Tying in to the Digital Thread, p. 22

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January 2020

DesignCon Show Issue

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CIRCUITS ASSEMBLY

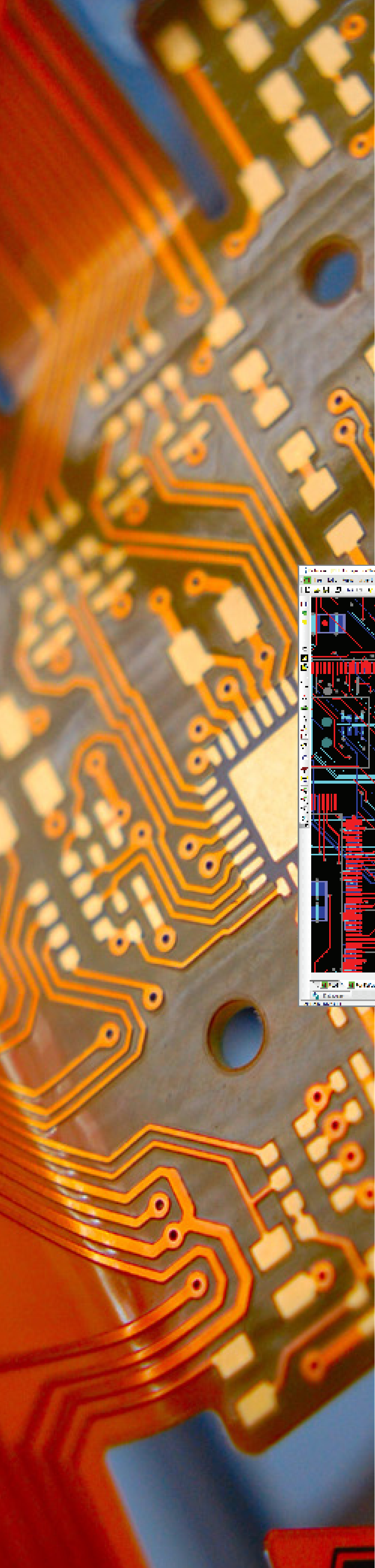
Downtime Reduction Tools

KEEP THE LINE MOVING

Next-Gen ***Loss Requirements***

Solder Joint Crack ***Inspection***

Rocket Men:
The CIRCUITS ASSEMBLY EMS
Company of the Year

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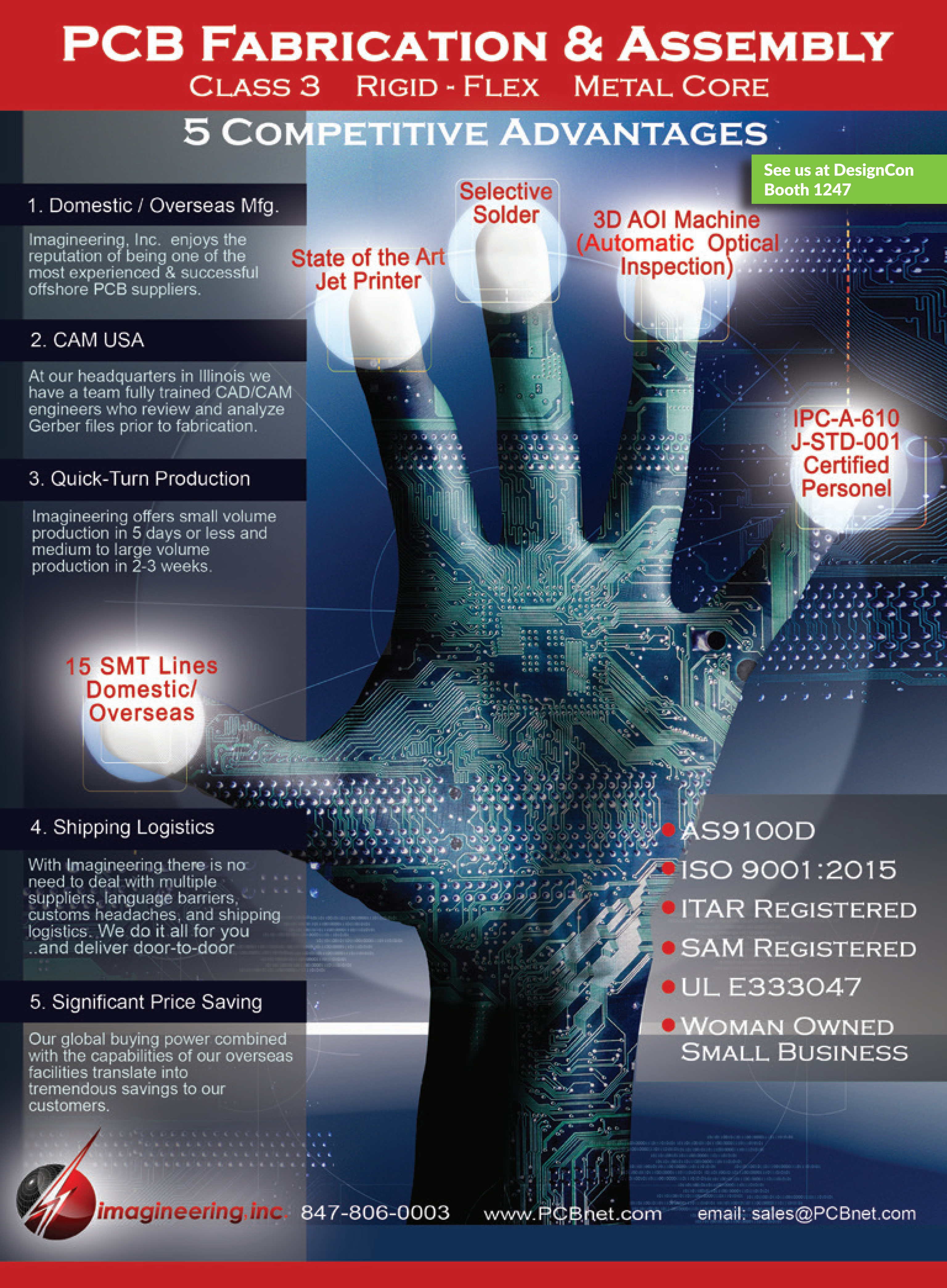

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with DAVID HELLER

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MIKE BUETOW
EDITOR-IN-CHIEF

After 30 Years, The Recorder Goes On

THIS year marks the start of my fourth decade in the electronics industry, and if you find that hard to believe, well, so do I.

I was reminiscing with a couple of other "old-timers" in recent weeks over the changes that have occurred since I first stepped foot in a factory. I was a graduate of the University of Illinois, and recently relocated to Chicago, when I joined a few others on a tour of the just-revamped Allen-Bradley plant on Second St. in Milwaukee.

Who remembers any of these names: deHaart. HTI. Conceptronic. Dynapert. Sensbey. Celmacs. Those were some of the bigger names in assembly equipment at the time. Many key suppliers then were subsidiaries of end-product OEMs. Kester was owned by Litton. Dynapert was a unit of Black & Decker.

Forget "lights-out" manufacturing. Even "hands-free" was more theory than reality. Semiautomatic machines, including printers and even placement, were common. DEK had just launched the programmable automatic printer it called the 265. What we now call solder paste was in some circles referred to as solder cream. In those days, as many equipment vendors made IR reflow as forced convention.

The big placement equipment OEMs included Siemens and Philips. Zevatech (purchased by Juki in 1999), promoted its first dual-placement machine, capable of 4,200cph, considerably faster than rival Quad's 3,400cph "production volume placer." Companies still pitched manual assembly workstations.

The big names in cleaning were Westek, Accel and EMC. ECD was around, but it made dispensers.

Fine-pitch was 25 mils, and to inspect it CyberOptics had invented something called an "SMT Process Control Cell." The global SMT assembly market added up to about $8.2 billion. That was about 40% of the size of the bare board market, pegged by IPC at $20.5 billion. The market for solder paste ("cream") was about $120 million worldwide. Contract manufacturers (the term "electronics manufacturing services" had yet to be coined) were starting to be leveraged by OEMs that didn't want to tie up all their capital in new surface mount machines.

That Allen-Bradley plant was revelation. A-B had teamed with Digital Equipment to install computer-integrated manufacturing throughout the production area. It invested nearly $10 million (in 1991 dollars) to overhaul the 28,000 sq. ft. space in downtown Milwaukee with screen printers, dispensers, placement lines, and IR reflow systems from Universal Instruments. Electrovert provided the wave machines, and H-P supplied the inline ICT systems.

Product traveled the factory in an "S" pattern from top-side SMT to through-hole insertion to bottom-side SMT, then manual assembly, wave solder, ICT and repair, and finally routing. One-day throughput without a qualification run was achieved, and work-in-process was cut to one day. One of the novel features was overhead conveyors that moved panels past the operations that didn't need to touch the product, such as ICT.

The design side was no different. Signal processing speeds were just breaking 50MHz. One of my first stories was on the state of the CAD industry. I discussed Cadence, Intergraph (fresh off its acquisition of Daisy-Cadnetix) and Valid Logic.

Geographically, the market consisted of the US, Japan and Europe. China wasn't on the radar of many. The dissolution of the USSR in late 1991 had the seers excited over the potential Eastern Europe, however, with some calling it the most dynamic economy in the world. That the industry would someday chase low labor rates was not a commonly held view at the time. John Maxwell, a leading component guru and one of my early advisors, went so far as to say, "There is little to be saved when high technology production is moved to low-labor-rate countries. The Japanese have proven without a doubt that labor is not a major factor in production cost."

In Maxwell's defense, I've made far worse assessments. So, too, has the industry. Sometimes we learn; sometimes we don't. Failure is an integral part of progress.

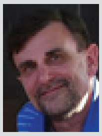
As for that Allen-Bradley plant? It's still humming, and it's still pushing the edges of software-driven processing as part of Rockwell Automation's Smart Manufacturing vanguard. (In fact, the term "connected enterprise" comes from Rockwell Automation's CTO.)

The people and companies that push the envelope don't always succeed in the long run, but they pave the way for those who do – and make it interesting for the recorders of history like me.

mbuetow@upmediagroup.com
@mikebuetow

P.S. Join us for our annual NPI And Service Excellence Awards on Feb. 4 at IPC Apex Expo, booth #2748!

PCDF People



Amphenol Printed Circuits named **Bob Wolfe** PCB design engineer. He has 35 years' experience in design with Executone, Kimchuk, IPC Systems and others.

Bernie Kessler, a member of the IPC Hall of Fame and an epoxy-glass laminate pioneer, passed away Dec. 2. He was 96.

Nano Dimension appointed **Yoav Stern** president and CEO. Stern is a turnaround specialist with experience in building smaller companies. He has been cochairman of Bogen Corp. for 22 years and was executive chairman of Kellar Aerospace for eight years.

Unimicron named **Christina Jien** manager. She has nearly 20 years in PCB fabrication with Tripod, Elite Material, Atotech and Compeq.

Ventec appointed **Anthony Jackson** general manager UK. He was previously in senior management at Amphenol-Invotec and has experience at Manchester Circuits, Viasystems and DDI Thomas-Walter.

PCDF Briefs

Accucode purchased a **Nano Dimension** DragonFly LDM additive manufacturing system, its second.

Element Solutions announced a $15,000 prize competition aimed at students in metal coatings science.

Firan Technology Group's new contract with its represented employees at its Aerospace – Toronto facility has been negotiated and ratified.

Founder PCB will open a smart factory for high-end communication equipment by June next year.

MoDeCH launched an English language version of its e-commerce site. Previously available only in Japan, Model On! Search provides access to design and simulation models, device models individually and on-demand. It enables customers dependent on simulations performed using PSpice and LTspice to make design decisions.

Most printed electronics today rely on high-quality inks to produce conductive patterns, but new technology from **Space Foundry** uses atmospheric pressure plasma to print and finely tune conductive materials onto 3-D substrates.

Cadence to Acquire NWR for $160M

SAN JOSE – Cadence Design Systems on Dec. 2 signed a definitive agreement to acquire AWR, a developer of high-frequency RF EDA software.

Cadence will pay National Instruments $160 million in cash for AWR, which NI acquired in 2011. The deal is expected to close in the first quarter of 2020.

Cadence expects 110 AWR employees to join the firm.

"Companies designing communication and radar chips, modules and systems face increasing time-to-market pressure in high-growth 5G/wireless applications. Creating differentiated products while reducing cycle time requires a seamless design, simulation and analysis environment," said Dr. Anirudh Devgan, president, Cadence. "The addition of AWR's talent and technologies will enable us to provide more integrated and optimized RF design solutions, thereby further accelerating system innovation as we execute our intelligent system design strategy."

Cadence expects to integrate AWR with its own Allegro PCB design flow and other platforms for RF IC design, plus its Sigrity, Celsius and Clarity tools.

The flows resulting from the integration of AWR and Cadence software are expected to be tightly connected with the NI LabView and PXI modular instrumentation systems and semiconductor data platform as part of a new strategic alliance, the companies added. – *CD*

Report: Chiplets' Influence to Spike

AUSTIN, TX – Continued monolithic integration is expensive and can suffer from the defect density yield loss associated with large die.

As a result, an increasing number of companies are turning to new architectures using chiplets to achieve the economic advantages lost with expensive monolithic scaling.

That's according to a new report from TechSearch International. Advanced Packaging Update (APU) details advantages of chiplets and provides examples in production today, as well as a preview of future end-products. The 45-page report provides an update on embedded bridge developments and a forecast for high bandwidth memory (HBM). The TechSearch report also peeks inside Apple's latest iPhone with a count of the wafer-level packages (WLPs) and finds a surprising amount of underfill. – *MB*

LG Innotek, Samsung E-M to Trim HDI Units

SEOUL – Saying its market for HDI boards has dried up, LG Innotek will cease production of PCBs this year, the company said. The company cited lower demand for mobile devices and increased competition.

In a statement on Nov. 28, the PCB fabricator said it has decided to focus instead on semiconductor substrates.

The company was expected to end PCB production by the end of December and close out inventories by June. Staff and related equipment will be transferred to the semiconductor business.

HDI sales make up 3% of LG Innotek's overall sales.

Likewise, Samsung Electro-Mechanics plans to shut down its HDI PCB manufacturing facility in Jiangsu, China, here as a result of poor profits, according to reports. The site will cease production and sales, and the company will sell its assets there. – *MB*

RECOM Power is launching digital models for its entire product catalog in collaboration with **SnapEDA**.

TTM Technologies announced the opening of an engineering center in Binghamton, NY, following the acquisition of manufacturing and intellectual property assets from **i3 Electronics**.

CA People

ACL Staticide appointed **Dan Kaiser** national sales manager. He has more than 20 years' experience in electronics distribution and business development.

Columbia Tech named **Peter Wise** principle manufacturing quoting engineer.

Indra Setiawan of SIIX EMS in Indonesia won top honors in the annual IPC hand soldering world championship.

IPC named **Alison James** senior director, Europe, and **Charlene Gunter du Plessis** senior director, IPC Education Foundation.

Plexus promoted **Ursula Marquez de Tino**, Ph. D. to customer quality manager. She joined Plexus in 2010 as a senior staff process engineer, and prior to that spent seven years as a process and research engineer at Vitronics.

Michael Joseph Connolly, former superintendent of printer and card manufacturing at IBM and vice president at SCI, has passed away.

VJ Electronix and VJ Technologies named **Lian Li** general manager operations in China. She has a degree in mechanical technology and equipment and was an engineer at SciEnScope and vice general manager at Unicomp.

CA Briefs

Arch Systems announced an agreement with **Flex** to supply real-time access to and analysis of manufacturing data at its facilities.

Computrol installed a Mycronic LX-300 placement line and Agilis tray magazine tower.

East West Manufacturing, a design, manufacturing and distribution company, has acquired **Adcotron EMS** for an undisclosed sum.

NCAB Acquires Altus PCB

BROMMA, SWEDEN – NCAB Group signed an agreement Nov. 14 to acquire 100% of the shares in Altus PCB for an undisclosed sum. Cresskill, NJ-based Altus had revenue of $4.8 million in 2018.

"We are very happy to join forces with Altus PCB," said Martin Magnusson, president, NCAB Group USA. "NCAB Group USA and Altus share a vision to provide PCBs with quality first in mind, and excellent service and engineering support to our customers. With our combined purchasing power, we will have more leverage to continue to provide PCBs to all our customers at the lowest total cost."

"This is a great opportunity for all of us," said Zohar Shinar, president, Altus PCB. "Altus PCB is privately owned and dominated by a customer-driven culture with a goal to deliver superior performance and value. Being selected by NCAB Group to be a part of their North American growth is a great compliment. Joining with NCAB will give us access to their purchasing power, 65-person factory management team in Asia and industry's best PCB facilities. I am looking forward to working for NCAB Group USA to solidify the transition, continue to grow our business and tackle the most demanding PCB requirements in our industry." – *CD*

USI to Acquire AsteelFlash in Largest EMS Deal in 10+ Years

SHANGHAI – Universal Scientific Industrial, also known as Huanxu Electronics, has signed a preliminary letter of intent to acquire the parent company of AsteelFlash for $450 million. The deal is expected to close by September.

In a filing, Huanxu said it will finance the deal through a combination of new shares and cash. Following the acquisition, which is expected to close in the third quarter of 2020, Asteelflash will become a subsidiary of USI. Asteelflash's existing operations management team will be retained, according to public reports.

The deal would merge the no. 13 and 27th ranked companies on the CIRCUITS ASSEMBLY Top 50 into an EMS firm with nearly 35 manufacturing sites worldwide and with combined revenues topping $6 billion annually.

If consummated, it would be the largest pure EMS to EMS acquisition since Flex acquired Solectron in 2007.

