time-to-market and cost challenges. The process just needs to be there to enable timely and effective access to this content.

Jordan: I agree design reuse is critically important. While boards themselves are not increasing in complexity as fast, electronics engineers regularly design with new components that have unique I/O and power requirements, so as much as possible it helps to be able to reuse and automate other aspects of the design. Part of that is access to the device manufacturer's reference designs, and part of it is allowing the designer to keep a library of known-good blocks, which is always a feature of good mainstream tools.

Williams: Both. I see a big mix. There are lots of very basic boards you could probably design with very low-end systems. We recently had one with just under 100,000 microvias and 14 layers; that's a decent design. You get a mixture of all of it. What you don't get is much in the middle. There's not much that's 6 to 8 layers, but lots of 14 layers and above.

McLeroth: If you consider "informal" design reuse where is it a copy-and-paste function or a logical/physical library component, that could be easily provided by a mainstream tool. If you consider "formal" reuse where the block is version controlled, where-used is available by version, and the design cannot be released to manufacturing unless it has the latest version – these are more in line with enterprise class capabilities.

Incorvaia: We did see quite a bit of flex out there, but it's leveled off. The industry segments that are using flex, we know who they are.

The one area that is becoming a trend, particularly for customers doing more sophisticated designs, is interest in more of a codesign between the board, package and silicon. We certainly see that trend happening, even with some smaller companies that want to make sure a custom piece of silicon is going to work in the context of the design and meet certain performance parameters of the package, and want to be sure the package and board can be designed in coordination.

Jordan: Only one thing tends to force PCB designers into more layers and density: chip manufacturers that insist on making parts with much smaller packages, a push driven predominantly by the desire for increased profit margins.

Marcano: While designs may have a few layers or components, the interfaces are fairly complex and require validation, or the case is so small that space is critical, requiring high-density design techniques. Supply-chain management and sourcing are also now mainstream concerns, as time-to-market pressures require you to design with availability and compliance in mind. So, while the traditional layout of a design may seem simple, the execution and engineering of the design has gotten orders of magnitude more complex.

PCD&F: Are today's mainstream tools *generally* capable

of meeting the technology requirements of the types of designs most prevalent today? If not, where are they insufficient?

Jordan: Yes, they pretty much all are. The question is do they help the user or get in the way? I could design an arbitrarily complex board with an open-source tool, for instance, but it would certainly take many times longer than with a commercial mainstream tool because the workflow is nonuniform and cooked up by too many chefs, and of course there are missing features. A lot of the time spent designing modern PCBs is not as much in the placement and routing as it used to be because those are solved problems. Where the users are more likely to have wasted time and frustration is with collaboration outside the PCB: i.e., ECAD to MCAD, library management, supply chain integration and such. Although users may appreciate some of the obvious aspects of the software they use – like good routing or synchronization between schematic and PCB – some of the greatest benefits are not immediately recognizable and would be seen only by performing post-release project analyses to see that, in fact, you are much more productive overall than you used to be.

Romine: I have a couple of opinions here. First, the most capable designers/engineers can pick up more or less any tool and design the most advanced boards. This has probably always been true because it's more about the design engineer's skill than the tool they use. However, we must strive to create design tools that empower the most junior designers to develop the most advanced boards. However, if you look at what engineers and their organizations care about, these two factors can often be at odds. Most engineers and designers get excited about the technologies they are designing. This often results naturally in the pushing of the technological limits of the tools. Organizations, however, primarily care about time-to-market, cost and marketable features. The old saying is you can usually pick two of these at the expense of the third. Evidence shows this is seldom because the engineers/designers or their tools weren't capable of getting the design done, but almost always because the process of collaboration let them down.

Marcano: You can design anything with today's mainstream tools within reason. However, in my opinion, the design methodology and data management are the main differentiators and success drivers. Again, it is all about time-to-market. The tools can only take you so far. The process and methodology need to be there as well to ensure you are putting yourself on a path for first-time correct design.

McLeroth: The majority of today's mainstream PCB tools are capable of meeting today's common PCB needs. But not all mainstream tools are created equal. Many of today's mainstream tools are 20 years old and built on 2-D technology. Today is the world of the digital twin and 3-D design. The insufficiencies are those that go beyond basic place and route of the board into true 3-D ECAD/MCAD collaboration, integrated IC packaging, the need for customization, technologies such as RF design, and advanced DfM checks for flex.

Williams: Absolutely. There's always new technology that someone's developing, but there's not much we've come across that most tools can't handle.

MCAD figures pretty highly. Realistically, in most companies a completely different person is doing MCAD. You need a good interface for the two. It's not just a case of hooking up and using MCAD; you have to send them a file to use. The integration and viewers have to be nice.

It's a bit like autorouters. A lot of people don't use them because they don't trust them. It's the same with SPICE: Do I trust it? There's a demand for it but it's not as big as the emphasis put on it

FIGURE 3. Collaboration across the organization is a feature developers say will come to mainstream tools.

Incorvaia: We see particularly in the mainstream market design engineers trying to design more of the electronics. In the past we saw a lot of specialists. So, we see a need for investment in the whole user experience, making sure the tools are easy to use, so an occasional user can be up and running quickly.

PCD&F: What is/are the main driver(s) of mainstream tool developments and improvements?

Jordan: As mentioned, the software companies on the ball are working hard on improving collaboration and workflows within the design process. At the same time, increasing automation of repetitive tasks and improving access to reuse and secondary data sources.

Incorvaia: We want to take some of the technology, particularly in the verification space, that historically has been limited to the design experts and put it on the desktop, so they can have access to those capabilities without being an expert. That's not to say the need for the expert goes away, but what you want is

the expert to work on the really difficult problems, while the design engineer can work on signal integrity, analog design or other verification problems. To do that, they have to have tools that are intuitive to use that help guide them to the solution for the problem because they may not be an expert in that space, and I think that trend will hit the mainstream market first. That's where we are starting to see design engineers take on more responsibility for the entire design.

McLeroth: Mainstream PCB users are looking for a reliable, high-performance, low-cost, and easy-to-use tool with a good source of self-help content. As the design community moves toward digital engineering, support for more standards like IPC-2581 and integration with cable design tools will become more important. The risk is not to venture too far from the mainstream market by adding product complexity. Time-to-productivity is an important measure of a tool's compliance with mainstream objectives.

Williams: We talk to our users and ask, what do you need in the tool? There's always an element of what's required in the market, but ours is very highly generated by user requirements. We push ease-of-use really hard, but everyone does that. That's hard to articulate to someone.

FIGURE 4. Our panel agrees the desktop ECAD market isn't broken, but some hint that disruption is ahead.

Marcano: Simply put: customer demands.

PCD&F: In your view, does the existing market (size and margins) support long-term development of mainstream tools that are both easier to learn and use and keep pace with the features asked for by users?

Marcano: Yes. Although what is mainstream may be blurring. There is a general requirement for tools that meet the technical challenges presented, while providing an easy-to-use, repeatable environment for success. I see content and design methodology being key enablers to improving the mainstream design process going forward.

Williams: For us, definitely. In comparison, we are dynamic and driven by our users, but we can certainly put in the level of functionality our users are requesting.

Jordan: I look at that from a more historical perspective. The EDA market used to be a burgeoning land-grab with many competitors, and now there's really just a handful, and most of them are not significantly profitable but hanging in nonetheless. The ECAD market is mature, so it can sustain and marginally grow a few companies, but the tremendous growth opportunities for the future of ECAD are not so much in ECAD itself but the business processes surrounding it. There is, as in any mature market, room for disruption, and mainstream vendors like us are always considering how to make that happen, rather than be blindsided by it. Either way, it will happen.

Incorvaia: I think so. There are a lot of design engineers, so you can certainly amortize the cost over a large number of users. The key is making sure we have technology that is scalable across the markets. While there are specific needs that mainstream users have in terms of wanting a simpler solution, a lot of that core technology is the same.

Marcano: The lines between enterprise and mainstream are very blurred. Small customers are creating incredibly complex designs, while large organizations may be building fairly simple products. The key is to be able to support the unique needs of each design team, while being able to provide the content, process, and methodology that can be leveraged effectively across an organization in a scalable fashion.

Incorvaia: There are a lot of things we can do to augment the design flow in terms of supply chain integration, better access to libraries, providing more capabilities to ensure the design can get into manufacturing. Those capabilities are applicable across all market segments.

McLeroth: The mainstream market has the size and opportunity to support continuous development. The proliferation of electronics in all sorts of products will continue driving the need for mainstream tools. ❑

MIKE BUETOW is editor in chief of PCD&F/CIRCUITS ASSEMBLY; mbuetow@upmediagroup.com. Listen to A.J. Incorvaia and Manny Marcano discuss recent trends in the mainstream ECAD market on the PCB Chat podcast at pcbchat.com.

The Influence of QFN PACKAGE CONSTRUCTION on Solder Joint Durability

A case study characterizes solder joint integrity of different BTC constructions in an accelerated lifetime test.

by TIM PEARSON, DAVID HILLMAN, ROSS WILCOXON and ONEL VALDEZ

The electronics industry has extensively documented the influence of component construction on solder joint integrity. Materials used in the construction of a component package body result in a composite coefficient of thermal expansion (CTE) for the package that may result in the degradation of the package solder joint integrity. The industry discovered in the 2000s the construction design of ball grid array (BGA) packages had a significant influence on solder joint integrity. BGA solder balls located directly beneath and sometimes adjacent to the package internal die-to-package transition region (i.e., the die shadow region) failed first due to the CTE mismatch forces.[1-3] Extensive finite element modeling, combined with use environment experiences and test data[4-5] resulted in package redesign protocols that for the most part eliminated die shadow solder ball failure in BGA packages.

This paper documents an investigation of the impact of bottom-terminated component (BTC) package construction on solder joint integrity using thermal cycle testing (-55° to +125°C) in accordance with IPC-9701.

