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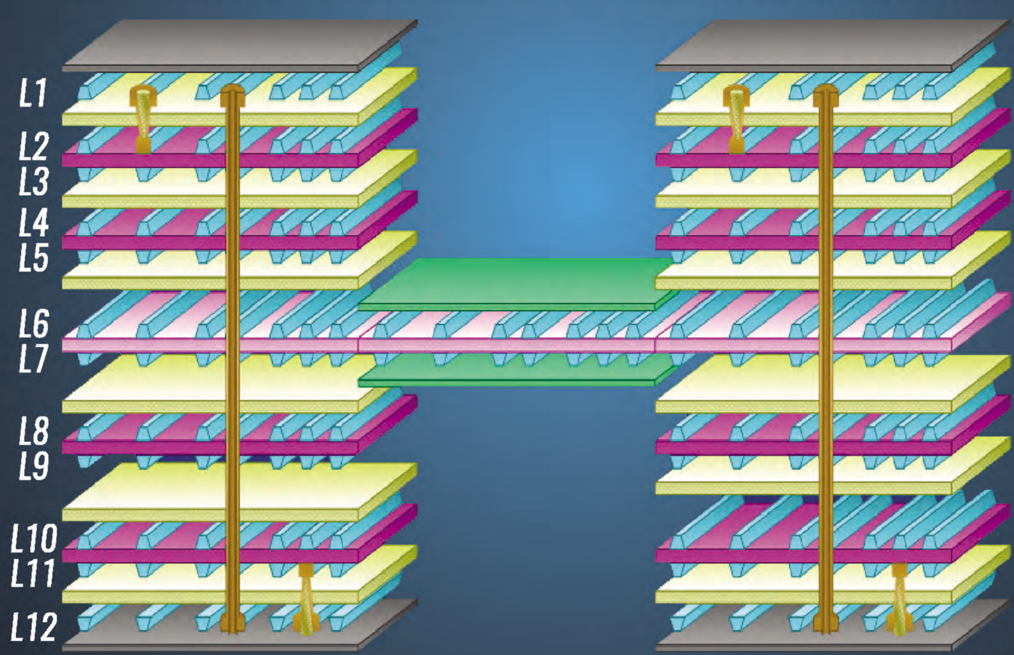

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E. Jan Vardaman

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OFF THE SHELF

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DESIGNER TRAINING

'We Teach the Engineering of PCB Design'
Outside of internal training programs, talent development in electronics hardware development falls to the handful of colleges, universities and third parties involved in teaching printed circuit design and manufacturing. With his PCB design courses at Palomar College, John Watson aims to train the next generation of designers.
by MIKE BUETOW

QUALITY ASSURANCE

Rightsizing Continuous Improvement Focus
Just as different types of manufacturing projects are often best served by different tiers in the EMS industry, regional EMS companies often need to right-size internal processes to match the resources that make sense in that scale of business. One area that can benefit from this rightsizing approach is quality management and continuous improvement.
by MATT CLINE

CLEANING

Key Considerations When Selecting a Replacement Vapor Degreaser Cleaning Fluid
When selecting a replacement cleaning fluid, factors to consider include the substrate being cleaned, the type of contamination being removed, and the long-term availability and sustainability of the replacement fluid. Using these factors, manufacturers can make an informed decision and select a replacement cleaning fluid that meets their specific needs while minimizing any negative impact on their cleaning processes.
by ELIZABETH NORWOOD

THERMAL MANAGEMENT (COVER STORY)

Understanding Criticality of Thermal Performance in Thermal Interface Material Applications
Common practice among design engineers is to utilize output from thermal modeling and simulation to specify a TIM with a certain thermal conductivity to meet the system's thermal needs. What many engineers miss is the impact of thermal boundary resistance that could have significant effect on the overall thermal management of the design. Explained is how to characterize thermal performance of TIM beyond the bulk thermal conductivity using a real application scenario.
by RITA MOHANTY, PH.D.

ON PCB CHAT (PCBCHAT.COM)

PCB TRAINING AT THE COLLEGE LEVEL
with JOHN WATSON

RELIABILITY TRAINING
with MICHELLE LEDET HENLEY

THE INTEGRATION OF AI INTO INSPECTION SYSTEMS
with ARIF VIRANI and BART PIWOWAR

THERMAL INTERFACE MATERIALS
with CLAIRE WEMP, PH.D.