The acquisition of Financière AFG (FAFG) is not expected to constitute a major asset reorganization, Huanxu said in the filing. FAFG is the holding company of AsteelFlash and its majority owner.

The companies signed a formal transaction agreement on Dec. 12, but the specific transaction plan is still under discussion, Huanxu said. Audits, legal and financial advisory work is pending, as are approvals from China, the US and the EU.

FAFG is made up of multiple investor groups, including SPFH Holding Korlatolt, (62% stake), ASDI Assistance Direction (27.6%), Arkéa Capital Investissement (5.25%) and other minority shareholders. – *MB*

Element Solutions Acquires Kester for $68M

MIAMI – Element Solutions, the parent company of Alpha, has acquired Kester from Illinois Tool Works for $68 million in cash. The acquisition brings together two major players in the electronics solder materials industry.

“Kester is a high-quality business with a great brand and strong legacy that brings us new capabilities and broader market access, while fitting well within our existing electronics assembly materials business,” said Benjamin Gliklich, CEO, Element Solutions. “This acquisition is a model for the prudent, highly strategic acquisitions that Element Solutions aims to pursue, alongside the judicious return of capital to shareholders in its capital allocation strategy.”

Kester was founded in 1899 as the Chicago Solder Co. and acquired by ITW in 2006. It has manufacturing facilities in the US, Singapore and Germany.

Element Solutions is the former Platform Specialty Products, a conglomerate formed in 2013 that includes the former MacDermid and Alpha brands. – *MB*

Final DoD Rule Issued on Counterfeit Parts Reporting

WASHINGTON – The Department of Defense, GSA and NASA are issuing a final rule amending the Federal Acquisition Regulation (FAR) to require contractors and subcontractors to report to the Government-Industry Data Exchange Program (GiDEP) certain counterfeit or suspect counterfeit parts and certain major or critical nonconformances.

The final rule does not apply to contracts and subcontracts for the acquisition of commercial items, including commercially available off-the-shelf items. Section 818(c)(4) of the NDAA for 2012 will not apply to contracts and subcontracts at or below the simplified acquisition threshold.

In addition to the requirements for section 818(c)(4) regarding electronic parts for the DoD, the rule focuses on supplies that require higher-level quality standards or are determined to be critical items.

The rule also exempts medical devices subject to the Food and Drug Administration reporting requirements; foreign corporations or partnerships that do not have an office, place of business, or paying agent in the US; counterfeit, suspect counterfeit, or nonconforming items that are the subject of an ongoing criminal investigation, unless the report is approved by the cognizant law enforcement agency; and nonconforming items (other than counterfeit or suspect counterfeit items) for which it can be confirmed the organization where the defect was generated has not released the item to more than one customer.

The final rule is available at https://tinyurl.com/qnvh777. – *CD*

Engo Holdings launched a computer and mobile phone assembly and manufacturing plant in Uganda.

Eurocircuits invested €5 million in equipment and software in 2019, primarily to enhance EMS work at its plant in Eger, Hungary.

iNEMI is conducting a survey to assess the planning and readiness levels of the electronics manufacturing industry for the implementation of low-temperature solders in high-volume board assembly. The consortium also released chapters on Ceramic Interconnect & Photovoltaics, Connectors, and Passive Components from its *2019 Roadmap*.

Insituware appointed as manufacturers’ representatives **Southwest Systems Technology** in Texas, Oklahoma, Arkansas and Louisiana, **Horizon Sales** in the Midwest US, and **WittcoSales** in Southern California, Southern Nevada, Tijuana, Mexicali and Baja California.

Keytronic has started shipping product from its new 133,000 sq. ft. manufacturing facility in Da Nang, Vietnam.

Kurtz Ersa Asia opened an expanded building in Zhuhai.

Mouser opened a customer service center in the Philippines.

MRSI moved to a new 102,000 sq. ft. facility in Tewksbury, MA.

Nordson Advanced Technology K.K. Japan has relocated to a new, larger office and has demonstration facilities in Central Tokyo.

Nortech Systems implemented **Check-Sum’s** UI for its end-of-line testing.

Panasonic will build its first consumer electronics plant in China in 16 years.

Qisda plans to expand its medical unit into Southeast Asia to boost its revenue by 30% annually next year.

Salcomp, one of **Apple’s** major suppliers, agreed to buy **Nokia’s** Chennai plant for around $30 million.

Seho Systems is establishing a subsidiary in Shanghai to focus on the requirements of its Chinese customers.

SEMI has developed “SEMI SMT-ELS (Equipment Link Standards),” a suite of standards for SMT assembly lines. The new suite replaces SMEMA and adds data communication capabilities to add intelligence to assembly lines.

Shinry Technologies purchased three **Universal Instruments** Uflex placement platforms.

Sumitronics Manufacturing (Cambodia) launched EMS operations in Poipet, Cambodia.

Swissbit opened a state-of-the-art electronics production facility in Berlin.

TopLine announced expanded collaboration and technical cooperation with **VPT Components** to provide CCGA column attachment services.

Universal Instruments opened a software center in its corporate facility in Bratislava, Slovakia. It also installed a **GPD** Global MAX II dispenser in its Advanced Process Lab in New York.

Virtex has acquired fellow EMS **Precision Technology (PTI)** for an undisclosed sum. PTI is based in Plano, TX, and has been in EMS for more than 20 years.

EDITED BY CHELSEY DRYSDALE

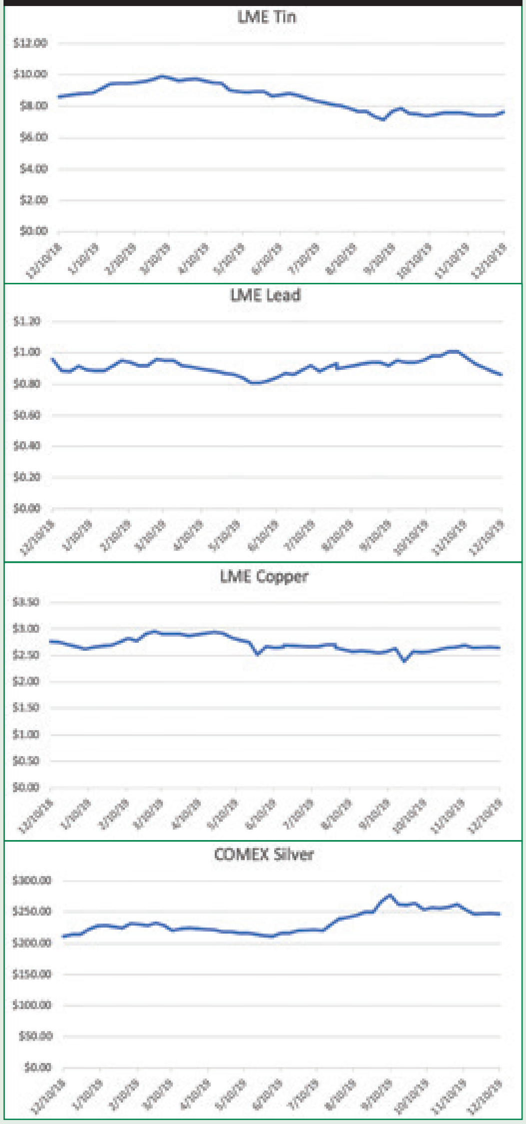
STORAGE BURSTS

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

	% CHANGE			
	Aug.	Sept.	Oct.	YTD%
Computers and electronics products	-0.3	-0.3	05.	3.9
Computers	-2.0	-7.1	1.5	-23.5
Storage devices	-0.3	-11.3	26.7	19.9
Other peripheral equipment	4.6	2.4	-2.3	5.1
Nondefense communications equipment	0.0	0.2	-0.3	10.9
Defense communications equipment	-3.0	-0.4	-8.1	-3.0
A/V equipment	-8.0	-3.9	4.4	28.4
Components[1]	2.2	-1.5	-0.4	4.2
Nondefense search and navigation equipment	-0.1	-5.7	4.7	2.5
Defense search and navigation equipment	-0.7	1.4	0.1	3.3
Medical, measurement and control	-1.0	0.3	1.3	0.3

[r]Revised. *Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: U.S. Department of Commerce Census Bureau, Dec. 5, 2019

METALS INDEX



2020 Memory Outlook Looking Good

SCOTTSDALE, AZ – The 2020 NAND flash market is expected to rise 19%, reversing a 27% decline in 2019. DRAMs are forecast to grow 12%, another strong turnaround from 2019, added IC Insights.

Solid-state computing is expected to drive demand for high-density, high-performance NAND flash this year, even as mobile applications continue to be a significant application. Momentum for 5G connectivity, AI, deep learning, and virtual reality in mobile, data center and cloud-computer servers, automotive, and industrial markets will boost growth in NAND flash and DRAM. Other drivers include increasing electronic content onboard new cars.

Among the IC product categories, 26 are forecast to show growth in 2020, an impressive turnaround from 2019 when only six IC product segments showed sales gains. Five products are expected to enjoy double-digit growth in 2020, an increase from four in 2019 but down from the 17 product categories with double-digit growth in 2018. Seven products are forecast to show flat growth or a market decline in 2020.

Hot Takes

- Taiwanese fabricators see an improving order picture in 2020. (TPCA)
- Global electronic equipment sales increased an estimated 0.3% in the third quarter, based on a combination of company financial reports, individual company projections and estimates. (Custer Consulting)
- Wearable technology continues to gather pace, building an ecosystem of connected devices and capturing consumer attention to the tune of $108 billion by 2023. (Futuresource Consulting)
- Worldwide net additions of autonomous vehicles will reach 745,705 units by 2023, up from 137,129 units in 2018. (Gartner)
- Global AR/VR spending is forecast to be $18.8 billion in 2020, an increase of 79% over 2019. (IDC)

US MANUFACTURING INDICES

	JULY	AUG.	SEPT.	OCT.	NOV.
PMI	51.2	49.1	47.8	48.3	48.1
New orders	50.8	47.2	47.3	49.1	47.2
Production	50.8	49.5	47.3	46.2	49.1
Inventories	49.5	49.9	46.9	48.9	45.5
Customer inventories	45.7	44.9	45.5	47.8	45.0
Backlogs	43.1	46.3	45.1	44.1	43.0

Source: Institute for Supply Management, Dec. 2, 2019

KEY COMPONENTS

	JUNE	JULY	AUG.	SEPT.	OCT.
Semiconductor equipment billings[1]	-18.4%	-14.6%	-10.5%	-5.7%[r]	3.9%[p]
Semiconductors[2]	-16.5%	-15.5%	-15.4%	-14.6%[r]	-13.1%[p]
PCBs[3] (North America)	1.00	1.00	1.02	1.04	1.11
Computers/electronic products[4]	5.46	5.46	5.48	5.52[r]	5.48[p]

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

- Vendor revenue in the worldwide server market declined 6.7% year-over-year to $22 billion during the third quarter, while shipments dropped 3% to 3.1 million units. (IDC)

New Year, Same Problems

Changes in materials and components mean yesterday's issues are also today's.

INDUSTRY IS MUCH like the classic Bill Murray movie *Groundhog Day:* We work on a technical challenge, solve it, and wake up the next day and solve it again.

A recent industry gathering offered such an example. The subject was profiling ovens used in the assembly of circuit boards. Over my decades-long career I have seen dozens of presentations on that very subject. Each time the challenge was the same: new solder materials, laminate or components require tighter and more-defined performance from the oven; thus, the oven must be profiled with ever-greater accuracy and precision.

This recurring phenomenon is not unique to the PCB industry. The original automotive engineers worked on how to make a car accelerate and brake faster, just as their successors do today. The materials, control technologies and performance demands may change, but the recurring engineering challenge is there, whether it's for an auto braking system or wave solder process.

And that is what makes technology industries so exciting. Once you have met "the" challenge, a new material, process or requirement forces you to rethink that solution in favor of an even better one.

The drivers behind the technical challenge always seem new, and often awe-inspiring, channeling out-of-the-box thinking. In reality, however, they are most likely the usual suspects.

Materials. The appetite is insatiable to develop new materials that enable tighter, smaller, lighter and more feature-rich performance laminates capable of higher temperature performance; films and coatings that support finer definitions; the list goes on.

Chemicals. With advancing performance requirements and evolving environmental demands, few categories have required such constant rethinking of processes and processing, with no end in sight.

Manufacturing equipment: Becoming more sophisticated as sensors, software and achievable tolerance advances enable capabilities only dreamed of a few years ago.

Data and analytics. Call it smarter processing, ERP software or Industry 4.0, the ability to collect and move data among equipment and processes, and slice and dice that data to generate usable analytics to improve quality and throughput, the future of manufacturing is entering the next phase of information sophistication.

People. The skills needed to manage equipment, process, product or enterprise are changing, challenging all to rethink what we need to master to meet the new and recurring challenges of evolving materials, chemistry and equipment.

All the above have been evolving for centuries. New materials, chemistries and equipment may show more obvious transformations, yet data too has changed from simple observation and verbal communication to written documentation to typed documentation through various iterations of computerization. And despite what some proponents of AI may think, people are still at the center of creativity, process and material improvement, as well as harnessing the equipment and data to move product and industry forward.

Anyone who feels stagnant or bored in their current role, regardless of their level or job task, pull off those blinders and look around. Even the most rote and seemingly basic task requires commitment to meet the new challenges. Maybe it's a different way of handling necessitated by a change to material or process; maybe it's understanding that tolerances require sharper attention to detail to ensure compliance; or maybe it's managing employees differently to teach new skills or techniques. For some, opportunity may be as simple as an attitude adjustment.

For people beginning their career, regardless of education or discipline, our industry offers opportunity. Being part of technological advancement that enables new and exciting products essential to and enjoyed by users is just one reason. Unlike many careers, in electronics you are actively involved in the future of technology and products. In addition, our industry has an unprecedented number of people approaching retirement age. For anyone who is smart, hardworking and ambitious, there is no better career track than an industry that offers both a bright future and ample opportunity for relatively rapid advancement.

So, as we embark on a new year and the next decade of this century, there's much to look forward to. There will always be new challenges, technical as well as commercial. There will be new solutions in need of thorough vetting, but that might improve quality and enhance technical performance and capabilities. Many of these challenges will appear the same as in the past; others will at first glance look completely different but may require leveraging methods and tactics that have been successfully implemented to meet past challenges. All, however, will require every participant to collaborate and creatively think and rethink how to meet that challenge. Much like *Groundhog Day*, face the new challenge, overcome it, and repeat! ❑

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Are You Giving Away Your Customer's IP?

And does your purchasing department know what to send, and what not to?

MANY COMMERCIAL EMS and OEM companies have a gaping hole in the system to protect the intellectual property (IP) of their customers.

I can't count the number of emails from customers requesting a quote for a printed circuit board that include not only the Gerber file(s) for that PCB, but also the assembly drawing, the bill of materials, and the schematic drawing for the entire product.

Companies in our industry take a number of steps to protect customer IP. They require signed nondisclosure agreements for all involved in the manufacture of their PCBs. They verify the identity of any visitors to their secured US manufacturing facilities and assign outsiders mandatory escorts. They may ban cellphones or any other devices that could be used to record inside those facilities.

However, with a press of the Send button, all that IP protection goes out the door.

It's no secret the vendors I recommend for PCB manufacture are based in Asia. Yet routinely, without any precautions, all the information required to build a particular product is emailed to me and my team, which is located on the other side of the world.

I don't know whether to laugh or cry.

Is it any wonder the theft of intellectual property is such a pressing problem, in our industry, as well as in many others?

It's not necessarily the fault of PCB buyers or program managers. With everything converted to bits of data and the number of purchasing personnel greatly reduced, buyers and program managers may not get the same opportunities they once did to understand the end-products being produced, let alone who they are produced for. And they may not even understand the circuit boards they've been tasked to buy.

While buyers may have received cursory training in protecting customer IP, many still simply forward files to overseas PCB vendors, not realizing what they're doing.

In other words, they don't know any better because they lack the knowledge needed to review PCB fab specs themselves. Unfortunately, custom-made PCBs have come to be viewed as just another commodity that does not require specialized training, and concern for IP protection (at least in the quoting phase) often goes by the wayside.

The same lack of understanding often surfaces in orders for military and ITAR PCBs, where the consequences for mishandling information can be dire, including fines, vendor disqualification, and lost revenue. In many cases, sensitive documents related to military and ITAR orders are not clearly marked.

So how do OEM and EMS companies plug that gaping hole in customer IP protection?

It begins with the sales department. Have a documented discussion with your customers about which information needs protection and which does not. This documented discussion should be required reading for buyers and program managers.

Avoid the temptation to label every aspect of a project as intellectual property (when it's not actually necessary), as that will make it harder for your quoting and manufacturing teams to function in a timely manner.

Your organization also needs a designated department (usually engineering or quality) with the ability to review all customer files (electronic and hard copy) and determine which information needs IP protection and which does not. This department should label protected documents with an easily recognizable code or prefix, making it clear to all personnel that the information contained therein is confidential and is not to leave the facility without appropriate precautions.

Having such a department assigned the responsibility of designating protected customer IP makes it easier for quoting and purchasing teams. They can focus on their jobs, while your customers (and management) can rest easy knowing information is properly handled.

PCB buyers today seem responsible for the acquisition of everything from HDI boards to cable assemblies to, sometimes, even the office toilet paper. Unfortunately, most have been given only on-the-job training for their wide-ranging responsibilities. This is often inadequate to the task.

EMS and OEM firms, especially those that tout their ISO certification and supply-chain prowess, should provide professional corporate training to ensure their procurement departments are not inadvertently releasing unsecured information that could be harmful to their customers and their own bottom lines. ☐

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Meeting Gamers' Demands Has Made Life Better for All

If you want to know where tech is going, watch the kids.

