PCEA
Printed Circuit Engineering Association

Bigelow: Are Auditors a Dying Breed?

# PRINTED CIRCUIT DESIGN & FAB

pcdandf.com
circuitsassembly.com
December 2022

# CIRCUITS ASSEMBLY

## Reliable TIM Assemblies

Clock Management

Low-Temp Rework

Service Excellence Awards

This issue of Printed Circuit Design & Fab/Circuits Assembly is brought to you by:

DECEMBER 2022 • VOL. 39 • NO. 12

# PRINTED CIRCUIT DESIGN & FAB CIRCUITS ASSEMBLY

## FIRST PERSON



## MONEY MATTERS



## TECH TALK



## DEPARTMENTS



## FEATURES




## ON PCB CHAT (pcbchat.com)

PCB Chat

**HDPUG PB-FREE PROGRAMS**
with MADAN JAGERNAUGH

**SMTA PAN PACIFIC SYMPOSIUM**
with CHUCK BAUER, PH.D., and KEITH BRYANT

APCT
Passion | Commitment | Trust

# APCT CAPABILITIES

## TECHNOLOGIES

### RIGID THROUGH-HOLE

| | |
|---|---|
| Standard: | 2 – 28 Layers |
| Advanced: | 30 – 38 Layers |
| Development (NPI only): | 40+ Layers |

### HDI; BLIND/BURIED/STACKED VIA

| | |
|---|---|
| Lam Cycles: | Up to 8x |
| Micro BGA Pitch: | .2 Millimeters |

### FLEX / RIGID-FLEX

| | |
|---|---|
| Standard Flex: | 1 – 6 Layers |
| Rigid Flex: | 4 – 22 Layers |
| Rigid Flex HDI Lam Cycles: | Up to 2x |

## LEAD TIMES

### RIGID THROUGH-HOLE

| | |
|---|---|
| Standard: | 20 Days |
| 2 – 10 Layers: | 24 Hours |
| 12 – 24 Layers: | 48 Hours |

### HDI; BLIND/BURIED/STACKED VIA

| | |
|---|---|
| Via in Pad Standard: | 20 Days |
| Via in Pad Expedited: | 3 Days |
| HDI Standard: | 25 Days |
| HDI Expedited: | 5 – 12 Days |

### FLEX / RIGID-FLEX

| | |
|---|---|
| Flex 1 – 6 Layers Standard: | 25 Days |
| Flex 1 – 6 Layers Expedited: | 5-15 Days |
| Rigid Flex 4-22 Layers Standard: | 25 Days |
| Rigid Flex 4-22 Layers Expedited: | 20+ Days |
| Rigid Flex HDI 2x Lam Cycles: | 30 Days |

## CERTIFICATIONS

- ISO 9001 Certified
- AS9100D Certified
- MIL-PRF-31032 Certified (MIL-P-55110 Certified)
- MIL-P-50884 Certified
- ITAR Registered at all sites
- IPC 6012 Class 3 & 3A
- IPC-6013 Class 3 & 3A
- IPC-1791 Trusted Electronics Qualified Manufacturers Listing (QML)*

*APCT Anaheim & Orange County Only

## QUANTITIES

- Prototypes
- Mid-Production
- Production Orders through Offshore Partnerships

Printed Circuit Board Solutions


APCT.com

| APCT Santa Clara HQ | APCT Anaheim | APCT Orange County | APCT Wallingford | APCT Global |
|---|---|---|---|---|
| 408.727.6442 | 714.921.0860 | 714.993.0270 | 203.269.3311 | 203.284.1215 |

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

The Circuits Assembly Directory of EMS Companies


### 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., Joseph Fama, Mark Finstad, Nick Koop, 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

brooke@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.

MIKE
BUETOW
PRESIDENT

# Keep an Eye on the Cameras

WE'VE ALL AWAKENED to the fact that our environment is watching us.

It happens in the home, where we are surrounded by Rings and Nests and Alexas, tracking our movements (slow), our room temperatures (cold), our conversations (yikes!).

It happens in our vehicles. Our insurers, for instance, want to know how fast we drive (very), so they can adjust our premiums accordingly.

Or perhaps we are taking advantage of one of the many "safety" apps like Life360 to track our child's whereabouts. (I do.)

Indeed, we are surrounded by spies, but the context to date has been framed in personal terms.

Have you considered, however, the possibility that some of these devices could unwittingly be turning us into moles, too?

US Rep. August Pfluger (R-TX), a retired US Air Force colonel and member of the US National Security Council, thinks so.

In a letter to the US National Highway Traffic Safety Administrator last month, Rep. Pfluger laid out what he called the "national security implications" of autonomous vehicles (AVs). The next generation of autos, Rep. Pfluger says, could very well be Trojan Horses, allowing foreign countries access to all sorts of data and images of highly sensitive areas.

Much like the TikTok app jarred US security officials because of the possibility the personal data it captured could be shared with the Chinese government, AV technology could be harnessed and exploited by adversaries.

If you've traveled in the Silicon Valley lately, you almost certainly have seen the stream of test cars, loaded with high-res cameras and sensors, navigating the Bay Area's streets. These vehicles are capturing and sharing massive streams of images. That information is sent to purpose-built Edge Inference computers capable of handling the 4TB to 5TB of data AVs produce per vehicle per day.

Imagine, for instance, an employee working for an intelligence-gathering organization such as the Central Intelligence Agency or National Security Agency. That worker's AV could be turned into a transmitter, beaming out pictures of coworkers' cars and, perhaps, faces, thus revealing identifications and relationships. Or perhaps even images of secret sites would suddenly become available.

The questions over what policies are appropriate for the US (and for that matter, the West) are still being formulated, as are the parameters for what data foreign-based companies can collect and share abroad. But the paranoia is a two-way street: Reuters last June reported China restricted Tesla vehicles from the site of its annual Chinese Communist Party meetings for the very same reason.

Rep. Pfluger is calling for oversight of Chinese companies testing AVs to head off the potential transfer of critical data offshore, which he says "constitutes a serious national security threat." It is similar, he says, to Huawei's infiltration of American infrastructure.

I can't imagine why someone other than me would care that my son has stopped at Chipotle for the fifth time this week. But just in case, maybe we'll hang on to our ancient Honda Pilot a little longer.

**Recognizing the NRTL.** Speaking of bans on foreign-made technology, we have begun hearing of US companies clearing out their Lenovo computers, which strikes me as a bit underwhelming, unless they also shed all the HPs and Dells that also are made in China.

But we are also hearing that audits are taking place to ensure machinery bears OSHA's Nationally Recognized Testing Laboratory logo. Per OSHA, the NRTL is a certification that ensures certain products meet the requirements of OSHA electrical standards. Remember, CE logos are not accepted for US equipment, and OSHA no longer recognizes UL 94 or UL 796.

In practice, this means some engineers are being required to look outside their processes to individual parts. This includes poring over self-opening doors and motors and circuit breakers, looking for NRTL labels. And certification isn't cheap: $2,500 per machine, we've been told.

In speaking with several fabricators and contract assemblers, the "good" news is this latest certification push doesn't seem to have taken hold beyond defense contractors. But it is one more thing to be aware of.

**Goodbye, 2022.** Most of us were probably glad to be done with 2020 and 2021. We at PCEA will miss 2022, a milestone year in our association's history. The acquisition of UP Media Group, coupled with a broad uptick in business, made this a tremendously successful year. We are thankful to our readers, advertisers and exhibitors, and wish you all a joyful and healthy 2023.

mike@pcea.net
@mikebuetow

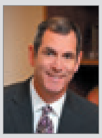
## PCDF People

American Standard Circuits appointed **Robert Duke** head of ASC's new Global Sourcing division.

**Russell Briggs,** who developed the first electronics design automation program to run on a minicomputer, passed away.

**Mat Gosselin Sr.,** 67, the founder of Circuit Board Express, has passed away.

The Printed Circuit Board Association of America named **David Schild** the association's first executive director. Schild is founder and managing partner of Three Rivers Strategies, a strategic public affairs firm, and spent several decades in the aerospace and defense industry, managing political engagement, employee communications, advocacy campaigns, executive coaching and public affairs for TRW, United Technologies and Raytheon.



Rogers Corp. plans to promote **Colin Gouvei** (pictured) to CEO, effective Dec. 31, replacing **Bruce Hoechner,** who is retiring. Since June 2019, Gouveia has been senior vice president and general manager of Rogers' Elastomeric Material Solutions business unit. He has more than three decades of cross-functional experience in the specialty chemical and materials manufacturing industries.

Ventec appointed **Paul Cooke** senior director of business development. He has 30 years' combined sales and engineering experience with FTG, AGC-Nelco, and other electronics companies, and is a leading contributor to PCB standards organizations, including IPC, HDPUG and SMTA.

## PCDF Briefs

**Elvia PCB** will not rebuild its fabrication plant in Saint-Ay, France, which was destroyed by a fire earlier this year.

**Mitsui Mining & Smelting Co. (Mitsui Kinzoku)** has joined the **High Density Packaging (HDP) User Group.**

**Keysight Technologies** has licensed its electromagnetic simulation technology to develop power analysis solutions for PCB designers to **Altium,** which integrated the technology with its GUI to create Power Analyzer.

**Molex** opened a 60,000 sq. m facility factory in Guadalajara.

**University of Copenhagen,** Copenhagen, Denmark researchers developed a record-

## DuPont Terminates $5.2B Rogers Buyout

**WILMINGTON, DE –** DuPont on Nov. 2 announced it is terminating a $5.2 billion buyout of Rogers Corp. after the two companies were unable to obtain timely clearance from all the required regulators.

The two companies previously agreed to the buyout last November, with DuPont offering $277 a share. DuPont said in September that it had received all regulatory approvals except from China, and the company had withdrawn and refiled the notice of the parties' planned merger with the State Administration for Market Regulation of China.

In a statement, Rogers said the company is currently evaluating all options to determine the best path forward in response to DuPont's notice.

"Rogers remains an exceptional company, and the team continues to execute on our successful growth strategy. Our strong competitive position innovating across fast-growing markets, including EV/HEV, is underscored by continuing design wins, broad customer enthusiasm and a robust pipeline of opportunities," the statement said.

## EMA Announces New Support+ Program for Cadence Customers

**ROCHESTER, NY –** EMA Design Automation in November announced a new program with unique content, discounts and tools to help engineers get the most from Cadence design software.

EMA Support+, available to all EMA customers on active maintenance, includes:

- Access to EMA's new Knowledgebase, with solutions, tips, and guides
- Discounted access to EMA E-learning, with over 100 hours of training
- The EMA Toolkit featuring integrated apps to improve efficiency.

"EMA has been delivering world-class EDA support for over 30 years," said Manny Marcano, president and CEO, EMA Design Automation. "We are very excited to be able to offer this benefit as another example of the unique value EMA brings to the engineering community worldwide."

The EMA Support+ program features the EMA Toolkit, a collection of apps designed to improve user productivity and help designers get their boards done right the first time. Version 1.0 of EMA Toolkit consists of five apps:

- Find in Design – Quickly scan multiple designs to find where specific components are used
- CircuitFit – Calculate and analyze board space occupied by components before committing to layout
- PCB Clustering – Advanced PCB placement and clustering for faster more efficient layout
- Highlight Part by Property – Automatically color-code parts by properties for easy identification
- CIS BOM Template – Easily generate a fully formatted and branded BOM from CaptureCIS.

"We are just getting started," said Marcano. "The team has great plans ahead for this program to keep adding value for our customers."

The EMA Support+ program is available now to all active maintenance customers at no charge. Learn more and request your EMA Support+ benefits at go.ema-eda.com/support-plus.

## Firan Announces Deal to Acquire IMI

**TORONTO –** Firan Technology Group in November entered into an agreement to acquire IMI, Inc., a manufacturer of specialty RF circuit boards focused on the aerospace and defense markets.

FTG will acquire 100% of the common shares of IMI for cash consideration of approximately C$2 million ($1.5 million), subject to typical closing adjustments.

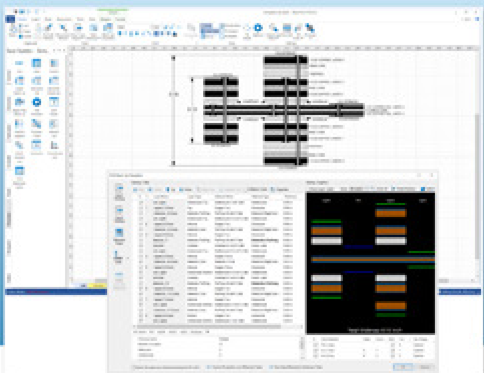
# Support For Flex, Rigid Flex and Embedded Component Designs Now Available.

BluePrint-PCB®

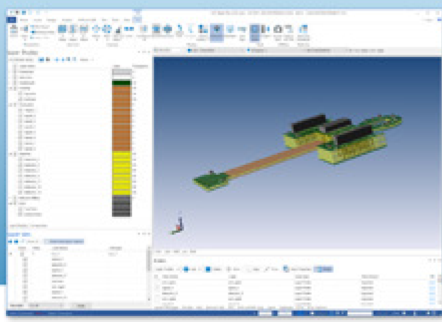
CAM350®

DownStream's CAM350 and BluePrint-PCB support importation and visualization of PCB designs containing Flex, Rigid Flex or Embedded components. Visualize designs in both 2D and 3D, and easily document complex Flex or Rigid- Flex Stack-Ups for submission to PCB Fabricators.

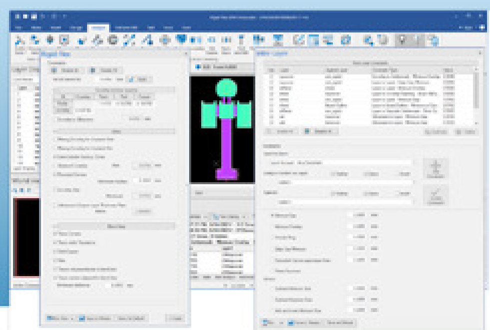
- Import and Visualize Flex, Rigid-Flex and Embedded Component Designs
- 3D Visualization to Validate PCB Construction and Component Assembly
- Manage Variable Stackup Zones for Rigid-Flex Designs
- Easily Create Custom Flex or Rigid-Flex Fabrication and Assembly Documentation
- Use DFM analysis to analyze a flex or rigid-flex design for potential fabrication or bend related defects



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



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



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

DownStream Technologies

For more information visit downstreamtech.com or call (508) 970-0670 breaking optical chip capable of transmitting 1.8 petabits (1.8 million gigabits) per second, roughly twice the world's total Internet traffic (per second).

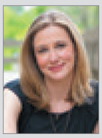
Three memoranda of understanding were inked between businesses in Taiwan and India for cooperation in electronics manufacturing and green technologies.

**Trackwise Designs** said it secured a new agreement with a UK electric-vehicle manufacturer.

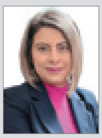
**Zuken** is accepting abstracts for Zuken Innovation World Americas 2023, to be held on June 5-8 in Scottsdale, AZ.

## CA People

Altus Group named **Jiri Kucera** operations director, overseeing all after-sales operational elements of the business's strategy. Most recently, he was head of engineering for STI Ltd. and has held similar top-tier management roles as operation director at Fabrinet.

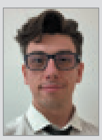


Arch Systems named **Luisa Hermann** head of product. She has 10 years' experience in product management and product marketing, launching products, building teams, and scaling organizations in the data software space, and a bachelor's in chemical engineering from the University of Pennsylvania.



CalcuQuote appointed **Nour Labiedh** European business development manager. She has previous experience in EMS as a purchaser and sales experience in global electronics distribution.

Icape appointed **Christelle Bonnevie** chief industrial officer.



Indium promoted **Sze Pei Lim** to senior global product manager, Semiconductor and Advanced Material, and **Theo Ruas** (pictured) to global sales manager for Metals and Compounds.

Jabil named **Kenny Wilson** the company's next chief executive.

Mycronic named **Kevin Clue** vice president of global sales.

Pride Industries named **Charles Sharp** senior vice president and chief financial officer.

StenTech appointed **Greg Starrett** director of sales – United States. He has more than 29 years' experience in all aspects of the SMT business.

IMI reported annual sales of approximately C$4 million ($3 million) to C$5 million ($3.76 million) in its unaudited financial statements over the past few years.

Closing is expected to take place in the first quarter of fiscal 2023, subject to approval by the Committee on Foreign Investment in the United States (CFIUS) and other customary closing conditions. The companies will shortly apply for CFIUS approval.

"FTG had identified a desire to increase its product offering of RF Circuit Boards for aerospace and defense applications," said Brad Bourne, president and CEO, FTG. "This acquisition, if completed, will complement FTG's existing facilities, add new customers and provide a broader product offering to our existing customer base. [IMI CEO and president] Peter Bigelow has done an excellent job building IMI's RF capability through investments in people, processes and technology and FTG plans to grow IMI from its current location."

"I am pleased with the sale of IMI to FTG, as I believe FTG will continue to build the business going forward to the benefit of IMI's customers, employees and other stakeholders," Peter Bigelow, president and CEO, IMI, Inc.

Bigelow will remain with the company as president for a period of time after the closing.

# NCAB Group Acquires Bare Board Consultants in Italy

**MILAN, ITALY** – NCAB Group on Nov. 24 signed an agreement to acquire 100% of the shares in Bare Board Consultants based in Codogno, south of Milan.

The transaction is expected to close in January.

The acquisition will be accretive to earnings per share in NCAB Group in 2023. Synergies are expected in suppliers, payment terms, factory management, and logistics.

Bare Board Consultants, founded in 1990, serves customers in Italy and expects net sales of about SEK 90 million ($8.6 million) in 2022 with an estimated EBITA of SEK 9 million. The company provides customers with PCBs in the HMLV (high-mix, low-volume) segment, mainly in the industrial and medical sectors. Its suppliers are located in China.

In a press release, Anders Forsén, CFO, NCAB, said: "Bare Board Consultants is a well-known trader of high-quality PCBs and complements our Italian business very well. It is an important component of NCAB's strategy to actively participate in the consolidation of the market. Bare Board Consultants will be integrated with NCAB Group Italy."

Added Luigi Faliva, former owner and chairman, Bare Board Consultants: "We are happy to be joining forces with NCAB Group. Bare Board Consultants is a customer-oriented organization with a strong focus on quality, reliability and service. Becoming part of NCAB Group will give our customers access to the best technology and their extensive factory base in Asia and Europe, as well as increased resources and competence worldwide."

Bare Board Consultants' employees will relocate to NCAB's existing office in the area.

## Tempo Automation Finalizes Merger, Goes Public

**SAN FRANCISCO** — Tempo Automation announced on Nov. 23 it had completed its business combination with ACE Convergence Acquisition Corp., a special purpose acquisition company traded on Nasdaq.

ACE's shareholders approved the business combination at an extraordinary general meeting held Nov. 17.

The combined company will operate under the name "Tempo Automation Holdings, Inc." ("Tempo Automation"). Tempo Automation's common stock and warrants are now traded on Nasdaq under the ticker symbols "TMPO" and "TMPOW," respectively.

Tempo Automation's management team will continue to be led by chief executive

## CA Briefs

**Bright Machines** raised $132 million to accelerate the company's growth and aid the development of new software and service offerings to add to its existing portfolio of automation projects.

**CalcuQuote** announced an integration with **WireMasters,** a source for mil-spec wire, cable, connectors, and harness management products.

**Ducommun** reopened its wire harness assembly facility in Guaymas, Mexico.

The Gujarat, India, government announced a new electronics policy with the aim to create one million jobs – double what was promised in the earlier policy.

**Hentec Industries/RPS Automation** has published a technical paper describing the suggestion to establish a partnership with an experienced soldering equipment supplier.

**Incap** installed an **Mirtec** MV-3U Omni desktop 3-D AOI.

**Indium** has expanded its operations in Malaysia with a new 37,500 sq. ft. manufacturing facility in Penang.

**Jabil** and **Supplyframe** believe organizations must lay the foundation for resilience by treating commodity/category management as equally important to transactional sourcing, and ensuring short-term wins are not at the expense of long-term needs.

**Kitron** has entered an NOK750 million production agreement with **Kongsberg Defense & Aerospace** for electronic modules for a remote weapon station system.

