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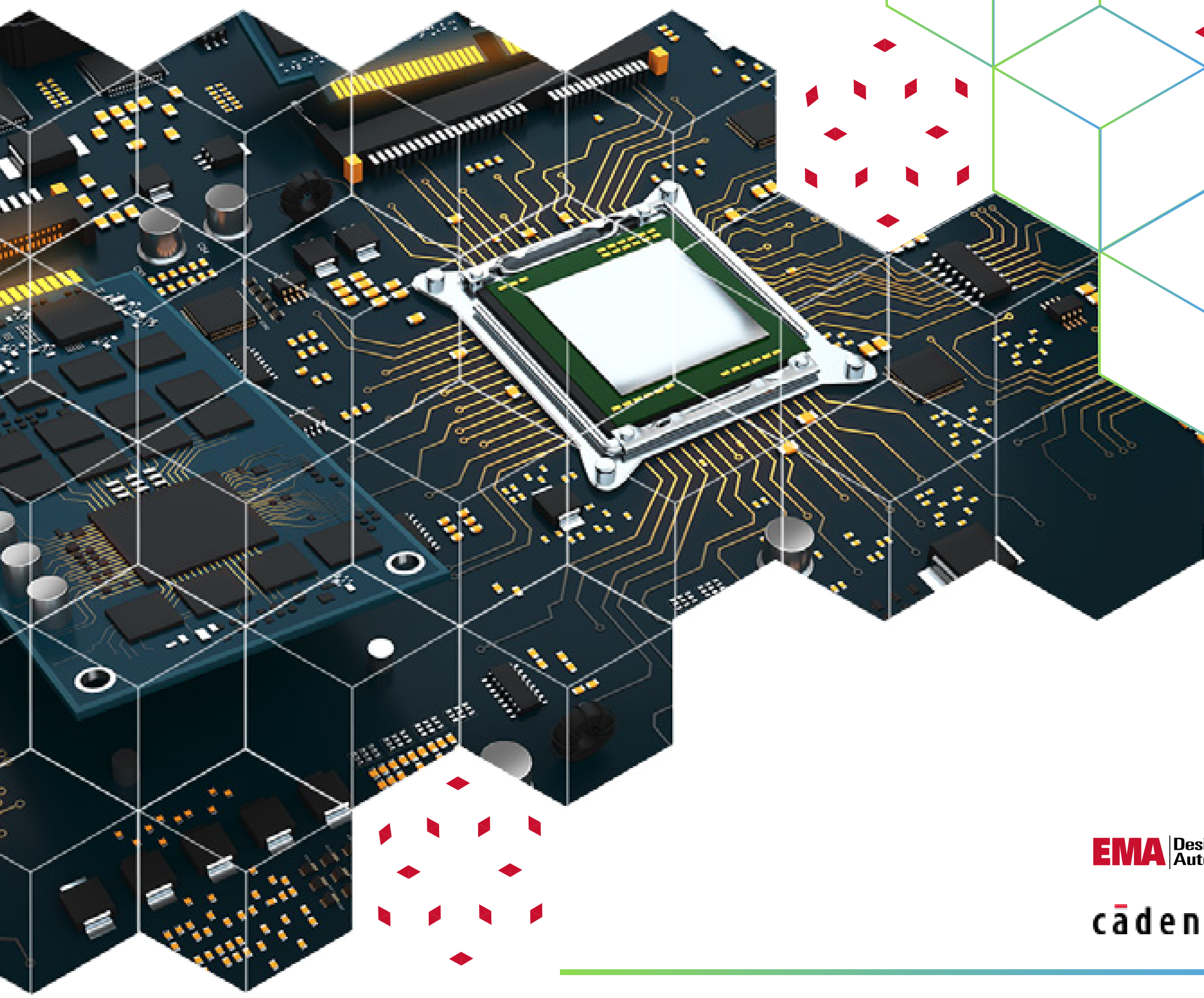
October 2021

AOI Goes LIGHTS OUT

- Designing with 008004s
- Solder/Surface Finish Interactions
- Solder Mask on Flex



OCTOBER 2021 • VOL. 38 • NO. 10

PRINTED CIRCUIT DESIGN & FAB CIRCUITS ASSEMBLY

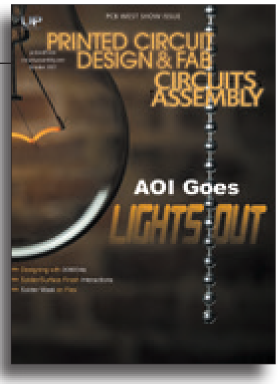
FIRST PERSON

MONEY MATTERS

TECH TALK

DEPARTMENTS

FEATURES



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BUETOW
**EDITOR-
IN-CHIEF**

Making Progress

I ONCE HEARD the actor Tom Hanks – probably the first time he's been referenced in these pages – describe a brain game he plays with friends. The challenge, he explained, is to define a concept in as few words as possible. The example he offered was "time," which he characterized as "progress."

Now, it's easy to find physical and historical examples that disprove Mr. Hanks' conceptualization.

More than a few readers probably studied physics in high school or college. Einstein's relativity theory of time, of course, states that time changes depending on your frame of reference, and that the faster you travel the slower time moves.

And the ecologist and author Jared Diamond argues that there's evidence some populations such as Austronesians began to use metal tools – an obvious improvement over rocks and bare hands – only to later shed them.

Much, much earlier, the Greek philosopher Aristotle surmised that change is distinct from time because change occurs at different rates, whereas time does not.

Where these ideas converge, however, is around the notion that progress means change.

Design engineers today have access to so many materials, final finishes and solder masks (see Nick Koop's column starting on pg. 26), and components (assuming they are in stock, which is a big assumption right now). There is this sense they sometimes look at all these choices as plug-and-play items, whereas any worthwhile manufacturer will tell them that's not the case at all.

It's almost like building with Legos: You could stick your hand in the bucket and attach whatever piece comes out to your creation. But, when you step back and look at the finished product, it probably will not be what you planned.

Too many engineers I come in contact with seem stuck in their ways of doing things. This seems especially true for those working at large companies. Whereas bigger enterprises in theory have more resources to explore new concepts, somewhat paradoxically they often come across as less open to doing so.

When in doubt, these engineers defer to the component data sheet. It might not conform to consensus industry standards; indeed, it probably won't. But it's the safe choice, or so they think. Then the design gets held up at fabrication or assembly because the design doesn't match the master drawing callout to use, say, the relevant IPC standard, and the project grinds unnecessarily to a halt.

To paraphrase a well-worn cliché, man can't live by data sheet alone. And perhaps the best way to stretch your thinking is to engage others in the same industry but outside your company.

I see companies like Tempo Automation turning the concept of design to assembly on its head. If you can make money building circuit boards in San Francisco, you can do so anywhere.

Then I hear about other manufacturers that haven't even introduced factory-level software in their plants, instead using manual inputs. What?!? How long will you be able to compete that way? Do you believe workers of tomorrow aspire to repetitive keystroking?

The world is changing and getting younger. Smart companies are leveraging the knowledge of others, and sometimes more than that, to remake the industry in their image. Are you ready for that?

How do you measure progress (change)? Are you making progress? In your career? In your life? And if not, do you plan to start?

mbuetow@upmediagroup.com
@mikebuetow

P.S. See us this month at PCB West at the Santa Clara Convention Center and next month at SMTAI in Minneapolis.

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

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PCDF People

Altair named **Harry Kennedy** technical specialist, electronic system design.

Out of the Box Manufacturing named **Mark Thompson** engineering manager.

PCDF Briefs

Additive Circuits Technologies completed its acquisition of **Bench 2 Bench Technologies,** a Fullerton, CA-based flexible circuit board manufacturer.

AGC Multi Material America named **Tritek Circuit Products** West Coast distributor.

Cerebras Systems, builder of the world's largest computer chip, has now developed technology that lets a cluster of those chips run AI models that are more than a hundred times bigger than the largest ones today.

Element Solutions has closed its previously announced acquisition of **Coventya Holding.** Coventya joins **MacDermid Enthone Industrial Solutions.**

Fair-Rite Products is the first **Altium** partner to launch Nexar's GP&A embed on its website.

Holders Technology's UK and German subsidiaries have agreed to sell certain PCB assets for €1.9 million ($2.2 million).

IMI Inc. installed a **Keyence** VHX-970 digital microscope with VH-ZST zoom lens.

NCAB Group in September signed an agreement to acquire 100% of the shares in **RedBoard Circuits.** RedBoard has five employees, and 2021 revenue is estimated to reach approximately $5 million. No financial terms were disclosed.

Rush PCB announced the release of a new platform for buying PCBs.

Sanaya Environmental Services has completed its previously announced acquisition of PCB fabricator **CPH** for S$22 million ($16.1 million).

Win Semiconductors plans to spend $76 million to increase its stake in copper-clad laminate manufacturer **Iteq,** with the intent to expand the firms' partnership for 5G and autonomous vehicles, according to reports.

CA People

Axiom Electronics promoted **Rob Rowland** to director of engineering.

Honeywell named **Brian Lau** director of business development.

HP named **Hames McCall** chief sustainability officer.

Javad EMS announced **Arturo Castillo** as business development manager.

Pending Defense Appropriations Bill Includes Anti-China Provision

WASHINGTON, DC – The US House Armed Services Committee in September voted overwhelmingly in favor of the National Defense Authorization Act (NDAA) for Fiscal Year 2022, which includes tighter language over sourcing of printed circuit boards from adversarial nations.

The committee passed the annual defense appropriations bill, also known as H.R. 4350, by a 57-2 margin on Sept. 2. The $744 billion bill includes a provision for improved printed circuit board supply chains. It tightens restrictions on the acquisition of certain printed circuit boards for which supply chains may be susceptible to interference by the Chinese government and directs the Secretary of Defense to investigate whether to extend the prohibition to other uses.

"The Secretary [of Defense] shall use the report to determine whether any systems (other than defense security systems (as defined in section 2533d(c) of title 10, United States 16 Code)) or other types of printed circuit boards should be subject to the prohibition in section 18 2533d(a) of title 10, United States Code.

"These provisions will reduce supply chain risk in critical defense systems, and will encourage development of reliable, effective, and efficient sources of printed circuit board technology in the United States and its allies and partners," the NDAA summary says. (MB)

Consortium Investigates Warpage, Die Shift in Large-Format Reconfigured Panels

BERLIN – The second incarnation of a panel level packaging consortium, PLC 2.0, investigated warpage and die shift in large-format reconfigured panels (18" x 24"), and considerable progress has been made toward understanding the root causes.

The first incarnation of Panel Level Packaging Consortium (2016-19) consisted of 17 international partners from industry and focused on the entire process chain in panel-level packaging: assembly, molding, wiring, cost modeling and standardization.

With the second consortium, the focus has shifted to die placement and embedding technology for ultra-fine-line wiring down to 2µm lines and space with a potential move to 1µm. As such, migration effects and ways to exploit the migration limits of fine line wiring have become areas of interest for the consortium, whose members include Amkor, ASM, AT&S, Atotech, Corning, DuPont, Schmoll, and Showa Denko, among others.

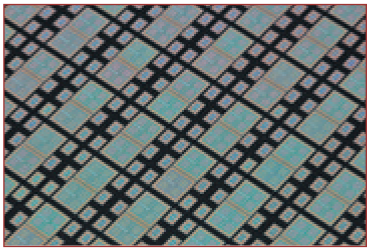
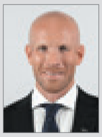


FIGURE 1. First results of PLC 2.0: Detailed view of a fully populated panel with embedded chips.

One major focus of the project has been the investigation of warpage and die shift in large-format reconfigured panels, and the group reports "considerable progress" has been made toward understanding root causes. With these insights, the relevant parameters can now be controlled better to enable large-area fine-line RDL processes. The analytical effort has paid off, as RDL could be scaled down considerably on the panel level, making the most of the advantages of both wafer and panel-level technologies and paving the way for an entirely new process chain with new equipment and materials.

The partners are now expecting 12 months of agile progress, developing and managing viable process options on the road to a complete high-yield process chain. Test vehicles for electrochemical migration tests were designed in accordance with IPC standards; the design of the test vehicles was guided by the standard's description of the IPC multi-purpose test board, but with the structure sizes matched to the geometries



Kitron named **Kristoffer Asklöv** chief operating officer. He has more than 20 years' experience in electronics production and an executive MBA in leadership and management.

Libra Industries named **Joe Anderson** senior director of business development. An established global sales executive with more than 20 years in EMS, he served for 12 years as director of business development for TT Electronics.

Libra also named **Wade Henderson** vice president of business development. He started in electronics in 1990 as an engineering manager at DSC Communications, and has a bachelor's in engineering and an MBA.

Segue Manufacturing Services announced **James Wright** as vice president of engineering and quality.

Parallel Wireless named **Jon Saunders** senior director of operations and supply chain.

Tempo Automation named **Mattias Cedergren** chief manufacturing officer.

CA Briefs

Absolute EMS has implemented soldering to aluminum using **Averatek's** Mina chemistry.

Aeye announced a partnership with **Benchmark Electronics** to manufacture optical modules for next-gen adaptive LiDAR sensors.

AIM Solder has begun generating solar power at its Cranston, RI, facility.

Austin American Technology added **Envoy Imp. Com. e Rep. Ltda.** as distributor in Brazil.

Basil Street Pizza is partnering with **Celestica** to build its automated pizza kiosks.

Benchmark Electronics appointed **Dave Clark** senior vice president, chief procurement officer.

BEST Inc. installed an automated reballing machine for large reballing work.

Circuit Technology Center has expanded its Haverhill, MA, facility by over 10,000 sq. ft.

CMS Electronics Group installed a **Juki** G-Titan screen printer, RS-1R placement machine and an automated tray handling device.

CyberOptics received new orders valued at $1.7 million from a recurring customer for its MX3000 memory module inspection systems.

reflecting the goals of the PLC 2.0 project as interdigital structures. Researching a combination of economic and environmental assessments to promote more sustainable production approaches is another strong part of the PLC 2.0. A first model to estimate the carbon footprint of the PLP technology has already been established. This first calculation will help all members identify the most energy-intensive stages and further improve the data quality in the most relevant steps.

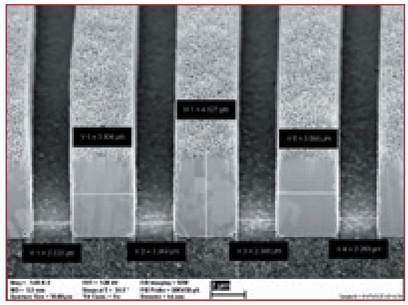


FIGURE 2. FIB cut of an ultrafine line wiring layer on panel size (pitch: 5µm).

Creation Builds with Computrol Addition

BOSTON, MA – After a long pause, Creation Technologies is back on the acquisition trail. The EMS company on Sept. 9 announced its second acquisition of the fall, acquiring Meridian, ID-based Computrol for an undisclosed amount.

In August, Creation announced plans to acquire IEC later this year.

"The addition of the Computrol team will significantly enhance our ability to serve customers. Computrol shares our values of providing exceptional customer service and outstanding quality," said Stephen P. DeFalco, chairman and CEO, Creation Technologies.

Creation said the acquisition expands its capabilities in the medium volume/high reliability segment servicing Aerospace & Defense, Medical, and Tech Industrial customers. It adds locations in Meridian, and Westminster, CO, offering seven highly automated state-of-the-art SMT lines and over 100,000 square feet of production space.

As a result of the acquisition, Creation will establish a New Product Realization Center by moving its design services team from Golden, CO, to Computrol's Westminster site. The center will feature Creation's Launch with Excellence to Advanced Production (LEAP), a stage gate NPI process that improves the ability to rapidly launch new designs. (MB)

Spartronics Acquires Inovar

WILLIAMSPORT, PA – Spartronics has acquired fellow EMS Inovar for an undisclosed amount. This is Spartronics' second acquisition in the past nine months.