VIDEO GAME SALES were valued at $79 billion in 2017, larger than the global PCB market and growing at about 14% per annum. As far as gaming hardware is concerned, combined sales of pure game consoles and high-performing PC graphics cards for gaming generate about $50 billion each year.

Short product lifetimes mean gaming hardware is a constant revenue driver. In addition, gamers' demands for more lifelike experiences have driven rapid technological change, including the development of dedicated high-performance graphics processing units (GPUs), which first emerged in the late 1990s.

The GPU was initially conceived to boost 3-D graphics performance, taking on specific workloads such as triangle calculation. As GPU capabilities have increased, game designers have increased the complexity of their scenes to ensure ever-greater realism. Ultimately, of course, the benefits of this "arms race" have transcended the gaming community: GPUs are now found to be remarkably adept at taking on performance-hungry workloads such as AI acceleration and blockchain mining, tasks that much of today's world depends on but that could barely have been on researchers' radars when the first GPU chips hit the market.

The gaming industry can also take a great deal of credit for the development of augmented reality and virtual reality (AR/VR). Although Google failed to enthuse the general public to live routinely in augmented reality with its Glass experiment, industries are now embracing the technology to gain competitive advantages in areas such as production assembly and logistics. AR headsets can make perfect sense in a working context. Having live instructions such as how to assemble a mechanism, or the correct torque for specific fixings, presented directly in the field of view – just when needed and in the correct sequence – is not only faster than checking against a hard-copy instruction book but also greatly reduces opportunities for human error.

Virtual reality headsets are becoming more affordable, and there is more choice, too, as manufacturers differentiate their ranges from entry-level to high-end. Now, developers of professional tools are utilizing high-performance VR engines originally built to power realistic gaming experiences. They are being used to create immersive new apps for purposes such as medical training, athletic performance analysis, product design, and remote equipment maintenance.

It's not difficult to understand the benefits to be gained from practicing within a realistic, digital simulation before beginning a risky surgical procedure on a real patient. Or being able to visualize every aspect of a component or product and assess form, fit and function, and to quickly make changes and assess their impact, before committing to build even a first prototype. A further step is to take advantage of virtual reality in conjunction with other technologies such as digital twin to create live simulations of equipment in the field – such as a jet engine or power station – that are continuously updated with real-time data and allow experts to "walk around" digitally to identify potential problems or areas where the design could be improved.

Conversely, mobile gamers can thank the communications industry for forthcoming improvements to their online experiences. I've mentioned 5G in this column several times because it will profoundly change the way almost all of us work, live and play. For gamers, low-latency communication will transform their experiences by simultaneously enabling faster action and more sophisticated contexts, while also alleviating the frustration of games lost due to connection problems that always seem to occur at a crucial moment.

At the nexus of gaming and the real world, eSports is driving the emergence of a whole new kind of sports hero. Professional teams, such as soccer teams, are embracing this field not only to generate publicity for their brand but also as a standalone revenue center. Thousands of spectators join eSports events, both live at the venues where they are played and online, so there are potentially huge worldwide audiences.

A key enabler underlying all this is the continued exponential increase in computing performance achieved through developments in large-scale silicon integration. Although we now know simply shrinking the feature size to the next process node can no longer maintain progress along the lines of Moore's Law, techniques such as 3-D die stacking are being developed to continue increasing the number of transistors on-chip and the peak performance capability of future generations of processors.

All this, of course, challenges the PCB industry to provide new products and materials compatible with the increasing signal speeds into and out of the chip, and across high-bandwidth external memory interfaces. We need to keep developing advanced low-loss materials to minimize the heating effects high-frequency signals can have on the substrate, just as much as we need them to ensure adequate signal integrity at such high speeds.

It's not just the patience of gamers at stake, but the solutions the world needs to continue increasing the quality of healthcare, raising industrial productivity, maintaining trust in the internet and our financial systems, and myriad other improvements we all hope new technology will make possible. □

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Enabling the Electronics Digital Thread

Model-based enterprise initiatives often ignore electronics.

REAMS OF PRESENTATIONS land data support efficiencies gained by digital thread initiatives, but much of the dialogue is driven by mechanical design processes with little regard for the electronics components of a product being developed, deployed and maintained. To review some of these basic concepts, see **FIGURE 1**, which starts with model-based design as a foundation of a model-based enterprise. This enables a robust digital thread that feeds into Industry 4.0 with smart factory initiatives under a framework of communication and collaboration that is defined as intelligent information management (IIM).

In particular, the digital thread is focused on breaking down the data and workflows that are siloed inside of and among companies that need to be connected in the product lifecycle. This enhances organizational decision-making by getting the proverbial right information to the right people at the right time. For electronics, however, engaging these initiatives is not a simple matter. To understand the problem, Google the phrase "model-based definition" and you would be hard-pressed to find electronics. Mechanical design was the leading edge of model-based practices starting 10 or more years ago, and accordingly, the search results still show pages of MCAD images and GD&T samples, along with tons of conversations related to MCAD system best practices for eliminating traditional paper and 2-D drawings to improve communication and efficiencies.

Today's complex products are not just composed of machined parts. A properly connected digital thread relies on access to the electronics information. If an entire domain of information in the digital thread that defines a product is missing, the digital thread could unravel.

The solution to this problem seems easy, right? The perfect provider will offer best-in-class design solutions for MCAD, PCB and wire harness, all under the umbrella of a seamless data management system perfectly synced to the best ERP, MRP or supply-chain systems. Those who have tried to accomplish this have mostly been more vision than reality. Interoperability challenges, changing software releases, legacy vs. modern data needs, mergers and more hinder the integration of common functions and make communication and collaboration between organizations and product domains difficult.

A proper digital thread solution will be able to access authoritative information, regardless of whether it is legacy or modern MCAD/ECAD, and publish it with value-added inputs from other user segments, such as sales, sourcing and manufacturing. For electronics it starts with a better understanding and visualization of PCB or wire harness information using a neutral browser-based approach that anyone, not just design tool experts, can access, comment and

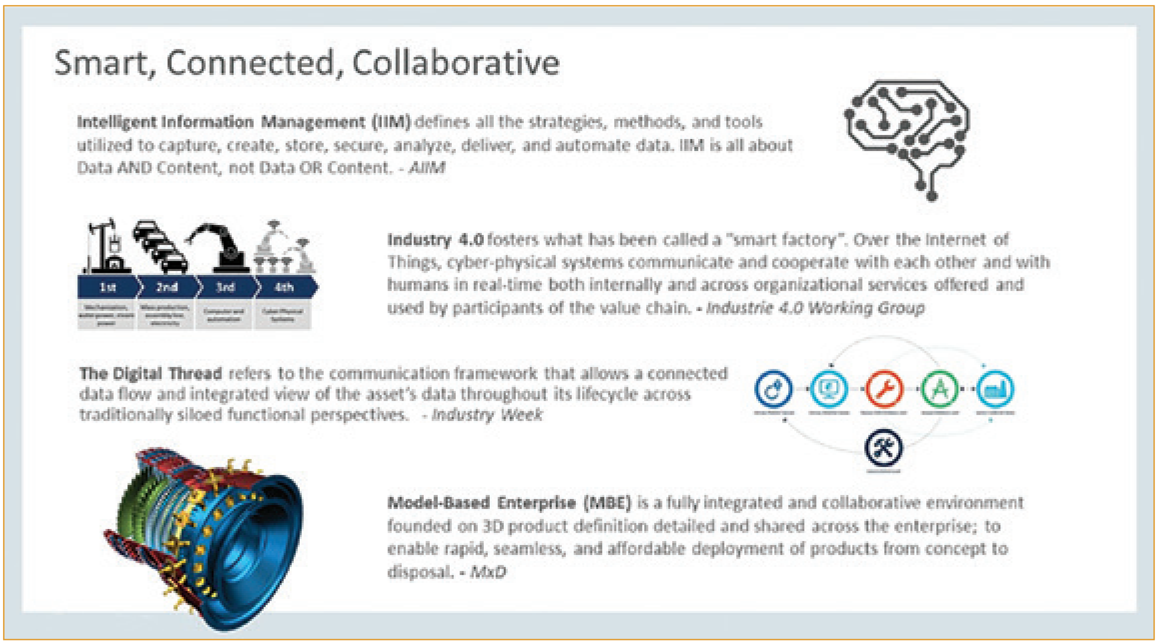

FIGURE 1. Model-based enterprise as a foundation of intelligent information management.

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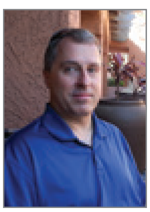

collaborate with (**FIGURE 2**). This content must be controlled such that only the appropriate persons can view and mark it up as needed. This is all part of IIM, providing a visually collaborative environment based on standards such as STEP, IPC-2581, HTML5 and more.

A suitable visual collaboration solution will merge the mechanical and electrical functions, which is critical to best understand packaging and work instructions (via animation and other techniques) to show how a complete system is assembled. For example, a work instruction step can show how the electronics subassembly is mounted into the product and tested (**FIGURE 3**). With a consistent browser-based interface, electrical-mechanical processes can be executed, tracked and verified with all the details synced to background manufacturing, quality and supplier systems, as needed. When any changes are needed in the presentation and type of information from authoritative systems, the impact to the combined electric-mechanical presentation of information is minimal. This is the definition of a flexible and resilient digital thread that fully represents today's complex products.

Even high-reliability, documentation-intensive customers ranging from aerospace to defense to automotive can use such a platform to visualize wire-harness 3-D work instructions for manufacturing or field maintenance. In the past, these same clients were exchanging paper, checking documents, coordinating between mechanical and electrical designs and could waste more than 50% of their time figuring out what needed to be done before they could start work. A tablet PC with the information at their fingertips greatly improves productivity and reduces costly errors. Streaming this type of information to wearable devices for hands-free work further improves the situation.

For a true electrical-mechanical intelligent information management approach to work, it is necessary to face the challenges of organizational culture. Digital transformation can be accelerated by standards-based solutions, but changing any process, especially a closer intermingling of the silos where mechanical and electrical have traditionally existed, requires management support and a vision that spanning domains will result in better products. A solution that reuses and maintains your existing authoritative data will make it easier to overcome organizational resistance and rapidly accelerate companies to a true digital thread solution that fully includes electronics. ▫

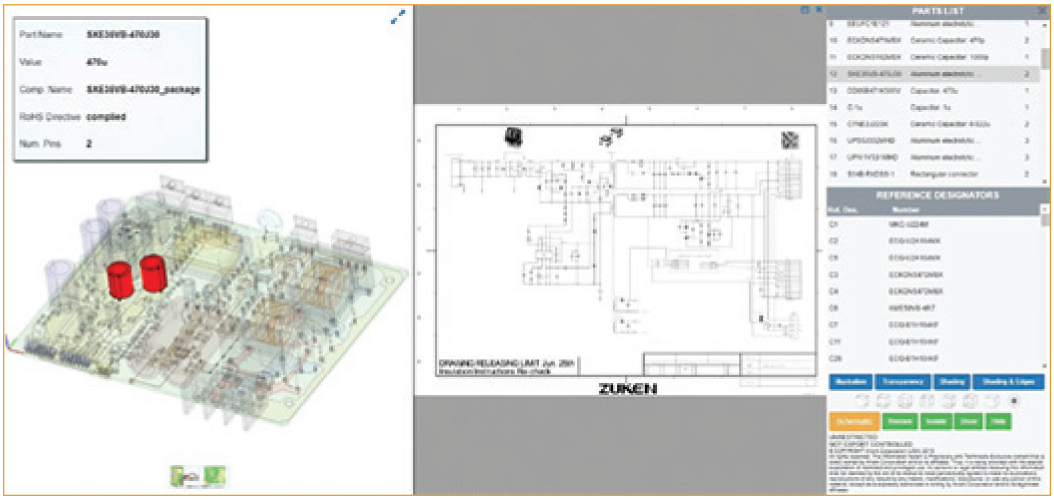

FIGURE 2. PCB, schematic and reference designators can be visualized in a neutral browser.

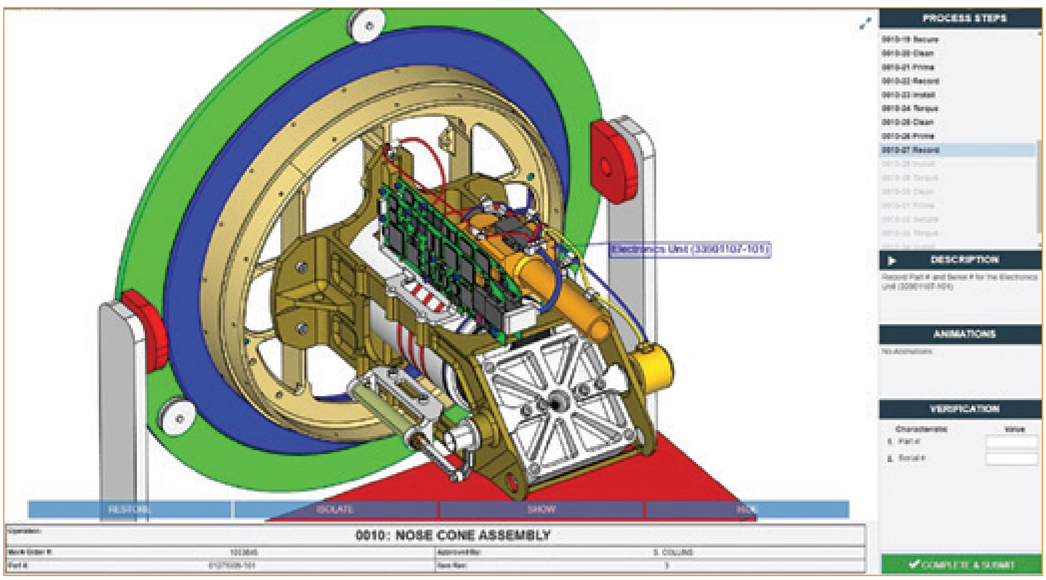

FIGURE 3. Work instructions combining PCBs and their form factors can be demonstrated in a video animation.

Preparing for Next-Gen Loss Requirements

Can signal-integrity test vehicle results be accurately simulated?

Ed.: This is Part 1 of a three-part series on preparing for next-generation loss requirements.

THERE ARE A lot of factors to juggle to stay on top of the parameters that contribute to loss. Frequency, copper weight, resin system, glass characteristics, dielectric thickness, trace width, copper roughness, and fabricator processing all contribute to the discussion if you're savvy and driving fast, with both eyes open.

If frequencies aren't increasing, no need to worry. But if your windows are getting chopped in half year-over-year, read on.

Background. Several years ago, I marketed laminates for servers. Older generations bumped up frequencies incrementally, but then we ended up dealing with frequencies that *doubled* from one generation to another, with downward pressure on costs.

There are multiple server platforms, of course, but a quick review of Intel's PCIexpress (PCIe) trends shows performance jumps going from 8Gbps (4GHz) to 16Gbps (8GHz) to 32Gbps (16GHz) with PCIe 5.0. Those are incredible jumps, particularly when also trying to hold down material costs. The world would be easier if no one had to pay for the performance improvement, but *loss* and *cost* are intimately intertwined. And it's not just Intel and PCIe. Multiple interconnect standards have transitioned from incremental speed increases to doubling generation-over-generation.

To accommodate, it's common in the server world to build test boards with defined geometries, tracking all the relevant parameters noted above across multiple laminate vendors, resin systems and fabricators, but the process of doing so takes about six months from concept to completion. In today's design environment, who can wait that long? A lot of designers, I would expect, don't have the luxury of long server-ecosystem lead times, where the entire system architecture is the long pole in the project schedule tent.

For the purpose of reeling in schedules and narrowing the solution space, I've been focused on developing tools that make tradeoffs early in the system-design process, including frequency, interconnect loss budgets, and the design knobs that designers control, including resin system, cost, copper roughness and trace length.

My big question. My BIG QUESTION, which I don't fully know the answer to before simulating, is whether I could have predicted what I already know from SITVs (signal-integrity test vehicles), based on frequency, resin-system properties, copper characteristics, etc.

I know before performing any simulations what products were successful meeting the loss requirements in TABLE 1, but my interest is actually knowing whether simulation would have provided assistance toward predicting the outcome.

SITVs are designed to emulate typical design configurations, while isolating the relative performance of 3- and 4-mil cores, both in microstrip and stripline configurations, using the same test vehicles (TVs). For simplicity, this column focuses on striplines, but the same process applies to microstrip-signal requirements.

Backwards engineering platform A (legacy). Platform A had an insertion-loss requirement of 0.48dB/inch for the platform's low-loss boards. Built into this target, of course, are typical interconnect lengths for the platform. Test vehicles for many different competitive mid-to-standard-loss laminate systems were created across multiple PCB fabricators, to find the sweet spot for cost and loss. If you have a lot of money and time, that's certainly one way to do it.

My first objective, using the specified SITV cross-

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TABLE 1. Insertion Loss Targets across 2 Server Generations for Microstrip and Stripline Signals at 3 Different Frequencies.

TYPE		PLATFORM A (LEGACY)			PLATFORM B (NEW)		
		4GHZ	8GHZ	12.89GHZ	4GHZ	8GHZ	12.89GHZ
Mid Loss	Stripline	0.65	1.25	N/A	0.65	1.16	1.74
	Microstrip	0.69	1.38	N/A	0.69	1.27	1.93
Low Loss	Stripline	0.48	0.9	N/A	0.5	0.85	1.25
	Microstrip	0.55	1.05	N/A	0.58	1.05	1.58
Ultra-low Loss	Stripline	N/A	N/A	0.83	0.35	0.58	0.83

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SMT Assembly Boot Camp, PHIL ZARROW

This SMT electronics assembly class is a practical overview of the many different processes and materials used in through-hole and surface mount technologies (SMT). It is a focused, two-day long class, which provides students with the opportunity to learn and understand the processes, tools, and materials used in today's manufacture of electronic assemblies.