**Koh Young** named **Lean Stream** technical sales representative across northern California and Nevada.

**Mack Technologies** added four surface mount lines to its EMS operations across multiple sites.

**NationGate** has received approval from Bursa Malaysia Securities for the EMS company to list on the ACE Market.

**Nordson** in November completed its previously announced acquisition of **CyberOptics.**

**Spartronics'** newest EMS facility will open this fall in Binh Duong City, Vietnam.

**Starlight Refined Technology** purchased a **Hentec Industries/RPS Automation** Pulsar solderability system.

**West-Tech Materials** has entered a sales agreement with **Trans-Tec,** distributor of **Yamaha** SMT equipment.

Joy Weiss and chief financial officer Ryan Benton.

In a statement, Weiss said: "We are excited to begin our journey as a publicly traded company and continue executing on our vision of building the preeminent electronics manufacturer serving the approximately $290 billion US prototype and on-demand manufacturing market."

"It's been an honor helping Tempo Automation on their path to becoming a publicly traded company, where they can leverage the public market capital to scale, and realize their vision of becoming the leader in the software-driven PCB prototyping industry," said Behrooz Abdi, chairman and CEO of ACE and incoming chairman of Tempo Automation.

## All Circuits All Full, Looking for New Plants

**MEUNG-SUR-LOIRE, FRANCE –** All Circuits is looking for room to grow its operations by purchasing a new EMS plant in France or elsewhere in Europe.

The company opened a 6,000 sq. m. expansion at its production facility in Meung-sur-Loire, in southern France, earlier this year, and that expansion is already at full capacity, All Circuits President Bruno Racault told Evertiq.

"All of the new wing that we added this year is fully booked already, so I'm looking to purchase a new plant now," he said.

Racault said he would prefer the new plant be located in France if possible, or at least somewhere in Europe to supply the local market, and the new facility would have sales of around 100 million to 200 million euros ($103 million to $206 million).

"The business is there and it's really booming," he said.

All Circuits also needs a new facility in China to serve the local market there, and that would be in two or three years, Racault said.

## Salary Budgets Rise Sharply in 2022, Says New IPC Study

**BANNOCKBURN, IL –** A sharp increase in salary budgets and use of flexible hours programs for North American electronics assembly companies are among the findings of a new study published by IPC in November.

The 2022 *Wage Rate & Salary Study for the North American Electronics Assembly Industry* found the 2022 projections are 10%, well above the 2021 rise.

Responding companies reported annual average percent change in salary budgets in 2021 was 3%. Comparatively, salary budgets grew an average of 8.6% in 2019, the trade group said.

## Saki Opens New Solution Center in Thailand

**TOKYO –** Saki Corp. held the opening ceremony for its solution center in Nonthaburi, Thailand, on Nov. 29. The Saki Solution Center Thailand holds the recently relocated main offices for Saki Asia Pacific (Thailand) Co. Ltd., as well as a wide range of Saki's inspection machines for on-site and online demonstrations and hands-on access to customers.

The machines on display include 3-D SPI equipment, 2-D automatic visual inspection equipment, and the its next-generation 3-D AOI. A 3D-AXI machine will be added to the center's lineup in 2023.

The facility was developed as a demonstration hub for manufacturers across the Asia-Pacific region, as well as customers from Europe and the Americas with manufacturing facilities in the Asia-Pacific region. The center is also equipped with sophisticated online demonstration facilities for customers unable to visit personally.

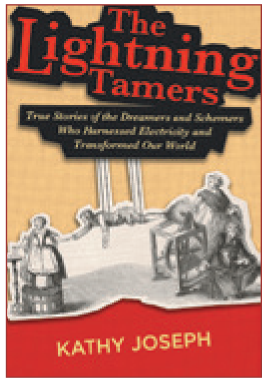
"The ability to have a hands-on experience with Saki's world-class machines allows for a far greater understanding of our total inspection line solution for both new and existing customers," said Jayson Moy, general manager, Saki Asia Pacific Thailand. □

# PCB Carolina a Success

**RALEIGH, NC** – PCEA's RTP Chapter held its annual trade show here in November and by all accounts it was a success. The show floor was sold out and registration was its highest ever, the show producers reported.

More than 1,000 professionals registered for PCB Carolina this year, which was held on Nov. 9 at the McKimmon Center on the North Carolina State University campus.

The conference featured scores of vendors involved in PCB design software, fabrication, assembly, components, materials and more, plus two hands-on soldering workshops and 16 technical presentations throughout the day that covered topics such as Safeguarding Electronics with Nanocoating Technology, Making Intelligent Material Decisions, Understanding Semiconductor Lead Times, and PCB 101: How Boards are Manufactured.




*The Lightning Tamers* author keynoted PCB Carolina this year.

Kathy Joseph, host of the Kathy Loves Physics YouTube channel and author of The Lightning Tamers, keynoted the event. Her presentation, "The Origins of the World's Electricity," chronicled names and stories – some familiar, some less so – to tell the story of the birth of electricity and explain quirks of the world's electrical systems, such as the reasons why most countries use around 220V and 50Hz for their main voltage while the US and Canada use around 120V and 60Hz.

Those looking for the next generation of printed circuit engineers will be pleased to note the chapter recruited volunteers from NC State and local community colleges to man the doors and provide support.

## Chapter News

**Ontario, Canada.** On Nov. 24 we held a virtual Lunch' n' Learn featuring Ata Syed, field application engineer at PFC Flexible Circuits. Syed is starting a multipart series on flex circuits. In this first session, he covered the five "W's" of flex technology:

- What is flex?
- Why use flex?
- Who should know flex?
- When to use flex.
- Where to use flex.

**Membership committee update.** In early December Mike Creeden will lead a couple of leadership sessions for existing and startup chapters. We will give updates on the association, strategic plan and education committees, and events planned for 2023. Q/A is a big part of these sessions. The sessions will be recorded for chapter leaders who cannot make the live call.

**Education Committee update.** The abstracts deadline for PCB East 2023 has ended and we have received about 50 abstracts. The Conferences task group is led again by Rick Hartley. A PCEA Conference Abstract Selection Process will be used for the first time for this event. The target date for releasing the three-day technical program is Jan. 3, and PCB East takes place May 9-11 in Boxborough, MA.

PCB Carolina reported record attendance at its annual trade show in Raleigh, NC, in November.

# IPC: Electronics Manufacturers Bracing for Recession

**BANNOCKBURN, IL** – New data from IPC show that most electronics manufacturing industry executives see a recession as inevitable. IPC's October Monthly Economic Outlook and Global Sentiment Survey found that 27% of industry executives believe the economy is already in a recession, 45% believe the economy will enter a recession in 2023, and 13% believe the economy will enter a recession in the fourth quarter of 2023. Industry executives expecting a recession are bracing for a longer one.

The survey queried hundreds of companies around the world, representing a range of company sizes across the full electronics manufacturing value chain.

"Tight financial conditions and an uncertain economic outlook are making both businesses and consumers more cautious," stated Shawn DuBravac, chief economist, IPC. "We have reached the end of the post-lockdown rebound."

Among other conclusions, the IPC survey results show:

- After declining for two consecutive months, the Materials Cost Index rose three points
- Three-fourths (73%) of electronics manufacturers indicate labor costs are on the rise
- Ease of recruitment, profit margins and inventory available from suppliers are presently declining
- Positively, manufacturers expect to see a decline in backlogs over the next six months.

Inflation continues to dominate the narrative, with the US likely past peak inflation, while the situation worsens in Europe. Europe is expected soon to reach peak inflation, and prices continue to rise. Projections for economic growth in Europe in 2023 have been lowered, and now show a decline for the first time for the entire year. China's economy remains below the targeted 5.5% growth expected for the year, with growth likely to be closer to 3% in 2022. The yuan has fallen to its lowest level in 14 years.

### CHIPPING IN (% CHANGE)

*Trends in the US electronics equipment market (shipments only).*

| | JUL. | AUG.[r] | SEP.[p] | YTD% |
|---|---|---|---|---|
| Computers and electronics products | 0.5 | 0.0 | 0.7 | 6.3 |
| Computers | 3.5 | -2.0 | -1.2 | 0.1 |
| Storage devices | 0.0 | -0.6 | -2.7 | 14.2 |
| Other peripheral equipment | 26.9 | 3.0 | 4.4 | 31.7 |
| Nondefense communications equipment | 1.8 | -2.8 | -0.8 | 10.1 |
| Defense communications equipment | 3.3 | -1.4 | -1.4 | 6.7 |
| A/V equipment | 10.9 | 0.3 | 0.8 | 27.8 |
| Components[1] | 1.1 | -0.6 | 0.7 | 14.2 |
| Nondefense search and navigation equipment | 0.8 | -0.4 | -0.8 | 1.6 |
| Defense search and navigation equipment | -0.8 | 2.1 | 0.6 | 0.4 |
| Medical, measurement and control | -0.8 | 0.5 | -0.2 | 4.3 |

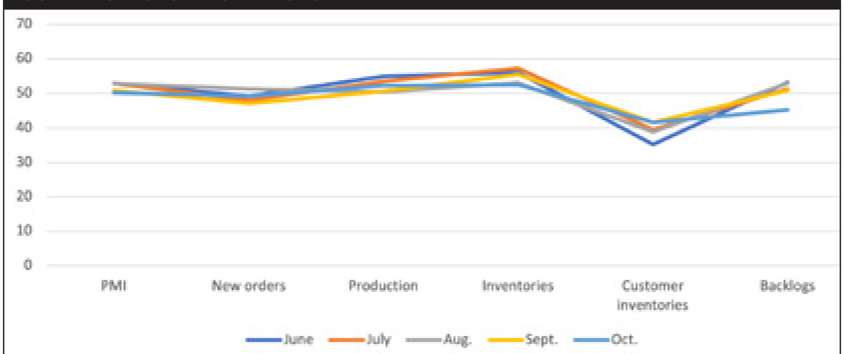
[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: U.S. Dept. of Commerce Census Bureau, Nov. 3, 2022

### KEY COMPONENTS

| | MAY | JUN. | JUL. | AUG. | SEP. |
|---|---|---|---|---|---|
| EMS (North America)[1,3] | 1.37 | 1.41 | 1.39 | 1.31 | 1.29 |
| Semiconductors[2,3] | 18%[r] | 13.3% | 7.2% | 0.0%[r] | 3.0%[p] |
| PCBs[1,3] (North America) | 1.05 | 1.03 | 0.98 | 0.98 | 1.12 |

Sources: [1]IPC, [2]SIA, [3]3-month moving average, [p]preliminary, [r]revised

### US MANUFACTURING INDICES




Source: Institute for Supply Management, Nov. 8, 2022

## Hot Takes

- **North American EMS shipments** rose 15.5% year-over-year in September, and 14.9% in October. Bookings were up 21% and 7.8%, respectively. (IPC)
- **Worldwide tablet shipments** were down 8.8% year-over-year in the third quarter, totaling 38.6 million units. (IDC)
- **Global silicon wafer shipments** are projected to increase 4.8% year-over-year in 2022 to a record high of nearly 14,700 million square inches (MSI). (SEMI)
- **North American PCB shipments** in September were up 14.6% compared to the same month last year. Bookings fell 2.6%. (IPC)
- **Refined tin use** in 2021 increased 7.6% to 389,500 tonnes with a strong recovery to pre-trade war highs. (International Tin Association)
- A steep drop in **sales sentiment for semiconductors** dragged the overall component sentiment index down 6.7 points to 75.6. (ECIA)
- **Worldwide smartphone shipments** declined 9.7% year-over-year to 301.9 million units in the third quarter. (IDC)
- **China's chip imports** fell 12.4% in September, continuing a decline amid tensions with the US and an ongoing chip shortage. (China Finance Ministry)
- The **Philippine electronics sector** is expected to hit 10% growth this year. (Philippines Department of Trade and Industry)
- Although some customers are deferring orders, **Taiwan's PCB equipment makers** remain optimistic. (DigiTimes)
- Worldwide **IT and business services revenue** is expected to grow 5.7% this year and 5.2% in 2023. (IDC)

# When It Comes to Auditors, is Our Luck about to Run Out?

The needed combination of experience and willingness to travel is hampering certification programs.

IN JUST ABOUT every industry, be it design, make, service, support or advisory, the most-heard complaint – and frequent challenge – is finding people. And while Barbara Streisand beautifully sang how "people who need people are the luckiest people," I think most in business would call themselves anything but lucky. Certainly, they are at a point where they too often are counting on luck to fill open positions.

Much has been written about the need for talent in our industry. Like most industries, we face a need to replace an aging workforce. In addition, there is momentum to bring design and manufacturing jobs from elsewhere in the world to North America. Together, the challenge to find, hire and train new talent is a tall one, made tougher by lack of aspiration of younger talent to enter manufacturing or commit their time to learn a specific industry or technology. That said, as bad as it may seem navigating staffing challenges we have in our industry, it could be worse.

Think of the businesses and jobs that rely primarily on the "gray hair" workforce and what they may soon face – or are already. Take quality auditors, for instance, specifically those who audit for ISO/AS/QS registrars. Over the nearly 30 years that ISO has been the universally required quality system, almost all the auditors I have encountered had long careers in quality management, then started new careers as ISO auditors. The benefit this provides both registrar and client is a skilled staff experienced in business and who understand the day-to-day challenges of delivering a product or service. It makes a difference when those auditing a quality system standard have both the theoretical knowledge of what that system requires as well as the practical experience to know what is truly doable.

After a recent annual surveillance audit, as the auditor was packing to leave, he commented that the number of AS9100 auditors is not enough to handle the demand. When asked if that was the case for just his registrar, the response was: "It's the same for all registrars. Many of us are getting old or no longer want to travel." These comments were certainly understandable based on the relative age and experience of most auditors, but the "what if" implications are concerning.

I am certain younger people are entering the registrar audit world, and some may be well qualified both in quality systems and real-world experience. All industries, however, whether manufacturing or service, are looking to fill internal positions in quality control and assurance. Will these workers leave in-demand positions to become ISO/AS/QS auditors? And after several years of a pandemic, how many will want to return to the heavy travel that auditing typically requires?

Possibly the biggest "what if" is, can quality systems that require external audits be performed on an annual basis survive without qualified auditors, or will they collapse due to a lack of talent to support the audit requirements? Will a new breed of auditor who has little shop-floor experience become the next generation of auditors, and if so, how will they react when auditing highly entrepreneurial businesses with minimal human or financial resources but lots of creativity? And what will industry do if they can no longer rely on quality systems that are externally certified?

Businesses, such as quality system registrars, that rely on seasoned, albeit aging, employees to perform tasks where experience as well as subject knowledge has been of value will need to pivot one way or another. Technologies such as Zoom, etc., may alleviate some of the challenges, especially where travel is a concern, but will not replace people walking into an office or onto the shop floor. And the next generation of auditors may need to be conceived based on the essential skills needed and experience level available.

Registrars must keep an eye on the available talent pool and how that talent is deployed. Once requirements such as periodic recertifications can no longer be handled within the timeline listed on the registration certificate, industry will indeed be looking for alternatives.

Hopefully, as registrars consider any such pivot or adjustment, the core concept of certified registration programs, be they for quality, security or any other process deemed essential and best monitored by a system of external eyes, will be reviewed and streamlined to eliminate, or at least reduce, duplication and frequency of audit. All industries could benefit from certification programs that are fewer in number but more universally accepted by customers across varying industries and technologies.

Which all goes back to people. When human resources becomes a bottleneck, in addition to seeking talent, maybe the process itself needs to be looked at. Reduction of duplication, applying standardization where feasible, and ensuring the workers you have are treated well so they stay with you all need to be considered. As the circuit board industry tackles these HR-centric challenges, be aware we are not alone!

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

# One Errant Click and IP Protection is Gone

Improper management of client info can result in financial or legal repercussions.

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

PRIOR TO ESTABLISHING any business relationship, most companies require signed nondisclosure agreements (NDAs) for all parties involved with the manufacture of their products. But an NDA is not a license to share everything about a customer's product. OEMs, EMS companies and PCB manufacturers have an obligation to protect their customers' intellectual property (IP).

I can't tell you the number of times I have received an email from a customer requesting a PCB quote that has attached to it not only the Gerber file(s) for the board, but also the assembly drawing, the bill of material *and* the schematic drawing for the entire product.

With the press of a Send button, every detail about that customer's product is exposed, and the associated protection of IP goes up in smoke. All employees should be educated in how to securely manage customer IP.

How is it that email is often such a gaping hole in what companies think is a secure system?

This "insider" threat is usually a combination of negligence and lack of training. Often, the sales department will flip an entire quote package it received from a customer over to purchasing. Most buyers will in turn send that same package to the vendor base for a quote, letting numerous suppliers sort through the zipped files looking for what they need to quote their portion of an assembly.

Yes, a supplier needs access to *some* sensitive information to provide an accurate quote or to perform the requirements of the contract, but they should only receive information pertaining to their services.

For example, to receive a PCB quote, sometimes only a PDF drawing is needed. If the board has some technology, then the Gerber files or electronic data for *that board only* are required for the supplier to provide an accurate quote.

What process does your organization have in place for reviewing files to ensure that vendors are sent only what is needed to generate a quote?

Your quoting team may not have the technical expertise to view electronic files and determine what is needed for a quote, so your company must invest in training so that everyone involved in handling a customer's sensitive information is on the same page.

The normalization of remote work means no face-to-face supervision and sometimes minimal training for handling IP risks. Employees may face more distractions in their home settings, where accidental disclosures can easily happen. Having a clearly documented and enforced organizational policy in place to prevent these self-inflicted threats is critical.

IP protection does not pertain only to commercial work. What is your corporate process to keep ITAR or MIL data from being sent offshore?

A PCB buyer *must* know what they are sending and to whom when seeking quotes. ITAR products are sometimes not as clearly identified as they should be. An ITAR print may not say anything about being export-controlled, and a buyer may inadvertently send protected information to an overseas supplier.

Has your PCB supplier let you know what they can or cannot legally receive? Do you have that in writing?

If the PCB manufacturer is purely a domestic facility, this is a non-issue. But you should still be sure you have the manufacturer's ITAR certification on file.

If the domestic manufacturer also brokers PCBs from Asia, ensure you have a copy of its ITAR certification, and then find out how it segregates quotes that are permitted to be sent offshore from those that must stay domestic.

If your supplier is a pure broker, there is a real possibility of files accidentally being sent overseas. It is vital to have an agreement in writing with all involved parties that breaks down how sensitive files are to be sent and received.

Along with the PCB customer, the board supplier is also responsible for ensuring sensitive information and files that are supposed to stay domestic do not end up in the wrong hands.

If, for instance, files are sent from a customer where there is no mention of domestic-only manufacture, but the fab drawing references a noncommercial spec or the drawing is stamped as a controlled item, the supplier must ask questions. Or when a customer says something like, "I am sending you files, but this can't be made in China," the PCB supplier should ask, "Is this a MIL/ITAR order?" or "This can't be made outside the US, correct?"

Whatever answers a board supplier gets to those questions must also be in writing.

Companies associated with the electronics manufacturing industry need to look carefully at everything sent by their employees *and* others associated with them. Failing to do so could result in significant legal and financial consequences, along with a loss of credibility in the PCB industry. □

# Preparing for 2023

Returning to normal is bringing new and familiar obstacles.

AS I LOOK back on 2022, I'm thankful for the return to normalcy I've seen. That said, this normal has new and continuing challenges for the electronics manufacturing services (EMS) industry. Here are a few that I see and some tips on better preparing for them.

**Materials availability may become even more unpredictable.** Cellphones, personal computers and data servers have been driving much capacity demand in the semiconductor industry and these segments are now slowing down. That isn't going to be a silver bullet for material availability issues overall, but it is a warning to start watching trends carefully. Inflation and rising interest rates are going to slow down other segments as well.

Consumers are already choosing between groceries and gas, and winter heating bills will exacerbate that situation. The downside of carrying two years of inventory is that, when the market turns, it will be difficult to liquidate that material if not consumed by planned demand. Next year may start with shortages and end with excess.

**OEMs are shopping again.** While material availability concerns have glued OEMs to their contract manufacturers regardless of performance through 2020-22, product teams have reached the point where they realize they need to release new products and update their sourcing strategy. The past two years have been a stress test for the EMS industry as whole and not every company is performing as well as necessary to keep customers locked in. And if material availability really improves, there will be a flood of shopping activity. For EMS companies, this is a signal to:

- Review contracts to ensure adequate protections are in place for all inventory liability and termination costs
- Review internal metrics and start focused improvement on anything you can control that needs improvement, particularly if customers are indicating it is an issue
- Review quote resources and cycle time to determine improvements that can be made, particularly if RFQ activity is increasing
- Ensure program management and sales are discussing any new trends in existing customer ordering patterns or prospect interest to make sure adequate new business development/support resources are in place and drops in demand are monitored.

