PCB West, September 19-22, Santa Clara

PCEA®
Printed Circuit Engineering Association

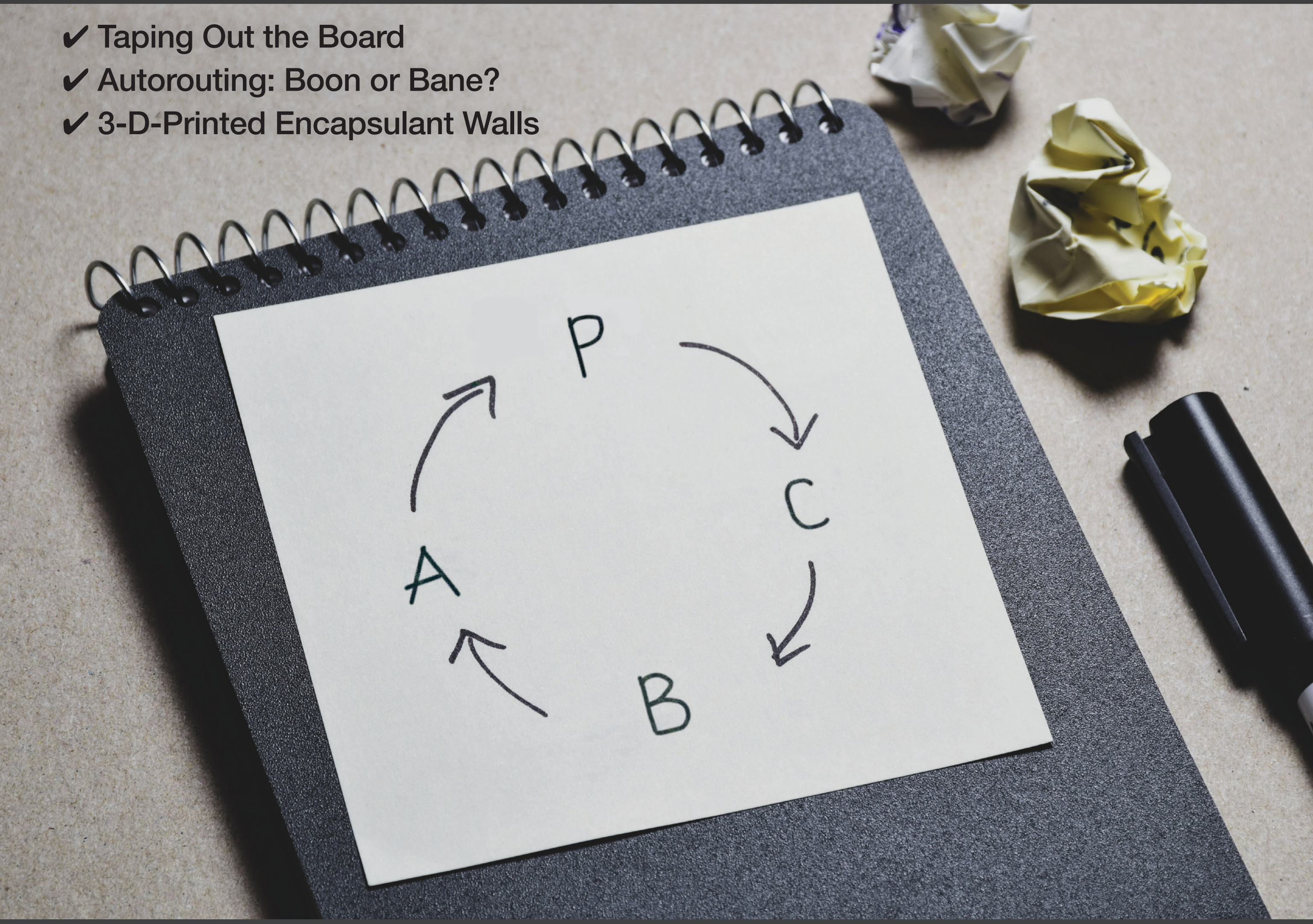
PRINTED CIRCUIT DESIGN & FAB

CIRCUITS ASSEMBLY

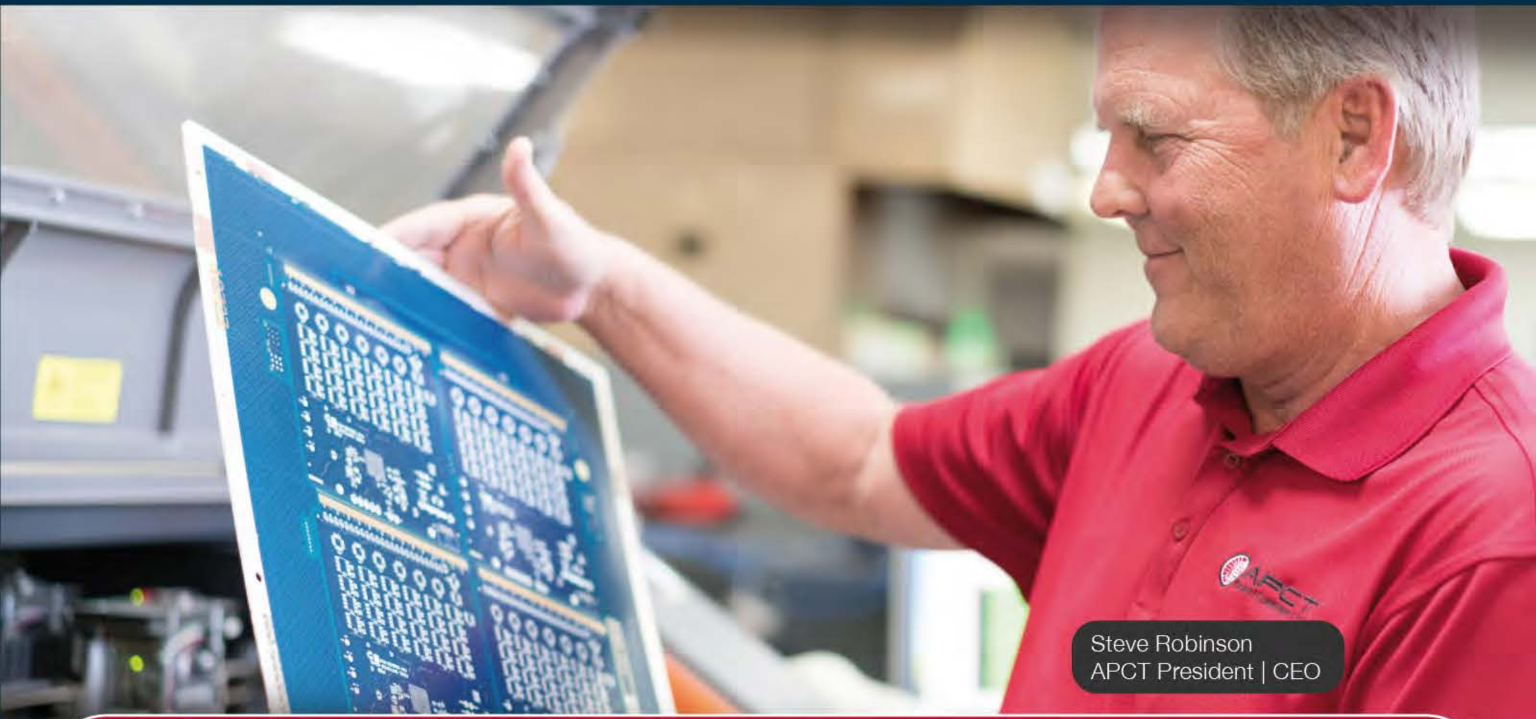
pcdandf.com
circuitsassembly.com
September 2023

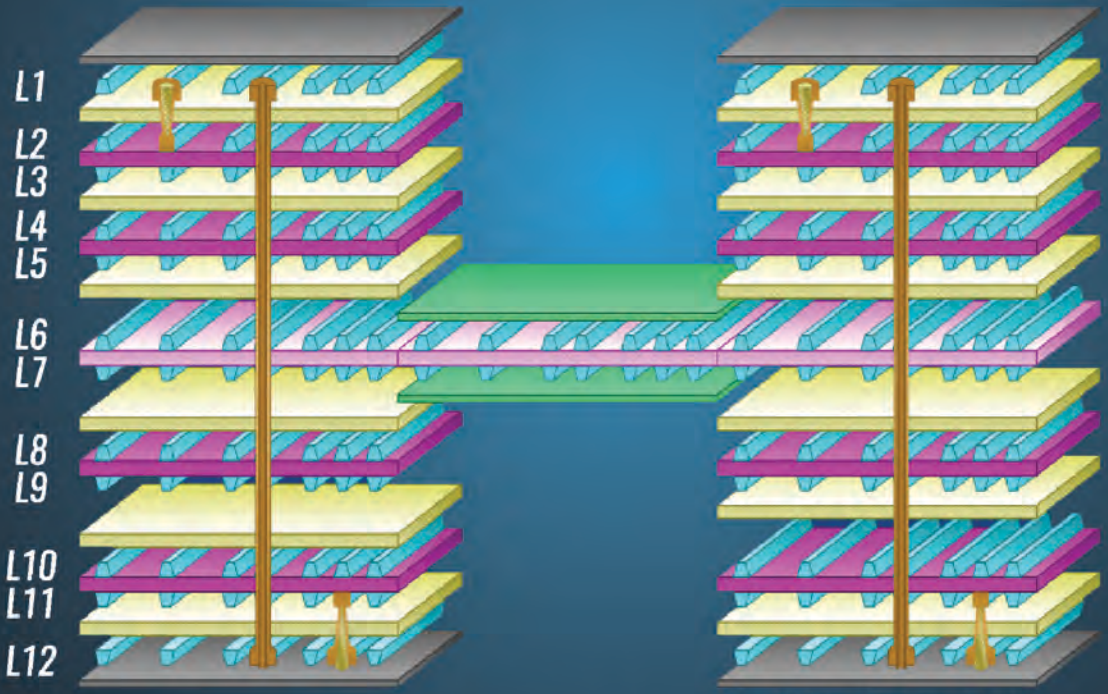
Closing the Loop

Printer-to-SPI Alignment



- ✔ Taping Out the Board
- ✔ Autorouting: Boon or Bane?
- ✔ 3-D-Printed Encapsulant Walls




L1
L2
L3
L4
L5
L6
L7
L8
L9
L10
L11
L12

SEPTEMBER 2023 • VOL. 40 • NO. 9

PRINTED CIRCUIT DESIGN & FAB
CIRCUITS ASSEMBLY

FIRST PERSON

THE ROUTE
Putting the M in OEM.
Mike Buetow

MONEY MATTERS

ROI
Balancing people and automation.
Peter Bigelow

BOARD BUYING
Can anywhere replace Chinese manufacturing?
Greg Papandrew

TECH TALK

DESIGNER'S NOTEBOOK
Preparing for the tape-out rush.
John Burkhert, Jr.

DESIGN BEST PRACTICES
Take your hands off the wheel.
Stephen Chavez

ROUGHLY SPEAKING
Trust data sheets, but verify them.
Geoffrey Hazelett

MATERIAL GAINS
Reshoring won't come cheap.
Alun Morgan

GETTING LEAN
Automating inspection in secondary assembly operations.
Filemon Sagrero

SEEING IS BELIEVING
Lessons learned from Techbros.
Robert Boguski

TECHNICAL ABSTRACTS

DEPARTMENTS

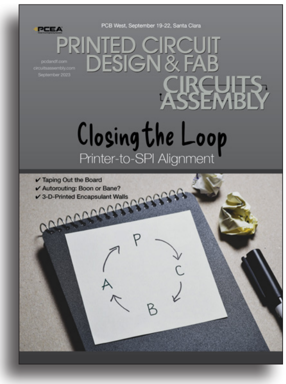
AROUND THE WORLD

PCEA CURRENT EVENTS

MARKET WATCH

OFF THE SHELF

FEATURES


PCB West, September 19-22, Santa Clara
PRINTED CIRCUIT DESIGN & FAB
CIRCUITS ASSEMBLY
Closing the Loop
Printer-to-SPI Alignment
✓ Taping Out the Board
✓ Autorouting: Boon or Bane?
✓ 3-D-Printed Encapsulant Walls

ADDITIVE MANUFACTURING

3-D Printing of Plastic Structures onto PCBs for Circuit Protection Strategies
Electronics for automotive applications, among others, are expected to reliably operate in harsh environments at a competitive cost, and 3-D printing offers a possible solution. A case study is detailed featuring the creation of 3-D-printed retaining walls, formed directly onto the surface of PCB substrates, without the need for separate parts, mold tools, mechanical or liquid fasteners, and complex manufacturing equipment.
by STANTON F. RAK, PH.D., and DAVID TSEUNG

2023 SALARY SURVEY

Show Them the Money
After last year saw an explosion in salaries among printed circuit designers and design engineers, this year's survey conducted by PCD&F/CIRCUITS ASSEMBLY found that salaries have continued to rise in 2023.
by TYLER HANES

STENCIL PRINTING (COVER STORY)

Closed-Loop Process Optimization between Screen Printer and SPI in an SMT Line
Screen printing is considered the most critical process in surface mount technology, and 70% of SMT defects can be traced back to that process. An experiment using a closed-loop system to monitor and correct solder paste deposition on a PCBA in real time is performed.
by MIGUEL ARROYO COLOMER, CSMTPE

SMTA WLP

The Power of Personal Branding: Creating an Authentic and Sustainable Perception
A frequently discussed subject among cohorts and in mentoring sessions is personal branding. The SMTA's Women's Leadership Conference at SMTA International will teach how to develop and refine a personal brand, and to expand networks and open new opportunities.
by PRIYANKA DOBRIYAL, PH.D.

ON PCB CHAT (PCBCHAT.COM)

PCB Chat

DFM BEST PRACTICES
with ANDREW WILLIAMS

MOISTURE MITIGATION STRATEGIES
with DAN JENKINS and ROB LOWRY

europlacer
Surface Mount Intelligence

Europlacer brings productivity solutions to electronics manufacturing.

EUROPLACER'S EXHIBIT at the forthcoming SMTAi conference in Minneapolis marks the first time the company will promote its new proposition to the electronics manufacturing sector as the industry's productivity experts.

Widely known for the exceptional flexibility of its placement systems that particularly suit high-mix production in low- to medium-volume applications, Europlacer's years of surface mount assembly experience show that line-wide productivity is only marginally related to placement speed. In some high-volume applications, throughput at the placement system can have a marked impact. However, for the majority of surface mount lines, productivity across the line supported by a defined process is the real measure that delivers efficiency and ultimately greater factory output.

Getting smart. Taking that pragmatic view of productivity to the next level, Europlacer has positioned itself to provide expertise and solutions that will help to turn existing SMT assembly operations into smart production lines. Part of the equation is down to the equipment. To that end, Europlacer will be running machine demonstrations on its SMTAi booth to showcase productivity solutions.

A key to smart production is connectivity, a proposition that features in Europlacer's new approach to the market. Connectivity drives businesses forward by allowing production engineers and operators to get the most out of the entire line. Proven smart accessories from Europlacer, such as the ii-Tab mobility solution can give greater control, improve communications efficiency, and provide real-time data to allow better decisions to be made.

Effective connectivity now from the very start of the line. A smart operation starts before the SMT assembly line, with intelligent warehouse and stock management tools, which Europlacer can demonstrate and discuss at SMTAi.

Europlacer will use SMTAi to preview a brand-new screen-printer. It is the company's fastest screen printer yet with upgraded software maximizing efficiency. Built-in CFX/Hermes compatibility delivers critical connectivity over accepted industry communication protocols. This puts the new printer in a special class for intelligent line-wide connectivity that equates directly to productivity as a meaningful measure. Ask the Europlacer SMTAi team for a preview.

Because productivity is needed. The focus on productivity is a constant when Europlacer is developing solutions with every part of the assembly line being reviewed for its efficiency. Europlacer is the full SMT production line expert, not just a machine manufacturer. As experts in equipment flexibility, Europlacer application engineers have countless examples of productivity improvement successes across the company's customer base. Improvements of up to 50% are not uncommon.

At the SMTAi event. Europlacer's SMT line specialists will be at SMTAi to discuss any production or productivity challenges. With ways to increase productivity being a key theme for the team, be sure to catch up with them to determine ways to get more out of your assembly line.

The SMTAi conference runs from 9th – 12th October at the Minneapolis Convention Center, Minneapolis, MN. The exhibition takes place on 10th – 11th October. Visit Europlacer at booth #1513. Scan the QR code to visit our events page.

PCEA
Printed Circuit Engineering Association

PCEA
PO BOX 807
AMESBURY, MA 01913

PRINTED CIRCUIT DESIGN & FAB
CIRCUITS ASSEMBLY
pcdandf.com
circuitsassembly.com

PCEA.NET

THE PRINTED CIRCUIT ENGINEERING ASSOCIATION, INC. BRANDS:

PUBLICATION	
PCD&F/Circuits Assembly	digital.pcea.net
WEBSITES	
PCD&F	pcdandf.com
Circuits Assembly	circuitsassembly.com
NEWSLETTER	
PCB Update	pcbupdate.com
PODCASTS	
PCB Chat	pcbchat.com
EVENTS	
PCB West	pcbwest.com
PCB East	pcbeast.com
EDUCATION	
PCB2Day	pcb2day.com
Printed Circuit University	printedcircuituniversity.com
AWARDS PROGRAMS	
Service Excellence Awards	circuitsassembly.com
NPI Awards	circuitsassembly.com pcdandf.com
DATABASE	
Directory of EMS Companies	circuitsassembly.com

PRINTED CIRCUIT DESIGN & FAB CIRCUITS ASSEMBLY
PCU
PCB EAST Conference & Exhibition
NPI NEW PRODUCT INTRODUCTION AWARD
PCB UPdate
PCB WEST Conference & Exhibition
CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS
PCEA TRAINING
The Circuits Assembly Directory of EMS Companies
PCB Chat
PCB2DAY

STAFF

PRESIDENT
Mike Buetow 617-327-4702 | mike@pcea.net

VICE PRESIDENT, SALES & MARKETING
Frances Stewart 678-817-1286 | frances@pcea.net

SENIOR SALES EXECUTIVE
Brooke Anglin 404-316-9018 | brooke@pcea.net

MANAGING EDITOR
Tyler Hanes 205-258-0067 | tyler@pcea.nett

PCD&F/CIRCUITS ASSEMBLY EDITORIAL

MANAGING EDITOR
Tyler Hanes 205-258-0067 | tyler@pcea.net

COLUMNISTS AND ADVISORS

Clive Ashmore, Peter Bigelow, Robert Boguski, John D. Borneman, John Burkhert, Jr., Stephen Chavez, Joseph Fama, Geoffrey Hazelett, Mark Finstad, Nick Koop, Geoffrey Leeds, Alun Morgan, Susan Mucha, Greg Papandrew, Chrys Shea, Jan Vardaman, Gene Weiner

PRODUCTION

ART DIRECTOR & PRODUCTION
blueprint4MARKETING, Inc. | production@pcea.net

SALES

VICE PRESIDENT, SALES & MARKETING
Frances Stewart 678-817-1286 | frances@pcea.net

SENIOR SALES EXECUTIVE
Brooke Anglin 404-316-9018 | brooke@pcea.net

REPRINTS

sales@pcea.net

EVENTS/TRADE SHOWS

EXHIBIT SALES
Frances Stewart 678-817-1286 | frances@pcea.net

TECHNICAL CONFERENCE
Mike Buetow 617-327-4702 | mike@pcea.net

SUBSCRIPTIONS

PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY is distributed without charge to qualified subscribers. To subscribe, visit pcdandf.com or circuitsassembly.com and click on Subscribe. For changes or cancellations to existing subscriptions: subscriptions@pcea.net

PRINTED CIRCUIT DESIGN & FAB/CIRCUITS ASSEMBLY is published monthly by Printed Circuit Engineering Association, Inc., PO Box 807 Amesbury, MA 01913. ISSN 1939-5442. GST 124513185/ Agreement #1419617.


Fischer
X ray
START
STOP
FISCHERSCOPE® X-RAY XDAL®

THE **ROUTE**

Add Wisconsin to the List of Failed Foxconn Bettors

THE INK WAS barely dry on the lawsuit filed by Lordstown Motors against would-be savior Foxconn when the next round of news hit: the world's largest ODM/EMS company is pulling out of Wisconsin.

If we go back to 2019, we will recall Lordstown opening the doors of its plant, formerly owned by GM and seen as critical to its hometown's economic future, to Foxconn, which came bearing (the promise of) much-needed cash. In return, the ODM was to obtain access to Lordstown's electric vehicle technology, which Foxconn sought as it reportedly focuses on building electronics and other products for what is seen as the future platform for individual and fleet transportation.

That dream ended in a crash, unfortunately but unsurprisingly. The investment never really materialized, Lordstown went bankrupt, and the winners will be the lawyers.

Some 460 miles away, 30 miles due south of Milwaukee, Foxconn's much-ballyhooed splash into the Wisconsin cornfields is resolving with the sale of its 315-acre campus to Microsoft.

That's a far cry from the $10 billion in investment and 13,000 jobs the company forecast – and lots of politicians touted – as longtime homeowners were hit with eminent domain mandates to make way for the 200,000 sq. ft. plant. Some $500 million of taxpayer money later, the prairie landscape is left with a mostly vacant shell. Likewise, company plans to build innovation centers in Madison, Milwaukee, Green Bay, Eau Claire and Racine have mostly been shelved, and the properties are going on the block.

What both deals had in common was that they took place in states that of late are highly contested in federal elections. That's no surprise: Foreign companies have often (always?) tried to influence the outcome of US elections to suit their strategic interests. (The constraints foreign entities should have on such maneuvers, if any, are for others to decide.)

Experienced bettors know when to fold their cards, however, and Foxconn is well-known for exiting the table when it doesn't like the stakes. When the trade winds blew cold, the company headed for warmer climes.

So a shoutout to Georgia, Arizona and Nevada, among others: If Foxconn comes calling, look hard at the cards before asking for a hit.

In-house production making a comeback? A few years back – well, probably 10 or so – I saw a glimpse of a trend by OEMs to start bringing assembly back in-house. The moves weren't typically wholesale. In many cases, they supplemented existing arrangements, ensuring that they would have at least some internal capabilities.

The thinking went that, if their quarterly build volume peaked at, say, $30 million, they would install a sufficient number of lines to handle that level of production.

This was borne out by some very real developments. Blue chip companies like GE, Eaton, Otis and others were opening captive shops. And other OEMs were adding some level of assembly through acquisitions. Likewise, companies such as Quanta, Compal Electronics, Wistron and Pegatron – all former assembly units of major OEMs – were investing considerable capital in vertical capabilities. The evolution appeared to be OEMs divested their assembly operations, then eventually the EMS companies became ODMs, and ultimately ODMs became OEMs.

The reasons for this are plenty. Knowledge of manufacturing makes for better designs. The ability to build things provides a certain amount of supply-chain resiliency (which wasn't a term then) in the event key suppliers aren't delivering. Maintaining control of critical IP helps keep competitors at bay.

We are seeing echoes of this again. BYD's pending $2.2 billion acquisition of Jabil's mobile unit puts the EV maker squarely in the mix of the top rank electronics manufacturers. Starlink is outfitting a massive manufacturing plant in Austin. Micross Components purchased Technograph Microcircuits, and medical manufacturing OEM Ocutrx Technologies nabbed Spectrum Advanced Manufacturing Technologies.

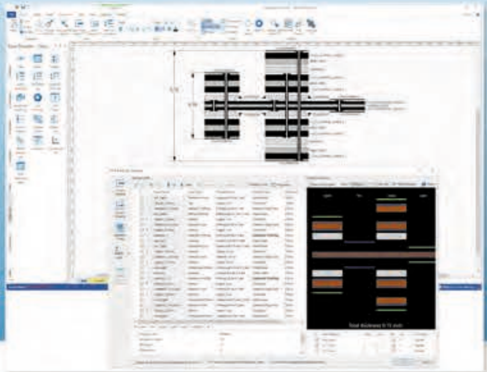
Likewise, Space X (Starlink), Schweitzer Engineering Laboratories and Vicor are among those OEMs that have announced or opened bare board fabrication plants in the past year.

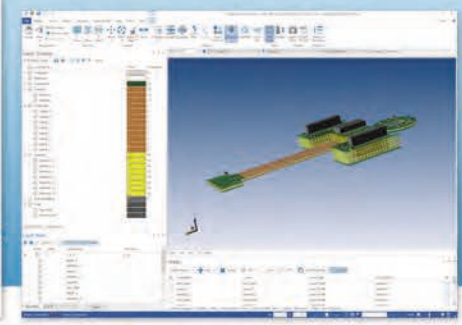
Is my long-ago prediction actually becoming a trend? Possibly. But while for many the supply-chain problems of the past few years have underscored the reasons for bringing production in-house, I do worry that the mode in some cases might be more reaction than planning. What difference does it make? Nonstrategic acquisitions don't take long to become nonstrategic divestitures.

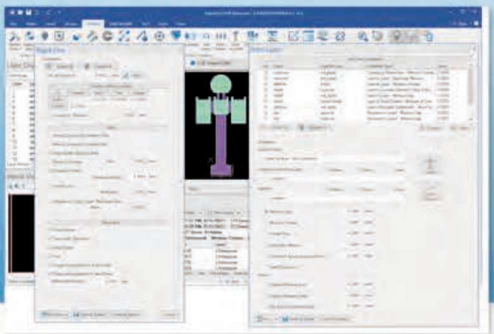
mike@pcea.net
@mikebuetow

P.S. See you this month at PCB West (booth 113), the largest trade show in the Silicon Valley for the electronics industry, next month at SMTAI, and in November at Productronica.

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







Trackwise Designs Puts Itself Up for Sale

TEWKESBURY, UK – Trackwise Designs has launched a sales process for its business after reviewing options for the company's future. The move comes after the printed circuit fabricator lost a major customer.

In mid-July, Trackwise announced that after a year of working with a Tier 1 supplier on the opportunity to supply Cell Connection System flex circuit assemblies, Trackwise was informed by the customer that it had not been successful in securing the business.

The company had delayed release of its annual financial results twice this year, most recently in August, and the London Stock Exchange has suspended trading in the company's shares due to the delay. In the same announcement announcing the delayed results, Trackwise said its board was reviewing options for the future of the company.

Trackwise said that parties with interest in the acquisition of the company should contact the corporate finance team at FRP Advisory Trading, and it reserves the right to alter any aspect of the sale process or to terminate it at any time, and in such cases will make an announcement as appropriate.

SIA: US Faces Tech Worker Shortage

WASHINGTON – The United States faces a significant shortage of technicians, computer scientists and engineers, with a projected shortfall of 67,000 of these workers in the semiconductor industry by 2030 and a gap of 1.4 million such workers throughout the broader US economy, according to a study released by the Semiconductor Industry Association in partnership with Oxford Economics.

The report, titled “Chipping Away: Assessing and Addressing the Labor Market Gap Facing the U.S. Semiconductor Industry,” also makes a set of policy recommendations to help close the talent gap and complement the workforce development initiatives that are already being carried out by semiconductor companies across the US.

“Semiconductor workers are the driving force behind growth and innovation in the chip industry and throughout the US economy,” said Matt Johnson, president and CEO of Silicon Labs and SIA board chair. “Effective government-industry collaboration can overcome the talent shortage facing our industry, build the strongest American tech workforce possible, and unleash the full potential of semiconductor innovation.”

With demand for semiconductors projected to increase significantly by 2030 and beyond, semiconductor companies are ramping up production and innovation to keep pace. Thanks in large part to enactment of the CHIPS and Science Act in 2022, a significant share of new chip manufacturing capacity and R&D is expected to be located in the US. As America’s semiconductor ecosystem expands in the years ahead, so too will its demand for semiconductor workers with the skills, training, and education needed in the highly innovative semiconductor industry.

The study projects the semiconductor industry’s workforce in the US will grow by nearly 115,000 jobs by 2030, from approximately 345,000 jobs today to approximately 460,000 jobs by the end of the decade. As noted, an estimated 67,000 of these jobs risk going unfilled in the absence of action to close the gap.

To meet this challenge and address the talent gap, the SIA-Oxford Economics study presents three core recommendations to strengthen the US technical workforce:

- Strengthen support for regional partnerships and programs aimed at growing the pipeline for skilled technicians for semiconductor manufacturing and other advanced manufacturing sectors
- Grow the domestic STEM pipeline for engineers and computer scientists vital to the semiconductor industry and other sectors that are critical to the future economy
- Retain and attract more international advanced degree students within the US economy.

“Our analysis showcases the critical high-skilled roles across the semiconductor sector and the likely skill shortages the industry will face, if proactive talent development measures are not taken,” said

Dan Martin, senior economist and lead researcher, Oxford Economics. "The CHIPS Act set the stage for US long-run investment and increased global competitiveness in semiconductor design and production. Moving forward, tens of thousands of new post-secondary-trained workers will need to fill the roles created as the industry increases their productive capacity in the US."

Of the total estimated semiconductor technical workforce gap of 67,000 by 2030, the study estimates approximately 39% of the gap (26,400 jobs) will be in technician occupations, 41% (27,300 jobs) in engineering occupations, and 20% (13,400 jobs) in computer science. Because semiconductors are foundational to virtually all critical technologies of today and the future, closing the talent gap in the chip industry will be central to the promotion of growth and innovation throughout the economy.

The US semiconductor industry has, for decades, engaged in programs to recruit, train, and employ a diverse and skilled workforce. Across the nation, chip firms have longstanding and expanding partnerships with community colleges and technical schools, apprenticeship programs, universities and laboratories, and regional education networks. As the industry grows to meet demand alongside CHIPS investments, companies are growing their workforce development footprint. At the same time, the US government must work with industry and academia to prioritize measures to address the skills gap facing the broader economy and the semiconductor industry.

"Along with making historic investments to reinvigorate domestic semiconductor production and innovation, the CHIPS and Science Act anticipated the need to strengthen the semiconductor workforce in America," said John Neuffer, president and CEO, SIA. "We look forward to working with government leaders to advance policies that build on our industry's longstanding workforce development efforts, expand the pipeline of STEM graduates in America, and retain and attract more of the top engineering students from around the world."

China's Victory Giant to Buy Singapore's MFS Technology

HUIZHOU, CHINA – Victory Giant Technology has agreed to buy fellow PCB fabricator MFS Technology for up to $460 million.

Victory Giant will pay cash to acquire Pole Star Ltd. to indirectly own MFS Technology and all its subsidiaries, with equity value worth of about $365 million and debts worth up to $95 million, according to a filing by Victory Giant in the Shenzhen Stock Exchange.

Acquiring the target, which makes flexible printed circuits, will diversify products and improve competitiveness for Victory Giant, which is strong in making rigid printed circuit boards, the filing said.

Already a top 25 PCB fabricator in terms of revenue according to the NTI-100, Victory Giant will likely move into the top 20 worldwide after closing on the deal. Singapore-based MFS has three plants in Japan and one in Zhuhai, China.

Sanmina Keen on Building Indian Fab Facility

PALO ALTO, CA – Sanmina has reportedly expressed interest in building a PCB fabrication facility in the Indian state of Odisha after a delegation of the state's officials visited the company in Silicon Valley.

According to India's Kalinga TV, the Odisha delegation met with Sanmina CEO Jure Sola, senior vice president Sundar Kamath, senior vice president Michael Sparacino, and vice president Bill Pappani to give a detailed presentation on Odisha's industrial ecosystem to the company's officials and brief them on the various incentives available under Odisha's different policies.

The Sanmina team also gave a presentation to the Odisha delegation, providing details of its products and solutions and some of its expansion plans – including its favorable view of India as an expansion target to diversify its global supply base.

According to the report, Sanmina expressed its intent to submit a detailed proposal to Odisha's government, and the delegation assured all possible support in facilitating the investment journey and highlighted the different packages of incentives that are available based on investment size.

IPC, PCBAA Seek Clarity on CHIPS Act

Plans

BANNOCKBURN, IL – IPC and the Printed Circuit Board Association of America are calling on the US Department of Commerce to clarify its plans for bolstering the domestic development and fabrication of advanced printed circuit boards as a key part of the CHIPS for America program.

In a letter sent to Commerce Secretary Gina Raimondo, IPC president and CEO John W. Mitchell and PCBAA chairman Travis Kelly applauded the "positive signals" that have been sent by the Biden administration regarding greater support for PCBs:

In March, President Joe Biden issued a "Presidential Determination" under the Defense Production Act (DPA) that prioritizes the domestic manufacture of PCBs as a matter of national security.

In launching the first round of funding under the CHIPS for America program, Raimondo announced the US will become a global leader in related chip packaging technologies. The week before that, Raimondo confirmed that some of the CHIPS Act funding will go to "smaller firms," including "circuit-board companies."

"As the electronics sector faces significant challenges in the global market, it is crucial to develop strategies that foster growth, innovation, and competitiveness across this vital industry," Mitchell wrote. "Chips, in fact, have no functionality until they are packaged and placed on PCBs by electronics manufacturers who assemble systems. Yet, the United States is more dependent on overseas suppliers for PCBs and packaging than they are for semiconductor chips."

IPC is also calling on the Defense Appropriations Subcommittees in the House and Senate to allocate $100 million in Fiscal 2024 to implement President Biden's presidential determination on PCBs. The funding also would advance the goals of the CHIPS and Science Act, which aims to ensure the autonomy and resiliency of the U.S. supply chain for semiconductors and advanced electronics.

A 2022 report by the Commerce Department noted, "PCBs are essential for the electronic functions of ICT hardware as well as for a wide array of automotive, defense, and medical devices. [But] In the past 20 years China has overtaken the U.S. as the global leader in PCB manufacturing and sales." A 2018 Commerce Department report characterized the PCB sector as "dying on the vine."

According to "Leadership Lost," a report published by IPC, the United States "has lost its historic dominance in the PCB sector." Since 2000, the US share of global PCB production in dollar terms has fallen from over 30% to just 4%, with China now dominating the sector at around 50%. Any loss of access to nondomestic sources of PCBs would be "catastrophic," the report said.

Shengyi Building $196M Plant in Thailand

DONGGUAN, CHINA – Shengyi Technology, the world's second-largest seller of copper clad laminate, will invest CNY1.4 billion ($196 million) to establish a new plant in Thailand to meet international clients' demand for the PCB component.

In a statement, Shengyi said it will purchase a piece of land in an industrial park in Chachoengsao province in south-central Thailand, but it did not disclose the planned annual capacity for the plant or the construction timetable.

Setting up the plant in the Southeast Asian country will help the company respond more flexibly to any possible adverse impacts of changes in the macro environment, industrial policies, and international trade, Shengyi said, adding that it still needs to gain approvals from Chinese and Thai authorities.

Altium 365 Integrates with SiliconExpert

SAN DIEGO – Altium has announced an integration collaboration with SiliconExpert, a provider of electronic component data and parts management software, to provide Altium 365 users with direct access to comprehensive, real-time component data whenever it is needed during the design and product lifecycle.

With SiliconExpert's data on more than 1 billion electronic parts, Altium 365 users can soon access more detailed component information than they have had before, using data sourced directly from manufacturers, which helps ensure accuracy and reliability in decision-making.

"We are thrilled to build the integration as part of a continuing collaboration between SiliconExpert and Altium 365," said Ananth Avva, GM and senior vice president of cloud platform at Altium. "Supply chain of components in the electronics lifecycle management remains a key topic for many of our customers. We are continuing to enrich component data for our customers, and SiliconExpert is one source that is in high demand. We believe this integration will continue to improve the way teams across all disciplines – from designers to operations, procurement, finance, and quality and compliance – approach component selection, risk analysis, and compliance management."

Technoprobe Finalizes Harbor Electronics Acquisition

MERATE, ITALY – Technoprobe, an Italian manufacturer of chip testing solutions, has finalized its $50 million acquisition of Harbor Electronics, a California-based PCB maker.

Harbor Electronics, founded in the 1980s in Santa Clara, California and acquired in 2015 by the Shenzhen-headquartered Fastprint Circuit Tech group, is a manufacturer of advanced PCBs for testing systems for major semiconductor manufacturers.

The acquisition will strengthen Technoprobe's technological competencies in testing by vertically integrating its production process through the in-house production of advanced printed circuit boards for its probe cards and final test boards, the company said in a release.

"We are proud to have finalized the acquisition of Harbor Electronic and pleased to continue to collaborate with Fastprint," said Stefano Felici, CEO, Technoprobe. "The synergies from the acquisition will allow us to continue to grow in the testing market including through our entry into the Final Testing segment."

"The acquisition by Technoprobe gives us access to new resources and markets and thus further expands our expertise in PCB manufacturing for probe boards, with the goal of increasingly supporting the semiconductor test market," Christoper Cuda, CEO, Harbor Electronics. "Our engineers, production staff and support team at Harbor look forward to working with and continuing to grow with Technoprobe."

Teltonika to Build PCB Plant in

Lithuanian Capital

VILNIUS, LITHUANIA – Lithuanian company Teltonika has been cleared to build a PCB production plant here. The €143 million ($156 million) plant will be based in the Teltonika High-Tech Hill technology park in the Liepkalnis neighborhood in the capital city.

Teltonika plans to invest €2.1 billion ($2.3 billion) in the Teltonika High-Tech Hill technology park over the next five years.

Power Group Property, part of the Teltonika Group, will carry out the construction, which is planned to be completed in December 2024.

Nano Dimension Acquires Additive Flow Technology

WALTHAM, MA – Nano Dimension has announced the acquisition of the technology and intellectual property of the UK-based company Additive Flow, which supplies solutions for 3-D design simulation and optimization.

Additive Flow has developed high-performance and high-quality simulation software for mechanical, thermal, thermo-mechanical properties, along with frequency and fatigue across a range of materials and processes. Their product addresses design, production, and quality decisions, while optimizing for cost, weight, manufacturing productivity, and manufacturing yield – all simultaneously, Nano Dimension said in a release announcing the acquisition.

The company said the acquisition signals a successful milestone in its product development roadmap, as computer-aided engineering and design components are a core part of Nano Dimension's design-through-manufacturing product strategy. Simulation algorithms and optimization capabilities are particularly crucial for leveraging the advantages of additive manufacturing. Additive Flow's AI and GPU accelerated software will enhance the ability of Nano Dimension customers to replicate, design, and augment AME electronic components' prototypical layouts, in a rapid and cost-effective manner. Additive Flow's core technology will be integrated into Nano Dimension's proprietary design package suite, FLIGHT.

"The Additive Flow team is thrilled to join Nano Dimension. Our solution was born out of real engineering challenges we faced to harness the capability of advanced manufacturing," said Alexander Pluke, CEO, Additive Flow. "Our platform is built from the ground up to handle all the complex data and decisions of digital engineering, so teams can focus on their key goals. We are fortunate to have found a great partner in Nano Dimension where our innovation can be leveraged to its maximum potential. We look forward to building on our impressive track record and continuing to develop Additive Flow's software and enhance Nano Dimension's leading AM and AME product offerings."

"We have been looking at the software market for simulation and optimization offerings for some time," said Nano Dimension senior chief technology officer Nick Geddes. "There are many strong solutions in the market that do certain elements of those complicated tasks, but it is Additive Flow's product that stood out in terms of the functionality we needed for a holistic solution, especially in the context of our requirements across AME and multi-dimensional polymer, metal and ceramic AM. The acquisition will add considerable firepower to the ability of our customers to leverage our leading digital manufacturing solutions."

KingClean Electric Takes Major Stake in PCB Maker

SUZHOU, CHINA – Chinese home appliance maker KingClean Electric plans to acquire a 96.5% stake in PCB maker Suzhou Lihua Technology for 272.5 million yuan ($37.4 million).

Kingclean will buy the stake from Lake Electric Investment Group and RayVal Holding. Suzhou Lihua Technology, established in August 2003, also produces computer and peripheral products.