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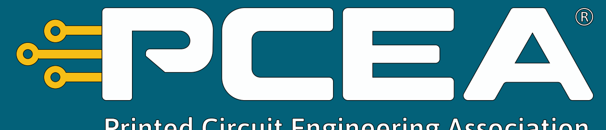

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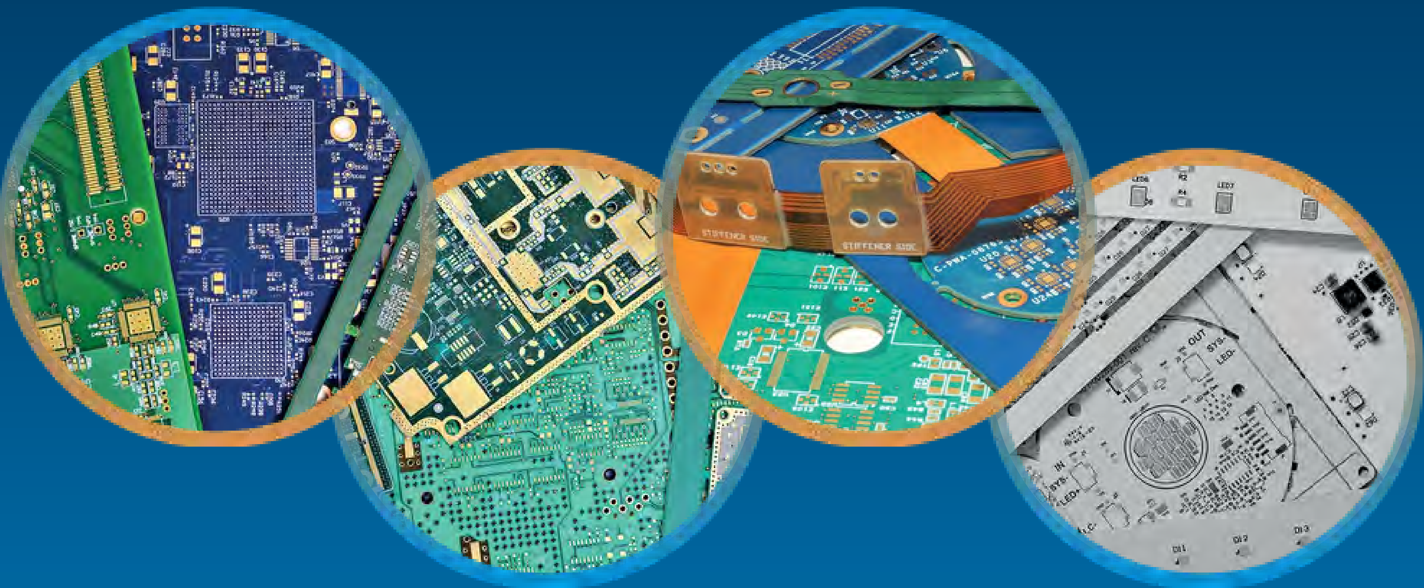

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Some Thoughts for Summer

RANDOM THOUGHTS AS the summer kicks in:

• Is anyone surprised the Foxconn investment in Lordstown Motors has run out of gas? It was an odd marriage in many ways – the world's largest ODM buying up the assets of a failing Midwestern automaker – but Foxconn took a similar approach with Sharp and, from a technical perspective, it gained crucial knowledge in electric vehicles, which it likely will need to keep its hooks in Apple, its biggest and most important customer, which almost assuredly is developing its own vehicle as a platform for its future software products.

Lordstown is now suing Foxconn over the breakup. Critics, on the other hand, are noting the long line of Foxconn promises that failed to materialize as planned and suggesting this was all too predictable.

• Speaking of Apple, the cellphone, and more precisely, the smartphone, may be the greatest consumer invention in the past 100 years. It's certainly among the most ubiquitous. About 68% of the world's citizens have smartphones, which given a global population of about 8.05 billion, suggests some 2.58 billion or so people are still walking around without an electronic device glued to their hands. (Bully for them.) While that means a huge market remains to be captured, the market share has been steady-state for the past five years.

But … overall shipments have dropped the past two years, the first back-to-back declines on record. (Some people, not all of whom are professional athletes – wink wink – are known to carry multiple phones.) With the population rising by about 82 million a year, perhaps we will eventually see a swing up. IDC thinks so, forecasting shipments to creep up at a rate of 2.6%

compounded annually through 2027.

For the needle to really move, however, either of two things must happen. Africa – home to 1.28 billion including five of the 10 most smartphone-starved nations – must level up. Or, phone designers will either roll out a physical device that is truly novel and a must-have, or the next-gen networks (true zero-latency?) will require substantially more memory or processing power than current models can provide. As for me, I'd settle for anything that provides a more consistent voice connection. That in 2023 I can't maintain a two-way conversation in many places in New England with my two-year-old Samsung is an ongoing source of frustration and bewilderment.

• The North American printed circuit board and EMS book-to-bills rose in tandem in May for the first time in more than two years. Granted, EMS companies buy most of their boards offshore, and the PCB ratio (0.89) remains under the benchmark 1.0 level that suggests future growth. Further, board orders typically lag EMS bookings, so the two indicators won't always move the same direction at the same time even in a broadly rising market. Still, it's an interesting marker for those like me who like watching statistical trends. As an aside, most of the publicly traded EMS and PCB companies have reported solid quarterly revenues thus far this year, and the Semiconductor Industry Association is forecasting the June quarter as the bottom of the semi slide, with recovery starting in the current period. At the risk of speaking too soon, we may have dodged the recession bullet.