**Good workers are still hard to find, but inflation is increasing the incentives to find higher-paying jobs.** This is a time when HR marketing in nontraditional resources may be a good idea. One of the reasons people don't apply for factory work is because they don't know anyone who works in a factory. The electronics manufacturing environment offers a significant number of benefits not found in service-sector jobs. More flexible full-time work schedules, a full range of benefits, the ability to increase salary by learning new skills, and tuition reimbursement are just a few of the benefits commonly offered by EMS providers. Consider doing a day in the life of a production worker with your local newspaper, and include posts about work-life quality in your blog and link to your Facebook or LinkedIn feeds.

Incentivize employee referrals and consider providing them with handout material to give to friends. In the retail sector, people in some areas are taking two jobs to pay their heating bills, and one upside of this economy is that those in jobs with little advancement potential are rethinking their options. That said, not everyone is cut out for the structure of working on a production floor. Companies with good pre-employment screening processes and first 90-day mentoring programs for production workers have lower attrition rates.

**Quiet quitting is worse than an empty slot.** Today's quiet quitting is similar to what we used to call burnout. In the dynamic environment of EMS, someone who is taking up workspace but not putting in any effort to do more than their basic job description is not an asset. The stress in EMS has been high for several years and burnout is a predictable result., In that type of environment, however, quiet quitting can be as contagious as Covid if quiet quitters are allowed to slack off without consequences. Why put in 110% when your coworkers aren't helping you solve problems?

That said, draconian one-size-fits-all measures are seldom effective in changing behavior. The best option is to discuss the issue with the underperformer and determine if any workplace or work schedule issues could be changed to improve the situation. In conjunction with HR oversight, try to reach an agreement on quantitative performance goals to bring the employee back to expected productivity levels over a defined

*continued on pg. 68*

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

# It's About Time: Clocking a PCB Design

Aligning signals to attain perfect synchronicity.

**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.

CLOCKS ARE ESSENTIAL gatekeepers of the digital domain. Setting the pace for all that follows the clock can be a single trace or a partnership of two traces that carry complementary signals. Either way, the function of a clock is to switch from high (a logical 1) to low (0) up and down continuously; on, off, on, off, all day long. Signals controlled by the clock switch only when activated by the code, meaning that other signals do not change their state with every cycle of the clock.

An obvious example comes to mind because it interrupts every TV show or conversation that happens in my living room **(FIGURE 1)**. I'll break it down for you.

- Even when no one is home, "Grandma's clock" rocks one of four tunes every 15 minutes. (Westminster, two "baroque metal" chimes, or the one where the monks took an oath of silence.)
- It all runs on a 1Hz gravity-powered system. You could say 500mHz if you count tick and tock separately. That, by the way, is the general principle behind double data rate (DDR) memory.
- Of course, the "seconds" hand moves every second. In a quiet room, every tick seems to get a little louder. Isn't that irritating when you want to sleep? There's your noise floor in action.
- "Tick" and "tock" are not exactly a half-second apart. Perhaps a little phase mismatch? Maybe there's work and then there's tock.
- The "gravity" is good for a week before someone must pull the three chains that raise the weights. One is as heavy as the other two combined. One "voltage" for the time, one for the song and another for the gong. VBAT!
- The sporadic chiming of the hours (gong, gong, gong) and all the other mechanical complications in a tall clock play out over periods of time. The circuit is the same dance with a different song. An endless heartbeat gets to meter whatever event comes next.

**FIGURE 1.** Seconds, minutes, hours and moons in motion.

Noticeable at the top of Figure 1 is the gear reduction (the clockwork that drives the hands) and the lunar cycle rotating on the part that looks like a saw blade. Below is the music box with the pendulum hanging from the center bar at the bottom. Forty-something years ago, this was technology for the home.

**Mitigating cross-coupling.** Since the clock is the busiest of the bunch, it stands to reason that it would generate a little buzz in the system. That, by itself, is fine and expected. Also expected, but not so fine, is the natural occurrence of cross-coupling, where clock pulses are picked up by a neighboring trace. Giving the noisy trace a little more space helps keep crosstalk to a minimum. Some traces are more susceptible than others to pick up stray oscillations from a clock signal. If the clock is a bad neighbor, then increasing the air gap around the trace is desirable.

Every design will have a victim/aggressor dynamic. Some will have lots of potential encounters. Be aware of this in a simple design, and document it in a medium or larger design. In this case, "document" refers to the constraint manager and the ability to select certain types of nets and apply as many rules as it takes to define the system's acceptable parameters.

A clock would be worthless without some companions. Data are usually a good bet to follow a clock. All the acronyms are at your disposal: PCIe, WiFi, SPI, MIPI and USB to name a few; all have their own clock. They vary in terms of edge rates and how finely the group should be matched in length, if at all. You will have to find that out for yourself. The easiest way is to do it right the first time, so it helps to learn what you can about whatever bus you are, ahem, driving.

*continued on pg. 52*


TUNING

# How ‘In Silico’ Diagnostics are Democratizing Healthcare

So-called “labs-on-a-chip” are leading a testing revolution.

IT’S WELL KNOWN that the world’s healthcare needs are increasing as the population is aging. The proportion of the world’s population over 60 years old is projected to rise from around 10% today to 16% by 2040. With this aging, the types of required treatments are also expected to change. Instances of cancer, for example, are expected to increase 47% by 2040.

We would all like to see treatment for serious illnesses like cancer become less invasive and deliver better patient outcomes. In a previous column, we discussed the opportunity for machines like ORNL’s Frontier to perform supercomputing to help get ahead of diseases and delay their onset. We are also seeing great advancements in diagnostic research using lab-on-a-chip biosensors by the University of Bath’s Centre for Biosensors, Bioelectronics and Biodevices in the UK.

These sensors shrink all the processes needed to analyze a disease onto a single chip, so instead of sending samples away to the lab, diagnoses can happen in the presence of the patient. It’s not only faster, but also more efficient, more affordable and easier to deliver in developed and developing countries. There is also no chance for samples to become mixed up or lost in transit.

In a conventional lab, where analysts must process slide after slide, the repetitive and laborious nature of the work increases risks of misdiagnosis. In contrast, the new biosensors eliminate errors by digitalizing and processing the information directly on the chip. The technology is already enabling the world’s first personal saliva diabetes tests, which make routine self-testing easier, as well as less invasive and more comfortable than at any time before.

Whereas traditional medicine has been performed “in vivo” on patients or “in vitro” on a glass slide or culture dish, we can now say that advanced healthcare is going “in silico” with these lab-on-a-chip sensors.

Among the projects ongoing at Bath, researchers are working with the University of São Paulo to develop biosensors suited to point-of-care testing for diseases such as prostate and breast cancer. As lab-on-chip sensors continue demonstrating great results, the research is beginning to focus on ways to make the sensors manufacturable in high volume, at low cost. Printed circuit board technologies have a critical role in this and, indeed, Dr. Despina Moschou – a microelectronics Ph.D. leading the lab-on-chip research at Bath – is closely connected with the EIPC and has presented her department’s work at several events.

It's great that our industry can contribute to this work, leveraging, for example, the proven processes that companies already have in place for scaling up production and minimizing costs. There will also be issues to tackle such as biocompatibility of the chosen materials, and further development of materials and fabrication techniques cannot fail to deliver improvements such as increased performance, greater repeatability, and yield growth leading to lower costs.

And then, of course, there are the opportunities to leverage AI to assist with analysis and diagnostics. After digitizing the sensed data – be they blood or saliva analysis from a lab-on-chip sensor, cell biopsies, or radiographic image data – AI can help in several ways, including screening the data to filter items of concern and highlighting them for the attention of specialists. This can greatly accelerate analysis and drive out human error, as well as reducing the number of specialists needed to serve the aging population.

Reducing our reliance on human analytical skills is important. Although there is an increasing demand for pathologists to perform these analyses, the number of trained practitioners is an acknowledged shortfall. AIs can be trained relatively quickly, which can help to meet demands for healthcare services in the future. Trials of Deep Learning-based Automatic Detection (DLAD) algorithms are already showing that these can help reduce instances of overlooked tumors when assisting specialists to analyze patient radiographs. By integrating the use of these algorithms within standard practice, healthcare providers can enable more patients to begin treatment at an early stage, leading to better outcomes.

Moreover, AI’s ability to analyze data collected from large numbers of patients can improve the study of disease progression throughout a specific population or throughout the world. With these machines, we can identify trends hidden in vast quantities of data a human observer could never detect, and thus gain insights that help to plan future services and drug development. It’s also worth mentioning they can be programmed to operate without bias and can therefore contribute toward democratizing access to high-quality healthcare.

One major issue to overcome is public trust in such powerful technology. When clinical errors are caused by humans, the reasons are examined, any negligence discovered is punishable, and practices are modified if

*continued on pg. 68*

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

## OUR SPONSORS

DownStream Technologies

EMA Design Automation®

PCB TECHNOLOGIES USA™ leading the way

Polar®

## WHO'S EXHIBITING

Accurate Circuit Engineering
American Standard Circuits, Inc.
APCT
Blueshift
DirectPCB LLC
DownStream Technologies
Electronic Interconnect
EMA Design Automation
GS Swiss PCB AG
HZO
Imagineering, Inc.
JBC Tools USA Inc.
Metallic Resources
Nano Dimension
PCB Technologies – USA
Polar Instruments, Inc.
PCEA
Quantic Ohmega/Quantic Ticer
Sierra Electrotek
SVTronics, Inc.
Trilogy-Net
Ventec International Group
VGTPCB
Zuken USA

# PCBEAST.COM

# Clear Drawing Notes are Good. Too Much Detail, Not So Much.

Clarify key features, but don't use 10 notes where one will do.

YOU HAVE BEEN tasked with documenting a flexible circuit you are preparing to send out for quotes. Should specific drawing notes be included?

I recently received a drawing from a prospective customer for a simple two-layer flex circuit. The first page of the drawing had their drawing notes … all 42 of them. While every good drawing should include notes to clarify important features, you don't want to over-specify either. As I worked my way through the notes on this particular drawing, I quickly realized a large majority were restatements of requirements already in IPC-6013, and could have been covered with the note, "Circuits shall conform to the requirements of the latest revision of IPC-6013, type X, class X, use X (replace "X" with the type, class, and use of the circuit being specified). That single note would have eliminated more than half the notes on this drawing!

Your best bet when generating drawing notes is to begin with the IPC-6013 note referenced above. Beyond that, focus notes to attributes specific to the design, and limit them to features critical to the performance and/or reliability of the circuit. Next, I will go through some of the most common features to cover in your notes.

**Materials (should include stackup).** Flexible circuit base materials options are plentiful: different manufacturers, different thicknesses, etc. Ensure the drawing clearly specifies any materials critical to the function of the circuit. At the same time, over-specifying can unnecessarily increase the cost of the circuit without providing any benefit in performance.

For instance, virtually all materials used in a flexible circuit are documented in one of the IPC material specifications (i.e., IPC-4202, IPC-4203, IPC-4204). All critical features of each material are covered in the associated slash sheets in these specifications, which can be referenced in the drawing notes block. All manufacturers of these materials must ensure their products conform to these specifications. For this reason, I typically recommend that the drawing does *not* specify a particular manufacturer.

The same is true of material thicknesses. The drawing should include a cross-sectional view that depicts each unique construction area of the circuit. All material thicknesses critical to the performance of the circuit should be clearly labeled in the cross-sectional view. If the individual material thicknesses for specific performance attributes (like impedance) are required, they should be specified. If no critical material thicknesses are required, specify only overall finished thickness in each unique construction area. By doing this, the supplier has the option to pick the materials that best meet the final thickness requirements and will also work best with its processing methods.

**Final finish.** While IPC-6013 specifies solder as the default final finish if nothing is indicated on the drawing, far and away the most common final finish currently used is ENIG (electroless nickel immersion gold). If a final finish is not specified in the notes, most fabricators will want to use ENIG. This is fine if the circuit has only ZIF contacts or SMT components. But if the application requires a solder finish or wire bonding, specify that requirement in the notes. Soft gold over nickel or ENEPIG (electroless nickel electroless palladium immersion gold) are the most common finishes for wire bonding. Solder finish is becoming so uncommon, many flexible circuit suppliers do not even support HASL equipment. For this reason, if a solder final finish is needed, specify only something like "solder finish," rather than "HASL solder finish." That will give the fabricator the option to add the solder in a way that works best for them (e.g., solder plate and reflow, etc.). Also, if the design requires RoHS compliancy, reference it in your final finish drawing note.

**Miscellaneous requirements.** Any other requirements critical to the performance or reliability of the flex circuit should also be covered in the drawing notes. These include, but are not limited to:

- Static or dynamic application (unless you already use "A" or "B" in previous note)
- Operating temperature range (use C?)
- Bend areas
- Bend radius
- Bend angle
- Environmental exposure.

Including notes on the above items will permit the fabricator to evaluate if the flex as designed will be suitable for the specific application. For example, if I get a drawing that states "Use B and Use C," I would have concerns and relay them to the customer. "Use B and C" would indicate a dynamic application in a high-temperature environment. Typically, those two requirements don't play well together.

If multiple signatures on the drawing are required prior to formal release, it is not a bad idea to let the fabricator review it prior to the signature rounds. This way, the fabricator can do a quick "once over" and flag any omissions. ❑

**MARK FINSTAD** is director of engineering at Flexible Circuit Technologies (flexiblecircuit.com); mark.finstad@flexiblecircuit.com. He and co-"Flexpert" **NICK KOOP** (nick.koop@ttmtech.com) welcome your suggestions.

# CIRCUITS ASSEMBLY Announces 2022 Service Excellence Award Winners

CIRCUITS ASSEMBLY in November announced the winners of its 2022 Service Excellence Awards (SEAs) for electronics manufacturing services (EMS) providers and electronics assembly equipment, materials and software suppliers. CIRCUITS ASSEMBLY recognized companies that received the highest customer service ratings, as judged by their own customers, during a ceremony at the SMTA International trade show in Minneapolis.

In the EMS category, the overall winners were Lacroix (sales over $500 million), Mack Technologies (sales of $100 million to $500 million), Electronic Systems Inc. (sales of $20 million to $100 million), and XLR8 Services (sales under $20 million). The EMS companies with the highest scores in each of seven individual service categories also received awards. (Overall winners were excluded from winning individual categories.) In the small-company category, RBB Systems won for technology; BESTProto won for dependability/timely delivery, responsiveness, manufacturing quality, flexibility and overall satisfaction; Kodiak Assembly Systems won for dependability/timely delivery; and Revco won for value for the price.

For companies with revenue between $20 million and $100 million, Absolute EMS excelled in all seven categories.

For firms with revenue between $100 million and $500 million, Unigen won for value for the price; EI Microcircuits won for dependability/timely delivery, responsiveness, technology, flexibility and overall satisfaction; and Vexos won for manufacturing quality, value for the price, technology, flexibility and overall satisfaction.

For EMS companies with revenue over $500 million, Creation Technologies won for technology, and Kimball Electronics won for dependability/timely delivery, manufacturing quality, responsiveness, value for the price, technology, flexibility and overall satisfaction. Electronics assembly supplier award winners were Anda Technologies for automation/handling equipment; Aegis Industrial Software for automation/manufacturing software; Europlacer Americas for screen printing; Anda Technologies for dispensing; Europlacer Americas for pick-and-place; KIC for soldering equipment; Kyzen for cleaning/processing materials; Koh Young America for test and inspection; and Datest for test laboratories.

"Service comes in many forms, but for so many companies it is the differentiator for sustaining long-term and mutually beneficial supplier-customer relationships," said PCEA president Mike Buetow, in presenting the awards. "This is not an easy award to win. It requires daily commitment to excellence, because the judges are the entrants' own customers."

Customers of SEA participants rated each company on a scale of 1 (poor) to 7 (best in class) in seven service categories.

This is the 30th year CIRCUITS ASSEMBLY has sponsored the awards program.



*Presenting 2022 SEA Awards*
*Mike Buetow, PCEA President*

**"THIS IS NOT AN EASY AWARD TO WIN.**
IT REQUIRES DAILY COMMITMENT TO EXCELLENCE,
**BECAUSE THE JUDGES ARE THE ENTRANTS' OWN CUSTOMERS."**


CIRCUITS ASSEMBLY'S
SERVICE EXCELLENCE
AWARDS
2022
WINNER

# Dispensing

CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS 2022

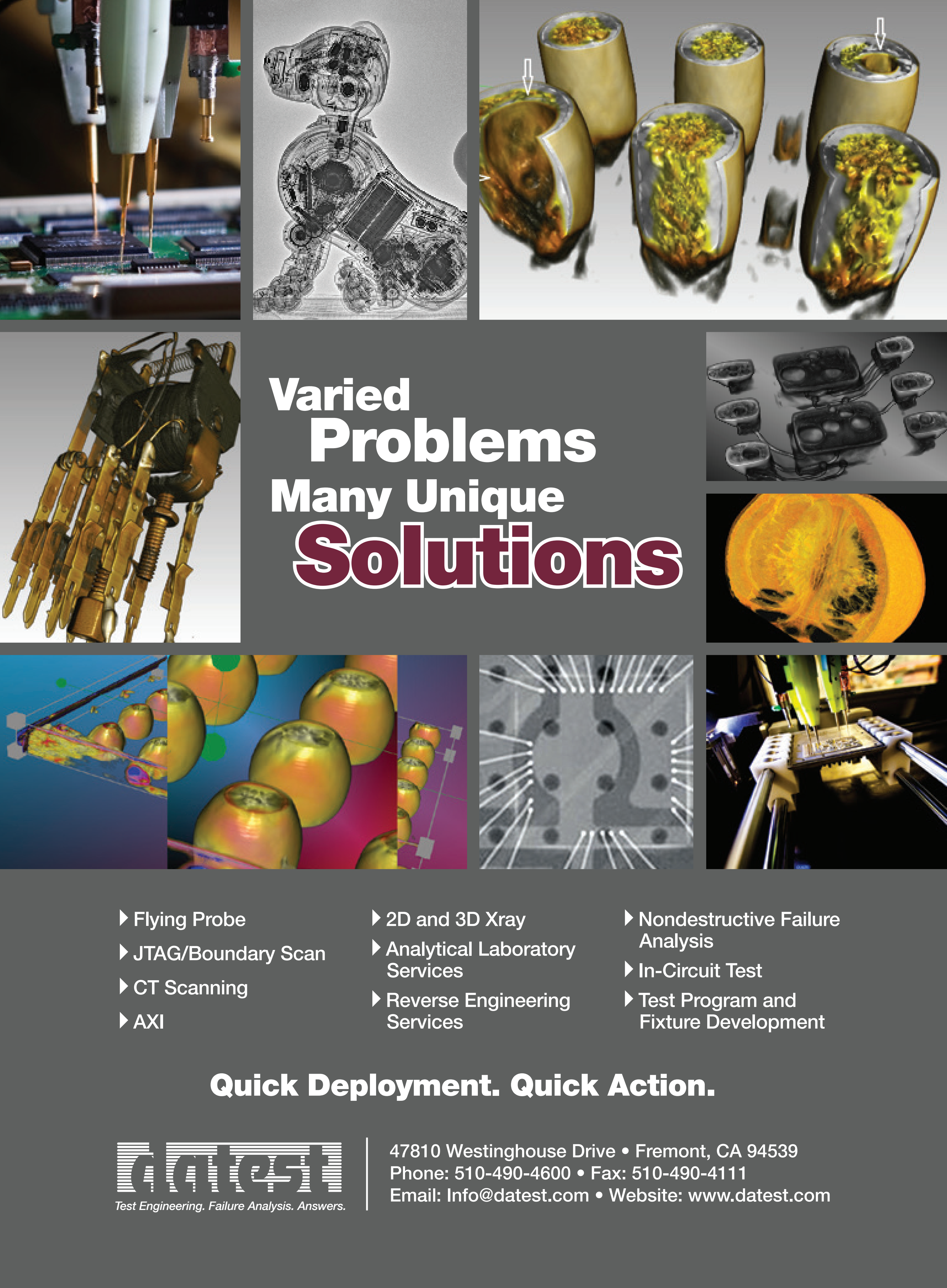
WINNER

# Test Laboratories

datest

CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS

Congratulations from CIRCUITS ASSEMBLY


Varied
Problems
Many Unique
Solutions
Flying Probe
JTAG/Boundary Scan
CT Scanning
AXI
2D and 3D Xray
Analytical Laboratory Services
Reverse Engineering Services
Nondestructive Failure Analysis
In-Circuit Test
Test Program and Fixture Development
Quick Deployment. Quick Action.
Test Engineering. Failure Analysis. Answers.
47810 Westinghouse Drive • Fremont, CA 94539
Phone: 510-490-4600 • Fax: 510-490-4111
Email: Info@datest.com • Website: www.datest.com


# Revenues from $101 to $500 Million

EI MICROCIRCUITS

Expect solutions.