KingClean said it has decided to acquire Lihua as it is bullish on the global market for electronic products.

Würth Elektronik Completes APPLAUSE Research Project

NIEDERNHALL, GERMANY – Würth Elektronik Circuit Board Technology, along with 31

European partners, have completed the three-year Advanced Packaging for Photonics, Optics, and Electronics for Low-Cost Manufacturing in Europe (APPLAUSE) project, which looked to strengthen the semiconductor value chain for the medical sector in Europe by developing new tools, methods, and processes for volume production.

The project partners consisted of competence leaders from the fields of electronics packaging, optics, and photonics, together with leading equipment manufacturers and medical technology experts. The €34 million ($37 million) project was funded by ECSEL JU (Electronics Components and Systems for European Leadership Joint Undertaking) as part of the Horizon 2020 EU funding program.

Würth Elektronik Circuit Board Technology participated in the following three use cases:

- **Low-cost thermal imaging systems.** A hybrid panel-level packaging process was developed for use in a thermal imaging camera here. Printed circuit boards formed the basis for the assembly and connection technology of the system-in-package (SiP). The main areas of development were printed circuit board technology, wire bonding and encapsulation of large optical chips.
- **Minimally invasive cardiac implants.** A catheter was equipped with accelerometers to measure contractions of the heart in this context. Würth was involved in the design of the circuit boards and production of the substrates. To this end, novel ultra-flexible and rigid-flexible stackups were designed with the project partner OSYPKA AG, and the printed circuit boards were manufactured on the basis of skin-friendly substrates.
- **Cardiac monitoring systems.** Würth participated in the development of an intelligent patch (smart patch) for cardiac monitoring. Two systems – a minipatch (three electrodes, short-term monitoring) and a maxi-patch (six electrodes, longer, steady-state monitoring) were set up. Würth focused on designing the layout of the stretchable substrates and manufacturing them. A completely new approach to integration was developed in this work. It was based on a stretchable printed circuit board made of thermoplastic polyurethane (TPU). It was possible to make this using standard PCB production techniques, which brought many of the advantages of conventional PCB technology, such as assembly of components using pick-and-place machines. This advantage was exploited by integrating the electrical functions into a dual system-in-package (SiP) design that could be mounted directly on the flexible/stretchable PCB. Printing the electrodes directly on the flexible printed circuit board and integrating all the electronics into a textile substrate represent crucial advances in the

> development of medical patches for monitoring bodily functions. The high degree of miniaturization and tight integration resulted in a very unobtrusive form factor, while the stretchable PCB provided a very pliable, biocompatible substrate. In addition to Würth, other partners, including Fraunhofer IZM, Fraunhofer ENAS, Interuniversitair Micro-Electronica Centrum (IMEC) and Precordior OY played an important part in the implementation of this use case.

"Through the work on the APPLAUSE project, we have taken significant steps forward in the development of complete medical systems and, in particular, close-to-body applications," said Dr. Alina Schreivogel, head of the research center at Würth Elektronik Circuit Board Technology. "This is down to the synergies and excellent collaboration between the partners within the consortium. Discussions are currently being held with some of the project partners on finalizing the development after the project has been completed with the clear aim of moving on to industrial production."

APCT Now Offering Full Turnkey Solutions

SANTA CLARA, CA – Following the acquisitions of Advanced Circuits and San Diego PCB Design earlier this year, APCT has become the second-largest printed circuit manufacturer in North America offering design, fabrication and assembly.

The company's design team can offer its expertise in a number of design layout services, including standard through-hole, high density interconnect (HDI), signal/power integrity design, dense high-speed digital, and RF & rigid-flex.

The assembly operation is located within the ACI headquarters in Aurora, CO, and is currently only offered as a "value add" to APCT's customer base. Offerings include both through-hole and surface mount capabilities, supporting prototype quantities of standard technology, with all assembly being completed in-house.

PE Firm to Acquire Humiseal Parent for $1.3B

WESTWOOD, MA – Chase Corporation, a manufacturer of industrial coatings and tapes, has entered into a definitive agreement to be acquired by an affiliate of investment funds managed by investment firm KKR for an all-cash transaction of around $1.3 billion. Chase supplies the Humiseal brand of conformal coatings.

Under the terms of the agreement, KKR will acquire all outstanding shares of Chase common stock for $127.50 per share in cash.

The transaction is expected to close in the fourth quarter of 2023, subject to the receipt of approval from the company's shareholders and certain required regulatory approvals, as well as the satisfaction of other customary closing conditions.

"At Chase, we have always been deeply committed to continuously improving our operating performance while providing an outstanding customer experience," said president and CEO Adam P. Chase. "In KKR, Chase has found the right strategic partner with strong cultural alignment combined with the experience and resources to help support our mission and drive future growth."

"Over its nearly 80-year history, Chase has established itself as a leader in highly engineered protective materials and built a portfolio of trusted brands, while delivering outstanding customer service," said Josh Weisenbeck, a KKR partner who leads the firm's Industrials investment team. "We look forward to supporting Chase on its next phase of growth through developing exciting new products, executing upon strategic acquisitions, and serving customers in growing end-markets, including critical applications in electronics, fiber optics and electric grid infrastructure."

ECIA's GIPC Publishes Cyber Security Guidance Document

ATLANTA – ECIA members face a broad spectrum of cyber risks that could potentially impact their business operations. These risks can be more complex and challenging due to their international scope. In response to these concerns, ECIA's Global Industry Practices Committee (GIPC) has published a guidance document, prepared as the result of a cooperative effort between electronic component manufacturers and their authorized distributors.

The document outlines key areas that executives need to consider:

- Cyber threats when operating internationally
- International laws impacting cybersecurity
- An international response plan and scheduled tests
- Allocating resources to protect international operations.

The report reveals that approximately 60% of incidents were discovered within days, but 20% could take months or more before organizations realized something was amiss.

“Spending more money on cyber security doesn’t necessarily make you more secure,” the report cautions. “It’s crucial to ensure that the money is spent effectively on measures that genuinely improve your cyber security posture. This might include hiring skilled personnel, investing in advanced security tools, and regular staff training.”

ECIA members can access the report here.

Additive Manufacturing Continues to Flourish, Jabil Finds

ST. PETERSBURG, FL – The adoption of 3-D printing continues to increase in production environments despite ongoing roadblocks with the cost and availability of additive materials, according to a survey by Jabil.

Jabil has conducted a biennial survey since 2017 to trace the trajectory of additive manufacturing while identifying the most promising opportunities and lingering challenges facing decision makers.

“The results of our latest manufacturing survey confirm our experiences in helping customers leverage the speed and agility of 3-D printing to transform different manufacturing steps-from prototyping to production,” said Luke Rodgers, Jabil’s senior director of R&D for additive manufacturing. “In particular, this survey underscores how increased adoption of additive manufacturing is driving demand for differentiated additive materials with improved physical properties to deliver greater functionality, increased sustainability, and economies of scale."

Jabil commissioned SIS International Research to conduct the 3-D Printing Technology Trends Survey with participation from 200 additive manufacturing stakeholders worldwide. Questions were designed to offer a better understanding of decisions concerning 3-D printing and additive manufacturing materials based on current opportunities, challenges, and industry developments. More than half of the top executives surveyed regard additive manufacturing as a strategic opportunity to enhance their organizations, while 40% consider 3-D printing as a viable alternative to designing and/or producing products.

A vast majority of the participants (97%) currently are using 3-D printing to produce functional or end-use parts. Nearly three-quarters of participants produced at least 10,000 3-D-printed parts over the past year, and more than a third printed up to 100,000 parts. Overall, participants anticipate an uptick in the use of 3-D printing for production parts or goods in the next three-to-five years, despite being less bullish about overall 3-D printing industry growth than previous participants of additive manufacturing surveys.

Other key findings include:

- The top three use cases for 3-D printing are prototyping (97%), research and development (75%), and production parts (59%)
- 3-D printing use for bridge production (moving from prototyping to initial production) grew from 23% in 2017 to 59% in 2023, while 3-D-printing jigs, fixtures, and tooling nearly doubled from 2017 (30%) to 2023 (58%)
- Prototyping is widely recognized for delivering the most significant impact to product lifecycles by 95% of the participants, followed by product designs (52%) and small-scale production (27%).

Additive manufacturing benefits have remained consistent since 2019, with the ability to deliver parts faster, decrease production costs, respond to issues on production lines, as well as enable production of personalized and customized goods.

Materials were identified as the primary financial or cost burden to adopting 3-D printing by 79% of participants, up from 18% just two years prior. Moreover, nine in 10 of those surveyed assert that the biggest challenge is the unavailability of desired materials.

Two-thirds of this year's participants say they utilize custom-engineered materials as part of their overall additive manufacturing strategies. This finding may be in response to ongoing materials shortages, along with increased demands to produce parts with superior performance characteristics. Increased use of engineered materials with value-added attributes also reflects continued innovations in additive materials to improve the physical properties of end-use parts for greater utilization at lower costs, as well as faster delivery and less waste.

Overall, the use of plastics/polymers has been consistently pervasive among survey respondents since 2019. The use of metals, however, has greatly increased, from 39% in 2019 to 92% in this year's survey. More than 96% expressed a preference for using metal materials under the right conditions, up from 63% in the 2019 survey.

TT Electronics Expanding Footprint in Mexico and Malaysia

WOKING, UK – TT Electronics has announced that its Global Manufacturing Solutions business is expanding its footprint in the Americas by opening a new facility in Mexicali, Mexico, and is investing in its Asia Pacific operations to increase capabilities at its existing Kuantan, Malaysia, facility.

"As a strategic manufacturing partner, we have built a solid reputation for delivering agile solutions and excellent customer service," said Michael Leahan, COO, TT Electronics. "We continue to invest in our global facilities and supply chain resources to directly support customer growth, and we are excited to announce significant expansion to our footprint in our GMS division."

The new 75,000 sq. ft. Mexicali facility will employ around 250 people with capacity for up to six highly automated SMT lines and will complement the company's 125,000 sq. ft. operation in Cleveland, OH, by offering fully integrated electronics manufacturing solutions, including PCB assembly, system integration and testing. The facility is on track to be operational in early 2024, the company said.

The 26,000 sq. ft. Kuantan, Malaysia, plant expansion includes the installation of a new high-speed SMT line to support customer demand and increase production capacity. The facility is currently delivering first article systems for the healthcare and semiconductor equipment industries.

"Whether customers are seeking best-value-geographies for their product, risk mitigation against geopolitical uncertainties, or looking to reduce their carbon footprint by manufacturing locally to the end market – TT is well-positioned to support their needs," said Leahan.

Jabil Breaks Ground on Croatian Plant

OSIJEK, CROATIA – Jabil in early August announced that it has begun construction on a production facility here.

The factory will span some 48,000 sq. m. (516,667 sq. ft.) and is scheduled to be completed in July 2024. The finished factory will eventually employ 1,500 workers.

"This project is very important for Osijek, Slavonia and the regional development and will offer numerous opportunities for economic growth and progress," Victor Morales, head of works, Jabil, in a statement.

"This expansion is a strategic move that aligns with Jabil's focus on long-term secular trends and growth in renewable energy, electric vehicles, healthcare, 5G, and cloud," said Gerald JJ Creadon, executive vice president in charge of operations, Jabil.

Osijek is the fourth-largest city in Croatia, with a population of 96,848 in 2021. It is located in the eastern Croatian region of Slavonia.

Scanfil to Pump $22M into New Poland EMS Facility

SIERADZ, POLAND – Scanfil will invest €20 million ($22 million) in a new 14,000 sq. m. electronics manufacturing factory here, which will be ready for production in mid-2025.

The new building will increase the factory floor area by over 70%. The project will start this month and is expected to be ready for production in the second quarter of 2025.

The site includes a new building and will require additional investments in production and warehouse technology. Additional investments will be made gradually in line with production volume growth.

The new factory building will be powered by solar panels and the indoor climate will be heated and cooled by geothermal energy. The chosen solutions reduce CO_2 emissions significantly compared to traditional alternatives.

“This investment will ensure our capacity to serve the growing manufacturing needs and volumes of our existing and new electronics customers in Europe. This is the second large investment in less than a year in Sieradz. In January, we decided to invest €6 million in the electronics manufacturing capacity that is now in use in August,” said Petteri Jokitalo, CEO, Scanfil.

IMI Sells STI to PE Firm

HOOK, UK – British private equity firm Rcapital has agreed to the purchase of STI Ltd. from Integrated Micro-Electronics for GBP2.2 million ($2.8 million).

After the closing of the acquisition, Rcapital will work on refinancing initiatives for STI that will enable the business to accelerate its growth strategy, at a time when STI’s core aerospace and defense markets are experiencing significant growth, STI said in a release.

STI provides electronics design and assembly primarily for the aerospace, defense and security sectors. It has two factories in the United Kingdom and one in Cebu. It also operates a design center in London. The current management team, led by Simon Best and Tony Best, will remain in place.

“This is fantastic news for STI. We would like to thank IMI for the past six years of their ownership and we wish them well in their new direction. We are delighted that ownership will pass back into the hands of a British company that has a track record of helping companies grow,” said Simon Best. “Our order books are stronger than they have ever been and we are anticipating significant new contract wins in the next few months. I’m excited by what the future holds in store for STI and look forward to guiding it through this next chapter in its history.”

“We were introduced to STI earlier this year and have been consistently impressed by STI’s people and capabilities,” said Chris Campbell of Rcapital. “Following a highly competitive sales process we have now exchanged contracts and look forward to completing the transaction later this year. It’s a great business in an industry that we know well through our portfolio businesses that have exposure to the aerospace and defense markets.

"With a highly experienced team, decades of experience in mission critical applications and very strong relationships with global blue-chip clients, we have absolutely no doubt that STI will prosper in the years ahead."

Tempo Automation Outsources Manufacturing to Network PCB

SAN FRANCISCO – Financially strapped EMS Tempo Automation has established a manufacturing outsource agreement with Network PCB, a PCB manufacturing and assembly company located in San Jose, CA.

The company laid off 62 of its employees in mid-July, leaving only seven employees on its payroll, while CEO Joy Weiss and CTO Ralph Richart saw their base salaries cut by 50%.

In a filing with the SEC, Tempo said the layoffs and executive salary cuts come as a way of reducing corporate overhead to better position the company to fund its planned operations while meeting obligations as they come due. Tempo has "experienced negative cash flows since inception that raise substantial doubt about the company's ability to continue," the filing said. The company's revenue in the first quarter of 2023 was $2.8 million, while its net loss was $7.4 million.

Current Tempo customers have been given the option to move their account to Network PCB, purchase the inventory for an active job currently held at Tempo, have their consigned parts returned to them, or purchase additional inventory that they may have used as part of orders built by Tempo in the past.

Kaga Electronics Expanding Mexico Presence

TOKYO – Kaga Electronics will build a new factory in Mexico to meet customers' growing needs in the US market.

In a release announcing the new construction, Kaga said the purchase of land and construction of the new facility is expected to total around 5 billion yen ($34.2 million) over the next five years. The new facility, which will be built in the Parque Industrial Millennium in San Luis Potosí, will feature 20,000 sq. m. (215,000 sq. ft.) of floor space and when in full operation, the company anticipates a need for 700 employees. Construction is planned to be completed in April 2024.

Taxan Mexico, the company's EMS subsidiary in Mexico, was established in 2017, and has primarily focused on the assembly of lighting units used in vehicles in the US market. After seeing an increase in orders from those existing customers and expecting to gain new customers requiring the assembly of circuit boards to be used in air conditioning equipment, Kaga saw the need to expand beyond its existing 8,200 sq. m. (88,000 sq. ft.) Mexican facility, the company said.

In addition to unit assembly and circuit board assembly, Kaga plans to make the new factory into an integrated production base that includes component molding, sheet metal processing, and finished product assembly. The company said its aim is to capture local production demand for products intended for the US market, where opportunities are expected to increase in the future, and turn the Mexican operation into Kaga's largest EMS business base, with net sales of 50 billion yen ($342 million) and approximately 2,000 jobs to be created within five years from the start of operation.

StenTech Acquires Photo Etch Technology

WYLIE, TX – StenTech in August announced the acquisition of stencil manufacturer Photo Etch Technology, along with its affiliate Utz Technologies.

Photo Etch has four locations, with a headquarters in Lowell, MA, and operations in Santa Clara, CA, Clearwater, FL, and Montville, NJ, and the acquisition deepens StenTech's existing footprint in Silicon Valley and New England while simultaneously extending its reach into Florida through Photo Etch's Clearwater operation, the company said in a release announcing the acquisition.

"We were looking for a partner who could continue providing our customers with the quality of service they deserve," said Lisa Guidi, owner and CFO, Photo Etch. "Having worked closely with StenTech's leadership over the past several months, I am confident they will honor our company's important legacy while providing our customers with access to additional resources through the StenTech platform."

"I am thrilled to be joining forces with the team at Photo Etch," said StenTech President and CEO Brent Nolan. "This acquisition represents StenTech's continued growth and innovation, and we are excited by the opportunity to serve Photo Etch's customers."

Tide Rock Acquires Pro-Active Engineering

SAN DIEGO, CA – Tide Rock, an unlevered buyout firm, has announced the acquisition of Pro-Active Engineering, an EMS solutions provider for the military & defense, industrial, medical, renewable energy and aerospace sectors.

Pro-Active specializes in end-to-end solutions for printed circuit boards, encompassing electronics design, rapid prototyping, short-run and large-scale production, box builds, programming, testing, potting and conformal coating as well as software and firmware development.

"We are excited to add Pro-Active Engineering to Tide Rock's growing group of manufacturing companies," said Brooks Kincaid, president, Tide Rock. "Pro-Active expands Tide Rock's EMS footprint adding complementary services and expertise. The company brings design engineering, quickturn prototyping and commercial-scale production capabilities as well as a valuable customer base. Pro-Active is poised for significant growth."

Pro-Active vice president Paul Schwanbeck will continue to lead the team from its facility in Sun Prairie, WI. Toby Klusmeyer founded the business in 1996 and will retire by the end of the year.

"With over 27 years of leadership in the EMS industry, I am genuinely excited about the prospects this acquisition opens up for Pro-Active," Schwanbeck said. "We are now primed to scale our operations and elevate the business to new heights, all while upholding our commitment to delivering exceptional service and top-tier quality to our valued customers."

ITIDA, GIZ to Promote Egyptian

Offshoring

CAIRO – The Information Technology Industry Development Agency (ITIDA) and the German Agency for International Cooperation (GIZ) have signed a memorandum of understanding to promote Egypt's offshoring sector and integrate Industry 4.0 digital technologies in local electronics manufacturing.

The focus will be on two pilot clusters, namely the Industry 4.0 Innovation Centre in the Knowledge City, and the Innovation Cluster at Borg El Arab City. The two parties hosted a round table meeting for local and foreign companies specializing in IT outsourcing and global business services to discuss the available growth opportunities, potential partnerships, and means to enhance their operations to help them expand their global delivery centers in Egypt.

ITIDA CEO Ahmed El Zaher said this was a step in the constructive cooperation between Egypt and Germany in the IT sector and is in line with ITIDA's endeavors to drive growth and strengthen Egypt's global position as a reliable offshoring hub for IT and business services, with great potential in the high-end, value-added services and electronics industry.

ITIDA and GIZ will work to strengthen offshoring activities in both Egypt and Germany, in addition to the EU at large, by attracting more German companies to establish global delivery centers in Egypt and will also promote digitization in Egypt through training programs and support for at least 50 Egyptian companies to enhance job creation and employment.

ECIA Publishes Results of Future Workforce Focus Groups

ATLANTA – Winning the race for talent has never been more critical as the entire tech industry faces alarming shortages of skilled workers. To address the challenge, in May and June of 2023, two focus groups were conducted by the Electronic Components Industry Association and its newly established Industry Recruiting Committee.

The objective of the ECIA's research was to gain insights into what motivates individuals to enter the electronic components industry and to learn how to attract and retain talent, and the research will be used to create strategic marketing collateral for ECIA members to use in recruitment efforts and inform members on best recruitment tactics.

The focus groups consisted of 25 participants and a committee of six ECIA members. The participants had less than five years in the electronic components industry. Some participants were brand new, and others had been in the industry for only a few years. Age was not a determining factor. While many participants were considered the “next generation,” seasoned individuals that were new to the industry were able to participate as well.

Insights include which qualities candidates find attractive about the industry, those that help retain employees and how to keep talent motivated.

ECIA members can access the report here.

PCD&F

Altair was named one of Fortune's 2023 Best Workplaces for Millennials.

Amphenol agreed to pay $18 million to the federal government to resolve allegations that it submitted false claims for electrical connectors.

Bürkle has divided into four independent divisions to better serve customers.

Flexium Interconnect said the company will focus on maintaining its profitability in the second half and will strengthen its smart manufacturing capability and management efficiency.

G42 and **Cerebras** have partnered to build a $100 million AI supercomputer consisting of 64 connected Cerebras CS-2 wafer-scale AI accelerators.

Hubei Quanchengxin Precision Circuit Co.'s 1.2-billion-yuan PCB plant in Xiaochan, China, has begun production.

Jianding purchased a PCB factory in Vietnam earlier this year and is expected to invest another 100 million to 200 million yuan ($14 million to $28 million) on improvements.

LiloTree's named **Taiyo America** sales representative for North America and Europe.

Nano Dimension withdrew its special tender offer to **Stratasys'** shareholders and ceased its efforts to replace Stratasys' board of directors.

Optomec announced its vision to drive digital transformation throughout the company to deliver modern capabilities and efficiencies to customers.

Yuanyu Electronics plans to invest 200 million baht ($5.8 million) to set up a subsidiary and production base in Thailand.

Zhen Ding Technology announced plans to set up a new plant in Thailand, primarily to produce automotive and AI server products.

Zhongfu Circuit has raised RMB5 million ($694,000) for construction of its Thai PCB subsidiary.

CA

Absolute EMS invested in the training of its touchup, quality control, and final quality assurance operators to J-STD-001 Class 3 standards.

Adtran announced the expansion of advanced telecommunications equipment manufacturing at its facility in Huntsville, AL, to meet the growing demand for domestically produced network electronics.

Analog Devices and **Foxconn** have partnered to work toward the development of the next-generation digital car cockpit and a high-performance battery management system (BMS).

Asteelflash opened a new manufacturing line for **Nextracker's** self-powered controller and high-voltage power supply used in solar tracking technology.

BidChip announced its new online platform for buying and selling excess semiconductors.

The **EPIC Foundation** has signed an MOU with the **Andhra Pradesh Electronics and IT**

Agency with an aim to strengthen the electronics sector in the Indian state.

Foxconn has initiated the sale of its properties in Green Bay and Eau Claire, WI, signaling its abandonment of the concept of establishing regional centers throughout the state.

Foxconn Industrial Internet will reportedly exclusively supply Apple with made-in-Vietnam servers for training and testing artificial intelligence services.

Gelest broke ground on a new 50,000 sq. ft. production facility in Morrisville, PA.

Green Circuits achieved IPC Certification for J-STD-001 Space and Military Addendum.

Henkel announced an expansion of its portfolio for wearables in healthcare applications.

Heraeus Electronics commemorated its 10th anniversary in Romania with a celebration at its facility in Timisoara.

IMI and **Zero Motorcycles** inaugurated the first high powered e-motorcycle manufacturing assembly line at IMI's Technopark facility in Laguna, Philippines.

Jabil Mexico achieved MedAccred accreditation for printed circuit board assembly at its Chihuahua facility.

Kitron received a sub-contract from **Northrop Grumman** for production of AN/ASQ-242 Integrated Communications, Navigation, and Identification (CNI) modules for the F-35 Lightning II program.

Kulicke and Soffa announced a collaboration with **TSMT** to advance mini-LED backlight and direct emissive displays for high-volume adoption.

Novagard announced that it received UL 746E certification on two of its conformal coatings.

Nokia is partnering with **Fabrinet** to manufacture fiber broadband optical modules at

Fabrinet’s facility in Santa Clara, CA.

Optiemus Electronics is poised to ramp up its production in response to escalating demand.

PG Electroplast is likely to explore the emerging opportunities in the Indian laptop manufacturing space using its capability to produce PCBAs.

Protektive Pak named **Murray Percival** to distribute ESD packaging solutions.

Rehm Thermal Systems named **Methods Automation** to handle the sales, service and support of its vapor phase soldering systems in North America.

Saki opened its new Mexican office in Zapopan, Jalisco.

Skalarki Electronics purchased **Essemtec** equipment to enhance its production capabilities.

StenTech relocated its stencil operation to a new state-of-the-art facility in Manchester, NH.

Viscom named **BarTron** sales partner in Michigan, Ohio and Western Pennsylvania.

Weidmüller is building a new electronics manufacturing facility in Detmold, Germany.

Yamaha Motor USA announced the launch of its new, updated, interactive website.


PLM INTEGRATION
BOM OPTIMIZATION
SUPPLY CHAIN INTELLIGENCE
CHANGE MANAGEMENT

PEOPLE

PCD&F

Confidee’s **Craig Haywood** was approved as an EASA Part 21 Subpart G auditor.

Polar Instruments appointed **Lupita Maurer** president.

Rogers Corp. named **Griffin Gappert** chief technology officer.

TTM Technologies announced CFO **Todd Schull** intends to retire at the end of 2023.

CA

Altus Group appointed **Andras Fekete** after sales support engineer for Ireland.

Absolute EMS appointed **Ray Amirkiai** quality manager.

Amtech Systems appointed **Bob Daigle** CEO.

Escatec appointed **Charles-Alexandre Albin** chief sales officer.

FHP Reps named **Brian Smith** manufacturers sales representative.

Frontgate Technologies named **Denis Boulanger** senior manager, manufacturing engineering.

Jabil announced the retirement of **Steven D. Borges,** executive vice president and CEO, Diversified Manufacturing Services, effective Dec. 31.

Koh Young promoted **Brent Fischthal** to head of global integrated marketing.

Kyzen named **Adam Klett, Ph.D.,** director of science.

MicroCare appointed **Dan Sinclair** strategic account executive.

Promex promoted **David Fromm** to chief operating officer.

PVA appointed **Shashank Prakash** regional sales manager for the western US and Canada.

SmtXtra USA named **Tony Longo** director of sales.

STI Electronics named **Nika Bailey** quality control technician.

Tektronix named **Mahmoud Wahby** global business development director – power segment.

QUALITY AUTOMATION ACROSS THE BOARD

FUJI
innovative spirit

FUJI understands that quality is paramount.

We also understand that not everyone is ready to dive into the deep end of automation all at once, which is why we make it easy to adopt various quality controls as you see fit.

With machines that have an accuracy of +/- 0.025mm, FUJI starts you off at the highest baseline for quality in the industry. When coupled with options for LCR and 3D Coplanarity checks, intelligent part sensors, and heightened accuracy modes, defects are eliminated via automation with ease.

With FUJI's Nexim software, you can choose how much automation you want for quality control. Features like the Defect Analyzing Master, Machine-to-Machine Feedback, and IPQC are able to be added anytime, letting your reach Smart Factory levels of automation at your own pace.

CONTACT US TODAY

☎ 847-913-0162   www.fujiamerica.com

National News

Designer Certification Program Updates

PEACHTREE CITY, GA – As noted last month, PCEA has closed on the acquisition of the assets of PCBDesign-Edu (PCE-EDU), including its industry leading printed circuit designer training and certification program. The deal extends PCEA's position as the leading association for training printed circuit engineers worldwide.

We have updated the company name to PCEA Training, rolled out the new website (at pceatraining.net) and revealed the new logo.

Upcoming classes will be held Oct. 2-6 and Dec. 4-8. For more information about the Certified Printed Circuit Designer program, visit pceatraining.net.

PCB West Keynoter to Focus on MBSE and AI for Electronics Design

PEACHTREE CITY, GA – PCEA announced Louis Feinstein as keynote for PCB West in September. His talk, titled Revolutionizing Electronics Cyber-Physical Systems: Unleashing the Power of MBSE and AI for Electronics System Design, focuses on the next paradigm in Electronics Cyber-Physical Systems (ECPS) development.

Feinstein is high tech industry strategy director, High-Tech at Dassault Systèmes. He is a seasoned executive and visionary engineer with profound knowledge and experience in the high-tech market.

The keynote takes place Sept. 20 from 11 a.m. to 12 p.m., and is free to all conference and expo registrants. Visit pcbwest.com to register.

Louis Feinstein

By leveraging model-based systems engineering (MBSE) and artificial intelligence (AI), we accelerate the design of electrical and electronic systems. MBSE streamlines integration, while AI-driven optimization ensures alignment with design intent and derived requirements. The synergy of MBSE and AI empowers efficient ECPS development, establishing new benchmarks in quality and speed. A use case will be showcased to validate the approach, paving the way for the future of ECPS.

Feinstein's diverse background, which ranges from design systems to the assembly floor at leading companies like Dassault Systèmes, Textron and EMC, makes him ideal to explain the impacts of the array of coming technologies on the day-to-day operations of almost every engineer and production staffer.

Trace Temperature Video Released on PCU

PEACHTREE CITY, GA – Stop thinking about current density! In a new 30-minute video, Doug Brooks and Dr. Johannes Adam explain the material parameters and properties that determine the temperature of a trace, how these are calculated, and show results of some simulations of vias of varying widths and amps.

The video is available for free at PrintedCircuitUniversity (printedcircuituniversity.com), PCEA's online training platform.

Brooks and Adam are coauthors of several publications on trace and via temperatures, including *PCB Design Guide to Via and Trace Currents and Temperatures and Predicting Fusing Time of Overloaded PCB Traces Can We Predict It At All?*

Conferences TG Set to Release PCB East Call for Papers

PEACHTREE CITY, GA – The Conferences Task Group is preparing the call for abstracts for PCB East 2024.

The task group, which is headed by Troy Hopkins, will have examples of good (and incomplete) abstracts available at pcbeast.com to help prospective speakers with their submissions. Other task group members include
Steph Chavez, Tomas Chester, Rick Hartley, James Jackson, Matt Leary, Matthew McBride, Dale Parker, Carl Schattke and Susy Webb.

PCB East 2024 will take place Jun. 2-5 in the Boston suburbs.

PCEA CURRENT EVENTS BRIEFS

Chapter News

Silicon Valley. The chapter held a meeting on Aug. 30. The technical topic was Leveraging Advanced Technologies to Accelerate Electronic Systems Design, and the speaker was David Wiens, Xpedition product manager, Siemens.

PCB WEST 2023
Conference & Exhibition

Conference: September 19 – 22
Exhibition: Wednesday, September 20
SANTA CLARA CONVENTION CENTER

WHO'S EXHIBITING

Accurate Circuit Engineering
Acorn Assembly
AGC Multi Material America, Inc.
All4-PCB
All Flex Solutions
Allfavor Technology, Inc.
AllSpice.io
American Standard Circuits, Inc.
APCT
Archer Circuits
Arlon EMD
Baoyuejia Electronics
Bay Area Circuits, Inc.
Best Technology Co., Limited
Bittele Electronics Inc.
Cadence Design Systems
Cicor Group
copperdot, A Bosch Business
DIrectPCB
DownStream Technologies, Inc.
DuraTech Industries
Dyconex AG
Dynamic Electronics Co., Ltd.
Elsys America
EM Solutions Inc.
EMA Design Automation
Emerald EMS
Finest Printed Circuit Board Limited
Firan Technology Group
Fischer Technology, Inc.
Flexible Circuit Technologies
Freedom CAD Services
Fujipoly America Corp
GS Swiss PCB AG
Guangdong BOYU Electronics
HZO Inc.
IBE Electronics Inc.
ICAPE Group
IDENTCO
Imagineering, Inc.
InstaDeep
Insulectro
IPC-2581 Consortium
Ironwood Electronics
ISOLA
JetPCB USA
Jove Enterprise Limited
Kinwong Electronic
Leader Tech, Inc.
Luminovo GmbH
MaRCTech2, Inc.
MFS Technology (S) Pte Ltd.
MVINIX Corporation
Newgrange Design
Notion Systems GmbH
Oak-Mitsui Technologies
OKI Circuit Technology Co., Ltd.
OM Circuit Boards
Optiprint AG
PalPilot International
Panasonic Electronic Materials
PCB Connect
PCB Fab Express
PCB Technologies – USA
Polar Instruments, Inc.
Printed Circuit Board Association of America (PCBAA)
Printed Circuit Engineering Association (PCEA)
Quantic Ohmega/Quantic Ticer
Rogers Corporation
San-ei Kagaku Co., Ltd.
Sanmina
Schmid Systems, Inc.
SCORE Silicon Valley Chapter
Screaming Circuits
SEP Co., Ltd.
Shenzhen Grandtop Group Company
Shenzhen TALIAN Technology Co. Ltd.
Sierra Circuits
Siemens
Sourceability
Summit Interconnect
Sunshine Global Circuits
Sunstone Circuits
Surface Mount Technology Association (SMTA)
SVTronics, Inc.
Taiyo America Inc.
TCLAD Inc.
Trilogy-Net Inc.
Trylene Inc.
Ultra Librarian
Vayo Technology
Ventec International Group
Veritiv Corporation
Vias3D
Victory Giant Technology
Win-Source Electronic Technology Limited
XDry Corporation
Zuken USA Inc.

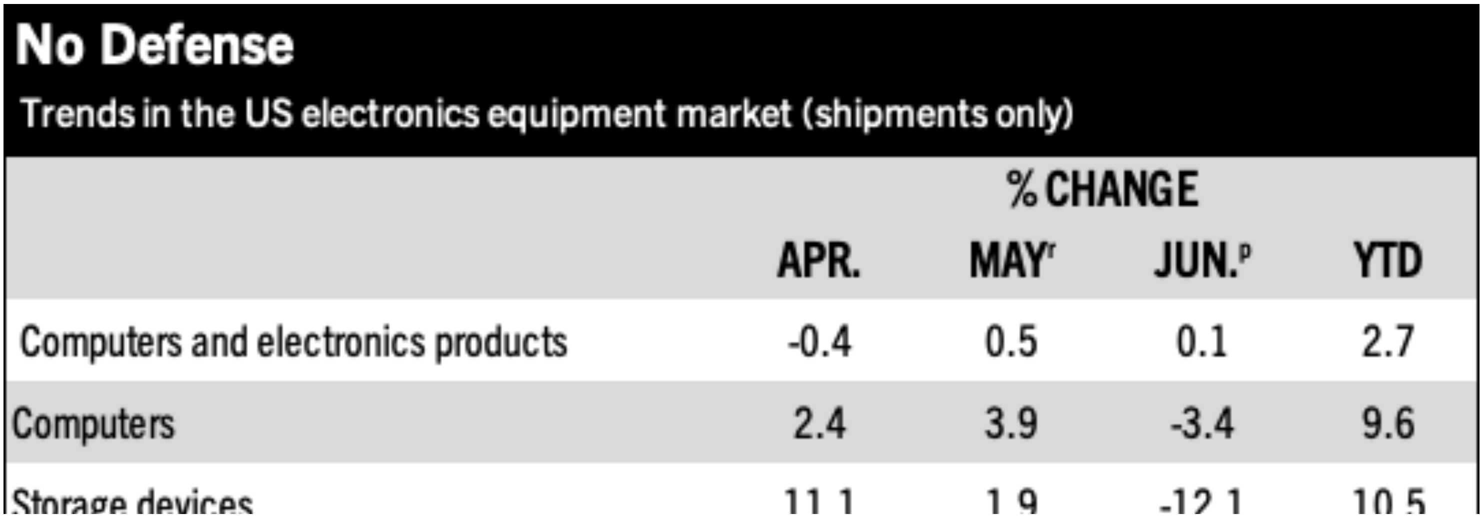
PCBWEST.COM

PCB Outlook for 2023 Mixed, but Slow

TAIPEI – The printed circuit board industry endured customer inventory adjustments in the second quarter, mostly due to lower demand. Sales of consumer electronics, such as TVs, laptops, memory modules and wearables have stabilized and cellphone demand typically rises in the third quarter in the US, although the Chinese market has not yet improved. Still, the inventory problems of the past year have in general returned to healthier levels, but under the haze of inflation, consumption is still conservative, and a modest recovery is expected for the second half.

Demand for AI servers is boosting that segment, and is expected to continue in the third and fourth quarters. As for the general server market, inventory adjustments of the first half have come to an end, and a third quarter ramp has begun. Meanwhile, automotive – both gas and electric vehicles – has performed better than last year, and the second half is not bearish.

Prismark Partners forecast PCB output values to show a year-over-year decline of about 1.9%. Based on current demand levels, however, Shen Qingfang, chairman of Zhen Ding, expects this year's PCB output will drop by double-digit levels.



No Defense

Trends in the US electronics equipment market (shipments only)

	% CHANGE			
	APR.	MAY^r	JUN.^{p}	YTD
Computers and electronics products	-0.4	0.5	0.1	2.7
Computers	2.4	3.9	-3.4	9.6
Storage devices	11.1	1.9	-12.1	10.5

Other peripheral equipment	-0.1	-5.4	9.9	47.6
Nondefense communications equipment	-1.8	-1.9	1.3	-0.7
Defense communications equipment	1.5	-0.1	-3.4	3.5
A/V equipment	0.3	26.2	3.6	-5.9
Components[1]	-3.1	2.7	0.8	1.8
Nondefense search and navigation equipment	1.4	0.2	-1.2	1.9
Defense search and navigation equipment	1.7	1.3	-0.2	3.0
Electromedical, measurement and control	0.4	-0.1	0.4	1.6

[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.