• At the PCB East conference and exhibition in May, PCEA chairman Stephen Chavez and I held an impromptu focus group over lunch with the conference attendees. We tallied more than three pages of ideas for new technical presentations, which was invaluable feedback. More than that, however, registrants told us they want more time for networking between presentations and events. And perhaps somewhat surprisingly to me, but good news for the exhibitors, the conference attendees want more open time during the show hours so they can talk to exhibitors. We will happily incorporate those suggestions into next year's PCB East, which takes place June 4-7 in Boxborough, MA.

• While the feedback from PCB East wasn't received in time to make wholesale changes to the PCB West schedule, we did tinker around the margins to reduce the number of classes overlapping the exhibits. This year's show takes place Sept. 19-22, again at the Santa Clara

(CA) Convention Center. And new this year, we will have experts in printed circuit design and manufacturing on hand to answer attendee questions during the exhibition on Sept. 20. Among the industry experts who will be available are Rick Hartley (signal integrity and noise control), Susy Webb (design layout and routing), Nick Koop (flexible circuits), Stephen Chavez (PCB design), and Keven Coates (design for assembly). They will be available at scheduled times at the PCEA booth during the show hours of 10 a.m. to 6 p.m. Visit pcbwest.com to see the schedule and to register.

Hope you have a great summer, and we look forward to catching up soon.

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Schmid Group Aims for Listing on NYSE

FRANKFURT – Schmid Group plans to list in New York via a special purpose acquisition company (SPAC) in a deal estimated to give the technology firm a valuation of $640 million.

The fifth-generation family-owned business, which specializes in electronics, would become a publicly listed company on the New York Stock Exchange in the fourth quarter this year.

The transaction will be through blank-check company Pegasus Digital Mobility Acquisition Corp. led by Ralf Speth, the company said in a statement.

"We have been considering this step for some time and see the NYSE and the US capital markets as much more suitable for a technology company," CEO Christian Schmid told Reuters.

Founded as an iron foundry in 1864 and headquartered in Freudenstadt, Germany, Schmid has more than 800 employees and develops equipment and manufacturing processes for printed circuit boards, as well as technology for industries including renewable power and energy storage.

The Schmid family will maintain majority ownership and management positions following the potential merger.

AT&S Celebrates Plant Construction Milestones

LEOBEN, AUSTRIA – The exterior shell of AT&S' new R&D and IC substrate center here has been erected just 14 months after groundbreaking, and the company's new plant in Kulim, Malaysia, has

also reached a significant milestone with the completion of the facility's construction and installation of the first systems.

When complete, the company's €500 million ($537 million) plant in Leoben will include 11,000 sq. m. of clean room production area, and the gross floor area is 39,000 sq. m. (420,000 sq. ft.).

Once the project is complete in 2024, the facility will be the first in Europe to produce IC substrates – essential for future-oriented applications in microelectronics.

"It is something unique in and for Europe to set up this technology outside of Asia and to bring an IC substrate production of this dimension to the western world for the first time," said project manager Nikolaus Bauer-Oeppinger. "We are right on target with the construction site planned and parallel to the final outdoor work, we started bringing in the first production machines in April. Nothing stands in the way of the early start of qualification, so that our customer portfolio can be broadened and our customers can be supplied even faster and better."

In Kulim, AT&S top management recently celebrated the completion of another new plant and the installation of its first systems. The construction of a second plant has also been completed, and the start of production there will depend on the development of the market.

The Kulim project will have a clean room area of 120,000 sq. m., with production set to begin next fall.

"I am very pleased that we were able to achieve these two important milestones within 15 months after the groundbreaking – a great success after facing enormous challenges in the areas of health (pandemic), Resources and logistics had to be managed," said Ingolf Schröder, executive vice president of the AT&S microelectronics business unit.

"The construction of such a large plant was mainly possible thanks to a pool of experienced experts and a mature electrics and electronics ecosystem," said Vittorio Villari, managing director, AT&S Malaysia. "AT&S works with multinational companies that have been operating in Malaysia for more than 50 years, as well as our own future-oriented technology for high-quality IC substrates."

Element Solutions Acquires Copper

Nanotech Developer

MIAMI, FL – Element Solutions in June announced the acquisition of Kuprion, a developer of nano-copper technology for the semiconductor, circuit board and electronics assembly markets.

Kuprion's ActiveCopper technology addresses effects of thermal expansion in a host of growth applications, including electric vehicles, high frequency 5G networks, IC substrate manufacturing, advanced packaging, mission-critical aerospace and defense systems, and datacenters.