Procedures

Test components. Quad flatpack no-lead (QFN) components are a type of BTC that are soldered directly to a circuit board without compliant leads. They typically include a large solder pad, which is directly under the die, that provides a mechanism for holding the part onto the PCB and the primary thermal path/electrical out of the component. This pad is surrounded by one or more rows of I/O pads that provide electrical connections between the PCB and component. Two individual functional QFN components, component A and component B, were procured from industry component suppliers. A total of 24 individual QFN components were populated on one side of each test vehicle. The QFN components were procured with a matte tin surface finish. The use of functional components eliminated the ability to use event detection monitoring. Metallographic cross-sectional assessment at predetermined sample intervals was used to determine solder joint integrity. The QFN details are shown in **TABLE 1.**

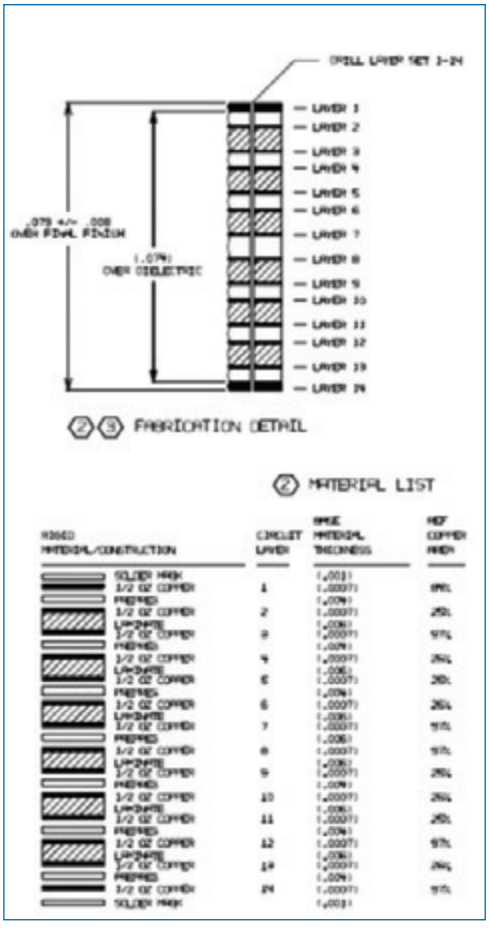


FIGURE 1. Test vehicle construction details.

TABLE 1. BTC Component Details

Part Identifier	I/O	Part Type	Size	Pitch	Surface Finish
Component A	16	QFN	3mm X 3mm	0.5mm	Tin
Component B	20	QFN	4mm X 3mm	0.5mm	Tin

AIM Tech Tutorials

New **video series** featuring AIM Technical Experts

LEARN MORE TODAY AT
www.aimsolder.com/videos

AIM's worldwide technical support network of IPC certified engineers assists customers in obtaining optimal results in local time and local language.

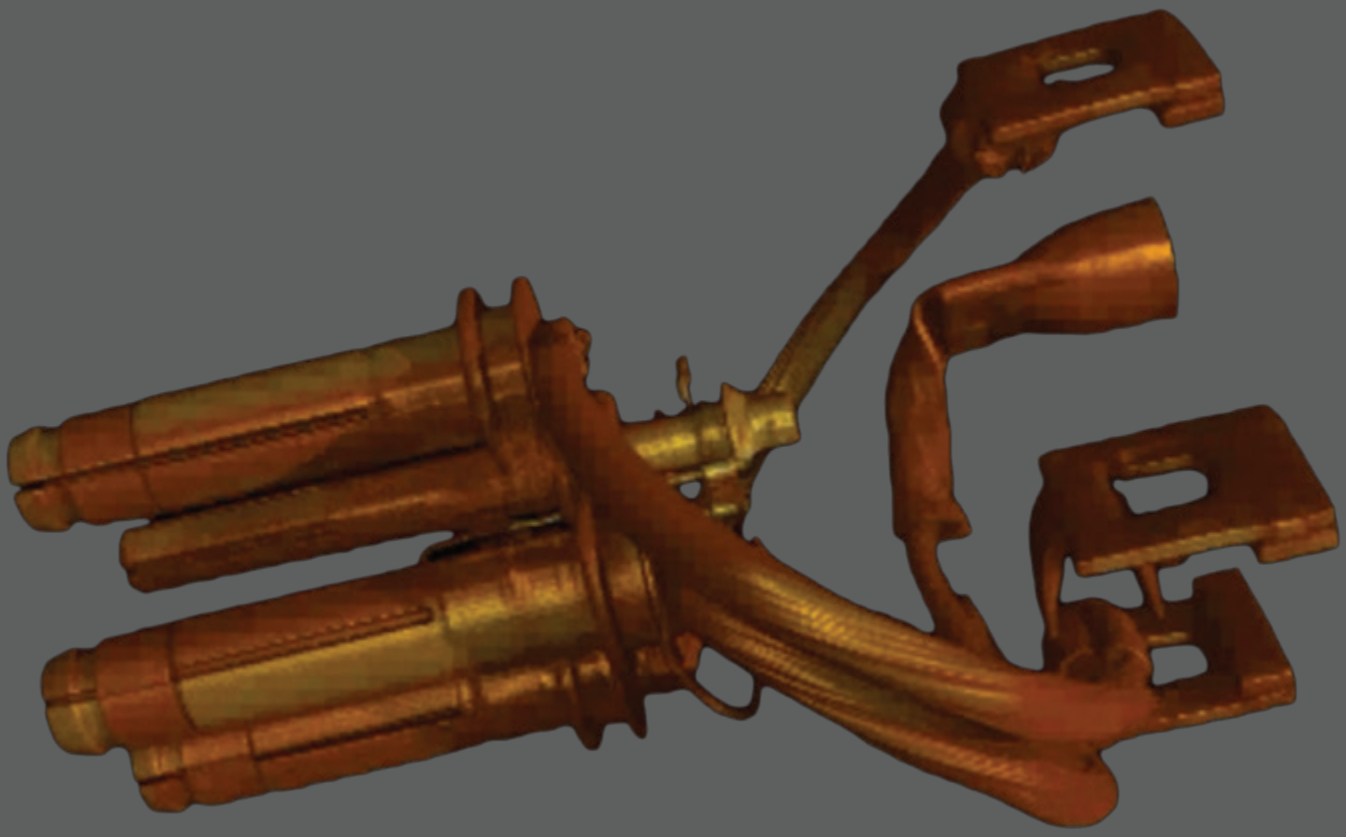
AIM's commitment to ongoing research and development enables the company to develop innovative solutions for the manufacturing challenges of tomorrow.

AIM facilities are IATF 16949 and ISO 14001/9001 certified, ensuring sustainable, reproducible results around the globe.

AIM Global Solder Solutions

www.aimsolder.com | info@aimsolder.com

You have a problem, Datest has the solution.



Datest features fast, high-energy microfocus CT services for anyone who wants to know why something broke, stopped working, won't start working, or never worked.

OK, so it's bad news, but it's news. You can work with that.

DATEST

47810 Westinghouse Drive • Fremont, CA 94539
Phone: 510-490-4600 • Fax: 510-490-4111
Email: Info@datest.com • Website: www.datest.com

Test vehicle. The PCB used for the evaluation was 0.079" ±0.008" thick with 14 internal layers mimicking ground and signal planes of a typical functional product in Collins Aerospace equipment. The board was constructed using FR-4 material in accordance with IPC-4101/126 with an immersion silver surface finish. A total of five test vehicles was included in the test. Each board had 16 of each component populated, with half the parts edge-bonded. **FIGURE 1** illustrates the test vehicle construction, and **FIGURE 2** illustrates an assembled QFN test vehicle.

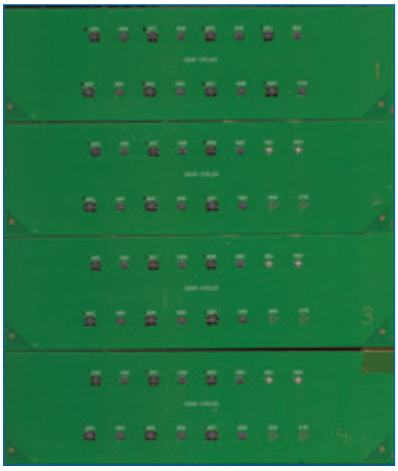


FIGURE 2. Assembled QFN test vehicle.

Test vehicle assembly. The test vehicles were assembled at the Collins Aerospace production facility in Coralville, IA. An MPM UltraPrint 2000 automated stencil printer using a 0.004" thick stainless steel stencil applied solder paste to the test vehicles **(FIGURE 3).** The solder paste was Indium 8.9ES SnPb eutectic solder deposited with a 0.004"-thick stencil.

The test vehicles were reflowed with a 14-zone Heller 1912EXL convection reflow oven. A test vehicle specific reflow profile was created and validated using a KIC profiler system for the SnPb solder paste to ensure acceptable solder joint reflow. The test vehicles were permitted to cool after reflow, then placed in an Electrovert Aquastorm 200 inline cleaning system for removal of solder flux residues and other contaminants from the assembly. The inline cleaner used Kyzen Aquanox 4625 saponifier in deionized water.

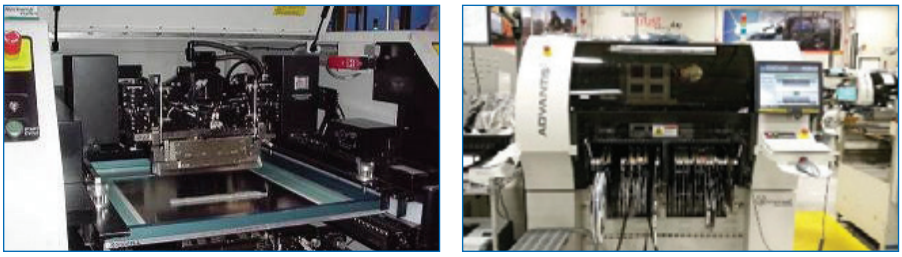


FIGURE 3. MPM stencil printer (left) and Universal Advantis placement system (right).

After assembly, the components were assigned to two different sets: no edgebond or edgebonded with Zymet UA2605 material. The edgebond material was applied using the perimeter dispense method illustrated in **FIGURE 4.** The edgebond material was cured in an oven at 130°C for a duration of 10 min. at cure temperature. The application of edge-bonding was included in the investigation to determine if the edgebond material would provide a solder joint ruggedization option.

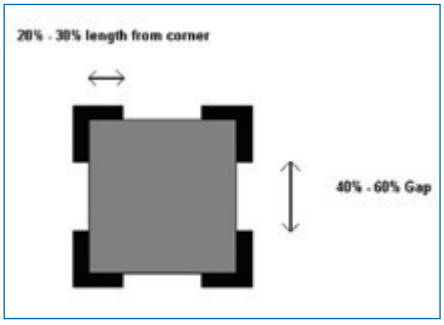


FIGURE 4. Edgebond material perimeter coverage.

FIGURE 5. Thermal cycling chamber.

Thermal cycle testing. The temperature cycle range used in this study was -55° to +125°C with a minimum 10 min. dwell at each temperature extreme and a maximum temperature ramp of 10°C/min **(FIGURE 5).** Three thermal cycle sampling intervals were used in the investigation: 500, 1,000 and 2,129 cycles. **FIGURE 6** illustrates the thermal profile recorded using the Graphtec Midi Logger GL220 temperature acquisition unit.

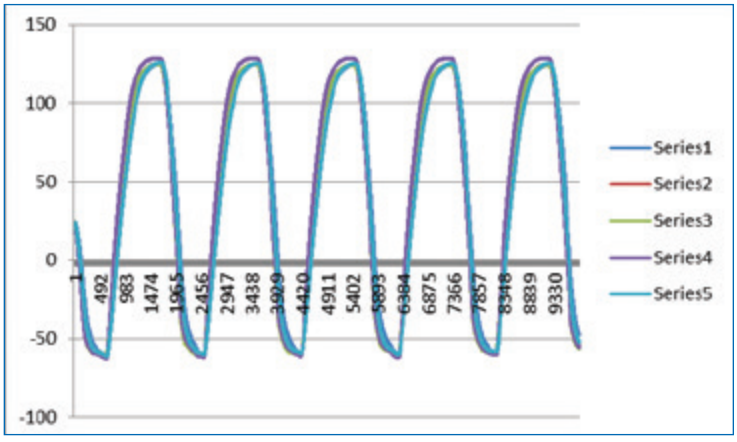


FIGURE 6. Thermal profile [*y* axis = temperature (°C), *x* axis = time (sec.)].