Inovar provides engineering, manufacturing, product assemblies and aftermarket services used by OEMs in the aerospace, defense, medical and industrial markets. It has estimated revenues between $125 million and $150 million.

"Inovar is the Rocky Mountain leader for full-service Tier 3 electronic manufacturing services," said Paul Fraipont, president and CEO, Spartronics. "It focuses on the same core market verticals as Spartronics, with a very strong position in aerospace and defense. Acquiring Inovar sharpens our focus on those core market verticals. Inovar's attractive near-shore footprint in Tecate, Mexico, complements our unique and growing offshore capability in Vietnam."

"Inovar and Spartronics have deeply aligned values, commitments and ideals toward customers and employees," said Blake Kirby, founder, Inovar. "This acquisition will provide world-class resources and a broader geographic footprint for customers, while creating opportunities for the team." (CD)

Neways Agrees to Infestos' Acquisition Bid Pending Shareholder Vote

SON, THE NETHERLANDS – Neways has agreed to be acquired by an investment firm in an all-cash deal worth approximately €177.5 million.

DarkPulse acquired EMS firm **TJM Electronics West** for $450,000 in cash.

Electronics Technicians purchased a new reflow oven, upgraded **Europlacer** feeders, and board conveying and handling equipment.

Enics is expanding its high-volume manufacturing site in Suzhou by 50% to over 22,000 sq. m.

Essemtec hired **Restronics** as manufacturers' representative in Florida.

Foxconn and **Stellantis** announced a joint venture called Mobile Drive, which focuses on making a "smart cockpit" for vehicles that will feature navigation, voice assistance and payment services.

iNEMI is holding a call-for-participation webinar Oct. 13 and 14 for its new project on artificial intelligence enhancement to AOI for printed circuit assemblies.

ITW EAE moved its Germany sales and customer support offices from Dreieich to Alzenau.

Kasdon Electronics has moved into a new 20,000 sq. ft. EMS factory in Willenhall, West Midlands, UK.

Kimball Electronics debuted Kimball Medical Solutions.

NOTE has signed a partnership agreement to manufacture **Ferroamp's** EnergyHub energy storage system.

Optiemus is expected to invest some $200 million to ramp electronics manufacturing of smartphones and laptops with **Wistron** over the next three to five years, with the partnership generating over $5 billion within five years.

Samsung will invest $206 billion in the next three years to expand its footprint in artificial intelligence, semiconductors and robotics, among other areas.

Scanfil plans to expand its factory in Suzhou, with an estimated investment of €6 million to more than double production space. The company expects to start construction in 2022.

Sierra Circuits has installed five Seica flying probe test systems for its new facility in San Jose.

Thermaltronics opened a second facility in the US, this one in Florida.

The **US Department of Defense** has signed into effect updated guidance for the procurement and operation of its Unmanned Aircraft Systems (UAS), allowing the DoD to take advantage of technological advancements in the commercial market and reaffirming the department's recognition that certain foreign-made commercial UAS pose a threat to US national security.

Virginia Tech is set to break ground Sept. 14 on the first building for its $1 billion Innovation Campus in Alexandria, including a $10 million center for artificial intelligence and data analytics and an electronics assembly space.

Volex has acquired **Irvine Electronics** for $16.4 million.

Z-Axis added an **Austin American Technology** HydroJet inline cleaning system.

Since late June, Infestos has had a standing offer of €14.55 in cash for all issued and outstanding ordinary shares in Neways, a premium of about 33.5% over Neways' closing price on Apr. 29, and a premium of 65% over the average daily volume weighted price for the six months prior to that date.

Neways' management board and supervisory board said in a statement they fully support the transaction and unanimously recommend the deal to shareholders. A shareholder vote will take place this month.

The offer is subject to certain conditions, including a minimum acceptance level of 60% of the shares, or such lower amount as determined by Infestos in consultation with the boards but with a minimum of 50.01% of the shares.

Infestos, which holds 8.4% of Neways' shares, said it has commitments from other shareholders totaling 50.17% of the shares needed to approve the deal.

The companies jointly said the deal would result in no material reorganizations or restructuring.

Neways has been the object of acquisition bids all summer, as VDL Group and Infestos went back and forth with bids for the EMS firm. VDL pulled its €13.00 per share bid in early July, leaving the door open to Infestos to complete the transaction. Still, VDL holds a 27.6% stake in Neways, which could complicate closing the deal. (MB)

NCMS Publishes Report Analyzing Digital PLM Implementation

ANN ARBOR, MI — The National Center for Manufacturing Sciences published a report featuring analysis for successful digital product lifecycle management implementation, covering insight from years of collaborating with government and industry partners to determine a more cost-effective way to launch specific PLM processes, which can enable small- and medium-sized companies to make the leap. The nonprofit manufacturing consortium has developed a commercial off-the-shelf solution: PLM-in-a-Box–Early Acquisition Edition, which focuses on the needs of the government partners.

Through a series of test projects, NCMS has worked with government partners who wanted their logistics and engineering communities to have a standardized, integrated method of accessing product lifecycle information for their larger assets. They wanted to focus on developing a PLM solution that could manage configuration control and synchronize successive changes in PLI.

The method of introducing a PLM system has been demonstrated to improve upstream acquisition activities and downstream sustainment engineering processes, which have resulted in improved supply chain and maintenance customer support. The test projects showed introducing a PLM gradually is a cost-effective way to begin gaining the advantages of a digital PLM system.

"Significant work is being done by industry, the government and NCMS to create and improve technological advances," said Pam Hurt, vice president for Business Capture, Communications and Partnership, NCMS. "Making these advances visible and available to a wider audience is the purpose of the NCMS Technology Brief series. Our hope is collectively we can build on what has already been accomplished, strengthen the US manufacturing industry and continue to successfully compete globally."

To read the document, visit www.ncms.org/evolving-strategies-for-initiating-product-lifecycle-management-. (CD)

Hot Takes

- **Smartphone shipments** are expected to grow 7.4% in 2021, reaching 1.37 billion units, followed by 3.4% growth in 2022 and 2023, respectively. (IDC)
- **The US PC market** grew 17% year-over-year in the second quarter, with total shipments of desktops, notebooks, tablets and workstations reaching 37 million units. (Canalys)
- **Worldwide PC shipments** are expected to grow 14% to 347 million units in 2021. Tablet shipments are expected to grow 3.4%. (IDC)
- **DRAM suppliers'** second quarter revenue reached $24.1 billion, up 26% sequentially. (TrendForce)
- **Global wearables shipments** grew 32% year-over-year as volumes reached 114.2 million during the second quarter. (IDC)
- **Total North American EMS shipments** in July were down 2.9% year-over-year. Sequentially, July shipments fell 26%. EMS orders rose 1.7% compared to July 2020 but dropped 31% compared to June 2021. (IPC)
- **Both Intel and Infineon** have cautioned that the semiconductor shortage may persist throughout all of 2022.
- **The global semiconductor packaging market** is expected to reach $60.4 billion by 2030, a CAGR of 9.1% from 2021 to 2030. (Allied Market Research)
- **Worldwide server market revenue** declined 2.5% year-over-year to $23.6 billion during the second quarter on a 0.1% increase in shipments. (IDC)
- **The Confederation of Indian Industry (CII),** Coimbatore, says Tamil Nadu, India, is looking at $40 billion worth of electronics manufacturing in the state by 2025, and Coimbatore should capture at least 30% of it. (CII)
- **The cooling of electronics components sales** is expected to moderate in September and through the end of 2021. (ECIA)
- **Electronic skin patch revenue** will top $30 billion by 2031. (IDTechEx)

Taiwan Sees Major H1 Uptick in PCB Sales

Despite concerns over national sovereignty, the business relationship between Taiwan and China remains robust. Taiwan-based PCB fabricators saw year-to-date revenues rise 19% year-over-year through June to NT$356 billion ($12.9 billion), its highest collective first-half showing, and expect growth to continue throughout the year, reaching an estimated annual output of NT$773.8 billion ($27.9 billion). That's according to the TPCA, which noted some plants in Taiwan are at 100% of production capacity, and seeking new factories on the island.

TPCA said the growth has been broad-based, with higher demand for IC substrates, multilayer boards, single- and double-sided boards, HDI and flex circuits. End-markets including tablets, PCs, automotive, servers and Netcom products are driving growth.

The only segment to slow, TPCA said, is rigid-flex, mainly because of end-product changes such as Apple's wireless Bluetooth headset, which now features a SiP design, and its battery module board, which is now all flex.

LOOKING GOOD

Trends in the US electronics equipment market (shipments only)	% CHANGE MAY	JUN.	JUL.	YTD%
Computers and electronics products	-0.6	-0.1	0.4	7.5
Computers	0.4	-0.4	0.7	3.4
Storage devices	5.5	-0.7	-1.8	32.7
Other peripheral equipment	-9.8	-6.8	6.5	8.0
Nondefense communications equipment	0.7	0.8	0.2	11.7
Defense communications equipment	5.1	3.9	0.0	3.9
A/V equipment	6.4	-12.9	10.3	-2.0
Components[1]	-1.8	0.0	2.0	6.5
Nondefense search and navigation equipment	-3.0	1.7	0.8	2.0
Defense search and navigation equipment	-1.6	0.4	1.2	2.8
Medical, measurement and control	-0.6	-0.3	-0.5	8.2

rRevised. *Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: U.S. Department of Commerce Census Bureau, Sept. 2, 2021

KEY COMPONENTS

	MAR.	APR.	MAY	JUN.	JUL.
Semiconductor equipment billings[1]	47.9%	50.3%	53.1%	59.2%r	49.8%p
Semiconductors[2]	17.8%	21.8%	26.2%	29.2%r	29%p
PCBs[3] (North America)	1.22	1.16	1.11	1.15	1.29
Computers/electronic products[4]	5.18	5.18	5.29	5.26r	5.25p

Sources: [1]SEMI, [2]SIA (3-month moving average growth), [3]IPC, [4]Census Bureau, ppreliminary, rrevised

US MANUFACTURING INDICES

	APR.	MAY	JUN.	JUL.	AUG.
PMI	60.7	61.2	60.6	59.5	59.9
New orders	64.3	67.0	66.0	64.9	66.7
Production	62.5	58.5	60.8	58.4	60.0
Inventories	46.5	50.8	51.1	48.9	54.2
Customer inventories	28.4	28.0	30.8	25.0	30.2
Backlogs	68.2	70.6	64.5	65.0	68.2

Source: Institute for Supply Management, Sept. 1, 2021

Redefining Craftsmanship

Today's builders have data analytics skills that match their manual dexterity.

SOMETIMES YOU SEE things a hundred times or more before it hits you the image presented does not match the message it intended to convey.

Case in point: A common television ad of late for a fairly high-tech product. The message was about the quality that goes into "making" these devices. So far, so good. But the ad fades to a man decked in a flannel shirt, blue jeans and the obligatory well-groomed beard, eyeing with pride some woodworking project. I get it: Pride in workmanship. The skilled craftsman produces a fine item. The message and imagery are ageless. One problem, though: That's not how it goes!

It's been decades since I purchased an item that is not the result of vigorous, data-driven engineering, followed by a slew of process, manufacturing, quality, and even finance folks obsessed with the analyses, measurement, inspection and costing of every piece of anything that gets even close to the product. While I'd like to think some flannel-shirted woodworker hand-built a device, the reality is data, and more data, and a little data on top of that, are what it takes to turn a concept into a successful product.

Our industry may be the poster child for how craftsmanship continues to evolve. Time was, the operator was the sole process expert who could impact how a circuit board would be plated, or how tight the registration was. Now, equipment with sensors, computers, and vision systems unimaginable a few years ago are not just performing processing steps but also providing data to process engineering and machines up- and downstream to improve throughput and yield. Quality today has more to do with data "nerds" than the lone craftsman. Yes, we still need and value individual skills, and – make no mistake – fabricating or populating a circuit board continues to require dedicated, quality-conscious skilled labor. But the ratio of skilled labor touching product vs. staff with analytics skills collecting and deciphering data to improve efficiency and quality throughput has shifted.

In all industries, the goal is to design and produce high-quality, leading-edge products. Everyone wants to believe their product represents the best in craftsmanship, but maybe it's time to redefine craftsmanship. I doubt that woodworker in the advertisement ever had a slew of people grill him on how much wood, varnish, paint and supplies were used per piece. No one ever asked that woodworker for a complete accounting of time spent in design, fabrication and assembly. Yet, each of those metrics is critical for the new benchmarks of craftsmanship.

Craftsmanship, by definition, is the quality of design and work of something that is made. Many, if not most, associate the term only with the work, not the design, and assume it means work done only by hand. Well, hands do operate complex machines, and hands do enable the collection and sharing of data in collaboration to improve quality and achieve the desired design. A craftsman needs to use the best available information to accomplish the goal.

Over and over, we hear the importance of measurement, and in every company across the globe, measurement is the tool of choice to ensure product is built to the highest quality. Measuring time, pieces, costs, overhead – and scrap (!): That's the start of the craftsman's database. Analyses, performed rapidly via artificial intelligence or through methodical review by trained staff, enable improvements and solutions to problems.

The technology available today is amazing compared to what was available in the past, and in many ways contributes to the redefinition of craftsmanship. The days when every task was done by hand, and hardware the only type of tool available, are long behind us. The craftsmen of today are not tied to tools of the past, nor are they intimidated by new technology, but instead rise to the challenge of harnessing the best available technology or tool to provide the instantaneous feedback necessary to build quality product. A craftsman is someone who takes that instantaneous feedback, translates it, and communicates or applies it as needed.

Some things have not changed. Pride and dedication remain the bedrocks of craftsmanship. Employees, be they on the shop floor or in the back offices or at final inspection, must be dedicated to continuous improvement and take pride in their work. Dedication and pride can be difficult to muster in an environment where the product, quality expectations and tools are constantly changing and when processes and components are constantly revised. Like every generation of worker who has strived for quality and being the best, however, the tools, parts and processes always evolve in a way that rewards those who are really craftsmen.

Maybe it's time we think of craftsmanship in a more contemporary way. Circuit boards still need to be drilled, imaged, pressed, plated, depanelized, and inspected. Being a craftsman is not just about those processes, however. It includes the technology, equipment and analysis to make those pieces of equipment do more, faster and better. Being a craftsman today includes data analysis, programming, and making sure reports, certifications and final inspections receive the attention and pride that go into building product. Only together is there true contemporary craftsmanship. □

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

Making a Good Business Case When Delivering Bad News

The wrong attitude can send customers shopping for a new EMS provider.

I FREQUENTLY SAY program management is the most difficult job in the electronics manufacturing services (EMS) industry. Program managers play a dual role of their customers' champions within their organization and their employer's enforcer to ensure each account hits its revenue and profit targets. I see great similarities between PMs and airline gate agents, for whom getting customers where they need to go is often impeded by forces outside an agent's control.

If we use that gate agent analogy to describe the program manager's dilemma in today's chaotic materials situation, the plane is running four hours late; the passengers who were loaded an hour ago now need to be told the crew needs to deplane because they've exceeded their legal flight time limits, and there are no alternate flights because a bad storm has shut down the entire East Coast. The state of imbalance between supply and demand in today's materials market is so bad, the issue isn't whether customers will be disappointed but how badly they will be disappointed. Program managers are the point people in delivering that bad news.

The silver lining, as it were, is everyone is experiencing these challenges. It isn't just the small EMS firms or ones that specialize in certain industries. Material is becoming so constrained even brokers are failing to deliver. The gate agent analogy can be helpful to keep program managers on track about the best approach to this challenge. Anyone who flies a lot knows there are two types of gate agents. The first type hates bad flying days and depends on the structure of the job to insulate themselves from angry passengers. They make gate announcements discussing delays as infrequently as possible. They respond to questions by saying nothing can be done about the situation. When a late plane is ready to board, they handle the boarding process exactly as they would an on-time plane.

The second type of gate agent puts themselves in their passengers' place. They share information as they get it, help delayed passengers with information on their options, even when there are none, and work in tandem with the flight crew to speed the boarding process. Which agent do you want at your gate on a bad travel day?