Element Solutions, the parent of MacDermid Alpha Electronics Solutions, said the acquisition has been structured with an upfront payment and potential earn-out payments based on milestones associated with product qualification and revenue over several years.

"The current weakness in the electronics sector represents an attractive opportunity to invest and position ourselves for the inevitable recovery," said Benjamin Gliklich, president and CEO, Element Solutions. "Our acquisition of Kuprion brings another highly-differentiated capability to our portfolio together with the world-class R&D and applications team who developed it. Their technology is designed to solve the increasingly difficult challenges associated with thermal management and adhesion in leading-edge electronics. We believe this represents industry-changing technology with broad applications across our portfolio, from semiconductor packaging to IC substrate metallization and electronics assembly. Combining Kuprion's solutions and technical capability, already sought after by many of our largest customers, with our breadth of sales, service and applications expertise will create tremendous growth opportunities."

Altair Survey Finds Friction Points for Enterprise AI and Data Projects

TROY, MI – A survey by Altair found high rates of adoption and implementation of organizational data and AI strategies globally, but also found that project successes suffer due to three main types of friction: organizational, technological, and financial.

"Organizations today recognize the imperative of using their data as a strategic asset to create competitive advantages," said James R. Scapa, founder and chief executive, Altair. "But friction

points clearly exist around people, technology, and investment preventing organizations from gaining the data-driven insights needed to deliver results. To achieve what we call 'Frictionless AI,' businesses must make the shift to self-service data analytics tools that empower non-technical users to work easily and cost-effectively across complex technology systems and avoid the friction inhibiting them from moving forward."

The independent survey of more than 2,000 professionals in 10 countries and multiple industries showed a high failure rate of AI and data analytics projects (between 36% and 56%) where friction between organizational departments exists.

Overall, the survey identified organizational, technological and financial friction as the main culprits hindering data and AI project success. The survey cited the talent gap as a significant cause of friction as organizations struggle to fill data science roles.

- 75% of respondents say they struggle to find enough data science talent
- 35% say AI literacy is low among the majority of their workforce
- 58% say the shortage of talent and the time it takes to upskill current employees is the most prevalent problem in their AI strategy adoption.

More than half of respondents say their organization often faces technical limitations that are slowing data and AI initiatives. And almost two-thirds said their organization tends to make working with AI-driven data tools more complicated than it needs to be.

Finally, despite organizations' desire to scale their data and AI strategies, teams and individuals keep hitting financial obstacles. Some 25% of respondents cited financial constraints are negatively affecting AI initiatives within their organization, with 28% calling leadership too focused on upfront costs.

Still, organizations across industries and geographic regions using AI persist despite high project failure rates. Despite AI project failures, organizations continue to use AI because they believe the opportunity exists to level up capabilities or services in the long run (78%) and its minor successes have shown potential for long-term breakthroughs (54%).

To read the full *Frictionless AI Global Survey Report,* visit https://altair.com/frictionless-ai.

Zhen Ding Building $700M Headquarters in Taiwan

TAOYUAN, TAIWAN – Zhen Ding will invest 5 billion yuan ($701 million) to build a 14,000 sq. m. green energy headquarters here.

The new facility will be located near the Taoyuan Qingpu High-Speed Railway Station and will be the new home for the PCB maker. Zhen Ding has been the global leader for PCB production for the past six years, and Taoyuan's PCB production value accounts for 29% of the world's total production and 84% of Taiwan's.

Zhen Ding chairman Shen Qingfang said the company has been expanding its production capacity in mainland China due to the unavailability of suitable land in Taiwan, but the new headquarters will permit the company to make an investment in his hometown of Taoyuan.

"The establishment of the Taiwanese headquarters will enable easier employee travel to and from major production bases, improve communication between the group's plants, increase investment in various plant areas in Taiwan, and encourage related supply chain manufacturers to cluster together for greater efficiency," he said.

Ventec to Build New Factory in Southeast Asia

SUZHOU, CHINA – Ventec International announced plans to open a new manufacturing facility in Southeast Asia by 2025/26 to extend its manufacturing capabilities beyond China and Taiwan and enhance global supply chain resiliency.

The new factory will duplicate manufacturing capability for Ventec's full range of high-reliability and high-performance products and mitigate supply chain risks for PCB manufacturers, OEMs and EMS companies across all regions by adding geographical diversity to the company's operations, Ventec said in a release.

"Now is the right time to invest in establishing a local manufacturing presence to support the

expanding southeast Asian electronics industry, which is experiencing significant growth across consumer, industrial, and automotive sectors," said Ventec CEO Jason Chung. "Moreover, this new factory will enhance our global supply chain security promise to our global PCB and OEM customer base as we plan to manufacture the complete portfolio of advanced high-reliability and high-performance materials."