Test Results

Metallurgical cross-sectioning. **TABLE 2** illustrates the overall metallographic cross-section analysis results for the two BTC components. Metallographic

TABLE 2. Thermal Cycle Results

Component	No Edgebond Condition			Edgebond Condition		
	500 cycles	1000 cycles	2129 cycles	500 cycles	1000 cycles	2129 cycles
A	Pass	Pass	Pass	Pass	Pass	Pass
B	Fail	Fail	Fail	Pass	Pass	Fail

cross-sectioning was performed to assess the solder joints' condition and to determine the progression of cracks resulting from the global CTE mismatch stresses induced by the thermal cycling. Photographic documentation was performed for a typical solder joint for each of the tested components/conditions **(FIGURES 7 to 18).**

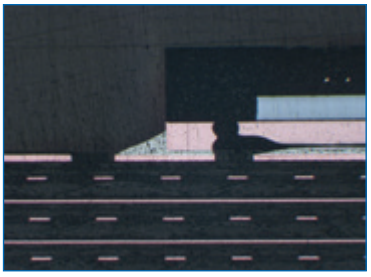


FIGURE 7. Component A, no edgebond, 500 thermal cycles.

FIGURE 8. Component A, edgebond, 500 thermal cycles.

The cross-sectioning of component A solder joints revealed no solder joint issues for either the no-edgebond or edge-bonded conditions after 2,129 thermal cycles. The cross-sectioning of component B solder joints revealed significant solder joint microstructure coarsening and some instances of solder joint cracking for the no-edgebond condition. Component B edgebond condition had acceptable solder joint integrity at the 500 and 1,000 thermal cycle intervals but exhibited solder joint cracking at the 2,129 thermal cycle interval.

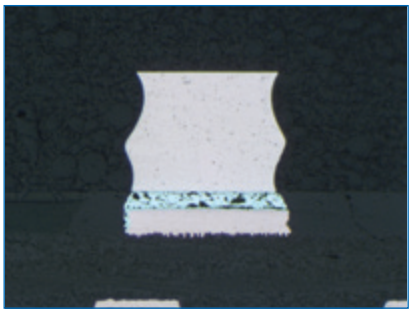


FIGURE 9. Component A, no edgebond, 1,000 thermal cycles.

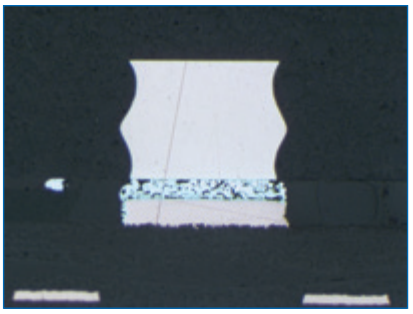


FIGURE 10. Component A, edgebond, 1,000 thermal cycles.

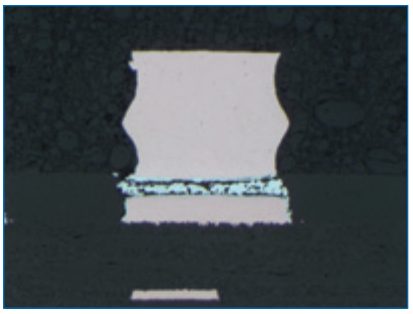


FIGURE 11. Component A, no edgebond, 2,129 thermal cycles.

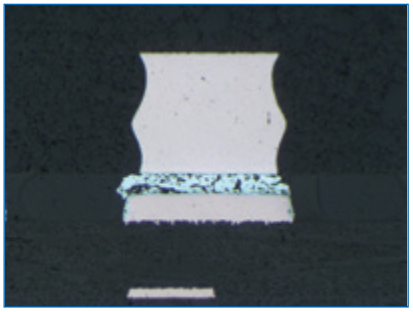


FIGURE 12. Component A, edgebond, 2,129 thermal cycles.

FIGURE 13. Component B, no edgebond, 500 thermal cycles.

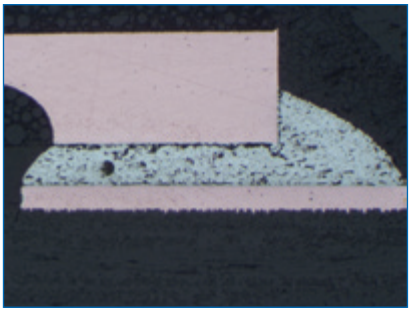


FIGURE 14. Component B, edgebond, 500 thermal cycles.

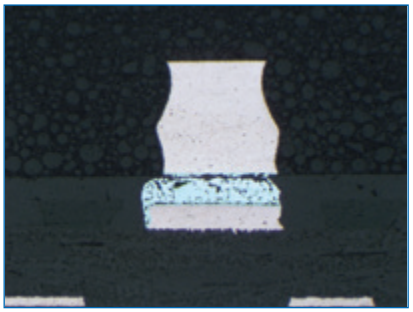


FIGURE 15. Component B, no edgebond, 1,000 thermal cycles.

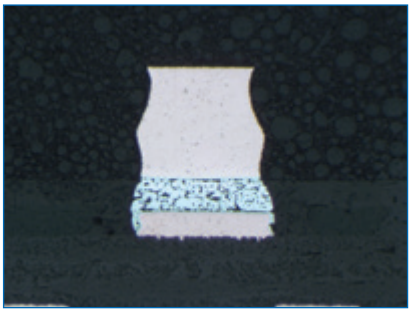


FIGURE 16. Component B, edgebond, 1,000 thermal cycles.

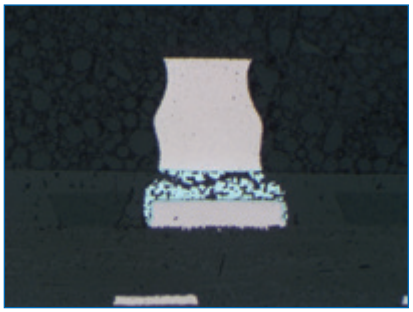


FIGURE 17. Component B, no edgebond, 2,129 thermal cycles.

Discussion

A review of the QFN failure analysis results revealed a distinct difference in the two QFN components tested. Historically, QFN components have been extremely robust, with many configurations surviving 1,500+ thermal cycles or more in solder joint durability assessment testing,[3] so the failure of the Component B was unexpected. An x-ray examination of each of the QFN package constructions revealed a potential solder joint failure root cause. The component A package has a square shape with a large thermal pad in its center. Component B has a rectangular shape with off-center, very small thermal pads. **FIGURE 19** illustrates the differences in the QFN package construction.

A top grind was conducted on the two QFNs with the results illustrated in **FIGURE 20.** The Component A package die has a square shape symmetrically located with the package body with wire bonds connecting the die to the lead frame. The Component B package die has a rectangular shape with an off-center location to the package body and has a direct flip-chip attach style to the lead frame, transferring

FIGURE 18. Component B, edgebond, 2,129 thermal cycles.

WEBINAR

PCB2DAY

SPONSORED BY

Global Solder Solutions

March 2, 2021

1:00 pm – 4:00 pm ET

Tuning Up Your Stencil Printing Process

Chrys Shea

$95

Limited seating, register today!

pcb2day.com

Professional Development Certificate included!

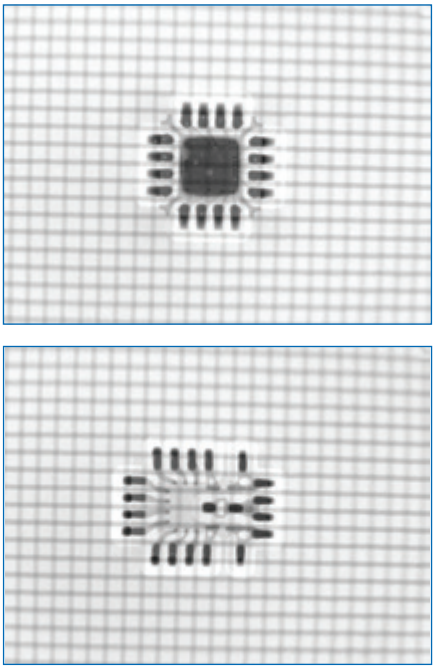


FIGURE 19. Package x-ray images – component A (top), component B (bottom).

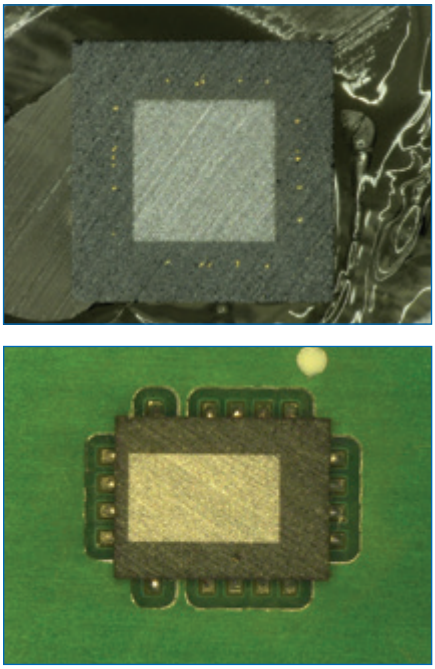


FIGURE 20. Package top grind images – component A (top), component B (bottom).

stress more directly to the solder joints.

Metallographic cross-sections shown in Figures 7 and 13 illustrate how configuration size/position impact solder joint integrity. Component A package's symmetric shape and die location do not concentrate CTE mismatch stress on the I/O solder joints. Component B package's rectangular shape and die location, which shadow the I/O solder joints on one end of the package, induce CTE mismatch stresses that cause solder joint cracking in thermal cycling. All the cracked solder joints found with Component B were directly under the die edge. Die shadow-induced solder joint cracking was observed in the early days of BGA package design, but this test was the first time we have seen a die shadow failure mode on a QFN component. The application of the edgebond material as a ruggedizing protocol improved solder joint life for component B. Ruggedized components that failed without edgebond exhibited solder joint integrity that was acceptable for 500 and 1,000 thermal cycles but not acceptable for 2,129 thermal cycles.

Conclusions

Solder joint integrity of components on printed circuit assemblies can be influenced by their construction parameters. This investigation documented how the die parameters of a QFN package can lead to solder joint integrity failure under IPC-9701 thermal cycle test conditions. Proactive reviews of BTC package construction can be used to avoid printed circuit assembly solder joint integrity issues.