The course combines lecture, videos and discussion and is intended for those that are new to electronics assembly and want to come up to speed on the processes, materials, equipment and procedures.

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Design Essentials for PCB Engineers, SUSY WEBB

Engineers designing their own boards will need to understand and use the same science that seasoned PCB designers have built up over many years. For example, the way parts are built, or a board is designed can make a huge impact on the ease of fabrication and assembly, just by the practices put into place while working. Those practices can increase yields and lower the cost for all, and this two-day workshop starts with thoughts about that. There are many ways to place parts on a board, but some work much better than others for the physics, electrical and mechanical purposes. We will discuss the order of placing parts, setting up routing, and placement ideas that will lead to better flow.

On Day 2, fine-pitch BGAs will be examined. Their size and pitch make them increasingly challenging to work with, as do the signal integrity and EMI issues that come along with them. We will look at through-hole and HDI examples for fanout, grid and routing information, and their specific manufacturing needs. In the last section we will delve more into the science of how everything works together by discussing the electronics and physics, controlling impedance and high-frequency energy, and stack-up and power issues. There will be examples of how a signal's field energy actually flows through layers of the board, and steps to take when routing signals through the board. The workshop will conclude with a brief discussion of autorouting vs. hand routing.

section, was to determine which Df characteristics would be required to meet the insertion loss (IL) goal. **FIGURE 1** shows that at 4GHz a laminate with a loss tangent of 0.013 would meet the 0.48DB/in. target with a little margin. This Df number was determined by entering all the SITV cross-section data, including the Dk from one of the materials under consideration, along with copper roughness, and then determining what Df value met the IL threshold. This is helpful going in. We're looking for resin systems with actual Dfs at 0.13 or slightly lower.

My second objective was to take one of the laminate systems that was successful on Platform A, with known IL test results, to see whether vendor-published Df numbers would produce the same insertion loss. The vendor-published Df for Laminate A was 0.008 at 4GHz. For this material and the construction shown, the simulated IL using the published Df was fine, but measured insertion loss was just beyond the 0.48dB/in. low-loss requirement at 0.485dB/in., which tells us the actual Df may be a good bit closer to 0.013 at 8GHz. Toward that end, the test vehicles indeed taught us something. As I recall, the laminate in question was bumped down to the mid-loss applications, while slightly more expensive materials were used for the low-loss applications.

This wasn't a super-high-tech laminate, but the process certainly scales to higher speeds, as we will see below.

Low-loss requirements at 8GHz. Platform B (new) shows a low-loss IL (8GHz) requirement of 0.85dB/in. for a stripline. This guideline is based on typical interconnect lengths for the platform, frequency and the receiver's tolerance for loss. Using the same SITV cross-section noted above and Dk/Df values from one of the vendor materials proposed for this application, Laminate B, we can see in **FIGURE 2** that the laminate-vendor-published Df at 0.007, along with other factors such as the Rz=1.3μm copper roughness, resulted in an insertion loss of 0.60dB/in. This is more than enough margin against the 0.85dB/in. target, which is a good thing. However, in hindsight, the SITV-measured insertion loss was 0.645dB/in., meaning the actual Df was a little bit higher. Trial-and-error with the field solver reveals a Df (8GHz) of 0.008 may be more realistic for this particular laminate. Simulation also showed a Df of roughly 0.013 was needed to meet the IL target at 8GHz.

Low-loss requirements at 12.89GHz. The process is similar but gets more expensive at higher frequencies, requiring we work with sharp pencils. 12.89GHz is the PAM4 Nyquist frequency for a 100 Gbps signal. I like to start these simulations with a material that's been proposed for this space, so I'll change the Dk and Df accordingly as a starting point, modeling Laminate C. **FIGURE 3** shows the results, with a vendor-published 0.005 Df at 10GHz. The 0.74dB/in. result, using 1.1μm copper (Rz), is well within the 1.25dB/in. low-loss target, but this is just a first pass with datasheet Df numbers. To meet the requirement for a 12.89GHz Platform B signal, simulation shows we need a 0.013 Df (12.89GHz) material.

Using hindsight, we're able to backwards-engineer the effective Df from actual, fabricated SITVs. Of course, we wouldn't typically have the IL loss in the planning phase when we're selecting materials, unless the PCB fabricator had collected it for another project as part of its laminate offering. Our

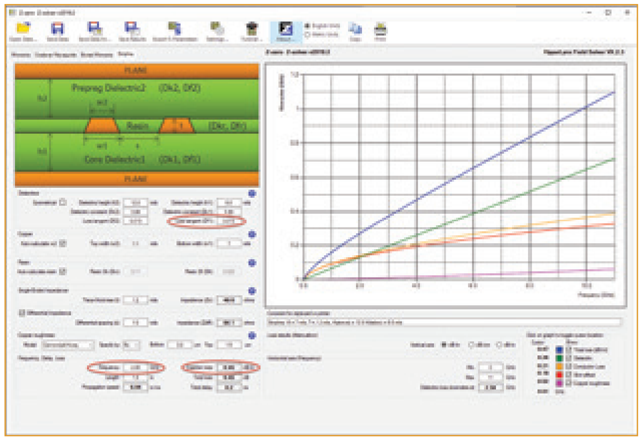

FIGURE 1. Differential insertion loss of 0.45dB/in. computed from a loss tangent of 0.013 using Z-zero Z-planner software and Mentor's HyperLynx field solver.

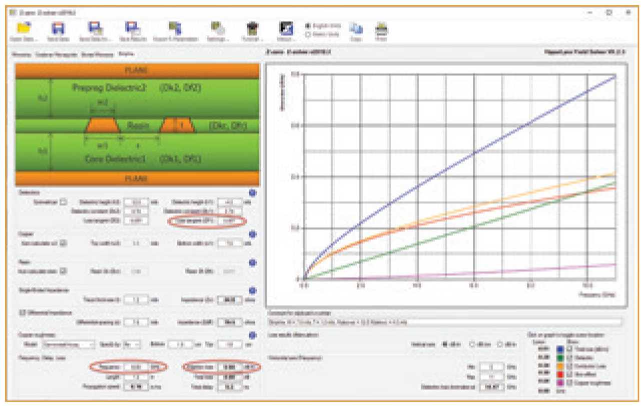

FIGURE 2. Differential insertion loss of 0.60dB/in. computed from a loss tangent of 0.007 at 8GHz using Z-zero Z-planner software and Mentor's HyperLynx field solver.

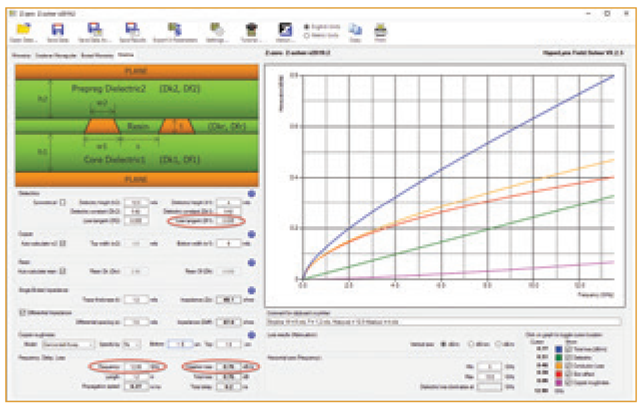

FIGURE 3. A laminate with a published loss tangent (Df) of 0.005 at 12.89GHz results in an insertion loss of 0.75dB/in. per Z-zero Z-planner software and Mentor's HyperLynx field solver.


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main purpose here, however, is to guide how we may need to interpret vendor Df numbers when framing the solution space for a new platform. The fabricated SITV's measured IL loss was 0.684dB/in. for this configuration. In this case, we learned vicariously that the published Df number for this material was reasonably accurate. We also learned Laminate C, a PPE resin system at more than two times the price of the next step down, was overkill for the low-loss target. The good news is we've found a potential material for the ultra-low-loss boards. The question becomes whether we can stretch the lower-priced Laminate B discussed in the 8GHz section to cover this application, and that's exactly what happened in practice.

Keep in mind we're now talking about 12.89GHz. It's a completely different league than the 4GHz we started with, and that's a key point in this column.

Conclusion. The point here was to demonstrate a methodology by which a PCB fabricator, design team or laminate vendor could convert interconnect loss requirements into Df requirements and project a material's insertion-loss performance, without spending several months – from laminate production to PCB fabrication to testing – making SITVs. Doing so without spending tens of thousands of dollars and months of waiting for SITVs is a big benefit. Which makes the most sense: spending $100,000 and waiting six months for answers, or spending a fraction of that and simulating what to expect prior to SITV fabrication?

Along the way, we see sometimes vendor Df numbers a good bit higher in practice than the published vendor value, in some cases by as much as 0.004. With this word of caution, it's helpful to know a good 2-D field solver can be employed at any point in the design cycle without going to the trouble of building and testing test vehicles.

In Part 2 of this series, I'll outline the means by which insertion-loss requirements are determined. In Part 3, I'll suggest a better method for obtaining more accurate Df numbers without building test boards.

Finally, on Jan. 29, I'm hosting an expert panel session at DesignCon to discuss glass-reinforced or PTFE dielectrics that can support the needs of 28, 56, 112 or 128Gbps, along with developing a system for winnowing the list of laminate possibilities from different vendors, or from the same vendor once you've chosen a laminate. I won't be the smartest guy in the room that day by any stretch, but feel free to join us as we finally nail down the answers to this quintessential design concern – or entertain you while some of the experts slug it out! A webinar will follow, so if the subject interests you, send me an email for an invitation. ▫

Merger Complete, MENTOR SEES More Convergence Ahead

How the ECAD giant's integration into Siemens is shaping up.

by CHELSEY DRYSDALE

As a telecommuter who has favorable, nostalgic feelings about her leafy university campus, visiting Mentor Graphics near Portland in June elicited office envy. A forest surrounds the peaceful Mentor property, which contains several large buildings encircling a park – reminiscent of Aldrich Park at the University of California, Irvine, where I attended a different lifetime ago.

At its US headquarters, Mentor has a highly rated daycare center, a hair salon, a masseuse (!), a gym, a basketball court, hiking trails, and a café. Lest we not forget, it also offers electronic design automation software.

Larry Toda, senior marketing communications manager and a Mentor alum of two decades, gave me a tour of the campus, while Dave Wiens, product marketing manager, who has been with the firm more than three decades (including acquisitions), kindly invited me into his office for a lengthy interview.

As most in the industry are aware, since March 2017, Mentor has been part of Siemens. For now, the branding concession was to drop "Graphics" from the Mentor name , replaced with "A Siemens Business." Eventually, Wiens said, Mentor will just be "Siemens."

Integrating two billion-dollar MNCs takes time, of course. Product lines, distribution, staffing and cultures must be aligned. But two years on, managers remain bullish the merger holds tremendous potential for synergy.

"A large company acquiring another large company is hard because of things like healthcare benefits and compensation," Wiens allowed. "The reality right now is Mentor is still a separate company with separate sales channels, but there's a huge opportunity across domains. We grow by getting customers to adopt more technology."

More technology, in this case, means moving up the ladder to design software with greater functionality, and adopting cutting-edge tools, in particular those that perform upfront "virtual" product development – the simulation process known as the "digital twin."

Single Source

The Siemens deal expanded Mentor's scope well beyond its traditional ECAD and assembly process suites. Customers now have access to tools for mechanical builds, software, cabling and the tie-off to manufacturing. Mentor says customers find that "enticing," as it reduces the number of partners to one.

On paper, Siemens didn't need much help. It's among the 75 largest companies in the world, based on annual revenues. Its electronics and related businesses make up more than $33 billion in annual sales and have more than 140,000 employees. It paid $4.4 billion to nab Mentor – an amount some analysts found excessive – and yet just over a month later its stock hit an all-time high.

But from Siemens' perspective, it had a "electronics hole" in its offerings. For its part, Mentor had some product lines of interest – from IC design through PCB systems – to complete the digital twin Siemens is betting on. This includes the design-to-manufacturing suite Mentor acquired as part of its purchase of Valor.

Data Path

The new Mentor is all about getting from ideation to realization to utilization. As Wiens puts it, "Maintaining a path of data is a key thing. How does that impact the next step?" The ideal is a digital thread that simulates the product – virtually, of course. Those data are also used to shape actual automated and manual manufacturing processes. Then the digital twin is looped back to the creators, where it is analyzed and refined as needed. Physical prototype costs are reduced or eliminated. Brute-forcing a product gives way to a much more refined, faster, and cheaper methodology.

This is where Valor comes in. The longtime data transfer standard known as ODB++ is another digital thread story, Wiens says, that solved a critical need by keeping all the data together.

The biggest technology concern for Mentor's customers revolves around increased design complexity. In their parlance, this means "doing more in less space for cheaper and faster with better quality." Mentor is trying to enable continuous automation and improve design abstraction by streamlining the processes. Or as Wiens puts it, "In EDA, the key word is automation."

The solution, Mentor feels, is to perform thorough analysis of the complete system before production begins. Says Wiens: "A complete digital twin enables engineering teams to design, optimize and verify a product before it ever hits manufacturing. Within the electronics domain, that means a friction-free transfer of information from system architecture into manufacturing, possibly encompassing multiple boards, ICs and their packages. To verify electronics, accurate digital models are critical and must scale from silicon-level through entire systems. Of course, electronics are just one domain in a system. Mechanical structures must be modeled within the electronics – rigid-flex, for example – as well as multiple levels of enclosures and moving parts. Software and electrical connectivity via cables and harnesses must also be considered."

That's not all, he says. The digital twin reflects the actual lines themselves. And that means working with a large set of tools, often from other suppliers, including competitors.

"Entire lines can be modeled and optimized, leveraging the digital twin of the product," Wiens says. "Finally, a digital twin can be used once a product hits the market for servicing and analysis of field failures. Enabling collaboration across multiple disciplines requires multiple software tools to recognize a common digital model. This is most often done with industry standard formats but can be streamlined when the teams designing the tools work together closely. This is the case at Siemens, where we have the largest portfolio of tools for electronics system design, covering IC, package and PCB, as well as mechanical, cabling and software design and verification, all within the framework of a PLM system. The synergies we've been able to achieve are industry-unique, but to support our customers, we also continue to maintain openness with competitive tools. Significant steps have been taken to achieve this digitalization, but it's a journey that's far from complete. I'd recommend every engineering team review their current design processes and collaboration platforms to identify optimization opportunities leveraging a digital twin."

Siemens and Mentor are excited about artificial intelligence and what it portends. "With Siemens, AI, machine learning and additive manufacturing are near at hand," Wiens says, although he was not at liberty to disclose details. He did allow that Mentor is "heavily invested" in making technology more accessible by integrating in the design space. Through machine learning, designs can be optimized, and analysis tools are integrated into the flow earlier and earlier in the process to provide design recommendations.

"The age of IoT is certainly increasing the volume of edge-node products, which are smaller and, on the surface, simpler. In reality, they are anything but simple, requiring tight alignment with the mechanical enclosure, and in some cases merging into one electro-mechanical structure (e.g., flexible hybrid electronics). At the same time, these products exist within an ecosystem of other devices and information-processing hubs that all must work seamlessly together. I do see a need to simplify design, but that is common across all complexities. It will drive IP reuse, automation (of design and verification), definition of higher levels of abstraction (a close cousin to automation), and potentially even generative design."

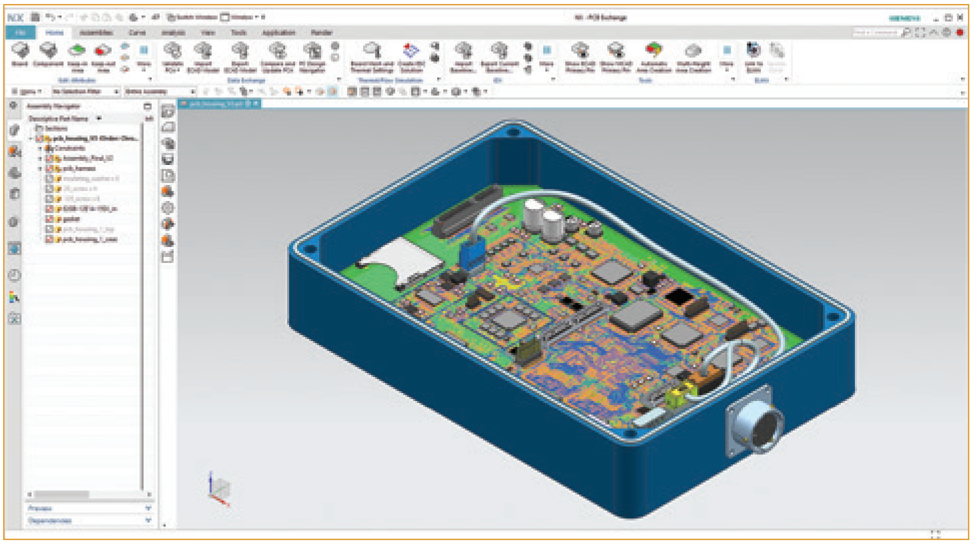

FIGURE 1. The digital twin is a computer-based model of all the physical dimensions and functions of an electronics system, including the PCB.