Aohong Electronics Commits $84M to Thai PCB Plant

CHANGZHOU, CHINA – Aohong Electronics has announced plans to spend as much as 600 million yuan ($83.7 million) building a new PCB fabrication plant in Thailand.

The project, set to be constructed in an industrial park in the Prachin Buri province, will be built in phases and aim for mass production to start in 2026, the company said.

Aohong has two production bases in China with a total annual output of 4 million sq. m. of PCBs for home appliances, consumer electronics, power sources, network communications, and vehicle electronics for clients that include LG Electronics, Whirlpool and General Electric.

The Prachin Buri project will enhance Aohong's core competitiveness by better serving existing and potential key clients and lowering production costs, the company added.

Icape Group Acquires German PCB Distributor HLT

FONTENAY-AUX-ROSES, FRANCE – Icape Group has acquired the operating assets of HLT, a German PCB distributor that generated revenue of €4.1 million ($4.4 million) in 2022.

HLT, based in Baden-Württemberg, a state known for its automotive industry, supplies PCB to around 50 well-known customers in various sectors, such as automotive, home automation, telecommunications, aerospace and medical. HLT has a network of six strategic suppliers and its own logistics capabilities, providing a range of high value-added services in high-mix low-volume markets.

The acquisition was carried out by the subsidiary Icape Deutschland GmbH and is financed 100% in cash.

In a release announcing the acquisition, Icape Group said HLT's operating assets will strengthen its position as a leading player in one of the major markets for PCB distribution in Europe and worldwide. The acquisition will also consolidate and optimize the global network structured by Icape Group, offering a significant value creation potential.

"We are enthusiastic to strengthen our position in Germany through the acquisition of HLT's operating assets," said Cyril Calvignac, CEO, Icape Group. "Its highly skilled team works daily for some of the biggest names in the industry and their expertise will be a great asset to our development in this mature market. HLT's values, focused on high value-added service quality, match ours perfectly. We are confident that many synergies will arise from the combination of our know-how, particularly at the local level."

"By joining the Icape Group, we are partnering with a world leader in PCB distribution, whose purchasing power, supplier network and logistics platform will enable us to deliver an even more differentiated service to our customers," said Ralf Heissenberger, managing director, HLT. "We look forward to working with the group's teams, both in Germany and internationally, to leverage all the synergies that can be deployed between our two structures.

Siemens Allocates $2.2B in New Manufacturing Capacity

MUNICH – Siemens will invest €2 billion ($2.2 billion) to expand its manufacturing in Asia, including a new plant in Singapore and a capacity expansion at a factory in China, to meet rising demand in the region.

In Chengdu, the conglomerate will spend up to €140 million to expand the site, which makes factory automation products. Likewise, the Singapore investment of €200 million will result in a new facility for producing factory automation devices.

ECIA GIPC Launches 2-D Barcode

Review

ATLANTA – ECIA's Global Industry Practices Committee has launched a five-year review of its 2-D Barcode Specification, which published its last revision in 2018 to continue guiding the industry on the use and value of this technology for product identification labeling.

Concurrent with the publication of the specification, ECIA launched new initiatives to promote the use of this technology throughout the electronic component channel, and over the past decade there has been widespread adoption, substantially improving the efficiency of the end-to-end order process.

The five-year review process began on May 11, and consists of reviewing and updating the entire 44-page document line by line. The SME (Subject Matter Expert) work group includes nearly 20 companies representing a broad range of ECIA member component distributors and manufacturers. They will meet bi-weekly until the task is complete. Once the specification is updated, it will be submitted to ECIA's standards team to convert the specification into an official industry standard.

"ECIA's 2-D Barcode Specification has now been widely adopted by the industry because it dramatically improves the efficiency of the end-to-end order process. But a lot has happened in the last five years and it's important to keep this document current," said Don Elario, vice president of industry practices, ECIA. "After applying requirement changes, industry best practices and reaching the international adoption levels we have, it's now time we convert this labeling specification to an ECIA (EIA) standard."

To learn more about the initiative, visit https://www.ecianow.org/2d-barcode-labeling or contact Don Elario at delario@ecianow.org.

JEDEC Publishes Major Update to JEP30 PartModel Guidelines

ARLINGTON, VA – JEDEC Solid State Technology Association has announced significant updates to the JEP30 PartModel Guidelines, including all reference documents and related XML Schema files. JEP30 and its constituent documents are available for free download from the JEDEC website.

JEP30 establishes requirements for the frictionless digital exchange of part data between part manufacturers and their end customers responsible for electrical and electronic products creation. The JEP30 guidelines define a standardized format that can be efficiently consumed across different CAD tools and environments. By defining a common framework for part model creation and verification and helping to ensure different tools can accurately interpret and utilize the models created by the full spectrum of part manufacturers, JEP30 offers a transformative resource for both component manufacturers and designers.