Acknowledgments

The authors would like to thank Ken Blazek, Adrianna Roseman, Morgan Van Staalduine, AOE, for metallography and photo-documentation assistance, and Dave Girling and Coralville production for assistance in test board assembly.

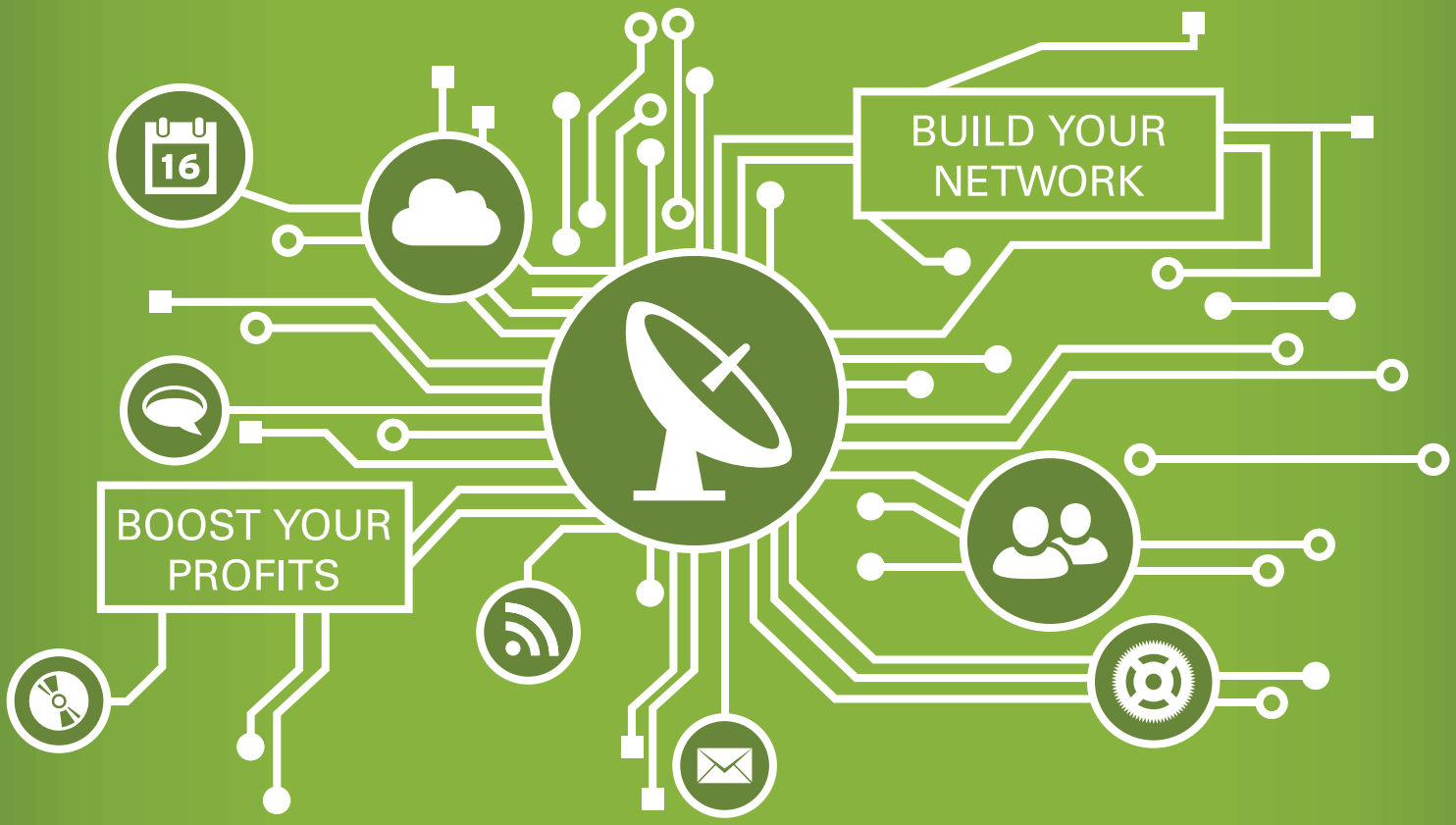
REFERENCES

1. J. Li, J. Karppinen, T. Laurila and J. Kivilahti, "Reliability of Lead-free Solder Interconnections in Thermal and Power Cycle Tests," *IEEE Transactions on Components and Packaging Technologies,* vol. 32, no. 2, June 2009.
2. B. Carpenter and T. Koschmieder, "Solder Joint Reliability of 0.8mm BGA Packages for Automotive Applications," SMTAI International Conference, October 2015.
3. K. Eu, *et al,* "Solder Joint Reliability Performance of Flip Chip Molded Ball Grid Array (BGA) Package for Network/Communication Application," International Electronic Manufacturing Technology (IEMT) Conference, November 2006.
4. X. Fan, M. Pei and P. Bhatti, "Effect of Finite Element Modeling Techniques on Solder joint Fatigue Life Prediction of Flip Chip BGA Package," Electronic Components and Technology Conference (ECTC), May 2006.
5. X. Fan, M. Pei and P. Bhatti, "Reliability Analysis of SnPb and SnAgCu Solder Joint in FC BGA Packages with Thermal Enabling Preload," Electronic Components and Technology Conference (ECTC), May 2006.

Ed.: This article was first published in the SMTA International Proceedings in October 2020 and is republished here with permission of the authors.

TIM PEARSON is senior materials & process engineer, **DAVID HILLMAN** is technical fellow, materials & process engineering, and **ROSS WILCOXON** is associate director, mechanical engineering at Collins Aerospace (collins.com); **ONEL VALDEZ** is a student at Iowa State University; timothy.j.pearson@collins.com.

The *Circuits Assembly* *Directory of EMS Companies*



- Build your EMS database
- 3,000+ facilities worldwide
- Sortable in Excel
- Unrestricted use
- Includes contact info, no. of lines, markets served and more!

CIRCUITS ASSEMBLY

circuitsassembly.com/dems

Effect of UNDER-STENCIL WIPE CHEMISTRY on Print Performance

Can a change of solvent in the printer improve SMT printing?

by TIMOTHY O'NEILL and LOGAN JELINSKE

Any engineer will testify lab testing may not correlate with field results. Laboratory data are developed under ideal conditions to generate accurate and repeatable data, whereas a production setting introduces variables not reproducible in the lab environment.

In this report, AIM's application lab approximated a production environment in a multi-hour printing test to quantify the effect of under-stencil wipe solvent on solder paste performance. This experiment compared isopropyl alcohol (IPA) and a novel stencil cleaner. IPA is not recommended as an in-process stencil cleaner, but is often used because it is inexpensive, effective and readily available. However, IPA is not a constituent of solder pastes and can therefore cause changes to paste that will negatively impact performance.

One example of this change is that paste exposed to IPA can become sticky, thus reducing transfer efficiency. This effect can be easily detected by solder paste inspection equipment (SPI). Subtler changes can result in issues that are more difficult to detect. Solder paste that has been compromised can cause flux buildup on the underside of the stencil. Flux buildup can reduce print resolution, which can lead to a variety of soldering defects, including bridging and solder beads/balls.

A series of 0201 components were chosen for the experiment because they best demonstrate the most challenging aspects of a typical assembly. **TABLE 1** shows dimensions of the stencil apertures for the tested 0201 component. **FIGURE 1** shows a section of the test vehicle used for the experiment.

This experiment required simulating a production environment while isolating the effect of the wipe solvent on a SAC 305 no-clean solder paste **(FIGURE 2).** Using the same test vehicle, 80 print cycles were executed in 30 min. with a wet-vac-dry under-stencil wipe cycle performed after every five PCBs. After 30 min., five virgin test boards were printed and SPI height and volume measurements collected. The test was performed for 8 hr. (a typical production shift), and solder paste was not replenished during the duration of the test to minimize dilution of the under-stencil solvent in fresh paste.

The measured paste deposit volume and height were averaged for each board tested. SPI min./max. limits are commonly set at 100% ±50%. **FIGURE 3** shows how to read the test results. Excess paste volume can lead to defects such as solder beads and bridging where insufficient paste volume can result in difficult-to-detect non-wet opens and increased voiding. Height is also an important measurement because variation in paste height, or "dog-ears," can cause inconsistent soldering performance. **FIGURES 4** to **7** show SPI results of the paste deposits of a sample 0201 component. Test boards with the recommended cleaner were consistently within the paste deposit limits for volume (Figure 4) and height (Figure 6), whereas when IPA was used the values exceeded the maximum limits occasionally for volume (Figure 5) and repeatedly for height (Figure 7).

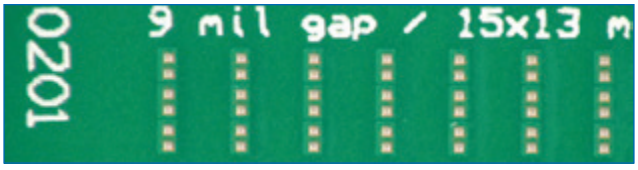


FIGURE 1. Test vehicle showing 0201 component series.

TABLE 1. Stencil Aperture Dimensions Test Data Collected on 0201 Components

Stencil Apertures						
Ref	**Length (µm)**	**Width (µm)**	**Area Ratio**	**Stencil Thickness**	**Components per Board**	**Pads per Board**
201	368	310	0.82	4mil/100µm	30	60