The Designer as a Specialist

With so many design-to-manufacturing tools now available all under one (enormous) roof, what does this mean for today's users? "There's a demographic shift at play that's been happening as long as electronics have been digital," Wiens explained, pointing to the ongoing crossover in domain expertise. "Users have to learn more and more things. Layout is smarter about manufacturing. Layout has to know mechanical. Schematic knows layout. Everyone's knowledge base has to grow to know more about adjacent domains."

Still, he notes, there is a dichotomy at play in PCB design and engineering. To wit, while engineers are learning layout, and place-and-routers are learning physics, the specialist might prevail in the end.

"People say layout designers are dying off," Wiens said. "Going from tape to CAD was a big leap." But while new technology can be easier to use, it often lacks the functionality of more capable systems. What Wiens refers to as "old and complex tools" often represent a tradeoff in that they offer more capability but also take more time to learn. An analogy, Wiens says, is the functionality and complexity of professional cameras compared to the point-and-click modules on cellphones.

Training such as the IPC Certified Interconnect Designer program is keeping layout designers more relevant, Wiens asserts, adding that in some ways, they are more up to date than engineers. Still, he says, the "ubiquitous person who knows all is unlikely." As such, "to excel, you have to become a specialist."

A domain has the opportunity to create excitement, but "you don't just get people interested. They have to *be* interested." This issue is "not distinctly North American. It's also Europe. But not Pac Rim. In China, most come out of school with an EE, and assume jobs across the design process. But at some point, they may also specialize."

As our time came to an end, Wiens listed four areas Mentor is most known for, including managing complexity: "enabling designs larger than anyone else can do," which has led to program wins; enabling collaboration: managing across different domains; validating designs with virtual prototyping: they can simulate verification of physical prototypes, which shrinks design time and produces an optimized product; and managing IP: reuse of designs and IP blocks and managing entire designs/libraries/common data.

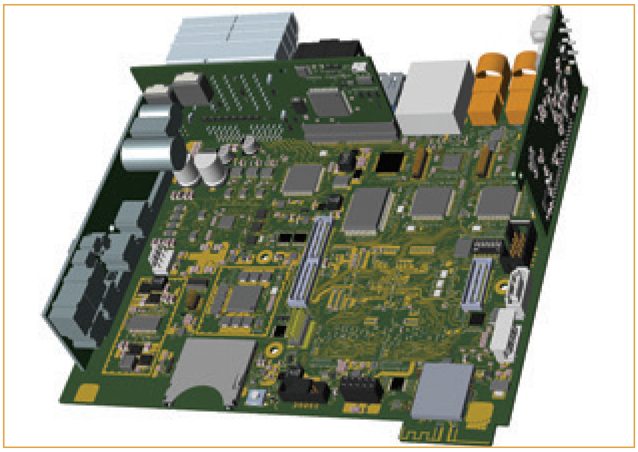

FIGURE 2. Mentor was attractive because it gave Siemens a complete ECAD-MCAD product offering.

Before I let Wiens get back to work in his Zen office, I looked out his giant window at the gorgeous green trees of the Pacific Northwest and made a mental note to get a standing desk like his, even if the only view I have at home are a few measly trees in my backyard. At Mentor, one can literally see a forest outside; inside, each minute detail doesn't obscure the important big picture: the digital factory, where data never have to be recreated. ❑

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ROCKET MEN

Silicon Valley's fastest-growing EMS is taking flight.

by MIKE BUETOW

It's cliché to say profitability in electronics manufacturing services is not about making better solder joints but rather turns on a company's ability to manage its supply chain.

Hundreds of millions of dollars have been invested in software and other tools designed to ensure optimum inventory levels and real-time feedback loops. But as an industry we have yet to overcome the wild inventory swings and occasional lead-time fiascos.

One Silicon Valley EMS is edging closer, however. Santa Clara-CA based Rocket EMS is betting its future on homegrown software that oversees every aspect of its operations, from ordering to inventory to line management.

Rocket EMS founder and president Michael Kottke is already something of a legend in the Valley, having cofounded three other successful EMS companies. He's worked in the industry since he was a child, learning assembly at the feet of his father, Dennis, a successful electronics executive in his own right.

With Rocket EMS, the younger Kottke's goal was to maximize every moment from end to end, even before an order is received.

"If you can't process jobs at the front-end, machines sit idle," he says. "So, it's a race to how much you can feed a machine. You can set up a factory that could build 50 jobs a day but can't get programs through the front-end to the line. Take a machine that holds 2,500 parts, and you have 55,000 parts in a stockroom. You have to figure out how to manage it.

"Machines are so much faster that everything related to the supply chain has to be done in the front-end. The only way to do that is to have an encompassing software."

Kottke's solution: Voyager. Voyager is part database, part MES, part best friend. It's the byproduct of reams of weekly meetings where the team of developers outlined projects, staff and priorities with the goal of one tool to rule them all.

Kottke, whose other passion is motorcycles, draws on racing analogies to make his points. The analytics in Voyager, he says, look at the "best lap" – the optimal configuration of time, inventory, staff and processes – to show where and how to shave off time. "We're a data collection company that builds circuit boards," he maintains.

Picture Perfect

Another invention is the so-called photo booth. No, the staff isn't posing for candids. Rather, Rocket worked with a robotics company to build a booth through which it automatically sends every board for imaging. Panels are stitched together and logged into Voyager, where customers can see how it was when it left the plant.

Meanwhile, Voyager is tracking the performance of employees, counting everything from time spent and the number and type of defects tied to each worker. And it collects and collates the photo booth images to help staff understand and correct their defects. Rocket will build five of these, ultimately with conveyors, and install them in strategic spots in the factory, including final inspection and shipping.

About that staff. Rocket employs 255 workers, of which about 230 are in Santa Clara, with the rest in India. Between the Santa Clara and India staff, there are 25 manufacturing engineers and 20 PCB layout engineers. "I could not imagine running a contract manufacturer, especially with our diverse customer base, without an engineering and design group working hand-in-hand 24/7 creating MPIs, machine programs, stencil designs, and every shred of data needed for the manufacturing floor to be successful," Kottke says. This engineering effort begins the moment they get files from a customer, which eliminates what is typically the biggest front-end bottleneck.

As an example of Kottke's pride in this engineering capability, he almost brags that Rocket's stencil costs are 25% more than all its competitors. "We put a ton of engineering into stencils, so we avoid all the touchup by uncontrolled manual labor at uncontrolled (soldering) temperatures. The first one that touches a defect is in final inspection." Sure enough, our walkthrough revealed no soldering irons near the wave soldering or SMT operations.

Armed with such inputs, Voyager can predict labor costs "so deadly accurate it will hurt your head," Kottke says. Moreover, the firm can push more material through the front-end to the lines, thus optimizing the capital equipment investment.

Supply-chain management is clearly Kottke's obsession. In turn, he thinks contract manufacturers don't build their supply chains to meet the type of product they build. "I would love for a distributor with a lot of money and a lot of pull to sit with me and map out how to make a Voyager-type supply-chain tool. Why can't Avnet and DigiKey and Arrow get together and say, 'The customer sends its BoM out to Distributor 1, which supplies X% of the parts, and the others supply the rest. Then you click a button and all the parts come in one order.' It should be a straightforward thing." (And lest you think he's nuts, consider that Amazon does this every day.)

Voyager sits on top of the ERP system now, but in the current year will become a standalone MES. Voyager runs labor reports by customer and can compare the current job to a previous one.

The latest endeavor involves trying to prepare Voyager to start preemptively feeding design issues and schedule changes. A module that handles SMT scheduling by measuring, among other things, takt time generated by SMT programs is in beta. "We have 12 to 15 customers we try to feed information upstream to," Kottke says. (Of this transparency, Kottke, who is also a walking soundbite, chirps, "If the customers can see the skeletons, you tend not to have skeletons – unless you like the customer beating you up.")

Voyager is in a constant state of improvement. It tracks employee movements and outputs starting with time in and out and ranging from ESD defects to total scans. Each job is scrutinized just as closely. Events and jobs are color-coded to visually show if an action took longer than it is supposed to. With this level of granularity, Rocket can perform quote models by customer, not department.

"We can see in real-time where we are making money on a job, and there are alerts if the profit level starts dropping," Kottke explains. "We can tell how long each part number took at each process step and compare that to the Rocket EMS average for that workcell for that customer." And because Rocket EMS captures an image of each part at incoming inspection showing the lot code, part number and other key details, Voyager will eventually be used to show polarity, which could save 25 minutes on kitting, Kottke calculates. Other add-ons will include all preventive maintenance and employee certifications.

Another novelty: the stock room. Parts are managed by size and shape, not by customer. Doing so allows Rocket EMS to put more inventory in a smaller space. For instance, Kottke says, they increased the number of reels to 3,300 from 1,500 in the same area. The stockroom shelves are 14" wide, able to handle 7" reels back to back. Shelves are geared exactly for size and shape. "We could have 88 different customers on one shelf," Kotte says. "Different customers' parts are on the same reel."

The results are staggeringly effective: "We put 60,000 parts in a location where we once had 25,000," he notes.

Next up: restocking parts by frequency of use. This is where the engineering really kicks in. Per Kottke's thinking, every second counts. "If we could save 30 seconds here and there, pretty soon we've saved a whole person."

The 36,000 sq. ft. factory has a traditional straight-line layout, with the stock room at the head, just a couple steps from the lines. (Bulk kitting is performed in a 4,000 sq. ft. building offsite.) The machine mix includes Juki GKC printers, Parmi Sigma-X SPI, Juki pick-and-place, three JT RS-1000 and one Vitronics convection reflow ovens, new Juki FlexSolder selective soldering, and Vitrox AOI on two lines. Three PVA conformal coaters were also added in the past year. Feeder trolleys are staged in front of the lines. This setup has eliminated 35% of the time per line. The goal, Kottke says, is 50%.

Material is tracked through the plant by barcode. RFID would be ideal, but the nature of the high-mix, lower-volume jobs would require too many readers, Kottke says.

Besides the aforementioned inspection equipment, Rocket features Nordson Dage Diamond x-ray with X-plane CT

continued on pg. 38

FIGURE 1. Novel storage practices more than doubled reel capacity.

FIGURE 2. The Santa Clara, CA, layout is a traditional straight-line configuration.

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functionality, Agilent i3070 in-circuit test, Spea flying probe testers, and another new Vitrox machine was on order. Inspection is paramount to its quality system. Rocket "x-rays the hell out of everything," Kottke says, adding the company uses the Vitrox machines to "control" its test operation. "We know every detail of every defect. It's like we put a manufacturing process into test."

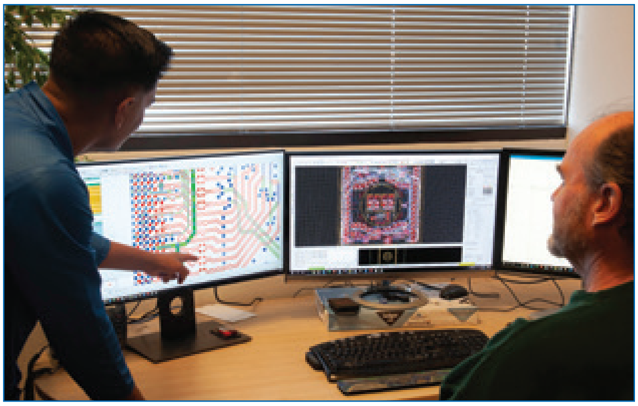

FIGURE 3. Manufacturing engineers work directly with staff PCB designers to ensure designs are buildable.

Constant Motion

In the decade I've been following Michael Kottke, I have come to understand he is never satisfied with the status quo. Always on the move, he has pinpointed a site just over the border from California in Nevada, where he would like to build a second factory. He also wants Rocket EMS to start developing its own products. One that Rocket EMS designed is ready for release, and the first customer is expected to purchase nearly 10,000 units.

A second product is an automation product, currently in beta testing. Over time, Kottke says, it will be worth more than Rocket EMS. The new site will use a lot of automation, he thinks.

Then there's Voyager. Kottke envisions a Web version for staff and a portal for customers.

Since its founding in 2011, Rocket EMS has surged to more than $60 million in annual sales. Kottke has set $100 million as a revenue goal. When we visited in September, Rocket EMS was maintaining 2.5 shifts, and edging toward a third.

For its constant inventiveness and willingness to venture where other EMS companies fear to tread, Rocket EMS is the 2019 CIRCUITS ASSEMBLY EMS Company of the Year. ▫

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Automating Detection of PICK-AND-PLACE NOZZLE ANOMALIES (An IIoT Case Study)

Tools to identify anomalies, and trends for reducing downtime and defects while driving operations productivity.

by GREGORY VANCE, FRANCISCO MATURANA, MIKI CVIJETINOVIC

In the SMT pick-and-place operation, components in tape or tray are vacuum picked and placed in solder paste on a PCB location. An optical inspection step takes PCB images to detect the components' centroid and other possible displacements. Nozzles are mounted to spindles contained within a head that moves at high speed. The equipment in this study can use up to 30 nozzles per head and may have one to four heads per machine. Nozzle vacuum degradation (from clogging, tip wear or mechanical issue) increases the likelihood to mis-pick components and increases the potential of an end-of-line defect. The challenge is to leverage the knowledge extracted during this operation to learn potential defects and other tendencies.

To manage the pick-and-place process, operators monitor the machines using machine management data that conveys process information such as feeder, component and nozzle reject percentages and total rejected counts over the course of a production run. These metrics, coupled with machine utilization, allow operators to identify a component pick or inspection problem that requires domain-expertise support for troubleshooting.

In addition to monitoring each production run, weekly mis-pick and reject parts per million (PPM) data are used to monitor each electronic assembly plant over time, shown in a control chart. When a shift or out-of-control point is discovered, it is investigated for root cause and corrective action. These actions have helped improve pick performance 43% over five years.

Some out-of-control events were traced to a problem with an individual nozzle or spindle on the pick-and-place machine. Machine operators didn't detect these events. As a nozzle starts to clog or fail, it tends to mis-pick components. As this error rate increases, it can cause downtime and reduce efficiency. By detecting or predicting degradation of the nozzles, the anomaly alerting is provided to support personnel to proactively troubleshoot the nozzle before it becomes a significant problem.

One goal is to control downtime by anticipating nozzle failure based on factual calculations. A second is to reduce false alarming to avoid overwhelming the operators and support staff.

Solution Overview

Analytics overview. Manufacturers desire to transform their processes from reacting to predicting a downtime problem. This progression is described below:

- Descriptive: Most solutions today are around descriptive analytics, with charts, reports, trends, etc. These are good examples of descriptive analytics; they tend to be "rearview mirror" systems that describe what has happened.
- Diagnostic: These types of analytics focus on "why" things happened and try to get to the root cause of why issues occurred.
- Predictive: A system that alerts a user of what will happen. Predictive maintenance use case is where the system uses advanced machine-learning techniques to look at historical data (downtime tracking and process historical data) to then predict failures on assets by finding the "signature" of what happens before a failure (using the history) and then looking for that "signature" to happen again.
- Prescriptive: This is one of the most advanced analytical techniques. The system can go so far as to help determine what the manufacturer should do, and even do it for them, if they choose.

Pick-and-place dashboard.[1] A descriptive-analytic-based solution was initially built to establish a platform for visualizing the behavior of the machine, nozzle and process per work order (**FIGURE 1**). Based on this knowledge, the team was able to define a predictive monitoring algorithm, which required a high-performance computing workbench with AI helpers and parallel data processing engines.

Governance of data flows, security, and data preparation were fundamental for achieving a clear view of the performance. A significant amount of time was required to establish an understanding of good data versus noise.

The pick-and-place data are configured to refresh every 15 min. Each segment of data is moved to a data lake in the cloud via a plant-floor gateway. The data lake was built

using big data components such as Hadoop, Spark and Kafka. In the data lake environment, micro services were created to handle data governance, ETL and analytics. Classical data wrangling and data transformation (supported spark-based services) were accomplished in the data lake level. A separate folder will host the curated data for further model development. Power BI was used to visualize the data.

The team collected operator experience into the design of the predictive solution. Interviews with the operators provided insights about other aspects that affect pick-and-place performance.

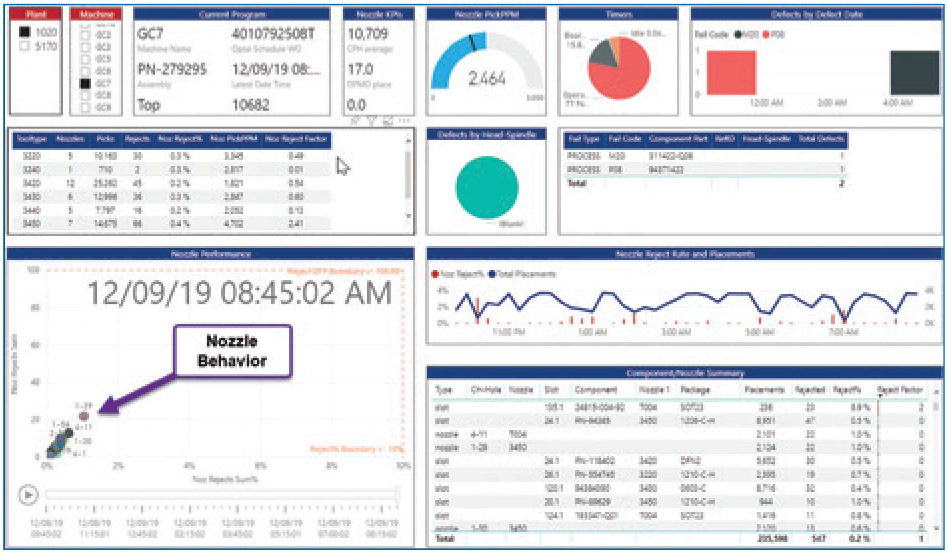

FIGURE 1. Descriptive analytics machine nozzle performance dashboard.