MISSION
VISION
PURPOSE
VALUES

EI MICROCIRCUITS

## VALUES

01 CUSTOMER-FOCUSED

02 FAMILY-ORIENTED

03 ETHICAL

04 DRIVEN

05 INNOVATIVE

### Mission

To be the premier provider of innovative solutions.

### Vision

To focus on technology solutions allowing us to expand our reach across the nation.

### Purpose

EI Microcircuits will be the premier manufacturing solutions provider to our customers in order to invest in our employees, their families, and the communities in which we live and serve.

**Expect Solutions**

www.eimicro.com

CIRCUITS ASSEMBLY'S
SERVICE EXCELLENCE
AWARDS
2022
WINNER

# Pick-and-Place Equipment

europlacer


CIRCUITS ASSEMBLY'S
SERVICE EXCELLENCE
AWARDS

Congratulations from
CIRCUITS ASSEMBLY


# EMS Revenues over $500 Million

Kimball® Electronics

Lasting relationships. Global success.

CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS

Congratulations from CIRCUITS ASSEMBLY

Kimball® Electronics
Lasting relationships. Global success.

CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS

Service Excellence Award Recipients
- Nine Consecutive Years

# Who We Are

Kimball Electronics is a global, multifaceted manufacturing solutions provider recognized for its reputation of excellence. We are committed to a high-performance culture that values personal and organizational commitment to quality, reliability, value, speed, and ethical behavior.

# What We Do

Kimball Electronics provides end-to-end engineering, design and manufacturing solutions, including contract Electronics Manufacturing Services (EMS), Diversified Contract Manufacturing Services (DCMS), and Automation, Test & Measurement services to customers in the automotive, medical, industrial, and public safety end markets. We deliver award-winning service through our highly integrated global footprint, stringent quality systems, customer relationship management model, and supply chain support.

# Our Package of Value

Our package of value includes our set of robust processes and procedures that helps ensure we deliver the highest levels of quality, reliability, and service throughout the entire life cycle of our customers' products.

## MARKETS WE SERVE

AUTOMOTIVE

MEDICAL

INDUSTRIAL

# End-to-End Partnership Solutions

Engineering, Design & Development › Prototyping › New Product Introduction or Transfer of Existing › Manufacturing › Testing › Support and Aftermarket Support Services


# Test and Inspection Equipment

KOH YOUNG AMERICA

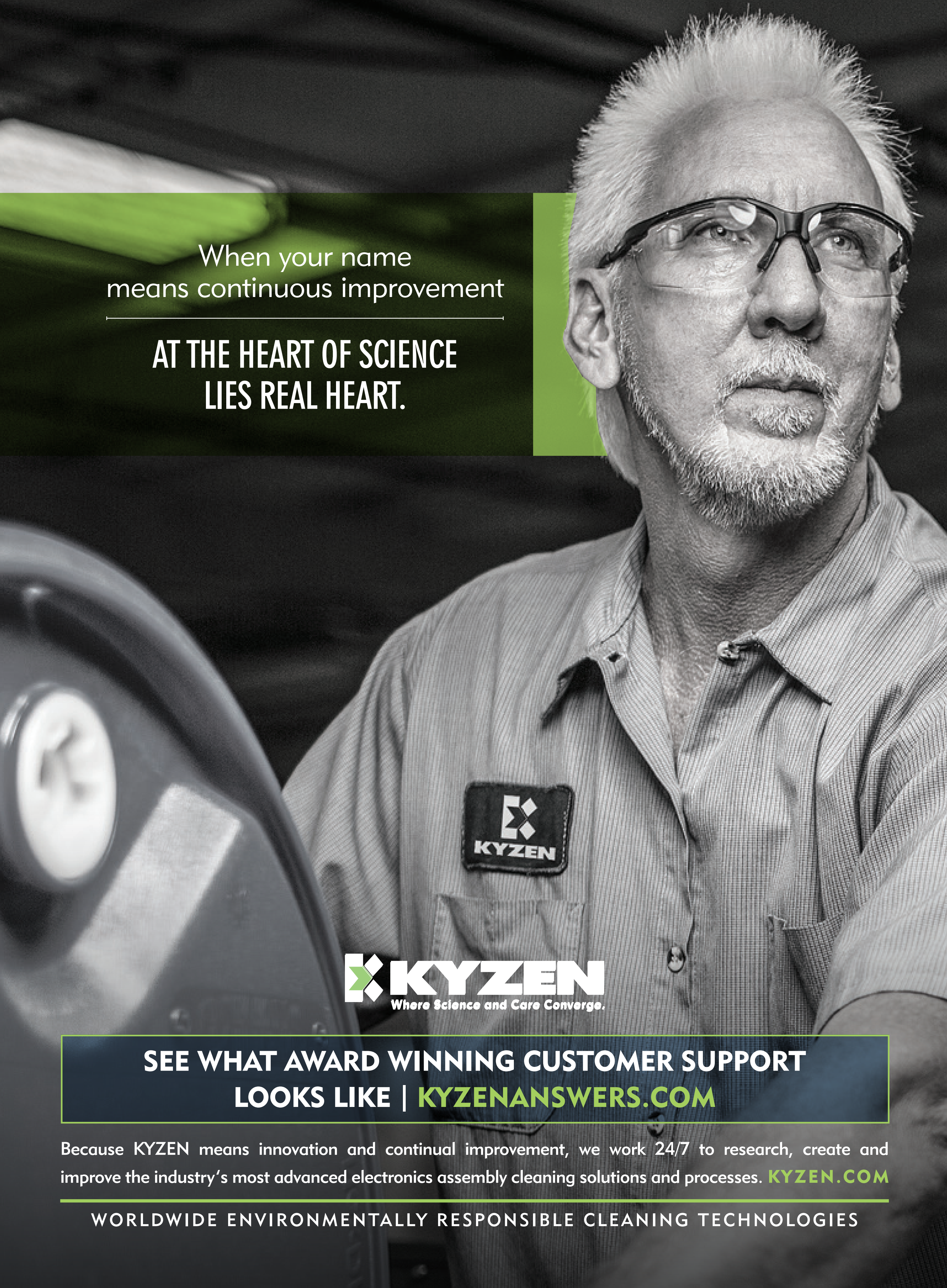
CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS

Congratulations from CIRCUITS ASSEMBLY

CIRCUITS ASSEMBLY'S
SERVICE EXCELLENCE
AWARDS
2022
WINNER

# Cleaning / Processing

KYZEN
Where Science and Care Converge.


When your name
means continuous improvement
AT THE HEART OF SCIENCE
LIES REAL HEART.
KYZEN
KYZEN
Where Science and Care Converge.
SEE WHAT AWARD WINNING CUSTOMER SUPPORT
LOOKS LIKE | KYZENANSWERS.COM
Because KYZEN means innovation and continual improvement, we work 24/7 to research, create and improve the industry's most advanced electronics assembly cleaning solutions and processes. KYZEN.COM
WORLDWIDE ENVIRONMENTALLY RESPONSIBLE CLEANING TECHNOLOGIES


# Revenues under $20 Million

## REVCO PRODUCTS

ELECTRONIC CONTRACT MANUFACTURER

PCB LAYOUT • ASSEMBLY • TEST


# Revenues from $101 to $500 Million

## VEXOS

Local Service. Global Capabilities.

CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS

Congratulations from CIRCUITS ASSEMBLY

CIRCUITS ASSEMBLY'S SERVICE EXCELLENCE AWARDS 2022

WINNER

# Revenues under $20 Million

## XLR8 SERVICES

Contract Manufacturing & Design

# UPDATING an Existing Design

A basic process for revising a client-supplied CAD database.

by JAMES O. JACKSON, CID

Not all designs start from scratch. Not all designs start with a schematic and then "ECO'ing" it into the PCB, and then working from there creating the board outline and placing the footprints, followed by routing and completing the design, generating all the necessary fabrication and assembly files.

Some designs, like the one described here, are provided by the client, and require changes. Typically, these would be a simple set of changes in the schematic that need to be transferred via engineering change orders (ECO) to the PCB layout, followed by a series of updates on the PCB side to incorporate any parts added or deleted from the design.

In this case, the schematic and PCB layout – somehow – got out of sync. The set of database files provided were no longer linked. The PCB database was found but did not match what was considered the latest schematic. Actually, several schematics were available to choose from, as were several PCB layouts. After a bit of sleuthing, the schematic and PCB layout to use were determined. I was told to move forward with linking the two databases and updating the PCB database.

The original PCB was a six-layer board measuring 8.7" x 6.5" (FIGURE 1). The previous designer had only about one-half of the footprints with embedded STEP files.

The design had four voltages: 3.3V, 5V, +15V and -15V. These were scattered across the board, and some were run using traces.

Of course, before I could update the PCB, a few minor changes needed to be made to the schematic. After making those changes, I ECO'ed the PCB. This created all sorts of issues on the PCB side. I wound up deleting all the traces and vias to help eliminate many of the issues. I then set out to update the PCB.

First, I created a PCB library for the footprints. I then added the 3-D STEP files to the footprints. I verified the footprints were accurate by comparing them to their datasheets. (I don't trust "free" footprints.)

I then grouped the footprints – per the schematic – by voltage and purpose. Bypass capacitors were appropriately placed, as well as the microprocessor's crystal.

One of the goals was to keep the input and output connectors in their relative locations, since this is an existing design and must fit into an existing box and connect to external wiring with minimal changes.

As I untangled the "spaghetti," I noticed that the design began to flow, and realized that six layers were not needed. I eliminated two. Now the board was a four-layer design.

Once placement was complete, the design was reviewed. At this point, the board had a lot of extra space. The client approved a size reduction – with the proviso that the input and output connections remain in (or near) their original locations.

As such, I was able to reduce the original 8.7" x 6.5" PCB to 8.7" x 4.2" (FIGURE 2). Doing so required minor adjustments to the component placement, but I was able to accommodate the smaller PCB size with minimal issues.

The new revision boards were fabricated and assembled. The client was able to put them into service, replacing the previous version boards. The client was very pleased with the perfor-

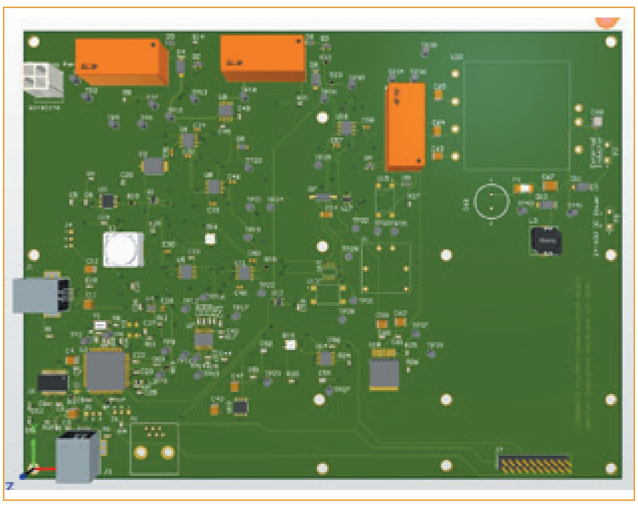


FIGURE 1. The original board design.

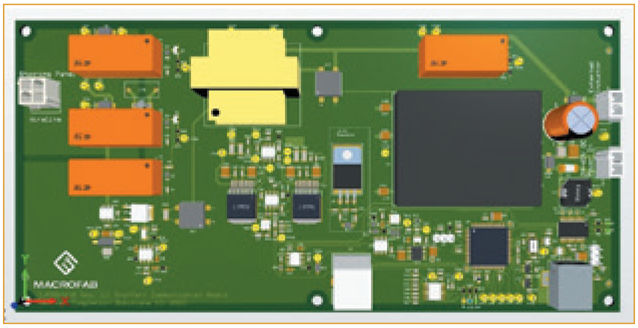


FIGURE 2. The redesigned board has two fewer layers and a smaller outline.

mance, and indicated the revised design was very stable, unlike the previous version.

Disclosure: The schematic had a small issue. A few parts on the schematic were unnecessary but were not seen during the design reviews. As a solution, these parts were not assembled. Instead, a jumper was run on the board to bypass their function. If this board is respun, this will be corrected and there will probably be other functionality added, but there is no immediate need to do so. □

JAMES JACKSON, CID, is a senior PCB layout designer at Oztronics (oztronics-tech.com); joj@oztronics-tech.com.

---

*Designer's Notebook, continued from pg. 22*

**DDR memory impact on system design.** This is great stuff because it allows a 2X increase in DRAM (volatile memory) performance without doubling the clock rate. Breakthroughs don't come along every day. We need advancement in technology of this magnitude every other year or so to keep the whole thing going. Using the rising and falling edge of the clock's pulses to sweep the memory registers more efficiently, so it is here to stay, for now.

Routing DDR (pick a number) comes down to knowing which data lines are associated with a given clock and which address lines go with a particular strobe. Bypass capacitors are vital in terms of their placement. When all the registers slam to zero, it's the caps that pour out a surge of voltage in that instant. They keep the system from freezing up. This is probably truer with mobile devices where power is at a premium.

**External oscillators.** Crystals are a standard part of a typical microcontroller with anything wireless. Even when there is an on-board clock, the ability to have options is provided for better devices. There are set-value crystals, and others with a bit of variability on hand called VCXOs. It is natural for the frequency of a crystal to change over temperature. TCXO, or temperature compensated crystals, have built-in compensation circuitry to keep them on track. Another type is an OCXO, or oven-controlled external oscillator, which is a level above the TCXO in terms of linearity at higher temperatures.

Implementing crystals is usually straightforward. They are placed next to the XO pins of the device and routed through a couple of passive components with short lines. When the layout does not afford a nearby placement, take extra care to create a guardrail around the traces between the crystal and the IC it is driving. If you happen to flood the outer layer with ground pour (and you probably should), a slot around the three exposed edges of the crystal will help prevent noise from going where it should not go.

The crystals ring at a fundamental tone, 10 to 20MHz perhaps, and there will be peaks on the spectrum from harmonics of the fundamental frequency. This kind of electromagnetic radiation can cause a product to fail FCC tests for noise emis-

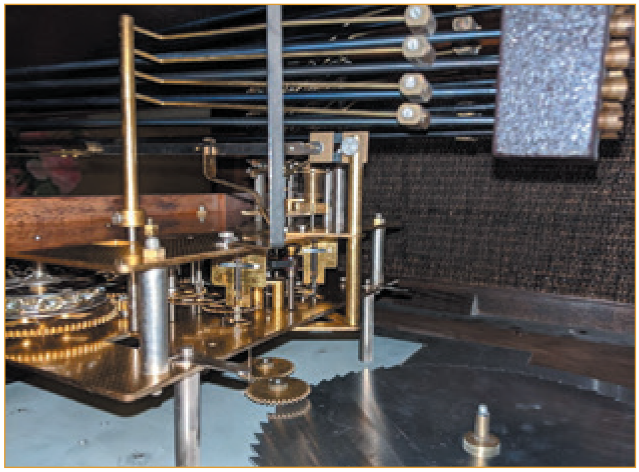


FIGURE 2. The gong quartet of hammers, ready to strike.

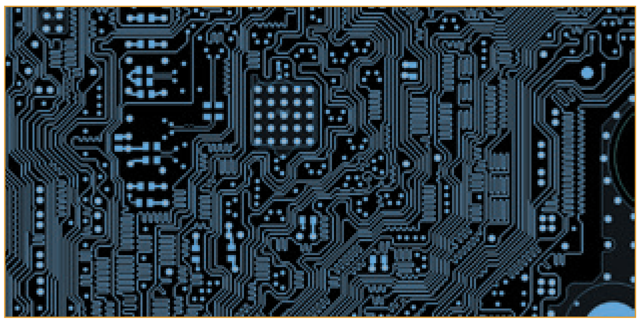


FIGURE 3. Some busses have many members; others, not so much.

sion and immunity. Anything other than an ideal layout for the oscillator(s) should be tightly engineered to contain EMI.

**Timing budgets.** The timing budget narrows with the number of conductors in the data bus. Keeping impedance mismatches to a minimum and giving the CLK nets high priority when it comes to routing obstacles are basic requirements. Shielding sensitive lines away from the all-night party is a step in the right direction. Aligning the signals so everything happens with perfect synchronicity is the fun and rewarding part. Getting done on time? That is also up to you. □

# Basics of Polymers for THERMAL MANAGEMENT of Electronic Devices

Thermal interface materials provide much-needed heat relief for electronic assemblies. by **CLAIRE K. WEMP, PH.D.**

Overheating is the number one cause of electronic component failure and requires aggressive thermal management strategies. That's why thermal interface materials (TIMs) have become ubiquitous in today's electronic assemblies, working to dissipate heat from heat-sensitive components, improve device reliability, and prevent premature failure.

The two main categories of thermal interface materials are TIM1 and TIM2. Used together, they create a comprehensive thermal management solution at both the chip and semiconductor package level.

TIM1 materials remove heat at the chip level, creating a thermal conduction pathway from the heat-generating chip to its metallic lid. As the first line of defense against overheating, TIM1 materials are vital for long-term reliability. TIM1 materials are formulated to meet rigorous requirements. They must withstand temperatures up to 150°C (in reliability cycling), effectively wet adjoining surfaces, and mitigate heat induced mechanical stresses caused by CTE (coefficient of thermal expansion) mismatches. CTE is a material property that describes the extent to which a material expands and contracts due to changes in temperature.

TIM2 materials remove heat at the package level, creating a thermal conduction pathway from the exterior of the semiconductor package to a heatsink, heat pipe, or other heat spreader. TIM2 materials are the second line of defense against overheating and must withstand temperatures up to 120°C for reliability aging tests.

In use, TIM1 and TIM2 materials will see a range of operating temperatures, dictated by the type of chip with which they are connected. In automotive Mosfet or IGBT chips, operation temperatures can run well over 120°C at the die interface. Operating temperatures are cooler for data center chip packages, and even cooler for portable electronic devices.

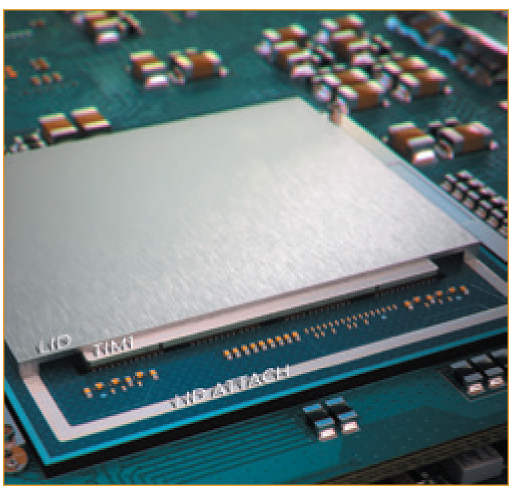



**FIGURE 1.** A typical TIM1 assembly configuration.

Thermal cycling and surface adhesion are major challenges that affect long-term reliability and performance of TIM materials. Raw materials and fillers must be carefully selected and formulated to avoid embrittlement and delamination when exposed to thermal cycling. And they must be able to retain their conformability in extreme environments for the lifespan of the device, taking on the contours of rough adjoining surfaces to fill air gaps and voids.

All electronic components generate excess heat. As electronic devices become smaller, faster and more functional, they generate even more heat in smaller more confined spaces, which can lead to serious reliability issues if maximum operating temperatures are exceeded. This phenomenon is referred to as increased heat flux (measured in Watts/$cm^2$).

Heat is a major reliability issue in electronics, and thermally conductive materials are an essential part of solving the problem of heat-related failures, which is why the TIM market is booming. Grand View Research estimates the global TIM market was $1.84 billion in 2021, and predicts it to expand at a compound annual growth rate (CAGR) of 11.4%, to reach $4.86 billion by 2030.