In short, even when the situation is completely out of the program manager's control, it is important that customers see a program manager who is committed to doing their best to mitigate issues that negatively impact each program. People trust those who appear to be trying much more than those who demonstrate in words and actions that the situation is hopeless.

What is the best way to communicate the current situation?

- Be transparent. Understand what your company can and can't do relative to each customer's constrained components. Be candid. Share bad news immediately.
- Be proactive. Analyze each customer's program for current and near-term risks and present them with your assessment. Update it regularly. Many EMS providers are developing customized reporting to make this easier.
- Coach. Discuss options for lengthening forecasts, choosing alternates or setting a range for PPV. The current situation requires a higher degree of collaboration and visibility in demand trends in the coming year.
- Build a business case. Most customers understand costs are increasing across the board. It is customer nature to push back on price increases, however. When price increases are necessary, be able to discuss the underlying drivers.
- Be knowledgeable. What is your company doing to level the playing field? Be able to discuss those efforts.
- Understand the role EMS providers play in the cash conversion cycle. Like it or not, many domestic EMS providers fulfill the role of a bank for their customers by absorbing inventory and manufacturing costs during production cycle and permitting the customer to pay a month or more after they've received products. The margins for this are thin compared with those

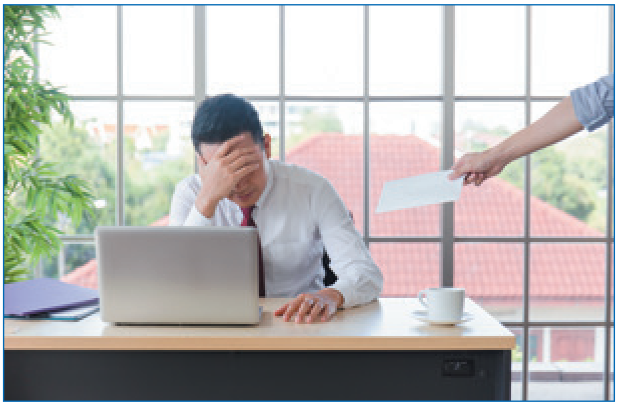


FIGURE 1. Be transparent, and share bad news immediately.

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.

most OEMs enjoy. When higher levels of inventory must be held, there needs to be cost sharing. Be able to walk the customer through that added part of the value equation because the ones who measure cost per placement on a spreadsheet as part of their outsourcing model don't understand it.

- **Document everything in writing.** EMS companies are holding more inventory than usual to hedge against supplier decommits. That could translate to excess inventory if the market normalizes, demand drops, or a product line is discontinued or redesigned. Document every conversation that involves buying long lead-time items beyond contractual terms, acceptance of price variance, use of nonauthorized resellers or increasing either raw material or finished goods Kanban. Customer memories get short when there is excess material or a market downturn.

> "ANALYZE EACH CUSTOMER'S PROGRAM FOR CURRENT AND NEAR-TERM RISKS AND PRESENT THEM WITH YOUR ASSESSMENT."

- **Be prepared for a rant.** Sometimes letting a frustrated person vent is the best way to calm them down. Keep emotions in check and you'll control the outcome of the conversation. Respond in kind and nothing will get resolved.
- **Stay optimistic.** All cycles eventually end. Things will improve. Program manager optimism that all options are being explored keeps customers, particularly if efforts result in even small successes. An attitude that nothing can be done tells customers they have nothing to lose by shopping for a new EMS provider.

There is no question that the program manager job became a lot harder in 2021. That said, the skills set developed in times like these is seldom replicated in less challenging times. It doesn't just build great program managers. It builds people capable of moving up to higher levels in the EMS industry. Chaos creates opportunity. ❑

Microvias: An Answer to the High-Density Blues

Pros and cons – and costs.

IT'S ALMOST INEVITABLE that a component that works well and lasts a long time will eventually be put on a list of parts not to be specified for mass production. Newer, better parts are on the way. The thinking goes that the microcontrollers and other devices on a board are already fine-pitch, so another one can be accommodated. That's how we end up with those five-pin regulators with a tiny diamond-shaped pin trapped between four beveled rectangles.

Advantage: Component-to-component spacing. The via-in-pad trick enables high component density by enabling routing that is 100% internal to the board, with no exposed traces. The space normally set aside for the fan-out via can be used for the next component with the following stipulations:

- Test access is maintained
- Rework clearance (for desoldering)
- Electrical isolation (shielding)
- Thermal considerations (heat sink, heat pipe)
- Mechanical interference (headroom)
- Pick-and-place accuracy.

Within the above parameters, placement can be as tight as a jigsaw puzzle. Placement of discrete SMD components can get very cozy. When it comes to the smallest chip caps and resistors, a solder dam between their respective pads is sufficient space. This assumes the body of the part resides within the limits of the pads, as is typical of micro-caps. I normally recommend a solder mask dam with a minimum width of 100µm (4 mils). That said, 75µm is the new 100 as far as trends go among the fabricators putting down a solder dam.

An ancillary benefit of the via-in-pad method is shorter inductive loops of the decoupling capacitors as we skip the fan-out segments. Intuitively, the cap placement should create a bridge between a power pin and a local ground pin. In some applications, the exact pin-pair matters. Even if that information is in the relevant app notes, it is helpful to capture those types of provisions on the schematic diagram.

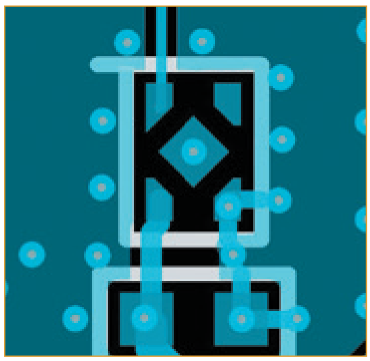


FIGURE 1. Many component types assume HDI technology will be used as a matter of course.

The most basic application of microvias. Setting the way-back machine to Y2K, the company I was working for was blazing a trail with a device package like a QFN (quad flat-pack no-lead), except it had two rings of pins around the central ground paddle instead of the usual one ring. They weren't really pins either, more like bumps spaced at 0.5mm with square pads all around.

The only escape for that inner ring was to use laser technology to form the holes from the surface copper to the layer below. The hole can be as small as desired, but the need to plate the resulting hole is the limiting factor. What works best is a hole that is wider than it is deep. The width-to-depth aspect ratio is the key to reliable plating. We want a hole with more width than depth.

As an aside, technology roadmaps are pointing toward a 1:1 ratio somewhere in the future, but right now a 0.6:1 ratio is mainstream enough to use with confidence. Meanwhile, the size of the SMD pad for the device was 300µm, so that was the designated via size. The problem we're trying to solve permits a finished hole size of 100µm when you allow for tolerance buildup.

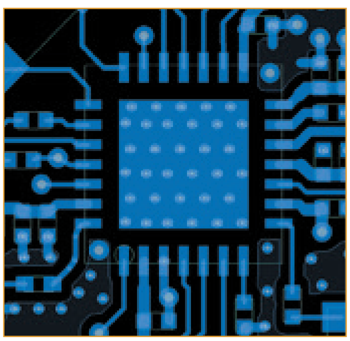


FIGURE 2. Microvias can be to get a good ground connection under hard-working parts.

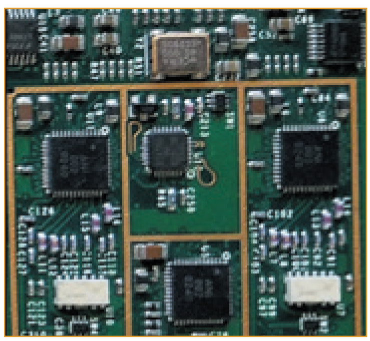


FIGURE 3. Microvias as a gateway to full HDI can be incorporated into EMI shields and QFP packages without compromising solderability.

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.

Disadvantage: Locked into thin dielectric materials. The end result is the maximum dielectric thickness we could use is 60µm due to the aspect ratio mentioned above. Note the thin prepreg materials are always in demand for the sequential buildup process. Writing paper is around 100µm in thickness. This material is half that and integral to the whole HDI technology solution.

A four-layer board using microvias will have a thick middle layer between layers 2 and 3 to create sufficient backbone rigidity. This leaves an asymmetric Faraday cage where layer 2 routing is closer to layer 1 than to layer 3. The better impedance calculators will have an option for this type of innerlayer routing.

The downside is trace impedance is a function of dielectric thickness. A rule of thumb is a 50Ω line width correlates with the dielectric thickness. The trace width is about the same as the dielectric thickness. The dielectric constant, copper thickness and presence of solder mask all play a part in the actual impedance calculations. It would be an elite vendor that could produce line widths in this range, especially on the outer layers.

Getting away from those lossy 60µm lines can be achieved by creating voids in the layer immediately below the transmission line. Then, a top-layer trace would use layer 3 for a reference plane. Observing the not-unusual-for-analog idea of making the trace width match pad size, the reference plane can be as far down as you like. This advice is mainly about the type of trace you would only route on an outer layer in the first place. Designing RF amplifiers is a thing unto itself.

The microvia as a thermal path. One of the best uses of the microvia from the outer layer to the first innerlayer is in the middle of a QFP type of package where a big ground pin is in the center of the package. It doesn't require much special handling to implement via-in-pad technology. The surface finish should be upgraded to electroless nickel/immersion gold (ENIG) to get flatter SMT pads that give better yields in assembly.

Adding vias to SMT pins should not alter the geometry of the original pin. Completely inside or outside of the pad rather than straddling the edge will make soldering more consistent. The fab notes should mention something about the maximum depth of dimples in the pad due to the via-in-pad. So-called "flat pad" technology might be a good keyword in your notes.

So, there you go. Microvias can tighten placement, shorten inductive loops, escape from "inescapable"

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Interaction: Cure for Industry Contraction

Back in the trade show swing.

IT SEEMS THE electronics trade show industry had been shrinking the past year only to swell with a sudden, extreme realization venues are opening and plans that went dormant last year are coming back to life. August provided a swell of relief in the form of DesignCon. DesignCon was held Aug. 16-18 at the San Jose Convention Center, and PCEA was happy to participate with its first-ever trade show booth **(FIGURE 1)**. A special nod from the PCEA executive staff to Eriko Yamato, our events coordinator, on design, coordination and delivery of our booth and some very special giveaway t-shirts for show attendees. Michael Creeden, PCEA vice chairman and treasurer/coordinator of our PCEA sponsors manned the booth throughout the show, with help from PCEA media coordinator Tara Dunn **(FIGURE 2)**. Mike reports that while the show numbers seemed down a bit, the show had the spirit of a family reunion, and quite a few attendees were interested in hearing about the value of joining PCEA.

Message from the Chairman

by Stephen Chavez, MIT, CID+

As I closed out my weekly "Post-It Notes" of action items, I noticed many of them are regarding PCEA. One common theme that puts a huge smile on my face is that PCEA is active and alive within the industry. Here are a few reasons I'm ending the week on a high note:

- PCEA had its first major physical presence (booth) at an industry conference, DesignCon 2021.
- The PCEA Ohio had its kickoff meeting to jump-start this new chapter.
- An industry veteran contacted me about initiating a new PCEA chapter in Texas.
- Our Education Committee is set to publicly release an official process for publishing industry technical content on our website.

And now I am looking forward to our next major event: PCEA's booth and presence at PCB West 2021! It will be my first face-to-face event since the pandemic hit the US. I can't wait to get with friends and fellow industry colleagues at this event!

As I reviewed the PCB West 2021 speaker list, I noticed several are PCEA members. I love this! Let's continue to support our fellow PCEA members and build the association at our next major event, PCB West 2021!

Warmest regards,

Steph

Next Month

As Steph mentions, our PCEA Education Committee has been hard at work crafting policies for publishing educational materials on the PCEA website and making it available to our members. Tomas Chester, our new head of the Education Committee, tells me the committee has been reviewing educational article submissions and web links to outside resources for possible posting on our website (pce-a.org), which he hopes will be an educational resource to the PCB engineering community. With some of the best minds in PCB engineering education on our PCEA Education Committee, I look forward to hearing more from Tomas and reporting on what they come up with.

FIGURE 1. Michael Creeden shows off the new PCEA trade show booth.

FIGURE 2. Michael Creeden and Tara Dunn looking forward to greeting show attendees at the PCEA booth.

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

Upcoming Events

Below is our list of upcoming events. Hope to see you at any of these!

- **PCB West 2021**
  Oct. 5-8, 2021
  Santa Clara Convention Center
  Santa Clara, CA
  www.pcbwest.com

- **SMTA International 2021**
  Nov. 1-4, 2021
  Minneapolis, MN

- **PCB Carolina 2021**
  Nov. 10, 2021
  Raleigh, NC

- **Productronica**
  Nov. 16-19, 2021
  Munich, Germany

- **IPC Apex Expo**
  Jan 22-27, 2022
  San Diego Convention Center
  San Diego, CA

- **AltiumLive 2022**
  Jan 26-28, 2022
  San Diego Convention Center
  San Diego, CA

- **PCB East 2022**
  April 11-13, 2022
  Marlborough, MA
  www.pcbeast.com

Spread the Word

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

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

Conclusion

We've been waiting for the industry to return to its robust form, once again enabling the flow of information and ideas. How great it was to experience this through our PCEA representation at DesignCon last month. Now is the time to tap the PCEA for what is coming your way. As Steph indicates, the organization is committed to trade show participation as a means to provide educational support to members. Who knows what great educational and organizational endeavors will grow from a simple booth on a show floor? I, for one, am excited to hear about any potentially historic and monumental leadership opportunities that may come about in the trade show industry as the PCEA sets up its next event right around the corner. Could we be looking forward to any big announcements? Yes, please!

See you next month or sooner! ❑

The Case of the Missing PDN Owner

With many disciplines contributing, who will manage the process?

AS TECHNOLOGY TRENDS toward smaller, faster, cheaper, the challenges around good PDN design get more difficult. With multiple requirements needed from many disciplines, the PDN's demands will only increase and become harder to maintain.

Over the past few months, we have discussed elements essential to power delivery and PDN requirements. Now that we have a better understanding of this, it's time to explore what is needed to create the ideal PDN product, and who is best equipped to bring together all the elements of the PDN.

What is a good PDN design, and how do you achieve it? Power-related design objectives tend to be similar in nature for all PCBs: to provide sufficient current at a stable voltage to each device. What does vary widely is complexity, however. Said objectives can range from simple single-supply, powering a solid power plane, to a multi-source, hot-swappable, self-monitoring, thermally sensitive, complex design that accounts for most components and a large amount of copper on the PCB. Simply put, good PDN design delivers power adequately and reliably.

Achieving this is not as simple as it sounds, however. Multiple disciplines and requirements play a role in the success of the PDN and, ultimately, product functionality. These requirements influence other design decisions and, if not considered at the right time, can be almost impossible to address as the process moves forward. The PDN, both parts and etch, typically are the most difficult to change.

PDN parts, particularly magnetics, filters and regulator-type devices often come with placement guidelines from different disciplines that can be conflicting and may ultimately need mediation. While never an advocate of the cookie-cutter approach, my advice is wherever possible to "route power first." Circulate it, review it, involve the other disciplines, and seek agreement. Use it for the canvas as you floor plan. Power problems are echoed on every signal on the rail and are a nightmare to fix.

In addition to the power delivery role, the PDN also typically carries the return current associated with the digital signals on the board. As a result, the copper shapes of the power nets are often influenced by adjacent signal routing, being reshaped to provide an uninterrupted return plane above and/or beneath routed trace. It is important to "size" the copper (i.e., define shapes and vias) based on simulated current density and voltage drop. This "best practice" can be achieved through visual inspection or with simulation tools.

Experienced design teams recognize solving power-related problems always involves "multi-physics" trade-offs, such as placing components far enough apart to permit heat to dissipate, but close enough to meet EMI requirements. This is in addition to any contributing factors that provide additional limits: for example, placing devices as close as possible for optimal signal integrity but not too close to prohibit rework.