It was discovered instantaneous measurements were not enough to unveil the anomalies causing defects. We learned the nozzle position relative to its cumulative rejects is an important indicator. This insight led the team to think in the direction of an AI-based algorithm that could learn and trace the behavior of individual nozzles (FIGURE 2).

Feedback from the support technicians using the visualization dashboard indicated they would prefer to be notified when a nozzle is out of control instead of monitoring a dashboard.

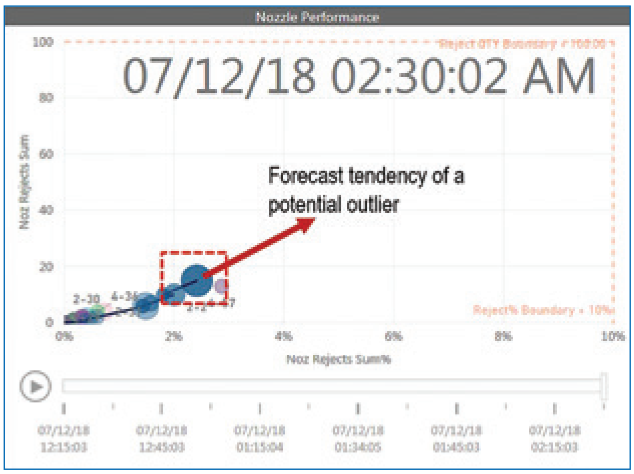

FIGURE 2. Illustration of nozzle performance trajectory.

Anomaly detection/prediction.[1] Collaboration with third-party software solutions was explored to understand if machine-learning techniques could be used to forecast nozzle performance. Mis-pick and reject performance can be erratic over time due to feeder exhaustion. Also, pick-and-place machines can automatically correct pick alignment over time. Such conditions can cause a spike in poor performance. Due to these inconsistencies, forecasting algorithms tended to flag a change in the process that was either a feeder that needed replenishment or a feeder the machine had the ability to self-correct. These false positives led us to consider other approaches.

Focusing on instances where a technician should have been dispatched to troubleshoot the machine, the behavior of nozzles was studied, as referenced in FIGURES 3 to 6. An idea was conceived to track performance of each nozzle over time and assign a score that would accumulate to a trigger value, indicating when technical support is required.

The Nozzle Performance "Bubble" Chart plots the incremental position of each nozzle over segments of time of the work order. The x-axis is the nozzle reject sum percentage by time, and the y-axis is the nozzle reject sum representing the accumulated sum of rejects over the entire work order. Nozzle reject percentage can increase and decrease throughout the work order and can move left and right in the chart, while nozzle reject sum can only stay the same or increase. Connecting

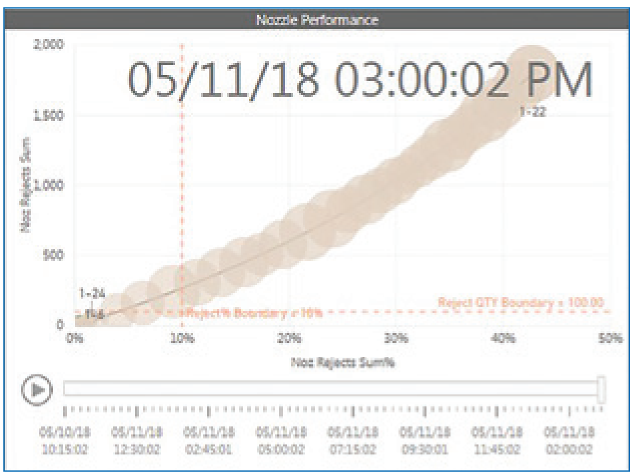

FIGURE 3. Nozzle 1-22 track, where nozzle percentage and sum increased each period over the 3.75-hr. work order.

these periods helps show if the machine is trending out of control (i.e., up to the right), improving (where the trend is moving straight left), or somewhere in between (where the nozzle reject percentage may stay the same or is slowly decreasing, but the nozzle reject sum continues to increase over time).

Constants were assigned for each nozzle's movement relative to the previous position of the nozzle in time (**FIGURE 7**). C1 to C5 are vectors relative to the severity of a movement in that direction summed over consecutive time periods. The vector states or slopes between consecutive points in time are assessed. A constant is assigned and accumulates in what is called a nozzle score; C1 to C3 are set to +1.0, C4 is +0.33 and C5 is -2.0. Each constant C1 to C5 is independent and can be assigned individual values. The nozzle score cannot be less than zero.

A trigger value is associated with the accumulated nozzle score of 5. Coupled with the nozzle score exceeding the trigger value, additional logic is checked to ensure the nozzle performance position is greater than or equal to X nozzle reject percentage (i.e., 10%) or greater than or equal to Y nozzle reject sum (i.e., 50). When this condition is satisfied, the anomaly detection system generates an alert that is routed to support personnel, notifying them via text or email with the machine name, nozzle location, nozzle type, and current performance statistics.

The vectors C1 to C5, trigger value, and additional logic that the current performance is equal to or greater than X (nozzle reject percentage) or Y (nozzle reject sum) can be changed to adjust the sensitivity to manage the rate of alarms to avoid overwhelming the support staff.

IIoT architecture. The anomaly detection algorithm is deployed on an industrial edge level device in a docker container. A container is an OS-level virtualization to deliver software packages. Containers are isolated from each other and bundled with their own software, libraries and configuration files; they can communicate with each other through well-defined channels. All containers are executed by a single operating-system kernel and are lighter weight than virtual machines.

As pick-and-place data stream through the gateway into the edge device, each nozzle score is calculated, and alerts are generated if the criteria are met and routed in near real-time to support personnel. The current nozzle scores are saved in memory until new data arrive. This has eliminated the 15 to 30 min. latency seen with cloud-level analytic dashboards. Long term, processing data at the edge may enable less data to be transmitted to the cloud, reducing the overhead of managing cloud storage.

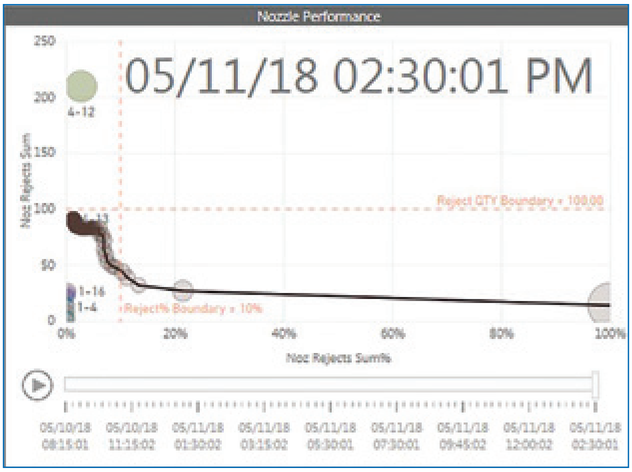

FIGURE 4. Nozzle 4-13 track, where first period had 100% rejects then dropped, but rejects continued to accumulate at slow rate over 6.25-hr. work order.

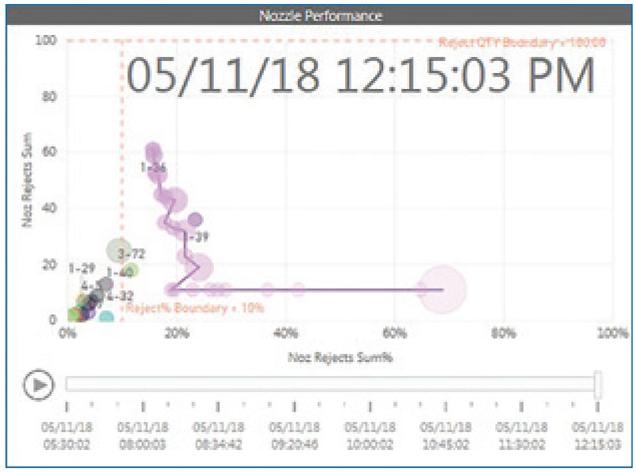

FIGURE 5. Nozzle 1-36 track, where the machine had the first period reject rate as ~70% and 10 rejects that were overcome; no additional rejects occurred for the next 10 periods and then held steady, and rejects started to occur over 6.75-hour work order.

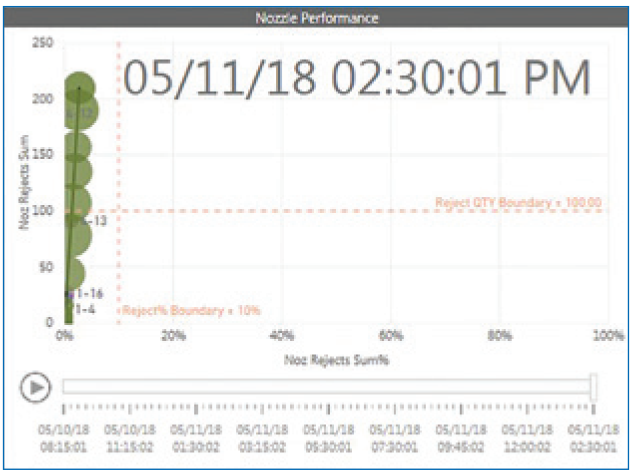

FIGURE 6. Nozzle 4-12 track steadily increases over successive periods to ~210 rejects and 4% over 6.25-hour work order.

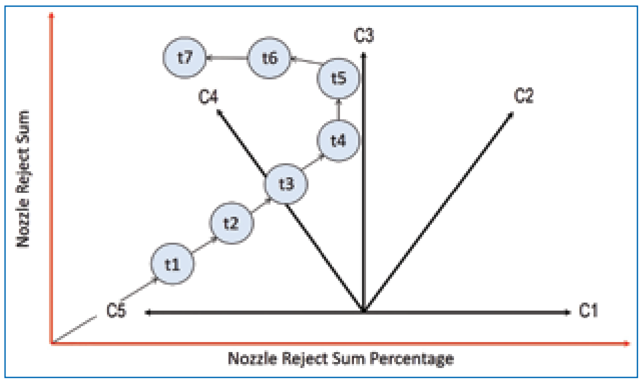

FIGURE 7. Illustration of constants relative to the successive time periods (t1 – t7) of the nozzle performance.

Mobile user app. A pilot mobile app was created that enables the user to observe plant, machine and nozzle performance summaries (**FIGURE 8**). For nozzles that receive an alert, a forecasting algorithm is used to predict the performance of the nozzle four periods into the future if action is not taken.

Solution Impact

The ability to add anomaly detection to the existing information has added visibility and priority, while eliminating the necessity to manually look and analyze issues. This was achieved by the anomaly algorithm and automatic notifications. The dashboard provides the ability to further assess nozzle behavior and trends should they need to be referenced by the support staff. This enables the support staff to respond prepared with the relevant information to what needs troubleshot and with the replacement parts in-hand. Typical process downtime to troubleshoot and repair a nozzle, feeder or inspection problem takes 45 min. With this information, this time is reduced to 15 min. or less.

A pick-and-place machine experiencing a pick or inspection problem impacts the productivity of the SMT line. If the machine experiencing the problem is the constraint machine, it impacts the overall flow of product through the line, reducing operating efficiencies. We have observed impacts as great as 35% reduction in CPH and line throughput.

When a machine is experiencing a pick problem, it has the potential to increase end-of-line defects, especially if the root cause of the problem is vacuum-related and the component is not held securely on the nozzle tip over the pick-and-placement cycle.

Conclusion

Manufacturers are challenged to improve productivity of their manufacturing lines. Improving the detection of a problem and reacting to it sooner eliminates wasted motion in the machine, improves flow of product on a line, reduces component scrap and can improve quality of product being produced. The Anomaly Detection Algorithm and the Nozzle Monitor Dashboard combined alert support staff to opportunities sooner than traditional methods of manual detection and reduce the chance of misdiagnosis.

Storing historical data in the data lake, along with other design and process data, provides other benefits. We have established other dashboards to analyze trends, as well as optimization and configuration opportunities. This minimizes the non-value-add time an engineer spends mining and contextualizing data and provides insight into opportunities in minutes. ❑

REFERENCE

1. Patent pending.

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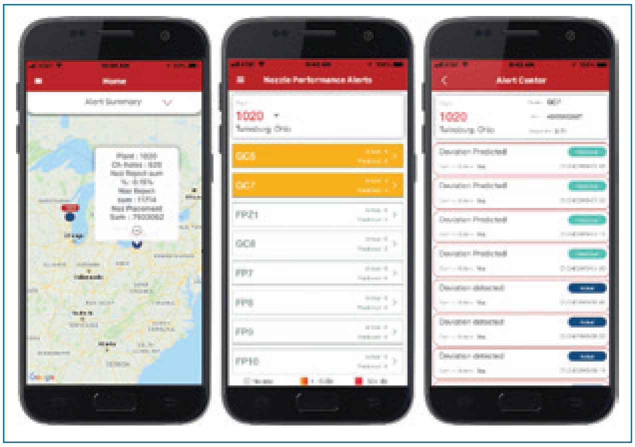

FIGURE 8. Nozzle Mobile App screens for plant summary, machine summary and machine nozzle alert list.

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How Aerosol Jet Works for Fine Circuit Creation

The mist-based dispensing method is adept at putting micron-sized lines on non-planar surfaces.

AEROSOL JET TECHNOLOGY is a fine-feature material deposition solution used to directly print functional electronic circuitry and components onto low-temperature, non-planar substrates.

Aerosol Jet printing functions on the principle of generating a mist through atomization of a nanoparticle colloid solution. Nanoparticle materials liquids, or inks as they are generally called, are made up of nanoparticle solids, solvents and organic binders and even some polymer resins, which are included to make the ink perform on different substrates. These inks must have a certain viscosity and particle sizing in order be printed with aerosol jet. That viscosity is generally less than 500 centipoise (cP), and the particle size must be under 100nm.

In Aerosol Jet, the liquid ink exits either pneumatically or with ultrasonic energy. This generates mist droplets ranging from 2 to 5μm. Then, a carrier gas, which in almost all cases is pure nitrogen, carries that mist through the print head. Inside the print head is a nitrogen sheath that collimates and accelerates the beam through a converging nozzle. What comes out is a beam of material made up of very small droplets that exits the nozzle at high velocity. This allows it to be anywhere from 1 to 5mm off the surface of the part and print right over the nonplanar substrate, so that the surface does not have to be flat. Because the nozzle is so far from the part, it can be moved in patterns to create circuitry on the surface of the part, regardless of the flatness.

Circuit definition. The amount of mist coming through the nozzle defines the metric of output we use, called mass output. Mass output is how much dry material is deposited per unit of time, which is normally in milligrams per minute. The specified print speed or nozzle surface velocity, and a given mass output, establishes the specified thickness.

The line width is controlled by the size of the nozzle orifice. Nozzles sizes can range from 100μm up to several millimeters. These control the feature size. Each nozzle has a range of feature sizes that it will work with. For example, a 300μm nozzle will be able to print from 30% to 50% of its nozzle diameter. Thus, a 300μm nozzle will print from about 90 to 100μm up to around 140 to 150μm.

The dispense rate is dependent on the ink, its viscosity and the particle size. The solvents in it control how much it dries out during printing, and can affect things like line edge quality. The ability to print very fine features is directly related to the type of ink used.

Just like different ink is used to create fine features, the same machine is not used to print all types of circuits. While Aerosol Jet can dispense a range of types of materials, its primary function is adding circuitry to 3-D injection-molded components, or antenna interconnects on semiconductor die to replace wire bonds with printed structures. It is also used for sensor printing and many other unconventional applications.

Creating functionality. Aerosol Jet is like a dispensing machine. Users develop a process, which results in a printed feature width and line. Then a structure is designed around that target printed feature. The process recipe becomes the definition or the resolution of the printing capability, and the entire structure gets built around that resolution.

But Aerosol Jet lives in a world of below 200μm features, which is rare for dispensers. It prints non-contact and on nonplanar surfaces, so it can do things other dispensers cannot. It is focused on applications that are very small such as wire bonds and antennas. The nonplanar conformal circuitry is what really enables the Aerosol Jet market.

Antennas in the context of 2-D PCBs are fairly straightforward, and most manufacturers aren't going to use Aerosol Jet technology for that. But for a very complex device such as a handset or a cellphone, which has multiple layers of materials that signals pass through, getting the signals out to the outermost corners of that handset are critical. 3-D antennas have been in almost every single phone sold for the past decade. In most cases, the antenna is digitally designed onto a 3-D CAD object and printed in a matter of minutes. There's no plating involved. There are no extra steps. The antenna is designed into the structure, simulation is performed, and then it is physically tested under traditional methods. Under these circumstances, Aerosol Jet is used for 3-D printed antennas.

Configurations. Aerosol Jet technology enables high-resolution electronic circuits and components to be printed on 2-D and 3-D surfaces from a wide range of materials. The technology is packaged into a variety of platforms. Inline systems are for printing patterns on substrates with components on them. The state-of-the-art can print at or below 200μm feature sizes.

Flexible systems can come in a three- or five-axis

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Solder Paste Migration

Are you vacuuming the right way?

THIS MONTH WE see a solder paste print deposit with what appears to be migration of paste particles away from the main pad. If this is just a one-off, a careful wipe with a cotton bud would avoid an unnecessary wash-off and reprint. Ensure the PCB surface finish can withstand a wash-off process; some surface finishes don't like it. Wash-off can affect wetting and final solderability.

A few reasons for this defect, each of which could be the root cause:

- Double printing or excess squeegee pressure
- Solder paste contamination on the bottom of the stencil from a previous print
- Misplaced or missing component
- Vacuum hold-down of PCBs during printing with exposed vias under BGAs.