**TIM1 materials.** TIM1 type materials are used as the first line of defense to prevent overheating and improve reliability of heat-sensitive components such as ICs. TIM1 materials are typically placed inside the semiconductor package, between the heat-generating chip/die and a heat-spreading metallic lid, making contact with both for more direct heat dissipation. A typical TIM1 assembly configuration is shown in **FIGURE 1.**

Increasingly, silicone is used as the base material of choice for TIM1 type materials, and formulations include carefully selected conductive fillers with conductivity and surface wetting. Wetting refers to the ease with which a material bonds with a given substrate. A variety of forces (ionic, static, polar, van der Waals, etc.) act to create chemical linkages and improve molecular attraction to ensure optimal wetting and reduced thermal resistance.

**TIM2 materials.** For high-heat-generating components – such as TOs, FPGAs, Mosfets and IGBTs – heat sinks, heat pipes, fans and heat spreaders are added on the outside of the semiconductor package. TIM2 materials are utilized in this configuration as the second line of defense to further dissipate heat, prevent overheating, and improve reliability. As shown in **FIGURE 2**, TIM2 materials are typically placed between the outside of the semiconductor package and a heatsink. When coupled with TIM1 products, TIM2 materials provide extra heat dissipation capability.

## Performance Requirements

From a technology perspective, TIM1 reliability and performance requirements are much more demanding than that of TIM2, requiring higher performance fillers and formulations.

TIM1 materials must withstand extreme temperature cycling from -40°C to 150°C, whereas the functional upper limit for temperature cycling TIM2 materials is typically closer to 120°C. While this 30°C difference in the upper temperature limit may not seem like much, it significantly eases the formulation requirements, permitting more variability in base and filler material selections. Certain epoxies or other thermoplastic materials that might otherwise be contenders for TIM1 applications cannot withstand temperatures of 150°C without hardening and delaminating, resulting in thermal failure.

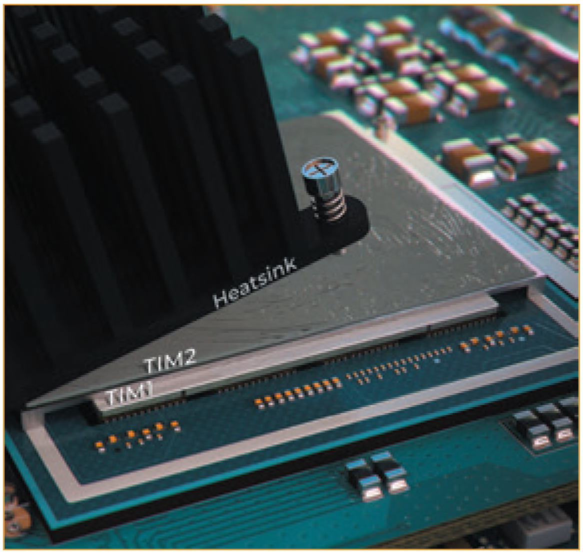



**FIGURE 2.** TIM2 materials are typically placed between the outside of the semiconductor package and a heatsink.

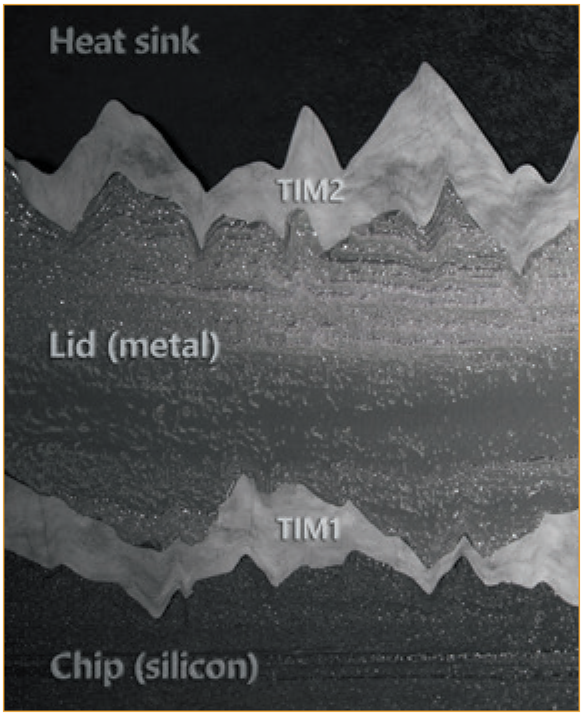



**FIGURE 3.** Surface roughness imperfections impede heat transfer by introducing microscopic air pockets.

For this reason, most TIM1 materials are silicone-based chemistries to meet the 150°C upper limit, and must also use surface treatments to functionalize the thermally conductive filler particles to endure extreme temperatures over time without becoming embrittled, changing their gel-like characteristics, and inducing mechanical stresses due to high CTE mismatch.

**Temperature cycling and reliability.** Understanding the relationship between CTE mismatch and end-use environment is important for designing reliable TIM assemblies. Extreme temperature variations can induce significant mechanical stresses due to CTE mismatch between adjoining surfaces, which can lead to delamination of the TIM material.

Heat transfer performance of both TIM1 and TIM2 materials is strongly influenced by the roughness of the surfaces on which they are applied. Surface roughness imperfections, like those illustrated in **FIGURE 3**, impede heat transfer by introducing microscopic air pockets which act as insulators. Small peaks and valleys on rough surfaces entrap air and increase thermal resistance. To transfer heat efficiently, TIM materials must be sufficiently soft and compliant to fill air gaps and voids. For this reason, most TIM1 materials are designed as dispensable gels that flow and wet adjoining surfaces without introducing compressive stresses, while TIM2 materials are designed to be malleable and deform under compressive stress to fill voids.

**Mechanics of thermal performance.** A common data point on a material's technical data sheet (TDS) is thermal conductivity, k, which indicates the material's inherent ability to conduct heat. Thermal conductivity is measured in watts per meter Kelvin (W/mK).

Note that a material's thermal conductivity value is only one part of a larger equation that predicts the ability of an assembly to conduct heat in real-world applications. The thickness of the thermally conductive material and surface irregularities on the adjoining surfaces also affect the ability of the assembly to conduct heat.

Total thermal impedance, $R_{th}$, is a better predictor of thermal performance than the thermal conductivity of the TIM material alone. Thermal impedance, the sum of all thermal resistances through the assembly, is measured in Kelvin centimeter squared per watt (Kcm²/W).

A typical TIM assembly and the calculation of its thermal impedance is shown in **FIGURE 4.**

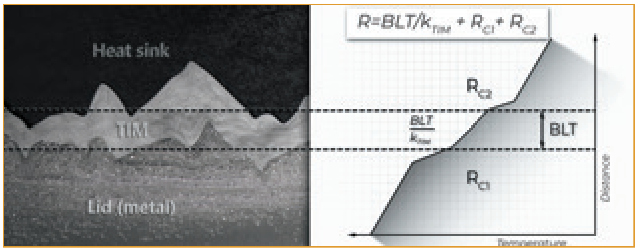



**FIGURE 4.** A typical TIM assembly and the calculation of its thermal impedance is shown.

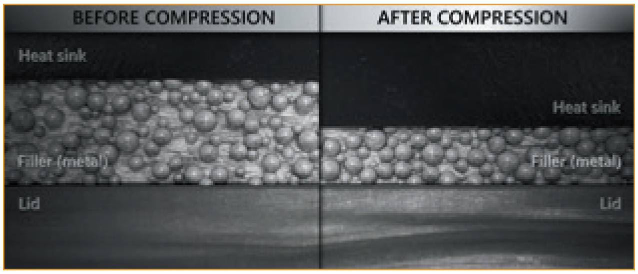



**FIGURE 5.** Pressure decreases overall thickness and creates intimate contact between the conductive filler particles, aligning them for optimal thermal performance.

Where $R_{TIM}$ is the bulk thermal resistance of the TIM material, $R_{C1}$ and $R_{C2}$ are thermal contact resistances between the TIM and adjoining surfaces.

An assembly that is better at conducting heat (higher k value) will have a lower $R_{TIM}$ value and typically have a lower thermal impedance (lower $R_{th}$ value) as well, but there are exceptions to this.

If a material has low $R_{TIM}$, but also has high contact resistance (it does not wet the adjoining surfaces effectively) it may actually have a higher $R_{th}$ than a material with lower thermal conductivity but very low contact resistance.

**Thermal conductivity and bond line thickness.** Optimizing bond line thickness (BLT) is one method of achieving lower thermal impedance and improving thermal performance of a TIM assembly. Selecting thinner TIM materials or applying compressive forces to TIM materials are common techniques used to minimize thickness and lower thermal impedance.

In TIM1 applications, however, where mechanical stresses are detrimental to the integrity of the die, adding too much pressure is avoided.

In TIM2 applications where substrates are more durable, conformable gap pads and gap fillers are used under pressure – which is typically applied through a mechanical clamping system. This mechanical pressure helps remove air gaps and voids, and compresses conductive filler particles closer together for improved thermal performance. The goal is to reach compression values that achieve the most advantageous thermal performance (typically 20 to 40psi). Chemical formulations and fillers will affect the pressure necessary to achieve the minimum BLT. As shown in **FIGURE 5,** when optimized, pressure decreases overall thickness and creates intimate contact between the conductive filler particles, aligning them for the best possible thermal performance.

The ongoing movement toward the implementation of 5G telecommunications is increasing demand for advanced TIM formulations. 5G antennas and devices generate more heat than their LTE predecessors due to 5G's mmWave frequencies. *5G Technology World* reports that when designing 5G into a router or other fixed-access device, thermal issues are encountered to a greater "degree" than in products that use LTE for wireless communications, even though the energy-per-bit might be less than LTE. Some mobile phones on the market today are already capable of receiving and interpreting 5G signals, but can do so only for short bursts before the hardware heats up, triggering the software to throttle back performance to protect the electronics and users from heat.

Automotive trends, such as advanced driver assistance systems (ADAS) and electric vehicles (EVs), are also driving the need for new TIM materials. High-speed ADAS electronics that enable improved driver and pedestrian safety, and high-power electronics for EV battery charging and discharging, create considerable amounts of heat. These, along with the potential for harsh temperature extremes in vehicle operating environments, create numerous real thermal challenges for automotive electronics.

## Conclusion

A comprehensive thermal management approach not only includes using the right TIM materials in combination with heat sinks, heat pipes, fans and heat spreaders, but also includes a good thermal management strategy that starts during the design phase. Electronic systems can be designed to include thermal management at all levels (chip, package, PCB, and enclosure). Thermal simulations can be run before actual systems are manufactured to identify issues and optimize solutions. For example, PCBs can be designed with thermal vias and copper layers that help spread and dissipate heat at the board level. Solving heat-related reliability issues is complex, involving many different variables that may require unique solutions for each specific application. □

**CLAIRE K. WEMP, PH.D.,** is thermal applications engineer at DuPont (dupont.com); clair.k.wemp@dupont.com.

# Addressing LOW-TEMPERATURE Rework Concerns

Material properties and considerations of a eutectic SnBi solid wire and SAC 305 flux cored wire. **by TIM O'NEILL, JEN FIJALKOWSKI, CARLOS TAFOYA, YUAN XU, STEVE HRCEK, LEO LAMBERT, BOB WILLIS AND S'AD HAMASHA, PH.D.**

Low-temperature (LT), high-bismuth solders are being carefully considered to replace SAC 305 for several reasons, including minimizing component warpage, reducing energy consumption and lowering the cost of solder, substrate, plastics, and other materials. Bismuth is strong but brittle, and has different mechanical properties than the SAC alloys they are targeted to replace.[1] Despite these drawbacks, consumer electronics not subjected to high thermal or mechanical stress may be candidates for low-temperature materials.

Most published studies have overlooked one important consideration when implementing low-temperature alloys: rework and post-assembly attachment processes. This article reviews issues associated with using low-temperature alloys in the benchtop setting and how these alloys can be implemented or combined with existing processes and materials.

SAC 305 is the PCB assembly standard solder since lead was banned from many electronic solders for environmental concerns in 2006. This change forced the implementation of new equipment and materials due to the higher melting temperature of SAC 305 versus the SnPb materials it replaced. One of the main benefits of SAC 305 is its compatibility with SnPb solders. Other elements considered for SnPb solder replacement were indium and bismuth, among others. Both were attractive as they lower the melting temperature of SAC alloys. However, indium was eliminated for supply and cost issues and bismuth was eliminated because when combined with SnPb, a ternary alloy with a melting temperature of 97°C is formed, causing an unacceptable loss of reliability.

Regulations limiting use of Pb in electronics have effectively removed it from most of the industry's material supply chain, reinvigorating the interest in Bi-bearing solder alloys. Given the advantages of a low-melting point alloy, solder manufacturers are motivated to develop commercially viable products for solder paste, solid alloy and flux-cored wire, but this is not without its challenges.

The physical properties of elemental bismuth are unusual. It has one of lowest thermal and electrical conductivity values of all metals, it is denser as a liquid than a solid, it expands on freezing, and is the most naturally diamagnetic element on the periodic table. Aside from these interesting factors, bismuth's brittleness is what has the greatest impact on its soldering performance. An alloy with a bismuth percentage above 6% will begin to lose ductility and become more brittle. Brittleness should not be confused with loss of strength; bismuth alloys are strong, but brittle.

Sn42Bi57Ag1 is eutectic at 138°C, meaning the liquidus to solidus are coincidental, there is no plastic/pasty state. Adding elements such as silver and indium can improve strength or ductility to high-bismuth alloys, but they will still behave like high-bismuth alloys – strong and brittle. This creates issues for PCB assemblers and has a profound impact on the manufacturability of SnBi wire solders. Manufacturing wire solder relies on the ductility of the alloy to permit it to be shaped and formed. When producing flux-cored wire, these traits are vital. Flux-cored wire is simply a metal tube formed around a die via an extrusion process, subsequently drawn through progressively finer dies. This thin metal tube is prone to cracking and breaking as the equipment relies on a continuous wire to operate correctly. Extrusion presses must be specially outfitted to run high-bismuth wires and run at significantly slower speeds compared to typical SAC alloys. These factors add considerable cost to manufacturing.

SnBi can recrystallize at room temperature. Therefore, this once-ductile material can become brittle over time, resulting in flux-cored wire solder being prone to breaking as it is unspooled. This makes low-temperature alloys poorly suited for fine-wire diameters or robotic soldering applications.

Finally, SnBi alloys are slower to wet compared to SAC, and therefore require more aggressive fluxes to promote spread and flow to facilitate barrel fill and sufficient wetting.[2] These realities leave assemblers using low-temperature solders with three practical options when reworking assemblies: implement high-bismuth, low-temperature flux-cored wire solder with the material; implement solid high-bismuth wire solder with an external flux; or use SAC flux-cored wire in combination with the low-temperature alloy used during the assembly process.

The study evaluated these three options, provides feedback on performance characteristics during processing, and compares the resulting solder joints using IPC-A-610, cross-section evaluation and shear strength testing.

## Experimental Methodology

Three rework conditions were followed to compare the performance of high-Bi solders to a SAC 305 baseline during rework and post-assembly processes. Condition 1 uses Sn42Bi57Ag1 paste and SAC 305 flux-cored wire. Condition 2 uses Sn42Bi57Ag1 paste but is different from condition 1 in that solid Sn42Bi57Ag1 wire and external flux is used. Finally, condition 3 employs SAC 305 paste and SAC 305 flux-cored wire for rework. All flux mediums in use are no-clean, thus cleaning was not performed.

The study used PC016 J-STD-001 REV F/G-LF Solder Training Kit **(FIGURE 1)** because of its combination of SMT and PTH component types. The surface finish was ENIG (electroless nickel immersion gold) with thicknesses of about 2[U]in gold and 120[U] in nickel, respectively. The assortment of components enables use of a combination of post-assembly soldering techniques. The following components were tested in this study.

- Cross-section: R1, U1, and CR3
- Shear testing: R3, R4, C3, C4, CR3, CR4, R5, and R6.

Phase 1 assembly took place in the company Solder Technical Applications laboratory in Juarez, Mexico. A 5-mil, laser-cut stencil using PHD stainless steel, mounted at standard tension (~34N/cm) with apertures designed to promote defects was employed. The stencil design included engineered defects such as BTC apertures combined into one to form solder bridging pads, indicated by the blue arrows in **FIGURE 2.** Also, one of each chip component outlined in red, per Figure 2, was printed using the inverted home-plate design while the second identical component was printed 1:1 with the pad to promote solder balling.

The pin-in-paste (PiP) method was used for PTH components. Deposits were inspected for consistent paste volume using a Parmi SigmaX SPI. After printing, the board was populated using an I-Pulse M10 pick-and-place machine and PTH components were inserted manually. Boards were then soldered with their respective profiles using a Heller model 1936 MK5 convection reflow oven. A total of 18 boards were assembled to permit experimentation and assessment of various rework techniques. Twelve boards, listed in **TABLE 1,** were assembled with the company no-clean Sn42Bi57Ag1 paste following the reflow profile in **FIGURE 3** with a peak temperature of 170˚C.

Solder paste was printed using a DEK HORIZON 3AA.

Six boards, listed in **TABLE 2,** were assembled using the company no-clean SAC 305 paste following the reflow profile in **FIGURE 4** with a peak reflow temperature of 246˚C.

After assembly, the next phase was simulating various rework/post-assembly processing techniques under each soldering condition. This was conducted at Eptac Corp. Rework was performed with a soldering iron with a chisel tip set to 630˚F/330˚C **(FIGURE 5).** The company no-clean flux-cored SAC 305 wire was used to rework 12 total boards: six of the 12 assemblies using Sn42Bi57Ag1 paste, per condition 1, and six assemblies using SAC 305 paste, per condition 3. The remaining six boards assembled using Sn42Bi57Ag1 paste were reworked using solid Sn42Bi57Ag1 wire combined with

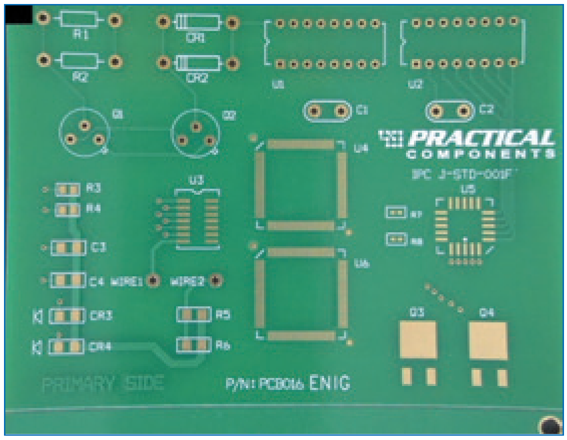



**FIGURE 1.** PC016-IPC J-STD-001-REV F/G-LF Solder Training Kit.

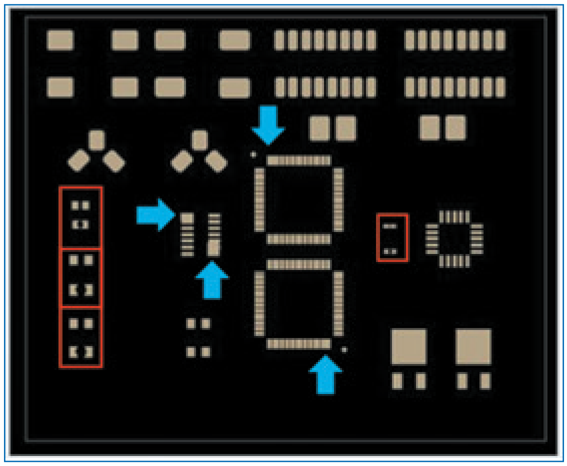


**FIGURE 2.** Stencil designed to promote defects.

**TABLE 1.** Materials and Peak Reflow Temperatures Used for Low-Temperature Solder Assemblies

| Board # | Paste | Peak Reflow (°C) | Rework Wire | Flux |
|---|---|---|---|---|
| 1 | Low-temp | 170 | SAC | cored |
| 2 | Low-temp | 170 | SAC | cored |
| 3 | Low-temp | 170 | SAC | cored |
| 4 | Low-temp | 170 | SAC | cored |
| 5 | Low-temp | 170 | SAC | cored |
| 6 | Low-temp | 170 | SAC | cored |
| 7 | Low-temp | 170 | Low-temp | liq./gel |
| 8 | Low-temp | 170 | Low-temp | liq./gel |
| 9 | Low-temp | 170 | Low-temp | liq./gel |
| 10 | Low-temp | 170 | Low-temp | liq./gel |
| 11 | Low-temp | 170 | Low-temp | liq./gel |
| 12 | Low-temp | 170 | Low-temp | liq./ gel |

the company no-clean liquid flux for PTH components and the company no-clean gel flux for SMT components, per condition 2.