The updated JEP30 part model guidelines can be used to define the digital twin of a part with the detail to enable significant process efficiencies throughout the part and product life cycles, including design, manufacturing, quality control, test, material declaration, and supply chain.

"The JEP30 PartModel is truly a disruptive technology that will revolutionize the way system design companies develop and manufacture their products by enabling the automation of manually intensive functions, prone to human error, that are prevalent in today's electronics design environment," said Michael Durkan, JEDEC task group chair and PartModel sponsor. "The PartModel is a secure, trusted digital container provided by component manufacturers that will streamline the design process by eliminating dependencies and establish integrity of part information at every step of a product's lifecycle."

For all forms of electronic parts, JEP30 guidelines define the XML structure for the assembly process classification, electrical, physical, thermal, material declaration, and supply chain characteristics including product change notices and product discontinuance. The guidelines are designed to be completely scalable to cover components available on the market today as well as new parts that emerge in the future.

"The increasing speed of innovation have mandated new technologies along the systems value chain to keep pace," said Mian Quddus, chairman of the JEDEC board. "The enablement of component manufacturers to create standardized digital part models that can be easily used by designers and engineers in all varieties of electronic systems, will help propel an industry forward with next-level digitalization and automation."

New PCB Assembler Launches in Quebec

QUEBEC – Fabrique Manic, a provider of PCB assembly services has opened here. Located in St-Augustin-de-Desmaures, just outside of Quebec City, the company was founded by two colleagues from the tech industry.

Dominic Gauvreau, president – electronic design and assembly, and Olivier Morin, vice president – business development, aim to deliver solutions that alleviate complexities and delays of the physical product production cycle. The firm offers electronic design and consultation, and manages rapid prototyping, including three-day turnarounds (upon receipt of parts). PCB-related assembly services include mechanical assembly, firmware programming, board modifications and more.

Prior to launching Fabrique Manic, Gauvreau worked full time at Orisha Automation as a hardware/firmware developer while performing consultation work part-time as an electronics designer, and Morin worked at UgoWork, a tech company in Quebec City that offers EaaS (energy as a service) with lithium-ion batteries to power forklifts.

Fabrique Manic also provides product testing, backed by strong quality control procedures using optical inspection, and the firm manages cable and housing assembly to accommodate some clients.

Incap Inaugurates 3rd Factory in India

TUMKUR, INDIA – Incap recently celebrated the opening of a new 26,500 sq. m. factory in India – its third in the country.

The Tumkur factory specializes in manufacturing electronics and box-build products, and features machinery suitable for common component technologies. Together with its location and skilled personnel, the company can provide high-quality manufacturing services to meet the most demanding customer needs, Incap said.

“Looking ahead, the EMS industry holds a promising future,” said Otto Pukk, president and CEO. “Therefore, we maintain our dedication to investing actively in our operations and fostering their development. I would like to express my sincere gratitude to our exceptional team in India whose collective efforts have played a crucial part in establishing our new factory.”

Incap India’s managing director Murthy Munipalli said the factory has been designed to be

sustainable and to provide a modern work environment.

"Incap's third factory in India has been carried out in line with sustainable building principles, paying special attention to efficient use of energy and water," he said.

The new factory was built to provide a comfortable working area with sufficient lighting and air ventilation, optimized space utilization and an easy emergency rescue route plan. Once installed, solar panels on the roof will provide renewable energy to the facility. In addition to environmentally friendly energy solutions, the factory also includes a new wastewater treatment facility. The new facility will help to purify water and preserve freshwater resources by using treated wastewater for other purposes, such as flushing, gardening and landscaping.

Rapid Manufacturing Unveils Kulim Expansion

KULIM, MALAYSIA – Rapid Manufacturing has announced a new facility here to serve the aerospace, telecommunication, medical, semiconductor, automotive and industrial automation sectors, as well as house a regional center to set up a center of excellence.

The company made the announcement in a joint statement with the Malaysian Investment Development Authority (MIDA) and the Northern Corridor Implementation Authority (NCIA).

Rapid Manufacturing subsidiary RPD MFG Connectivity managing director Yogendran Krishnamurthy said the company's investment is expected to create an estimated 2,000 jobs locally, including at least 500 high-income jobs.

COO Luis Espinoza said the company's key priorities are its commitment to hire and train local talent, as well as to enhance its vendor-development programs to provide adequate opportunities to local vendors.

MIDA chief executive officer Datuk Arham Abdul Rahman said Rapid Manufacturing's expansion of its production facility underscores the long-term global demand for its products.

"Malaysia is well positioned to capitalize on these opportunities," he said. "By leveraging the country's comprehensive electrical and electronics (E&E) ecosystem and our mature semiconductor

supply chain, the new facility is expected to have a positive impact on job creation, benefiting the local community while enhancing the country's supply chain to meet the rapidly changing requirements of the E&E industry."