Therefore, the PDN needs to be addressed as a system. Each individual power net, even if routed with exceptional precision, can be compromised if demands aren't properly considered. Additionally, each net in the power system must be capable of delivering adequate DC current on its own, while limiting its losses to an acceptable level (voltage drop). Individually, the nets must also be able to deliver that current not just in adequate quantity, but with the necessary responsiveness such that the voltage is stable, even to high-speed transients.

Like a plumbing system, we must ensure each pipe is sized to handle the flow. Not only does this pipe need to handle its own requirements, but it must also account for the requirements of the additional sources connected to it. To achieve our DC goal, we need to approach the PDN similarly. Therefore, before making important layout decisions, we must consider the requirements of adjacent disciplines such as thermal, EMI, mechanical constraints, safety, etc., for the best possible chance at first-pass success (as all affect PCB layout).

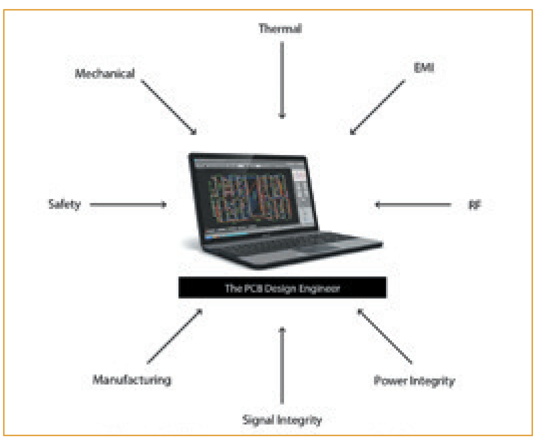
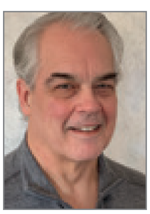


FIGURE 1. All design requirements converge at the layout.

Opportunity knocks. Everyone has a hand in the PDN, but no one owns

TERRY JERNBERG is an applications engineer with EMA Design Automation (ema-eda.com), with a focus on PCB design and simulation. He spent his early career on signal integrity simulation for the defense industry and was fundamental in the adoption of these tools at EMC and Bose. A vocal advocate for simulation, his enthusiasm for physical modeling has expanded to include power and thermal capabilities.



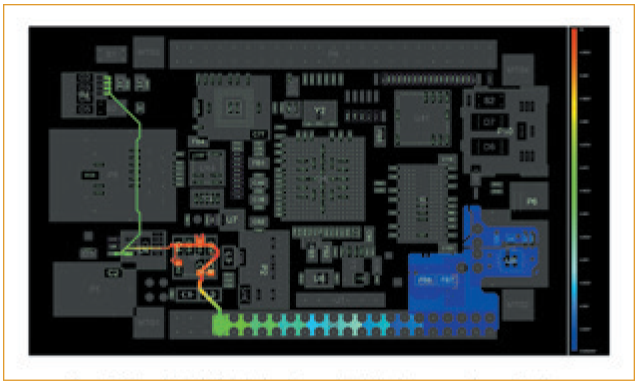


FIGURE 2. When electrical information is displayed on a board, the choices are data-driven.

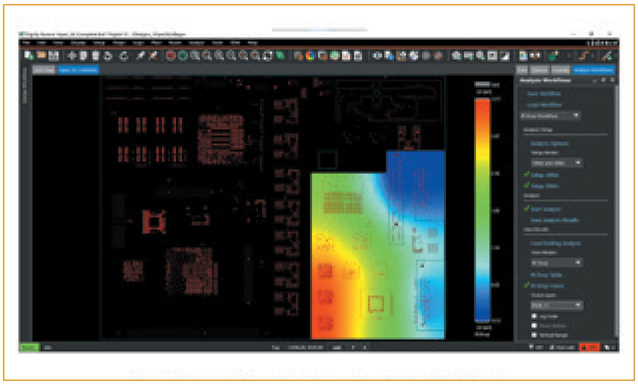


FIGURE 3. Example of power integrity used directly within the CAD tool.

it, unless you have an in-house power integrity engineer **(FIGURE 1)**. Everyone cares about their own design requirements, but no one owns how they all come together. This lack of ownership is the root of many PDN issues. Each of the disciplines involved in product development has requirements that must be met and are often determined far too late in the design cycle. For better or worse, all requirements will collide at layout.

The PCB design engineer must either meet or manage every requirement for all disciplines, making them best positioned to manage the PDN **(FIGURE 2)**. The impact of the PDN on the traditional PCB design process can enhance our ability to make informed decisions. For example, consider the task of splitting a plane to contain two distinct voltages. Now reconsider this knowing one of those nets carries nearly the full current of the power supply and the other carries but a trickle. With this knowledge, plane cuts would be different, affecting overall board performance.

Within the design process, every action has a multi-effect that needs to be balanced, and as time goes on its importance will increase. Someone needs to take on the role of managing these actions, and the PCB design engineer is the best person to do so. PCB design engineers understand how to balance design requirements with manufacturability and have the most influence over the success of the PDN. The multitude of tools available directly within the PCB canvas enables PCB design engineers to seamlessly incorporate both signal and power integrity within their design process, while minimizing time concerns.

The PDN is evolving. We must evolve with it. We've always had power, so what's different now? The PDN is evolving, and margins are shrinking. Operating voltages dropping from 1.8 to 1.5 and then 1.2 as the input current doubled for memory is a hallmark example of this evolution. As complexity increases, not having an owner increases the potential for failure.

The PCB design engineer has the most influence when it comes to ensuring good power delivery, as they control every element needed to build the PDN. The PDN is essentially a physical problem, and while it can be planned early in the design process, full definition and realization doesn't occur until PCB layout.

Most companies don't have the luxury of a designated power integrity engineer. As the needs of the PDN evolve, we must evolve with them. With the role of the electrical engineer morphing with the PCB designer, now is the ideal time to take this opportunity to incorporate power integrity with minimal disruption to the existing design process. □

Printed Circuit Engineering Professional

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Smart Manufacturing is Coming, but So Much More Could be Possible

We can make more (money) by making less (product).

ARTHUR C. CLARKE once said, "Before you become too entranced with gorgeous gadgets and mesmerizing video displays, let me remind you that information is not knowledge, knowledge is not wisdom, and wisdom is not foresight. Each grows out of the other, and we need them all."

Today, we're all familiar with gorgeous gadgets, and not only those we carry in our pockets, wear on our wrists or help us drive our cars. The factories we work in are dripping with sensors and automation, which is increasingly robotized, bringing a level of dexterity, efficiency, and reprogrammable flexibility that previous generations could only dream of.

We are fortunate to live in this period we now call the fourth industrial revolution, although we should recognize our predecessors have been working toward this for generations. It's simply human nature. Since the beginning of industrialization, people have been making analyses – of processes, end-products, and how things are done – to achieve some improvement. Often, the goal is to increase productivity and quality but also to ensure safety and reduce environmental impacts. Recently, of course, reducing pollution and energy consumption, while addressing issues like recyclability, has become increasingly important.

In the past, the sensors have been human eyes, sometimes hands or ears, and the storage has been a clipboard and paper notes or a report. The desire for smarter industry and smarter factories is not new.

Today, we are better equipped to realize it than at any time in history. Enabling all this is the incredibly diverse array of electronic sensors now available, which are affordable, known to be accurate, and provide digital outputs that are easy to record and store. We also benefit from low-cost mass storage that allows us to retain, organize and quickly access the data collected. And, of course, we have powerful computers to manipulate and analyze the vast repositories of data.

With all this at our disposal, how can we fail? Let's not forget the second part of Mr. Clarke's observation. Our powerful tools have allowed us to turn traditional data into Big Data. But this remains only the first step on the path to knowledge. And then we must turn that knowledge into wisdom and foresight – the ability to make better plans based on accurate predictions. For this, we need new skills like data engineering to be sure we capture the right data and prepare it correctly for analysis, followed by the data science and analytics needed to generate actionable insights.

These, the critical skills of the fourth industrial revolution, will take us toward truly smart manufacturing. As human workers are replaced by flexible, intelligent automation – robots are intrinsic to smart manufacturing – our future roles lie in learning how to handle the data and developing the AI algorithms that will enable smart management of equipment and processes.

We already know process capabilities must improve significantly to reach our future goals. The roadmap to advanced 5G services provides an excellent example. I remember hearing Ericsson's Stig Källman describe forthcoming demands on PCB manufacturing in a presentation to the EIPC, including the reductions in process variability needed to ensure signal performance for 5G data rates of 112Gbit/s and beyond. By 2023, tolerances for key parameters must reduce by about 50%, such as those for line width, which must reduce from ±30µm to ±12.5µm, substrate thickness (±10% to ±5%), layer-to-layer registration (±150µm to ±100µm), and impedance (±10% to ±5%).

PCB fabrication is typically batch-oriented, so the tighter tolerances required could be achieved by adopting single-piece flow manufacturing techniques, which some companies are already using. Aided by RFID technology that uniquely identifies each unit and its individual measurements and characteristics, successive fabrication processes can apply any necessary compensations and thus effectively optimize settings on a one-by-one basis to meet tighter tolerances at the end of line. It can raise yield, save corrective processes such as laser trimming, and reduce scrap.

Of course, smart processes and factories represent only one aspect of a bigger picture. We need to smart-scale the entire supply chain and throughout the enterprise to maximize the potential gains in business performance. It can also help us toward our environmental targets. It's not only about manufacturers sharing planning data with suppliers, a point I've made before. We need better tools to predict real customer demands. With this information we can use the world's resources to make the products that customers will buy and cut the waste associated with making unwanted products that do nothing more than sit on shelves. The dotcom/telecom infrastructure implosion of the early 2000s showed us how things can go badly wrong without a proper understanding of market demands and usage patterns.

Accurately predicting end-user market demands

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

What Kind of Solder Mask is Used on Flexible Circuits?

First differentiate between rigid-flex and true flex.

AS IS OFTEN the case with flex circuits, knowing which solder mask to use on flexible circuits is somewhat of a trick question, one with several answers. The decision boils down to circuit construction and design intent.

To start, there are several ways to insulate circuits in the flex world. These include solder mask, coverlay and coverfilm. In most cases, the designer may simply note solder mask per IPC-SM-840 and leave the rest to the fabricator. This allows the fabricator to use the proper mask in the proper setting.

When making a design decision, first differentiate between rigid-flex and true flex circuits.

Let's cover the easiest one first: rigid-flex. Typically, a rigid-flex construction will have solder mask applied to the external rigid layers to insulate all external traces, as well as define surface mount or BGA pads. It may also provide mask dams between pads to reduce the potential of solder shorts at assembly. This solder mask usually is classified under IPC-SM-840 as a type H solder mask, which denotes a high-reliability solder mask. These are the most common solder masks. Normally green in color, they can be modified for other colors, as desired. It is worth noting that if the color deviates from the as-formulated green option, there may be feature resolution and web size tradeoffs. This is because the additives used to change the color impact how the mask material absorbs light energy during the imaging process. As a result, the fabricator may need to ask for some relief for other colors.

Typically, the flexible portion of the rigid-flex does not use solder mask. The flex will use coverlay/coverfilm material, usually per IPC-4203. This is a laminated material completely covering the flex region of a rigid-flex. In some cases, openings in the flex coverlay expose solderable pads or edge connector traces, like a ZIF (zero-insertion force) connector pattern.

For "pure" flex circuits, that is, one- or two-layer or multilayer flexes, the decision gets a bit cloudier. All options are now on the table.

It is still most common for flexible circuits to use coverlay over the outer layers of a flex circuit. This is usually the default on all Class 3 applications, as well as any high-voltage applications. Coverlay material provides the highest level of dielectric strength, as well as flex endurance. It also is more rugged than solder mask. The overall thickness ranges from 0.001" (25µm) to over 0.006" (150µm). The adhesive thickness on the coverlayer material is selected to ensure complete conformance over and around all the conductors.

While coverlay is very good, in some conditions solder mask can provide an advantage over coverlay. When using solder mask on a flex circuit, we need to ensure a flexible formulation is used. IPC-SM-840 defines these as type "FH." This is because standard solder mask materials are brittle and will immediately crack and chip off a flex circuit once bent. They are not formulated to be bent.

The flexible solder mask is typically green or amber in color and has the same electrical properties as standard non-flexible options.

When is solder mask preferred on a flex circuit? In many commercial applications, solder mask can provide sufficient protection while doing so at a lower total cost. The material cost is lower and the processing cycle time is shorter. Therefore, solder mask is often used in these situations.

In other cases, solder mask provides an even thinner overall coating relative to coverlay. This may be important in a very constrained design. Because it is thinner, it is then assumed the part can be bent to a tighter bend radius. This is not always true. Coverlay can withstand far tighter bend radii than solder mask, and more total bend cycles overall.

Usually, flexible solder mask is used when the radius is relatively generous and in a "bend-to-install" situation. That said, we have built applications that use flexible solder mask in a dynamic way that work just fine. In these cases, the bend radius is larger, and the angle of the bend is much less than 90°.

HDI features may also drive the need for solder mask on flex. Standard coverlayer material is a combination of film and adhesive, which is first drilled, and then laminated over the etched pattern. The adhesive in the coverlay does flow and

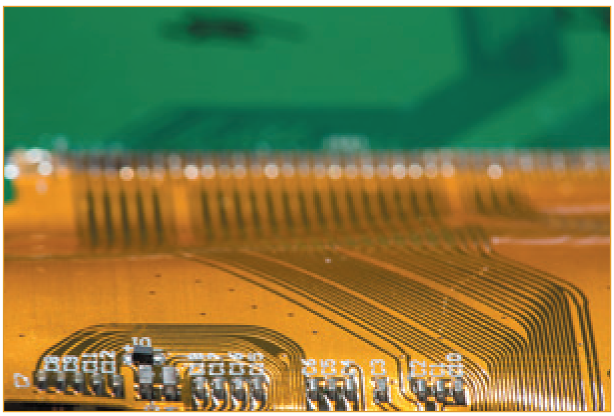
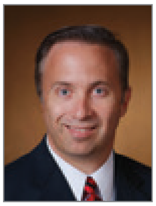


FIGURE 1. SMT on flex may require a hybrid strategy.

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



may encroach on pads. In addition, since it is drilled, openings in the coverlay can be any shape desired, provided they are round. We don't have square drill bits. This can be a problem with rectangular SMT features. In addition, a minimum of 0.010" of webbing between openings is required, which can drive the manufacturer to request large gang access openings, leaving no webs between pads. Solder mask can resolve these issues, which are becoming a driver for solder mask on flex.

What if you have a flex with SMT features that has a bending challenge too? Often a hybrid approach comes into play. In these cases, standard coverlay is first laminated in the bending regions of the part. Then, solder mask is applied in the areas with SMT patterns. The two materials overlap in areas where they meet. This provides the best of both worlds, with minimal additional cost.

An extra piece of advice: If your circuit requires a UL flammability rating, a one- or two-layer flex using adhesiveless copper-clad and solder mask may not pass UL flame testing. Adhesiveless copper-clads are inherently inflammable and thus contain no flame retardant. The flame retardant in the flexible solder mask may not be sufficient to self-extinguish. To get around this in UL applications, UL 94V0-rated adhesive-based copper-clad laminates should be coupled with flexible solder mask to meet UL flame testing.

Beyond this, additional solutions for flex can be employed for high-temperature applications, high-speed applications, and others. Your fabricator can leverage its experience to help you make the best decision for your specific design and end-use. ❑

Material Gains, continued from pg. 25

is probably the most difficult challenge of all, however. Consumers themselves often don't know what they want or need, and diverse interests – philosophical, commercial, political – are at work seeking to influence consumer behavior and buying patterns. Also, with the upheaval of the past two years, customer demand is currently a huge unknown and likely to remain that way for some time before settling down.