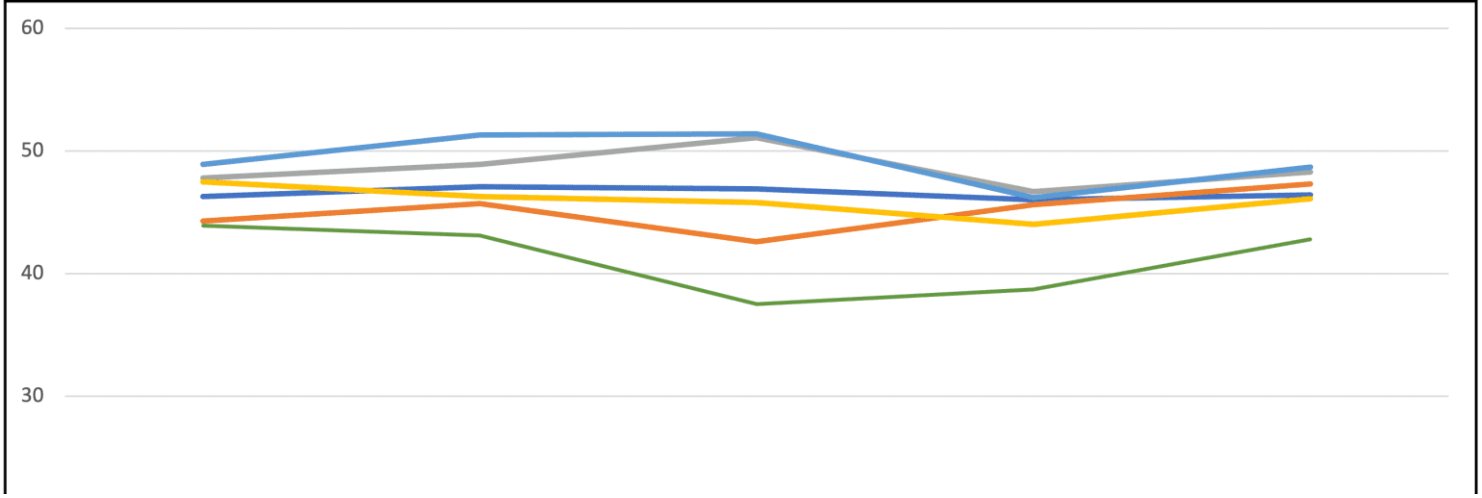
Source: US Department of Commerce Census Bureau, Aug. 3, 2023

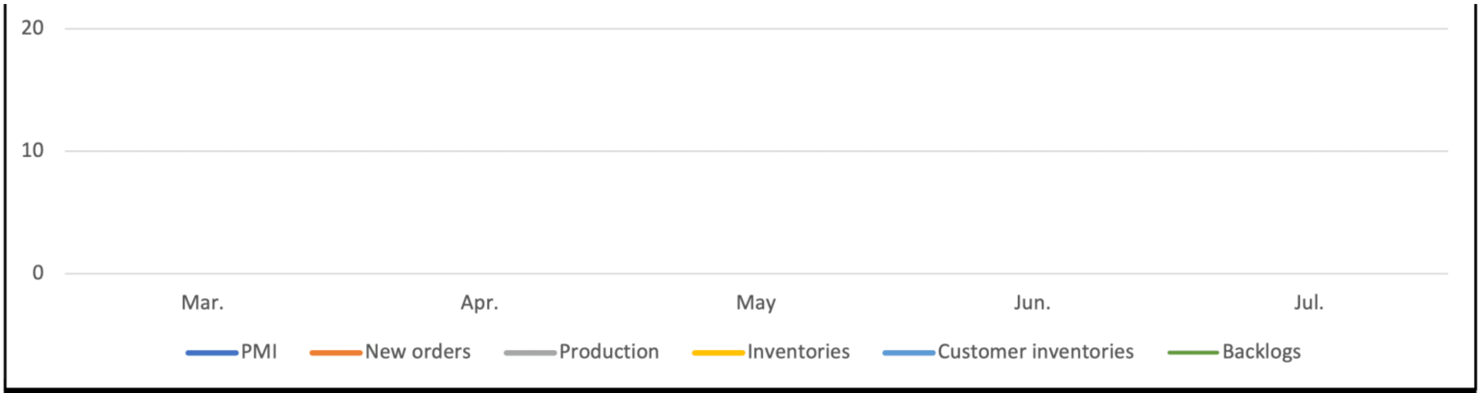
Key Components

	MAR.	APR.	MAY	JUN.	JUL.
EMS book-to-bill[1,3]	1.28	1.21	1.24	1.24	1.27
Semiconductors[2,3]	-21.3%	-21.4%	-21.1%	-17.3%	TBD
PCB book-to-bill[1,3]	0.91	0.88	0.89	0.98	1.01
Component sales sentiment[4]	90.6%	88.7%	72.2%	76.3%	83.0%

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

US MANUFACTURING INDICES





Source: Institute for Supply Management, Aug. 1, 2023

Hot Takes

The worldwide **contract manufacturing market** reached a new all-time high of $694.4 billion in 2022, but the year-over-year growth rate flattened from the previous year, decreasing to 1.7% from 14.8% – the lowest growth seen over the past five years. (New Venture Research)

The **global semiconductor industry** appears to be nearing the end of a downcycle and is expected to begin to recover in 2024. (SEMI and TechInsights)

Worldwide **semiconductor sales** totaled $124.5 billion during the second quarter, up 4.7% sequentially but down 17.3% from 2022. The three-month moving average sales rose 1.9%. (SIA)

Five **EMS transactions** were recorded in the second quarter, representing an increase from the four recorded in the second quarter of 2022 but a decrease from the nine transactions recorded 2021's second quarter. (Lincoln International)

Worldwide **tablet shipments** declined 29.9% year-over-year in the second quarter, totaling 28.3 million units. (IDC)

The surplus of **DRAM and NAND flash memory** has dramatically improved since the third quarter, with the oversupply ratio likely to turn negative as early as the fourth quarter, (DigiTimes)

While **semiconductor shortages** are still observed in certain technologies – MCUs specifically – the market in general is slowly improving with high-service distributors having more ex-stock availability and broadline distribution carrying increasing stock levels while also accepting orders to lead-time and pipelined inventories.

The Shipments Index, Orders Index, and Capacity Utilization Index all weakened in July, but at the same time, the **outlook for shipments, orders, and utilization** all improved. (IPC)

Worldwide **smartphone shipments** declined 7.8% year-over-year to 265.3 million units in the second quarter. (IDC)

Inventories are gradually going back to normal levels and the **PC market** is likely hitting bottom. (Intel)


ZENITH 2
KOHYOUNG
NEPTUNE C+
KOHYOUNG

ROI

Don’t Forget the People

An unchecked rise in automation could equal a decrease in quality of life.

THEY SAY THAT the more things change the more they stay the same. Sometimes, perhaps, but not all the time – especially when people are involved.

For ages, people have strived for a good lifestyle. In ancient times, simply surviving – literally – might have been the definition of a good lifestyle. Over time, the definition has pivoted, influenced by the times in which people were living. For over a hundred years, people took both the short- and long-term view when defining their lifestyle. Short term, the idea was to have a good job, one that paid as well as possible, provided upward potential for both compensation and responsibility while also offering a level of stability, so one did not have to worry every day, week or month “if” they would have that job.

Most in our industry entered it because they saw a potential for growth – personal growth, as well as growth for the organization with which they were working. Most also started in an entry-level position and through hard work, observation and learning, could either become an expert in the area or on the equipment/process they operate, or be promoted to managing process, people or both. And while living in this short-term lifestyle called a career, people also built a life that in the long term provided a comfortable and happy environment for themselves and their family. Some call this the American dream, but I view it as a global vision, one shared by citizens around the world.

The next generation coming along, however, seems to have a different interpretation of a good lifestyle. Possibly because of technology, or the changing world environment, the definition of a good lifestyle appears to be once again pivoting – and not so slightly.

A new generation is taking the stage that appears to value flexibility over stability, spontaneity over money and short-term gratification over a long-term career. The next generation appears less interested in committing to a career but rather favoring one-time, short-term gigs that, when they tire of it, can be exchanged like commodities. Flexibility, not commitment, is becoming the new definition of a good lifestyle.

On one level, that pivot is not an issue. Every generation redefines its own norm and every previous generation grumbles about the loss of "the good old days." With a variety of convergent technologies either already here or on the cusp of becoming reality, however, as the definition of a good lifestyle pivots, we may all need to pause and determine if that pivot may end up resulting in an unintended result of people not having any quality lifestyle!

Throughout the manufacturing industry as well as in service businesses, locating, recruiting, hiring and retaining employees – especially good employees – is incredibly difficult. Much has been written about companies everywhere seeing growth restrained simply because they cannot hire enough people. Compounding this labor shortage is the unprecedented number of the baby boomer generation at or approaching retirement. Hiring for growth is one thing, but also hiring to replace doubles the challenge and dramatically shortens the time businesses have to fill the growing gap.

In most industries, automation is looked upon as a possible savior to fill the labor gap. If enough "simple" tasks can be automated, then machines can replace people and relieve some of the burden of finding employees. This strategy has worked in the past and is applied throughout manufacturing and especially in our industry: producing advanced technology.

What may be a game-changer, and not necessarily in the best way, is the potential that artificial intelligence might offer as a replacement for people. For too many people, when they think of AI, they imagine a robot walking through a grocery store or possibly a software logarithm that enables quick answers when contacting a call center for information.

But what if the AI employed in manufacturing eliminates people operating equipment or producing product? What if the only jobs available for masses of people are manual labor or simplistic tasks that do not require experience or skill? Having a good lifestyle when there is no way to earn a reasonable income may not be possible. There will always be some who aspire to push themselves to get ahead, become competent and knowledgeable, and apply that to being successful in their field, business, and industry. But there are still others who might second-guess the strategy of living day-to-day by taking on a short-term gig versus committing to a long-term life plan.

For all, and especially the next generation coming along, we, together, need to make the effort to understand what can – and cannot – be done as well or better by both people and automation. If automation, and eventually AI, is implemented in the appropriate environments to perform tasks it is better suited to handle, everyone will be able to aspire to enjoy a good lifestyle. But if automation is utilized simply because of a perception that people are not dependable nor willing to commit to continual learning and contributing to the common success of the organization they are working for, then that lifestyle may not be good!

While everyone wants to live the best lifestyle they possibly can, and each generation transitions to their own "normal," the dawning of the next generation of automation called AI behooves readers to think wisely about what they want the future to look like.

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

There is No Drop-in Replacement for China PCB Manufacturing – Yet

Observations from Malaysia and Thailand.

THERE HAS BEEN a push of late by many OEM and EMS companies in the PCB industry – intensified by Covid and simmering trade and political tensions – to reduce the West's reliance on China for printed circuit board manufacturing.

In the past year, several of our customers, primarily from OEMs in the automotive, RF and testing industries, have asked for an "Out of China" or "China+1" strategy.

These customers have been buying boards from China for years for products or technology that does not fall under any export control.

So why the change now?

Concerns about IP protection and supply chain issues certainly factor in. But also, the optics of buying PCBs from China are not as favorable as they once were.

In that vein, we recently traveled to Thailand and Malaysia to search for PCB manufacturing facilities in those countries.

Our "test quotes" for the technology our customers require consisted of multilayer power boards with 3 oz. of copper each layer, and HDI product that was 14 layers and above, requiring 100-200 pieces to be built at a time.

What we found during this trip was that the task of decoupling from the very mature China PCB supply chain is easier said than done. There does not appear to be an immediate drop-in replacement to China's available capacity to produce high-mix, low-to-medium technology PCBs in a timely manner.

Everyone we met in Thailand and Malaysia seemed hopeful that business will soon return to normal. The PCB industry throughout Asia has been slow, so it can't come soon enough.

Our trip started in Taiwan and China, where we visited our current circuit board vendors. For me, it was the first time I'd been able to return after a nearly four-year hiatus due to the Covid restrictions.

While overall business in China was slow during Covid, that did not stop our vendors from making process and facility improvements.

Automatic optical and visual inspection (AOI and AVI) was much more prevalent than before. We saw more vertical plating lines and robotics – not robots in the sense of loading or unloading, say, a machine, but rather as transport devices that moved manufacturing panels from one department to another.

We even saw facilities that had automatic stockrooms where a robotic cart could fetch a bin containing a specific part number from an opposite side of the warehouse and deliver it quickly to the packaging area.

Thailand was chosen for this trip because two of our PCB manufacturing partners in China are building manufacturing facilities located a few hours outside of Bangkok, with completion expected next year.

Our visit coincided with the Nepcon trade show in Bangkok, where we searched for additional PCB manufacturers. We did our homework, of course, and reached out to several factories prior to our arrival. We hoped to find others at the show.

Surprisingly, though, while the show was large and well-attended, most board houses represented were from China.

We did later visit several Thai PCB manufacturers, and we were impressed by their size of operations. The industrial parks they are located within are large and spread out; it's not the usual claustrophobic feeling of an industrial area in Taiwan, China or India.

While Thailand produces over $4 billion annually in PCBs, we found the shops were limited in the availability of higher technology manufacturing. Most of the work in the factories we visited was of lower mix, medium-to-higher volume. While some shops did produce HDI boards, we saw nothing above eight layers.

Our opinion of the capability for PCB manufacturing in Thailand is obviously subjective and based on a single visit to available shops. We do believe, however, the capacity to do higher layer count boards in Thailand is limited.

Clement, who has extensive experience with PCB manufacturing in Asia, says there are not many "sub-cons" in the country. Unlike China, where you can get any process completed, Thailand is limited, and that is why it may be hard to service all of our customers' needs when it comes to certain technologies.

Most of the work we saw was for automotive, appliances and televisions, including remote control devices.

In fact, the silver-in-hole process is available – a technology we saw in the US PCB industry some 30 years ago.

Not as many AOI stations were available, but every shop had punch presses. Plenty of punching was going on with boards that required carbon ink.

Metal finishes available per manufacturer were limited, with OSP being prevalent, followed by ENIG. HASL came next, with immersion tin a hard option to find.

Some shops were more automated than others; in some places, we had concerns about the handling techniques.

Minimum order values quoted were higher, and lead times were longer compared to China or Taiwan.

Concerns we noted about the future of the Thai PCB industry are focused more on workforce than technology, however. Technology will come as the demand for that technology increases. However, while labor costs are less than that of China, there will be a workforce crunch come next year. Where will the operators and engineers come from when there will be multiple facilities opening in the next six to 18 months that intend to hire 300-500 people each?

Thailand's language barrier may also affect its PCB industry. With Taiwan and China expected to play a big part in the growth of the Thai market, a lack of Chinese speakers may be a problem. While English is prevalent in Thailand, Chinese is not.

In fact, one of our China manufacturing partners building a facility in Thailand has several key management personnel learning Thai in preparation for the new facility opening.

There is little doubt Thailand can become a PCB powerhouse. When it comes to automotive work in particular, a China +1 strategy featuring Thailand would be a good option. But what we see at present is a lack of capacity in the country to build higher layer-count boards at medium to lower volumes and in a reasonable amount of time.

We may have to wait until our China manufacturing partners open their facilities in Thailand next year to place orders like we have become accustomed to placing in China or Taiwan.

Our trip took us next to Penang, Malaysia, to visit one of our OEM customers. We wanted to check out a few board houses during this visit, hoping to find a shop to meet our immediate high-layer count requirement. But it was just as challenging as Thailand.

One of the PCB factories we visited was immaculate, and it had a great sales and engineering team in place. Communication was excellent, as English is the country's official second language.

However, this facility still uses film throughout manufacture – no LDI anywhere. It had plenty of mass-lam capability, usually building four- or six-layer product, with the occasional eight-layer. As in Thailand, the Penang facility made heavy use of punch presses and had OSP as one of the main finishes. We will keep an eye on this facility. It is expanding, and we hope it will increase its layer-count capacity and its technology.

Just as in Thailand, however, Malaysia does not appear to be an immediate alternative to China for PCB manufacturing. If you need PCB assembly rather than bare board fabrication, however, the island city of Penang is the place to be. You'll find many well-known names in the electronics manufacturing industry there.

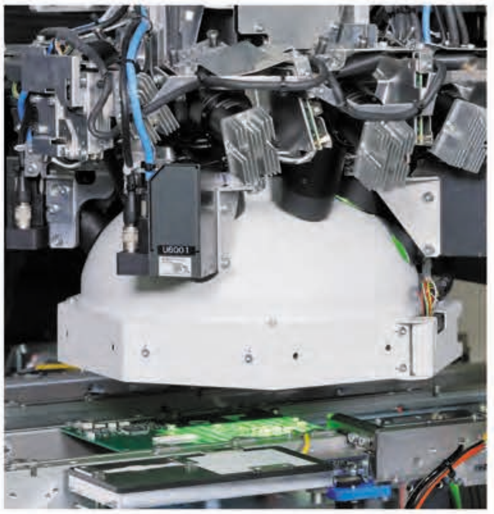
We did not have enough time on this trip to visit India, South Korea or Vietnam to assess PCB manufacturing possibilities in those countries. We will report on that on our next trip.

Thailand and Malaysia each have their strengths and weaknesses in PCB pricing, technology and preferred order values. But they both share the same capacity limitations compared to that of China.

For now, a China+1 or Out of China policy is possible if your company's technology and/or order size(s) will permit it. But for many PCB buyers, realistically, China will continue to be the only game in town for some time to come.

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


YRi-V
YRi-V

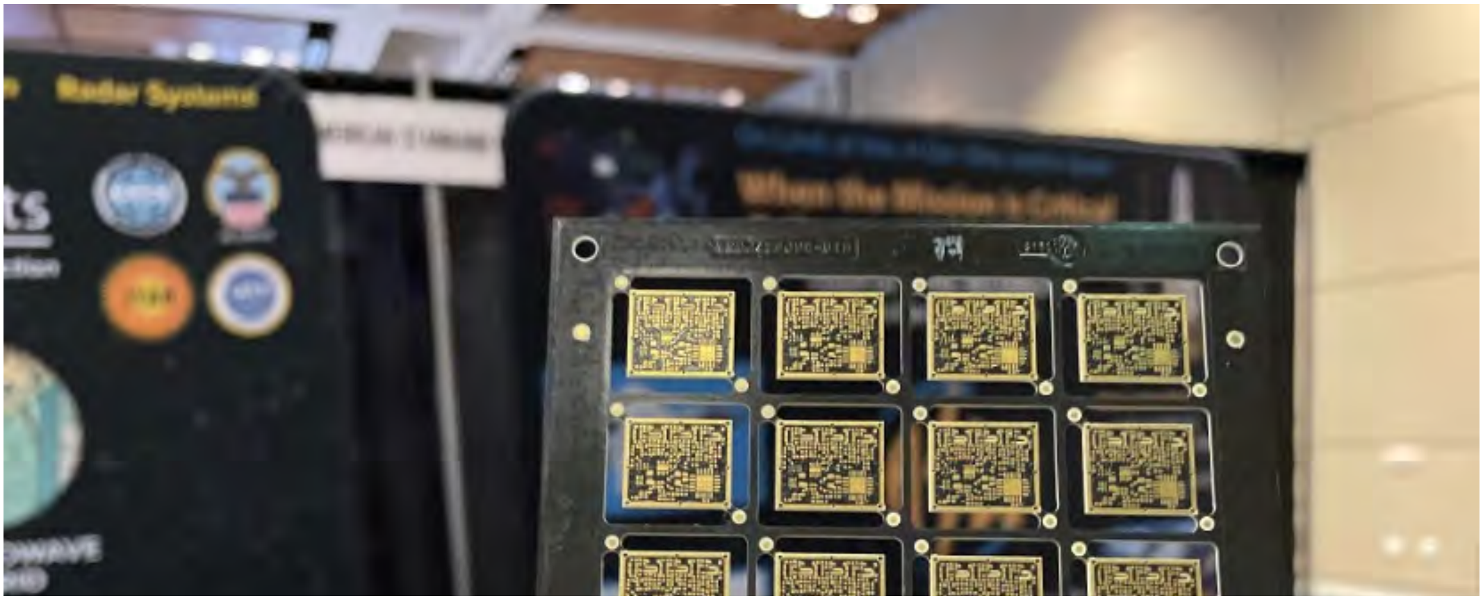


Surviving the Rush to Tape Out the Printed Circuit Board

Design constraints often morph with lessons learned from the prototype.

CAN WE JUST assume that every board design is going to be a nonlinear effort? While we know that everything is subject to change except the tape-out date, there are a few ways we can taxi toward the runway of product launch.

Today's supply chain is tighter than the one in the textbooks on product management. The printed circuit boards are often in the critical path, whether they are test jigs for prototypes or the final mass-production units. A schedule slip on P1 cascades to P2 and everything gets compressed. Execution is essential. Otherwise, we won't have time to learn the lessons of the first iteration before committing to the next.



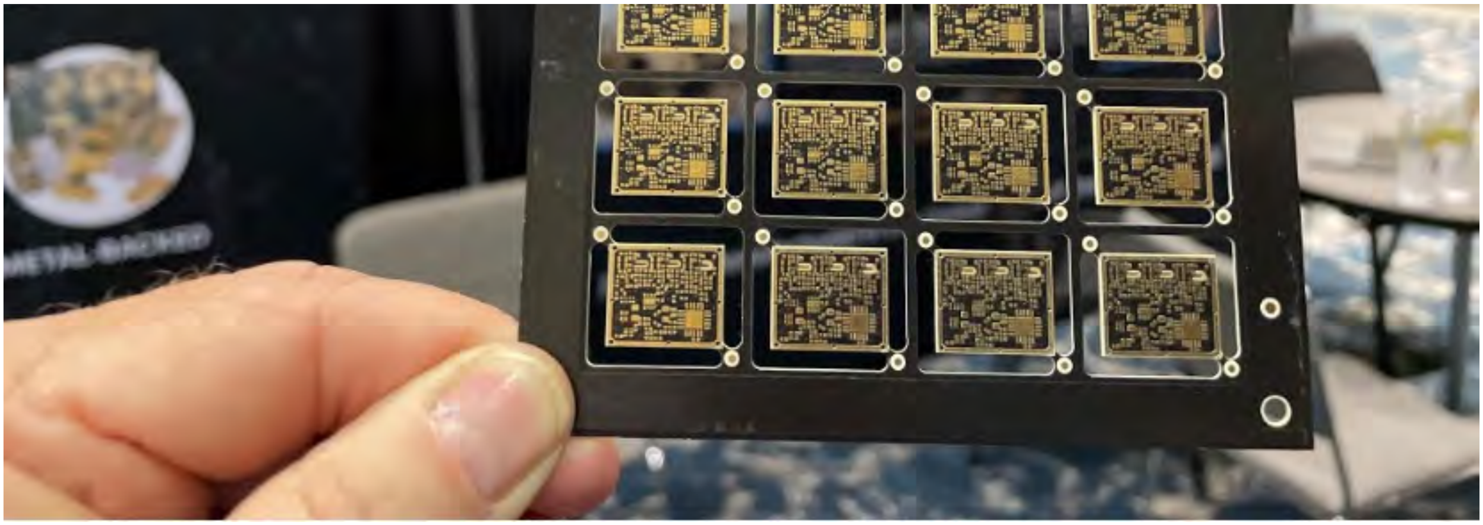


Figure 1. A masterpiece on a postage stamp is one where it is easy to underestimate the effort required, especially with concurrent development. (Source: Author)

This creates a dynamic where there are likely to be updates to the schematic at different points in the layout cycle. When we're designing something that is new from the ground up, we make educated guesses and assumptions about almost everything. Chips don't lie and can't fix themselves after a layout that doesn't "let them eat."

Keep 'everyone' in the loop for drastic revisions. Fundamental lessons learned on the initial design are inevitable. Thus, the designer must be able to create a second revision where it doesn't appear to have bug-fixes slapped on top of the first try. An example of this is when an analog circuit needs to have a series element added.

The first version used a placement that had the absolute minimum length of RF routing. The whole chain is made up of parts at minimum spacing. This is what you should do every time, so that's what ended up happening the first time. Forget that old board and redo as much of the placement as it takes to have impeccable transmission lines again. When you're done, it will look like it was always meant to be that way. It may happen again. Scratch that. It will happen again. You just have to cycle through it enough times that you're not surprised at the design review.

Doing your best work and being willing to rip it right up for something better is the hallmark of a good design service. Taking pride in your work and being able to disown it later will help you cope. The "pointless" effort opened the door for the improvement to come. I have found that changes are easier to take if you frame them as improvements. As a team, we go from guessing what will work to learning what will and implementing that hard earned knowledge.

Widen the road between MCAD and ECAD tools. Improvements are inevitable and provide a never ending source of work. When times are slow, there will be a chance to look at the component library for anything that should be improved. It is common for the mechanical data concerning connectors to conflict with the footprint. Working from a step model, the mechanical engineer uses the nominal values for length, width and height.

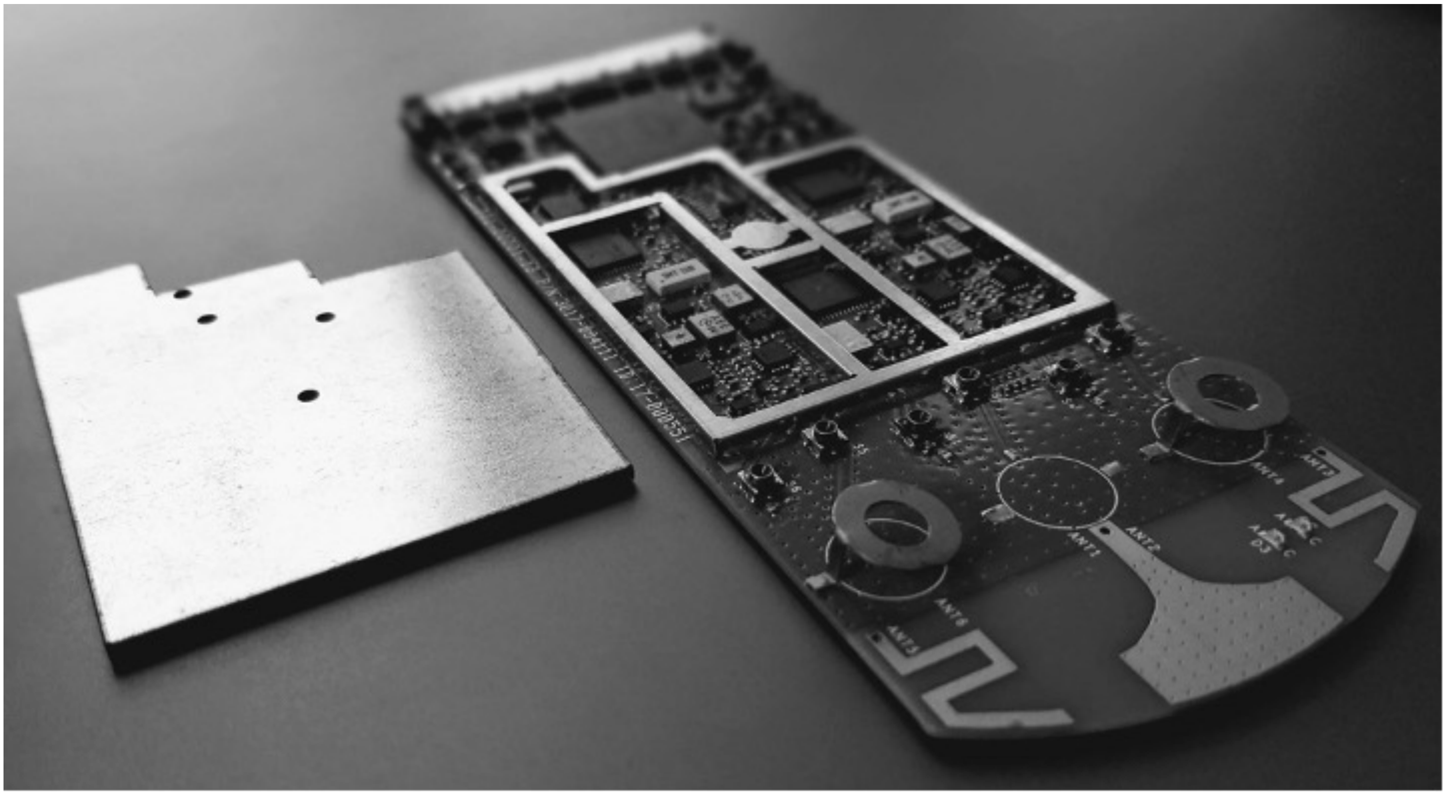


Figure 2. It's always about fitting together in the end. (Source: Author)

Librarians may have tried to help by using maximum height values or adding a courtyard that exceeds the specific zone created for that connector by the product designer. This is a case where building in a safety margin is working against the designer. A part placed in accordance with the mechanical engineer's intent should not cause design rule violations. It's a good use of spare cycles to strengthen the synapses between mechanical and electrical design.

One of my mistakes is to think I will have time to clean up the reference designators for the silkscreen and assembly drawings. Now, I try to consider the non-metal layers earlier so that only the new parts have wonky text at tape-out time. When you revisit these layers toward the end, the oversized, mislocated strings of text reveal the churn that happened along the way. That's reason enough to try to get ahead on this task. Look at all those improvements!

It's not just arranging text. The design constraints often morph a bit with the lessons learned from the original prototype. Fix the board by fixing the rules, and then following them. It will take longer the first time encountering a request for a specific line width/length. Having that information embedded with the layout will help with design verification and make it more repeatable after ripping up the previous incarnation.

Figure 3. The main logic board for a laptop took about three months to develop with a final

electromechanical definition coming in the last week. (Source: Author)

Do a tape-out just to see what happens. A dry run of the tape-out will reveal any showstoppers lurking in the design. Shapes can be corrupt from the beginning but only manifest when it's go-time. Making sure the part numbers and descriptions are all in alignment with the next revision will help.

As always, fab and assembly vendors play a key role in the PCB launch. Getting them onboard for the next wave is so important. No fun when you meet your part of the schedule but the vendor doesn't have a DfM slot or even material for your project. If no one else is managing that, then you should get out in front of that effort.

If failure is not an option, I would engage two (or more) vendors for the fabrication and let them have an undeclared race. The minimum order quantity and tooling charges could make that unfeasible, in which case the choice of vendors becomes very important. If you're bound to use a single source, know their capabilities and limitations. While dealing with one vendor is easier, the risk of schedule slip is higher. Spreading that risk is my key piece of advice on managing the supply chain these days.

In summary, it pays to improve your editing skills and to dabble in project management where necessary to have things in control as the board goes to fabrication. Digesting the lessons learned and getting as close as possible to a ready-to-go board file ahead of the last-minute rush will allow you to sleep better. You need your rest in that final push. Getting a solid inter-group process down will make life easier. Soften the barriers and remove the impediments that drag out the process by being an advocate for your own cause.

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.

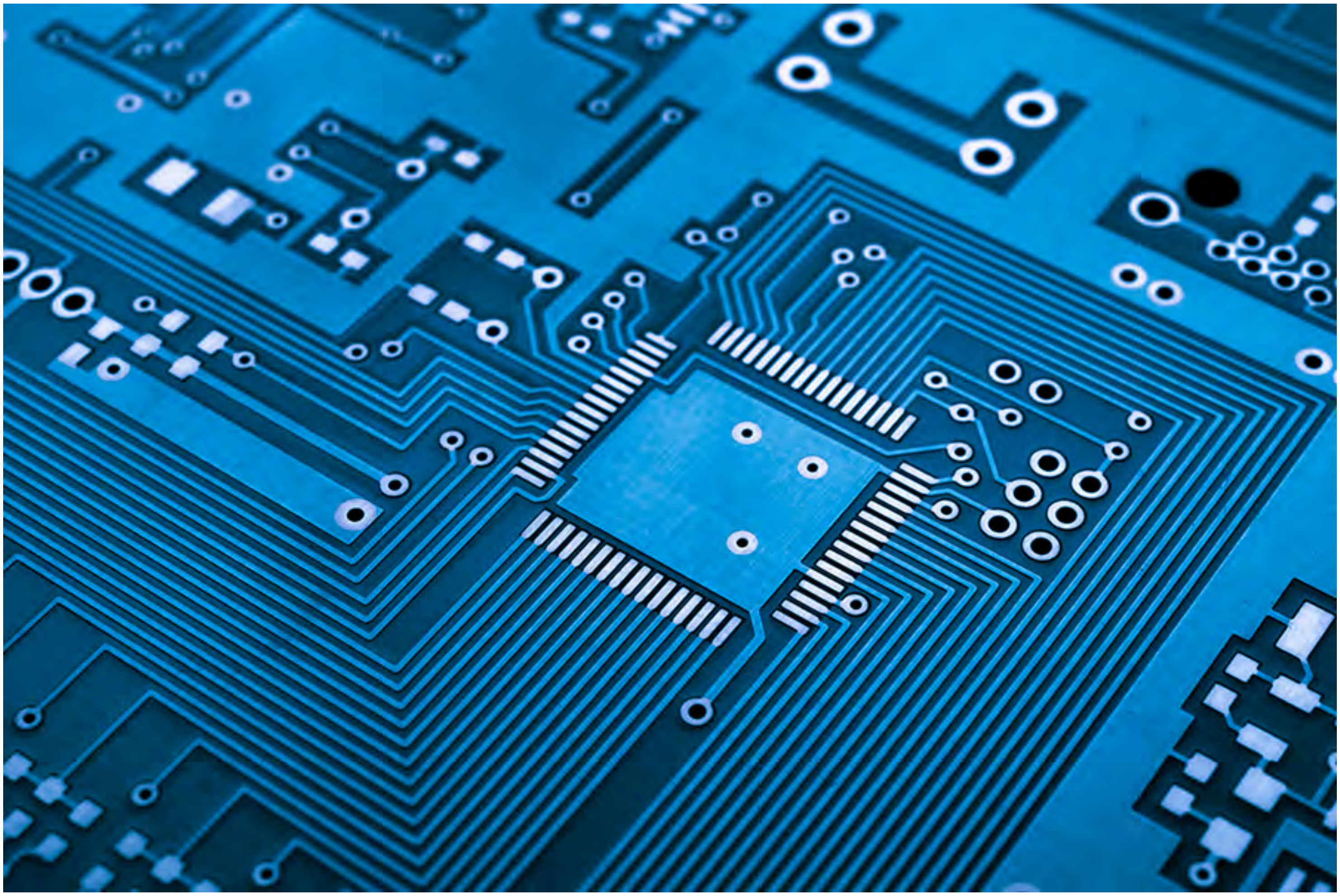
DESIGN **BEST PRACTICES**

Take Design Automation Along for the Ride

It’s far past time to use the complete power of the tool to your advantage.

DESIGN AUTOMATION IS one of my favorite topics. When I think of design automation, what first comes to mind are three words: optimization, efficiency and speed. Some design engineers and layout professionals are reluctant to learn new technology to design better, faster and more efficiently in the quest for delivering a quality product to market at the lowest engineering and manufacturing cost. Earlier in my career, I too was reluctant to give in to automation when it came to designing PCBs. I recall, about 20 years ago, I was under a typical project deadline in the project design cycle. You know what I’m talking about: “We need it done today! Oh, and by the way, we have more design changes for you to implement, but we still need it completed and released today!”

It was during that type of project for a specific aerospace customer where I made the decision to use automation to route signal traces. For the first time in my career, I used the autorouting feature in my tool. Talk about an uneasy feeling, like a stomach cramp. It was gut-wrenching to let go of my manual approach for designing PCBs, especially knowing I was under a very stressful and tight project time constraint. In the end, and to my surprise and amazement, I managed to successfully implement autorouting. By doing so, I managed to finish earlier than expected, which shocked the EE I was working with, along with everyone else on the project … and I came in with several alternate versions of the same design for the EE to choose from. Success! What a feeling! One of the highlights of my career, for sure. I have never looked back. To this day, more than ever, I stress harnessing the horsepower of the CAD tools and using their capabilities to your advantage.



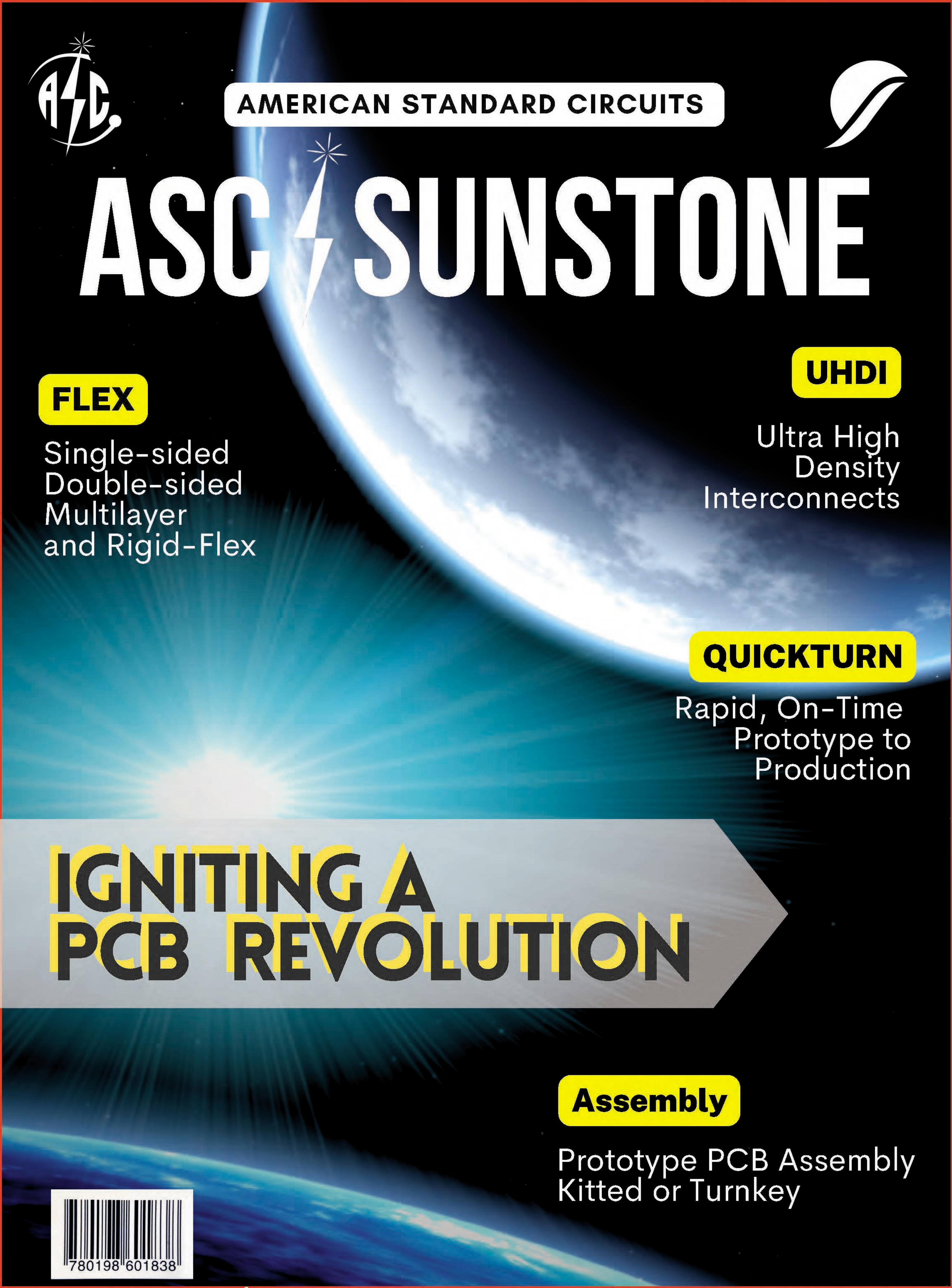
Another recent real-world experience of letting go and embracing automation reminded me of that first time. I was at a local auto dealership and wanted to test drive a specific SUV model. So, I'm in the middle of the test drive going down the local highway. My wife is sitting in the passenger seat and the salesperson was in the back behind her. As I drove along at about 70mph, with a left-handed curve to the road, the salesperson told me to enable the auto-drive feature of the vehicle. Knowing there were vehicles all around moving at about the same speed and with the curve fast approaching, I initially refused his command to enable auto-drive and let go of the steering wheel. I didn't want to crash, especially on the highway. The salesperson was persistent, however, saying, "Steph, trust me, I'm in this vehicle too. So just enable the auto-drive feature and let go of the steering wheel and remove your foot from both the gas and the brake pedals." As I did as he directed, that queasy feeling returned. I enabled the auto-drive feature and let go of all control of the vehicle, yet to our surprise and amazement the vehicle drove itself! It slowed down, sped up, and braked when needed as it drove along the curve in the highway with all the other vehicles. It successfully drove like this for about five miles before I decided to retake control of the vehicle. We were amazed with this advanced automation. When we got back to the dealership, I couldn't help but recognize the parallel mentioned to those engineers who don't want to let go of the manual approach to PCB design and embrace automation to their advantage.

Don't get me wrong about design automation. I am not suggesting that a designer can simply "push the button" and the PCB is magically laid out and routed. That approach will produce a PCB that looks like a plate of spaghetti! Some think that's what I am referring to when I talk about design automation. On the contrary, a PCB designer must be mindful of when to use automation. Design automation enables you to:

- Adapt to design changes much faster,
- Design and collaborate more efficiently,
- Continuously optimize the design process,
- Gain better control of product lifecycle management, and
- Produce a better-quality product with higher yields in manufacturing, and at a lower price point.

Embrace the evolution of design automation by letting go of the legacy manual approach to PCB design. Think about this. Take a very experienced, well-educated, and good PCB designer and arm them with one of today's industry leading EDA solutions. Then, sit back and watch magic unfold as a PCB masterpiece is produced. It's great to be a PCB designer these days, and it's why I love PCB design.

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



Models Can Be Deceiving: Trust, but Verify

Numbers on a data sheet are a good start, but confirm them with your own testing.