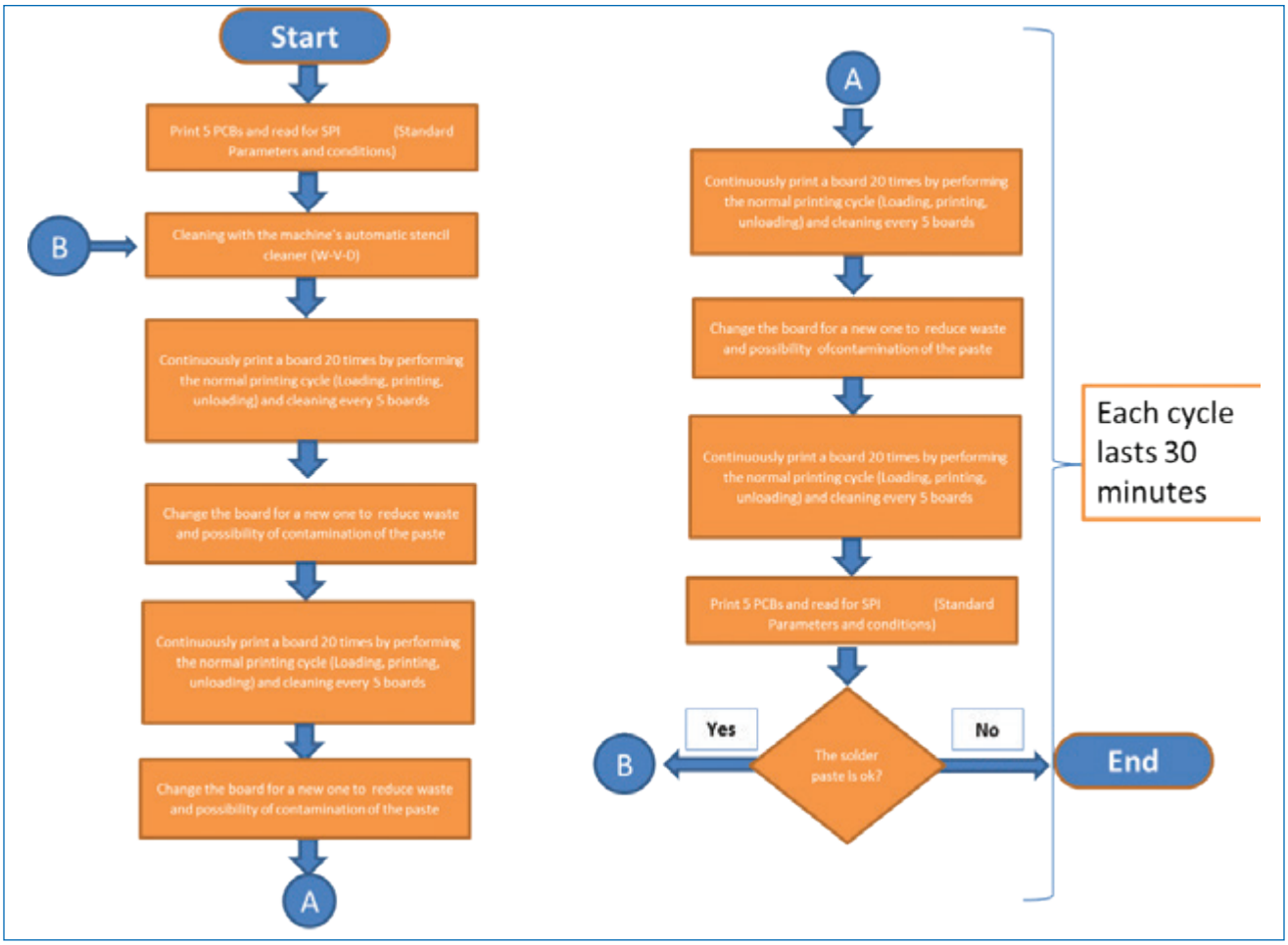


FIGURE 2. Experiment flow chart.

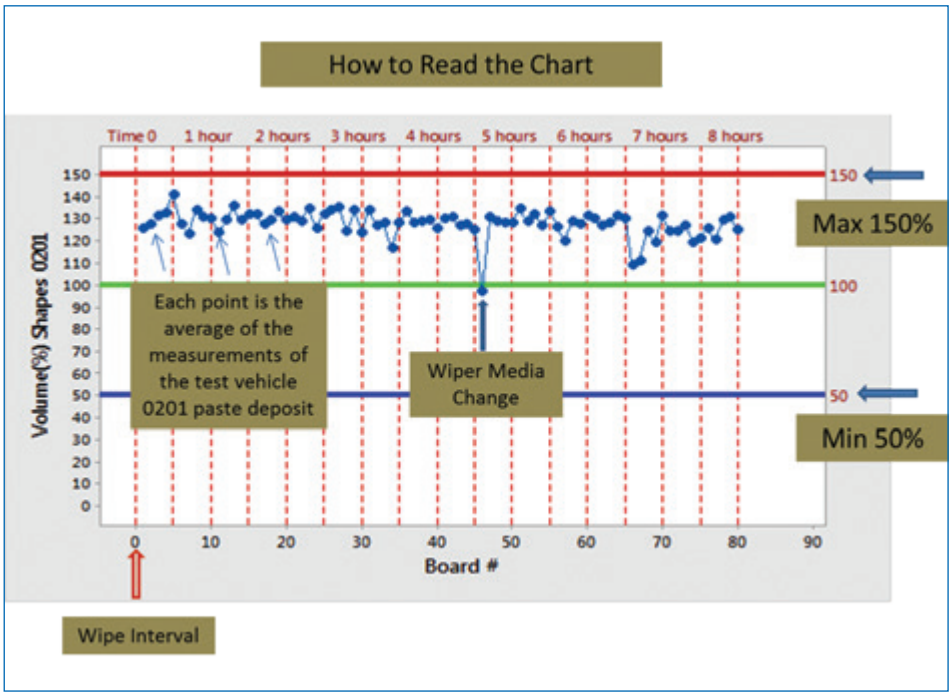


FIGURE 3. Explanation of SPI chart data.

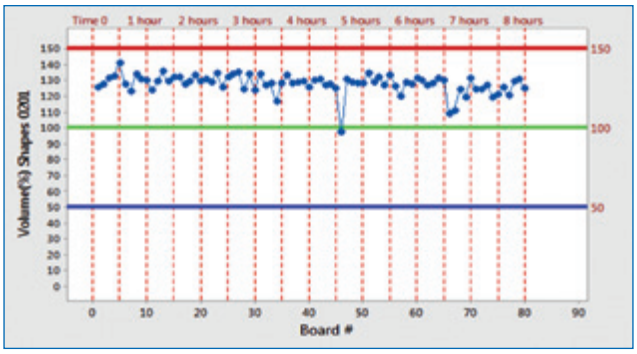


FIGURE 4. SPI values of solder volumes using AIM-recommended under-stencil cleaner.

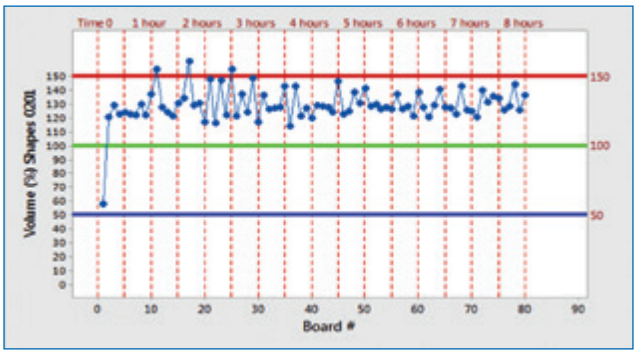


FIGURE 5. SPI values of solder volumes using IPA as under-stencil solvent.

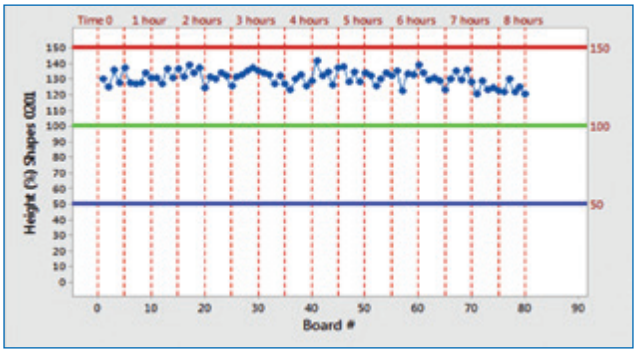


FIGURE 6. SPI values of solder height using AIM-recommended under-stencil cleaner.

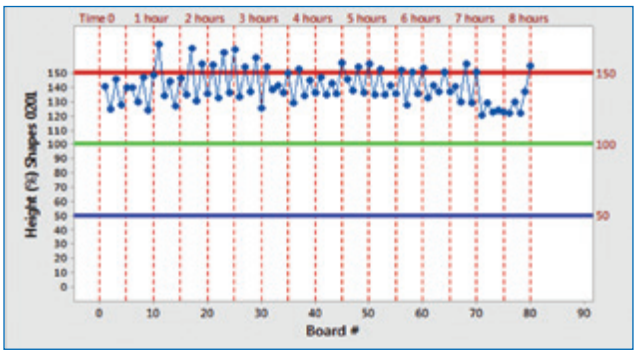


FIGURE 7. SPI values of solder height using IPA as under-stencil solvent.

TABLE 2. Data Point Measurements

Reference Data					
Boards Tested	**Total Components**	**Total Pads**	**Pads per Boards**	**Total Wipe Cycles**	**Total Print Cycles**
80	2400	4800	60	272	1360

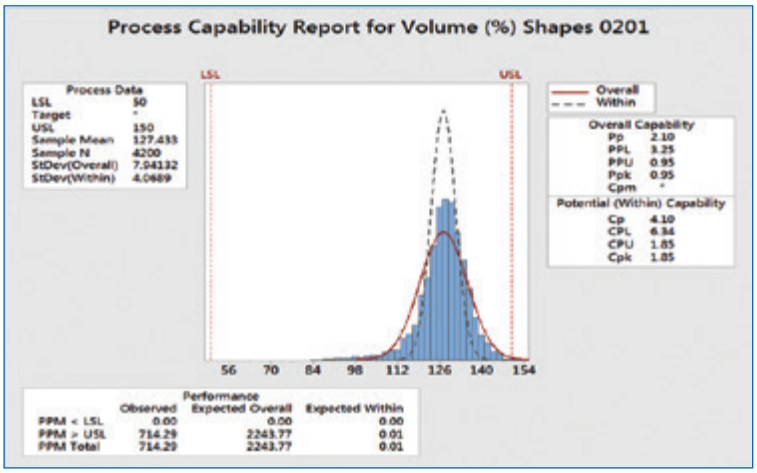


FIGURE 8. Process capability report using AIM-recommended under-stencil cleaner.

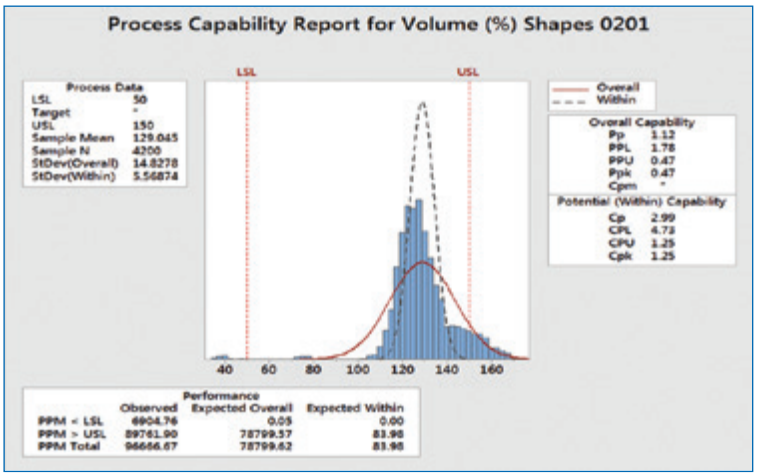


FIGURE 9. Process capability report using IPA under-stencil solvent.

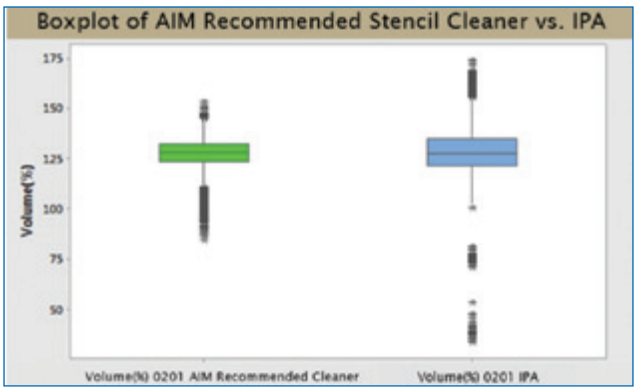


FIGURE 10. Box plots of all data.