AI can probably give us the power to cut through the noise to capture an accurate picture, but the data science directing those AIs will be critical. By mastering it, however, we might significantly reduce our impact on the planet, making fewer things by focusing on making only the things we need. ❑

008004s: Impractical, but POSSIBLE

Realizing advanced electronics with the world's smallest packages. **by MICHAEL SCHNEIDER**

Is it worthwhile to design printed circuit boards with the smallest component package available today: the 008004? And how do you do it correctly?

Several months ago, a hardware engineer in a high-tech company that is developing virtual reality headsets approached me. "These are special glasses that can integrate into game consoles in hundreds of millions of homes worldwide," he said with excitement. "This is innovative technology that will enable a totally different viewing and gaming experience than what's available at present."

Later in the conversation, he noted they are developing a common electronic circuit board for a project that, after successful programming, has been proved by means of an evaluation board.

On the surface it seems promising. He then qualified their progress, however, adding that because this circuit board has a wide range of applications but a very small footprint, there is no room on the board to place all the needed components. After I received the technical details of the circuit board and parts list, I understood the possibility of building this assembly, provided we use the smallest component package. This is a component with dimensions of quarter of a millimeter by an eighth of a millimeter, known in the industry as an 008004.

Use of electronics over recent years has expanded into a range of applications and accessories. Mobile accessories popping up in every corner and interest in turning inanimate products into communicative ones (e.g., the Internet of Things) are forcing an increasing need for more electronic functionality in a smaller area. Producing smaller components as a means to meet this challenge is insufficient. The dependency and relationship among the printed circuit board (PCB), materials and production processes require in-depth analysis of soldering processes and the points of failure while in the planning stage. Producers and planners of these components more than ever must closely cooperate to find creative and efficient solutions.

Maximum Functionality, Minimum Area

The 008004 started to appear in serial production about three years ago. The new package is half the area of an 01005 and therefore enables significant savings on the circuit board **(FIGURE 1)**. These components, which for the most part are passives (resistors, capacitors), have particularly small dimensions and weights. The component is invisible to the human eye, and its dimensions are 0.25mm (length) by 0.125mm (width). The height is typically 0.125mm. The distance between the component pads is 0.115mm, and its weight is approximately 0.02mg.

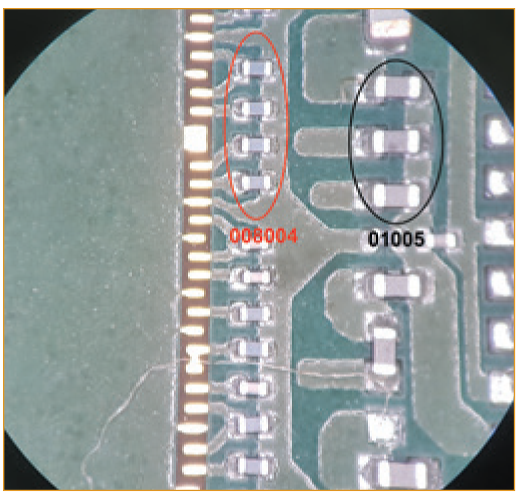


FIGURE 1. An 008004 package (left) and a 01005 (right), assembled at the Nistec Center plant. (Magnification 1:40)

Essential Use Only

If not essential, it is preferable not to use this type of component. Our plant in Petach Tikva, Israel, has assembled scores of circuits with this package with great success. Yet, as a technologist in a printed circuit assembly plant, I must mention, in principle, I do not recommend use of these components, at least at this stage, unless the circuit board application and footprint require it. Instead, as much as possible, given the constraints of the area, design the circuit with an 01005 component, which is much simpler and easier for assembly and maintenance.

Some of the challenges working with an 008004 include: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1. Manual repair is not possible. After machine soldering the board, it is not possible to repair the component manually. The component's small area and negligible weight make manual soldering impossible. In the event the component must be repaired post-soldering, the board will have to be reassembled.
2. Precise application of soldering paste. Correct application of the soldering paste is crucial to soldering success. This is even more important for tiny components such as 008004s. Use a particularly thin application stencil (0.075mm/0.003 mils) and design the stencil openings to component manufacturer recommendations. Note there could be different recommendations for different components, although they are the same size.
3. Uniformity of the rest of the components on the board. Because 008004s require accurate and delicate work during soldering, other parts on the board should be selected meticulously. Reduce the variety of types of components to enable uniformity and thermal balance during soldering. For example, in a circuit that contains an 008004, one should not also integrate a larger and heavier BGA.
4. Limited choice of assemblers. This is an advanced technology, and very few factories at present are capable of assembling these packages. Therefore, use of 008004s means working with a smaller number of assemblers.
5. High price. An 008004 component can cost 50% more than larger packages in the same passive category. In the coming years, however, use of the component will increase, and the price will balance out with other components in the market.

'50 Microns Accuracy'

The key to quality assembly of an 008004 component is accurate application of the solder paste. The maximum deviation is 50µm (0.05mm). In the assembly process, pay attention to the following:

- Define the component footprint per the component manufacturer recommendations.
- Use a 1:1 solder paste aperture ratio.
- Define the pads for the 008004 without release of the solder mask. That is with an SMD (solder-mask-defined) configuration, not as is customary for NSMD (non-solder-mask-defined) components. Furthermore, ensure solder mask is defined between the pads.
- Maintain a minimum distance of 6 mils between adjacent 008004 components.

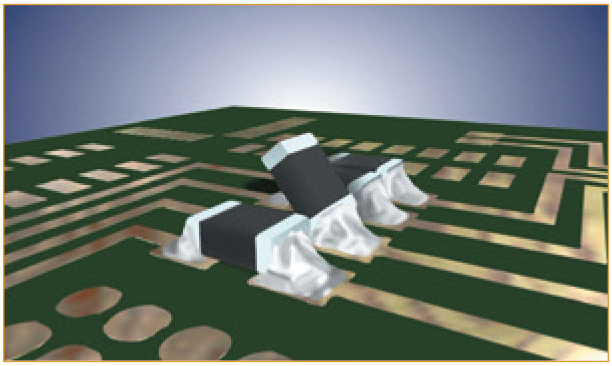


FIGURE 2. 008004 components are prone to tombstoning.

FIGURE 3. Solder bridging is another potential assembly defect.

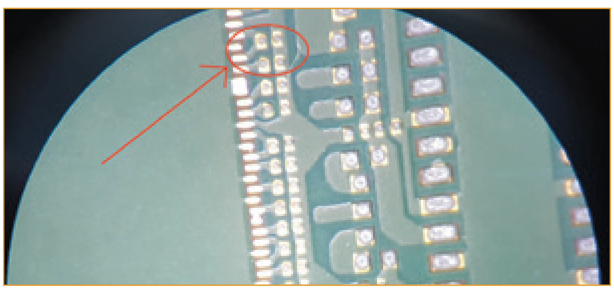


FIGURE 4. An 008004 post-printing.

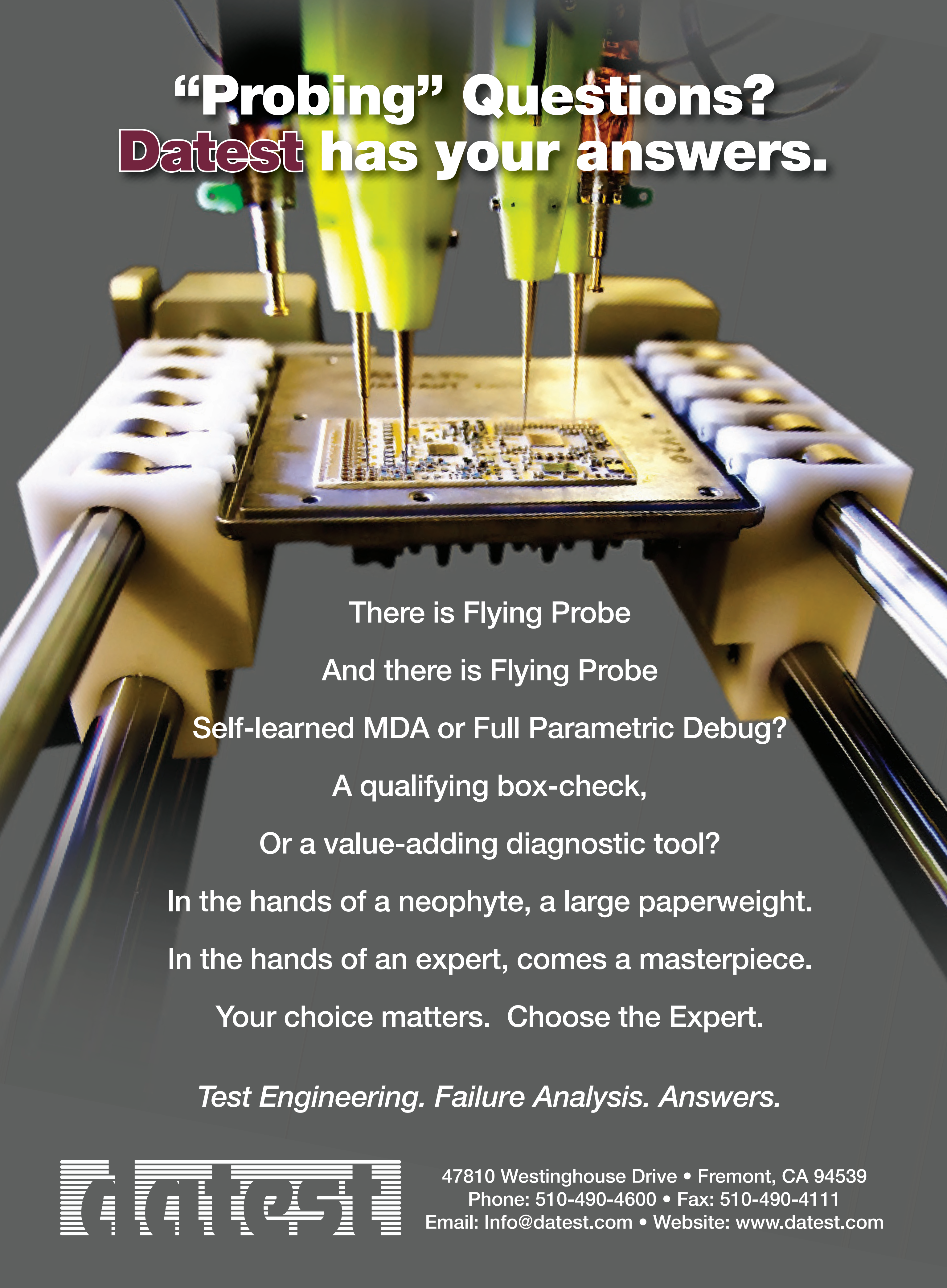
Challenging, Yet Possible

Soldering an 008004 component in an unsound process could lead to a significant number of quality issues. Common issues include:

1. Component lifting (tombstone). The component lifts during assembly. This is mainly caused by deviations in the solder paste application or imprecise component placement on the pads **(FIGURE 2)**.
2. Shorts (bridging). The component could attach to the adjacent component and cause a short. The root cause typically is inaccurate solder application or component positioning **(FIGURE 3)**.

As electronic products require increased functionality in smaller form factors, the 008004 package, with its minimal area and weight, could be an excellent solution. Although soldering the component means contending with several complex technological challenges, correct definition of the component during assembly and a highly controlled assembly process make quality soldering possible. For hardware engineers developing these products, these components can be simply little gifts for big dreams. ❑

MICHAEL SCHNEIDER is technologist, Nistec Center (nistec.com); michaels@nistec.com.



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The Interaction of 2 SOLDER PASTE ALLOYS with 5 Surface Finishes, Part 2

SAC 305 shows faster shear strength degradation than Innolot, while the surface finish has no effect.

by **PRITHA CHOUDHURY, PH.D., MORGANA RIBAS, PH.D., JOHN FUDALA and MITCH HOLTZER**

When a solder joint is exposed to cyclic stresses, thermally activated diffusion in the bulk solder, metallization and initial intermetallic (IMC) may take place. The growth of the interfacial IMC helps relieve the residual stress induced in the solder joint, and the growth rate corresponds to the magnitude of stress induced.[1] Solder joint strength also decreases during exposure to temperature variations. Therefore, shear testing is a useful method to assess solder joint strength degradation caused by thermal cycling.[2]

In part one[3] of this series we showed the voiding, solder spread and thickness of the high-reliability Innolot alloy compared with SAC 305 alloy solder pastes using five different surface finishes. Part two discusses thermal cycling effects on the growth in IMC thickness and solder joint strength. This study included two commonly used solder alloys in paste form:

1. SAC 305 (96.5%Sn, 3%Ag, 0.5%Cu) powder size distribution (PSD) type 4 with novel "CVP-390" paste flux
2. Innolot (91.95%Sn, 3.8%Ag, 0.7%Cu, 3.0%Bi, 1.4%Sb, 0.15%Ni) PSD type 4 with the novel paste flux and five variations of surface finishes, including
   a. Organic solderability preservative (OSP) (MacDermid Enthone Entek Plus HT) using two thickness levels
   b. Immersion tin (Ormecon CSN)
   c. Immersion silver (MacDermid Enthone Sterling)
   d. Electroless nickel/immersion gold (ENIG) (MacDermid Enthone Affinity).

Background

The ability of an electronic package to resist functional degradation in the intended environment of use determines its reliability[4,5] and is largely dependent on the reliability of the solder joint. During operation, electronic packages are subjected to a wide range of temperature variation. Differences in thermal expansion mismatch (CTE) of electronic materials within the assembly lead to cyclic thermal loading, resulting in thermal mismatch deformation,[1] crack formation in the solder joints and subsequent failure. Reliable solder joint shear strength is important because the solder joint itself must support a shear force due to mechanical shock and thermal stress.[2] The measurement of the solder joint strength can therefore be a function of this microstructural damage.[6]

Experimental Design

This article discusses the final IMC thickness and degradation of shear strength after thermal cycling from -40° to 160°C with 10 min. dwell time at each extreme temperature, up to 2,000 cycles, of two paste alloys on five different surface finishes, as mentioned above. The growth and morphological changes of the interfacial IMC on different surface finishes in R1206 and BGA84 (with SAC 305 balls) are studied and presented. Shear testing of chip resistors is also used for evaluation of the residual joint strength after thermal cycling.

Functions of surface finishes on PCBs. Formation of a strong bond via the interfacial IMC is essential for package functionality and reliability. As solder joint size decreases, the influence of IMC layer thickness on its reliability has become significant.[7] Solder joint reliability depends not only on the solder alloy but also the component, PCB finishes, and the IMC formed within and at the solder/substrate interface.[5,8,9] The most important function of the PCB finish is to increase substrate solderability so reliable solder joints are achieved at the board-level assembly.[4] Other common uses of surface finishes include prevention of oxidation of the copper metallization of the PCB, protection from contaminants, and damage from mishandling prior to assembly.

Significance of interfacial IMC for solder joint reliability. Interfacial IMC formation is strongly influenced by the processing parameters during reflow because of its effect on wetting and microstructure.[5,10] Some surface finishes may act as a barrier layer to reduce interdiffusion between the solder and copper base, thus reducing intermetallic compound (IMC) formation.[2,11] During service, joints may be subjected to elevated temperatures, resulting in IMC growth. These IMCs are generally brittle, and excessive growth can adversely affect solder joint reliability.[9] The stress type is the most important factor affecting brittle fracture due to IMCs.[12] High strain rate caused by rapid temperature changes, vibration, mechanical shock or bending of the assembly led to brittle fracture in most cases.

IMC formation kinetics on different surface finishes for SAC 305 – literature.