"TRUST, BUT VERIFY." While some readers will recall hearing this in the context of nuclear disarmament, I have it most notably drilled into my conscience by my first engineering manager while working in software quality assurance. And for good reason too! It was literally my role to verify the fixes that the engineers claimed they had implemented and to find the issues that were still open. While most of the time their fixes resolved the issue, sometimes it was only partially dispositioned.

So how do we successfully trust, but verify when it comes to information in data sheets for not just copper roughness, but other values significant for modeling signal integrity in printed circuit boards?

In a previous column, I discussed copper roughness and a partial story of the lifecycle of the copper as it moves along in the process of becoming part of a printed circuit board. In that article, I mentioned the dielectric constant/permittivity (Dk) and the dissipation factor/loss tangent (Df) of the resin/filler/glass combination. The data sheets used to be very secretive, with material suppliers concerned about corporate espionage regarding chemistries if the Dk and Df information was made publicly available. Depending on the material supplier and the materials in question, many times one can also find the construction data – glass weave style and quantity, resin content, and shelf thickness.

It wasn't that long ago that PCB laminate suppliers were very secretive about the construction and electrical performance of materials. Fortunately for designers today, almost all PCB material suppliers are more freely open with the Dk/Df and construction information in their materials, even going so far as to provide the data to third-party software vendors to help make the knowledge more accessible. This was an early element of Industry 4.0 in equipping designers, not just fabricators, with information to make informed decisions.

Many tools have been born from this trend of communicating such information and facilitating choices between designers and fabricators. One such toolset rising in prominence has been stackup tools. These were once tools exclusive to fabricators, with designers relying solely on their fabricator to develop a stackup. Modern stackup designs can be extremely complex and require sophisticated engineering to design and produce in order to connect all the components together properly.

Tools like Speedstack from Polar Instruments and Z-Planner from Z-Zero and Siemens **(FIGURE 1)** have interfaces which allow users to access material information much more quickly and readily than having to look up multiple data sheets. Some tools even offer complex comparison capabilities to help guide a designer in making material and trace dimension decisions based on glass-weave. The ease of interacting with the libraries of materials is another of those refreshing elements that are a part of the "digital thread" and Industry 4.0.

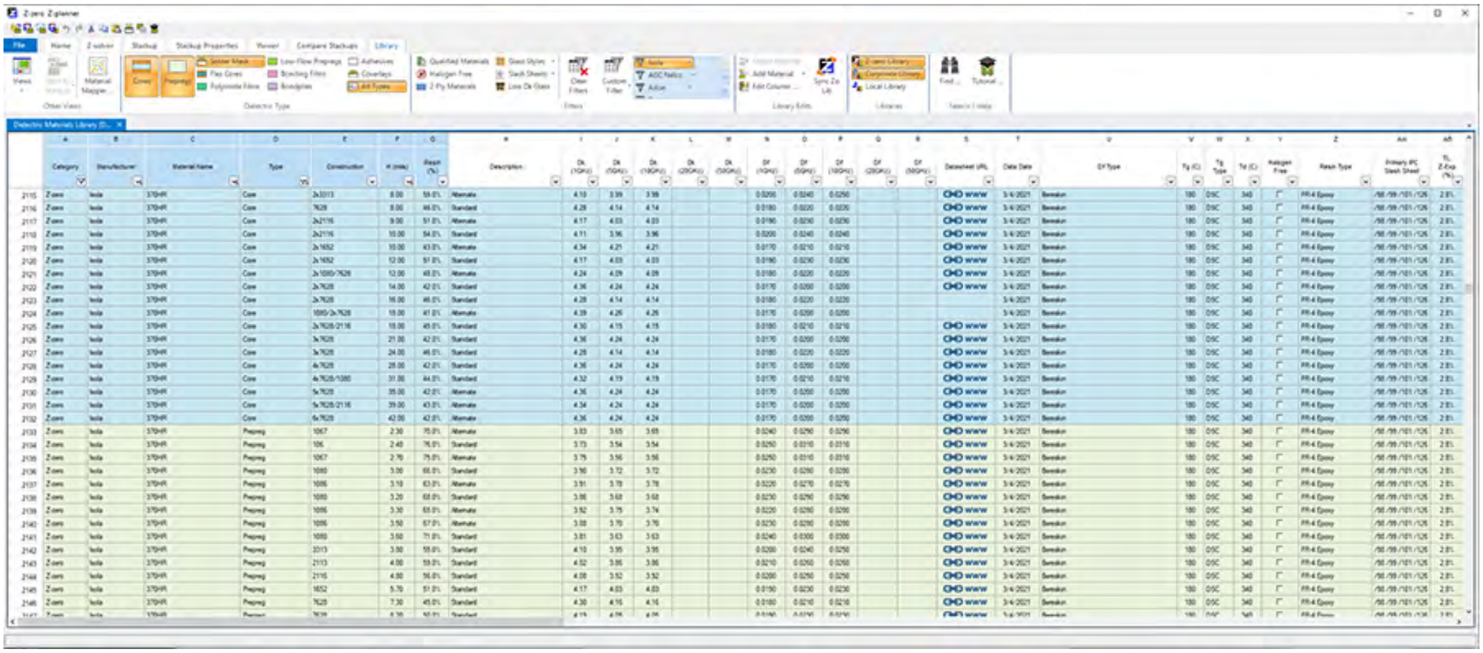


Figure 1. A material library interface from Z-Planner from Z-Zero and Siemens.

The dielectric information in the data sheets primarily comes from test methods that were developed well prior to Industry 4.0 and not entirely targeted to the audience looking for this data today. When reviewing the material data sheets, one may start to get lost in the various IPC-TM-650 test methods referenced to achieve the measured result. In some cases, like the Bereskin method, it is not a codified test method within IPC, even though it has been around for well over 20 years. In **FIGURE 2** we can see an example from a common laminate supplier's data sheet that there are four different test methods used at different frequencies. So which value should a designer use?

Dk, Permittivity	A. @ 100 MHz B. @ 1 GHz C. @ 2 GHz D. @ 5 GHz E. @ 10 GHz	4.24 4.17 4.04 3.92 3.92	—	2.5.5.3 2.5.5.9 Bereskin Stripline Bereskin Stripline Bereskin Stripline
Df, Loss Tangent	A. @ 100 MHz B. @ 1 GHz C. @ 2 GHz D. @ 5 GHz E. @ 10 GHz	0.0150 0.0161 0.0210 0.0250 0.0250	— — —	2.5.5.3 2.5.5.9 Bereskin Stripline 2.5.5.5 2.5.5.5

Figure 2. An example from a common laminate supplier's data sheet showing four different test methods used at different frequencies.

Each of the listed test methods in the far-right column is valid, but it is important to recognize that these test methods were not necessarily thought of for the designer. In many cases, they are part of the quality control cycle of the material supplier.

I have attended numerous IPC committee meetings where material characterization tests methods were discussed, and it became clear that the different committees on material testing were divided by industry segment, not necessarily by test method. One subcommittee meeting was filled with material manufacturers, another with copper suppliers, another with printed circuit board fabricators, and a fourth with mostly designers. Very little attendance crossover occurred among these groups as they all tried to achieve similar goals of measuring the materials – with their own (biased) priorities. One year, I noticed another outlier who was attending the same meetings with me: An FAE at a fabricator, who shared my sentiment that while the attendees were all pursuing the same goal, their biases were skewing the outcome to thinking that the quality control information from one block was relevant to everyone else.

For a designer, does this mean not all the test methods are meant for you?! How can this be? These results are all over the marketing materials, so why not use them?

One of these committees set out to figure out the commonalities among the results of these tests. This was the work of Glenn Oliver, Jonathan Weldon, John Coonrod, et al. in an award-winning paper released at IPC Apex in 2016 titled "Round Robin of High-Frequency Test Methods by IPC-D24C Task Group." The authors assessed multiple material characterization test methods to "report results of each method on a common set of sample material representative of what would be used at frequencies greater than 10GHz." Essentially, they crafted the early workings of a Rosetta stone to correlate measurements from one method to another.

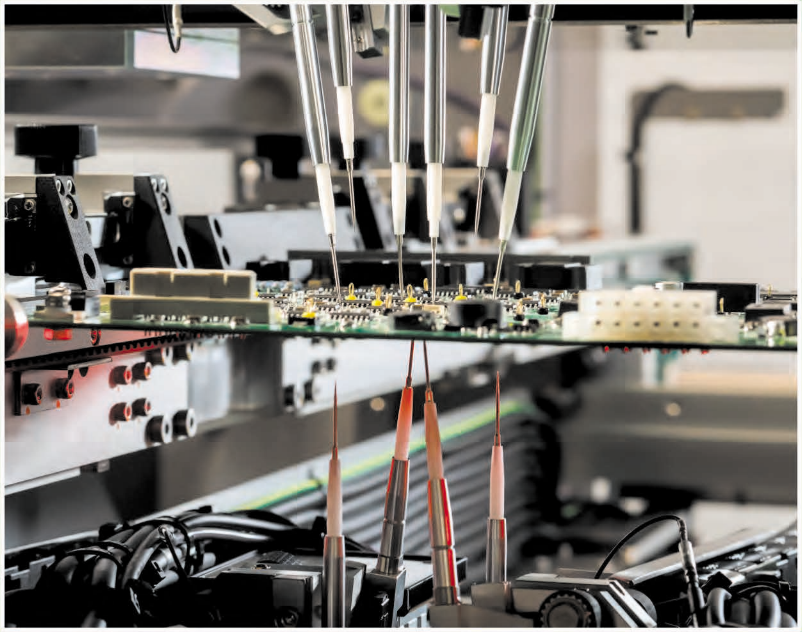
Coonrod, with Rogers Corp., recognized early on that designers needed data relevant to them, not just material characterization Dk/Df for marketing, but "design Dk" values for engineers to use in modeling. Some may contend this is still "marketing," but at least it was marketing to help designers close the gap between modeling and final product measurements.

So trust, but verify. With more test protocols coming into the industry, like 2.5.5.14 "Measuring High Frequency Signal Loss and Propagation on Printed Boards with Frequency Domain Methods," how much can you trust the data sheet values to be close to or match your final board's electromagnetic performance? Getting the numbers from the data sheet is a start, but verify those numbers with your fabricator's testing and your own. Impedance testing is a start, but fabricators can also test the boards to verify that all the pieces, copper roughness, Dk/Df, etc., are in place to ensure the materials selected and the fabrication processes result in the outcome sought to connect the chips together. In some cases, you may need to build test vehicles and measure them yourself. If you don't have the bandwidth or the technical expertise, you can turn to a third party, like Wild River Technology, which specializes in developing channel modeling platforms from real-world measurements to provide extremely accurate simulation models.

"Trust, but verify" applies to the data used in early modeling all the way through the final test of a printed circuit board and assembly. Trust that the data sheets will be close, but verify with your fabricator and your own test vehicles/prototypes. And always work toward the most accurate and precise Dk/Df values you can get.

GEOFFREY HAZELETT is a contributing editor to PCD&F/CIRCUITS ASSEMBLY. He is a technical sales specialist with more than 10 years' experience in software quality engineering and sales of signal integrity software. He has a bachelor's degree in electrical engineering; geoffrey@pcea.net.


APT-1600FD-A
TAKAYA



MATERIAL **GAINS**

The Cost of Reshoring

The rebalancing of high-tech power must involve the entire supply chain – and will increase prices for everyone.

ADVANCED TECHNOLOGY IS an important instrument of power on the world stage. Arguably more than at any previous time in history, it's closely linked to economic influence, energy generation and management, healthcare delivery, international diplomacy, and military strength including cyber capabilities. Access to advanced technology is the issue at the heart of the current maneuvering between western nations and China, in particular.

Concerned about the potential for Chinese control over its communication networks, the West has restricted involvement in 5G infrastructure projects. It's currently limiting shipments of advanced industrial technology. Of course, China has responded, announcing export controls on raw materials like gallium and germanium, which are basic ingredients for producing compound semiconductors: a critical enabling technology for future generations of equipment such as optical networking, 5G infrastructure, and high-efficiency power conversion needed to ensure affordable renewable energy and e-mobility.

China can flex its muscles over the supply of these raw materials to hold back progress in the West, since it sits on huge natural deposits: some estimates say as much as 98% of the world's gallium and about 60% of all germanium. Although compound semiconductors account for only about 20% of world semiconductor device production right now, they represent a sizable and growing proportion of the market as applications using this technology are increasingly becoming mainstream.

Prices for gallium and germanium are now about 20% higher than at the beginning of the year. The supply situation can potentially slow development, drive up the cost of compound-semiconductor components, and make next-generation products such as communication and energy-conversion systems less affordable for businesses and governments. Ultimately, it puts a brake on modernization.

The semiconductor industry is, of course, a large jewel in the West's crown. California is essentially the birthplace of chipmaking, following the inventions of the transistor and large-scale integration beginning in the 1950s/60s. Its power in this sector has diluted partly through inevitability, as the expertise has spread worldwide, but also as companies have pursued bigger returns by moving activities to locations with lower labor costs. In the 1990s, the US held about 37% of world semiconductor manufacturing and China had less than 15%. Today, the US has about 12% share and is only the fifth-largest chipmaking destination in the world, after Japan, South Korea, Taiwan and China. About 10% of manufacturing is based in Europe.

Now the West wants to reacquire its power in semiconductors, for political reasons and simply to restore resilience. The US government is committing $280 billion toward achieving this over the next 10 years, as it enacts the CHIPS and Science Act. About $200 billion is intended for scientific R&D, while $50 billion will go toward building wafer fabs. These fabs are expected to be in locations such as Arizona and Tijuana, Mexico, typically not in California. The European Chips Act proposes a rather more modest spend of 40 billion euros, although both are aiming to roughly double their global share of the market.

The intentions here are clear, although there will be a cost to everyone around the world.

The US plans are expected to drive demand for more than 250,000 extra engineers. It will take time to fill these opportunities and there is a shortage of the necessary skills, so wage inflation is anticipated. Generally, costs will be higher. TSMC's new US fab, currently being built in Arizona, represents an investment of $40 billion. That's about four to five times the cost of a comparable plant in the company's native Taiwan. Overall, chip prices could rise by as much as 50% in the future.

Rebalancing the power in high-tech will depend on more factors than simply increasing semiconductor manufacturing in the West. It's critical to build up the complete electronics supply chain and establish independent access to other important components, including PCBs. The US currently produces about 4-5% of the world's printed circuit boards, while less than 2.5% is made in Europe. Significantly increasing the western share of chip production would drive an even greater mismatch between this and other aspects of the supply chain. A rebalancing would strongly affect China, where a large portion of the world's PCB production currently happens. Already, driven by geopolitical factors as well as economic changes, fabricators and material suppliers are in the process of moving away to areas in Southeast Asia like Thailand and Vietnam.

The PCB-focused organizations, the Printed Circuit Board Association of America (PCBAA) and the European Institute for the PCB Community (EIPC), are making the case for broader support of the electronics supply chain. The message, that regaining high-tech power depends on more than simply bolstering the chip industry, makes perfect sense and may be winning acceptance.

There is a fine line between powering up the indigenous industry to increase its influence and competitiveness on the one hand, and plain old protectionism on the other. Whatever your position on the wisdom, or otherwise, of trade warfare, the West needs to invest in its high-tech industries. This has fallen short over the past two decades or more as companies have focused on driving down costs. Although prices are expected to rise, some of the skills learned in pursuit of keeping costs down could help to mitigate price increases.

However this situation evolves, we should all expect big changes to start happening in the technology available, and the prices we will pay, well within the next decade.

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

Book a flight

Plan your future in first class

TRILOGY-NET INC.™

The measuring stick of the PCB assembly industry

luminovo

Your copilot for the electronics supply chain

Part options

None 10 Single 40 Multiple 50

BOM items 100

Compliance

Lead time: 3 weeks

Unit price: $ 110.8606

Total price: $ 11,186.06 $ 100.00 Excess

Availability

Out of stock / Market	20
Insufficient stock / Market	30
In stock / Market	40
Inventory of EMS	5
Consigned	5

Lifecycle

Obsolete	5
EOL	20
NRND	25
Pre-release	40
Active	5
Unknown	5

Expected end of life

Trilogy-Net is a **transparent** manufacturer of PCBA's. Offering prototyping, mechanical assembly, and testing. Our R&D dept made us the measuring stick, by delivering unique specialized services in small component size (009005), EMI/EMC scanning, vapor phase reflow, and global supply chain and logistics.

Luminovo is the all-in-one software solution that manages the complexity of monitoring, quoting and procuring PCBAs and enables users to handle their BOM, PCB and manufacturing effortlessly. Our partners reach from distributors and suppliers to PCB manufacturers, ERP providers and others.

Visit Trilogy-Net

Meet us at PCB West Booth 516 & 518

Visit Luminovo

ADDITIVE
MANUFACTURING

3-D Printing of Plastic Structures onto PCBs for Circuit Protection Strategies

A design, equipment, process and materials methodological approach.

by STANTON F. RAK and DAVID TSEUNG

Electronics for automotive applications, as well as for other industries, are expected to reliably operate in harsh environments at a competitive cost. Advances in safety, communication and displays are driving miniaturization and integration of sub-devices onto the PCB assembly; e.g., cameras, sensors, and LEDs. Electrification trends are also leading to higher voltage requirements. In one example of a harsh environment application, automotive door and window control modules may have a critical circuit or component that is desired to function for a specified amount of time, even while submerged in water.

This paper describes an enabling technology to assist in the protection of critical functionality on PCB assemblies. 3-D-printed plastic retaining or “barrier” walls are formed to precisely control the location and height of a dispensed encapsulant in a region of the circuit that is sensitive to the environment. A case study was undertaken for the creation of 3-D-printed retaining walls, formed directly onto the surface of PCB substrates, without the need for separate parts, mold tools, mechanical or liquid fasteners, and complex manufacturing equipment. Also eliminated is the need to encapsulate or pot the entire PCB assembly, which adds additional complexity and cost. The encapsulant-filled retaining wall structure protects critical circuits from chemical, mechanical and electrical external factors such as moisture, fluids, gasses, particulate contamination, physical contact, or arcing in applications requiring high voltage. A 3-D model of the SIR test PCB having a representative retaining wall structure, surrounding an interdigitated test circuit, is shown in

FIGURE 1. The retaining walls hold a liquid-dispensed encapsulant in place, at a predetermined height. In the absence of a retaining wall structure, as shown in **FIGURES 2** and **3**, an encapsulate can spread uncontrollably across the surface of the PCB (Figure 2), or result in insufficient height of the encapsulant, exposing electronics circuitry (Figure 3).

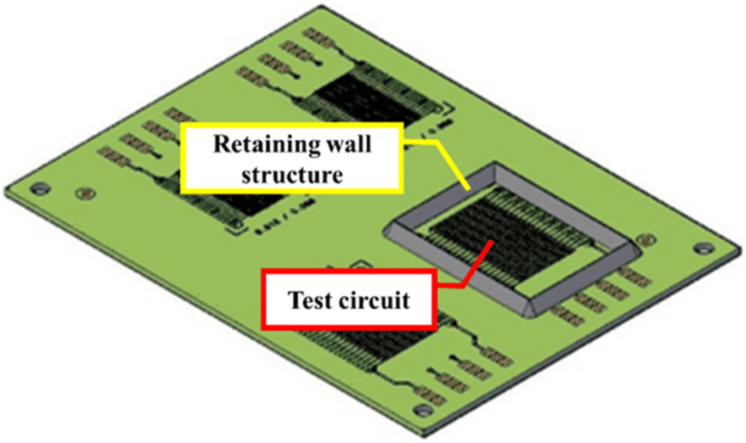


Figure 1. 3-D model of retaining wall on PCB.

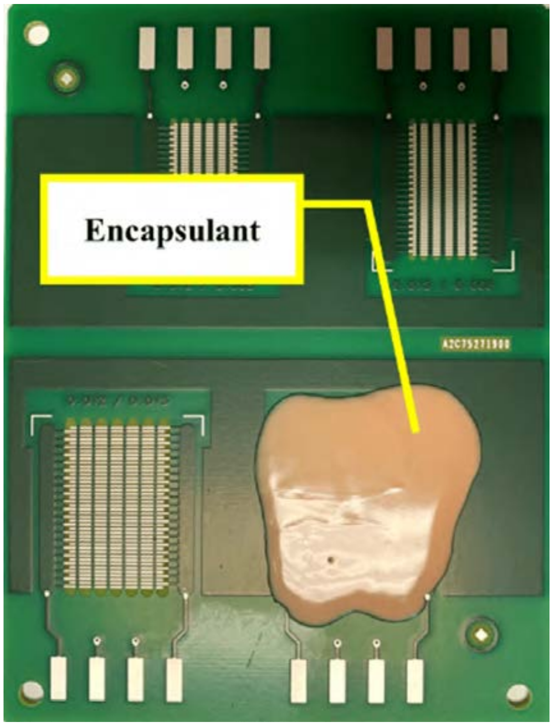


Figure 2. Uncontrolled flow.

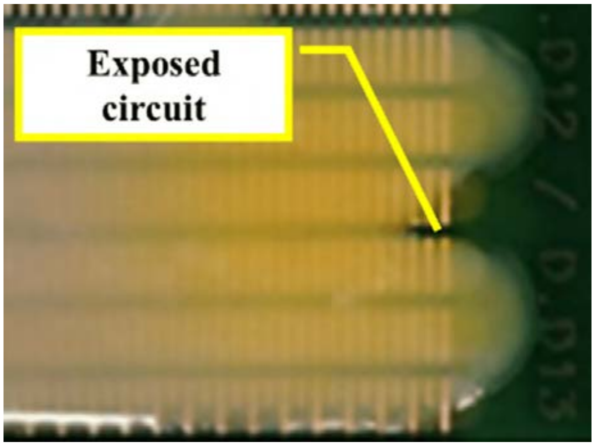


Figure 3. Exposed circuit.

3-D-Printed Retaining Walls vs. Current Practices

A common industry practice for controlling the positioning of an encapsulant on a localized area of a circuit assembly is to first dispense a “dam” material onto the PCB substrate forming the perimeter wall, in a “dam and fill” encapsulation process.[1] The dam material is separately dispensed from the encapsulant, or “fill” material, thus requiring additional equipment and manufacturing steps. The dam material may also require a separate cure process and must be chemically compatible with the fill material so as not to interfere with the fill material curing and the final mechanical and electrical properties. Challenges may exist to control the precise height of the liquid-dispensed dam material especially when encapsulating high-profile components. The width of the dam depends on the type of fluid and height. The ratio of the width to the height (i.e., aspect ratio), ranges from about 1.5:1 to 4:1 for different fluids.[1] Thus, if one desired to create a liquid-dispensed dam that was 4mm high, the width of the dam would range between 6mm to 16mm, which is an impractical use of PCB surface area for most microelectronics applications. Dam materials also have engineered dispense and thixotropy properties through use of filler additives and controlled molecular weight distributions. Such property manipulations are effective but add to the cost of the dam materials. Some dam and fill processes require a two-step curing process, with the second cure step taking place at 165°C.[1] 3-D-printed plastics do not require a curing process.

The cost and performance benefits of using 3-D-printed retaining walls for the encapsulation of critical circuits compared to traditional liquid-dispensed dam materials are apparent and can be summarized as: 1) the material cost; e.g., the plastic filaments described in this work cost between \$0.025 – \$0.035/g compared with the highly engineered liquid-dispense dam materials[2], which typically are 30-40 times higher cost; 2) no dedicated liquid-dispense machines are required; 3) cure ovens and curing processes are eliminated; 4) plastic filament materials can be stored at room temperature instead of requiring storage freezers and thawing protocols; 5) there is virtually no process waste of the plastic filaments compared to liquid-dispense materials; 6) material shelf life, handling and inventory control are simplified; 7) a plastic material can be selected that is unreactive to the encapsulant or polymer of interest; 8) the height of the printed retaining wall can be carefully controlled to minimize the amount of encapsulant material required to protect the sensitive circuit; and 9) an "inverted" aspect ratio, e.g., 1:4 (width : height), is theoretically possible for the printed wall, thus conserving PCB surface area compared to the liquid-dispensed dam approach. Such advantages for the 3-D-printed retaining wall approach make it both cost- and performance-attractive.

Alternatively, another current practice for the protection of critical circuits in harsh environments is to conformal coat or pot the PCB assembly. Conformal coatings are generally not considered a suitable protection strategy for fluid-submersion applications in automotive. Potting requires greater volumes of liquid-dispense polymers to protect electronic circuits from the environment when compared to a localized encapsulation design, as the subject of this work. The amount of potting material required depends significantly on the electronic package housing size and geometry, and can easily result in the need for tens or hundreds of grams of potting material to be used, compared with several grams for a localized encapsulation approach. Additionally, potting may present problems for certain types of electronic components that are sensitive to organic contamination, e.g., relays and contacts, or components with solder joints that could be weakened by thermomechanical stress induced by thermal coefficient of expansion effects. A localized encapsulation strategy compared to potting an assembly reduces material usage (read: cost), and avoids risks associated with the thermomechanical stress across a larger PCB assembly.

Scope of this Work

Emerging materials and manufacturing technologies used for additively manufactured electronics (AME)[3] and direct digital manufacturing (DDM)[4] are leading to exciting breakthroughs in circuit and device designs, as well as process simplifications, that are not possible with 2-D, subtractive PCB manufacturing technologies. The target of this work is of a different nature, instead, to utilize widely accessible FFF printing technology to modify conventional FR-4-based PCBs to add overall

PCB assembly and test functionality at a low cost. It was desirable to be able to print the plastic structures within a cycle time comparable to other PCB assembly processes, like a solder reflow process, where thermal profiles take approximately 5 min. to complete.[5,6] In this case study, plastic retaining walls were 3-D printed onto IPC-B-24 SIR test PCBs. The artwork of the IPC-B-24 coupon was modified slightly to suit specific materials qualification and application needs **(FIGURE 4)**.[7] SIR test boards can be used to perform a myriad of environmental exposure tests on different assembly materials and manufacturing processes.[8,9,10] SIR environmental testing itself is not covered here. A 3-D model of the SIR test PCB with the desired retaining wall structure located around an interdigitated test circuit is shown in Figure 1. Although common equipment and materials can be used to 3-D print the retaining walls, considerable process development was required to securely attach the printed plastic retaining walls onto the SIR test PCB. This work describes the methodology and experimental approach leading to the successful creation of 3-D-printed retention walls on FR-4 PCBs.

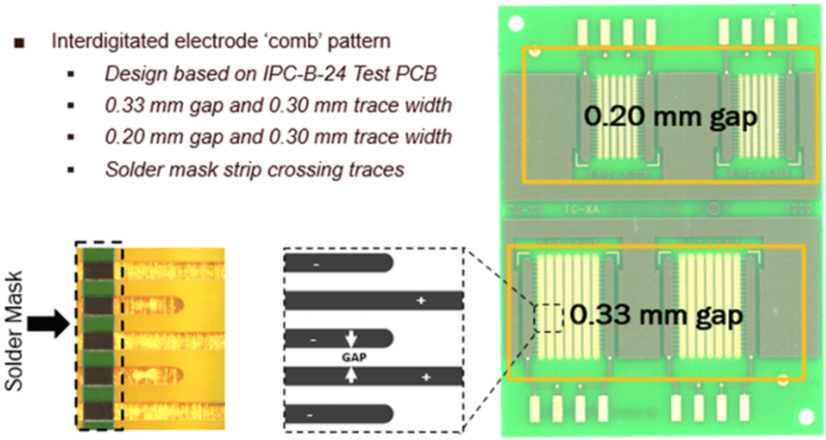


Figure 4. Design of modified IPC-B-24 SIR test board.

Basics of FFF 3-D printers. This work employed fused filament fabrication (FFF) 3-D-printing technology. FFF is a material extrusion technology and is one form of additive manufacturing (AM).[11] FFF 3-D printers evolved from filament deposition modeling (FDM) 3-D printers following the expiration of the pioneering patents.[12] The basic principles for FFF and FDM technologies are similar. The printing methods employ a plastic filament fed to a heating element by a gear mechanism and then extruded as a melted material from a nozzle onto a print bed or "build plate." **FIGURE 5** shows the key components of FFF/FDM printers.[13] Typically, the nozzle moves in the x,y-dimensions to form a layer of material. Once this first layer is completed, the plate is lowered in the z-direction, and a second layer is deposited onto the first. Layer by layer, this process is repeated multiple times to complete a three-dimensional print. FFF professional desktop printers are lower cost and have thus gained wider acceptance and use. FFF printer prices usually range in the single digit thousands of dollars and are readily available from a number of companies. FDM/FFF industrial printers are more sophisticated, having more capabilities for print control, and cost in the tens to hundreds of thousands of dollars.[11] FFF 3-D printing onto a PCB surface is nontrivial and the experimental methodology will be described in detail below.

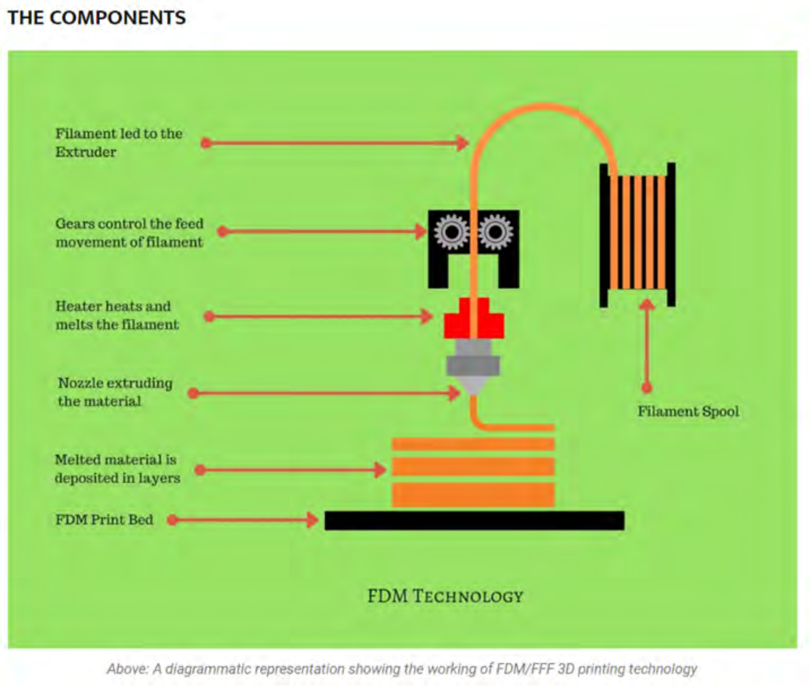


Figure 5. Components of an FDM/FFF 3-D printer.[13]

Build plates and bed adhesion. The standard approach when creating a 3-D-printed object using FFF is to print, layer by layer, by depositing melted plastic filament starting with the initial layer on the build plate surface (see diagrammatic representation shown in Figure 5). The build plate surface is flat (to maintain a controlled distance to the nozzle), typically made of glass (low cost, readily cleanable), and may be heated. **FIGURE 6** shows an example of an FFF-printed object created on a heated glass build plate. Other materials may be employed as build plates provided they are flat and lead to a characteristic called "bed adhesion." Bed adhesion is the ability of 3-D-printed plastic to remain attached to the build plate while printing. Movement of the 3-D-printed object on the build plate surface during the printing process leads to misregistration and scrap. Different build plate materials can be employed to assist with bed adhesion to different plastic filaments. Build plate materials used to establish bed adhesion include aluminum, stainless steel, glass, Kapton tape, PET tape, masking tape and PEI film.[14] Other aids can also be applied to a build plate surface to generate bed adhesion including salt-water solution, glue sticks and hair spray. However, someone skilled in the field of SIR testing understands to avoid the use of ionic surface treatments on PCB assemblies for concern of influencing their overall electrical reliability. Generally, heating of the build plate improves the bed adhesion of the melted plastic filament by enhancing wetting and reducing thermal stress between the extruded filament and cooling plastic layers, which can lead to stress-induced warpage and delamination. To summarize, it is important that the build plate surface is flat, has the option for heating, and is compatible with the printed plastic filament to establish sufficient bed adhesion.

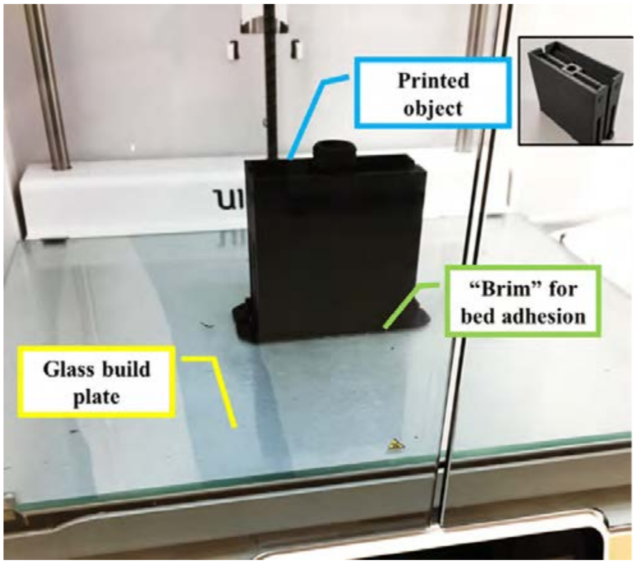


Figure 6. FFF printed object on glass build plate.

Experimental Methodology

Initial attempts at printing onto a PCB. A new aspect of this work compared to the prevailing FFF 3-D-print literature was the desire to print directly onto an FR-4 PCB rather than a traditional build plate. In actuality, the PCB becomes the 3-D-print "substrate," where the desired outcome is permanent attachment of the printed object to the PCB, thus forming a composite structure. This desired outcome varies greatly from traditional FFF 3-D-printing processes in which the object being printed is temporarily fixed to the build plate by bed adhesion for only the duration of the physical printing process. The FR-4 PCBs used for this case study, referred to as "SIR test PCBs" (see Figure 4), were of common construction materials, e.g., epoxy-acrylic solder masks, ImmSn, ENIG, and OSP surface finishes, and 125°C Tg (glass transition temperature) laminates. The initial printed feature attempted was a rectangular prism **(FIGURE 7)** intended to fully encapsulate one entire interdigitated comb pattern on the SIR test PCBs. Initial attempts to print ABS (acrylonitrile butadiene styrene) filament directly onto the SIR test PCB mounted to the top of the glass build plate resulted in the misprint condition shown in **FIGURE 8**. First, it was necessary to fix the PCB to the glass build plate with an adhesive, which has the potential to introduce contamination to an SIR test PCB and should be avoided. Second, it was not possible to efficiently transfer heat into the PCB from the heated, glass build plate for the melted ABS filament to wet to the surface of the PCB. Thus, a solution was needed to both firmly position and heat the PCB substrate during printing.

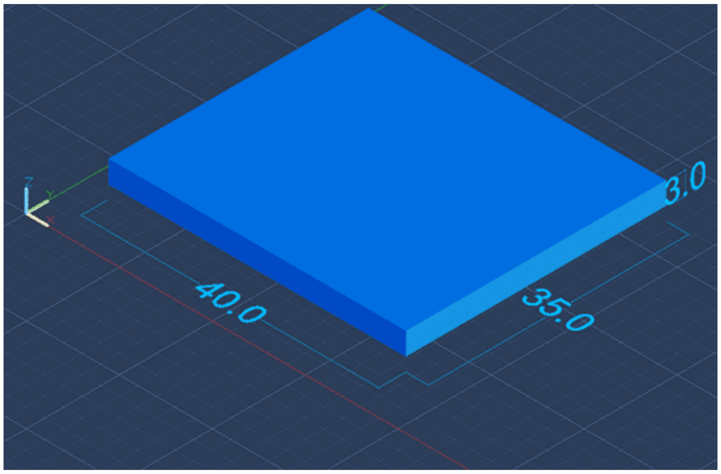


Figure 7. 3-D model, rectangular prism design (mm).

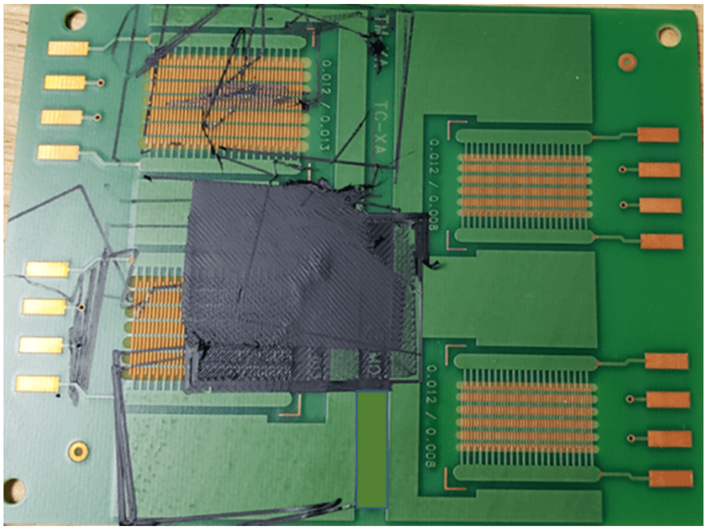


Figure 8. FFF misprint onto PCB using glass build plate.

Custom build plate. A custom build plate was machined from aluminum-2024 having a milled recess or cavity for positioning and retaining the SIR test PCB **(FIGURE 9)**. The aluminum metal also acts to transfer heat to the PCB surface to aid in filament wetting and improving adhesion to the PCB substrate. A thermal interface material may also be placed between the milled recess and PCB to assist in heat transfer to the substrate, if desired. The aluminum build plate could be directly inserted into the commercial 3-D printer. Aluminum-2024 is thermally stable and not prone to warpage. The aluminum plate was compatible with the active leveling program of the 3-D printer, even after 10 cycles. **FIGURE 10** shows the SIR test PCB positioned in the recess of the build plate. The 1.6mm thick PCB's surface is flush with the surface of the aluminum build plate. The 3-D-printer's "g-code" (described below in Equipment and Materials Used) was modified with the assistance of the equipment supplier to permit the build plate to remain heated between prints and to bypass the leveling routine. Heating the aluminum build plate to 120°C required 20 min., plus an additional 5 min. to perform the leveling routine. It was possible to bypass heating and leveling in-between prints and reduce downtime when printing on multiple PCBs.

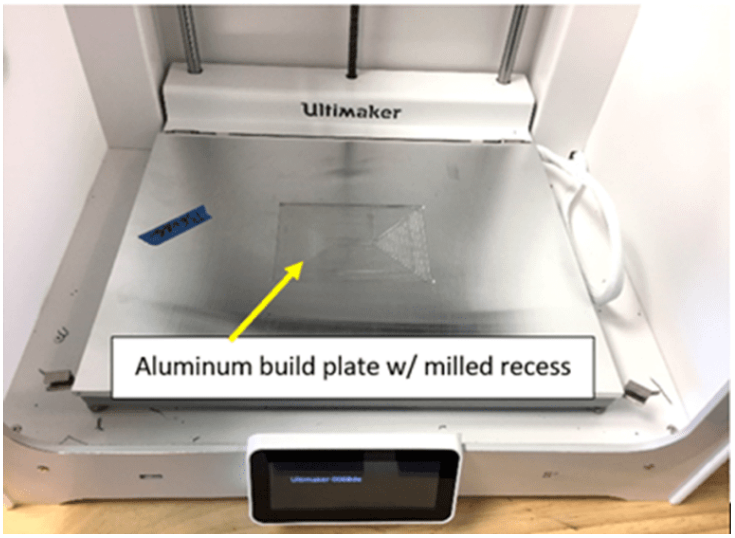
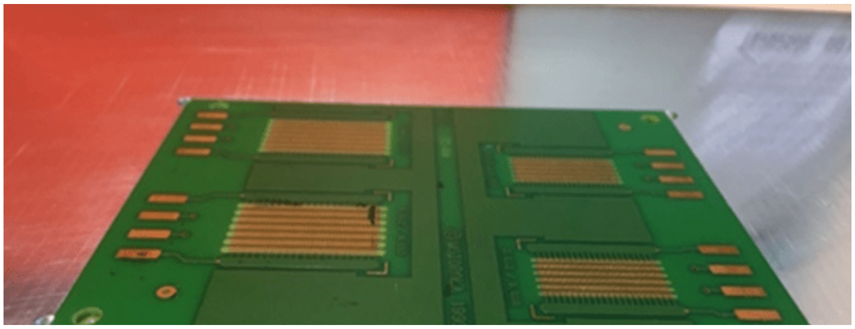


Figure 9. Aluminum build plate with milled recess.