The second part of this phase comprised reproducing the rework techniques applied and capturing them on video.

## Rework Techniques and Tooling

None of the components used in rework was prepped or pretinned prior to being assembled to the board.

PTH components were removed by cutting the component leads, applying liquid flux to the remaining solder joints, and removing the components with heated tweezers. Through-hole vias were cleaned with copper braid. Four axial components, two radial caps and one IC were removed from each board.

Surface-mount components were removed with heated tweezers. Pads were prepped for new components by applying no-clean liquid flux and solder braid to remove excess solder. No-clean rework gel flux was then applied, and a small amount of SnBi solder was applied to prepare for the installation of new components.

Once the pad terminations were prepared and fluxed, components were placed on the pads, the solder was reflowed using hot air, and the components were slid onto the molten solder alloy. The process was repeated on the opposite side.

Intentionally designed SMT

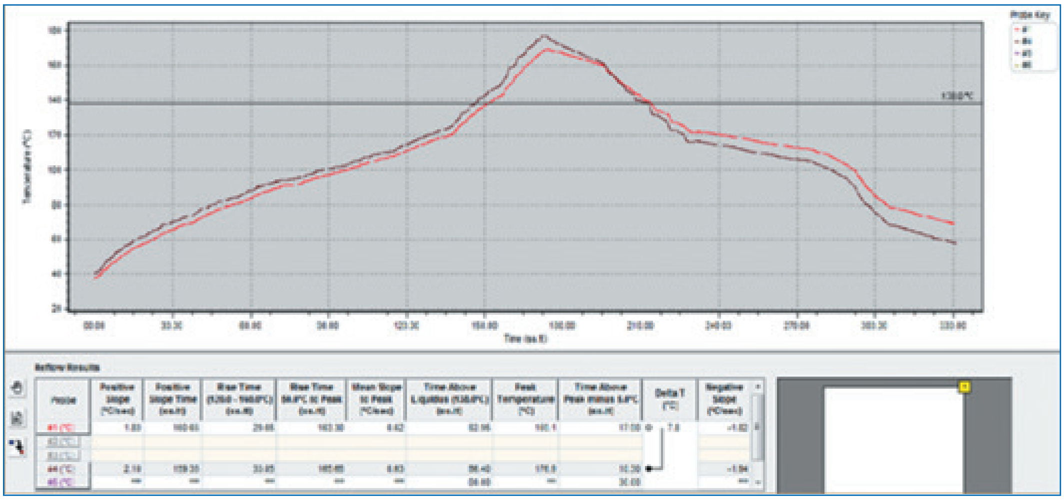


FIGURE 3. 170°C SnBiAg peak reflow profile.

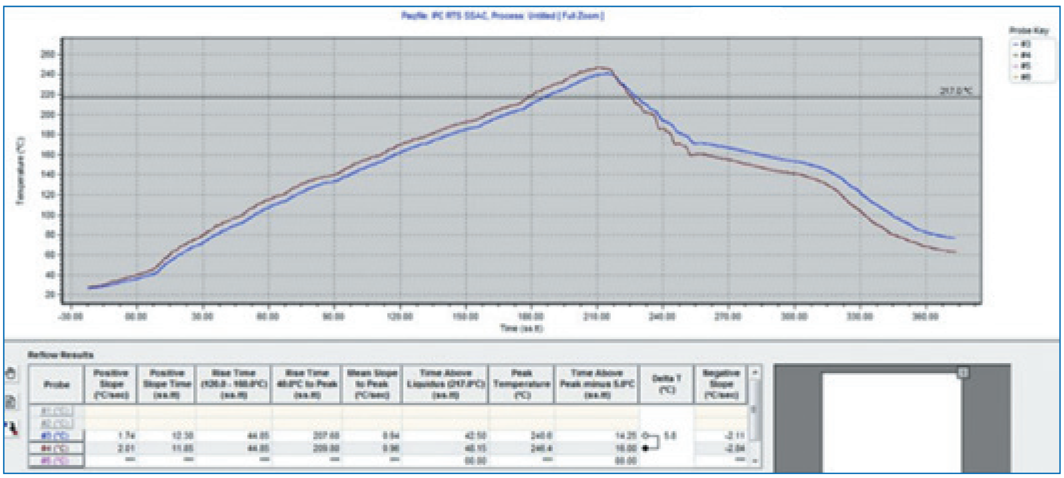


FIGURE 4. 246°C SnAgCu Peak reflow profile.

TABLE 2. Materials and Peak Reflow Temperatures Used for SAC Solder Assemblies

| Board # | Paste | Peak Reflow (°C) | Rework Wire | Flux |
|---|---|---|---|---|
| 13 | SAC | 246 | SAC | cored |
| 14 | SAC | 246 | SAC | cored |
| 15 | SAC | 246 | SAC | cored |
| 16 | SAC | 246 | SAC | cored |
| 17 | SAC | 246 | SAC | cored |
| 18 | SAC | 246 | SAC | cored |

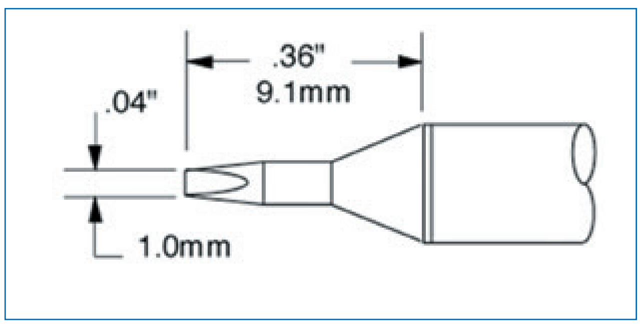



FIGURE 5. Chisel tip.

defects, such as bridges on the gullwing components, were reworked by applying gel flux and copper braid, and heated with the soldering iron to wick the solder away. The joints were refluxed with the no-clean gel and the low-melt alloy was reapplied to verify the joint met the requirements of J-STD-001.

## Analysis Methodology

Cross-section analysis was conducted on one PTH and two SMT components per soldering condition: R1, U1 and CR4, respectively. This was done to investigate the impact of the various rework techniques and soldering conditions on intermetallic compound (IMC) formation. Mechanical shear testing was conducted on SMT components R3, R4, C3, C4, CR3, CR4, R5, and R6 at a constant speed of 0.1mm/s and a shear height of 0.15mm.

## Results

**Rework observations.** All surface-mount components were prepared using no-clean gel flux and PTH components with no-clean liquid flux. Solid low-temperature solder did not wet the solder iron tip as well as the flux-cored SAC 305 wire, which was unsurprising.

The solid SnBi wire worked well with the addition of the application of external flux. Solder joints were visually inspected and met the requirements of IPC/J-STD-001. When using solid low-temperature wire, the solder iron tip remained tinned and functional, with no degradation of the tip tinning.

When using SAC 305 flux-cored wire, soldering the smaller-size surface-mount components proved challenging due to the large wire diameter. Although the joints appeared to have excess solder, they met the wetting requirements according to J-STD-001.

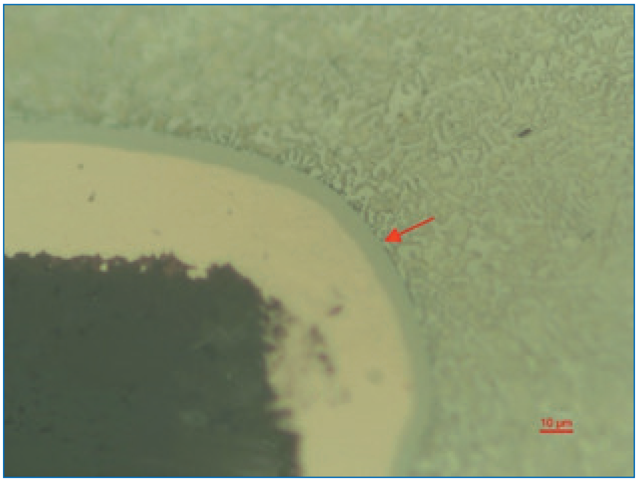


**FIGURE 6.** R1 PTH component assembled with Sn42Bi57Ag1 paste and reworked with solid Sn42Bi57Ag1 wire and external flux.

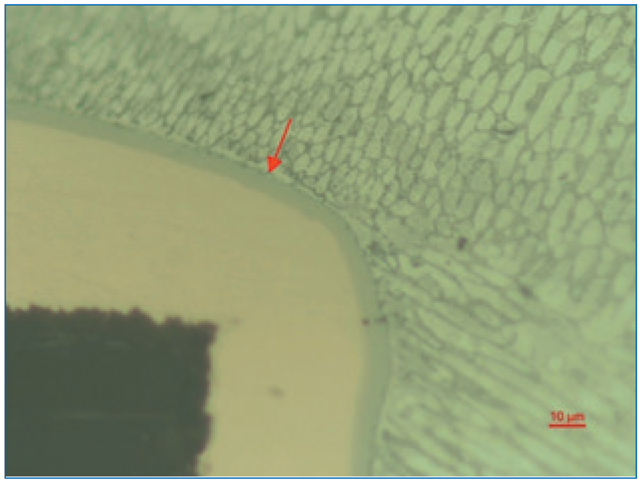


**FIGURE 8.** R1 PTH component assembled with SAC paste and reworked with SAC flux-cored wire.

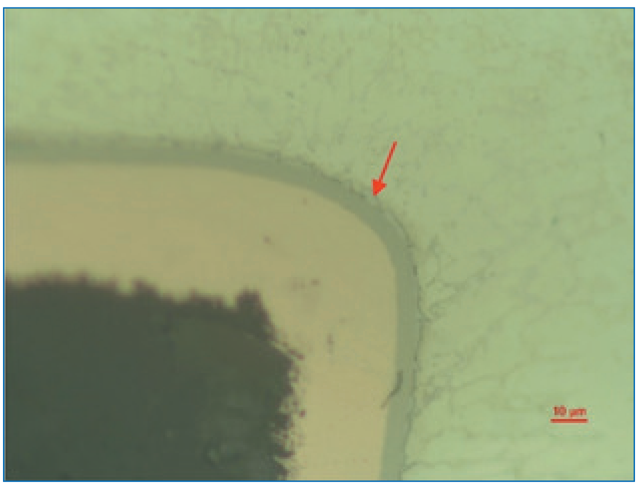


**FIGURE 7.** R1 PTH component assembled with Sn42Bi57Ag1 paste and reworked with SAC flux-cored wire.

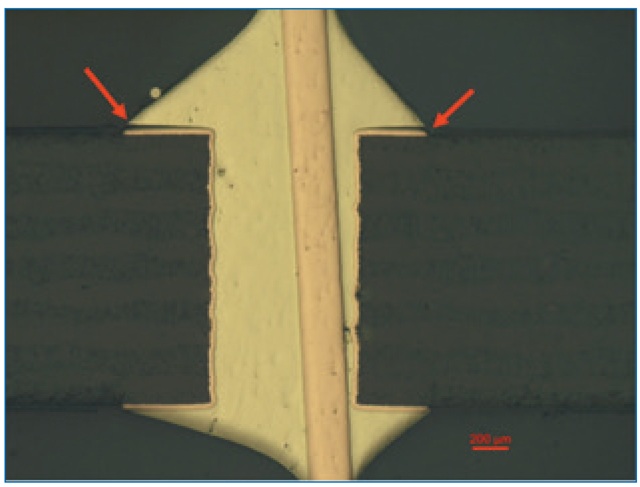


**FIGURE 9.** Fillet lift on U1 PTH component assembled with Sn42Bi57Ag1 paste and reworked with SAC flux-cored wire.

**Solder joint analysis cross-section analysis.** Cross-section analysis showed typical IMC formation for all the reworked joints. **FIGURES 6** to **13** display the typical IMC formation per each soldering condition. Figures 6 to 9 display PTH component, R1, while Figures 10 to 13 display SMT component CR4.

Almost all the PTH joints have 100%-barrel fill; however, the fillet-lifting phenomena on the topside were observed at R1 of board #2 and U1 of board #1 (Figure 8). Fillet lift is a common occurrence when using high-bismuth alloys and is not a defect per IPC-A-610.

On the SMT components, each IMC is well-formed, showing good wetting on the pads of the PCB and terminations of components. Figures 10 to 13 display the IMC formation per soldering condition on SMT component CR4.

In conclusion, rework has been successfully performed, with no observed defects under all test conditions. All solder joints were acceptable per IPC-A-610 inspection criteria.

**Shear testing.** Shear test results for components C3/C4, CR3/CR4, R3/R4, and R5/R6 are shown in **FIGURES 14** to **17.**

Each soldering condition performed comparably during shear testing per component type. The variation seen within a single soldering condition, no matter the component, is attributable to the variable nature of rework. Rework is a manual operation, and the quality of a reworked solder joint is highly influenced by operator input. Even the most expert operator producing acceptable solder joints will have variation in their work. Shear testing did not show a clear outlier in mechanical performance over the three soldering conditions. The low shear force values in Figure 13 can be attributed to inconsistent volumes of solder being applied to the joint, which is a result of the manual operation of rework.

**FIGURES 18** to **20** display the typical shape seen in a shear force versus extension relationship for each soldering

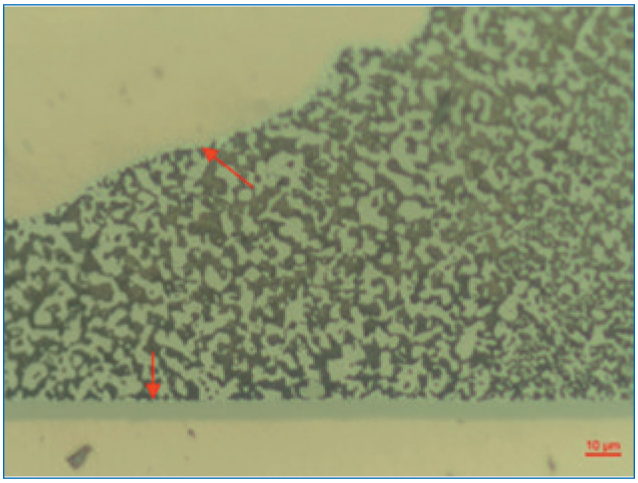



**FIGURE 10.** CR4 component assembled with Sn42Bi57Ag1 paste and reworked with solid Sn42Bi57Ag1 wire and external flux.

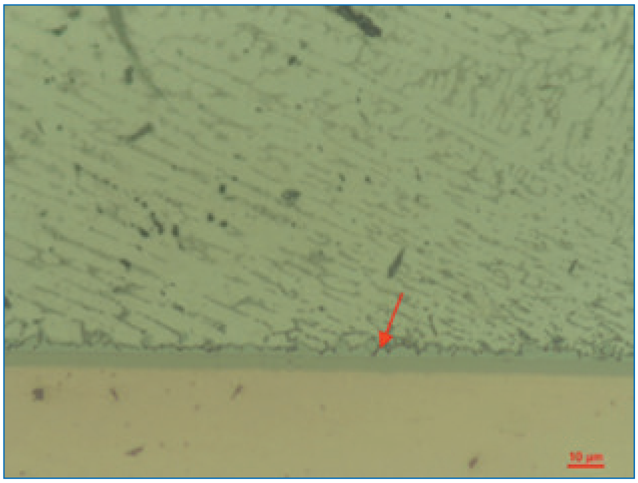



**FIGURE 12.** CR4 component assembled with SAC paste and reworked with SAC flux-cored wire, pad side.

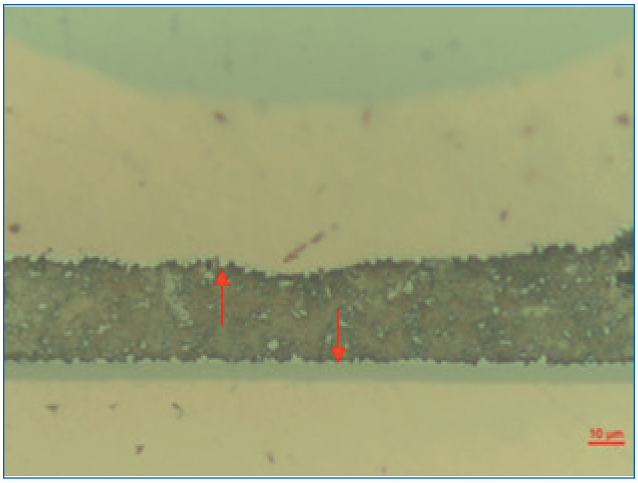



**FIGURE 11.** CR4 component assembled with Sn42Bi57Ag1 paste and reworked with SAC flux-cored wire.

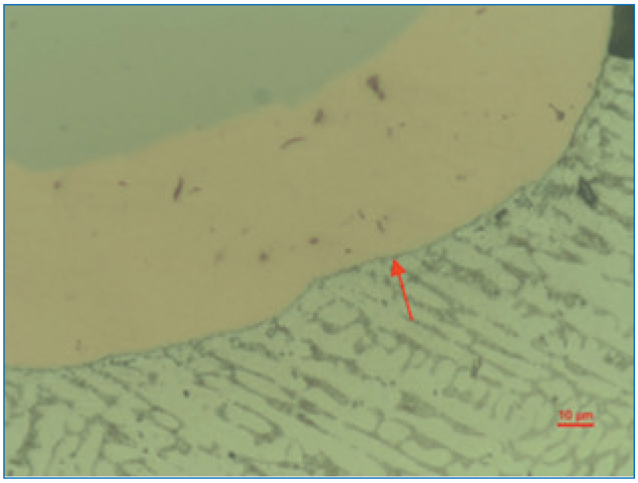



**FIGURE 13.** CR4 component assembled with SAC paste and reworked with SAC flux-cored wire, component side.

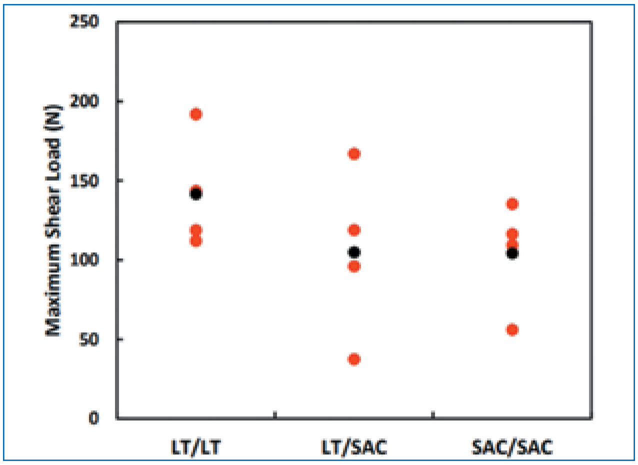



**FIGURE 14.** Shear force for C3/C4 components for the three test cells (red = each test, black = average).

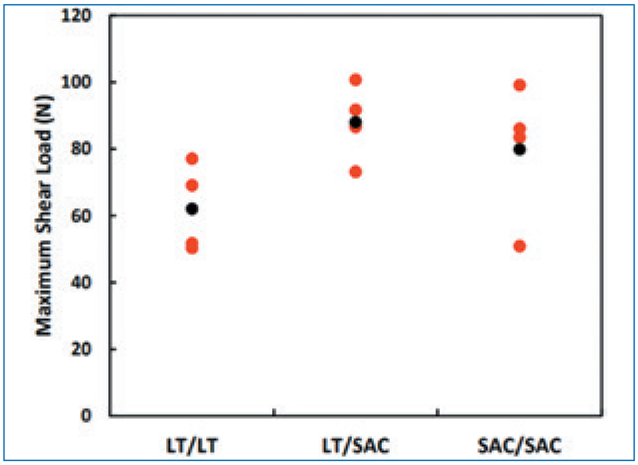



**FIGURE 15.** Shear force versus extension relationship for CR3 and CR4 components.

condition/test cell. The results of component R5 are shown in the following figures. The high-bismuth (LT reworked with LT) curve seen in Figure 18 is sharp, indicating that the alloy can withstand load (N) but breaks abruptly due to its brittle properties.

Figure 19 shows the curve of the LT paste reworked with SAC flux-cored wire, displaying a less sharp curve and greater extension (mm), indicating it is more ductile than the LT paste reworked with LT wire and external flux (Figure 18).

Finally, Figure 20 illustrates how the SAC paste reworked with SAC flux-cored wire extends the greatest but withstands less load (N) before extension compared to the LT paste reworked with SAC flux-cored wire (Figure 19).