- **As-reflowed condition:** Soldering of copper substrate involves (i) eutectic melting (reflow) of solder bump and (ii) reaction of molten solder with substrate, resulting in the formation and growth of one or two intermetallics, i.e., Cu_3Sn (ε-phase) and Cu_6Sn_5 (η-phase). Mechanical bonding is provided mainly by the η-phase that has a peculiar scallop-like morphology.[12] The η-phase changed from a scallop to a flat structure in the presence of as little as 0.05 wt% Ni.[12] Thermodynamically, a Cu_3Sn layer must exist between the Cu and Cu_6Sn_5. However, the Cu_3Sn layer, being very thin, is not visible after reflow and can be observed only after prolonged aging/reflow.[13] The presence of Ni changes the composition of the intermetallic to $(Cu,Ni)_6Sn_5$. The Cu_6Sn_5 layer thickness increases linearly with the square root of reflow time.[6] Cu_6Sn_5 and Cu_3Sn have been identified between SAC 305 solder and copper pads on IAg and ISn finishes. Ternary $(Cu,Ni)_6Sn_5$ forms on ENiG finish.[9] SAC 305 on IAg shows higher lead-pull strength than ENiG and ISn finishes.[15]
- **Effect of thermal cycling:** SAC 305 reliability on Cu OSP, IAg and ENiG was studied using chip resistors.[16] Solder joint lifetime was highest for OSP, followed by ENiG and IAg surface finishes. Increasing the amount of copper in SAC 305 on OSP increases the amount of copper precipitates, thereby strengthening the microstructure. On the other hand, excess void formation during reflow on IAg results in poor performance.[16] SAC 305 in BGAs on OSP and ENiG finishes have been tested during thermal cycling.[17] Multiple crack path fatigue, vertical cracks and typical component side fatigue have been observed in this study.

Effect of thermal cycling on IMC and joint strength of Innolot and SAC 305.

A. **IMC thickness.**

- **BGA84:** FIGURE 1 shows the IMC thickness on different surface finishes for Innolot and SAC 305. BGA84 is a hybrid joint with greater volume of available alloy at the joint compared to the resistor, resulting in thicker IMC after thermal cycling for both alloys. ENIG is an effective diffusion barrier for both the alloys, resulting in minimum growth of IMC. On ENIG finish with Innolot, Au, Ni, Cu and Sn have been observed on both the board and component surfaces of BGA84. The Ni-Au finish on the component adds to the presence of these failures on the component side regardless of the surface finish on the copper pad.
- **R1206:** FIGURE 2 shows the final IMC thickness on different surface finishes in R1206. As an efficient diffusion barrier, ENIG results in minimum growth of IMC for both alloys. The average growth in IMC is similar in both alloys for the remaining surface finishes.

B. **IMC morphology.** Extensive cracks are observed (FIGURE 3) in both alloys for the BGA and the resistor. The interfacial IMC being brittle relative to the matrix, cracks are formed at or near this IMC for both alloys and components. The presence of Bi and Sb in Innolot strengthens the Sn matrix by solid solution strengthening. Ni in Innolot substitutes for Cu in Cu_6Sn_5, resulting in the formation of $(Cu,Ni)_6Sn_5$. A detailed study of the interfacial IMC on different surface finishes is presented in FIGURE 4. The extension of cracks is less in Innolot than SAC 305. The distribution of Ag_3Sn needles in the Innolot matrix also enhances the matrix strength. All the above factors help retain the strength of the Innolot, even when exposed to extreme environmental conditions, thus resulting in a lesser

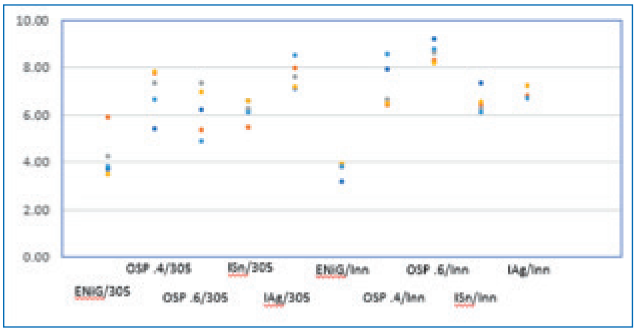

FIGURE 1. Final IMC thickness (μm) on different finishes in CTBGA84.

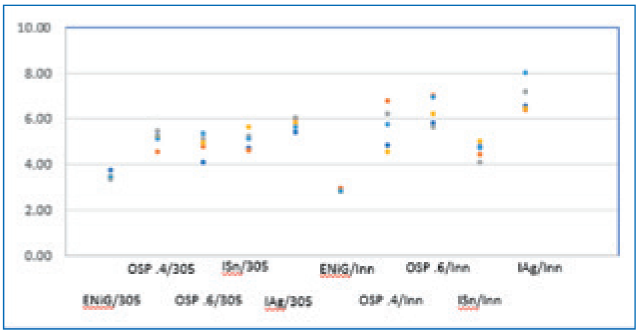

FIGURE 2. Final IMC thickness (μm) on different finishes in R1206.

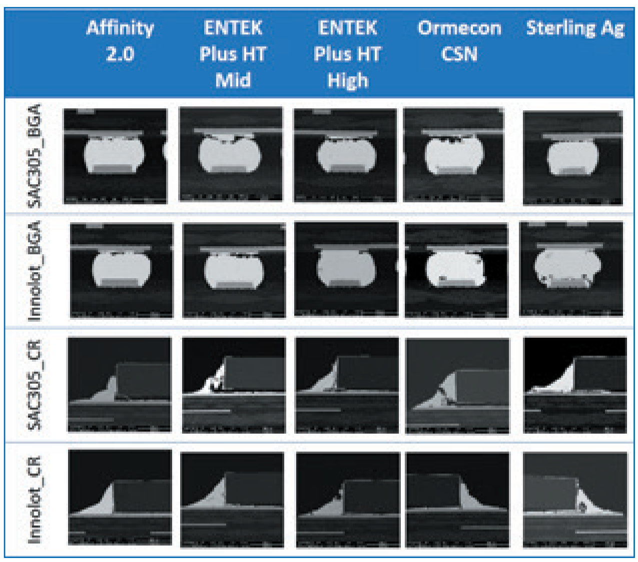

FIGURE 3. Morphology of the joints in CTBGA84 and R1206 after 2000 thermal cycles (TC).

extension of cracks. For SAC 305, all the surface finishes play an equal role in crack extension in either component. Innolot on "Entek Plus HT high" finish has a very small crack extension in the BGA (Figure 3). The IMC thickness on this finish is higher than the rest (Figure 1), and its brittleness is reduced by the presence of Ni, thus reducing crack formation. Crack formation and extension is similar across all surface finishes for Innolot and is mostly located at the corner in the resistor. The higher stress in this region results in greater crack formation and subsequent damage to the joint.

C. **Shear strength degradation.** Both alloys have similar shear strength after reflow as shown in FIGURE 5. Surface finishes do not have any effect on the initial shear strength of either alloy. The loss in shear strength due to 2,000 thermal cycles is 66% in Innolot, while that in SAC 305 is nearly 80%. The reduction of shear strength in SAC 305 is nearly twice that of Innolot. The greater retention of joint strength in Innolot is also supported by the lesser extension of cracks, as shown in Figure 3. After thermal cycling, surface finishes do not seem to have any effect on the shear strength for either alloy.

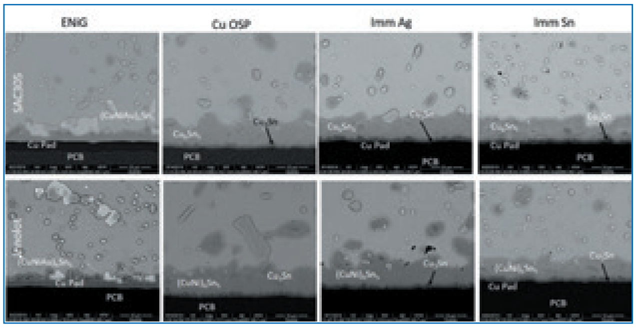

FIGURE 4. Interfacial IMC formation in SAC 305 and Innolot after 2000 TC.

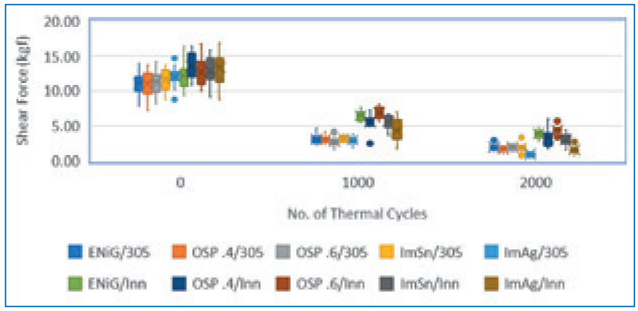

FIGURE 5. Shear strength (kgf) degradation with thermal cycling on different finishes on R1206.

Summary

Ever-growing demand for high-reliability solder joints is pushing requirements of solder alloys to higher levels. With a deeper understanding of the interaction between solder paste chemistries and surface finishes, the summary of the findings of this study are:

1. ENIG had the lowest IMC thickness after 2,000 thermal cycles.
2. Both tested solder pastes produced similar IMCs on a given surface finish.
3. Innolot solder paste with the novel flux outperforms SAC 305 solder paste with the same flux after thermal cycling for a given surface finish.
4. The complex microstructure of Innolot provides improved strength and thereby improved thermal cycling reliability.
5. Thermal cycling has a significant effect on shear strength degradation of both solder alloy joints.
6. Shear strength degradation is faster in SAC 305 than Innolot after thermal cycling.
7. The loss in shear strength is 66% in Innolot and 80% in SAC 305 after 2,000 thermal cycles.
8. PCB surface finishes do not have any effect on shear strength of either alloy before or after thermal cycling. ❑

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PRITHA CHOUDHURY, PH.D., is senior scientist R&D; **MORGANA RIBAS, PH.D.,** is manager of Metals Technology Group – R&D; **JOHN FUDALA** is senior process specialist, and **MITCH HOLTZER** is technical knowledge leader, Global R&D at MacDermid Alpha Electronics Solutions (macdermidalpha.com).

Designer's Notebook, continued from pg. 19

pins and increase reliability of the overall assembly. The main cost is the materials that come with the technology. These benefits can be had on a board that requires only a single lamination cycle.

The other end of the price spectrum is a board composed completely of microvias. These boards have numerous lamination cycles, as all the layers are buildup layers. The construction will resemble that of substrates that go between the chip and board. They are common in phones, watches and assorted entertainment systems where they compete on size and performance. The more extreme systems add the complexity of flex circuits between different functional aspects of the design. When your board is using microvias to this extent, hats off to you! Meanwhile, getting started with the basics is easy. □


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AOI OPERATION CONTROL by MES Using IPC-CFX

A connected factory automates the AOI validation process.

by MATTHEW FISCHER, RANKO VUJOSEVIC, PH.D. and LOC DO

Automated optical inspection (AOI) is typically used after solder reflow to detect missing components and defects. Performing a successful inspection of a panel is not enough, however. Manufacturing execution systems (MES) are used for process control and AOI data collection to ensure the following are accomplished:

- All prior routing operations passed.
- Valid test program is loaded on the machine.
- Test start- and end-times and test results are captured.
- Failed printed circuit boards (PCB) cannot advance in the production routing and must enter rework loop.

One of the fundamental features of an MES system is routing enforcement. A machine can perform an operation only if the MES system verifies all prior operations have passed and the correct test program is loaded. All PCBs must be serialized to capture the highest level of traceability. The MES verifies that PCBs entering the AOI machine belong to the program loaded on the machine. Once the operation is approved, the AOI machine performs the test, and it sends board-in and board-out events and test results to the MES. The MES collects test results into a central database, which permits factory-level reporting, avoids having to locate results on individual machines, and protects against data loss. The MES also controls the routing flow and prevents a panel that fails AOI test from moving to the next operation. The panel must enter a rework loop, and defects must be fixed or the panel scrapped. In addition, the MES can analyze the test results and provide automatic feedback and program modification for pick-and-place machines to eliminate problems that occur in the component placement operation. This was not in the scope of this project.

The Connected Factory Exchange (CFX) protocol was developed to facilitate Industry 4.0 implementation through vendor-independent integration among different equipment and between an MES and equipment.

The CFX-based integration between an MES system and an AOI machine presented here was tested on a Mirtec MV-6 Omni AOI machine at a customer site. Mirtec provided a full CFX implementation on the machine side.

IPC-CFX Applications for AOI Process Control

CFX is defined by IPC-2591. This standard defines the communication protocol among manual, semiautomated, and automated processes involved in printed circuit assembly.

Our goal was to implement complete CFX control of AOI machines by an MES. For that to work, AOI and MES must implement all necessary messages, and an AMPQ broker must be used to route messages between AOI and MES.

On the machine side, a full CFX implementation must support the following features[1]:

- Send details of the active recipe when a recipe is activated.
- Receive requests to activate recipes.
- Indicate whether the requested recipe was activated or not.
- Send the panel barcode when one is scanned.
- Wait for permission before running a test.
- Receive an indication of whether permission is granted or not.
- Display error messages to the user.
- Indicate when the test has completed.
- Provide the test results.
- Indicate when the panel has left the machine.

CFX messages implemented for MES control of AOI machines include:

Machine → MES	Broadcast Messages	• CFX.EndpointConnected • CFX.EndpointShuttingDown • CFX.Production.RecipeActivated • CFX.Production.UnitsArrived • CFX.Production.WorkStarted • CFX.Production.WorkStageStarted • CFX.Production.TestAndInspection.UnitsInspected • CFX.Production.WorkStageCompleted • CFX.Production.WorkCompleted • CFX.Production.UnitsDeparted
	Direct Messages	• CFX.WhoIsThereRequest • CFX.AreYouThereRequest • CFX.GetEndpointInformationRequest • CFX.InformationSystem.UnitValidation.ValidateUnitsRequest (Validation Types: UnitRouteValidation, UnitStatusValidation, and UnitTraceValidation)
MES → Machine	Broadcast Messages	• CFX.EndpointConnected • CFX.EndpointShuttingDown
	Direct Messages	• CFX.Production.GetActiveRecipeRequest • CFX.Production.ActivateRecipeRequest

Top-Level Interaction

FIGURE 1 presents the top-level control flow between an AOI machine and an MES.

When a panel enters the AOI machine, the machine scans the barcode and sends a CFX message to the MES requesting permission to proceed. The MES performs a number of checks (FIGURE 2) and returns its determination to the machine.

If the MES determines the recipe currently loaded on the AOI machine is incorrect for the panel it needs to test, it sends the name of the correct recipe back to the machine. The machine must then load the correct recipe and request permission again.

If the MES determines any other test conditions are not met, it returns an error message to the AOI machine. The AOI machine must display this message to the operator and wait for the problem to be resolved. Once the problem is resolved, the machine can request permission to run again.

Once permission is granted, the machine inspects the panel and sends its results back to the MES via the CFX UnitsInspected message (FIGURE 3). There is no reply message defined by CFX for UnitsInspected, so the machine must follow up by sending the ValidateUnitsRequest message to check whether the MES accepted the test results. If it did, the panel may exit the machine.

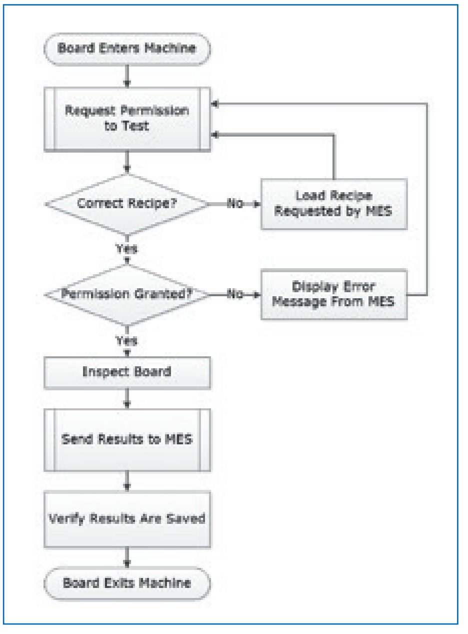

FIGURE 1. MES – AOI integration flow.

Permission to Test

The MES system decides whether a board can be tested. Figure 2 illustrates the interaction between the AOI machine and the MES when the AOI machine requests permission to test.