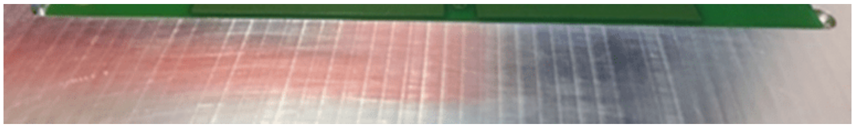


Figure 10. PCB positioned in aluminum build plate.

Design for 3-D printing – the retaining wall structure. The first structure printed onto the PCB using the modified aluminum build plate was a simple rectangular prism (43 x 33 x 3mm) made of ABS plastic (Figure 7). The print process was performed to observe the general adhesion of the material on the SIR comb test pattern. With this structure, the corners of the print contracted and warped **(FIGURE 11)** as the material cooled. This was observed without and with heating of the build plate at 120°C. The prism could be printed onto the PCB, but the adhesion was poor due to stress-induced warping.

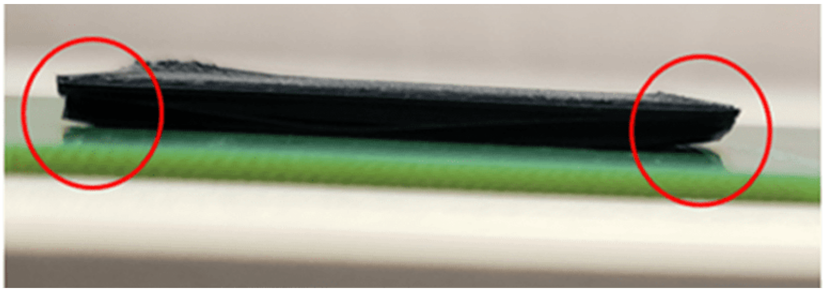


Figure 11. Warping of prism at squared corners.

To reduce the thermal stress on the material, the sharp corners/edges were removed from the original rectangular prism design. Corners were given a small radius, while the sides were tapered **(FIGURE 12)**. With the dimensional changes, the printed ABS filament no longer delaminated from the surface of the PCB. Thus, the thermal stress was reduced, and adhesion was improved.

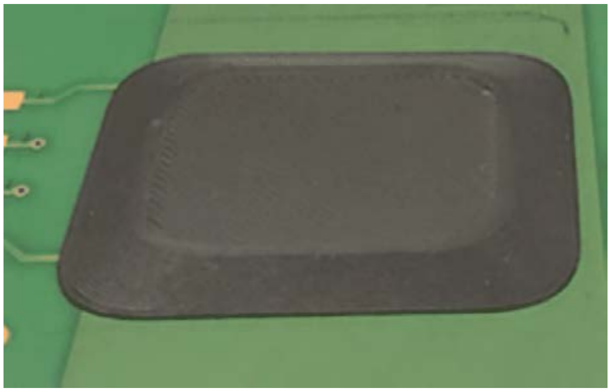


Figure 12. Rounded corners and tapered edges.

A similar design approach to reduce thermal stress was applied to generate the retention walls capable of retaining a liquid encapsulant. In the 3-D model shown in Figure 1, the retaining walls surround the perimeter of the SIR comb test pattern so that liquid encapsulant can easily fill the enclosed area. The dimensions (in mm; see **FIGURES 13** and **14)** represent a typical area and height that a liquid encapsulant may be required to provide protection for a component or circuit. The wall thickness selected for this case study was 4mm with the tapering angle 56° from the horizontal. The corners were rounded with a radius of 2mm to reduce stress on the retaining walls, prevent warping, and improve adhesion of the printed structure to the PCB.

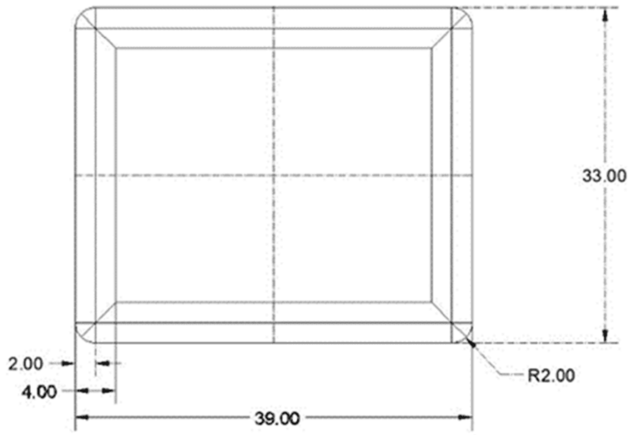


Figure 13. Top view of retaining wall dimensions.

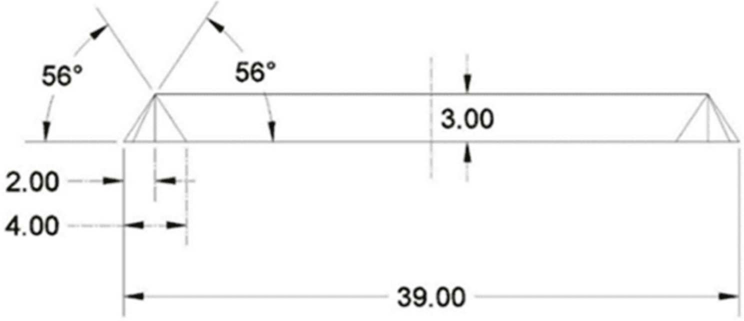
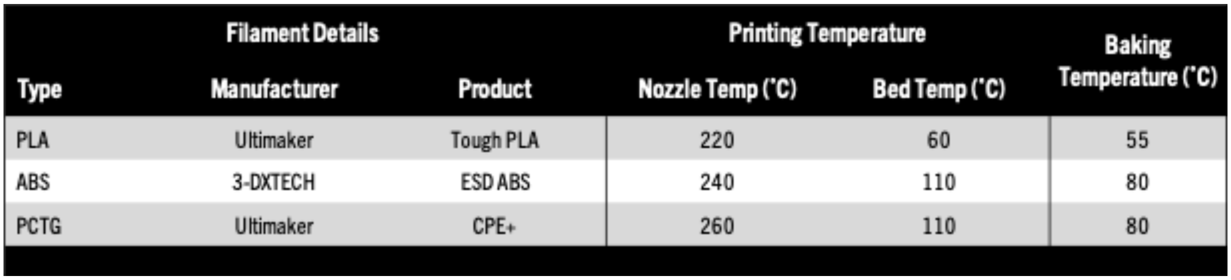


Figure 14. Side view of retaining wall dimensions.

Equipment and materials used. The FFF 3-D printer used for this investigation was a professional desktop Ultimaker S5 open-source printer, which is compatible with third-party plastic filaments. (Au: Note that this work is not a specific endorsement of any 3-D-printer manufacturer.

The methodologies described herein are generic and adaptable to various 3-D-printing equipment.) The filaments and their corresponding printing temperature parameters are listed in **TABLE 1**. Each material was dried at its respective baking temperature for 4 hr. before printing. Three different filament types were selected based on different needs including acceptance in the automotive manufacturing environment, ESD (electrostatic discharge) capability and temperature stability. The x,y,z-resolution of the 3-D printer is specified at 6.9, 6.9 and 2.5µm, respectively. Layer resolution for the 0.8mm nozzle is 20-600µm.

Table 1. Filament Information

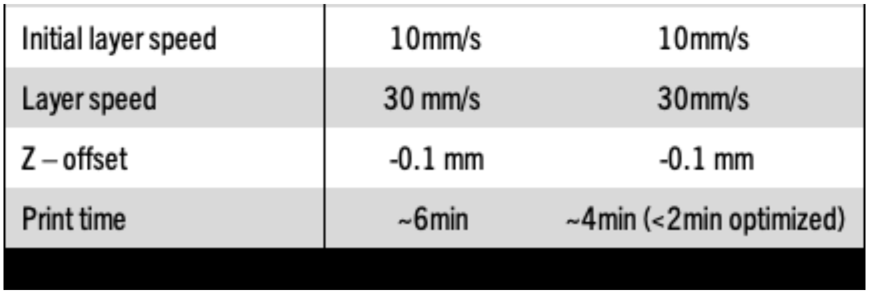


	Filament Details		Printing Temperature		Baking Temperature (°C)
Type	Manufacturer	Product	Nozzle Temp (°C)	Bed Temp (°C)	
PLA	Ultimaker	Tough PLA	220	60	55
ABS	3-DXTECH	ESD ABS	240	110	80
PCTG	Ultimaker	CPE+	260	110	80

The open-sourced software “Cura” was used to adjust print settings and to slice models. The slicing software slices the object “STL” file (drawing file) to contain the information needed to create a 3-D print.[15] The slicing software automatically converts an STL file to g-code. G-code is a widely used computer numerical control programming language in industry and is the language that the printer uses to physically print the 3-D object. The g-code language was modified with the assistance of the printer manufacturer for certain functional aspects described in this work. **TABLE 2** lists two sets of parameters used for the prints. The main difference is the diameter size of the nozzle, which directly influences the amount of extruded material. Although there are many settings to consider, the listed settings focus on the condition of the initial layer. The initial layer is critical to establish adhesion or “anchoring” and will be highlighted in the Results section.

Table 2. Printer Settings

Printer Settings



Initial layer speed	10mm/s	10mm/s
Layer speed	30 mm/s	30mm/s
Z – offset	-0.1 mm	-0.1 mm
Print time	~6min	~4min (<2min optimized)

Results

For the practical application of the retaining walls diagrammed in Figure 1, it was necessary for the printed walls to form a watertight seal with the surface of the SIR test PCB and to possess sufficient adhesive ability to withstand minor mechanical shocks without experiencing separation from the PCB surface. Several approaches were attempted: Approach I, no surface treatment of the PCB; Approach II, cast-polymer surface treatment of the PCB; Approach III, PCB having milled, thin grooves. The results are described below.

Print approach I: No surface pretreatment of PCB. To establish a baseline for adhesion, ABS filament was printed directly onto the SIR test PCB, which was not modified in any way. This approach resulted in poor adhesion of the printed retention wall structure to the PCB. The structures “popped off” with handling or by minimal force. It was estimated that the shear force to remove the material was <22N (<5lbF). The adhesion was too low to withstand minor mechanical shocks a PCB may experience in common handling. Although no shear force measurements were generated due to the poor adhesion, Approach I will be referred to as the “<22N reference for the PCB non-surface treatment” when comparing with the shear force results from Approaches II and III.

It should be noted that other strategies are widely used in the 3-D-printing field to improve bed adhesion by adding features called “brims.”[16] A brim is a layer of filament material that extends along the surface of the print bed from the edges of a 3-D-printed object. Brims help to improve bed adhesion and to prevent warping. The printed object is removed from the build plate after the printing process is complete and the brim is mechanically detached. Figure 6 displays an example of an FFF-printed object having a brim to assist with bed adhesion on the glass build plate. Unfortunately, the brim increases the surface area of the 3-D-printed object, which reduces the space available for components mounted to a PCB. Therefore, it was decided to avoid the use of brims on the retaining wall structure. Thus, another approach was desired to improve the adhesion of the printed retaining wall structure to the PCB.

Print approach II: Cast-polymer surface treatment of PCB. The use of "ABS Juice" has been reported in 3-D-print literature to pretreat the surface of glass build plates to improve bed adhesion and reduce warping of the printed object.[17] ABS Juice is dissolved ABS filament in acetone solvent and the procedure for its preparation is described in the corresponding reference. Generally, the ABS Juice is brushed onto the glass bed while hot and the acetone evaporates, leaving a thin cast film of ABS coating the build plate. To improve adhesion of the initial layer of printed ABS on the SIR test PCB, ABS Juice was prepared and brushed as a thin coating onto the PCB surface around the border of the interdigitated comb pattern where the ABS retaining walls will be printed. The ABS Juice was allowed to dry for 1 hr. at 25°C and then heated on the build plate at 100°C for 10 min. The acetone evaporated as the thin coating was heated, leaving a layer of ABS **(FIGURE 15)**. The deposited or "cast" ABS polymer layer acted as a foundation for the 3-D printer to print the ABS retaining walls. The printed retaining walls had greater adhesion than with no surface treatment of the PCB and could be measured using an Instron. The shear test configuration used to measure the push off force of the retaining wall frame structures is shown in **FIGURE 16**. The SIR test PCB was held on the bottom side in a vise and a chisel tool was used to push on one wall of the printed retaining wall from the top direction. The crosshead speed used for the shear test was 10mm/min. With the addition of the ABS Juice surface pretreatment, the average shear force to push off the printed ABS retaining walls increased to an average of 49N **(FIGURE 17,** orange dots indicate maximum shear forces at failure), compared to the <22N reference for the PCB non-surface treatment approach (red-dashed line).

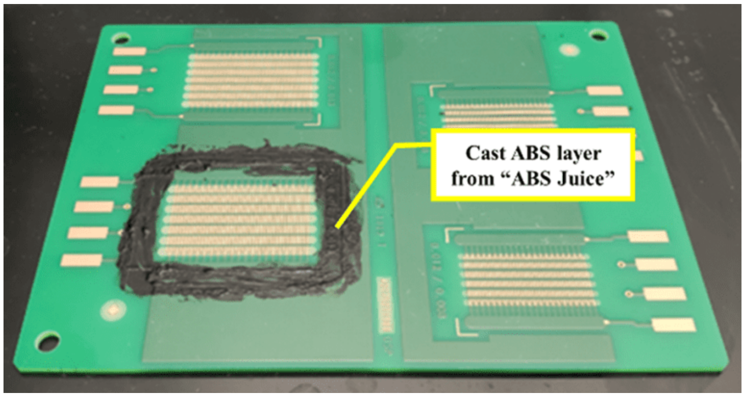


Figure 15. ABS layer cast around comb pattern.

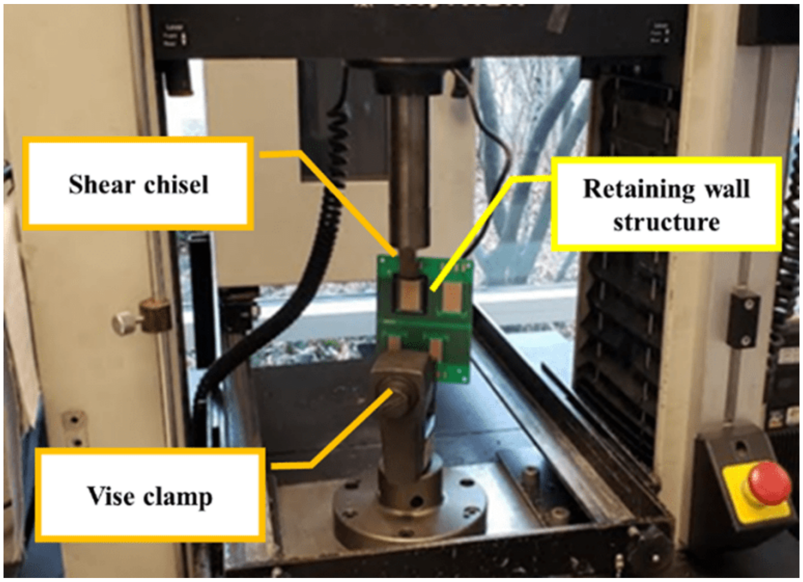


Figure 16. Instron setup for shear test.

The ABS Juice or cast polymer surface preparation method enhanced the adhesion of the ABS printed retaining walls to the point where the PCB composite structures could be handled carefully and remain intact. Note, however, that it is nonideal to use the solvent mixture to prepare the PCB surface for 3-D printing. Control of the applied ABS Juice is not precise and the solvent itself may result in adverse reactions hindering circuit reliability. Additionally, more aggressive solvents may be necessary depending on the type of plastic filament used to generate the cast polymer layer. Thus, another approach was desired to improve the structural adhesion of the printed retention walls other than polymer casting.

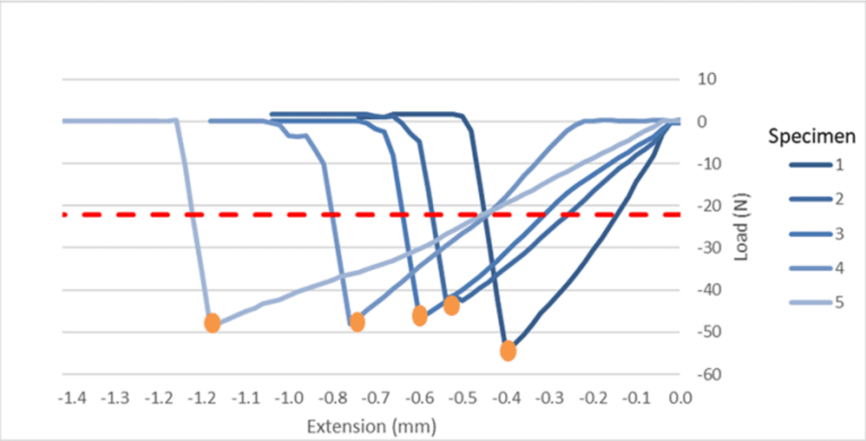


Figure 17. Shear force of ABS wall structure after pretreatment of PCB surface with ABS Juice.

Print approach III: PCB having milled, thin grooves. The next, and ultimately successful approach, was to enable mechanical adhesion or mechanical anchoring by physically modifying the PCB. The perimeter of the comb pattern was milled to create thin grooves on three sides of the PCB comb pattern (**FIGURES 18** to **20**). The grooves have a width of 0.8mm and a depth of 1.0mm. One side of the comb pattern was not milled to preserve the copper signal traces for SIR test measurements. Future work will place the signal traces on the opposite side of the PCB and use conductive vias to route to the comb test pattern. The 1.0mm deep milled grooves do not extend all the way through the 1.6mm thickness of the PCB and it is still possible to route traces under the milled grooves. The grooves can be created at the PCB suppliers' factories at the same time the standard routing and milling operations are performed. Thus, no secondary milling operation of the PCB would be required as was performed for this work.

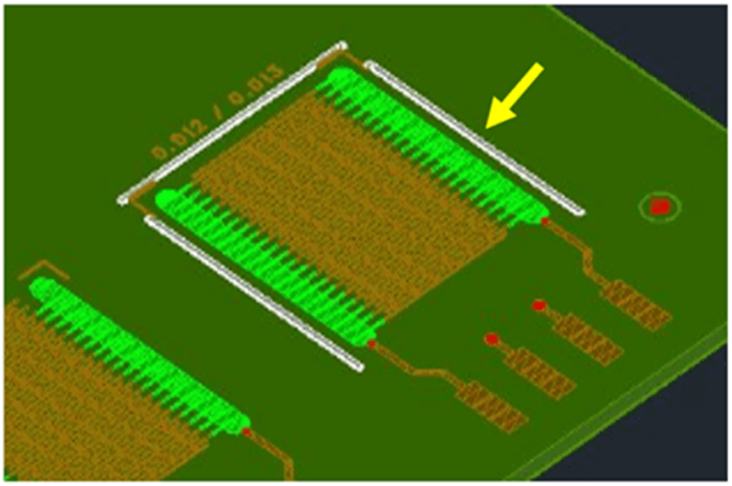


Figure 18. Drawing of milled grooves in PCB.

The FFF 3-D-printed filament was extruded into the milled grooves, using the printer parameters listed in Table 2, creating additional points of mechanical "lock & key," or anchoring within the PCB epoxy-glass laminate region. The possibility also exists for improved adhesion through attractive molecular forces of the glass fiber surface and the printed plastic. To fill the milled grooves, it was necessary to modify the g-code language and enable the printer to print with a negative z-offset over the grooves. Typically, there is a minimum z-offset to prevent the nozzle from impacting the build plate while printing, thus protecting the equipment. The negative z-offset setting was added to change the distance between the nozzle and the build plate. This permitted the nozzle to sit flush against the PCB grooves.

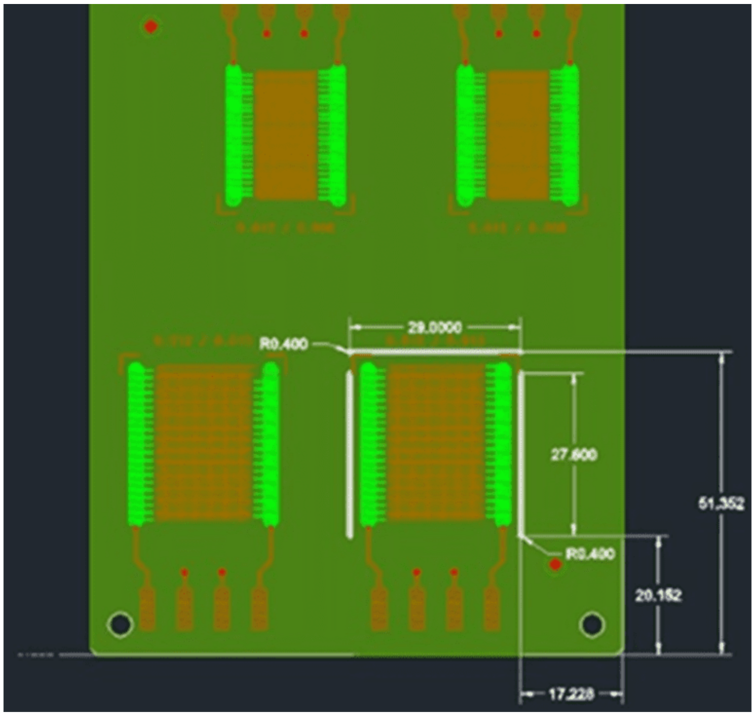


Figure 19. Groove dimensions, 0.8mm W x 1.0mm D.

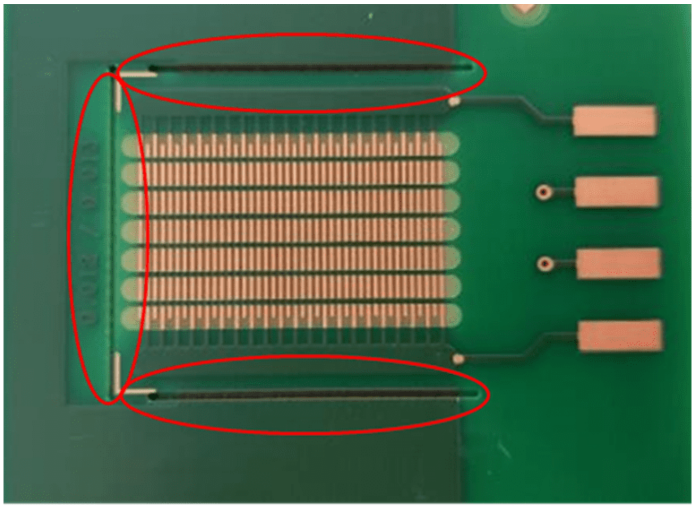


Figure 20. Milled grooves in PCB for anchoring.

In addition to the print parameters listed in Table 2, the ratio of extrusion nozzle diameter to the groove width is important for maximizing structural adhesion. Printing with a 0.6mm diameter nozzle into a 0.8mm groove yields the shear force data shown in **FIGURE 21**. As can be observed, the average shear retention force is increased to 111N (see orange dots for maximum shear forces at failure) using the milled, thin grooves. This compares to the approximately 49N for the ABS/acetone PCB pretreatment method shown in Figure 17 and the <22N reference for the PCB non-surface treatment approach (red-dashed line). There is a notable amount of variance between test specimens, however.

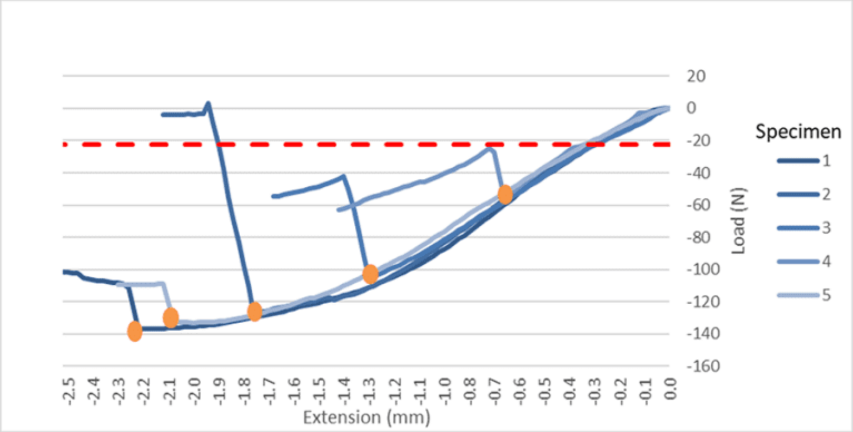


Figure 21. Shear force of ABS wall structure with PCB grooves; 0.6mm diameter extrusion nozzle.

When examining the underside of the removed printed retaining walls, it was observed that the ABS filament did not completely extrude and fill the grooves, see **FIGURE 22**. The incomplete filling of the grooves with ABS using the 0.6mm nozzle was believed to be a contributing factor behind the force variations observed in the shear data shown in Figure 21.

Figure 22. Removed retaining wall structures showing incomplete ABS extrusion into 0.8mm PCB grooves using 0.6mm diameter nozzle.

To maximize the potential benefits of the grooves for mechanical anchoring, additional PCB composite structures were printed using a 0.8mm diameter extrusion nozzle that matched the width of the PCB grooves. Printer variables including z-offset and print speed were held constant. **FIGURE 23** shows the 0.8mm diameter nozzle together with ABS filament gave consistent and higher shear force values, exceeding 133N, compared to the <22N reference for the PCB non-surface treatment approach (red-dashed line). The shear values would be even greater, but the plastic material itself deformed and cracked during the shear testing **(FIGURE 24)**. The mechanical anchoring ability of the groove features exceeded the strength of the ABS plastic walls. Please also note that the Instron chisel applied the push-off force directly to the one wall of the printed retaining wall frame that was not anchored by the milled grooves – i.e., the weakest of the four walls of the printed retaining wall structure – thus producing the worst-case shear result for the printed retaining wall structure.

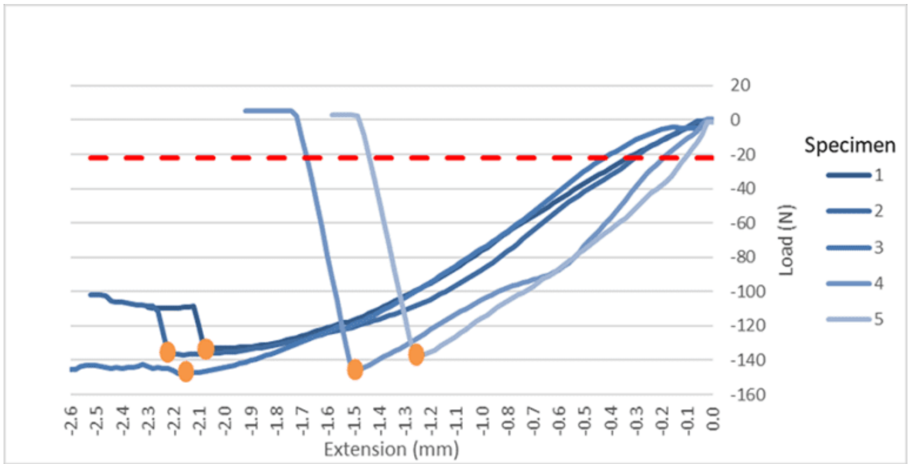


Figure 23. Shear force of ABS wall structure with PCB grooves; 0.8mm diameter extrusion nozzle.

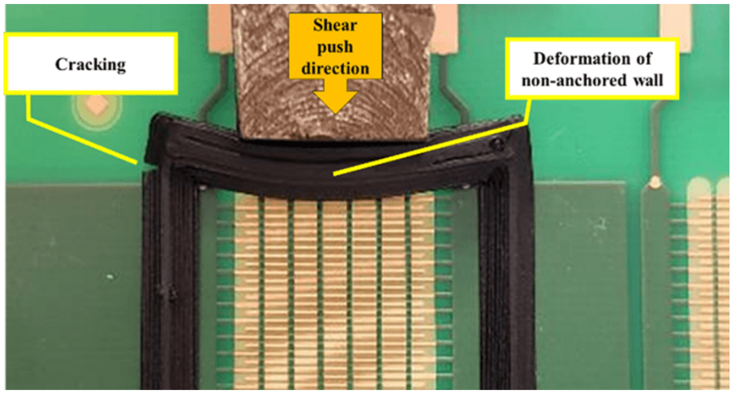


Figure 24. Deformation and cracking of ABS wall structure during Shear due to superior mechanical anchoring of filled 0.8mm grooves. Specimen printed using 0.8mm diameter extrusion nozzle.

Inspection of the removed retaining wall structure shown in **FIGURE 25** revealed that the PCB grooves had filled completely when using the 0.8mm diameter extrusion nozzle along with the same z-offset and print speed as used for the 0.6mm nozzle. Thus, matching the nozzle diameter with the PCB groove width is an important design-for-print parameter for creating robust PCB composite structures. The variance observed in the shear data for the 0.6mm diameter nozzle was no longer observed with the 0.8mm nozzle, thus confirming that the complete filling of the grooves with plastic is important to establish consistent anchoring strength. The 0.8mm width PCB groove/0.8mm diameter extrusion nozzle, along with the process parameters listed in Table 2, and the wall design features described in Figures 13 and 14, yielded a 3-D-printed, ABS retaining wall/PCB composite structure that could be securely handled for additional processing and testing.

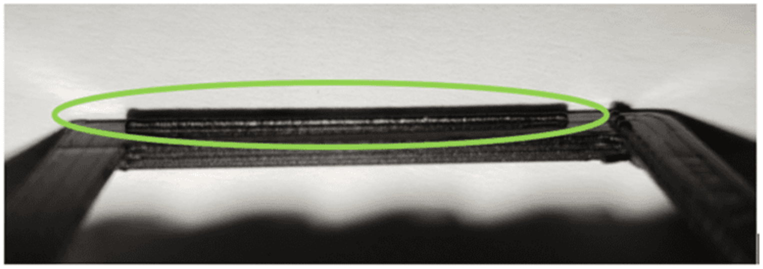


Figure 25. Removed wall structure showing full ABS filling of 0.8mm PCB grooves using 0.8mm diameter extrusion nozzle and parameters in Table 2.

The following investigations examined different plastic filament materials by applying the optimized 0.8mm diameter nozzle parameters from Table 2.

Plastic filament materials evaluated. As mentioned in Experimental Methodology, three different plastic filament materials were evaluated based on different needs: 1) acceptance in the automotive manufacturing environment, 2) ESD capability, and 3) temperature stability. All work described thus far has been with the ABS filament listed in Table 1. ABS filament is generally used for applications where strength, ductility, machinability, and thermal stability (95°C) are required. The ABS filament used for this work has an additional characteristic of being an ESD-safe filament, formulated for applications that require ESD protection. ESD protection is a general concern with the handling of electronics devices and the ESD-safe filament was thus evaluated. In addition to ABS, the FFF filaments "Tough PLA" (polylactic acid) and PCTG "CPE+" (polycyclohexylenedimethylene terephthalate glycol-modified) were also evaluated. PLA is a vegetable-based, renewable-source plastic. PCTG is a derivative of the PETG plastic category. PCTG is known for its toughness, wear, chemical, and temperature resistance (100°C vs. 60°C for PLA).

The same design-for-print methodology that had been implemented for the ABS filament (Table 2; 0.8mm diameter nozzle), was utilized for the PLA and PETG filaments to demonstrate whether the success described above for the ABS filament could be expanded to different filament materials.

The shear force data presented in **FIGURE 26** are for the printed PLA filament and in **FIGURE 27** for the printed PCTG filament. Unlike the ABS printed retaining wall/PCB composite structures, the PLA and PCTG printed retaining walls did not detach from the PCB during shear test. Instead, the retaining walls remained anchored in place, while the material deformed from the applied force of the Instron chisel. This observation was reflected within the shear force graphs – showing no instantaneous change in load indicative of a sudden separation. For this reason, these graphs are more representative of the material strengths of the PLA and PCTG filaments rather than their ability to remain mechanically anchored to the PCBs. The PLA retaining walls deformed at an average force of 165N as shown in Figure 26 vs. the <22N reference for the PCB non-surface treatment approach (red-dashed line). The PCTG retaining walls deformed at a lower applied shear load than with the PLA.

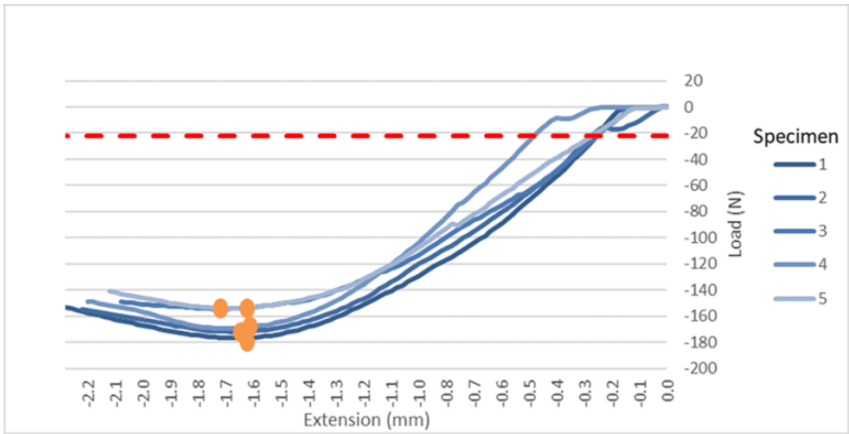


Figure 26. Shear force of PLA wall structure with PCB grooves; 0.8mm diameter extrusion nozzle.

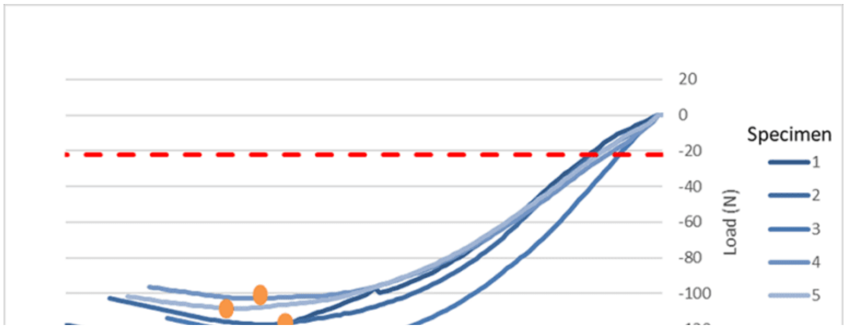


Figure 27. Shear force of PCTG wall structure with PCB grooves; 0.8mm diameter extrusion nozzle.

Figure 27 shows that the 0.8mm nozzle together with PCTG filament also gave very consistent shear values, 102-133N vs. the <22N reference for the PCB non-surface treatment approach (red-dashed line). The PCTG has higher temperature stability, and is also flexible, so the shear force data are not indicative of any loss of the mechanical anchoring adhesion of the PCTG to the milled PCB grooves, but rather the values are representative of the deformation of the PCTG plastic material itself. The 0.8mm width PCB groove printed with the 0.8mm diameter extrusion nozzle, along with the process parameters listed in Table 2, and the wall design features described in Figures 13 and 14, yielded 3-D-printed, PLA and PCTG retaining wall/PCB composite structures that could be securely handled for additional processing and testing.

3-D-print process time required to create the retaining wall structures. It was desirable to print the plastic structures within a cycle time comparable to other PCB assembly processes, such as a solder reflow process, where thermal profiles take approximately 5 min. With basic printer and software optimization enhancements, the retention walls were printed in under 2 min., using PCTG filament and the 0.8mm diameter nozzle, thus enabling the possibility of volume scalability. Extrusion of melted plastic into the milled groove is a key step requiring adherence to the parameters listed in Table 2 but the time required for printing the remaining retaining wall structure can be further optimized by employing additional print speed, layer height, infill pattern, and shell strategies with the slicing software.[18] There was a general concern that further effort to reduce print time could impact the print quality and mechanical properties of the retaining wall and the time limits were not pushed any further. 3-D printers and materials are experiencing rapid advancements which should lead to the possibility of further cycle time reductions in the future without a significant impact to quality.

Retaining wall / SIR test PCB composite structures filled with a liquid-dispensed encapsulant. **FIGURE 28** shows the PCTG printed retaining walls on the SIR Test PCB following extrusion into the fine grooves. The mechanical anchoring strength was greatly enhanced by the milled, thin groove features as demonstrated in the Figure 27 shear data. **FIGURE 29** shows the encapsulant-filled, PCTG printed retaining walls. **FIGURE 30** is a magnified view of the encapsulated comb circuit on the SIR test PCB. **FIGURE 31** shows the PCTG printed retaining wall composite structure's ability to create a watertight seal to the PCB surface.

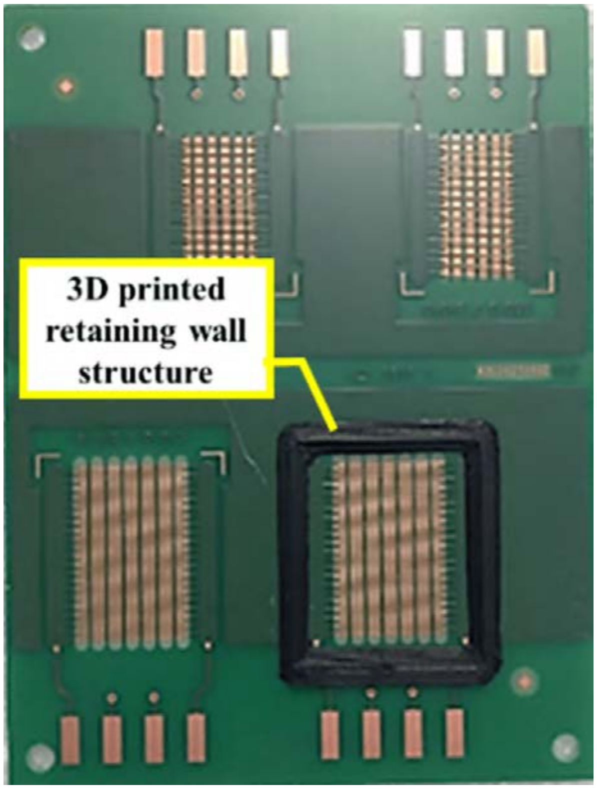


Figure 28. PCTG retaining wall on SIR test PCB.

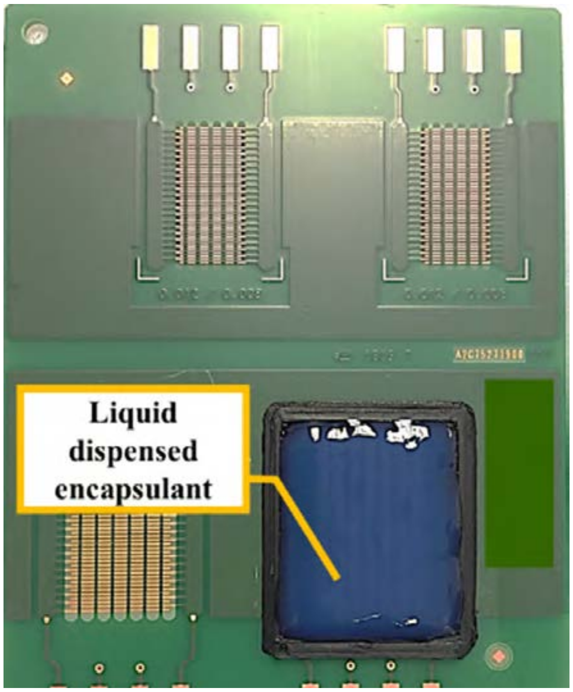


Figure 29. Encapsulated SIR test PCB circuit.