NCIA chief executive Mohamad Haris Kader Sultan said NCIA is committed to attracting and facilitating high-value investments in the Northern Corridor Economic Region (NCER) which includes the states of Kedah, Perlis, Penang and Perak. He said Rapid Manufacturing's investments in Kedah and Penang will considerably strengthen the supply chain ecosystem to support the activities of the E&E, machinery and equipment, medical technology and devices, telecommunication, automotive and aerospace industries within NCER.

"With the facilitation by NCIA via its various NCER incentives, it is confident that more companies will follow suit and invest in NCER, driving sustainable economic growth and creating job opportunities for the local community," he said.

Escatec Builds New Production Facility in Bulgaria

PLOVDIV, BULGARIA – Escatec has opened a new production facility here to meet an increasing demand for nearshoring production in Europe.

The 4,000 sq. m. facility is already operational to vertically integrate plastic molding and electronics assembly to support the company's production commitments in Europe, and Escatec said it is willing to expand capacity and capabilities at this new facility as order volumes pick up.

"Escatec Bulgaria is an important new site in Escatec's portfolio as we move to complete our global manufacturing footprint. Customers of Escatec can expect that we deliver a best-value solution, regardless of region, as we continue to harness the benefits of our multi-site strategy," said Charles-Alexandre Albin, Escatec's executive director and director of strategic development.

Escatec's customer base largely consists of major OEM brands based in Europe and North America, and the company's production network now comprises of two facilities each in Penang and Johor Bahru, Malaysia; two in Chomutov in the Czech Republic; one in Lutterworth in the United Kingdom; an advanced production facility in Heerbrugg, Switzerland; and the latest facility in

Bulgaria. The company also operates a design & development (D&D) center in Switzerland and has strategic partnerships in Croatia and the US.

Over the long-term, Escatec Bulgaria could become the company's main production facility in Europe for plastic molding and electronics assembly, due to Bulgaria's membership in the European Union and Plovdiv's strategic location, sizeable population, its large industrial base, and its transport links providing convenient access to the wider European market, Albin said.

"Escatec remains committed to expanding its global production footprint and capabilities to cater to customers that are in the process of bringing new technologies and products to market," he said. "Across the group, Escatec offers a complete and integrated value chain of EMS services, from D&D to product certification to mass manufacturing and after-sales services, ranging across electronics, electro-mechanical, MOEMS, box-build and plastic molding."

Compal Building New Vietnamese Plant

THAI BINH PROVINCE, VIETNAM – Compal Electronics has purchased a $30 million plot of land in Vietnam to build a new plant and expand production capacity.

The Taiwanese firm's Vietnamese subsidiary leased a 40-hectare plot in the Lien Ha Thai Industrial Park in Thai Binh province, Compal said in a stock exchange filing. Compal is already producing Apple products in Vietnam, with factories in Vinh Phuc, on top of its major production sites in China's Chongqing and Jiangsu as well as Thailand's Phetchaburi, according to Apple's latest supplier list.

Ekkaa Electronics Shifting to Consumer Electronics Production

SONIPAT, INDIA – Ekkaa Electronics has announced plans to build a new factory in Noida, India, that will produce LED TVs and other consumer electronics products like washing machines, smartwatches and hearables.

The company said it will be investing INR1,000 crores ($122 million) in the new manufacturing

unit, and the construction of the facility will mark a shift for the company from assembly to core manufacturing of consumer electronic products. With the growing demand for exports out of India, Ekkaa will soon launch an export arm as well.

“Out of the proposed investment of INR1,000 crores, 40% has already been aligned for land acquisition, construction, working capital, manufacturing, and R&D. The remainder of the investment will be spaced out over six months toward R&D, machinery and others. The infusion of funds will be a continuous process as we are not only increasing production capacity but also expanding our product lines,” said Ekkaa director Sagar Gupta. “The new facility at Noida will have an initial capacity to manufacture 500,000 units of LED TVs per month, which will make the plant the largest facility in terms of capacity in the country with the potential to ramp it up to 800,000 to 900,000 units per month in the next three years. The new facility will have a workforce of 1,500 employees, with plans to ramp to 3,000 over three years.”

Ekka currently caters to 150 pan-India and regional brands and exports to neighboring countries like Nepal, Bangladesh and Bahrain, but the new facility and product lines will enable it to export to countries in Africa, the Gulf nations eventually to Europe and the US, the company said.

“In our current manufacturing facility at Sonipat, we make motherboards and plastic injection molding for the LED TVs,” Gupta said. “However, going forward in the new plant, replete with machines like metal presses, backlight manufacturing facility for LED TVs, we have done a complete in-house integration comprising of design and manufacturing capabilities and marching toward core manufacturing of consumer electronics products.”