The best example of this type of fault is due to the incorrect use of vacuum to hold boards flat during printing. I remember seeing my good friend Alan Hobby from DEK (now retired) demonstrating this during one of our workshops.

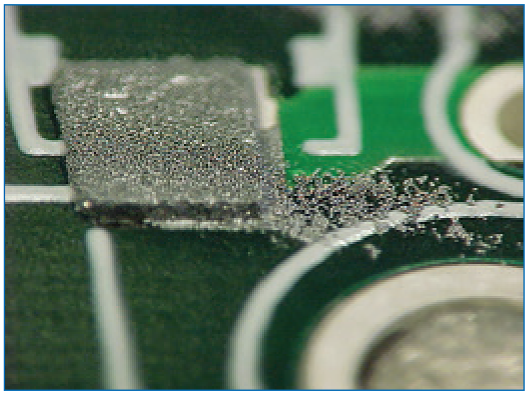
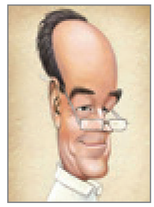


FIGURE 1. Solder paste print with stray solder paste particles on the surface of the solder mask.

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. ❑

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



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configuration. With the right software, these can handle low- or medium-volume production. There's a print engine that can be integrated into automation lines for high volume production. This is for specialized production use cases, because generally speaking, Aerosol Jet is not used for PCBs but rather for printing on unique shapes or objects and giving them functionality by adding circuitry. These could be 3-D objects that are large or small and have varying surface quality.

When specifying Aerosol Jet, most customers start with a material in mind or a problem they are trying to solve. One of the first questions often is, can you print this material? The supplier then tries to identify whether they have a material in-house or if one must be formulated. Aerosol Jet is not as ubiquitous as screen printing, where a single vendor may have catalogs of materials. That said, there are a large number of material vendors. We help find the right material for the application that meets the necessary conductivity or dielectric properties, adhesion and environmental performance, as well as the form factor of the application.

Buyers also typically want to know the print times, because that directly correlates to the economics of the purchase. Aerosol Jet is an additive technique, and material must be added everywhere it goes, which directly affects the cycle time associated with printing each part. Repeating such small features means the material usage rate is low. For a typical process, less than 10ml of ink will result in eight hours of printing time. Yield, then, is determined by the number of parts that can be printed in that 8 hr. ❑

Ed.: Aerosol Jet is a trade name of Optomec.

Great Expectations

"Customer" status comes with a catch: payments.

ANOTHER MORNING IN America. Mornings bring trouble. In various guises, but always in simple declarative sentences.

"Trouble here. Line down. Big problem. Management screaming. We need your immediate help."

Like clockwork.

No matter. Trouble is my business. (Cue breathy melancholic saxophone solo.)

This fine day's episode comes in the form of defective batteries. The call, invariably frantic, continues thus with the symptoms:

"We have six defective batteries that need to be CT scanned. Field failures. Possible cracked electrodes. Very upset and belligerent customer, threatening litigation. You come well recommended for speed and precision. We need time on your machine now. Our entire production is halted until we identify the root cause of this field failure. Quarterly results hang in the balance. When can we come in? Today, hopefully?"

Standard request. Civilization's survival is once again on the brink. We're all going to die. Again. Blah blah blah. I have a seven-inch thick file of 'em. Is melodrama an inherited skill or something best taught in graduate school?

Happily, we have immediate space.

How about this morning? 11am.

"We'll be there."

You're a new customer, right?

"Yes."

Do you have a purchase order? Can you get a P.O. set up now? How do you propose to pay for this? It could be expensive. Overtime, weekends, big data dump, etc., etc.

Silence. Then a throat-clearing noise.

"Oh, for that you'll need to talk to our purchasing people. They will need to set you up as a vendor. I need to go now, to round up our, ahem, charges, to bring to you."

Not so fast.

Please put us in touch with someone in your organization who can get us a purchase order.

We're used to it. Send us the paperwork so we can set you up, and you can set us up. Elementary. Sometimes I think form-filling is our real business.

Not so simple: They have a portal. We have to set up an account. They have contracted all accounting and purchasing functions to a third party. In Malaysia.

"This won't delay x-raying our batteries, will it?"

Perish the thought.

No, it will not delay x-raying your batteries. The 11am appointment stands as agreed.

We never delay x-rays. We want to be helpful and easy to do business with. However, they don't need to know (at this point) that we may delay their reception of the results. That nagging little payment thing again. The incriminating images remain ours until further notice. Do we know a thing or two about leverage? You bet we do.

Please give us the link to your portal.

"Oh, we can't do that. We can't permit you to establish an account on our portal before you sign our nondisclosure agreement. It's one of the built-in checks-and-balances we have in accepting new vendors in our system."

Very Orwellian. We need you desperately, but we really don't want you known or noted. The definition of an un-person.

"How long will it take your legal department to review our NDA once you receive it?"

Twenty minutes.

Silence again. Then astonishment.

"REALLY? How can you do that so fast?"

You really need to get out more. How can you ***not*** do that so fast?

We're good. We also review five NDAs a week. Most adhere to a familiar format. I know what I'm looking for and, if it's there, I sign it. If it isn't, I redline it and send it back to you for review. Simple and straightforward. Extra points if you limit the verbiage to one page. Double points if you insert a threat that if you violate the terms of this agreement, black vans with tinted windows carrying large unsmiling men in dark suits with wires in their lapels will alight at your door to administer swift, merciless corporal punishment with rubber truncheons. That delivers the unequivocal message, but I digress. Once I sign it, how long will it take you to countersign it?

"Oh, that depends on our legal department. Turnaround time averages three to six months. By the way, you're funny."

I'm here all week.

Whole historical eras have changed in three to six months. Depending which battle you choose (Gettysburg, Trafalgar, Waterloo), entire epochs have changed in the course of one day. Now some pencil-pushing pinhead wants to justify their existence by holding up an inevitability for the sake of propriety? Heaven help us. Meanwhile, the clock is still ticking, x-rays have yet to be performed, and management is still screaming.

To read six pages of a standard form that a six-year-old can navigate? That's how you define urgency?

"We're a big company. We have our ways."

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

No s--t, Sherlock.

My mind wanders to speculative thoughts about the number of jobs in America that involve actual productive, contributive work. Not many, I fear.

"This won't delay our urgent job, will it?"

That kind of depends on you.

"How so."

We like to get paid. It's a thing around here, kind of a quaint custom. You have yet to reveal how that will happen. We'll listen; we don't have a portal.

"We have systems for that. You need to have reservations in our portal."

I already have abundant reservations ***about*** your portal. What more do you want?

"Once you've signed and returned our NDA, we will electronically transmit to you an access code with a temporary password. This will give you eight minutes of access to our portal, enabling you to set up your own account login and unique password. With the password, be sure to use at least one number, one lower-case letter, one capital letter, and one special symbol to authenticate your password and make it sufficiently robust for our compliance team in Kyrgyzstan."

You mean like 'D3@th2PWDs!'

"Yes, exactly like that. So, you've done this before?"

Once or twice.

"Once you click *Submit* you will receive automated instructions via email about how to upload invoices. Oh, and be sure to click on the box accepting our net 120 terms. Otherwise you will not be able to proceed further with account setup. And you need to do this in eight minutes or less; otherwise the system will throw you out and you'll need to start over. If you are thrown out three consecutive times, you'll need to wait 96 hours to reset."

And while I'm sprinting to do this in eight minutes, does the theme music from Jeopardy play in the background?

"What was that?"

Nothing.

"You will also be asked a battery of security questions to further establish and validate your identity. This is part of our NIST 800-171 compliance. You know, the usual questions: First kiss; first traffic accident (when and where); where you lost your virginity (names and dates, please); first use of a misplaced modifier, dangling participle, or pluperfect subjunctive in a run-on sentence, etc. Basic questions, we think. We want to get to know you."

Sounds reasonable. Can I obtain a copy of these questions afterwards for my records?

"Oh no. Our privacy regulations are governed by the European General Data Protection Regulation (GDPR). By those terms we cannot reveal that information to anybody. Your signing up on our portal is tacit acceptance of these opt-out terms."

I see.

"We take your privacy very seriously."

Clearly.

"We use your personal data as part of our Industry 4.0 compliant ERP system. We monitor supplier trends this way, to see if they deviate from our standards."

What standards? My main question remains unanswered. Once I've successfully navigated this obstacle course, what assurance do I have that we will be paid timely?

"That's the exciting part! Once you've followed the 37 easy steps to upload each and every invoice, you may click Submit and a grey button marked *Appeal Payment* will turn blue. Click that button and a page will open, listing various discounts you will offer to expedite payment."

Will *offer?*

"Of course. Otherwise you'll need to wait 120 days for a check to be cut and sent via regular mail. From Malaysia. After vetting by the financial security compliance team in Moscow. (Could you please provide us with the configuration of your servers for the benefit of our Moscow team?) Be advised we cut checks on the fifth and 21st of odd-numbered months when those days don't fall on Sundays. Sundays are for rest and reflection, you know."

Naturally.

"If you offer a 2% discount, our accounts payable team will consider payment in 90 days. A 5% discount accelerates payment to 60 days, 10% to 30 days. The higher the discount, the more weight the team will give to accepting your application. Isn't that exciting? I call that progress!"

I call that bribery.

Not that I wish to take leave of this thrilling discussion about your extortionate payment methods, but weren't you folks interested in x-ray services on a bunch of bum batteries? At last glance you still had a problem, and we still have a solution. What should we do?

"Right. Almost forgot."

I didn't.

"I guess we have a problem regarding immediate payment, don't we?"

Very observant. Your talent precedes you. You big-company guys think of everything.

"Will you accept credit cards? We may need one for this first order, as I see no clear path to overcome the inherent slowness of our internal vendor portal."

Clearly nothing gets past you. Your organization must be so proud.

Yes, we accept credit cards for first orders. Be advised, however, you'll need a card with a high credit limit. This is a big job. It's going to be very expensive. This is not some $750 job. Plan on multiplying that number at least ten-, maybe twentyfold.

Silence once again. Then resolution.

"Very well. I'll put my credit card department in touch with your accounts receivable team. You should hear from them in the next 30 days, maybe sooner. After all, this is a rush job. Management is anxious." ❑

Lean Six Sigma Approach Helps Keep Costs on Track

Changes in purchasing and line practices can save big dollars.

THE BENEFITS OF implementing Lean manufacturing philosophy are higher throughput and elimination of the variation that can introduce defects into a process. In a static environment, implementing Lean philosophy creates significant efficiencies that stay in place with little oversight. Most electronics manufacturing services (EMS) providers have very dynamic environments, however, where supply chain, customers, project technologies, volumes, production personnel and factory floor layout change frequently. In that environment, inefficiencies can creep in. Six Sigma training provides employees with a formalized product-solving methodology that allows these inefficiencies to be corrected. SigmaTron in Tijuana, Mexico, uses Six Sigma as a tool to keep its team focused on eliminating inefficiencies. The facility faced three major challenges over the past year: changing dynamics in the materials market; more projects moving to Mexico for tariff mitigation; and spikes in demand at existing customers for their products. This column looks at four Green Belt projects that cumulatively have eliminated nearly $300,000 in unnecessary costs in the first five months of improvement implementation.

The Green Belt teams use a DMAIC (define, measure, analyze, improve, control) methodology to identify each improvement opportunity and strategize the appropriate solution. Their facility's Yellow Belts helped with their continuous improvement projects.

In the Define phase, teams develop a problem statement, identify critical to quality (CTQ) and defect metrics, create project objectives, determine the business case and financial impact of the desired improvement, determine customer impact, set milestones and a timeline, define the project scope and boundaries, and assign team responsibilities. In the Measure phase, the teams measure the variances they associate with the problem they've identified, utilizing core tools such as cause-and-effect diagrams and gage R&R measurements. In the Analyze phase, the teams analyze the data collected to determine trends and possible corrective actions. In the Improve phase, the teams implement improvements and then utilize design of experiments (DoE) to determine if the proposed solutions correct the problem. In the Control phase, measures to ensure continued achievement of desired metrics are implemented.

The first project involved material cost reduction. The goal of the team was to analyze the most active parts in major projects to ensure that as market constraints lessened, best material pricing was achieved. The team developed a list of over 250 parts that needed to be requoted based on changing market trends. They implemented additional negotiation training for their resident purchasing team, established goals for continuing cost reduction in a list of parts targeted for additional cost reduction, and implemented a more robust management review process. They also now measure cost savings by buyer. An annual cost saving improvement goal of 25% was set, and by month five of the project the cumulative average exceeded that goal.

The second project involved quality defects on a rapidly growing project in the SMT area. The defects on that specific project were substantially higher than defects in other projects in the SMT area. The goal was to decrease the defective parts per million rate (DPPM) by 70%. Defects are measured at the individual solder joint level. The team determined four primary improvement areas: solder paste deposition height, printing process parameter, squeegee maintenance and standardization of operator inspection criteria. They looked at two failure modes: solder defects and placement defects. They also did gage R&R measurements of the accuracy of operators identifying defects. The solution involved adjusting solder paste height, replacing solder paste squeegees more frequently, recalibrating some feeders on placement machines, providing additional IPC-A-610 workmanship standard inspection training to production operators, and developing a manual to better explain the inspection process. The result achieved the defect reduction target and significant cost savings by eliminating associated rework.

The third project involved reduction in solder dross. Initial measurement and analysis of wave-solder machines indicated one machine appeared to be generating more solder dross than the others on the production floor, so the team decided to study it first. Further analysis determined variance was caused by inconsistencies in preventive maintenance and weighing of the solder and dross in the container, so a standardized weighing and maintenance process was defined. The team also looked at optimum solder pot fill levels and whether residual dross on pallets contributed to an increase in overall dross accumulation. DoEs indicated that while fixturing to ensure a uniform fill level did impact dross accumulation, solder pallet cleanliness had no impact. Solder dross

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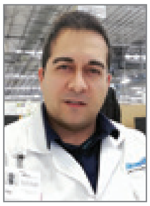

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Viewing Solder Joint Cracks in X-Ray

It's cheaper and faster to inspect by machine over microsection.

MOST OF MY columns have attempted to discuss the "typical," and often more obvious, solder joint failures that can be seen using x-ray inspection. This is usually the main and most important function of this type of analysis.

Nondestructive inspection of cracks within solder joints or components is also desirous, however, but this is much more difficult to evaluate optically or by x-ray. Even for those joints that are not optically hidden, optical inspection for cracks is likely limited to the very end of the termination and requires a mostly edge-on view at a reasonable magnification (FIGURE 1) to have the best chance of seeing a crack failure. When inspecting fully populated boards, achieving this level of magnification and orientation may be difficult to do optically, and any cracks present will need to be distinct by showing a separation in the joint. If the two halves of the cracked solder are still touching, then analysis may be almost impossible to make. Furthermore, such a crack will be at the end of the termination and not necessarily extending further back into the joint – for example, into the heel fillet of a QFP, which is more crucial to joint integrity. This may mean a cosmetic issue is seen on one joint, and the actual fault may remain hidden elsewhere.

If optical inspection does not help to see cracks, then can x-ray inspection? The first question to ask is, is there sufficient density difference between a cracked and non-cracked joint, so this density difference can be seen as different grayscale levels in the x-ray image? This depends on the board under inspection and the x-ray system capability. The thicker and denser the board, the greater the amount of material the x-rays must pass through before they go through the cracked solder joint. In other words, you have to look for the lower density of the crack against, and over, a much denser background. Second, the better the grayscale sensitivity of the x-ray system, the better the chance to see any subtle differences between cracked and non-cracked joints. This means x-ray inspection can provide an opportunity to see cracks, but it should not necessarily be depended on for quality control because of the potential for low-density variations; additional methods should be included or considered.

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Once you have images of suspect joints, my typical rules for x-ray inspection still apply: compare known good and bad examples and look for (in)consistency across all similar joints on the same component/board to confirm the analysis. In the case of cracks, however, also consider that if everything looks consistent, yet electrical tests report otherwise, ask if perhaps the x-ray system is not seeing what you need to.

To illustrate this point and show the subtlety of the grayscale differences likely for cracks, I am grateful to Bob Willis of bobwillis.co.uk (PCB assembly and optical images), Richard Boyle of Henkel (microsection images) and Peter Koch of Yxlon (x-ray images) for the following example. A test board was created and used to investigate thermal cycling failures of QFNs. Joint cracking of QFN packages containing over 40 pins is not uncommon, owing to the planar nature of the device and its positioning on a (likely) pliable surface such as a PCB. The boards were produced with SAC solder paste using a 0.005" stencil. They were reflowed in air in a 10-zone convection oven. The boards were not electrically connected to permit solder joint failures to be detected. X-ray inspection was used after 1,000 and 2,000 cycles, respectively, prior to microsectioning. The boards were visually inspected after approximately 500, 1,000 and 2,000 cycles (Figure 1). After 1,000 cycles, the onset of solder separation on the corner joints of the QFN packages was suspected. At 2,000 cycles it was believed the separation was increasing. FIGURE 2 shows the QFN and the planes across which it was subsequently microsectioned, first along the blue line and then along

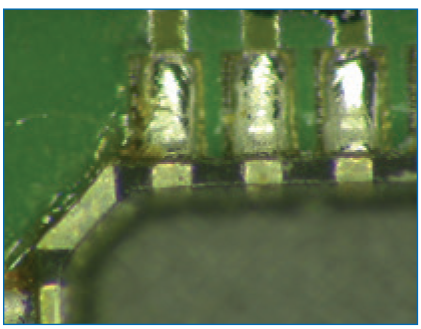


FIGURE 1. Optical image of QFN joints after 1,000 thermal cycles, where there is an indication of a separation between the joint and pad.