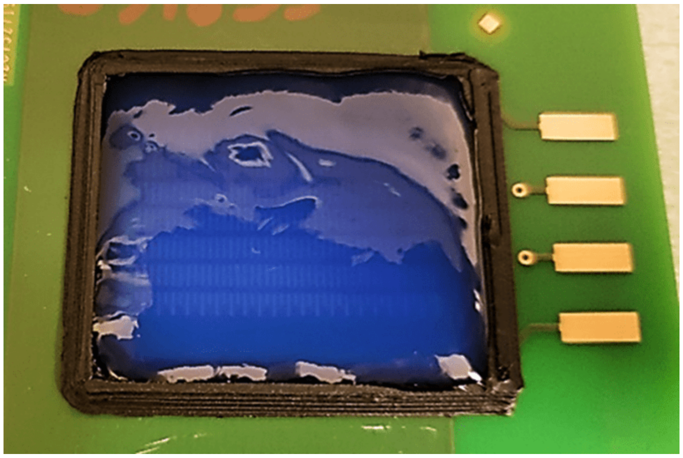
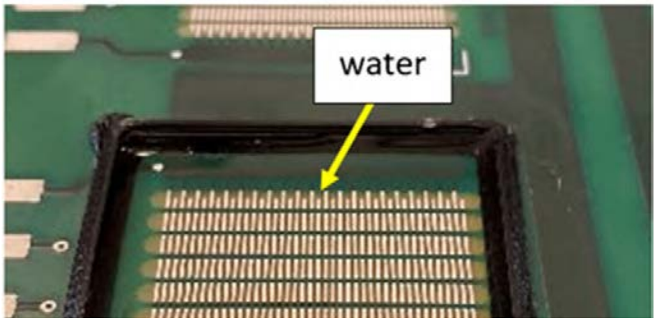


Figure 30. Magnified retaining wall with encapsulant.

Heat treatment impact on 3-D-printed, plastic/PCB composite structures. The impact of post-print heating on the adhesion of PCB composite structures was also investigated. Some liquid-dispensed encapsulants require heating to cure. To investigate the impact of temperature on adhesion of the printed structure, the PCTG/PCB composite structures were heated to 100°C for 1 hr. Next, the PCBs were cooled to room temperature and the shear force evaluated in the same manner as the printed retaining walls without the post-heat treatment. As observed in **FIGURE 32**, the shear force values were consistent and ranged between 111-133N, indicating no degradation in adhesion of the PCTG printed wall structures occurred due to thermal exposure when compared to the non-heat-treatment shear values in Figure 27. Once again, the red-dashed line represents the <22N reference for the PCB non-surface treatment approach.



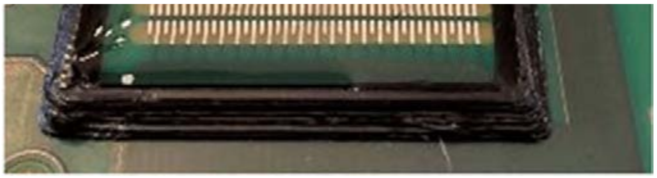


Figure 31. PCTG wall retaining water.

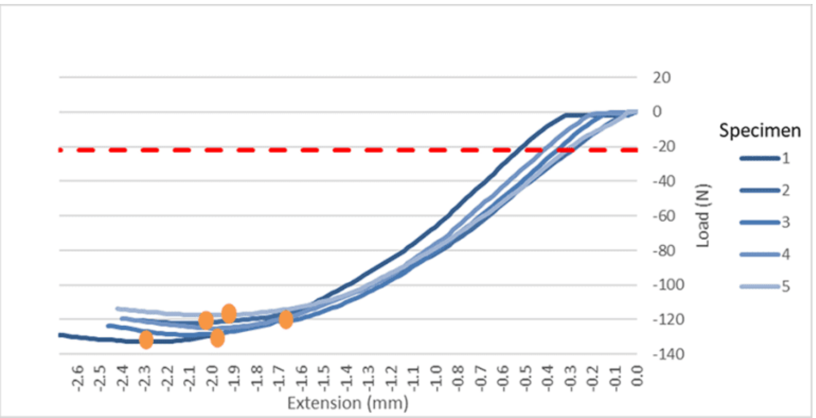
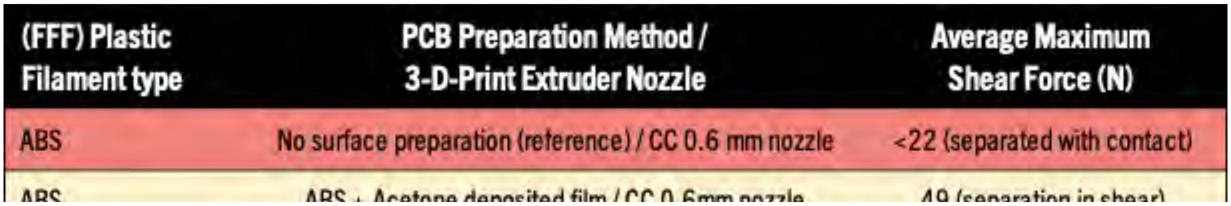


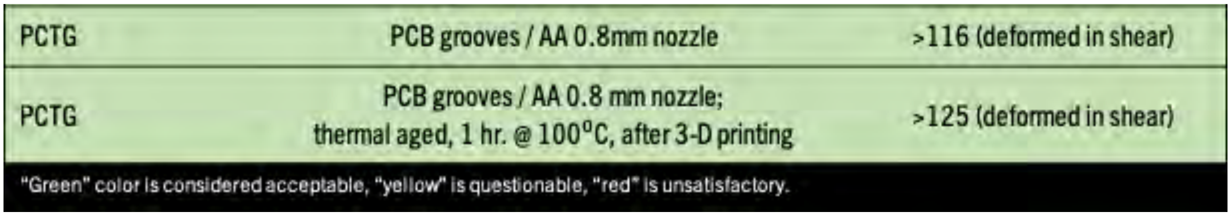
Figure 32. Shear force of PCTG wall structure with PCB grooves; 0.8mm dia. nozzle; exposure to 100°C for 1 hr.

The shear force adhesion data reported above are summarized and compared in **TABLE 3**. Note that printing into the milled, thin grooves of the PCB substrate provided excellent anchoring of the 3-D retaining wall structure for the three types of plastic filaments evaluated: ABS, PLA and PCTG. The plastic materials themselves cracked or deformed before the retaining wall structure detached from the PCB. The printed retaining wall/PCB composite structures could be handled normally during dispense and cure operations, with no separation of the retaining wall structures from the PCBs.

Table 3. Summary of Retaining Wall Structure Shear Test Results Based on Different Factors



(FFF) Plastic Filament type	PCB Preparation Method / 3-D-Print Extruder Nozzle	Average Maximum Shear Force (N)
ABS	No surface preparation (reference) / CC 0.6 mm nozzle	<22 (separated with contact)
ABS	ABS + Acetone deposited film / CC 0.6mm nozzle	49 (separation in shear)



PCTG	PCB grooves / AA 0.8mm nozzle	>116 (deformed in shear)
PCTG	PCB grooves / AA 0.8 mm nozzle; thermal aged, 1 hr. @ 100°C, after 3-D printing	>125 (deformed in shear)

"Green" color is considered acceptable, "yellow" is questionable, "red" is unsatisfactory.

Discussion

This article details a methodical experimental approach that ultimately led to the appropriate design, equipment, process, and material parameters required for the successful formation of 3-D-printed plastic/PCB composite retention wall structures.[19] The key parameters are summarized in this section.

FFF 3-D printer physical modifications. A conventional, desktop FFF 3-D printer was used and described herein. Professional desktop FFF printers are relatively low cost, ubiquitous in industry, and some offer open-source materials and software usage, which permit expanded development opportunities. However, in a paradigm shift from routine FFF 3-D-printing work, where objects are created layer-by-layer on the build plate and then removed afterward as a finished or semifinished part, the intention of this work was to create a structurally anchored object onto a PCB as a permanent composite structure. It was found that attaching a PCB to a conventional glass build plate led to a misprinted object due to insufficient "bed adhesion" to the PCB substrate. An aluminum build plate was developed (Figure 9), having a milled recess and specific dimensions to fix the PCB in the x,y-direction and flush with the aluminum build plate surface in the z-direction (Figure 10). Heat transfer to the PCB surface was improved and the PCB could be held in position without tape or fasteners. The modified aluminum build plate was inserted into the 3-D printer, replacing the glass build plate. Printing objects onto the "as received" PCBs was made possible with the aluminum build plate, albeit with limited adhesion initially due to thermal stress (Figure 11).

Design for stress reduction in retaining wall structure. One aspect for improving adhesion between the 3-D-printed retaining walls and PCBs was to maintain thermal stress to a minimum. Thermal stress leads to warping and often delamination from the build surface. To minimize stress, rounded corners and tapered edges were incorporated into the retaining wall design as described in Figures 12-14. The stress-minimized design led to a PCB printed structure without warping but adhesion was still not suitable for handling purposes.

Design of milled, fine grooves in PCB surface. The creation of milled, thin grooves (0.8mm width x 1.0mm depth) into the PCB surface, where 3-D printing of filament was possible, ultimately led to the robust mechanical anchoring, and water tightness, of the 3-D-printed retaining wall structure to the PCB. The milled, thin grooves are shown in Figures 18-20. The grooves did not extend through the entire thickness of the PCB (1.6mm PCB thickness vs. 1.0mm groove depth), thus leaving the possibility to route conductor traces opposite the thin grooves. The fine grooves were milled in-house but could also be created at the PCB manufacturers during standard routing operations. The grooves were not created where copper signal traces were present to allow for electrical testing. Future SIR test PCB designs will route the copper signal traces in a manner to permit groove formation on the full perimeter of the test circuit. Nevertheless, having grooves anchoring three of the four walls of the retaining wall structure was sufficient to produce secure handling and processability along with encapsulant (Figure 30) and water tightness (Figure 31). The effective mechanical anchoring of the 3-D-printed filaments to the PCB milled grooves required additional process development and minor software modifications discussed below.

Print parameters and printing time. The print parameters for the key initial print layer, required to fill the groves, are summarized in Table 2. Minor manipulation of the printer's g-code language was required to enable a negative z-offset print direction to fill the milled grooves on the PCB. Also important was to match the nozzle diameter with the groove width, at 0.8mm, in order to achieve complete fill of the grooves (see Figures 22 and 25). The time required for printing the retaining wall structure was optimized to under 2 min. without any rigorous effort invested to reduce the overall print time. The printer's g-code language was also modified to enable continuous heating and leveling of the aluminum build plate to eliminate downtime between prints. A print time of under 2 min. is comparable to other electronics manufacturing processes such as reflow soldering, which takes approximately 5 min. Additional print time reductions are possible by employing print speed, layer height, infill pattern, and shell strategies with the slicing software. Thus, high-volume scalability of 3-D-printed/PCB composite structures is possible under the appropriate circumstances. Additionally, 3-D-printer technologies including print capability and materials are developing rapidly and greater efficiencies are likely to be realized in the future.

Overall effectiveness and adaptability of the milled, thin PCB grooves and print parameters with different filaments. The effectiveness of the milled, thin PCB grooves, in combination with the print parameter development, in establishing mechanical anchoring adhesion, was demonstrated with three different filament materials, ABS, PLA and PCTG (see Figures 23, 26, and 27). The 0.8mm width PCB groove printed with the 0.8mm diameter extrusion nozzle, along with the process parameters listed in Table 2, and the wall design features described in Figures 13 and 14, yielded 3-D-printed ABS, PLA, and PCTG retaining wall/PCB composite structures that could be securely handled for additional processing and testing. The retention walls also maintained their adhesion during a subsequent heating process (representing the encapsulant cure). As summarized in Table 3, the three different filaments evaluated gave excellent anchoring adhesion that exceeded the inherent mechanical strength of the printed plastic materials themselves. The height of the retaining wall structures in this work was 3mm but could be made higher or lower depending on the circuit or component that requires encapsulant protection. The approach described in this case study to create 3-D-printed/PCB composite structures could be widely applicable to other designs, applications, and materials.

The encapsulant-filled retaining wall structures can assist to protect critical circuits from chemical, mechanical and electrical external factors like moisture, fluids, gasses, particulate contamination, physical contact or arcing in applications requiring high voltage. The retaining walls can be designed and printed to almost unlimited geometries and shapes to optimize the amount of protective material used and to protect varying topographies of devices and circuits. The SIR test PCB described in this work can be used as a basis to evaluate a myriad of encapsulants and polymeric materials under different environmental conditions. Similar design, process, and materials principles described in this work to create the 3-D-printed retention walls on an IPC-B-24 style test PCBs could also be considered for populated test assemblies like the IPC-B-52 test assembly.[20]

Conclusions

This paper presented the novel case study of using FFF 3-D printing to extrude melted plastic filament directly into thin grooves formed on a conventional PCB thereby creating mechanical anchoring adhesion from which to print retaining walls for the location-controlled encapsulation of critical circuits. Newly described in this work, 1) a 3-D-printer build plate, having a dimensionally specified recess, was developed using aluminum to fix and heat the surface of the PCB substrate, 2) an FR-4 PCB was used as a 3-D-print substrate to create a composite plastic structure, 3) plastic retention wall design features were developed to minimize thermal stress, 4) thin grooves were milled into the PCB surface and used to anchor the printed filament, 5) the 3-D-print dispense nozzle diameter was optimized to the width of the PCB milled groove and 6) 3-D-print process parameters were developed to ensure complete filling of the grooves during the first print pass. The design, process, and material parameters were detailed. Only minor modifications of the printer's g-code language were required to ensure filling of the thin milled grooves and to reduce downtime in-between prints that would have been caused by the re-heating of the aluminum build plate. The approach and methodology are flexible and adaptable and can be applied to the creation of other new 3-D-printed plastic/PCB composite structures. The equipment and materials used to create the 3-D-printed retention walls are low cost, readily available, and required only minor modifications. The 3-D-print time, under 2 min., is comparable to other typical manufacturing processes like reflow soldering and has the potential for volume scalability. The 3-D-printed retaining walls created on SIR test PCBs can be used to develop circuit protection strategies for products operating in harsh environments such as Automotive.

Acknowledgments

The authors would like to thank Jeremy Simon for helpful discussions on the printer's g-code and how it could be adjusted for certain aspects of this work, as described in the paper.

This article is adapted from a paper titled "3-D Printing of Plastic Structures onto PCBs for Circuit Protection Strategies" and was first presented at the 2023 IPC Apex Expo Technical Conference, with original work published within conference proceedings.

REFERENCES

1. S.J. Adamson and C.Q. Ness, "Dam and Fill Encapsulation for Microelectronic Packages," Proceedings of Nepcon West, February 1999.
2. J. Flynt, "How Much Does 3-D Printing Filament Cost?" *3-D Insider,* Sept. 10, 2017.
3. J. Nulman, "Advances in Multi-level and Multi-material Additively Manufactured Electronic (AME) Circuits and Devices," Proceedings of IPC Apex Expo, January 2022.
4. J. Benoit, N. Willey, J. Goldfarb and K. Church, "Conformal Printed Circuit Structures," Proceedings of IPC Apex Expo, January 2022.
5. J.H. Lau, C.P. Wong, N.C. Lee and S.W.R. Lee, Electronics Manufacturing with Lead-Free, Halogen-Free, & Conductive-

Adhesive Materials, McGraw-Hill, chapter 15, 2003.

6. IPC, IPC-7801, *Reflow Oven Process Control Standard,* section 4, March 2015.

7. L.C. Cohen and S.F. Rak, "SIR Test Method for Underfill Reliability in Automotive Electronics," IPC Electronics Materials Forum, Nov. 5, 2019.

8. IPC, IPC-9201A, Surface Insulation Resistance Handbook, August 2007.

9. IPC, IPC-TM-650, Test Methods Manual, Surface Insulation Resistance, method 2.6.3.7.

10. K. Bawagan, C.M. Pamatmat and S.F. Rak, "Surface Insulation Resistance (SIR) Test for Raw Material Release," IPC WorksAsia and Automotive Electronics Reliability Conference, Jun. 23, 2017.

11. BCN3-D Technologies, Inc., Introduction to Fused Filament Fabrication (FFF) 3-D Printing Technology, WH-03-EN-v1.2, 2019.

12. G. Khanolkar, "Difference between FDM and FFF Technologies," Mar. 15, 2018, https://blogs.truventor.ai.

13. Manufactur3-D, "How Does the FDM 3-D Printing Technology Work?" *Manufactur3-D Magazine,* Jan. 29, 2018.

14. B. Goldschmidt, "3-D Printer Bed Adhesion: All You Need to Know," *All3-DP,* Jun. 26, 2022.

15. Ultimaker "Cura" is a free 3-D printing software at ultimaker.com. It can be integrated with CAD software or customized.

16. A. Chavan, "3-D Printing Brim: When Should You Use It," *All3-DP,* Jul. 11, 2018.

17. MatterHackers (2015, December 18). *ABS Bed Adhesion Tips & Tricks,* www.matterhackers.com.

18. O'Connell, J. (2021, May 6) *Fast 3-D Prints: How to Increase Your 3-D Printing Speed, All3-DP,* ~~www.all3dp.com~~.

19. S.F. Rak and D. Tseung, Sept. 10, 2021, patent pending.

20. IPC, IPC-9202, Material and Process Characterization/Qualification Test Protocol for Assessing Electrochemical Performance, October 2011.

STANTON F. RAK, PH.D., is the Principal at S.F. Rak Company, specializing in materials science and electronics manufacturing consulting for the automotive industry. Previously, he worked 29 years combined at Continental Automotive and Motorola Automotive Group in global, manufacturing technology roles. Rak has a doctorate in organic chemistry from the University of Minnesota; stanton@sfrak.com. **DAVID TSEUNG** is a production engineer at Nouryon. He has a bachelor's in chemical engineering from Illinois Institute of Technology.

2023 **SALARY SURVEY**

Show Them the Money

Compensation continues to rise among PCB designers.

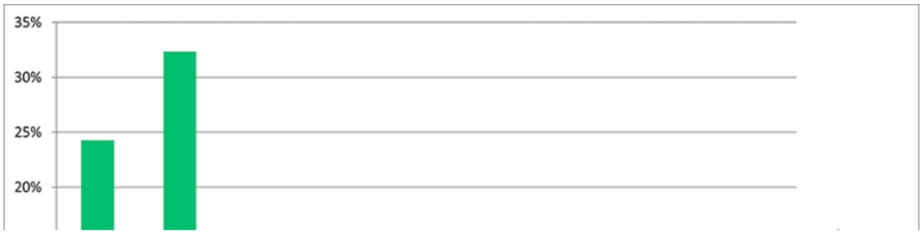
by TYLER HANES

After last year saw an explosion in printed circuit designers and design engineers reporting salaries above $150,000, this year's survey conducted by PCD&F/CIRCUITS ASSEMBLY found an even higher number, with 22% reporting their salaries in that range, compared to 19% in 2022.

The percentage of designers making more than $100,000 annually also rose from last year's results, with 55% in 2023 compared to 35% last year, and around 83% of designers reported receiving raises over the past year.

PCD&F/CIRCUITS ASSEMBLY surveyed designers and design engineers this year from mid-July to Aug. 23. More than 170 designers responded to the survey, answering questions related to job titles and functions, ages, years of experience, education, location, types of projects, annual salaries and sales, job satisfaction and challenges, ECAD tools used, and years left in the field.

As of August, the US unemployment rate stood at 3.5% with average hourly earnings increasing by 4.4% over the last 12 months.[1] For respondents, salaries have mostly followed in line with national trends. Of those who saw a raise, 32% of those surveyed said their pay increased 4-6% in the past year, 24% saw their salaries increased by 1-3%, and 16% felt the love from their employers with a raise of more than 10% **(FIGURE 1)**.



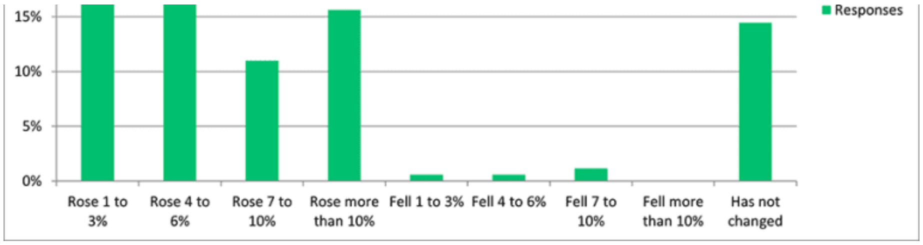


Figure 1. Change in salary over the past year. (n=173)

Nearly half of the respondents – 48% – said they were at the top of their company's salary range for their position, while 52% reported that they still have room to grow in their organization.

Salaries were not the only form of compensation that increased for the year. A greater percentage of designers – 64% – reported receiving an annual bonus, compared to 55% in 2022. The bonuses trended higher as well, with 47% of those receiving a bonus indicating that it totaled more than 7% of their annual salary **(FIGURE 2)**.

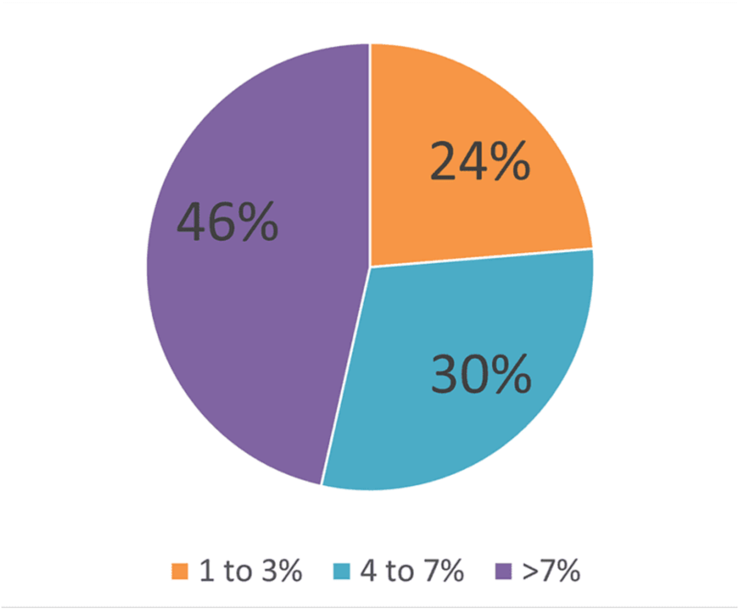


Figure 2. Percentage of current salary as bonus.
(n=119)

While the money continues to flow, more designers are indicating that they are satisfied with their current positions. Some 77% of respondents reported being mostly satisfied. But while they may be comfortable now, companies shouldn't rest, as just 44% of designers said they planned to be in their current job for the next one to five years.

Respondents. PCB designers are getting older, but there has been an influx of youth in recent years, as the top responses for years of experience in the industry were the upper and lower ranges.

Slightly more than 30% of respondents said they had more than 30 years of experience in PCB design, while 18% said they had been in the field just one to five years. Both responses are trending younger than last year's results, which found nearly 40% with more than 30 years of experience and 15% with one to five years **(FIGURE 3)**.

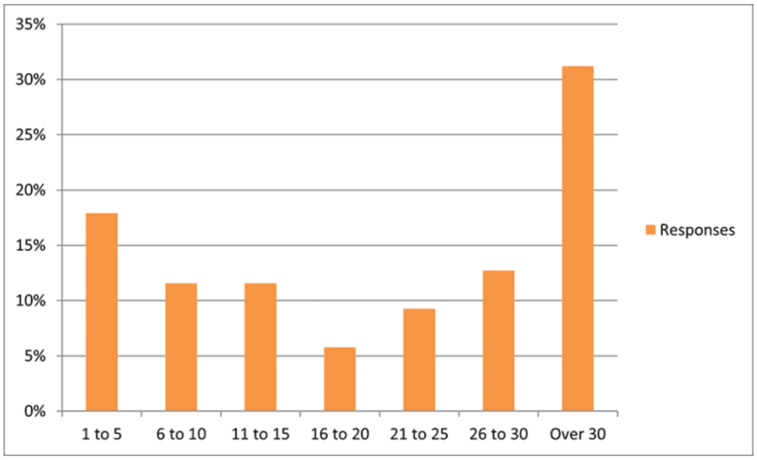


Figure 3. Years of experience among respondents. (n=173)

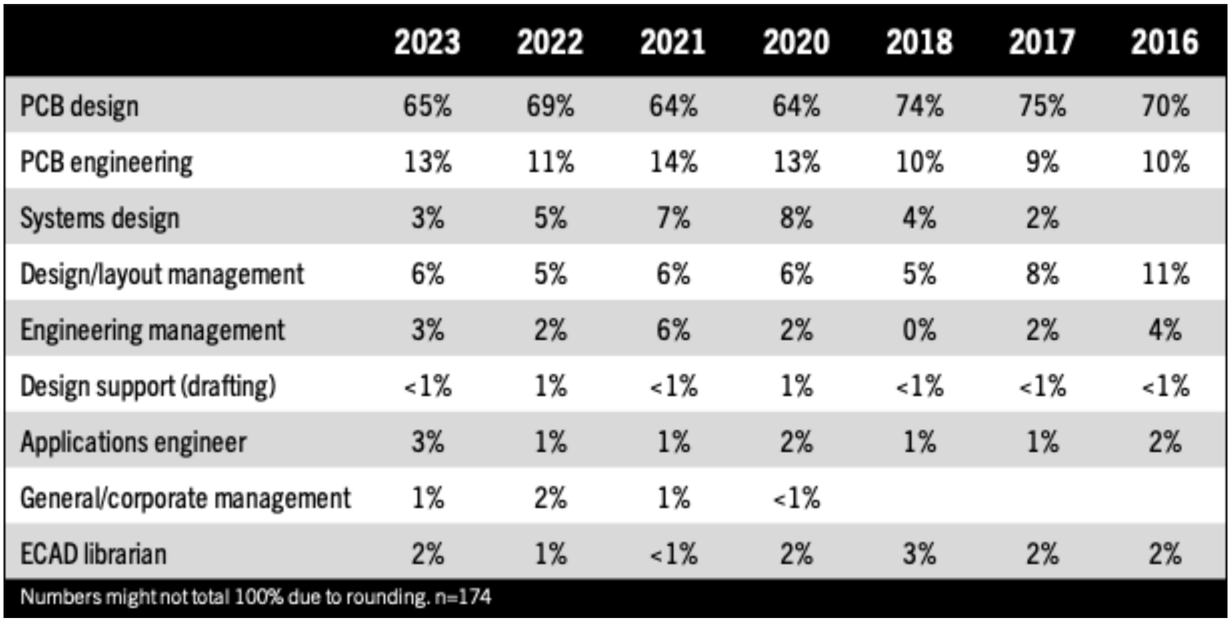
The years of experience were also reflected in the ages of respondents, with 23% reporting they were between the ages of 61-70, 23% were 51-60, and 25% were 41-50. Designers aged 26-30 made up 9% of respondents, while ages 31-40 made up 16%.

Most respondents – 68% – were from the US, with 12% coming from Central/Western Europe, 8% coming from Canada, and 3% reporting from Eastern Europe. While there were a handful of participants from India and Southeast Asia, there were no responses from China, which is likely due to the language barrier in non-English-speaking countries.

Job titles and functions. Nearly 38% of respondents indicated their position as a senior-level PCB designer or design engineer, while 20% reported PCB designer or design engineer as their job title. Rounding out the top job titles were senior hardware engineer and hardware engineer at 9% and 8%, respectively, while PCB design managers made up 6% percent of respondents and electrical engineers made up 5%.

Job functions were less varied, with 65% of respondents reporting that their principal function was PCB design, and 13% indicating that their main job function was PCB engineering **(TABLE 1)**.

Table 1. Principal Job Function



	2023	2022	2021	2020	2018	2017	2016
PCB design	65%	69%	64%	64%	74%	75%	70%
PCB engineering	13%	11%	14%	13%	10%	9%	10%
Systems design	3%	5%	7%	8%	4%	2%	
Design/layout management	6%	5%	6%	6%	5%	8%	11%
Engineering management	3%	2%	6%	2%	0%	2%	4%
Design support (drafting)	<1%	1%	<1%	1%	<1%	<1%	<1%
Applications engineer	3%	1%	1%	2%	1%	1%	2%
General/corporate management	1%	2%	1%	<1%			
ECAD librarian	2%	1%	<1%	2%	3%	2%	2%

Numbers might not total 100% due to rounding. n=174

More money, more responsibilities? More than half of designers said they produce between one and 10 new designs each year, with 32% producing one to five and 27% producing six to 10. On the higher end of the scale, the number of designers producing more than 30 designs per year rose to 11% **(FIGURE 4)**.

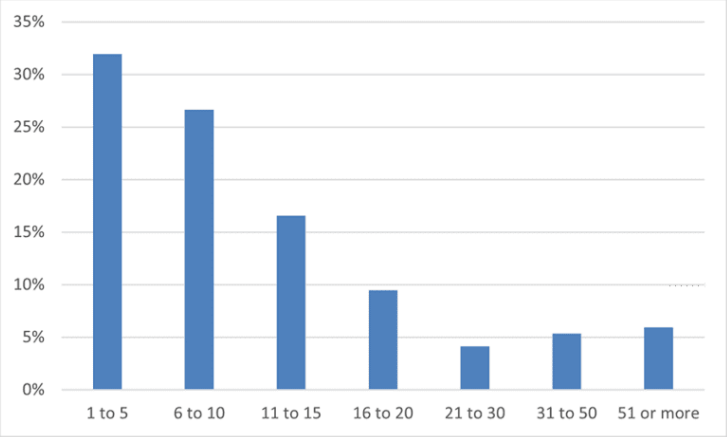
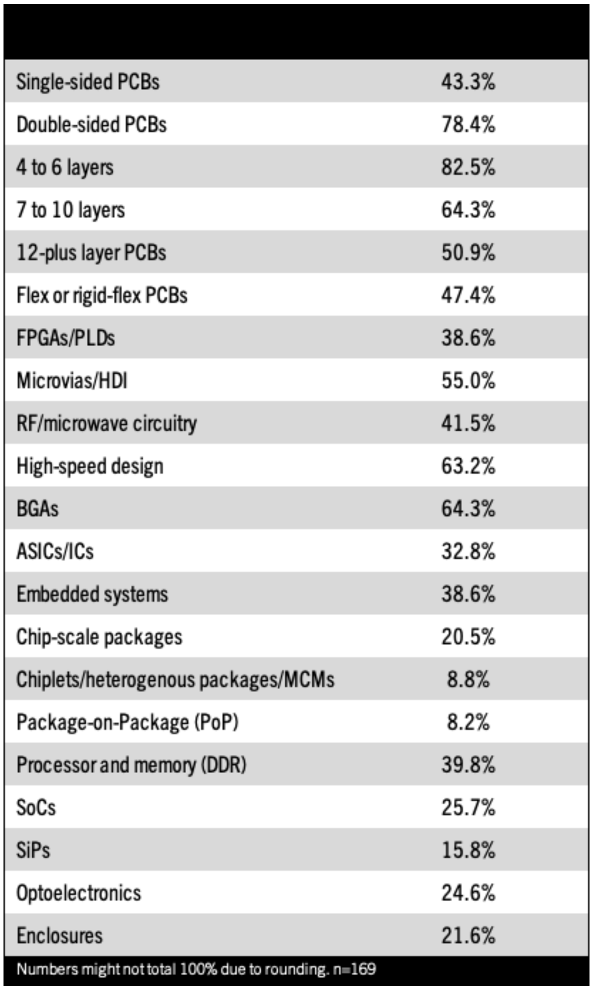


Figure 4. Number of new designs produced each year. (n=169)

More than 75% said they produce between one and 10 respins each year, while 11% said they produce 11-15.

More than 80% of respondents said they engineer, design, and/or lay out four- to six-layer PCBs, with nearly the same amount producing double-sided PCBs. Some 65% of designers said they produce seven- to 10-layer PCBs and BGAs, while 40% said they still produce single-sided PCBs **(TABLE 2)**.

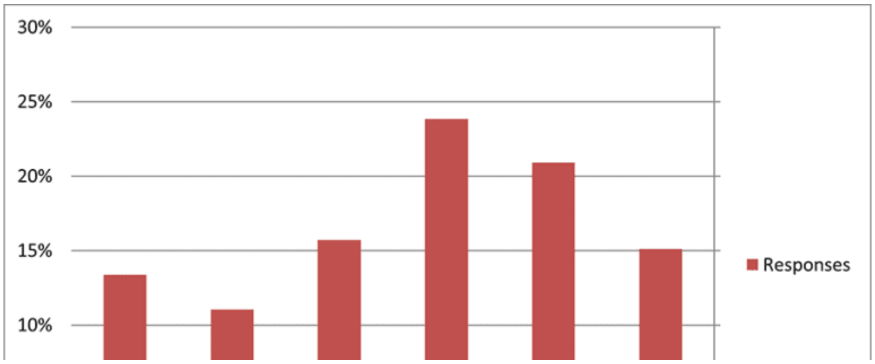
Table 2. Types of Projects

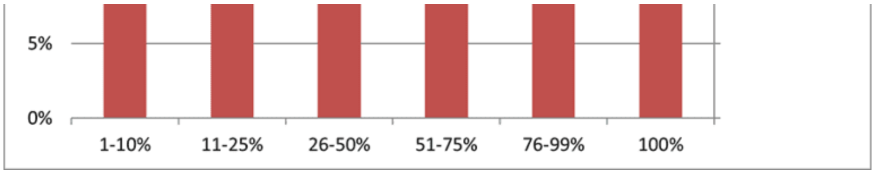


Single-sided PCBs	43.3%
Double-sided PCBs	78.4%
4 to 6 layers	82.5%
7 to 10 layers	64.3%
12-plus layer PCBs	50.9%
Flex or rigid-flex PCBs	47.4%
FPGAs/PLDs	38.6%
Microvias/HDI	55.0%
RF/microwave circuitry	41.5%
High-speed design	63.2%
BGAs	64.3%
ASICs/ICs	32.8%
Embedded systems	38.6%
Chip-scale packages	20.5%
Chiplets/heterogenous packages/MCMs	8.8%
Package-on-Package (PoP)	8.2%
Processor and memory (DDR)	39.8%
SoCs	25.7%
SiPs	15.8%
Optoelectronics	24.6%
Enclosures	21.6%

Numbers might not total 100% due to rounding. n=169

More than half of respondents said they spend at least 50% of their week on board design, but 24% said they spend 51-75% of their week on design, followed by 21% who spend 76-99% of their week on design **(FIGURE 5)**.





When asked what they believed to be their biggest challenges in the coming year, 66% of respondents answered workload, while 40% were worried about keeping up with changes in technology **(FIGURE 6)**.

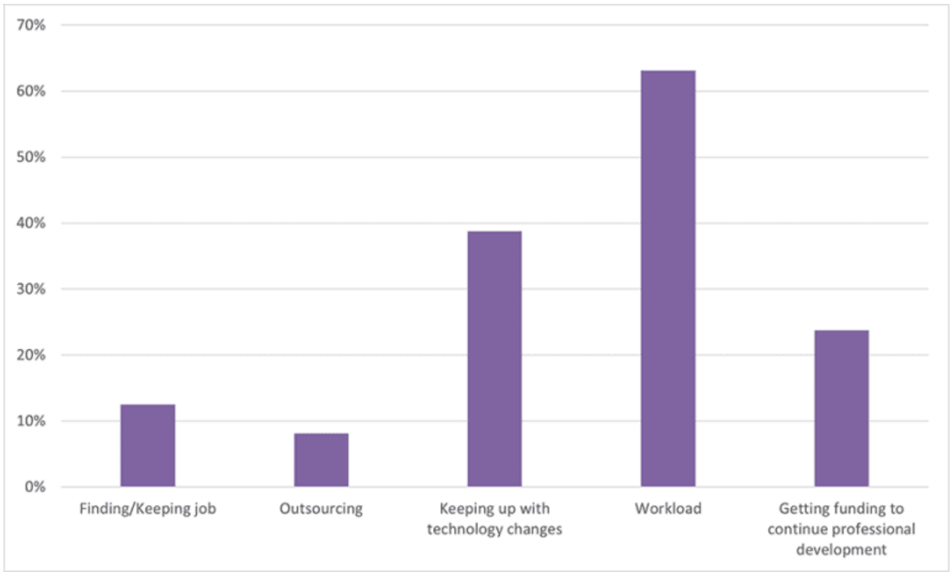


Figure 6. The biggest challenges designers believe they will face in the coming year. (n=154)

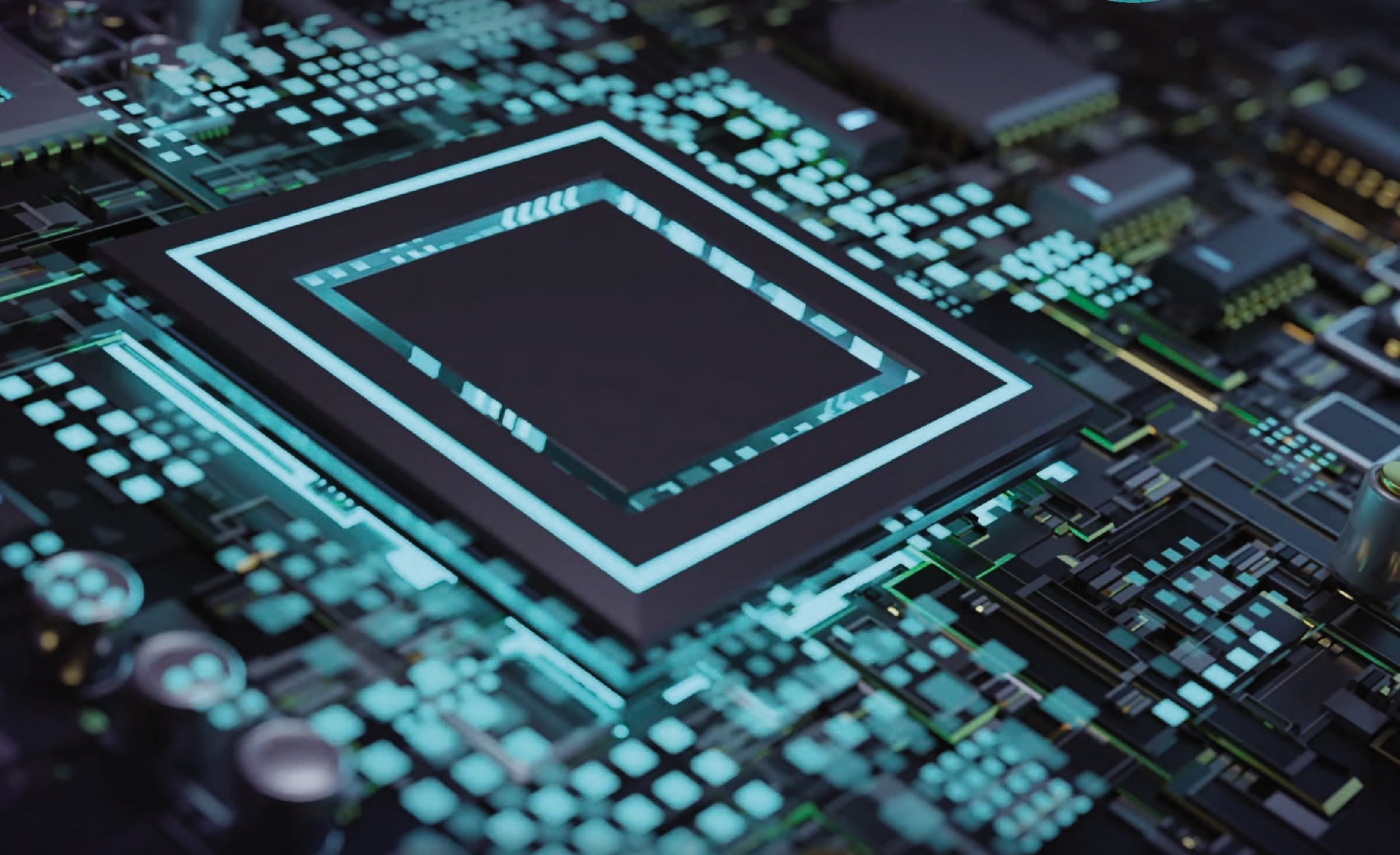
Other findings. Altium Designer remained the top ECAD software seeing regular usage among respondents, with 48% of respondents indicating they use it on a weekly basis, followed by Cadence Allegro at 28%, Siemens Xpedition at 22%, Cadence OrCAD at 14%, and Siemens Pads at 12%.