FIGURES 8 and **9** demonstrate that when using the recommended stencil cleaner, the C_{pk} value was 1.85, a 5-sigma process, compared to C_{pk} of 1.25, a 3-sigma process when using IPA. It is important to note the IPA wipe had a significant number of outliers, whereas the recommended stencil cleaner had none. The graphs represent 4200 data points; therefore, what may appear to be insignificant is in fact very important.

Continuous process improvement (CPI) is the foundation of Kaizen and ISO manufacturing principals. A simple change of solvent in the printer is a low-cost improvement that can have measurable benefits in an SMT printing process. Additional benefits may include decreased paste consumption as less paste replenishment is required and reduced wiper media consumption as wipe intervals can be increased.

Acknowledgments

Special thanks to the AIM Soldadura de Mexico applications lab manager, Andres Lozoya, for input on the design of experiment and execution, and Carlos Tafoya, AIM technical support director, for guidance and expertise. ▫

TIMOTHY O'NEILL is director of product management and LOGAN JELINSKE is technical marketing specialist at AIM Solder (aimsolder.com); toneill@aimsolder.com.

The Most Prevalent Printing Defects and How to Solve Them

Our expert troubleshoots three common problems.

REGULAR READERS OF this column and certainly most process engineers are acutely aware of the multitude of problems that can arise in the stencil printing process if it is not optimized. With numerous inputs and variables – shown in the fishbone diagram **(FIGURE 1)** – the number of things that *can* go wrong are many, but that shouldn't portend that things *will* go wrong. Stencil printing, as I've said before, can be simplified into having the right amount of material at the right time in the right place. Therefore, too little or too much material, or improper timing or location, can result in defects. On the flip side, knowing how to avoid or correct the most common printing defects can mitigate against proliferation and secure successful results. This month, we look at the basics, discuss the top three printing-related defects and the problems they cause, and share advice on how to resolve them. (Caveat: There are multiple potential causes and cures; here, we discuss the most common.)

Problem: Insufficients (too little material).
Potential result: A dry joint or a faulty/unreliability interconnect in the field can cause a broken circuit, often brought on by temperature or vibration stress.
How to avoid or correct:

- Material in front of the blade. Seems simple, but a lack of material in front of the squeegee blade causes problems. Many automatic systems monitor this condition, but, generally, there should consistently be 10 to 15mm of material in front of the blade. Too much and it won't roll correctly; too little and it will not fill the apertures.
- Proper material for the application. Ensure the paste type is correct for the application at hand. Following the five-ball rule (see our August 2015 column at https://circuitsassembly.com/ca/features-itemid-fix/408-screen-printing/25125-screen-printing-1508.html) is also essential, as not one solder paste fits all. Materials are application-specific.
- Blocked or poorly manufactured apertures. This is one of the first things to check if paste-on-pad volume is lacking. Look at the stencil apertures to ensure they are free of dried material and have been cut correctly.

Problem: Misalignment (paste not centered on the pad).
Potential result: Introduces possibility of bridging or tombstoning due to surface tension irregularities.
How to avoid or correct:

- Machine calibration. Nonnegotiable and the first thing to verify if alignment is off. Stencil printers should be properly calibrated on an annual basis at a minimum.
- Fiducial integrity. First, make sure the fiducial score in the software is set above 800 – or 80% – and maintain that standard. If it starts to fall off – i.e., the fiducial center is no longer reliable and repeatable – understand why. Is the fiducial worn, damaged, poorly manufactured from the start, or obstructed by solder paste? Any of these could be the case. Find the reason and correct it. Don't just start lowering the score (you know who you are!) to "fix" the problem, and deteriorate yield in the process.
- Secure board clamping. Over-the-top clamping is usually secure unless the clamp is damaged, in which case movement can occur. The same holds true for snugging systems; the board must be securely clamped. If not, alignment may appear fine during the alignment process, but once the board is

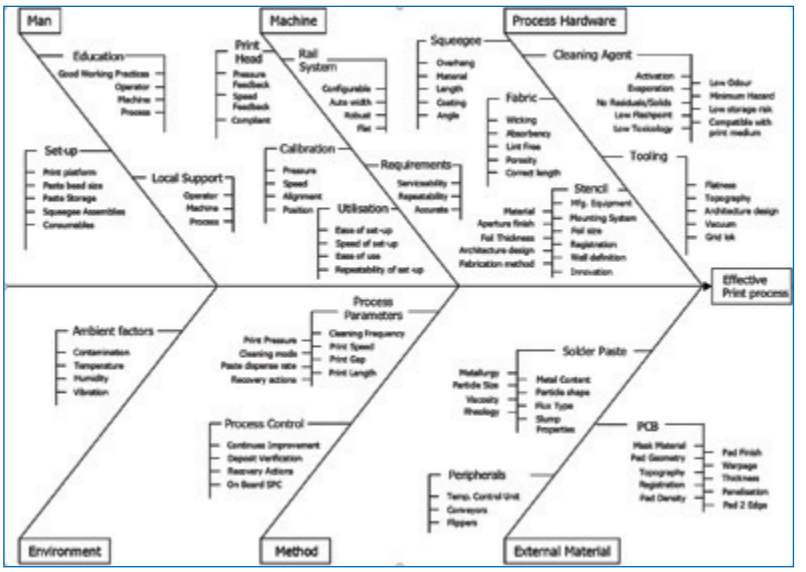


FIGURE 1. Printing inputs that influence outcome.

CLIVE ASHMORE
is global applied process engineering manager at ASM Assembly Systems, Printing Solutions Division (asmpt.com); clive.ashmore@asmpt.com. His column appears bimonthly.

placed underneath the stencil and pressure applied, movement may take place.

- Stencil movement. Both in the machine and in its frame, the stencil must be stationary once gasketed and during the print stroke. A worn stencil with loose mesh may result in movement during printing.

Problem: Bridging (too much material).

Potential result: Can result in shorts, especially with narrow gap and fine-pitch assemblies, or solder balls/mid-chip solder balling with chip resistors and capacitors.

How to avoid or correct:

- Board-to-stencil gasket. Assuming alignment is solid and good pad and aperture design, the most prevalent cause of bridging is a poor gasket between the board and stencil. The board and stencil must make contact and do so evenly across the board, especially on more challenging applications where there is little room for error. If bridging is taking place, evaluate for poor gasket causes, such as:
  - Stencil cleanliness. Any debris on the stencil can impact gasketing integrity.
  - Stencil damage. Coining or non-coplanar areas may induce a poor gasket seal.
  - Solder mask inconsistency. Although it may seem slight, in today's miniaturized world, solder mask thickness variations may introduce gaps.
- Proper/optimized squeegee pressure. Increasing pressure to overcome bridging is the wrong approach. Troubleshoot the bridging cause; unnecessary or excessive squeegee pressure can lead to other problems.
- Understencil cleaning regimen. Overcleaning or favoring the "wet" cycle may lead to bridging if cleaning chemistry penetrates paste during printing.

Printing has many inputs and potentials for defects. These are a few of the most common and hopefully a good reminder about getting back to some basic troubleshooting. □

Solder Toe Fillets or Not?

Should the toe be exposed?

THIS MONTH WE look at solder toe fillets. A solder toe fillet is part of the solder joint visible on most gullwing terminations. These are typically seen on SOIC, QFP and surface mount connectors. **FIGURE 1** shows satisfactory joints with no or limited toe fillets.

Providing solderability on the tip of the pins is good: A solder joint will form on the pad after reflow. No criteria exist for a wettable surface on the tips of the pins. Often the protective plating is removed or smeared when the leads are cut and formed; they may or may not be solderable or last long. The issue is similar with quad flat no-lead (QFNs) and why there aren't side joints on these packages. The base metal is exposed or the plating smeared on the pins.

Find out more on why you may not get a solder fillet at the tip of the pin with this DOTM video: youtube.com/watch?v=N1xaVL6CvCs&list=PL4CI0rmUZMViEzwxUtVi5s-f4CfPR4Wco&index=27.

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

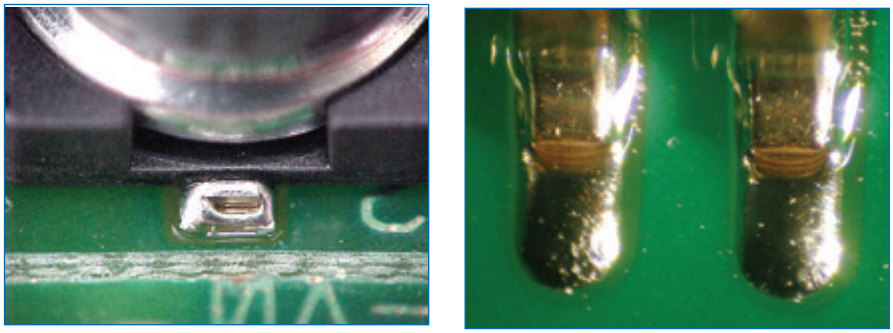


FIGURE 1. Solder joints with no or limited toe fillets.

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. ▫

Focus on Business, continued from pg. 14

prospect. Educational whitepapers or webinars, informative articles, choiceboards that allow what-if pricing comparisons, and short videos or case studies of common production challenges that have been solved are all good engagement tools. LinkedIn, blogs, media-driven whitepaper newsletters and searchable supplier directory websites are good ways to distribute this messaging widely within target markets. Executing that strategy requires good planning and a strong focus on ensuring the content delivered aligns with the information customers want and a format they find appealing.

If 2021 has a one-word theme, it likely will be evolution. This will be a year of changing dynamics. Those who evolve and carefully analyze the behavior changes in their target markets will see significant opportunities. Those who don't will be expressing frustration at the lack of opportunity. ▫

Material Gains, continued from pg. 18

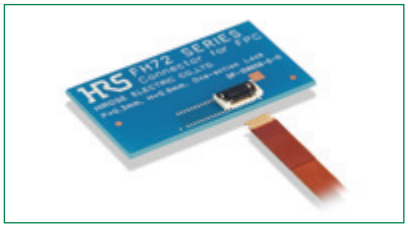
impossible becomes possible at an exponential rate, and we have learned never to say never as we engineer our way toward needed solutions.

While this is incredibly exciting, it challenges research organizations and investors to identify the most suitable projects to pursue. Previously, I have expressed my belief in the necessity of blue-sky research free of any business plan. On the other hand, there is a clear need for projects that can deliver a return within a predictable timeframe and provide a launchpad for ongoing innovation. The fact is we need both in order to move forward. I've said before that our greatest achievements are merely stepping-stones to a future we can barely imagine. The confidence to dream big grows from the commitment to keep taking those small steps. ▫

ORBOTECH INFINITUM

Infinitum performs high-throughput roll-to-roll direct imaging of flex circuits. Employs novel drum direct imaging for material handling and high-speed imaging. Compatible with range of resists and processes. Is capable of 10/15µm lines and spaces with +/-10µm accuracy. Handles rolls up to 50m long, and can process up to 2,700m/24 hr.