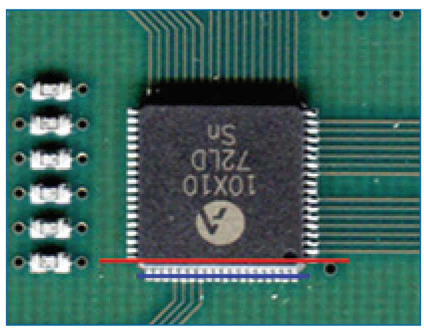


FIGURE 2. Schematic of the locations of the microsections.

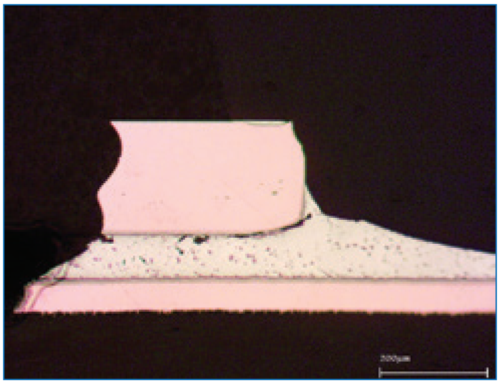


FIGURE 3. Microsection from along the blue line shown in Figure 2.

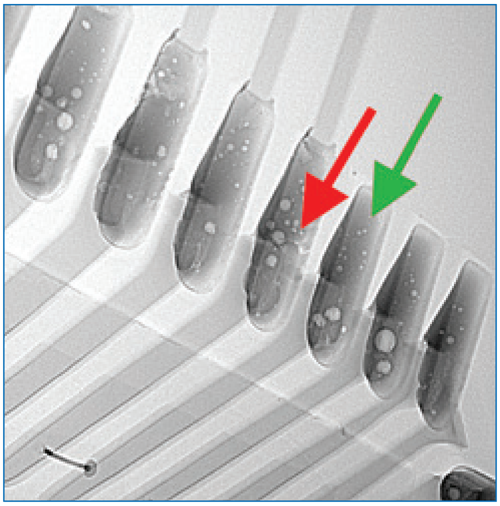


FIGURE 4. Microsection from along the red line shown in Figure 2. A crack extends across a substantial length of the joint.

the red. FIGURE 3 shows a microsection produced from along a section of the blue line and indicates cracks on all joints at that position.

FIGURE 4 shows a further microsection from along the red line in Figure 2, where a crack can be seen extending horizontally and under a substantial portion of one of the QFN edge terminations. The first microsection shows only that cracks are present but not how far they extend into the joint.

Obviously, microsectioning the board is a destructive process, so what can x-ray inspection tell us in this example ahead of cutting the board? FIGURE 5 shows an x-ray image of some of the QFN solder joints. The presence of cracks is shown (and highlighted). This is subtle and needs careful consideration, and comparison against other similar joints, but offers, in this example, some opportunity for seeing cracks nondestructively.

In Figure 5, we see some density variation in the highlighted joint compared to the adjacent joint. These suspicions can be followed up by using other tests and techniques. However, this example is a simple test board; in "real" boards it may be more difficult to see these subtle differences, as they may have many more layers with internal copper traces or other components obscuring the joints from view. Therefore, the use of appropriate oblique angle views to remove obscuring features from the field of view is important.

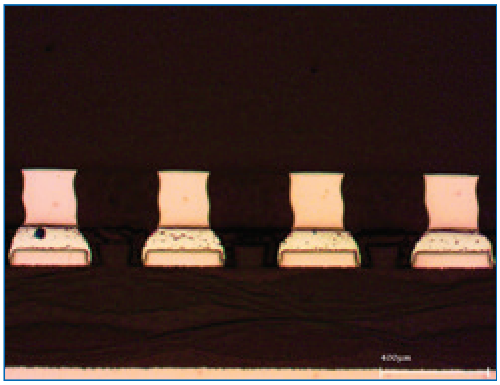


FIGURE 5. X-ray image of QFN joints prior to microsectioning. The crack seen on the highlighted joint is clearer compared to the adjacent joint.

If you suspect cracks exist, try x-ray inspection before cutting the board. But remember, not all x-ray systems have the same capabilities. To give yourself the best chance, consider the impacts of the board configuration and the sensitivity of the x-ray system. Then carefully analyze the images and compare and (ahem) contrast similar joints. □

Getting Lean continued from pg. 49

accumulation was reduced by nearly 50% in the first five months of the project.

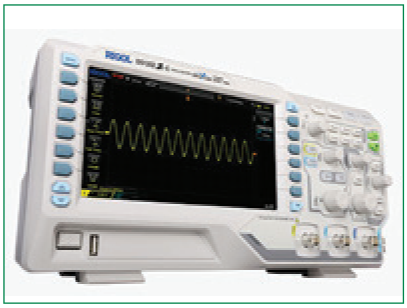
The fourth project focused improving production throughput for a customer whose project volumes were growing rapidly. The goal was to better balance the lines while improving revenue generated per employee. The entire production process was mapped to determine areas of processing inefficiency. It was determined production flow through the factory was inefficient, and the hot bar process represented a bottleneck, in part due to machine-related inefficiencies in temperature measurement. The process flow was redesigned to minimize the transport distance among work areas and to improve the layout efficiency of process lines and workstations. A faster thermometer was added to the hot bar stations to enable operators to monitor and maintain optimum temperature more efficiently.

Individually, the savings on any one of these projects in the initial stages aren't significant, but cumulatively these four projects are expected to represent nearly $750,000 per year in cost savings. More important, the three production-related projects increased standardization, which eliminates the variation that creates defect opportunities. The nature of the EMS industry creates inefficiency. Training employees in Six Sigma techniques helps ensure inefficiency is identified and eliminated on a continuing basis. □

BENCHTOP PLATING BATH ANALYSIS

QualiLab Elite supports multi-language operations and provides accurate analyses in an ergonomic design. Configurations range from compact single-sample manual analyzer to fully automated closed-cell system that can measure up to 42 samples without operator intervention. Offers high-precision selectivity and analyses with easy-to-use software, advanced reporting and data handling features, and analytical recipes.

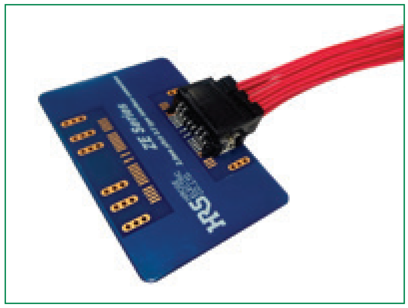
ECI Technology
ecitechnology.com



ANALOG OSCILLOSCOPE

DS1202Z-E 200MHz oscilloscope comes standard with two analog channels and 24MPts of deep memory. Has 60,000 frame segmented record mode, standard serial decode and triggering, high-res FFT, 15 trigger types and 37 integrated measurements.

Rigol Technologies
rigolna.com



HIGH-STRESS CONNECTOR

ZE05 series low-profile, 2mm pitch wire-to-board connector is for high heat and high vibration applications, including automotive, off-highway and transportation. Heat resistance up to 125°C. Maintains high electrical conductivity in severe heat environments. Has double-spring, three-point contact design with minimal clearance.

Hirose Electric
hirose.com

OTHERS OF NOTE

SOLDER MASK ADHESION PROMOTER

MultiPrep 200 copper surface treatment is for precleaning mask to enhance adhesion. Is said to maximize adhesion of solder mask, dry film, and liquid photo resist to copper traces. Leaves solder mask interface intact through final finish processing and assembly conditions.

MacDermid Alpha Electronics Solutions
MacDermidAlpha.com

HIGH-SPEED SPECTRUM ANALYZER

RSA3000E comes in 1.5GHz and 3GHz models with available tracking generators and performs real-time analysis for entry-level users. Comes standard with 10MHz of real-time analysis bandwidth with seamless capture and a 9.3 microsecond 100% POI. Provides seven rich visualization modes and powerful triggering capability.

Rigol Technologies
rigolna.com

HEAVY METAL CLEANER

MetalTreat Chelate Eliminator-8 is formulated to eliminate waste of highly chelated waste streams containing heavy metals. Enables effective waste treatment of chelated heavy metals from metal finishing and electronics manufacturing. Is alkaline blend of waste treatment constituents. Use after raising pH of waste stream to 11.

RBP Chemical
rbpchemical.com

HIGH-TEMP MLVS

TransGuard Automotive VGAH series glass-encapsulated SMT multilayer varistors are qualified to AEC-Q200, rated for operating temperatures up to 150°C, and for use in high-energy, harsh-environment automotive underhood, industrial, and oil and gas applications. Come in 1206, 1210, 1812, 2220 and 3220 sizes.

AVX
avx.com

PLATING SIMULATION SOFTWARE

PCBBalance evaluates the impact of a specific board/panel layout on the copper plating step during manufacturing. Simulation is carried out either on a virtual plating line, or on a digital twin of an in-house plating line. Jobs with various board/panel layouts can be simulated to compare plating uniformity and select optimum configuration. Identifies potential plating issues upfront. Embedded single-click balancing algorithm defines optimal copper balancing layout.

Elsyca
elsycapcbbalance.com

SMALL-SIZED MLCCS

CAS series surface mount device safety-certified multilayer ceramic capacitors (MLCCs) offer higher capacitance, smaller overall size and simplified assembly vs. leaded disc devices. For power adapters for mobile devices, industrial power distribution, and EV power inverters. Can place mains-connected filtering capacitors into smaller spaces.

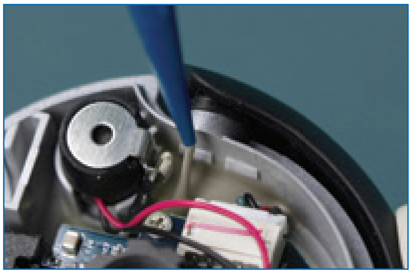
Kemet
kemet.com

CLOSED-LOOP CONFORMAL COATING

Panorama S-Line modular conformal coating line performs automated conformal coating in smaller footprint with overlapping line processes. Delivers a single point of contact for support and maintenance needs, process improvements, and smart solutions; range of equipment options; minimal operator interaction; closed-loop controls, parameter limits, and inspection; process data; stability and consistency. Includes conformal coater, exhaust conveyor or IR-cure, inspection module, curing module, and dryer.

Nordson Asymtek

nordsonasymtek.com



2-PART EPOXY

Master Bond EP29LPTCHT low-viscosity epoxy compound is for underfill and encapsulation applications. Does not need excessive heat for curing and has long working life at room temp. Is electrically insulative and thermally conductive with fine particle size filler material. Forms bond lines from 5 to 15µm.

Master Bond

masterbond.com

HIGH-POWER AXI

3Xi-M200 3D-CT inspects and measures insulated gate bipolar transistor power modules. 200keV high-precision x-ray imaging and 3-D reconstruction uses planar CT; provides clear images by penetrating through heat sink's multiple layers. Is equipped with detector that enables high-sensitivity imaging, while expanding field of view and updated 3D-CT reconstruction processing software. Handles board sizes of 50 x 140mm to 360 x 330mm. For 360 x 510mm boards, two-step image capture is available.

Saki Corp.

sakiglobal.com

OTHERS OF NOTE

HALOGEN-FREE SOLDER PASTE

SB6N58-HF350 is categorized as ROL0 per J-STD-004B. Sn3.5Ag0.5Bi6.0In composition is said to retain same level of joint reliability, viscosity stability, and meltability as conventional solder paste of same alloy. Thermal cycling testing (-40°/150°C) indicated no cracks at joint after 1,500 cycles. Melting point is 217°-219°C. For automotive, transportation and heavy-load applications.

Koki

ko-ki.co.jp

MODULAR DIGITAL CAMERA

C12s uses same large sensor unit as C12, delivering images with auto-focus and 12x zoom. Mounts to any Inspectis stands; uses all available lighting and lens accessories. Tilt stands and x-y tables can be added. Minimizes image glare and reflection of solder joints on PCB assemblies.

Inspectis AB

inspect-is.com

AUTO-SHUT-OFF VACUUM

Adjust-A-Vac Auto-Shut-Off ESD-Safe Kit has Buna-N static dissipative non-marking vacuum. Vacuum tweezer kit has auto-shut-off feature. Comes with ESD-safe Delrin small part tips and ESD-safe vacuum tips.

Virtual Industries

virtual-ii.com

LOW-MAINTENANCE DISPENSE VALVES

Material Application Valves are for the PrecisionCoat line of spray coating and dispense systems. Deliver material handling in modular configuration. Spray valve design integrates optional custom spacers between air cap and valve body to increase or decrease gap between air cap and nozzle. Are designed to eliminate unnecessary parts and associated routine valve maintenance and cleaning. Valve mounting grips and locks valve in place with one screw.

Specialty Coating Systems

scsequip.com

HIGH-REL CONFORMAL COATING

Elpeguard SL 1800 FLZ has thermal shock resistance from -65° to +125°C over 1,000 cycles. Can be used at high and low temperatures, for higher reliability of parts exposed to moisture. Can be soldered through in case of repair or removed with a dedicated thinner. Achieve crosslinking of silicone-contaminated surfaces.

Lackwerke Peters

peters.de

MATERIALS ANALYSIS TOOL

Vision Mark-1 performs electrochemical impedance spectroscopy (EIS). Reportedly can identify residues on an assembly, predict residue corrosivity, correlate it to SIR, and verify solder paste consistency and fitness for use. Uses localized extraction to collect a sample of the residue to test. Determines corrosion current and compares to control limits within one minute.

Insituware

insituware.com

In Case You Missed It

Embedded Cooling

"Orientation Effects in Two-Phase Microgap Flow"

Authors: Franklin L. Robinson and Avram Bar-Cohen; franklin.l.robinson@nasa.gov.

Abstract: The high power density of emerging electronic devices is driving the transition from remote cooling, which relies on conduction and spreading, to embedded cooling, which extracts dissipated heat on site. Two-phase microgap coolers employ the forced flow of dielectric fluids undergoing phase change in a heated channel within or between devices. Such coolers must work reliably in all orientations for a variety of applications (e.g., vehicle-based equipment), as well as in microgravity and high-g for aerospace applications, but the lack of acceptable models and correlations for orientation- and gravity-independent operation has limited their use. Reliable criteria for achieving orientation- and gravity-independent flow boiling would enable emerging systems to exploit this thermal management technique and streamline the technology development process. As a first step toward understanding the effect of gravity in two-phase microgap flow and transport, the authors have studied the effect of evaporator orientation, mass flux, and heat flux on flow boiling of HFE7100 in a 1.01mm tall × 13.0mm wide × 12.7mm long microgap channel. Orientation-independence, defined as achieving similar critical heat fluxes (CHFs), heat transfer coefficients (HTCs), and flow regimes across orientations, was achieved for mass fluxes of 400 kg/m^2 s and greater (corresponding to a Froude number of about 0.8). The present results are compared to published criteria for achieving orientation- and gravity-independence. (*Journal of Electronic Packaging*, vol. 141, no. 3, September 2019)

Molecular Electronics

"Single Molecule-Based Electronic Devices: A Review"

Authors: Bingrun Chen and Ke Xu

Abstract: As development of traditional silicon-based electronic devices is increasingly limited, a single-molecule electronic device is considered one of the most hopeful candidates to realize the miniaturization of conventional electronic devices. This paper provides an overview of single-molecule electronic devices, including molecular electronic devices and electrode types. First, several molecular electronic devices are presented, including molecular diodes, molecular memories, molecular wires, molecular field effect transistors (FET) and molecular switches. Then the influence of different electrode types of the transport characteristics is introduced, showing graphene is a promising electrode material for single-molecule electronic devices. Moreover, other excellent characteristics of molecular devices are briefly introduced, such as potential thermoelectric effects, new thermally induced spin transport phenomena and negative differential resistance (NDR) behavior. Finally, the future challenges to the development of electronic devices based on single molecules are described. (*Nano*, vol. 14, no. 11, November 2019)

Roadmaps

"Comparing Past Board Assembly iNEMI Roadmaps to Technology Outcomes"

Authors: Annaka Rose Balch; annaka.r.balch.19@dartmouth.edu.

Abstract: This project compares past board assembly roadmaps with actual technological outcomes, examining the progression of predictions across seven significant aspects of board assembly covered in the 1994, 2002, 2007, 2013 and 2017 roadmaps: 1) conversion costs, 2) NPI cycle time, 3) component trends, 4) solder paste, 5) bar solder, 6) wave solder flux and 7) die attach adhesives. It should be noted there are discrepancies between these roadmaps – from general outline to the many aspects of board assembly that are investigated. This project aims to bridge these discrepancies in a comprehensive fashion to better inform iNEMI and identify possible areas for improvement. (Pan Pac Symposium, February 2020)

Wearables

"Mechanically Transformative Electronics, Sensors and Implantable Devices"

Authors: Sang-Hyuk Byun, *et al.*

Abstract: Traditionally, electronics have been designed with static form factors to serve designated purposes. This approach has been an optimal direction for maintaining the overall device performance and reliability for targeted applications. However, electronics capable of changing their shape, flexibility, and stretchability will enable versatile and accommodating systems for more diverse applications. Here, the authors report design concepts, materials, physics, and manufacturing strategies that enable these reconfigurable electronic systems based on temperature-triggered tuning of mechanical characteristics of device platforms. They applied this technology to create personal electronics with variable stiffness and stretchability, a pressure sensor with tunable bandwidth and sensitivity, and a neural probe that softens upon integration with brain tissue. Together, these types of transformative electronics will substantially broaden the use of electronics for wearable and implantable applications. (*Science Advances*, Nov. 1, 2019, https://advances.sciencemag.org/content/5/11/eaay0418)

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.