On-the-job training was the top educational opportunity supported by employers, with 61% of respondents reporting its availability, followed by tuition reimbursement at 55% and classes at conferences at 52%. The availability of mentoring saw a slight bump to total 40%, as did industry certification, which also came in at 40%.

REFERENCES

1. US Bureau of Labor Statistics, Employment Situation Summary, Aug. 4, 2023, https://www.bls.gov/news.release/empsit.nr0.htm.

TYLER HANES is managing editor of PCD&F/CIRCUITS ASSEMBLY; tyler@pcea.net.



Closed-Loop Process Optimization between Screen Printer and SPI in an SMT Line

An experiment investigating print alignment adjustments.

by MIGUEL ARROYO COLOMER, CSMTPE

Printed circuit board assembly requires extraordinary precision and repeatability. The screen printing process is considered the most critical process in the surface mount technology (SMT) assembly process. According to some studies, 70% of SMT defects can be traced back to the screen printing process **(FIGURE 1)**. Component miniaturization has made this process more critical. Therefore, alignment of the apertures in the screen or stencil is key to an efficient and accurate solder paste transfer and there isn't such a thing as local offset.

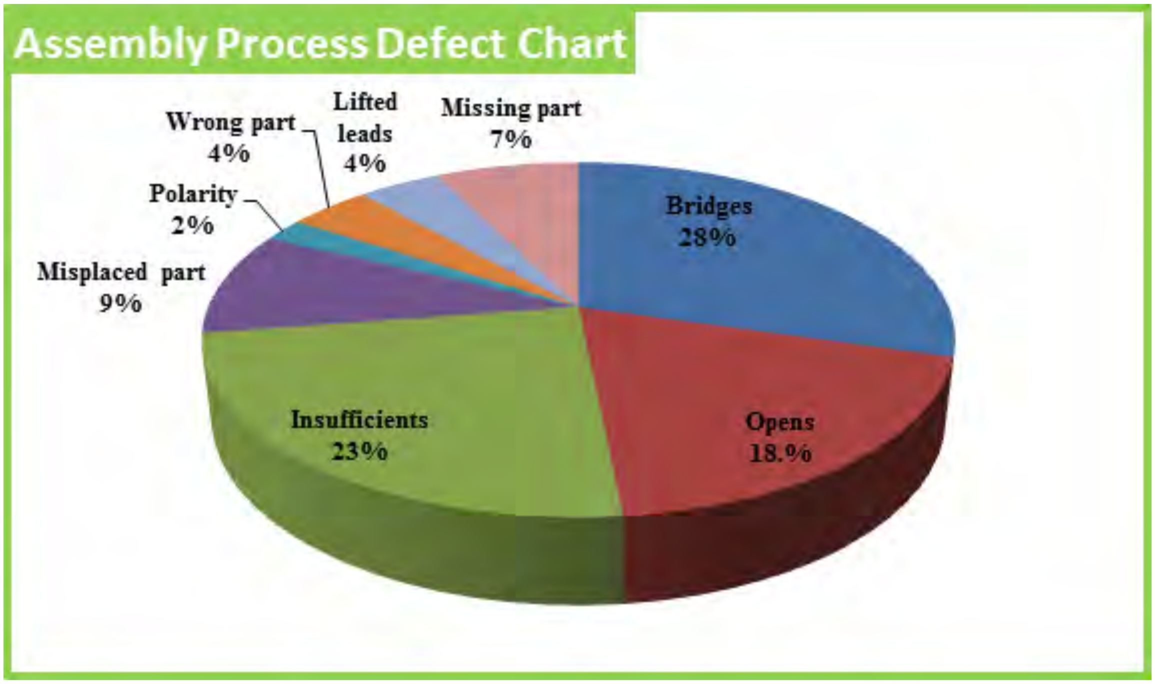


Figure 1. Solder paste defects, per Koh Young.

Every new generation of screen printers is more precise and repeatable than the previous one. External factors that cannot be controlled, however, affect the solder paste deposited on the PCBA's solder pads. One of these factors is the stencil or board stretching. The solder brick **(FIGURE 2)** (e.g., the area of solder paste deposited or printed onto the printed circuit board) can be right on the solder pads in one area of the PCBA, yet off in another. It is for this reason that, sometimes, print offsets are required. This is a manual process that is performed one time. The solder paste brick could be overhanging from its solder pad if there is stencil and/or PCBA variation (stretching).

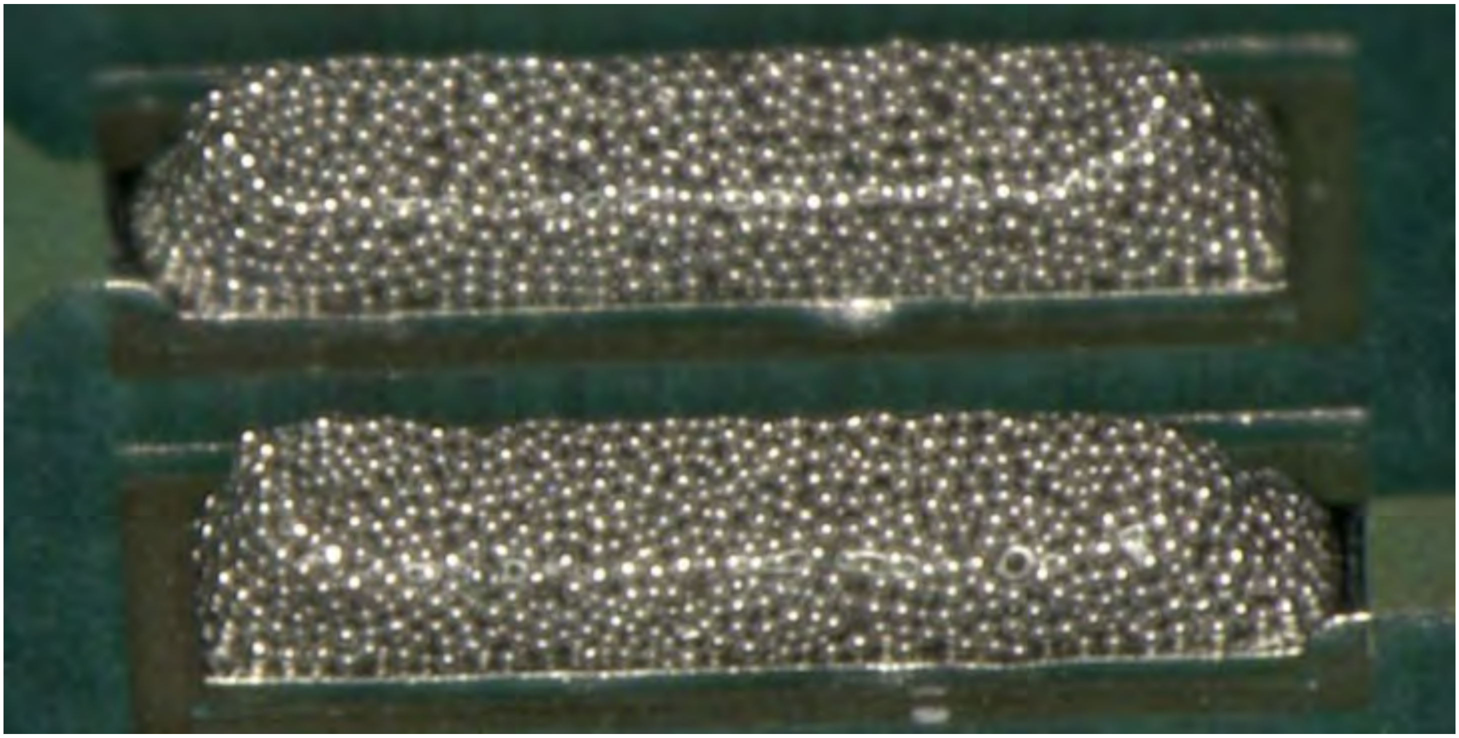


Figure 2. The solder brick.

For this reason, closed-loop systems have been developed to monitor and correct the solder paste deposition on a PCBA in real time. The closed-loop system is between the screen printer and solder paste inspection (SPI). The screen printer uses solder paste alignment information generated by the SPI to make print alignment corrections.

Stencil alignment has become extremely important due to the size and complexity of new components' solder pads. A misalignment could compromise the gasket between the PCBA solder pad and stencil aperture, resulting in excess or insufficient solder deposition.

Screen printers have mechanisms to calculate offsets between the solder pads and stencil apertures. The methodology is limited to a few position samples, however.

The screen printer is the first process in a SMT PCBA line. To reduce the number of defects generated by this process, an SPI is placed in the line prior to the screen printer to inspect the solder paste deposition on the PCBA. The SPI measures the solder paste volume and position of the solder bricks across the entire PCBA. The results are then used by the screen printer to make print alignment adjustments **(FIGURE 3)**.

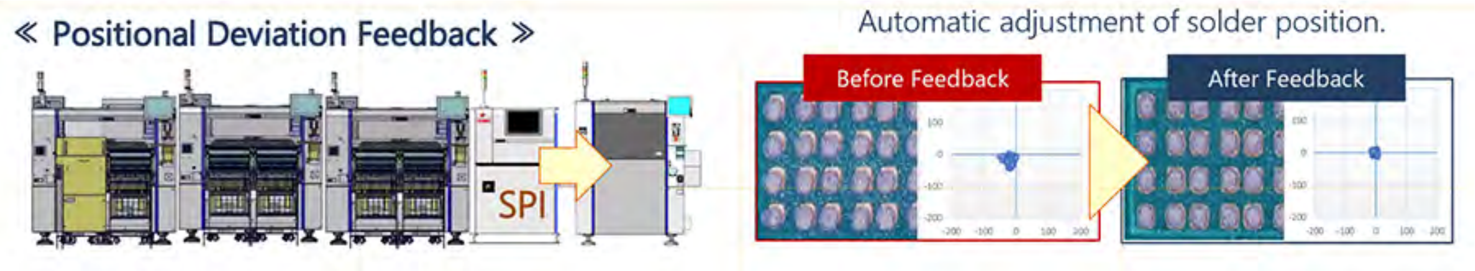


Figure 3. How solder paste alignment improves with closed-loop feedback.

This function performs a printing position adjustment automatically, based on the SPI results. The correction values (x, y and Θ offsets) are applied to the "mask offset" of the printer program to adjust the printing position.

There are systems that require board serialization, which is another means to determine when to make the adjustments. For this test, a software counter was used to determine when to make the print alignment corrections **(FIGURE 4)**.

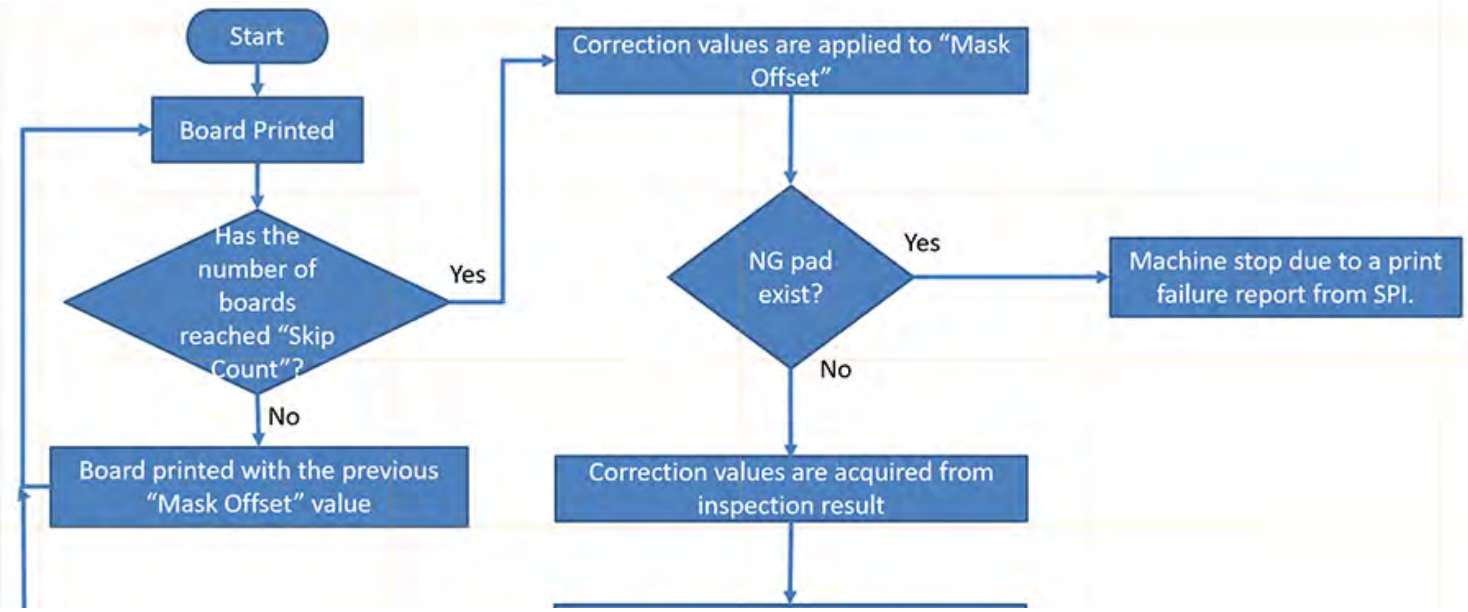


Figure 4. Closed-loop system using a counter (Skip Count).

Experimental

A closed-loop system between a screen printer and SPI machine was validated using a test vehicle **(FIGURES 5** and **6)**.

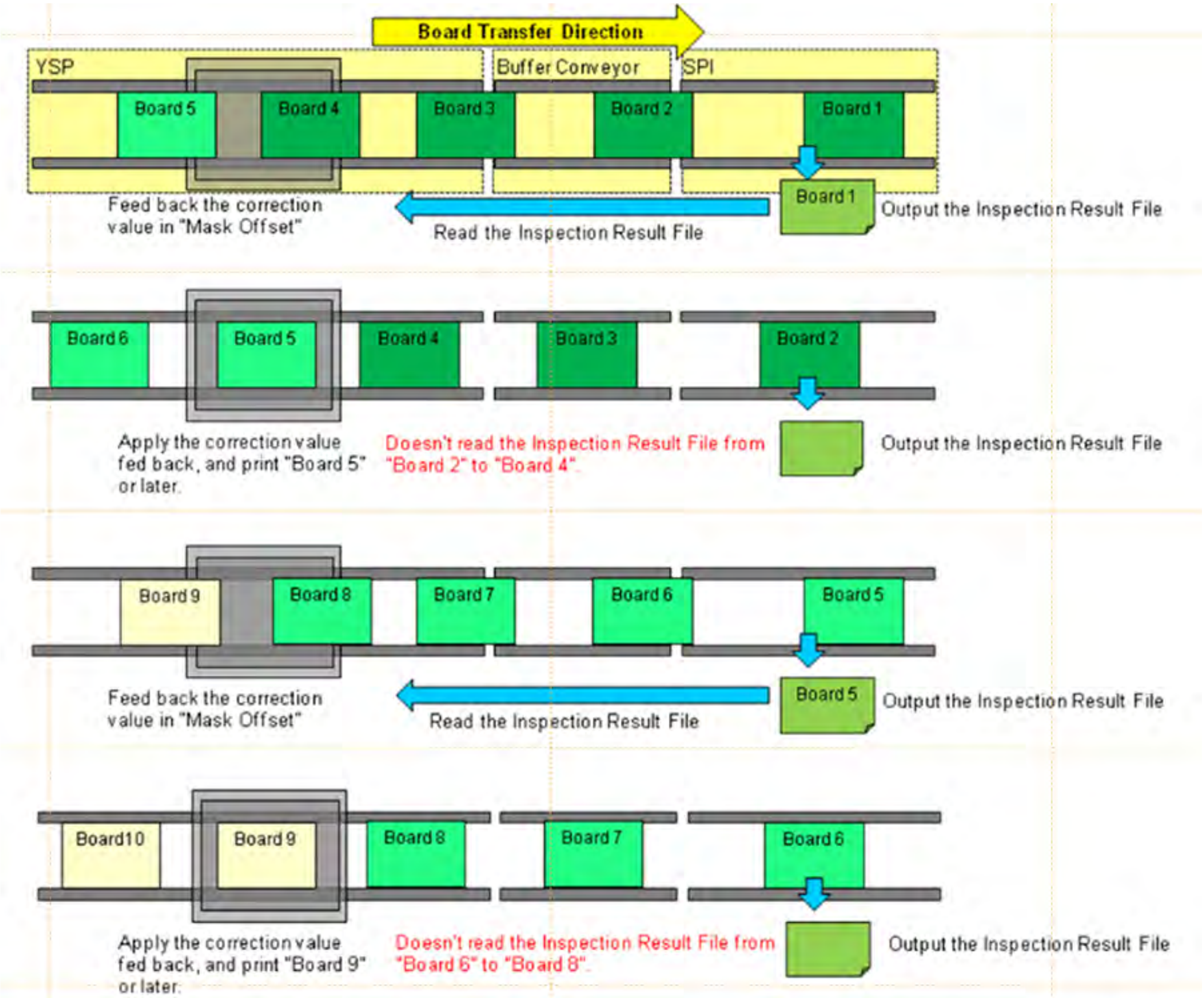


Figure 5. Diagram illustrating how closed-loop system works.

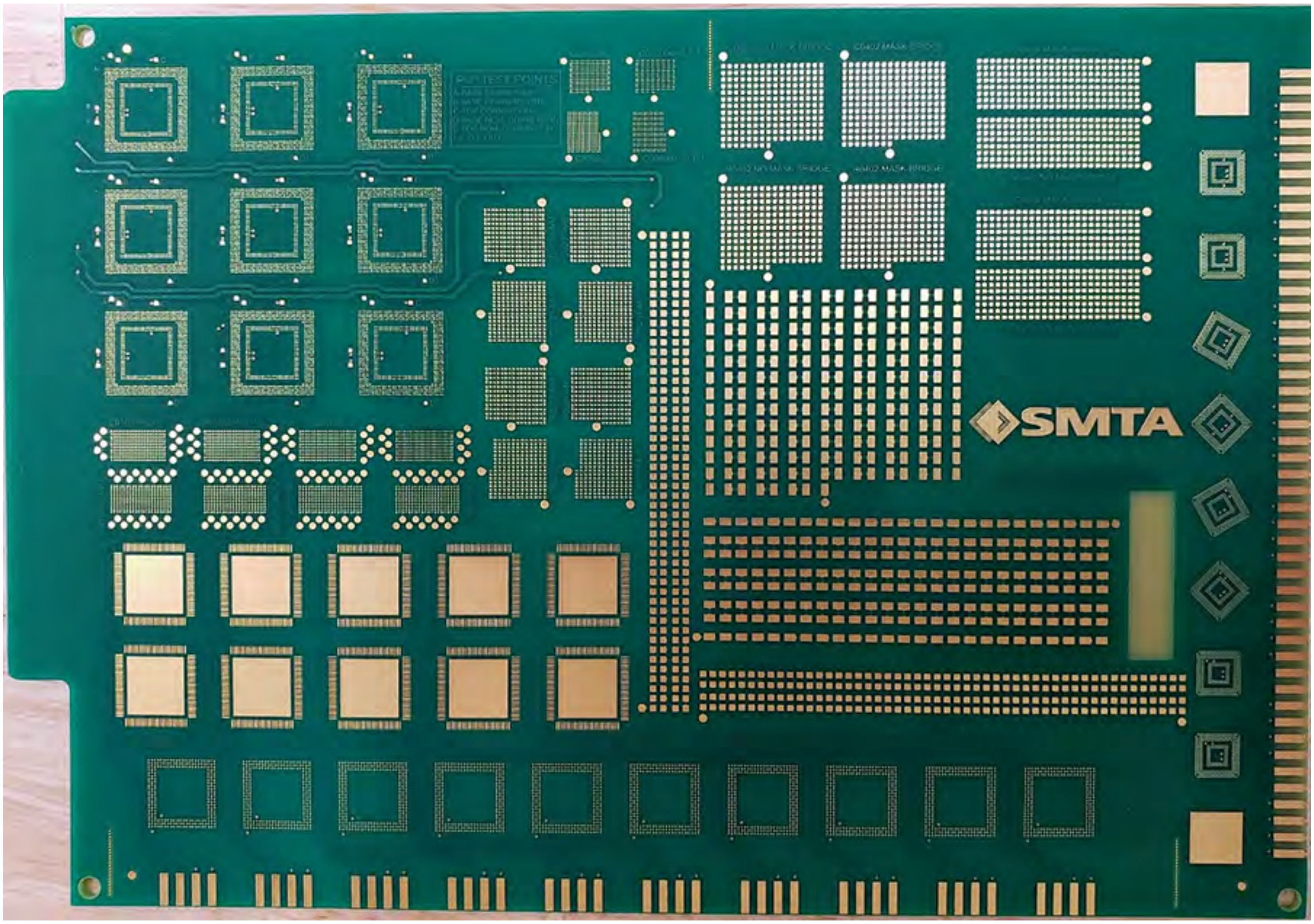


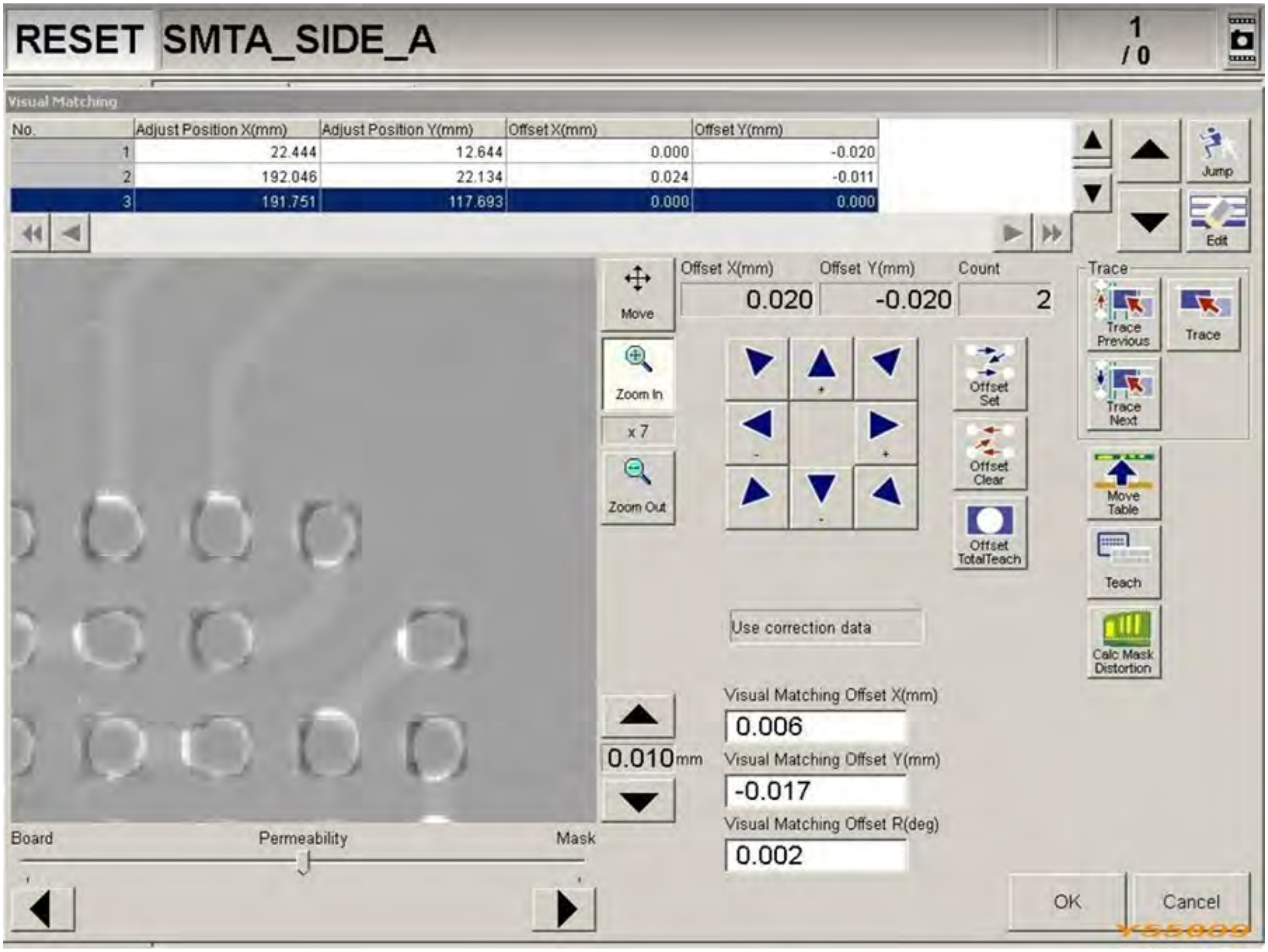
Figure 6. Test vehicle used for closed-loop validation.

Screen printer and SPI programs were developed for this test vehicle (shown). Before beginning the experiment, the offsets between the stencil apertures and PCBA solder pads were measured using the “Visual Matching” option **(TABLE 1)**. This option overlays solder pads with their apertures to calculate any offset due to stretching.

Table 1. Calculated Offsets Using Visual Matching

Visual Matching – Offsets (mm)	
x axis	0.006
y axis	-0.017
Θ axis	0.002

Ten PCBAs were processed through the SPI without using the closed-loop option.



RESET SMTA_SIDE_A

1 / 0

Visual Matching

No.	Adjust Position X(mm)	Adjust Position Y(mm)	Offset X(mm)	Offset Y(mm)
1	22.444	12.644	0.000	-0.020
2	192.046	22.134	0.024	-0.011
3	191.751	117.693	0.000	0.000

Offset X(mm)	Offset Y(mm)	Count
0.020	-0.020	2

Use correction data

Visual Matching Offset X(mm): 0.006

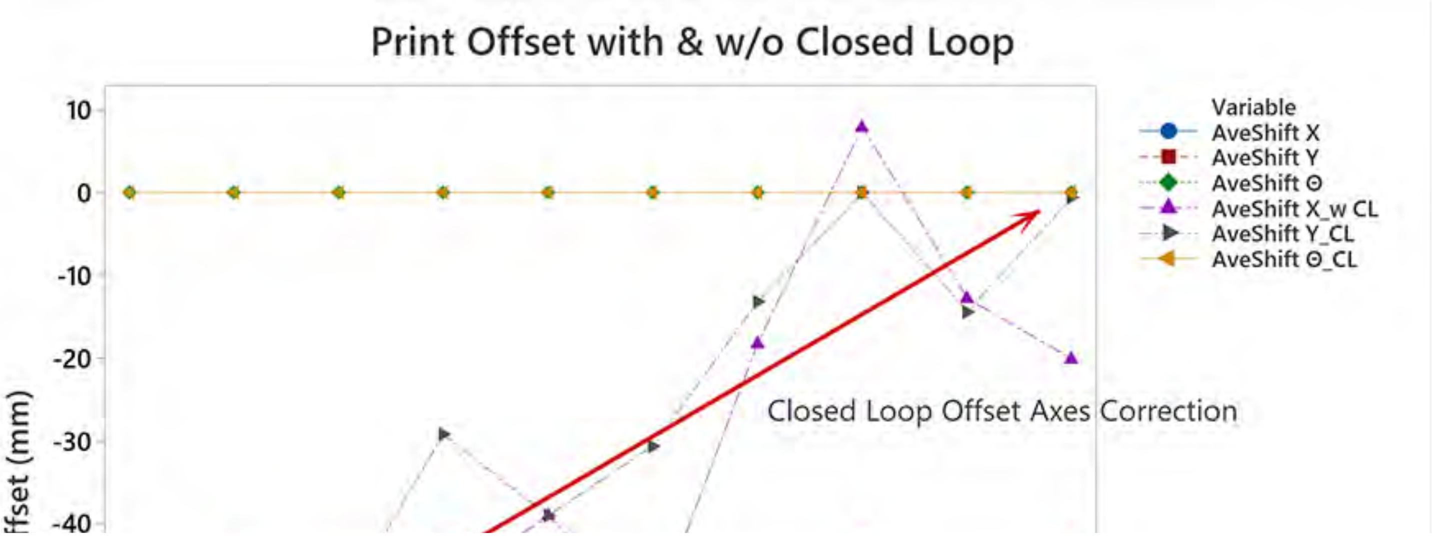
Visual Matching Offset Y(mm): -0.017

Visual Matching Offset R(deg): 0.002

0.010mm

x 7

Figure 7. The Visual Matching utility used to calculate the print offset before running the PCBA.



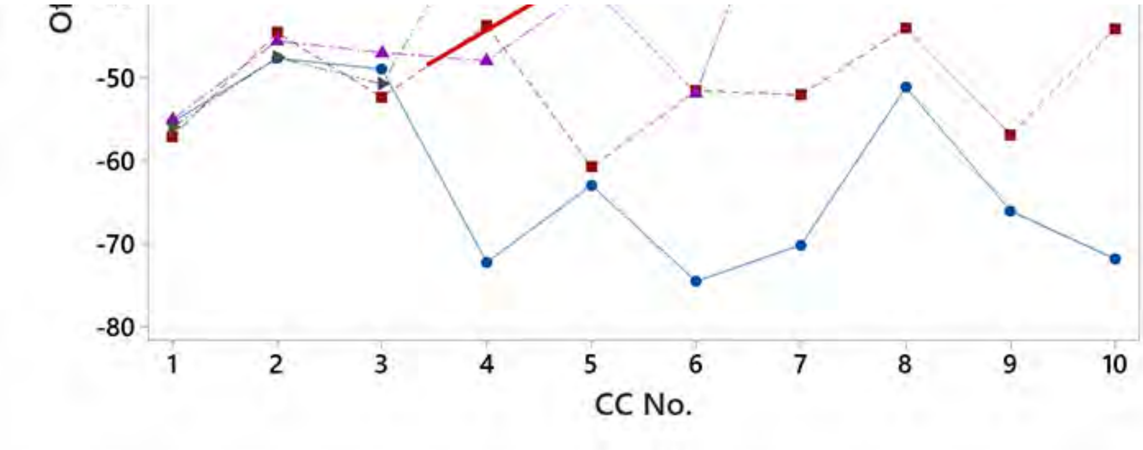


Figure 8. How the axes offset changed with and without closed-loop.

Once the print offsets using visual matching were calculated, an offset of 0.050mm in the x and y dimensions was added to the calculated offset, and the Θ axis was zeroed out **(TABLE 2)**. The purpose was to validate that the option was working properly. All 10 PCBAs were processed without automatic stencil cleaning between prints.

Table 2. Modified Axes Offset
Prior to Test

Visual Matching – Offsets (mm)	
x axis	0.056
y axis	0.033
Θ axis	0.000

Results

The screen printer uses the SPI axes offset calculation to update its print offsets. **TABLE 3** shows the final offset values after 10 prints with the closed-loop function enabled.

	Offsets – Visual Matching	0.050mm Offset added for Test	Offset Values after Test
x axis	0.006	0.056	0.008
y axis	-0.017	0.033	-0.007
Θ axis	0.002	0.000	0.000

We can conclude that a closed-loop system generates similar results than calculating the print offsets utilizing the printer's utility. This utility depends on a programmer for its implementation, and it is done once. By contrast, the SPI is providing solder paste deposition offsets constantly to the screen printer when the closed-loop feature is enabled.

REFERENCES

1. 1. Koh Young, "Why Solder Paste Inspection?" NMTronics, n.d., accessed Jul. 6, 2023, https://www.nmtronics.com/smt/koh-young.html.
2. PCBGoGo, "What is Solder Paste and How to Print It on PCBs in SMT Assembly?" accessed July 6, 2023, https://www.pcbgogo.com/Article/What_is_solder_paste_and_how_to_print_it_on_PCBs_in_SMT_assembly_.html.

MIGUEL ARROYO COLOMER, CSMTPE, is product application manager at Yamaha Motor Corp. – Robotics Division (yamaha-motor.com); miguel_colomer@yamaha-motor.com.

Humidity Controlled Storage

J-STD Storage of PCBs & MSD Components

DRY CABINET STORAGE

XDry humidity-controlled storage cabinets are self-contained, low-maintenance storage systems. There is no need for nitrogen or compressed air, just plug into the wall and they are ready to go! XDry storage cabinets satisfy standards such as IPC/JEDEC J-STD-033 and IPC/JEDEC J-STD-020. The cabinet environment can be maintained from ambient to 1% RH, providing constant & stable storage at precisely desired RH levels.

XDry cabinets are the ideal solution for printed circuit board and moisture-sensitive component storage.

HXD2-1106-01
Our largest heated dry cabinet

HXD1-703-02
Small footprint, but high capacity

XD1-302-02
Competitively Priced

XDRY CORP.

Corporate Office
3407 County Road 427
Anna, Texas 75409 USA

Phone: 214.296.4868

www.XDry.com

sales@XDry.com

The Power of Personal Branding: Creating an Authentic and Sustainable Perception

Learn from successful entrepreneurs and specialists at the annual Women's Leadership Program.

by PRIYANKA DOBRIYAL, PH.D.

We can find heroes all around us, but we will challenge you to look inside yourself and to not only identify your superpower but give you some tools to help define your personal brand. So, pick up your cape at the cleaners in time for the SMTA's Women's Leadership Conference at SMTA International. Show your support for diversity in engineering fields by joining us as we soar, explore and discover our very own Superheroes. The event is scheduled for Oct. 9 at the Minneapolis Convention Center.

A frequently discussed subject among cohorts and mentoring sessions is personal branding. And if you are assigned the duty of developing content centered around it, you could spend a considerable amount of time researching and reflecting on the fundamental aspects of this topic, as well as the genuine methods to build it. Hence, when the SMTA Women's Leadership Program (WLP) team chose to focus on the theme of personal branding for the 2023 session, we dedicated some time to create and offer tips for beginners on its development. We pinpoint three notable attributes for an authentic and compelling personal brand:

- Launching your personal brand rooted in core values
- Continuously adapting and refining the brand as your profile evolves and changes

- Implementing strategic approaches to establishing and promoting your brand.

In the world of technology, personal branding is a crucial tool for professionals to differentiate themselves and showcase their unique abilities. It can be developed incrementally, however, by following the three-step process and then infusing your personal touch to make it unique. Begin with introspection on the three key elements mentioned above. The first step involves identifying your core values and recognizing your strengths or superpowers. In your personal experience, you might discover that the most effective way to go about it is by exploring mission and vision statements of different companies. Then, evaluate whether these statements truly reflect your perception of those organizations. This process can be followed by crafting your own mission statement and formulating a strategy to achieve it.

The next step is how to refine your brand as your profile evolves and changes. Consistency and credibility are vital when promoting your personal brand, aligning it with your true self. To achieve this, it is crucial to continuously update and adapt your brand as you transition between roles, companies and other aspects of your life. Devoting time to comprehend how you wish to be perceived and devising a corresponding strategy can prove immensely beneficial. Soliciting feedback on your existing perception versus your desired perception allows a thorough assessment of the necessary steps to bridge the gap.

The final and most important step is the implementation of the brand, which can be done through thought leadership, active participation in industry events (conferences, publications, presentations, panel discussion etc.), and online presence. This is all part of self-advocacy. One can leverage social media platforms to amplify their voices, share their knowledge, insights, and achievements. By consistently providing valuable content, one can attract a loyal following, expand networks and open doors to new opportunities.

After all the effort you've put into crafting your brand, feel empowered to proudly display it. Remember, it's crucial to realize that any time your actions don't align with the brand you've established, it can jeopardize your credibility. This is where the significance of saying "NO" becomes crucial. This tool is essential to establish boundaries, preserve our brand by focusing only on tasks and creating perceptions that align with our brand. Hence embracing your strengths (superpowers), deliberately implementing your brand and sustaining it by creating credibility can reflect our unique value proposition.

The Women's Leadership Program will start with three presentations from women leaders in the electronics and medical industry. These women have each charted a unique career journey which made them invaluable in the organizations they lead. Since our 2023 program theme focuses on personal branding, we asked our speakers to share their experiences, learnings and personal branding journeys in their presentations. The presentations will be followed by speed mentoring sessions, delving into the 5 Cs: clarity, content, connection, creativity and community. These crucial aspects encompass all the important facets of personal branding, allowing attendees to effectively characterize and refine their unique brand.

SMTAI 2022 Women's Leadership Program Details

1:30 – 3:45 p.m.: Invited Presentations
Co-chairs: Amanda Brawthen, John Deere Electronic Solutions; Marie Cole, ex-IBM

1:30 – 2:15 p.m.: Stephanie Pusch, executive vice president and cofounder, Trusted Semiconductor Solutions, "Growing a Semiconductor Start-up to a Mid-sized Business"

2:15 – 3 p.m.: Jennifer Fischer, CMO, Northfield Hospital, "After 20 Years, STILL Working on My Brand"

3 – 3:45 p.m.: Michelle Gebbie, strategic marketing & operations sr. manager, 3M Electronics Materials Solutions Division, "Your Personal Brand Exists; It's Up to YOU to Manage It!"

4 – 5 p.m.: Speed Mentoring Sessions
Co-chairs: Jessica Molloy, Zestron; Julie Silk, Keysight Technologies; Debbie Carboni, Kyzen

5 – 6 p.m.: Connection Reception
Co-chairs: Michelle Ogihara, Seika Machinery; Sherry Stepp, Kyzen

Growing a Semiconductor Start-up to a Mid-sized Business – Stephanie Pusch, Trusted Semiconductor Solutions

Stephanie Pusch

As cofounder of Trusted Semiconductor Solutions, I have seen what it takes to go from two employees, and their personal investments, to a multimillion-dollar business with over 50 employees. This presentation will share lessons earned on entrepreneurship and growing a business in the semiconductor industry without taking any external funding. My presentation is intended to inspire those starting new ventures by illustrating how hard work and perseverance can pay off.

Stephanie Pusch, executive vice president and cofounder of Trusted Semiconductor Solutions, has bachelor's and master's degrees in electrical engineering from the University of Wisconsin and Illinois Institute of Technology, respectively. She started her career at Motorola designing printed circuit boards, FPGAs and ASICs for cellular phones and infrastructure. She then joined Cadence Design Systems as an applications engineer, supporting its system-level design tools, and moved into technical sales. Following Cadence, she worked at Honeywell in business development for its microelectronics business unit and radiation hardened semiconductor foundry. Seventeen years ago, she and a Honeywell colleague started Trusted Semiconductor Solutions to offer US-designed and manufactured custom ICs to the high-reliability marketplace.