## Conclusions

Low-temperature alloys used in SMT and PTH processes can be successfully reworked using low-melting temperature solid wire and external flux as well as with flux-cored SAC 305 wire solder. Low-temperature solder behaves differently during processing than the SAC equivalent, but this was not an obstacle in creating quality solder joints. LTS solid wire with external flux will require qualification of an appropriate flux for the application requirements. As with any externally applied flux, residue and reliability characteristics due to processing techniques must be considered.

The resulting solder joints met IPC Class 1, 2 and 3 solder joint criteria. Shear test results were inconsistent due to the variable nature of rework, but trends are visible. SAC solder joints were more ductile than Bi-bearing counterparts. This is not unexpected. SAC+SnBi solder joints shear results reflected the properties of the combined alloys. The operator in this study was an IPC hand soldering certification instructor with decades of experience. Even with a highly qualified operator, results are variable. This highlights the importance of operator training in implementation of low-temperature rework.

When using SAC 305 flux-cored wire solder, the process was like existing SAC/SAC rework processes. No special considerations were noted other than to consider the use of finer wire diameters when reworking smaller components.

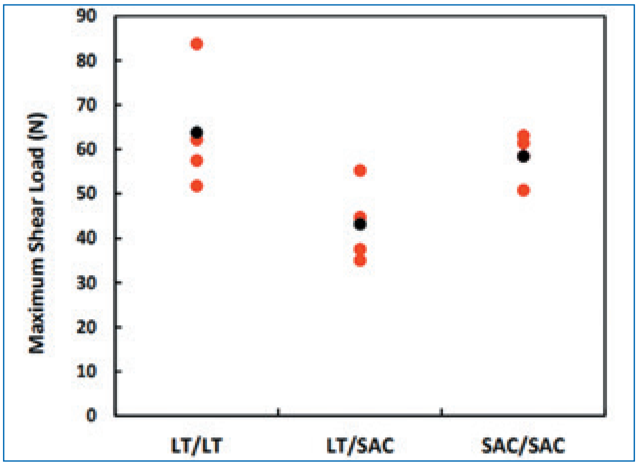



**FIGURE 16.** Shear force for R3/ R4 components for the three test cells (red = each test, black = average).

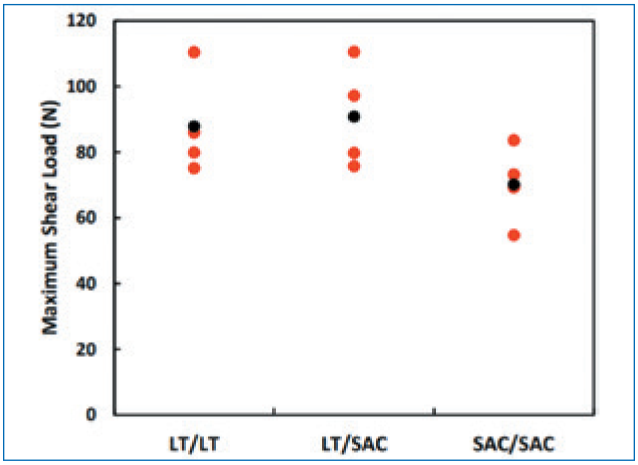



**FIGURE 17.** Shear force for R5/ R6 components for the three test cells (red = each test, black = average).

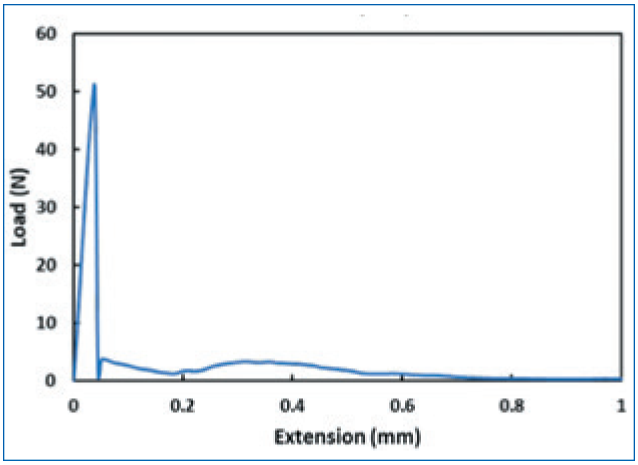



**FIGURE 18.** Typical shear force versus extension relationship for component printed with LT paste and reworked with LT wire and external flux (R5).

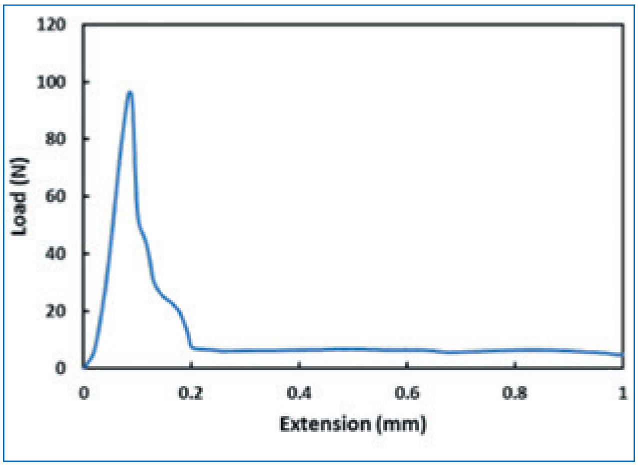



**FIGURE 19.** Typical shear force versus extension relationship for component printed with LT paste and reworked with SAC flux-cored wire (R5).

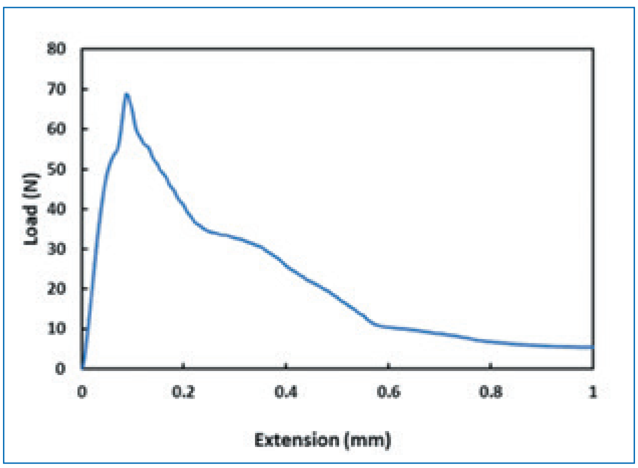



**FIGURE 20.** Typical shear force versus extension relationship for component printed with SAC paste and reworked with SAC flux-cored wire (R5).

Low-temperature flux-cored wire solder was not included in this study due to the prohibitive cost to the end-user and limited availability.

## Future Work

Based on the outcomes of this study, more testing has been scheduled. The effect of low-temperature alloys on soldering iron tip life and equipment will be evaluated. In theory, lower operating tip temperature will extend solder tip life, offering another cost-saving opportunity for low-temperature implementation. In addition, low-temperature alloy flux residue was noticeably darker than SAC alloy residue. Analysis indicated the presence of bismuth oxide, which is an aesthetic concern. Future testing will include the ease of cleaning these dark residues in both the assembly and rework setting.

## Acknowledgments

The authors would like to thank the Applications Lab Team at AIM, Andres Lozoya, Angel Lopez and Ruben Sanchez, for their patience and dedication. We would also like to acknowledge the input and guidance of Yuan Xu of the AIM metallurgy department, whose knowledge helped make this study possible. ❑

## REFERENCES

1. D. Witkin, "Influence of Microstructure on Mechanical Behavior of Bi-Containing Pb-Free Solders," IPC Apex Expo, 2013.
2. H. Osgood, D. Geiger, R. Pennings, C. Biederman, J. Jiang, J. Bernal, "Low-Temperature SMT Solder Evaluation," IPC Apex Expo, 2019.

*Ed.:* This article is adapted from a paper published at SMTA International in November 2022 and is reprinted here with permission of the authors.

**TIM O'NEILL, JEN FIJALKOWSKI, CARLOS TAFOYA, YUAN XU, AND STEVE HRCEK** are with AIM Solder; toneill@aimsolder.com. Leo Lambert is with Eptac Corp.; leo@eptac.com. Bob Willis is an independent consultant; bob@bobwillisco.uk. S'ad Hamasha, Ph. D. is at Auburn University; smh0083@auburn.edu.

# Hidden Gems of Printer Management

How lesser-known printer software features can improve process control.

AS A PROCESS engineer specializing in the stencil printing operation, I understand why many operators are unaware of the bells and whistles in advanced printing platform software – especially when working in a busy production environment. While the primary focus is speed, pressure and angle to ensure the best print at the fastest cycle time cadence, sometimes the production pace can be interrupted by unexpected events. I was reminded of this – and a couple of software tricks – recently when doing evaluation work in our lab.

Our team has been running a process with mixed apertures, the largest of which are 5mm square. During the evaluation, the SPI indicated an occasional paste height failure. The process was not in control, but in an extraordinarily random way. Examining the boards under a microscope revealed large drops/deposits of paste sitting on some of the perfect, uniformly printed deposits; extra material that looked like it had just been dropped on top of an otherwise well-printed deposit. This was causing the SPI to flag the extra height/volume. No pattern was identifiable, so more analysis was required to uncover the root cause. Further investigation revealed material building up on the back side of the squeegee blade.

Typically, if the boards being printed are made up exclusively of smaller devices, the squeegee blade goes across the apertures and hits the metal web of the stencil, which tends to seal everything quite nicely. The squeegee blade acts as a hydrodynamic pump, and with so much pressure and when printing large apertures, material can move underneath the blade and collect on its back to form a bow wave **(FIGURE 1)**. This phenomenon is exaggerated when apertures are larger, and in this case, we had small apertures alongside larger 5mm x 5mm openings. When the paste buildup reaches a critical mass on the back of the blade, that material will shear off and drop onto your skillfully printed deposits. This is precisely what was occurring in our evaluation.

The fix? Most stencil printing equipment software have a feature that tells the squeegee to do a short hop backwards under a small amount of pressure – the parameters of which can be specified – and clean the back of the blade of any residual solder paste buildup. The subsequent move forward puts the material back in the paste roll.

The back of the blade isn't the only place that material can accumulate, however. This can also happen on the underside of the stencil. Fortunately, there is a similar remedy. In the understencil cleaning operation, the cleaner/cleaning head returns to the same position once it runs its cleaning routine between prints. While in operation, the cleaner pulls material out of the apertures and onto the fabric. When the cleaning head stops at its resting position, a buildup of solder paste material can occur on the underside of the stencil in that area. If not corrected, a ridge of paste grows and can impact print performance.

Much like the remedy mentioned for the extra paste on the back of the blade, there is a software feature that allows lowering of the understencil cleaning plenum to drive a bit farther and clean the material ridge **(FIGURE 2)**. For manufacturers

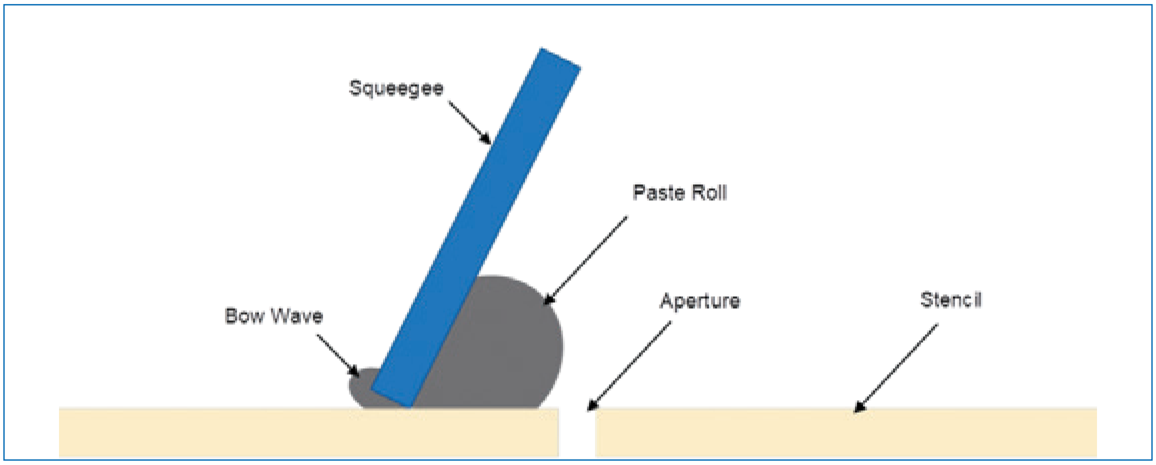



**FIGURE 1.** A bow wave can appear when extra material moves underneath the squeegee. If not removed, unwanted solder paste may randomly fall onto otherwise well-printed deposits.

**CLIVE ASHMORE** is global applied process engineering manager at ASMPT (asmpt.com); clive.ashmore@asmpt.com. His column appears bimonthly.

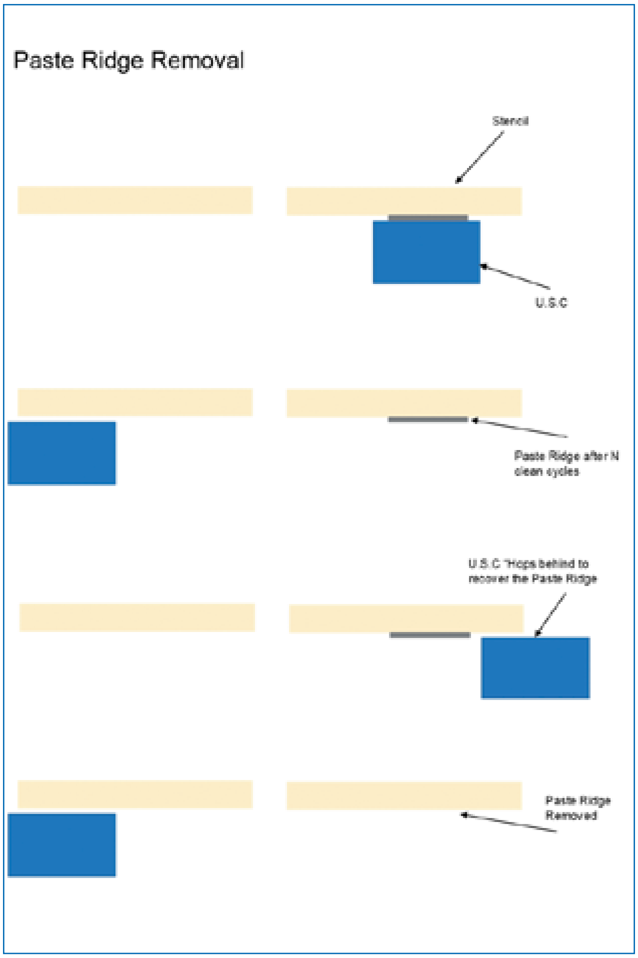



**FIGURE 2.** Solder paste may accumulate at the edge of the underside of the stencil after numerous cleaning operations. A programmable software feature permits the cleaning system to remove the paste ridge at set intervals, as determined by the operator.

that clean between every print – and there are more than you think, particularly those building mobile devices – this buildup may happen sooner rather than later and result in a nonuniform process. Like paste recovery, ridge removal can be programmed into the software at preferred intervals and align with the process cadence.

These simple functions, which operators often overlook or are unaware even exist, are handy solutions to ensure the process is controlled. Although both these software features – available on many stencil printing platforms – may add a couple of seconds to cycle time, it's certainly better than adding potential defects to the process. ❑

*Focus on Business, continued from pg. 21*

time period. If that doesn't happen, then follow HR policies on next steps.

**Is your organization incentivizing quiet quitting?** Quiet quitting can also be a symptom of an understaffed and over-challenged workplace. Covid drove a culture of doing more with fewer resources in an environment with new challenges every day. That level of effort is achievable when necessary for a short period of time, but when the challenges keep coming and additional staffing isn't put in place, a toxic work environment can develop. If that symptom is present in your workplace, it may be time to re-examine workplace quality of life. Surveys can be a good start to get a baseline on what employees find satisfying and dissatisfying in the workplace. Review recognition programs. Look at work scheduling and the benefits package. Are advancement paths clearly outlined? Could mentoring be improved? Can some repetitive tasks be better automated to free employees to focus on work that requires more critical thinking skills?

2023 will be a year with a lot of opportunities for companies that are able to stay responsive in the face of the challenges encountered over the past two to three years. That said, those challenges have left marks. Companies that are presently doing damage repair to address workplace quality of life and are assessing the risks of shifts in market dynamics will be better positioned to thrive. ❑

*Material Gains, continued from pg. 24*

necessary to prevent recurrence, but people continue visiting their doctors. On the other hand, misdiagnoses due to machine error – though far less common – will not be tolerated so easily.

Trust is usually aided and enhanced by transparency, which could be achieved if software providers were open about their algorithms. Naturally, they are likely to be guarded about their intellectual property, but we have already seen how the open-source software model has become commercially successful, benefiting both from community engagement in reviewing and refining published code while also effectively protecting creators' rights and revenues.

It will probably just take time for us to adjust, and for machine-based healthcare to establish its own track record. In a couple of generations' time, many people will have no experience of receiving healthcare any other way. Being diagnosed by machines, and even describing our own symptoms to machines, will become the norm quite quickly. We know human beings are highly adaptable creatures, and many of us will soon appreciate that machines can take better care of us than we could ourselves. ❑

## AMPHENOL SNAPEDA VIEWER

SnapEDA Viewer for Amphenol enables engineers to find readily available digital models – such as schematic symbols, PCB footprints and 3-D models – for over 21,000 products, including cable-to-board, D-sub, power, SFP, USB, and QSFP connectors. The models were created following Amphenol's recommended land patterns and a combination of IEEE-315, IPC-7351B and SnapEDA internal standards. Free to download on Amphenol website via the SnapEDA Viewer. Users can search for a needed product, preview and interact with CAD models, and download them in their PCB format of choice. Libraries are available to download in over 15 PCB design formats, including Altium, Cadence OrCad/Allegro, KiCad, Autodesk Eagle and Fusion360 and more.

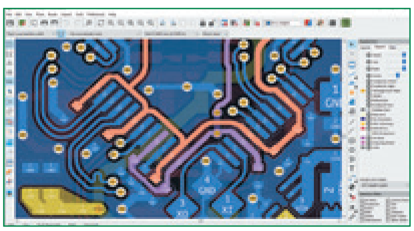
**Amphenol Communication Solutions**
**amphenol-cs.com**

**SnapEDA**
**snapeda.com**

## ANSYS GATEWAY

Ansys Gateway is powered by AWS and features on-demand access to Ansys applications and high-performance computing (HPC) resources on the cloud. Can manage and control CAD/CAE cloud consumption and costs on AWS while taking advantage of the scalable hardware and compute capacity. Is said to provide seamless cloud support for Ansys applications as well as other popular CAE/CAD software. Customers can bring their own licenses and easily manage user access, permissions, data and security.

**Ansys**
**ansys.com**



## KICAD 6.0 PCB DESIGN SOFTWARE

KiCad v. 6.0.0 features a refreshed UI designed to reduce barriers to entry for new users and ease friction when switching between KiCad and other CAD software. Visual design language, hotkeys, dialog layouts, and editing workflows have been harmonized to no longer feel like two different tools when switching between schematic and PCB editors. Schematic editor now uses same object selection and manipulation paradigm as PCB editor. Upgrades include ability to assign net classes from within schematic editor; apply line color and style rules to wires and buses individually or based on net class; and create buses that group together multiple signals with different names for easier hierarchical design. New schematic and symbol library file format is based on format used for KiCad board and footprint files. Enables embedding symbols used in a schematic directly in the schematic file, so cache libraries are no longer needed. PCB editor has complete look and feel upgrade, featuring new options to navigate complicated designs. Saves and restores custom view presets. Hides certain nets from rats nest. Controls opacity of zones, pads, vias, and traces independently. Sets colors for specific nets and net classes, and applies those colors to rats nest or to all copper attached to that net. Selection Filter panel controls types of objects to be selected.

**KiCad**
**kicad.org**

## TELEDYNE LECROY CAN-XL(R) OSCILLOSCOPE OPTION

CAN XL Trigger, Decode, Measure/Graph and Eye Diagram (TDME) oscilloscope software option enables users to test, validate and debug automotive electronic control units (ECUs) and 10Mb/s in-vehicle network (IVN) designs. Symbolic trigger setup, decode, and data extraction and graph setup using (customer-supplied) DBC or ARXML file. Supports 29-bit GM CAN Priority ID, Source ID, Parameter ID trigger and decode. Supports use of customer-supplied DBC or ARXML file for signal selection for triggering and CAN to Value serial data DAC setup. Decode annotation is in Symbolic format, with complete message and signal structures described.