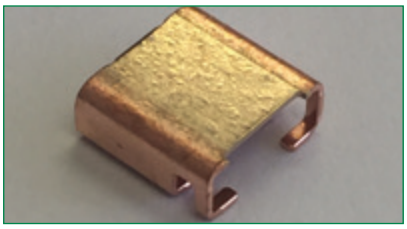
Orbotech
orbotech.com



HIROSE FH72

FH72 flexible printed circuit connector has single-action lock for portable electronic applications. Has height of 0.9mm and 0.3mm pitch. Suitable for consumer devices, gaming, industrial, medical and wearables. Rugged design with low FPC insertion force and high FPC retention force that is 4x typical non-ZIF design.

Hirose Electric
hirose.com/us



STACKPOLE HCSK4026

HCSK4026 high-current terminal shunt resistors now include 0.7mΩ and 3 mΩ resistance values. Can be used in wider range of precision power control applications where efficient sensing is critical. Applications include power management, power modules, battery charging, frequency converters, hybrid power current sensing, engine and motor controls, and PC graphics and motherboards.

Stackpole Electronics
seilect.com

OTHERS OF NOTE

INSPECTAR PRO V. 2.4

InspectAR Pro v. 2.4 PCB debugging tool includes color-by-net for probing, sniffing, soldering or otherwise making physical contact with PCB. Images show before and after on some I2C lines featured on Beagle Bone Black. Color-by-net improves way documentation is captured, especially with screenshot markup tool. Supports exports from Cadence, KiCAD, Altium, Eagle and Mentor.

InspectAR Augmented Interfaces
inspectar.com

WÜRTH WE-MK

WE-MK multilayer ceramic inductors have resonant frequency >10GHz. Come in 0201, 0402 and 0603 packages with inductance values from 1nH to 470nH. Have stable inductance over operating temp. range from -55° to +125°C, with inductance tolerances of ±5% or ±0.3nH.

Würth Elektronik eiSos Group
we-online.com

VISHAY SQJ264EP

SQJ264EP PowerPAK SO-8L dual asymmetric package is an AEC-Q101-qualified n-channel 60V Mosfet. Is designed for DC/DC switch-mode power supplies for automotive applications. Combines high- and low-side MOSFET in a 5mm x 6mm footprint, with low-side max. on-resistance down to 8.6mΩ. RoHS-compliant.

Vishay
vishay.com

VISHAY DALE IHLD-2525GG-5A

Dale IHLD-2525GG-5A automotive-grade, low-profile, high-current dual inductor in 2525 case size is designed to replace two inductors required in automotive Class D audio amplifier with single device. Reportedly reduces board space requirements and component counts, while providing improved THD performance over other inductor types. To provide noise filtering in Class D amplifiers, AEC-Q200 qualified device consists of two IHLP inductors with operating temp. up to +155°C.

Vishay
vishay.com

SNAPEDA ALTIUM PLUGIN

A new free plugin is for searching, finding and placing parts directly within Altium Designer. Contains CAD models for millions of electronic components, many of which have been created in collaboration with electronic component suppliers. Models can be placed directly onto Altium Designer schematic or layout or added to designer's library folder. Models imported via plugin are native Altium .SchLib and .PcbLib file types.

SnapEDA
snapeda.com/plugins

BOURNS MULTIFUSE MF-FSHT

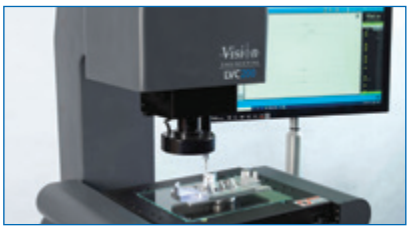
Multifuse MF-FSHT polymer PTC high-temperature-rated surface mount resettable fuses deliver overcurrent protection in applications with higher ambient operating temp., while lowering risk of generating tripping at elevated temp. between 85° and 125°C. Are for applications that encounter elevated ambient temp., including industrial equipment, outdoor security systems and computing/storage devices. Come in EIA 0603 footprint. RoHS compliant.

Bourns
bourns.com

INSPECTIS SIDEVIEW

Sideview BGA inspection system features tiny optical probe with built-in high-power lighting and 90° viewing angle. Produces high-resolution images of low-clearance areas beneath BGAs, µBGAs, CSP, CGA and flip-chip packages, with as low as 40µm standoff. Variable focus capability of optics images from first to up to 20 rows of BGA solder bumps with electronically dimmable fiber brush light as background illumination.

Inspectis
inspect-is.com



VISION ENGINEERING LVC200

LVC200 automated video measurement measures large components or multiple small components. Offers choice of measuring capacities and automated movement in all three axes. Nonstop measurement routines possible through programs that can have magnification changes built in. Multiple components can be loaded onto stage and measured in single program. Plus models have up to 700x magnification range.

Vision Engineering
visioneng.us

AHMT OMNIBUS

Omnibus data logger wirelessly analyzes settings of soldering ovens and conveyor belts and returns the measured values live. Detects faulty settings, necessary maintenance work and possible production errors at an early stage. Modular system. Handles operating temp. up to 300°C. For reflow, vacuum, conduction soldering (hot plate), selective and wave soldering, plus coating, curing and drying.

AHMT
ah-mt.com

OTHERS OF NOTE

FUJIPOLY SARCON LG23A, LG30A

Sarcon LG23A and LG30A two-component thermal gap fillers have electrical insulative properties. Are for filling large, complex and uneven gaps between heat-generating components that depend on reliable contact with heat spreader. Dispense in liquid form. Cure at room temp. or can be accelerated with exposure to temp. up to 100°C.

Fujipoly
fujipoly.com

VISICONSULT HIGH-PRECISION CT

High-Precision CT system integrates and monitors devices such as cooling systems, temperature and humidity controls. Handheld controller is used to fine-tune axes while user is standing next to it. Loads of up to 60kg and a diameter of up to 300mm can be loaded into system using overhead crane and then scanned. Options include filter wheel, shutter, target cooling and detector aperture. Can incorporate two different x-ray tubes.

VisiConsult X-ray Systems & Solutions
visiconsult.de

ROHDE & SCHWARZ SAM100

SAM100 microwave amplifier has 2-20GHz range with up to 20W output power. Targets manufacturers of passive and active microwave components and microwave devices for mobile radio (UMTS, LTE, 4G and 5G), IoT (WLAN, Bluetooth), satellite and radar applications. Focuses on requirements for design validation testing, system integrators and test engineers using system amplifiers for setting up automatic test systems for product validation tests, as well as for production validation of RF products.

Rohde & Schwarz
rohde-schwarz.com

KOKI S3X70-E160DN

S3X70-E160DN solder paste offers consistency without slumping. Is halogen-free and can be used in Mycronic MY machines. Is designed for high-speed and fine-pattern jet dispensing over 50k dots. Program can be adjusted to change size and/or location of dots. Is resistant to temp. variations. Solder alloy is SAC 305; leaded options available.

Koki
ko-ki.co.jp/en

GUYSON FORMULA 1400

Formula 1400 blast cabinet has been adapted for selective removal of conformal coating from PCBs. Comes with dust collector bag. Blasting is undertaken with standalone pressure fed pencil blast unit fitted onto external shelf on left-hand side of cabinet. Micro-nozzle propels blast media from single blast pot to selectively remove conformal coating.

Guyson International
guyson.co.uk

HENKEL BERGQUIST TGF 4500CVO

Bergquist TGF 4500CVO liquid gap filler combines thermal performance, high dispense rate and controlled volatility. Designed as a two-component material, it is built on a silicone chemistry platform capable of dispensing at speeds up to 300g/min., depending on the pattern. Thermal conductivity is 4.5 W/m-K. Has low assembly stress, thoroughly wets out for optimized heat transfer and can be used without fear of contamination. Minimal thermal changes at temperature up to 200°C. Room temperature storage.

Henkel
henkel.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.

3-D Printing

"Inflight Fiber Printing Toward Array and 3-D Optoelectronic and Sensing Architectures"

Authors: Wenyu Wang, *et al.*

Abstract: Scalability and device integration have been prevailing issues limiting the ability to harness the potential of small-diameter conducting fibers. The authors report inflight fiber printing (iFP), a one-step process that integrates conducting fiber production and fiber-to-circuit connection. Inorganic (silver) or organic {PEDOT:PSS [poly(3,4-ethylenedioxythiophene) polystyrene sulfonate]} fibers with 1- to 3-μm diameters are fabricated, with the fiber arrays exhibiting more than 95% transmittance (350 to 750nm). The high surface area-to-volume ratio, permissiveness, and transparency of the fiber arrays were exploited to construct sensing and optoelectronic architectures. The authors show the PEDOT:PSS fibers as a cell-interfaced impedimetric sensor, a 3-D moisture flow sensor, and noncontact, wearable/portable respiratory sensors. The capability to design suspended fibers, networks of homo cross-junctions and hetero cross-junctions, and coupling iFP fibers with 3-D-printed parts paves the way to additive manufacturing of fiber-based 3-D devices with multilatitude functions and superior spatiotemporal resolution, beyond conventional film-based device architectures. *(Science Advances,* September 2020, https://advances.sciencemag.org/content/6/40/eaba0931)

Conductive Inks

"Flexible Electronics Directly Written with an Ultrastable Ballpoint Pen Based on a Graphene Nanosheets/MWCNTs/Carbon Black Nanocomposite"

Author: Yu Liao, Yufei Tian, Xiaohua Ma, Meijun Zhao, Jun Qian, Xin Wang

Abstract: A water-based ink containing conductive carbon particles composed of graphene nanosheets, multiwalled carbon nanotubes and carbon black has been developed. Maleic anhydride modified rosin resin was added as a binder to reduce the ink's solid content and viscosity, and xanthan gum was added to stabilize the dispersion so the carbon wouldn't settle out of the ink. The researchers optimized viscosity and the size of the conductive particles relative to the pen tip to create a system that provided stable and smooth writing performance on both flat and irregular surfaces – even a loofah. Circuits drawn on paper with the pen withstood multiple cycles of folding without deterioration. The ink remained stable after sitting for 12 hr., released no harmful gases during use and cost much less than others reported in the literature. The pens could be used to draw flexible, wearable electronic devices on soft substrates or human skin. *(ACS Applied Electronic Materials,* December 2020; https://pubs.acs.org/doi/10.1021/acsaelm.0c00866)

Reflow Soldering

"The Effect of Thermal History on the Microstructure of SnAgCu/SnBiAg Mixed Assemblies"