After 20 Years, STILL Working on My Brand – Jennifer Fischer, Northfield Hospital

Jennifer Fischer

I did not take a traditional path into the medical world or management. I don't think I have all the answers, but am happy to share how I've dealt with barriers and frustrations in the ER, at home, and in my own head. At the very least, I hope you can laugh along at some of my mishaps.

Dr. Jennifer Fischer is a distinguished medical professional, renowned for her remarkable contributions to the healthcare industry as a staff physician at Northfield Hospital. Throughout her career, she has held several key positions, including Emergency Department (ED) Medical Director and EMS Medical Director, demonstrating her unwavering commitment to improving medical services and patient care. Moreover, Dr. Fischer's dedication extends beyond her roles at the hospital, as she has actively participated in various county and state workgroups concerning opioid use concerns, Covid response, disaster response, and EMS, striving to make a positive impact in her community and beyond.

Your Personal Brand Exists; It's Up to YOU to Manage It! – Michelle Gebbie, 3M Electronics Materials Solutions Division

Michelle Gebbie

As the title states, your personal brand already exists. But what does that mean and why does that matter? This overview of personal branding helps to both inspire and motivate women to act on either updating or crafting anew their individual personal brand. Gebbie shares her simplified approach to assessing your personal brand through focusing on three key components; and shares how to build your personal brand across various touch points in authentic and consistent ways to best reflect how you want to be perceived – and remembered – by others. You will leave with a worksheet to help capture important elements for your personal brand-building journey and you will hopefully feel more inspired to rethink what's possible for your personal brand!

Michelle Gebbie has an extensive background in branding, advertising, marketing, and communications over 25 years, 17 of which at 3M working across various divisions and corporate teams. The beloved Post-it Brand and Scotch Brand are on the roster, but she's also worked on 3M's employment brand and most recently has been working in 3M's Display Materials & Systems Division (a much more technical area of 3M – but geeky, tech stuff is up her alley). Midpoint in her career at 3M, she chose to spend some of her "3M 15% time" to develop a simplified "how to" approach for building one's personal brand. She thoroughly enjoys opportunities to inspire people to rethink what's possible – in both their professional and personal lives – and presenting on personal brand around 3M for the past 10+ years has been extremely gratifying. She cannot wait to promote the value of one's personal brand and talk about how to unleash it in this upcoming event!

Speed Mentoring Topics

We are happy to continue offering our speed mentoring session. In this impactful session, we will delve into the five crucial aspects of personal branding, also known as the 5 Cs. These elements will help you establish a compelling and authentic personal brand that sets you apart from the crowd and leaves a lasting impression on others.

Social/Networking Session

A social connection reception will conclude the Women's Leadership Program this year. This annual gathering provides a relaxed atmosphere to continue the conversations from the earlier segments of the WLP, fostering new and renewed connections across the SMTA community of organizers, speakers, exhibitors and attendees.

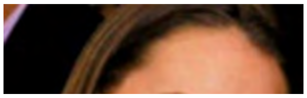
Debbie Carboni

Marie Cole

Julie Silk

Karlie Severinson

Elizabeth Benedetto




Jessica Molloy


Priyanka Dobriyal


Michelle Ogihara


Sherry Stepp

PRIYANKA DOBRIYAL, PH.D., is technical assistant/chief of staff, Memory IO Division at Intel (intel.com) and Program Track Director of the Women's Leadership Program for SMTAI.

GETTING **LEAN**

Continuous Improvement and Mass Inspection

Automating inspection in secondary assembly operations.

ONE OF THE first lessons in quality management is the difference between quality assurance and quality control. Quality assurance focuses on eliminating defect opportunities before they occur, while quality control focuses on inspection strategies that eliminate defects before they escape the factory. There is universal agreement that quality assurance is more cost effective than quality control. Lean manufacturing principles are based on a quality assurance focus. That said, use of automated inspection equipment has been growing dramatically in recent years because increasing density and complexity in printed circuit board assemblies (PCBAs) is driving the need for a blended quality assurance/quality control approach that includes mass inspection.

Over the past 18 months, SigmaTron International's facility in Tijuana, Mexico, has been exploring the best way to automate inspection and integrate the captured data into real-time corrective action throughout its entire PCBA assembly process. A July 2022 PCD&F/CIRCUITS ASSEMBLY column, "An Industry 4.0 Approach to Employing 3-D AOI on an SMT Line," discussed the journey of integrating Industry 4.0 capabilities in a Lean Six Sigma framework in this facility's SMT area. Once that phase was completed, implementation of 3-D AOI capability began in secondary assembly work cells. Typical secondary assembly operations include soldering cables and components such as switches which can't be reflowed, adding rubber caps and placing QR labels.

Unlike the SMT area where PCBA handling, assembly and inspection operations are inline and automated, secondary assembly operations include semiautomated and manual processes plus manual handling during transit among work cells. This stage of the process introduces a higher potential for variation and associated defect opportunities, particularly in complex PCBAs. Monthly volumes are in the millions on many part numbers. The goal of utilizing 3-D AOI for mass inspection following secondary assembly wasn't to implement a long-term 100% inspection process for every product. Instead, two 3-D AOI machines have been installed in the secondary assembly area to focus on complex products with low yields. Defect data for all products built are analyzed. PCBAs showing lower yields in secondary assembly are shifted to 3-D AOI inspection to better determine defect root causes and implement corrective action. When results show desired improvement levels, new products destined for continuous improvement action are shifted to inspection.

The project implementation team included a Six Sigma Black Belt, a fixture designer/continuous improvement technician, an SPI/AOI programmer/continuous improvement technician, an AOI technician associated with quality assurance and a project administrator/trainer who is also a continuous improvement assistant.

In setting up the systems, the implementation team utilized Gage R&R (GR&R) studies for repeatability and reproducibility using the Automotive Industry Action Group's acceptability definitions. C_p and C_{pk} ratios were also calculated to measure the process capability against voice of the customer (VoC) standards and requirements, ensuring machine programming reflected all failure modes identified by the customer on the products under study. Once control limits were established, programming parameters were adjusted for each PCBA to assess acceptability based on IPC-A-610 and customer documentation requirements. The programming process differed from the SMT setup in the number of datasets required. Setting up the 3-D AOI program validation database for SMT required 16 datasets, while secondary assembly required 32 datasets for the initial products under study. As with the SMT area setup, there is a methodology for utilizing trends tracking in continuous improvement activities. Data are available in real-time to correct defects immediately and can also be viewed remotely for more detailed trends analysis. The 3-D AOI machines continue to learn as they analyze trends.

Two Kaizen events were held to improve initial implementation assumptions related to fixturing. Analysis of initial trending indicated that the fixturing design to facilitate inspection did not have enough support for the solder side of the PCBAs and was causing board warpage. The fixture design was modified to include additional support. Additionally, the initial fixture storage setup did not make it easy enough for operators to easily identify correct fixtures. To counter this, 5S principles were implemented that segregated fixture storage by product in custom-designed storage carts.

Since implementing mass inspection, customer report card data shows an over 50% improvement in yields on the inspected boards. Use of 3-D AOI instead of manual inspection is also reducing inspection time on complex PCBAs while improving accuracy of defect identification. SigmaTron's team is working with the customer on design for excellence (DfX) suggestions to further improve yields on PCBAs with manufacturability issues contributing to lower yields. The result is a stronger partnership with customers that focuses on improvements in quality assurance as a result of data derived from quality control activities.

FILEMON SAGRERO is continuous improvement engineer at SigmaTron International (sigmatronintl.com) and a Six Sigma Black Belt; filemon.sagrero@sigmatronintl.com.

Steve Robinson
APCT President |CEO

SEEING **IS BELIEVING**

Driving Fast, Caring Not a Whit

Lessons learned from dealing with “the most important guys in the room.”

“Move fast and break things.” – *Attributed to Mark Zuckerberg*

THIS MORNING, ON my inbound commute, I stopped at a red light. I stopped just in time to see an expensive-looking SUV turn, oblivious to oncoming traffic, into my lane from the crossroad. It accelerated rapidly in the same direction I was traveling. Really rapidly. Propelled like a medical emergency. An impending birth, perhaps? This anxious vehicle exuded affluence. It was coming from the venture capital side of the Bay. Perhaps headed east to merge and acquire. It had that private equity look to it. You know the kind. Maybe the driver was late for surgery, living out his college-age nightmare in real time. Or he forgot his online bank account password, and, in an instant of thoughtless panic, was racing to make an in-person withdrawal from an almost-shuttered Silicon Valley funding source. Not to name names. Whatever the impetus, they drive with. Because they can. Nobody ever told them “No.”

Important guys (invariably guys) having to be at important places, doing important work. Get out of my way.

Progressive politics notwithstanding, our region suffers from delusions of permanent adolescence.

Even artificial intelligence recognizes the type. ChatGPT, riding shotgun with me that morning, observed the evidence, and was sufficiently disgusted to risk a stab at generalizing the species:

> The term “tech bro” is a colloquial and somewhat derogatory slang used to describe a specific type of individual who is typically associated with the tech industry, particularly in the Silicon Valley or other technology hubs. It is a portmanteau of “tech” (referring to technology) and “bro” (short for brother and often used to describe a particular type of stereotypical young, white, affluent, and arrogant man).
>
> A tech bro is commonly characterized by certain traits and behaviors, which may include:
>
> 1. Gender and diversity issues: Tech bros are often criticized for being predominantly male-dominated and displaying a lack of diversity in their workplace or social circles.
> 2. Arrogance: They are often perceived as overconfident and arrogant, believing their ideas or opinions are superior to others.
> 3. Disregard for social norms: Tech bros may display a lack of social skills or empathy, leading to a perceived insensitivity toward others.
> 4. Startup culture: They may be associated with the startup scene, often focusing on entrepreneurship and innovation.
> 5. Casual attire: Tech bros are known for their preference for casual clothing, such as hoodies, jeans, and t-shirts, regardless of the occasion.
> 6. Tech savvy: As the name suggests, tech bros are generally well-versed in technology and may often talk about the latest gadgets, apps, or programming languages.
> 7. Frat-like culture: They may exhibit behaviors reminiscent of fraternity culture, including partying, drinking, and engaging in “bro” banter.
>
> It’s essential to remember that the term “tech bro” is a generalization, and doesn’t apply to all who work in the industry. While some in the tech sector fit the stereotype, many others are inclusive, respectful and committed to promoting positive change.

For those who fit the stereotype, Musk and Jobs are models to be emulated, not cautionary tales.

Which is why some have no compunction about ruining weekends of others, and at no charge to them, naturally. The journey remains the reward. Consider yourselves blessed that we called you, no matter the day and time.

Saturday morning, the day after the traffic encounter. A new email (probably not from the same person, although it would be comforting to indulge cultivation of the stereotype). Its salutation graces me a new name:

“@Robert Boguski

I cannot finish a flying probe program. The machine manufacturer won’t return my calls for help. Can you help? We need to ship boards to our customer next week.”

Manufacturers generally return calls (although not often on weekends) if you pay for the annual service contract. Lacking service contracts, curiously, they have better things to do. Which makes us Plan B. Lucky us.

“We authorize you to remote login and modify our program using the advanced debug features of our flying probe tester’s operating system (same as yours). We created a program using the express features, but coverage was insufficient for our customer’s requirements. We lack experience with advanced debug, so we need your assistance. Please do so over the weekend or Monday morning at the latest so we can maintain our ship schedule.”

Must have been something in the water that weekend because the next day, a Sunday, came a second request. Also to my involuntary new name.

“@Robert,

We have an urgent need for imaging and possible destructive analysis of a malfunctioning pump motor. We will send six RMA units to you Monday morning. X-ray them immediately at specific pin locations (see accompanying screenshots) to identify evidence of solder joint separation under mechanical load. Depending upon the evidence imaging provides, we will select the worst example of the six units as a candidate for further destructive testing (cross-sectioning). Our courier will arrive at precisely 8 a.m. Monday. We do not have a PO, but we authorize you to proceed. Send us your quotation on Monday, and we will follow with a purchase order. In the meantime, go.”

“Please” was nowhere to be found. “Entitlement” was implied.

Thus began our week.

@Techbro2's pump units for inspection arrived punctually at 1 p.m. Monday. We received four units, not six.

@Techbro1 granted us remote login credentials to his flying probe operating system that same morning. Within a few hours, our engineer had the customer's program debugged and running. Life as we know it continued. @Techbro1 vanished.

@Techbro2 emailed Monday afternoon to say that he needed x-ray results immediately, to show management, and could we expedite the cross-section results so that they could be presented to decision-makers no later than one week from today? Once again, a PO was promised upon receipt of our quote. Our quote, with applicable expedite adders, was drafted, approved and submitted that same afternoon.

A quote for programming services was also submitted that day to @Techbro1. It reflected a minimum charge for our time.

Monday came. Monday went. No responses from either customer to our quotes.

Tuesday dawned.

Imaging identified the worst offender, with the largest open pin, among the four pump motor units sent by @Techbro2. We proceeded to cross-sectioning.

There was silence Tuesday from @Techbro1. Evidently, they were busy generating revenue, enabled by our programming debug solution to their problem.

Tuesday passed.

Wednesday brought a request from the quality assurance manager of @Techbro1. True to form, looking for a Root Cause:

"Could you provide us with a detailed breakdown of your time spent debugging our flying probe program on Monday. We do not understand why you are proposing to charge so much."

Our reply listed the details, and further explained that our quote represented a minimum charge for our time, whether that time was one minute or six hours. In any case, their problem was solved, so clearly the expense was worth paying.

No comments on Wednesday from @Techbro2. And no PO.

Thursday morning silence turns to Thursday afternoon irritation. Where the hell are the POs?

We email both customers.

@Techbro1 doesn't respond.

@Techbro2 replies by saying that the manager with signature authority to approve POs is on PTO this week. It will take until next week to secure approval. You'll just have to wait until next week ("Our approval chain is linear," whatever that means). Meanwhile, keep going. We need results by Monday, to present to our management and to our customer (presumably, without contractual sanction by purchase order).

Our response is immediate: no PO, no results. Management will see a blank screen on Monday. You will have some explaining to do to your customer. Surely you don't ship to your customer without purchase orders, right? Why would you expect us to act differently?

@Techbro2, provoked, responds: "That's reasonable. I'll see if I can find someone in management to sign the requisition."

Such a smart boy.

We receive our purchase order within the hour.

Thursday afternoon we email @Techbro1, reminding them of services rendered, revenue realized only by means of our help, etc. Once again, we ask about a purchase order. Crickets.

Friday morning, @Techbro1 emerges, like an oracle. A bewildering oracle. Their CEO personally replies, using circular reasoning, to dismiss our demands for a PO. He claims they are not obligated to pay us because A) they do not have a purchase order with us; and B) they do not need to issue us a purchase order because third-party service expenses are charged back to their customer, but since, in this case, they are unable to do so (customers are usually reluctant to reimburse suppliers for outside support, prompted by insufficient technical expertise), their expectation is that our work with them will be handled on a pro-bono basis.

Thanks again for accepting the privilege of serving us. See you next time.

George Orwell, call your office.

@Techbro2 also emerges Friday morning, with his micromanagement chromosome fully enabled. He wishes to organize, without delay, a three-way video conference, consisting of himself, his management, and our imaging and cross-sectioning teams. The goal is to review images and our capabilities, and establish stability and uniformity in service levels and, by extension, in pricing.

To @Techbro1, we reply that we will never provide programming or any other consulting services to them again, at any time, under any circumstances, without a prior purchase order in place. They will just have to explain their lack of shipments to their customer as best they can.

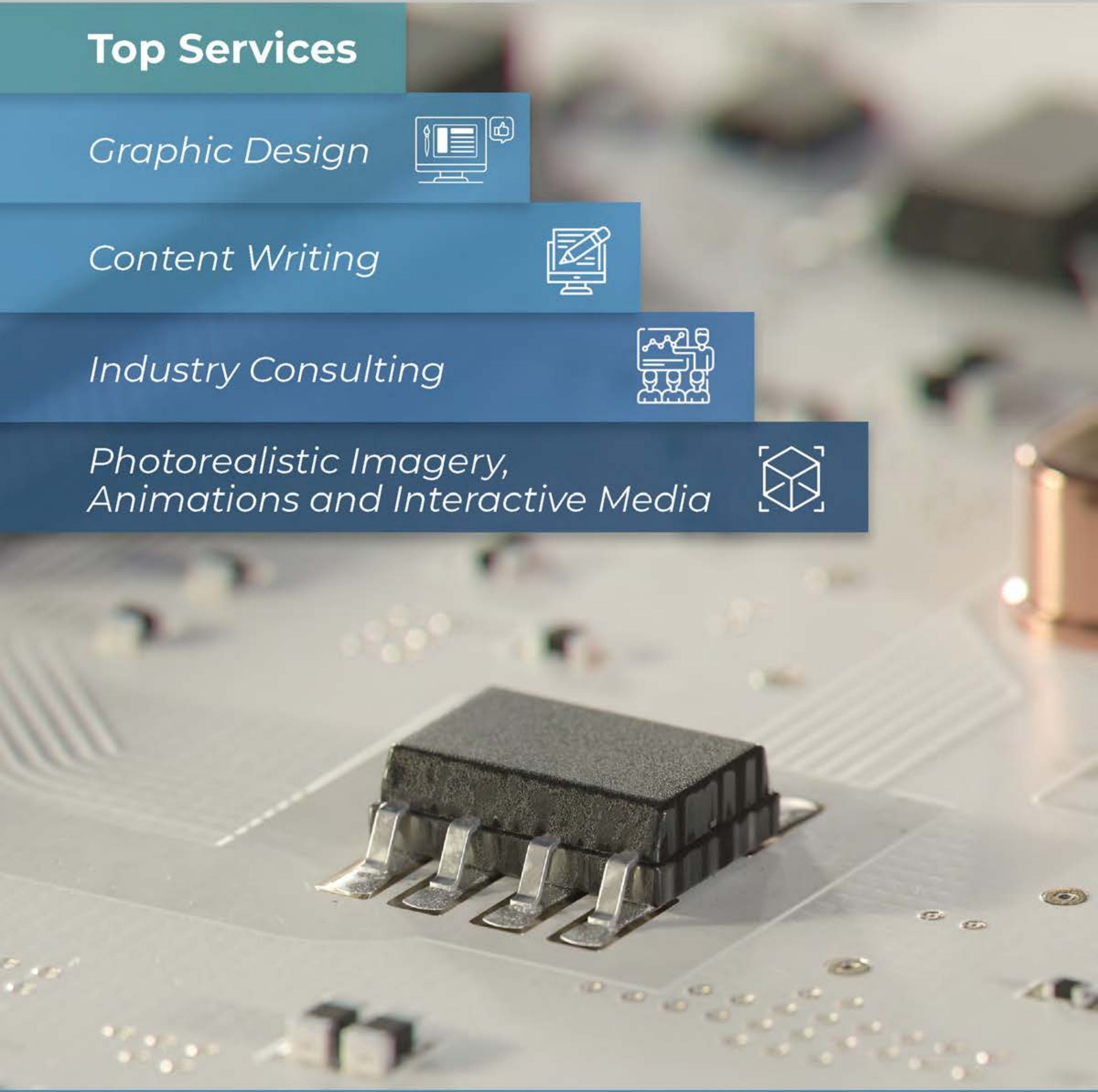
To @Techbro2, we reply that stability and process uniformity begin at home; once they have established their own repeatable performance, we can discuss uniform service levels. Until then, it's time and materials. Physician, heal thyself.

And to both, the same admonition:

Please do me the courtesy of addressing me by my actual name and remove the @ from in front of your salutations. This is not Twitter or some other adolescent game. I address you by your first name; I expect reciprocation from you. Even if you are a customer.

Especially if you are a customer.

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



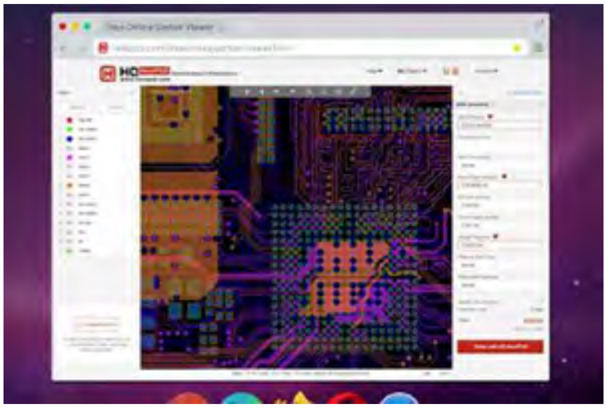
PCD&F

3D SYSTEMS ACCURA AMX SLA MATERIAL

Accura AMX Tough FR V0 Black flame-retardant material for stereolithography is also available as Figure 4 Tough FR V0 Black for use with 3D Systems' Figure 4 platform. Delivers enhanced part quality and resolution for SLA previously only achievable with selective laser sintering (SLS) and fused deposition modeling (FDM) technologies. Achieves UL 94 V0 rating and features a combination of flexural modulus and unmatched elongation at break of nearly 35%, which combine with long-term stability to make the material ideal for applications such as printed circuit board covers, semiconductor equipment, electrical housing, covers, hangers, brackets, and flame-retardant parts for trains and buses.

3D Systems

3dsystems.com



HQ NEXTPCB HQDFM GERBER VIEWER

HQDFM Gerber Viewer and DfM Analysis Tool is a free online tool for displaying and reviewing PCB Gerber files and OBD++ files. Incorporates NextPCB's design for manufacture algorithms and allows designers to navigate and analyze production files and check for design issues that may impact manufacturing or cause long-term reliability issues. Based on the free desktop software

HQDFM and available to anyone, including Mac and Linux users, with no download or install and no signup.

HQ NextPCB

nextpcb.com

KEYSIGHT N9912C FIELDFOX ANALYZER

N9912C FieldFox handheld analyzer is a software-defined radio frequency testing platform that offers more than 20 vector network analyzer, cable and antenna tester, and spectrum analyzer options for upgrade and download. Enables engineers to mix and match software applications for their specific analysis needs on a single handheld device and is fully upgradable with license-key activated maximum frequencies, analyzer types, bandwidths and software applications. Provides spectrum and network analysis down to 3kHz and up to 10GHz to test and troubleshoot a wide range of high frequency and wireless applications.

Keysight Technologies

keysight.com

KYOCERA 6893 SERIES FPC/FFC CONNECTORS

6893 Series connectors for flexible printed circuit boards and flexible flat cables feature 0.5mm-pitch one-action locking. Feature proprietary contact-pin structure with twice the foreign-matter removal effectiveness of conventional Kyocera products, ensuring a superior electrical connection that reduces contact failure rates and improves connection performance and reliability. Also features restructured locking section that locks the FPC/FFC in a single operation, reducing assembly labor by two-thirds. Heat-resistant up to 125°C and mountable on in-vehicle devices such as HUDs, clusters and CIDs with strict high-temperature compliance.

Kyocera

kyocera.com

NI LABVIEW ANALYSIS TOOL

LabVIEW systems engineering software now includes more features to enable engineers in their use of test insights and data to drive product and business performance. New features include Zoom for Block Diagram, quick change for faster object creation, double-click to create control or indicator from a wire, visual improvements to Highlight Execution and option for execution speeds, faster re-building of applications and packed project libraries, and virtual environment support for Python and LabVIEW users.

NI

ni.com

ROGERS TC SERIES LAMINATES

TC Series laminates are designed to address the critical thermal management needs of applications requiring high-power RF signals, offering improved performance and reliability in demanding environments. Composed of PTFE, woven fiberglass, and high thermal conductivity ceramic-filled materials, which provides a range of benefits including low loss tangent, high thermal conductivity, low CTE, and excellent temperature phase stability. Offer reduced junction temperature, improved reliability, and enhanced thermal dissipation capabilities for high-power applications, and can maintain a stable dielectric constant (Dk) even with temperature variations.

TC350 laminates offer a Dk of 3.50, thermal conductivity of 0.72W/m-K, TCDk of -9ppm/°C, and are for power amplifiers, communication systems, and thermal solutions.

TC350 Plus laminates feature a Dk of 3.50, z-axis thermal conductivity of 1.24W/m-K, TCDk of -42ppm/°C, and are for applications that demand superior thermal management and reliability.

TC600 laminates offer a Dk of 6.15, thermal conductivity of 1.1W/m-K, stable TCDk of -75ppm/°C, and are for backhaul radios, thermal solutions, and communication systems.

Rogers Corporation
rogerscorp.com

ROHM R60XXRNX SERIES MOSFETS

R60xxRNx series is an addition to its PrestoMOS lineup of 600V Super Junction mosfets. Maintains the high-speed trr characteristics of PrestoMOS while minimizing noise. Achieves trr of 40ns by improving conventional lifetime control technology, reducing switching losses by approximately 30% over general products, and newly developed Super Junction structure is said to reduce noise characteristics by about 15dB compared to standard products.

Rohm Semiconductor
rohm.com

TORAY MILLIMETER WAVE ABSORPTION FILM

Absorption film can efficiently absorb millimeter wave band electromagnetic waves employed in 5G communications and other applications. Uses nano-multi-layer film technology to deliver an absorption capacity of at least 20dB (99%) for millimeter waves and make it possible to select absorption frequency. Is one-fifth the thickness and one-tenth the weight of conventional counterparts and eliminates electromagnetic interference in 5G devices incorporating millimeter wave modules while also helping to lighten devices and enhance design flexibility.

Toray Industries

toray.com

VIRTUAL SYSTEMS ENGINEERING PREVIEW PRO

Preview Pro is a physics-based modeling and simulation platform that can complete analysis and test iterations virtually, thus reducing time expended and money spent. Features a virtual 3-D environment that allows users to import from STEP, visualize integrated form fit, visualize PCBs, including layers, traces, pads and vias, and visualize PCAs, including components, connectors, etc. Data coordination features include the ability to automatically search and display parts, visualize component data with graphical feedback, and replace/exchange parts based on specs and criteria. Physics-based testing features a virtual multi-meter, upstream package-analysis studies, component- and system-reliability analysis, and the ability to integrate with thermal and EMI/EMF software.

Virtual Systems Engineering

virtualsystemsengineering.com

CA

COUNT ON TOOLS 2023-5260 VACUUM NOZZLE

2023-5260 specialized vacuum nozzle is designed to handle all types of odd-shaped components with unmatched precision. Is paired with two outlying supports to offer exceptional accuracy and consistency during the placement process, allowing customers to effortlessly and reliably place the challenging SKT108775GQS header – a feat that previously relied on a manual hand placement process.

Count On Tools

cotinc.com

HERAEUS PTC4900 HEATER INKS

PTC4900 series self-regulating heater inks offer enhanced performance, expanded operating temperatures, and additional customization options. Designed for precise temperature control and are suitable for various applications, including EV battery heaters, ADAS heaters, flooring heaters and cabin comfort heaters. Target heater operating temperatures between 50°-90°C, with products targeting temperatures above 100°C currently in development. Permits precise heating with self-regulating properties, eliminating time-consuming adjustments and permitting wider process windows.

Heraeus Electronics

heraeus-electronics.com

HUMISEAL UV550 CONFORMAL COATING

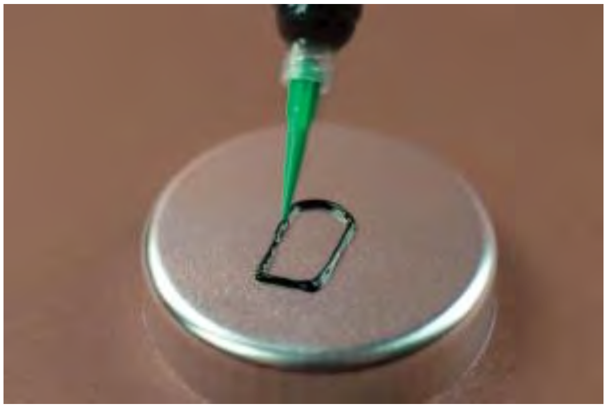
Humiseal UV550 is a solvent-free, UV-curable elastomeric acrylate conformal coating. Exhibits company’s highest performance to date regarding thermal and mechanical shock testing when compared to previous generation UV curable conformal coatings and has shown the capability to withstand and resist cracking under 1000 or more cycles of thermal shock in standard testing protocols. Can be cured by single-wavelength LED lights and is compliant with key worldwide environmental standards including RoHS Directive EU 2015/863, China RoHS 2, and China Standard GB30981-2020.

Humiseal
humiseal.com

JIDOKA FUJIN INSPECTION UNIT

Fujin hardware unit is designed to detect small and minute defects in flat surfaces that require scrupulous inspection and are imperceptible to the human eye. Is a two-axis table for end-of-line inspection where its motion can be designed to be used to move the product in front of the stationary camera or to move the camera across the length and width of the stationary component and is said to be able to capture small defects on the order of 0.1mm on a 500mm product. Customized to the product type, complexity in shape, size, nature of defects, and production volume, and fits in seamlessly on the production line for in-process as well as end-of-line inspections. Depending on component size and requirements, can detect defects and anomalies in products with a speed of three to five parts per minute and an accuracy rate of at least 98%.

Jidoka Technologies
jidoka-tech.ai

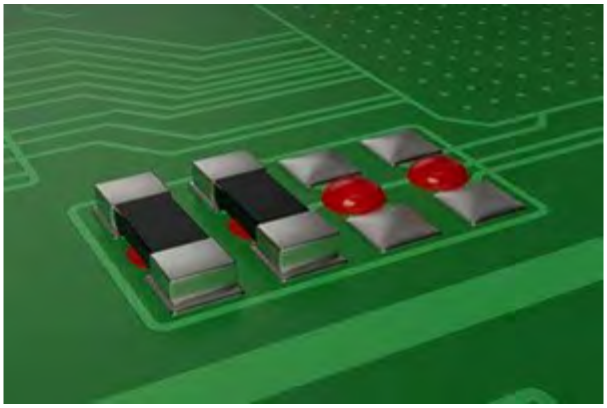


MASTER BOND SUPREME 3DM-85 EPOXY

Supreme 3DM-85 no-mix, non-solvent-based, one component epoxy is formulated to serve as the damming compound in dam-and-fill encapsulation applications. Can be used for bonding and sealing, especially where no flow is needed since the material cures in place and will not run or slump. Requires a relatively low heat cure of 85°C for 2-3 hrs., is thermally conductive and electrically nonconductive. Features a thermal conductivity of 5-10 BTU•in/ft^2•hr•°F [0.72-1.44 W/(m·K)] and is said to play an important role in facilitating effective heat dissipation and preventing overheating, especially in densely packed electronic assemblies. Maintains a Shore D hardness of 75-85, offers excellent damp heat resistance and has a good physical strength profile. Serviceable from -100° to +350°F (-73° to +177°C).

Master Bond

masterbond.com



PANACOL STRUCTALIT 5604 ADHESIVE

Structalit 5604 is a one-component epoxy resin adhesive that contrasts well with green PCB material due to its red color, allowing for visual inline inspection. Can be dispensed in production through jetting, valve dispensing, or screen printing, and its ideally adjusted viscosity and high thixotropy index enable high-speed dispensing, precise dot profiles, and non-slumping wet adhesion prior to curing. Thermal cure occurs within minutes, even at low temperatures, and when fully cured, is extremely temperature resistant. Can withstand short-term temperatures of up to 270°C, making it suitable for reflow soldering processes. Is also particularly shock-resistant and adheres to FR-4 printed circuit boards, metals, and epoxy-based molded materials. Has high ionic purity and thus provides optimum protection against internal corrosion, and due to high glass transition range of >115°C, is ideal for electronic component assembly.

Panacol

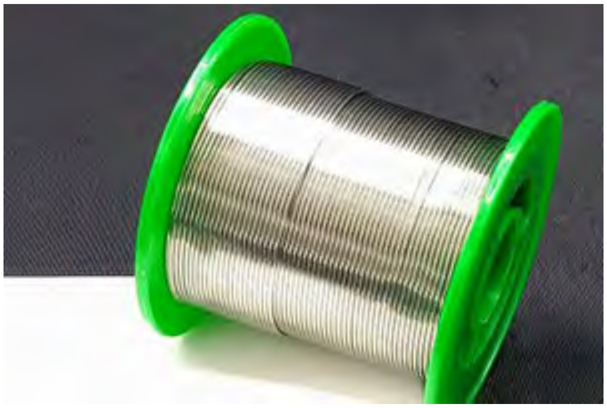
panacol.com

PANASONIC CONNECT NPM-GP/L SCREEN PRINTER

NPM-GP/L screen printer brings together hardware and software in a complete manufacturing solution, along with a full services support package. Production line changes can occur within a cycle time of 12 sec., including the cleaning cycle and with ±3.8μm positional repeatability. Handles a variety of PCB sizes up to 510 x 510mm and includes functions to achieve high-quality printing, including mask adhesion to prevent dragging, adjustable squeegee for optimum fill, and a solder and adhesive dispense head. Delivers sub-4 min. automated production line changeover from start to end, including automatic solder paste transfer, metal mask changer, and support pin replacement. Automates additional tasks during production, including solder supply using a perforated pot and a paper-free wiping unit that does not require solvent. Maintains status of materials during production and can automatically change printing parameters to achieve stable production. Machine-to-machine process control is enabled via communication with nine industry solder paste inspection partners across 29 different models.

Panasonic Connect

na.panasonic.com



SHENMAO PF735-LT201 SOLDER WIRE

PF735-LT201 low-temperature lead-free no-clean solder wire offers exceptional solderability and reliability for low-temperature PCBA soldering and rework processes. Achieves solderability by incorporating special low-temperature rosin and activators, ensuring optimal adhesion and a strong bond. Soldering process results in colorless flux residue, thanks to the inclusion of special surfactants. Is halogen-free (ROL0) and fully compliant with RoHS, RoHS 2.0, and REACH regulations, and enhances the working environment through reduced splash and smoke during soldering.

Shenmao America

shenmao.com

STACKPOLE CSRF1225 FOIL

CSRF foil on ceramic carrier series of current sense resistors now offers a 1225 size resistor rated at 3W. Available in resistance values from 1mΩ to 100mΩ in tolerances down to 0.5% and TCR as low as 50ppm. For power supplies, motor controls, industrial controls, voltage regulators, and LED drivers.

Stackpole Electronics

seielect.com

TAGARNO ZAP MICROSCOPE ACCESSORIES

Zap stereo microscope now includes accessories that permit the features and ergonomic benefits of a digital microscope without the need for a complete overhaul. Transforms existing stereo microscope with a ø76 yoke by removing the eyepiece and inserting the camera head, which enables the benefits of a digital microscope without disassembling and rebuilding the entire setup. Optimizes workflow, achieves ergonomic benefits, and seamlessly integrates digital microscopy into existing equipment.

Tagarno

tagarno.com

TRI TR5001E SII ICT

ICT TR5001E SII series offers comprehensive testing capabilities by consolidating MDA, ICT and FCT functionalities into a single platform, streamlining production lines and reducing costs. User-friendly interface simplifies programming and debugging supported by auto-tuning. With extensive functionality, including on-board programming, boundary scan, LED analysis, and more, it can handle various tests such as R/L/C measurements and capacitor polarity tests. Capacity of up to 3,456 testing points.

Test Research, Inc.

tri.com.tw

TRI TR7007Q SII 3-D SPI

TR7007Q SII 3-D SPI system is designed to maximize production efficiency. Delivers up to 50% faster inspection compared to previous models and is equipped with a 9.8μm high-resolution 21MP camera to deliver enhanced measurement accuracy and stability. Effectively inspects bumps, flux, mini LED solder and bare boards. Improved accuracy and stability enable precise solder measurements and minimize false calls, and is equipped with a wide spectrum light system and coaxial lighting to provide higher contrast, exceptional clarity and uniformity to improve detection rates.

Test Research, Inc.

tri.com.tw

In Case You Missed It

Characteristic Impedance

"Identifying and Modeling Resonance-Related Fluctuations on the Experimental Characteristic Impedance for PCB and On-Chip Transmission Lines"

Authors: Yojanes Rodríguez-Velásquez, Reydezel Torres-Torres and Roberto Murphy-Arteaga

Abstract: It is well known that the fluctuations in experimentally obtained characteristic impedance versus frequency curves are associated with resonances originated by standing waves bouncing back and forth between the transitions at the transmission line terminations. In fact, microwave engineers are aware of the difficulty to completely remove the parasitic effect of these transitions, which makes obtaining smooth and physically expected frequency-dependent curves for the characteristic impedance a tough task. Here, the authors point out for the first time that these curves exhibit additional fluctuations within the microwave range due to standing waves taking place within the transition itself. Experimental verification of this fact was carried out by extracting this fundamental parameter from measurements performed on on-chip and printed circuit board (PCB) lines using probe pad adapters and coaxial connectors. The authors demonstrate that the lumped circuit approach to represent the transitions lacks validity when the additional fluctuations due to the connectors become apparent, and we propose a new model including transmission line effects within the transition. *(Electronics,* July 2023, https://doi.org/10.3390/electronics12132994)

Component Reliability

"The Failure Mechanism of Common-Mode Chip Inductors"

Authors: Jin Chen, et. al.

Abstract: The failure behavior of common-mode chip inductors (CMCIs) on printed circuit boards was investigated to reveal the failure mechanism of low-temperature cofired ceramic (LTCC) devices. A specific model of CMCIs (0806-type) with an insulation resistance greater than 109Ω was used in this research. In the highly accelerated life test (HALT), the insulation resistance of the CMCI was rapidly reduced to less than 103Ω, which was determined to be invalid. A variety of analytical techniques were used to determine the failure mechanism of the CMCIs, including computed tomography (CT), optical microscopy, scanning electron microscopy (SEM) with energy-dispersive x-ray spectroscopy (EDS), and x-ray photoelectron spectroscopy (XPS). The results show that silver migration and Na enrichment are the direct reasons for the failure of the CMCIs. The Na+-β/β″-Al_2O_3 formed in the sintering provides pathways for the migration of Ag+ and Na+ in the LTCC under an electric field. With the further reaction, Na is enriched in the LTCC near the low potential while Ag+ is reduced to Ag and deposited in the LTCC near the high potential, which causes the gradual failure of the insulation resistance of the CMCIs until a short circuit occurs. (*Journal of Electronic Materials,* May 2023, https://doi.org/10.1007/s11664-022-10105-y)

Tin Plating

“The Influence of Element Lead (Pb) Content in Tin Plating on Tin Whisker Initiation/Growth”

Authors: David Hillman, *et. al.*

Abstract: The implementation of the Restriction of Hazardous Substances (RoHS) European Union (EU) Directive in 2005 resulted in the introduction of pure tin as an acceptable surface finish for printed circuit boards and component terminations. A drawback of pure tin surface finishes is the potential to form tin whiskers. Tin whiskers are a metallurgical phenomenon associated with tin rich/pure tin materials and have been a topic of intense industry interest. The acceptance and use of pure tin by the electronics industry component fabricators is understandable as the pure tin surface finishes are inexpensive, are simple plating systems to operate and have reasonable solderability characteristics. However, high performance/harsh environment electronics typically have product lifecycles that are measured in decades and therefore are much more susceptible to the potential long-term threat of tin whiskers. GEIA-STD-0005-2 “Standard for Mitigating the Effects of Tin

Whiskers in Aerospace and High Performance Electronic Systems" established the definition of the term "Pb-free tin" as "pure tin or any tin alloy with <3% lead (Pb) content by weight." A functional definition of "pure tin" was necessary so the electronics industry could establish tin whisker risk protocols against a known acceptable target value in terms of soldering materials and processes. An investigation was conducted to determine the influence of 1-5% elemental lead (Pb) content in tin plating on tin whisker initiation and growth. The investigation results were used in the revision of GEIA-STD-0005-2 technical discussions. (*Journal of Surface Mount Technology,* March 2023, https://doi.org/10.37665/smt.v36i1.28)