Every time a machine requests permission to run, the MES performs a sequence of checks to ensure the PCBs are ready to be inspected. If any check fails, the problem must be resolved, and the machine must request permission again.

The first check ensures the serial number has been defined in the MES database, and that it is able to get basic information about it, such as the work order it belongs to.

The next checks involve locking. Often, time is wasted by repeatedly testing PCBs that have the same defect, or testing with a broken AOI machine. The MES prevents that from happening by locking the AOI machine, all serial numbers in a work order, or a particular PCB when set failure thresholds are met. Locking involves setting a flag in the MES database. The MES will not grant permission for a flagged item until the flag is manually cleared by a supervisor.

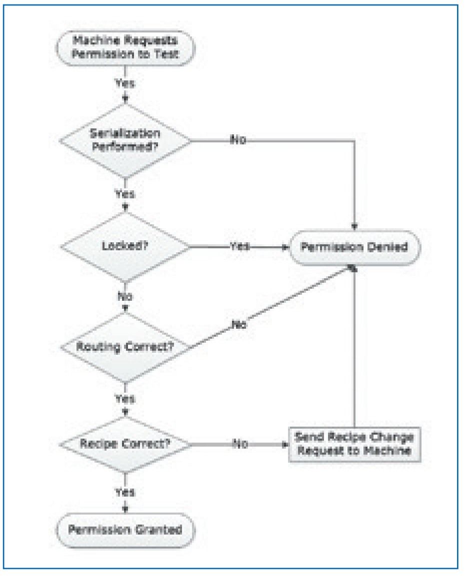

FIGURE 2. Permission to test logic.

After that come checks related to the routing. The MES checks the history of the PCBs on the panel in the machine. It checks whether any were scrapped in a previous operation, or whether any failed a previous operation and have not yet completed rework routing. It also checks whether any operations were skipped or performed out of order.

The last checks involve the recipe the AOI machine uses to inspect the panel. The MES compares the name of the recipe currently loaded on the AOI machine with the correct recipe for the product. If it is incorrect or the machine did not inform the MES of its current recipe, the MES sends a request to the machine to change to the correct recipe.

If there are no problems, the MES grants the AOI machine permission to proceed with inspecting the PCBs.

Uploading Results

When the AOI machine completes its inspection of the PCBs on the panel, it sends the results to the MES. The MES performs some checks to determine if the test was valid, and if so, it saves the results in its database. If the test was valid, and any of the PCBs failed AOI inspection, the MES updates its locks based on what failed and how many times it has failed. The locks will then be consulted when the AOI machine or other operations after AOI in the routing request permission to run.

Based on the inspection results uploaded to the MES, the PCB is marked as one of the following statuses for the AOI operation:

- Failed, if any true failure.
- False call, if any false calls.
- Passed, if all passed.

If one or more PCBs on the panel tested fail, the failed PCBs cannot proceed to the next operation and must be sent to rework first. A rework routing, describing the sequence of operations needed to rework a PCB, is attached to the PCB. All operations in the rework routing must be completed before the failed PCB can be brought back to the AOI machine for retesting.


PICK-AND-PLACE

Conclusions

Just inspecting a board and reporting it passed or failed is not enough. All test data must be captured and assigned to PCB serial numbers to ensure a defective PCB does not advance through production, and AOI test data are used to provide feedback to solder paste printing and pick-and-place operations in order to eliminate the problems found, without much production interruption. Integration with an MES can accomplish these objectives. CFX is a powerful standard to permit an MES to completely control the AOI operation. More and more AOI vendors are implementing CFX in full. Benefits of such integration for electronics assembly companies include preventing delivery of defective products to customer, higher line yield, increased productivity, and reduced cost. ☐

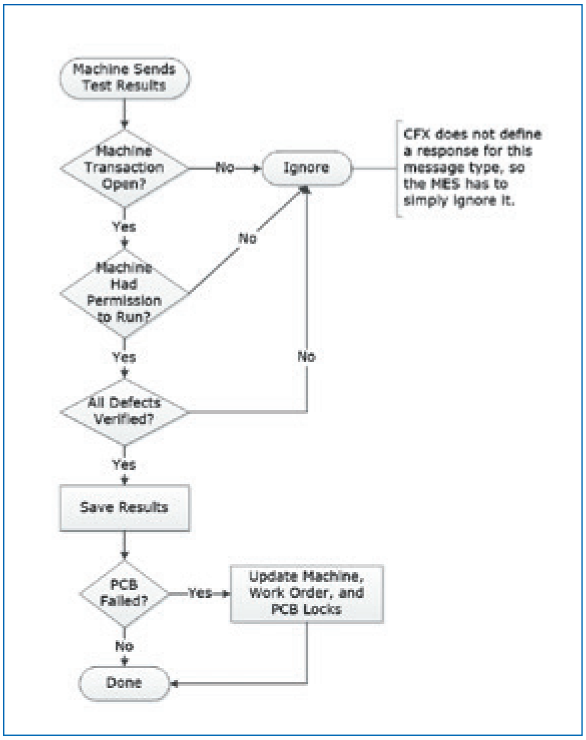

FIGURE 3. Test data collection and saving.

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MATTHEW FISCHER is a senior software engineer, RANKO VUJOSEVIC, PH.D., is CEO, and LOC DO is a senior application engineer at Optel Software (optelco.com); ranko@optelco.com.

Inventing Your OWN PATH

The annual Women's Leadership Program at SMTA International features two leading engineers.

by PRIYANKA DOBRIYAL, PH.D.

SMTA International returns to an in-person format this year, with a virtual option, and the Women's Leadership Program is in-person on Tuesday, Nov. 2! The past 18 months have been a time of reflection and transition for many of us. Many professionals are reassessing their career goals and career paths. In keeping with this trend, our 2021 WLP theme, "It's good we are not all the same," was chosen to encourage attendees to explore career transition options.

The WLP this year will focus on the success stories of women who have created varied career paths, applying core technical strengths to a variety of areas and succeeding consistently. Hear how their diverse career experiences have contributed to their long-term success. Our two distinguished speakers have blazed unique career paths and will share their stories with the audience.

Dr. Gayle Schueller

Dr. Gayle Schueller, senior vice president and chief sustainability officer at 3M, is recognized as a positive change agent at the crossroads of technology and business leadership. She started in 3M's corporate laboratory and has over 25 years of technical and business leadership experience. She has led a broad range of businesses from electronics to healthcare to consumer industries. Her leadership spans technical and business teams around the world, including Europe, Asia, Latin America and North America. Gayle's previous assignments include directora general and VP for 3M Mexico, one of 3M's largest and most vibrant subsidiaries, VP Global Sustainability, covering all 3M businesses and geographies, and VP R&D and Design for 3M's multibillion-dollar consumer business, including global technology development, customer technical engagement, strategic direction, and new product design and commercialization.


Amanda E. Mikhail

Amanda E. Mikhail began her career at IBM in 1999 as an engineer in hardware development. During her time at IBM, she served as a project lead managing a $1.5 million budget guiding multiple teams through expedient program delivery and became a product development manager, where she led a team across many US states through significant product development commitments. Mikhail is an inventor on more than 25 US patents and was the second female in IBM Rochester's 50+ year history to receive an IBM Master Inventor award. In 2014, Mikhail left IBM to join Mayo Clinic. She currently serves as the administrative lead for research for the Mayo Clinic Department of Medicine, addressing the needs of patients through strategic discovery, translation, and application of capabilities. Mikhail also serves as co-chair of Mayo's Covid-19 Research Task Force and co-leads the DERIVE initiative: Departments Engaging Research for Innovation.

As we reflect on the particularly challenging times we have faced in the past 18 months, it is more important than ever to consider our own well-being, physically, mentally and emotionally. Incorporating mindfulness practices in your daily routine is recognized for its benefits to your health and productivity. Meditation is an essential mindfulness practice that can increase calmness and physical elation, improving psychological balance, and enhancing overall health and well-being. We will be joined by Tiffany Kari, St. Louis County health promotion coordinator, a motivator, teacher, and health and wellness enthusiast. She is full of energy, a lover of wellness, and passionate educator on all life topics. Tiffany has over a decade of speaking experience, event coordination, behavioral change coaching and educating, as well as fitness training. She will share valuable insights on establishing a meditation practice in your own life and how it can reduce stress.

Our popular Speed Networking returns to its "Table Topic" format, where attendees can choose from a variety of discussion topics hosted by SMTA leaders. This session will benefit all attendees by extending your network and helping you design your future. Interested in gaining new perspectives by speaking to experienced leaders, young professionals and a variety of peer attendees about topics related to your career and success in the workplace? Speed Networking will provide you with the opportunity to share experiences and knowledge in a group setting on several topics of your choosing. In keeping with our theme of transitions and growth, topics for this year include:

- Finding your strengths: personality analysis
- Identifying mentors and cultivating sponsors
- Reinventing and accelerating your career path
- Breaking through unwritten stereotypes
- The importance of strategic thinking
- Achieving positive outcomes from tough situations

Attend this session to develop your network and learn how to leverage their knowledge for career success and satisfaction. You may want to consider if you should avoid or invite disruption and how often. You can ask yourself why you are considering disruption or change. You may want to consider the advantages of constancy versus taking a risk on change. Transitions could be a catalyst to propel your career forward. Risk-taking may not always end in success, but not trying may have even greater risks. Each transition is unique and requires a unique strategy, with the experiences of others assisting you along your path.

An Ice Cream Social Connection Reception will conclude the Women's Leadership Program this year. This annual gathering provides a relaxed atmosphere to continue the conversations from the earlier segments of the WLP, fostering new and renewed connections across the SMTA community of organizers, speakers, exhibitors and attendees. Explore new flavors, as well as old favorites, to top off an engaging and energizing session with industry colleagues. Just like ice cream, it is good we are not all the same!

Ice cream comes in many flavors, and everyone typically has a favorite or two. How boring life would be if all the ice cream in the world was vanilla with no sprinkles or toppings. Nothing is wrong with good old vanilla, chocolate or strawberry, but imagine a world without rocky road, pistachio or butter pecan. I shudder at the thought. Join us as we mingle and celebrate the different flavors of people in our industry. (Don't be surprised to find a couple of nuts in the bunch.)

Favorite Quotes from WLP Organizers

- "If you're always trying to be normal, you will never know how amazing you can be." – Maya Angelou (Elizabeth Benedetto)
- "Courage is like a muscle. We strengthen it by use." – Ruth Gordo (Debbie Carboni)
- "The purpose of life is to live it, to taste experience to the utmost, to reach out eagerly and without fear for newer and richer experience." – Eleanor Roosevelt (Marie Cole)
- "Coming together is a beginning. Keeping together is progress. Working together is success." – Henry Ford (Priyanka Dobriyal)
- "Make the most of yourself, for that is all there is of you." – Ralph Waldo Emerson (Tanya Martin)
- "Ability is what you're capable of doing. Motivation determines what you do. Attitude determines how well you do it." – Lou Holtz (Jessica Molloy)
- "Optimism is the faith that leads to achievement. Nothing can be done without hope and confidence." – Helen Keller (Michelle Ogihara)
- "Wisdom is knowing what to do next, skill is knowing how to do it, and virtue is doing it." – David Star Jordan (Karlie Severinson)
- "Let us make our future now, and let us make our dreams tomorrow's reality." – Malala Yousafzai (Julie Silk)
- "Say what you mean and mean what you say. Don't be afraid to stand firm on the decisions that you make. Trust yourself. Believe in your instincts. Do what works best for you. Stay true to yourself and be good to yourself. Allow every decision that you make to empower, enrich, and add value to your life!" – Stephanie Lahart, author and self-help guru (Sherry Stepp)

Speed Mentoring Topics

- Breaking Through Unwritten Stereotypes: Good Old Boys Club, hosted by Chrys Shea, Shea Engineering Services, and Sherry Stepp, Kyzen
- Identifying Mentors and Cultivating Sponsors, hosted by Marie Cole, IBM, and Jessica Molloy, Zestron
- Importance of Strategic Thinking, hosted by Martin Anselm, Rochester Institute of Technology, and Tanya Martin, SMTA
- Relentlessly Reinvent and Accelerate your Career Path, hosted by Julie Silk, Keysight Technologies, and Amanda E. Mikhail, Mayo Clinic
- Positive Outcomes from Tough Situations, hosted by Mike Konrad, Aqueous Technologies, and Michelle Ogihara, Seika Machinery
- Find your Strengths: Personality Analysis, hosted by Debbie Carboni, Kyzen, and Priyanka Dobriyal, Intel ❑

PRIYANKA DOBRIYAL, PH.D., is technical program manager, Datacenter, Silicon Photonics, Intel (intel.com), and an organizer of the Women's Leadership Program at SMTA International.

Respect the Squeegee

Six areas to consider for optimal print quality and consistency.

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

IN THE STENCIL printing process, the squeegee blade often fails to get the recognition it deserves. Yet the squeegee is the item that does all the work and is the unsung hero. Consider a squeegee running in high volume on a 300mm board may put in between five and 10 miles per day of grueling aperture filling, and it becomes clear close attention to squeegee attributes may result in higher-quality results. With that said, here are my top squeegee awareness tips.

Material. In the early days of SMT, squeegee blades were predominately made from polyurethane (rubber), as the very first surface-mount printing processes used mesh screens. As the industry transitioned to metal-etched stencils and then laser-cut, stainless steel squeegees became standard. However, there are applications – such as heavily stepped stencils (say a 75µm step down on a 150µm-thick stencil) – where the compliance of a polyurethane squeegee is beneficial. The vast majority of squeegee blades today, though, are stainless steel. And not just any stainless steel; to be sure, a tremendous amount of IP and proprietary alloy formulation is in today's sprung steel compounds used to manufacture high-quality blades. They keep a good sharp edge and provide excellent consistency for the pressure and force applied, which delivers the aperture filling necessary for a repeatable process.

Angle. For mainstream production, two common squeegee angles are employed in stencil printing operations: 45° and 60°. The years have seen much debate over which angle is best. A 45° angle will produce higher fill pressure for rolling the material and shear thinning it. "Great," you say. Well, that depends. The challenge with high pressure at a tight angle is that, unless a perfect gasket (absolute seal of the aperture to the pad) is established, the likelihood that elevated pressure will break the seal and introduce smearing and bridging is fairly high. My general advice is to go with a 60° angle, as good pressure is created but not so much to introduce possible defects; it gives a slightly larger printing bandwidth. Like anything, there are exceptions: Applications that dictate a large volume of paste – such as backplanes with big components – and specialized processes like pin-in-paste can benefit from a 45° angle squeegee blade.

Overhang. Squeegee overhang is the amount of flexible blade that is visible outside of the assembly (holder); our company offers a 6mm and a 15mm overhang. With 6mm, pressure can be quite high, and the squeegee will not give or bend much at all, which is often preferred for boards that are ultra-flat and where absolute control is required, such as in semiconductor or ceramic printing. With SMT, and the variability of heavily routed boards, FR-4, and PCBs that may have a bit of warpage, 15mm is my go-to. It provides more flexibility, and the extra overhang depth permits a bit of pressure adjustment to create a customized angle for challenging assemblies.

Clamping. The mechanism by which the squeegee attaches to the holder can also be a variable. The incumbent is a system where the metal blade is clamped using conventional nuts and bolts. This makes changing out the squeegee a simple operation. A bonded squeegee is when the blade is glued to the holder. Like the polyurethane squeegee, this was the predominant design in the early days of SMT but is rarely used today. While this method does ensure excellent blade coplanarity and may be effective for some alternative applications or adhesive printing, conventional clamping is the most appropriate for the majority of SMT production.

Length. This is one of my soapbox issues. There are varying lengths for squeegee blades (our company supplies from 170mm to 535mm lengths), and it is *imperative* the length that matches the product is used. While changing blades may take a few minutes, it is well worth the time and effort to align the blade length to the product being printed. Do not assume a 300mm blade will split the difference and manage most products. Absolutely not. Printing with an oversized squeegee blade will most assuredly result in a reduction in print quality.