**Teledyne LeCroy**
**teledynelecroy.com**

## UCAMCO UCAMX CAM

UcamX v2022.09 CAM improvements, additions and options include YELO mask adjuster extensions, electrical test optimization, new default ucam.db settings, additional Ucam.properties settings, optimized Excellon 2 input, and improved GAR input.

**Ucamco**
**ucamoco.com**

## UCAMCO INTEGR8TOR V2022.09

Integr8tor v2022.09 pre-CAM software has new NEC layer naming convention added to layer stackup recognition engine, drill header recognition engine extensions, and improved from-to drill span recognition algorithms.

**Ucamco**
**ucamoco.com**

## VISHAY VITRAMON DC BLOCKING CAPACITORS

Vitramon DC surface-mount MLCCs are optimized for DC blocking applications. Industry's first such devices characterized for common frequency bands ranging from 3MHz to 18GHz. For RF, Bluetooth, 5G, and powerline communication circuits; military radios; infotainment systems; fiber optic lines; amplifiers; microwave modules; and high-frequency data links. Block DC voltages, eliminating the need for higher-cost broadband blocks, while efficiently transmitting the desired AC signal with less than 0.5dB insertion loss across the selected frequency band. Cover HF, VHF, UHF, L, S, C, X, and Ku frequency bands and offer resonance-free performance across the bands' range. Come in 0402, 0603, 0805, and 1210 case sizes, and operate over a voltage range from 25V to 500V and a temperature range from -55° to +125°C.

**Vishay**
**vishay.com**

## DATA I/O LUMENX PLATFORM WITH VERIFYBOOST

VerifyBoost delivers faster verify performance up to 750 MBps High-speed Gear3 x 2-Lane support for UFS devices, enabling the leverage of existing production capacity for significant throughput gains and reducing the total cost of programming. Delivers up to 4.5x improvement in programming performance and reduces total cost of programming up to 39%.

**Data I/O**
**dataio.com**

## ERSA I-CON TRACE IOT MANUAL SOLDERING STATION

i-CON Trace ensures traceability for manual soldering processes. Records process information and offers visual reports. Comes with WiFi, Bluetooth and optional network card, and has heating power of 150W. Characteristic operating concept can be controlled with mobile devices (notebook, tablet or smartphone). Use as standalone soldering station with preset parameters or integrate into MES-controlled production processes. Soldering tip range increases efficiency of energy transfer by up to 30%, and the Tip'n'Turn quickchange system allows simple, quick, and safe change of soldering tips offered in different shapes and sizes.

**Ersa**
**kurtzersa.com**

## HENKEL LOCTITE ABLESTIK ICP 2120 ECA

Loctite Ablestik ICP 2120 electrically conductive adhesive cures at room temperature, improving yield rates and protecting sensitive structures within mobile device compact camera modules. Is a moisture-cure ECA, designed to deliver robust electrical grounding performance. Distinctive chemistry provides low modulus (900 MPa @25°C) for drop performance, a curing profile for fast room- or low-temperature (50°C for 30 mins.) cure to enable high-volume processing, substrate protection and reduced energy consumption. Direct contact resistance of DCR @<5Ω/piece, and low volume resistance to ensure thorough removal of ESD from substrate for robust operation. Thermal conductivity is 7.0 W/m-K to dissipate operational heat to improve performance and reliability.

**Henkel**
**henkel-adhesives.com/electronics**

## INDIUM PICOSHOT WS-5M SOLDER PASTE

PicoShot WS-5M water-soluble and halogen-free solder paste is for Mycronic MY-series jet printers. Dot volume of 6.5nl/dot, 350µm diameter, precision deposit (x,y targeting), and long usage (syringe life >8 hr.). Can be used for jetting into cavities and uneven/warped substrates, high-mix/low-volume stencil replacement, CSP/µBGA solder attach, military and aerospace jetting applications, system-in-package, camera module assembly where an overmolding step is required, and shield-attach and secondary processing.

**Indium Corp.**
**indium.com**

## INDIUM, SAFI-TECH SUPERCOOLED BISN SOLDER PASTE

Supercooled BiSn solder paste encapsulates liquid metal in soft shell to keep solder alloy below its normal freezing point. Shell can be removed via traditional flux and reflow process or burst by compression. Can reportedly be fluxed and reflowed at 135°C. Target applications include flexible hybrid electronics and heat-sensitive applications currently using conductive epoxies.

**Indium Corp.**
**indium.com**

## ITW EAE CAMALOT PRODIGY DISPENSER SYRINGE COOLING OPTION

Prodigy dispensing system syringe cooling option increases "pot-life" of underfill materials by maintaining syringe at controlled temperature within the heated machine environment. Reduces material waste, reduces downtime and increases process stability. Works with all Camalot pumps. Accommodate 10cc to 55cc syringes and includes low-level sensor that alerts the operator when syringe is empty. Cooler unit temperature is set and monitored within machine's Benchmark operating system, and temperature setpoints are stored with the process program. Different temperatures can be loaded if more than one type of material is used. Temperature data is logged and can be transferred via OpenApps to MES.

**ITW EAE**
**itweae.com**

## MACDERMID ALPHA ALPHA ARGOMAX SINTER PASTE PACKAGING OPTION

Alpha Argomax sinter paste now comes in a jar with dispense port from which paste can be dispensed. Is said to allow more manufacturing options, facilitate high-volume implementation and support automatic sinter paste dispensing on a stencil. Reduces material waste, allowing utilization of ≥99% of the sinter paste, and reduces downtime changing containers with the jar available in sizes up to 250g. The jar is compatible with premixing and facilitates reuse of partially used containers. Automates dispense process or allows use of a mechanical handheld dispenser to improve paste replenishment repeatability.

**MacDermid Alpha Electronics Solutions**
**macdermidalpha.com**

## MASTER BOND MASTERSIL 323AO-LO SILICONE ELASTOMER

MasterSil 323AO-LO two-component silicone elastomer has self-priming feature. Is designed for bonding, sealing and gap filling. Electrically insulating and thermally conductive compound meets NASA low outgassing specifications and can be used in aerospace, electronics, optoelectronic and specialty OEM applications. Thermal conductivity is 1.15-1.30 W/(m•K). Tensile modulus of 500-700psi, elongation of 50-60%, and hardness of 70-75 Shore A. Is said to withstand aggressive thermal cycling and mechanical shock. Relatively high strength profile for a silicone, with a tensile lap shear strength of 250-350psi at room temperature. Bonds to a variety of substrates, including metals, composites, glass, ceramics, plastics, and other silicones without imparting residual stress when heat-cured. Serviceability from -65° to +400°F (-54° to +204°C). Paste-like consistency permits use as a gap-filling material where minimum flow after application is desired. Optimum cure is overnight at room temperature followed by 3-5 hr. at 125°-175°F.

**Master Bond**
**masterbond.com**

## METCAL MSA SERIES SMOKE ABSORBERS

MSA Series smoke absorbers are space-saving compact workbench fans that use activated carbon filters to extract harmful flux fumes and smoke during hand-soldering operations. MSA-35L is a versatile dual-position benchtop fan, designed for smaller spaces, which can be used vertically or horizontally for almost twice the airflow efficiency. MSA-25U, a smaller unit than the MSA-35L, features a USB plug that is compatible with any standard 5V USB power supply. Keep solder station operators safe by drawing smoke and fumes away from the workstation and filtering out impurities. Very quiet when in use, offer easy filter replacement, and ESD-compliant.

**Metcal**
**metcal.com**

## MYCRONIC IRIS 3D AOI FOR MYPRO I SERIES

Iris 3D AOI features a new generation of laser scanners, image sensors and computing systems, to improve test coverage while capturing nearly twice as many pixels at speeds up to 30% faster than previous technologies. Comes on MYPro I series 3-D AOI systems, and as a retrofit kit for existing K series 2-D AOIs in need of an upgrade to 3-D, as well as for K series 3-D AOIs that demand improved processing speed.

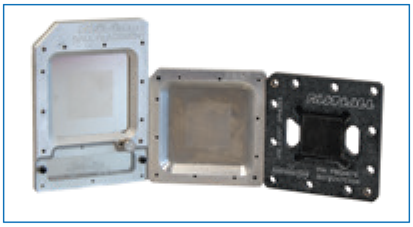
**Mycronic**
**mycronic.com**

## NIHON SUPERIOR LF-C2 SOLDER PASTE

LF-C2 Pb-free solder paste delivers long life in thermal cycling but with a compliance that means that it is resistant to cracking under stress typical with automotive electronics. Uses calibrated levels

of the two key strengthening tools available in solder alloy formulation, stable dispersed particles combined with solid solution strengthening of the tin matrix. Liquidus temperature of 213°C permits reflow at a lower temperature than SAC 305. Shear strength higher than SAC 305.

**Nihon Superior**
**nihonsuperior.co.jp**



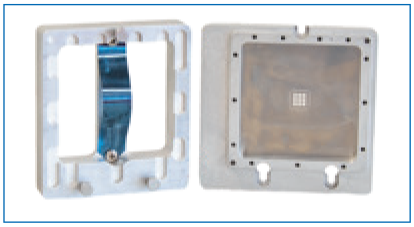
## PDR INTEGRATED REBALL SYSTEM FOR REWORK

PDR Evolution Series Rework systems now come with integrated reballing system. Incorporates both solder paste application and reball sphere attach in one easy-to-use system, incorporating advanced nanotechnology for a clean, high precision reball method for rework. Also incorporates integrated excess sphere recovery chamber to capture excess spheres that can easily be accessed on the reball platform for later use, or to accelerate the process when reballing multiple BGAs concurrently. Used with PDR's ThermoActive Suite Software Reballing Mode profiles, provides quality reballing results. Can be used as standalone devices for any reballing application.

**PDR Rework Systems**
**pdr-rework.com**

## PDR INTEGRATED SOLDER PASTE PRINT PART SYSTEM

Integrated Solder Paste Print Part System, for electronics rework, is treated with high durability carbon nanotube technology for superior paste-to-component release. Hands-free/tool-free calibrated pressure nest is said to ensure constant and direct pressure for paste application



and deposition, virtually eliminating the need for reprints. Mounts directly to all PDR Evolution Series Rework platforms for direct vertical lift utilizing PDR's Integrated Vacuum Pick Up Feature/Gram Force placement settings. Can be used as standalone device for general printing of solder paste to component.

**PDR Rework Systems**
**pdr-rework.com**

## ROCKA SMT STENCIL CLEAN ROLL

SMT Stencil Clean Roll removes solder paste residues or other viscous materials from stencil apertures or stencil contact side surfaces. Works with ultra-fine pitch apertures, improving cleaning cycle time due high absorption and paper texture permitting better vacuum performance. Is made of hydraulicly interlaced fibers with no chemical bonding; 100% PLP. Works with all stencil technologies, including nanocoated stencil foils, and all developed cleaning solvents including IPA.

**Rocka Solutions**
**rockasolutions.com**

## SAKI 3DI-LS3 3-D AOI

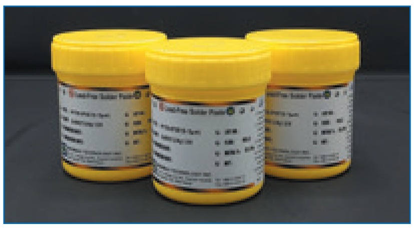
3Di-LS3 3-D automated optical inspection system has dome lighting option that enhances color profile of non-flat areas. Upgraded high-resolution camera and increased height-measurement capability provides inspection results at industry-fastest cycle times. Single platform concept allows 3Di AOI users to select between standard well-balanced ring lighting for general inspection and new high-quality dome lighting.

**Saki Corp.**
**sakicorp.com**

## SAKI 3XI-M200 V2 AXI

3Xi-M200 V2 3D-CT AXI reduces cycle time while improving inspection image quality and lowering maintenance requirements. Planar CT method enables high-definition tomographic images to be rendered with fewer image slices, fixed x-ray source and a rigid gantry for positioning accuracy, full stereoscopic images and noise-cancelation filters detect defects invisible from the outside, including voids in three-layer soldering. Imaging area 1.3x greater than before, upgrades to conveyor permit larger jigs, up to 460 x 600mm. Lead-protected design significantly reduces sensor's exposure, closed x-ray tube reduces need for maintenance, self-diagnosis functionality provides early-warning alarms prior to system issues.

**Saki Corp.**
**sakicorp.com**



## SHENMAO PF735-EP307 SOLDER PASTE

PF735-EP307 joint enhanced solder paste (JEP) is a low-melting-point epoxy-based solder material for extremely fine-pitch or fine-pad soldering, especially advanced display assembly. Has advantages of conventional solder paste and anisotropic conductive paste; i.e., self-alignment and planar insulation, respectively. Epoxy is cured after reflow and provides bonding strength and joint protection. Reliability performance is enhanced as well. Adopts newly designed epoxy-based flux that performs better for printability, longer printing lifetime and more reliability than typical epoxy-based solder pastes. Can reduce reflow temperature to below 190°C compared to Pb-free soldering, typically 240°-250°C, and hence decrease PCB and substrate deformation while saving energy, reducing thermal stability requirement of PCBs and components, and raising yield rates. Is halogen-free (REL0) and complies with RoHS. RoHS 2.0 and REACH. Works with various surface finishes and has clear flux residue. Suitable for fine-pitch applications and various IC packages, such as system-in-package (SIP), wafer-level-package (WLP) and flip chip.

**Shenmao**
**shenmao.com**

## SHENMAO PF606-P269J JETTABLE SOLDER PASTE

PF606-P269J lead-free solder offers workability and solderability for automatic high-speed jetting production. Is halogen-free (ROL0) and complies with RoHS 2.0 and REACH. Is formulated with SAC 305 alloy and powder size ranges from type 4 to type 7 for fine dot jetting. Is suitable for fine pitch and ultra-fine pitch applications and devices with uneven cavities and other difficult to print locations. Dot volume, size and shape can be adjusted and optimized for each individual component and pad on the board by using the jetting system, making it applicable for fine-pitch devices and minimizing failure rate in production.

**Shenmao**
**shenmao.com**

## SMARTSOL 4-AXIS SOLDERING ROBOT

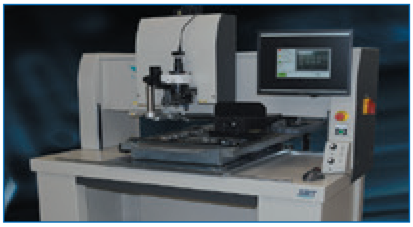
4-Axis soldering robot comes with a large power heating controller to ensure continuous soldering, auto cleaning system and more. Standard 200W programmable heating controller, process monitoring camera, programmable fiducial alignment, selectable soldering tip cleaner, tip position self-adjustment, and safety cover with light curtain and tower.

**SMarTsol Technologies**
**smartsolamerica.com**

## TRANSITION AUTOMATION DOUBLE-EDGE SQUEEGEE ASSEMBLY

Double-edge squeegee assembly for Yamaha YSP SMT printer platforms now has end-anchor points to improve life of assembly by preventing the boundary limited bonding that can cause separation. Designed to help eliminate machine downtime and repeat process interruption.

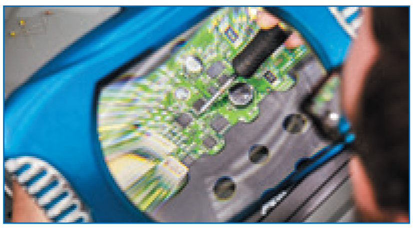
**Transition Automation**
**metalsqueegees.com**



## VJ ELECTRONIX SUMMIT 2200I REWORK SYSTEM WITH COMPONENT AUTO ALIGN

Summit 2200i rework system now comes with Component Auto Align option that permits alignment of components, including those larger than 100mm, with no operator intervention. Recognizes corners of component and site using fiducials, and then automatically determines pick locations (centerpoint). System can be upgraded via software or purchased new with Component Auto Align.

**VJ Electronix**
**vjelectronix.com**



## WELLER WXSMART SOLDERING PLATFORM

WXsmart soldering platform consists of 2-channel soldering station and includes WXair hot-air module for in-air and vacuum requirements. WXMPS MS smart soldering iron has ergonomic pencil design that fits in operator's hands, providing precision for small soldering applications under the microscope. Performs pico, micro and ultra soldering. Includes auto-calibration unit and soldering tip holder, and offers connectivity and traceability. Fully supports all IoT standards. Built-in cybersecurity.

**Weller Tools**
**weller-tools.com**

# In Case You Missed It

## Cleanliness Testing

"A Gauge Study of an Intercomparison Evaluation to Implement the Use of Fine-Pitch Test Patterns for Surface Insulation Resistance (SIR) Testing of Solder Fluxes"

*Author:* Christopher Hunt, Ph.D.

*Abstract:* SIR is a recognized tool for establishing electrochemical reliability of electronic assemblies. Currently the test patterns in standards reflect coarse-pitch components. An intercomparison has been completed with the aim of establishing the introduction of a fine-pitch SIR pattern with a 200µm gap. This exercise included contributions from seven international participants. This new pattern moves the test method forward into the realm of current technologies where components of this pitch are commonplace. The study reported here validates the basis for the introduction of the pattern, and confirms acceptable gauge R&R for the SIR technique. The analysis also highlights challenges in controlling humidity to achieve comparable results among different users. The results also point to challenges in achieving acceptable gauge R&R when measuring resistances $>10^{11}\Omega$. (*Journal of Surface Mount Technology,* https://journal.smta.org/index.php/smt/article/view/24, vol. 35, no. 1, 2022)

## Solder Reliability

"Interface Embrittlement Between 63Sn-37Pb Solder and Au Layer – Part 1: Physical Metallurgy of Liquid-State and Solid-State Reactions"

*Authors:* Paul Viano, Ph.D., *et al.*

*Abstract:* This study examined the interface microstructure that developed between 63Sn37Pb (SnPb) solder and the Au protective layer that was not fully consumed during the soldering process. This scenario leads to a Au interface embrittlement failure mode that places at risk high-reliability electronics using the eutectic SnPb solder and Au protective finishes. The sessile drop test sample assessed the roles of solder thickness and solid-state aging (55°-100°C; 5-40 days). The interface microstructure began with a contiguous, secondary AuSn intermetallic compound (IMC) layer adjacent to the Au layer and an accumulation of particles that would coarsen into the primary AuSn IMC layer next to the solder. The baseline condition, established by aging for 28 days at 25°C, caused a noticeable increase of Kirkendall voids along the Au/secondary AuSn IMC interface. The following trend was observed: Kirkendall voids increased with decreasing solder thickness. The risk of catastrophic failure was high when solder thickness was<50µm; the risk was low when solder thickness was>100µm. The thick solder layer also caused Kirkendall voids to develop within the secondary AuSn IMC grain structure and extended into the primary AuSn IMC layer. However, these voids posed a low risk to solder joint integrity. The Au interface embrittlement mechanism, which results from the incomplete removal of a Au protective finish, can lead to infant mortality failures prior to, or latent failures after, the solder joint has entered service. (*Journal of Electronic Materials,* Aug. 30, 2022; https://link.springer.com/article/10.1007/s11664-022-09880-5)

## Surface Finishes

"Impact of Gold Thickness on Interfacial Evolution and Subsequent Embrittlement of Tin-Lead Solder Joints"

*Authors:* Rebecca Wheeling, *et al.*

*Abstract:* Although gold remains a preferred surface finish for components used in high-reliability electronics, rapid developments in this area have left a gap in the fundamental understanding of solder joint gold (Au) embrittlement. Furthermore, as electronic designs scale down in size, the effect of Au content is not well understood on increasingly smaller solder interconnections. As a result, previous findings may have limited applicability. The current study focused on addressing these gaps by investigating the interfacial microstructure that evolves in eutectic SnPb solder joints as a function of Au layer thickness. Those findings were correlated to the mechanical performance of the solder joints. Increasing the initial Au concentration decreased the mechanical strength of a joint, but only to a limited degree. Kirkendall voids were the primary contributor to low-strength joints, while brittle fracture within the intermetallic compounds (IMC) layers is less of a factor. The Au embrittlement mechanism appears to be self-limiting, but only once mechanical integrity is degraded. Sufficient void evolution prevents continued diffusion from the remaining Au. (*Journal of Electronic Materials,* Sept. 20, 2022; https://link.springer.com/article/10.1007/s11664-022-09891-2)

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