Authors: Mohammed Genanu, Faramarz Hadian, Randy Owen and Eric J. Cotts

Abstract: The effects of reflow parameter values on the microstructure of SnAgCu/SnBiAg mixed assemblies were examined. The variation of the volume fraction of the hypoeutectic SnBiAg phase with respect to the peak temperature during reflow, and the initial volumes of the SnAgCu and SnBiAg phases, was characterized. A simple theory was developed to predict the volume of the SnAgCu and SnBiAg phases after reflow as a function of the peak temperature during reflow and the initial volume of the SnBiAg phase. This theory was based on a one-dimensional Sn/eutectic SnBi mixed assembly. Concentration gradients in the hypoeutectic SnBiAg phase after reflow were characterized and compared to results from the Scheil equation. *(Journal of Electronic Materials,* September 2020, https://link.springer.com/article/10.1007/s11664-020-08474-3)

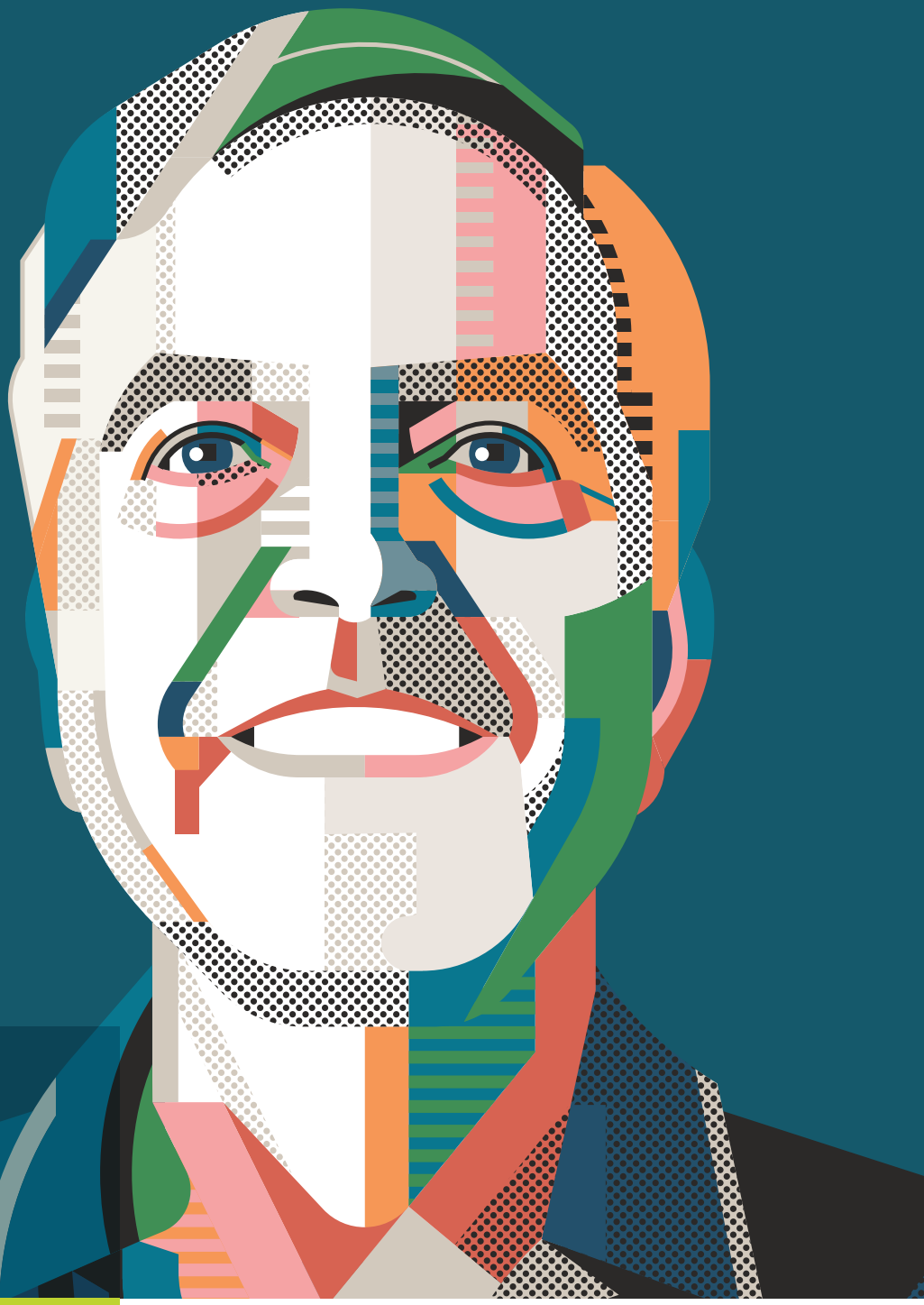
Solder Reliability

"Effective Solder for Improved Thermo-Mechanical Reliability of Solder Joints in a Ball Grid Array (BGA) Soldered on Printed Circuit Board (PCB)"

Authors: Joshua A. Depiver, Sabuj Mallik and Emeka H. Amalu

Abstract: This investigation determined the effective BGA solders for improved thermo-mechanical reliability of the devices. It utilized a conducted study on creep response of a eutectic Sn63Pb37 and four Pb-free SAC solders (SAC 305, SAC 387, SAC3 96 and SAC 405) subjected to thermal cycling loadings and isothermal aging. Ansys R19 software was used to simulate isothermal aging of some of the assemblies at -40°, 25°, 75° and 150°C for 45 days and model the thermal cycling history of the other assemblies from 22°C ambient temperature for six cycles. The response of the solders was simulated using the Garofalo-Arrhenius creep model. Under thermal aging, SAC 396 solder joints demonstrated possession of least strain energy density, deformation and von Mises stress compared to the other solders. Under thermal cycle loading conditions, SAC 405 acquired the lowest amount of the damage parameters in comparison. SAC 405 and SAC 387 joints accumulated the lowest and highest energy dissipation per cycle, respectively. It is concluded SAC 405 and SAC 396 are the most effective solders for BGA devices experiencing isothermal aging and temperature cycling during operation, respectively. They are proposed as the suitable replacement of eutectic Sn63Pb37 solder for the various conditions. *(Journal of Electronic Materials,* November 2020, https://link.springer.com/article/10.1007/s11664-020-08525-9)

Dennis Ralston
Sr. Director –
Government Relations and Cooperative R&D
KLA



YOU HAVE A VOICE.

WE MAKE SURE POLICY MAKERS HEAR IT.

Learn how SEMI Advocacy represents the industry with governments worldwide.

We amplify the voices of individual members and transform them into policy positions. To explore the ways we advance the health and prosperity of the global electronics design and manufacturing supply chain, visit **semi.org/semiismore**.

SEMI IS MORE

semi™

APCT

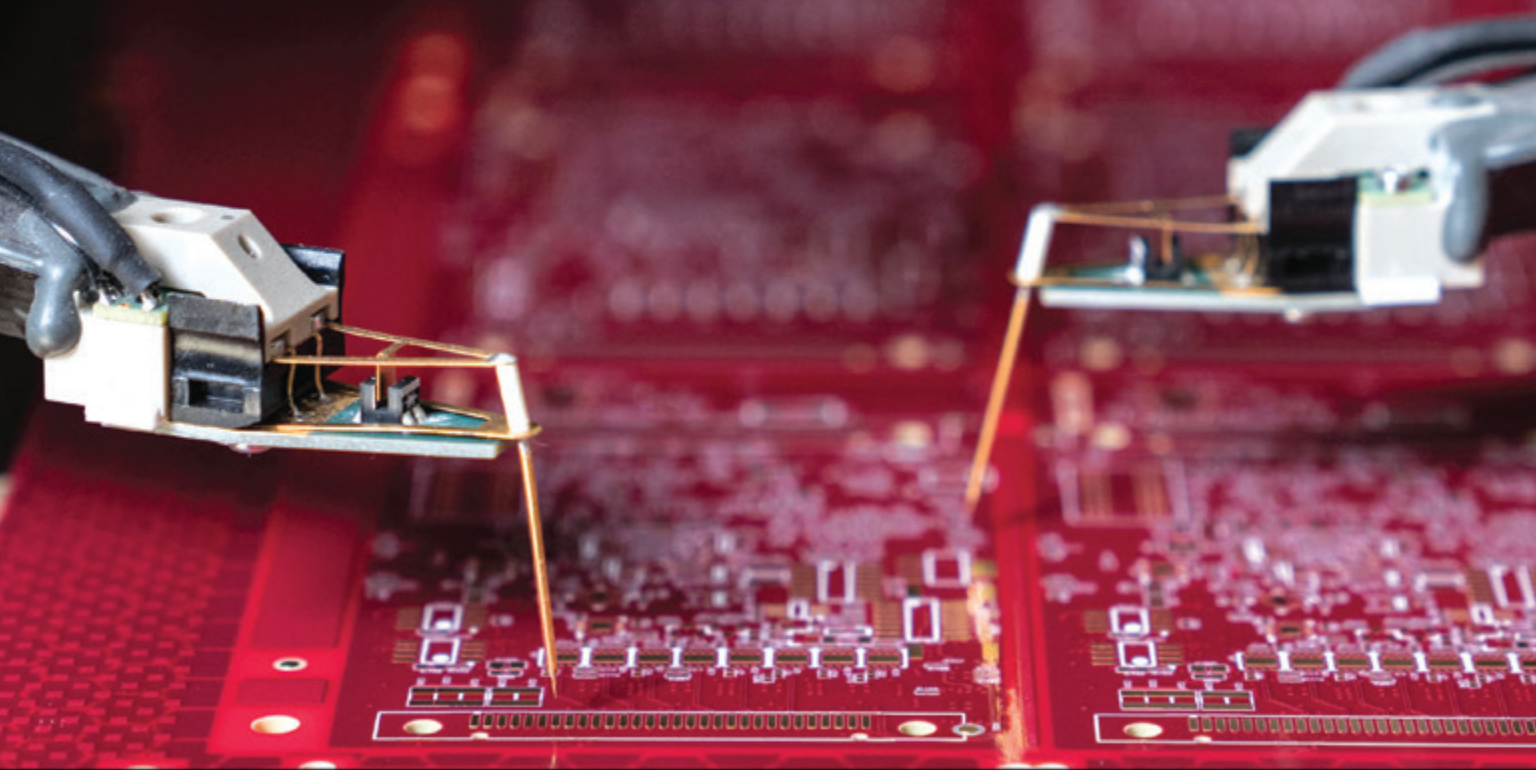
Passion I Commitment I Trust

Paying Attention To Details Achieves Excellence.

Superior Advanced Technology Capability
World-Class Engineering Support
A Diversified Offshore Supply Chain

APCT HAS THE SOLUTIONS

512.548.7435 | APCT.com



Printed Circuit Board Solutions

APCT.com	APCT Santa Clara HQ	APCT Anaheim	APCT Orange County	APCT Wallingford	APCT Global
	408.727.6442	714.921.0860	714.993.0270	203.269.3311	203.284.1215