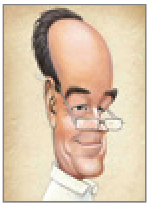
Coatings. In the early 2000s, squeegee blade coatings were all the rage. The truth is most users do not need coated blades. The idea was coatings would help solder paste material roll more consistently and permit it to drop off more cleanly at the end of a print stroke. Most materials roll fine without coated squeegee blades. Naturally, situations such as high-temperature operations or specific alloy-based materials have more difficulty rolling, and, in those rare cases, a coating may help. Otherwise, a highly polished steel blade is the way to go.

Close attention to all these tips, securing squeegee blades from a reputable screen-printing equipment or blade supplier, and examining squeegee blades frequently to ensure they are free of damage will do wonders for print quality and consistency. Respect the squeegee, reap the rewards. ❑

Microsections Can Show Much

Getting a close-up look at board quality.

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



A PRINTED BOARD microsection is one of the best ways to examine the quality of boards and any faults or failures.

The microsection **(FIGURE 1)** shows a plated through-hole that has been soldered with the nickel layer and through-hole copper visible. Normally, customers would accept the plating standards offered by the fabricator, or define their own, which may or may not impact the price. The nickel layer is part of the nickel/gold surface finish with the very thin gold of less than 1µm consumed during soldering and not visible. The remaining nickel is 5µm, and the copper is around 32µm. This is generous on many circuits board produced today and soldered very easily in production.

In this case, the board is fine and will continue to operate reliably in the field. No defects are present, just a little copper wicking into the glass bundle.

We have presented live process defect clinics at exhibitions all over the world. Many of our Defect of the Month videos are available online at youtube.com/user/mrbobwillis. Find out how you can share our new series of Defect of the Month videos to explain some of the dos and don'ts with your customers via CIRCUITS ASSEMBLY: https://bit.ly/3mfunlF. ❑

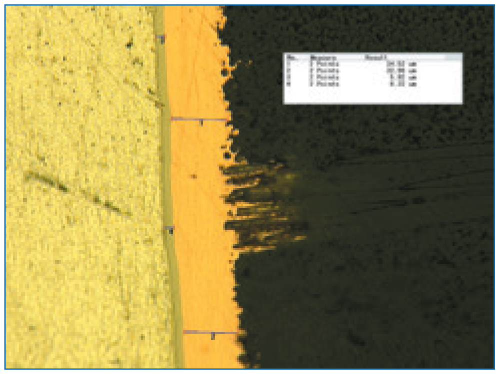
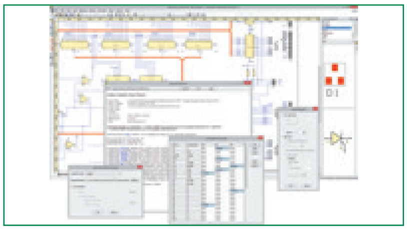


FIGURE 1. Microsection of a PTH with a visible nickel layer.



NUMBER ONE EASY-PC V.25

Easy-PC v.25 schematic and PCB layout tool has more than 25 new features. Libraries can be altered and extended. Component search engine has over 15 million parts available for free download. Now enables differential pair definition, parameters, addition, editing, checking, and reporting.

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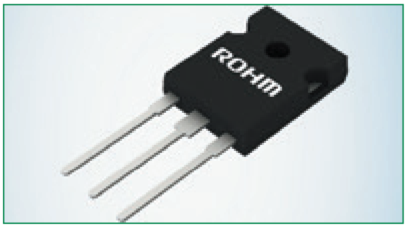
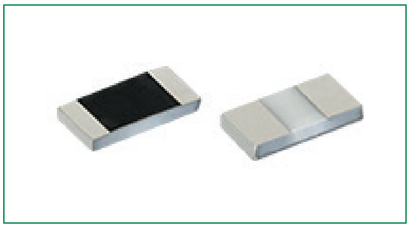


ROHM RGWXX65C

RGWxx65C hybrid IGBTs have an integrated 650V SiC Schottky barrier diode in the IGBT feedback block as a freewheeling diode that has almost no recovery energy, thus minimal diode switching loss. Significantly reduce IGBT turn-on loss. Up to 67% lower loss over conventional IGBTs and 24% lower loss compared with Super Junction MOSFETs (SJ MOSFETs) when used in vehicle chargers. AEC-Q101 qualified.

Rohm Semiconductor
rohm.com



VISHAY PHPA RESISTORS

Thin film wraparound PHPA series resistors have power ratings of 1.0W and 2.5W in 1206 and 2512 case sizes, respectively, with a self-passivated tantalum nitride film for moisture resistance. AEC-Q200 qualified, with TCR down to ±25ppm/°C and tolerance to ±0.1%. For automotive power supplies, braking systems, onboard chargers, and motor deflection circuits, and industrial test and measurement equipment. Resistance range is 10Ω to 30.1kΩ, noise less than -30dB.

Vishay
vishay.com

OTHERS OF NOTE

UCAMCO INTEGR8TOR V2021.04 CAM

Integr8tor v2021.04 CAM engineering tool has cut-out detection, Java 11 upgrade, Tomcat 8 web server upgrade, and QED PDF additions. Unintended small openings in painted areas are automatically removed. Includes improvements for recognition of stackup, naming conventions, drill span, and backdrill.

Ucamco
ucamco.com

AVX SCP SERIES PRIZMACAP

SCP series PrizmaCap standard and custom supercapacitors are engineered for SWaP-optimized, battery-powered products. Have operating temp. of -55° to +90°C. Capacitance is 3.5 to 15F, and energy density is 1.14–2.43Wh/kg. Weight is <2g, and form factor is 0.8 to 2mm based on propylene carbonate electrolyte technology.

AVX
avx.com

VISHAY T24 SERIES

T24 series HI-TMP surface-mount wet tantalum capacitors have operating temp. to +200°C in compact C case code. For military and aerospace radar applications. Measure 9mm x 7.1mm x 7.4mm. Feature tantalum metal case with glass to tantalum hermetic seal. Thermal shock capability to 300 cycles and life of 2,000 hr. at +200°C.

Vishay
vishay.com

UCAMCO UCAMX V2021.04

UcamX v2021.04 CAM software includes netlist extension, YELO copper adjuster extensions, YELO legend adjuster extensions, YELO mask adjuster (Beta) extensions, secure etch compensation file size reduction, Ledia output, and ODB++ output optimization.

Ucamco
ucamco.com

NANO DIMENSION FABRICA 2.0

Fabrica 2.0 micro additive manufacturing system is used in micron-level resolution of medical devices, micro-optics, semiconductors, microelectronics, microelectromechanical systems, and more. Uses digital light processor engine. Achieves repeatable micron-level resolution by combining DLP with adaptive optics. Engineered with array of sensors for closed feedback loop.

Nano Dimension
nano-di.com

XJTAG 3.11

XJTAG 3.11 boundary scan software has gas serial wire debug (SWD) support, user-defined libraries, and a new clock generator. Supports SWD protocol for ARM Cortex core devices via any two pins of the XJLink2. Permits an SWD-device to be controlled directly during a board test, e.g., for testing a peripheral such as an ADC and to program connected memories. Allows creation and management of user's libraries of XJEase device files and circuit code files.

XJTAG
xjtag.com

MIRTEC INTELLI-PRO AI

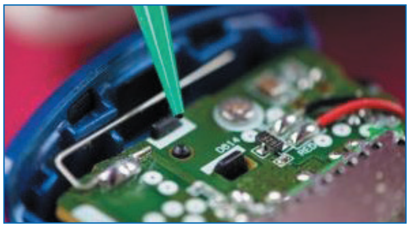
Intelli-Pro AI smart factory automation software and algorithm package consists of deep-learning-based automatic part search and teaching function; automatic parameter optimization; OCR; foreign object detection; placement inspection algorithms; and automatic defect type classification function. Cuts work time up to 90% over manual teaching and 50% vs. automatic teaching without deep learning.

Mirtec
mirtecusa.com

PALOMAR 3880-II

3880-II die bonder includes options to maximize productivity, reduce programming time by up to 95% and improve bonder productivity. Provides supports for rapid process development that minimize gaps in production caused by maintenance, calibrations, and process setups. New tool changer provides automated access to nearly unlimited tools. New contactless height measurement.

Palomar Technologies
palomartechnologies.com



MASTER BOND EP5G-80

EP5G-80 is a one-component, NASA low outgassing rated epoxy with temp. cure requirement of 80°C for 4 hr. Graphite-filled compound is not premixed and frozen and has unlimited working life at room temp. Volume resistivity of 5-15 ohm-cm and thermal conductivity of 2.88-3.46 W/(m•K) at room temp. For heat-sensitive electronics with high levels of conductivity.

Master Bond
masterbond.com

OTHERS OF NOTE

SOLDERSTAR SLX

SLX is a zero-setup profiler for reflow and wave solder applications. Includes statistical process control tool to leverage profile data for trend analysis and prediction of process problems before they happen.

Solderstar
solderstar.com

HUMISEAL VIVID CURE LCD

Vivid Cure LCD edge bonding adhesives are for high-speed LCD display assembly and are compatible with HumiSeal face bonding products. Currently available: UV6061T, UV7061T, and UV9118T-Black. Have fast UV curing mechanism for high-speed production; are thixotropic for ease of fluid handling; are compatible with LOCA grades. Made in US under ISO standards.

HumiSeal
chasecorp.com/humiseal

SAKI 3DI-LS2-CASE

3Di-LS2-CASE 3-D AOI's AI-based inspection automation functionality reduces false calls for solder defects (non-wetting) and improves speed and accuracy of solder defect detection. AI engine learns from an image data of good and bad products, which eliminates the need to tune data during solder inspection, enabling unskilled automated inspection. Simple data flow configuration is resilient to network problems, for construction of a stable system network with excellent maintainability. Highly rigid gantry structure.

Saki
sakicorp.com/en

SOLDERSTAR VP NANO

VP Nano captures thermal profiles of electronics assemblies that use numerous components or require higher mass PCB substrates. Is said to streamline the periodic checking of vapor phase machines and ensure uniform heating of boards being soldered. Includes a state-of-the-art rechargeable micro-miniature datalogger and improved thermal shield.

SolderStar
solderstar.com

DYMAX 9771

9771 conformal coating is for use on PCBs in missiles, satellites, and spacecraft. Is dual-cure and reworkable, and cures with light and moisture to ensure full cure underneath components. Low ionic content, meets low outgassing ASTM E595 for cleaner PCBs during extreme conditions, is certified to meet Mil-Std 883 Method 5011. UL 94 V0 flammability rating and UL 746E recognized.

Dymax
dymax.com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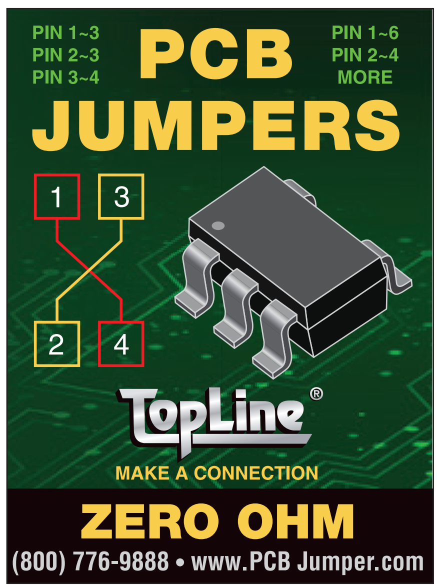
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In Case You Missed It

Soldering

"Influence of Ultrasounds on Interfacial Microstructures of Cu-Sn Solder Joints"

Authors: Xu Han, *et al.*

Abstract: This study aims to investigate the interfacial microstructures of ultrasonic-assisted solder joints at different soldering times. Solder joints with different microstructures are obtained by ultrasonic-assisted soldering. To analyze the effect of ultrasounds on Cu_6Sn_5 growth during the solid-liquid reaction stage, the interconnection heights of solder joints are increased from 30 to 50μm. Scallop-like Cu_6Sn_5 nucleate and grow along the Cu_6Sn_5/Cu_3Sn interface under the traditional soldering process. By comparison, the authors observed some Cu_6Sn_5 are formed at Cu_6Sn_5/Cu_3Sn interface, and some Cu_6Sn_5 are randomly distributed in Sn when ultrasonic-assisted soldering process is used. The reason for the formation of non-interfacial Cu_6Sn_5 has to do with the shock waves and micro-jets produced by ultrasonic treatment, which leads to separation of some Cu_6Sn_5 from the interfacial Cu_6Sn_5 to form non-interfacial Cu_6Sn_5. The local high pressure generated by the ultrasounds promotes the heterogeneous nucleation and growth of Cu_6Sn_5. Also, some branch-like Cu_3Sn formed at the Cu_6Sn_5/Cu_3Sn interface render the interfacial Cu_3Sn in ultrasonic-assisted solder joints present a different morphology from the wave-like or planar-like Cu_3Sn in conventional soldering joints. Meanwhile, some non-interfacial Cu_3Sn are present in non-interfacial Cu_6Sn_5 due to reaction of Cu atoms in liquid Sn with non-interfacial Cu_6Sn_5 to form non-interfacial Cu_3Sn. Overall, full Cu_3Sn solder joints are obtained at ultrasonic times of 60 sec. (*Soldering and Surface Mount Technology,* July 2021, www.emerald.com/insight/content/doi/10.1108/SSMT-06-2020-0026/full/html)

Sustainable Electronics

"Recycling of Nanowire Percolation Network for Sustainable Soft Electronics"

Authors: Yuxuan Liu, *et al.*

Abstract: Researchers at North Carolina State University have demonstrated a low-cost technique for retrieving nanowires from electronic devices that have reached the end of their utility, and then using those nanowires in new devices. The researchers demonstrated an approach that allows them to recycle nanowires, and think it could be extended to other nanomaterials – including nanomaterials containing noble and rare-earth elements. "Our recycling technique differs from conventional recycling," says Yong Zhu, corresponding author and professor of mechanical and aerospace engineering at NC State. "When you think about recycling a glass bottle, it is completely melted down before being used to create another glass object. In our approach, a silver nanowire network is separated from the rest of the materials in a device. That network is then disassembled into a collection of separate silver nanowires in solution. Those nanowires can then be used to create a new network and incorporated into a new sensor or other devices." (*Advanced Electronic Materials,* July 2021; https://onlinelibrary.wiley.com/doi/abs/10.1002/aelm.202100588)

Transfer Printing

"Instant, Multiscale Dry Transfer Printing by Atomic Diffusion Control at Heterogeneous Interfaces"

Authors: Seungkyoung Heo, *et al.*

Abstract: Transfer printing is a technique that integrates heterogeneous materials by readily retrieving functional elements from a grown substrate and subsequently printing them onto a specific target site. These strategies are broadly exploited to construct heterogeneously integrated electronic devices. A typical wet transfer printing method exhibits limitations related to unwanted displacement and shape distortion of the device due to uncontrollable fluid movement and slow chemical diffusion. In this study, a dry transfer printing technique that permits reliable and instant release of devices by exploiting the thermal expansion mismatch between adjacent materials is demonstrated, and computational studies are conducted to investigate the fundamental mechanisms of the dry transfer printing process. Extensive exemplary demonstrations of multiscale, sequential wet-dry, circuit-level, and biological topography-based transfer printing demonstrate the potential of this technique for many other emerging applications in modern electronics that have not been achieved through conventional wet transfer printing over the past few decades. (*Science Advances,* July 2021; https://www.science.org/doi/10.1126/sciadv.abh0040)

Others of Note

Discovery of new types of defects in 2-D materials may give insight into how to create materials without such imperfections, leading to better ultra-compact electronic devices, according to a group of Penn State researchers. (https://phys.org/news/2021-08-2d-material-defects-enable-electronics.html)

Recently, there has been renewed interest in mature thin film silicon technologies for display backplanes and sensing applications. However, the presence of kink effect remains a challenge for TFT design. (https://onlinelibrary.wiley.com/doi/10.1002/aelm.202100533)

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


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