PCD&F

Dynamic Electronics has accelerated the construction of its new plant in Thailand, which is scheduled to open in the fourth quarter of 2024.

Mitsubishi Gas Chemical will expand production capacity of BT laminates for semiconductor substrates at its Thailand campus.

Nan Ya released its plans for setting up factories in Southeast Asia between the end of the third quarter and the fourth quarter at the earliest.

Northern Copper announced plans to issue Series A shares to raise 1 billion yuan ($140 million) to increase PCB-related projects.

RBP Chemical Technology announced a strategic partnership with **Mid-States Graphics** to expand its product offerings.

Taiwan PCB Techvest announced plans to set up a new plant in Vietnam to produce PCBs for optoelectronics and notebook applications.

TSMC is reportedly contemplating a 3% to 6% price increase for its advanced process manufacturing beginning in January 2024.

Xinxing is actively deploying new products involving AI and is working closely with **Intel's** data center division to meet the demand for AI servers.

CA

Adco Circuits purchased a **Hänel** Lean-Lift vertical storage system and a **Scienscope** Reel Smart incoming material station, installed a new robotic thermal adhesive dispenser, and launched ADCOproto.com – an online tool that provides instant component availability for uploaded BoMs.

Advantex installed and commissioned a Milestone IP surveillance system along with a number of high-resolution Axis IP cameras at **Plexus.**

AIM Solder appointed **ACD Renaissance** manufacturers' representative in India.

Cetec ERP was chosen by **GoldStar Medical Instruments** to provide a web-based solution for inventory control, traceability, accounting and quality management.

Dixon Technologies said it is partnering with **Xiaomi's** Indian arm to make and export phones for the Chinese firm.

Firearm OEM **FN Herstal** is now offering contract assembly at its primary manufacturing facility near Liege, Belgium.

Hentec Industries/RPS Automation sold Pulsar solderability testing and Photon steam aging systems to a major aerospace contractor for its missile sector manufacturing facility.

EG Industries announced a partnership with **Yamaha** to establish advanced 5G automated intelligent SMT production lines for its upcoming smart lights-out factory in Batu Kawan, Penang.

Foxconn's new factory in Devanahalli, India, is anticipated to be valued at Rs.130 billion ($1.6 billion) and claims to offer approximately 50,000 job opportunities for its planned production of more than 20 million iPhones per year.

ITW EAE named **Macon** representative and distributor of Vitronics Soltec soldering equipment.

Lacroix has restarted production at its plants in France, Germany and Tunisia after they were disrupted by a cyberattack in mid-May. While the attack will have a temporary impact on the second quarter, the company said it does not expect any significant repercussions on the financial targets announced for the full 2023 financial year.

OSI Optoelectronics announced an expansion of solutions including new products and services including rigid flex board and flex circuit design, manufacturing and assembly.

Price Electronics purchased an **EVS** 500 Solder Recovery System.

Pegatron announced plans to purchase land and a building in Taoyuan, Taiwan, for a total of NT$755 million ($24.6 million).

Powin named **Jabil** to build its energy storage platforms.

Sourcemap announced the closing of a $20 million Series B investment to further expand its global footprint and add business-critical solutions to its supply chain mapping and monitoring software suite.

Tata Electronics is reportedly in talks with large global semiconductor companies and outsourced semiconductor assembly and test vendors to foray into advanced packaging of semiconductor components.

ThermOmegaTech recently merged with **TJM Electronics** and added PCB assembly to its manufacturing capabilities.

ViTrox named **TetraTronik Makine Ticaret** distributor in the Türkiye region.

Western Reserve Controls renamed itself **Anzer** and added a larger manufacturing facility, additional SMT equipment, a dedicated prototype production line and additional personnel.

Xiaomi India has begun producing audio goods in India in collaboration with Noida-based **Optiemus Electronics.**

Yamaha Robotics SMT delivered a complete SMT line to **Ouman Estonia.**

ZF Group is on track to grow its presence in China with additional production capacity for electronic power steering (EPS) systems.

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PCD&F

Confidee appointed **Patrick Sandberg** sales manager Germany.

Freedom CAD Services named **Kathy Carron** account manager.

Nano Dimension promoted **Shavi Spinzi** to VP AME and PCB technologies.

AIM Solder appointed **Nolan Neva** regional sales manager for the US west coast.

Ametek named **Rolando Castillo Andrade** engineering manager.

Ark Electronics appointed **Thierry Basse** to manage its new European office in Bordeaux, France.

Cyklos Materials appointed **Anandkumar R. Kannurpatti** CEO and co-founder.

Gen3 appointed **Daniel Ryland** area technical manager for the southern UK region.

Hanwha Techwin promoted **Mark Choi** to vice president of sales for the US and Canada.

Hirose Electric Americas named **Mark Kojak** president and COO.

Lunar Energy promoted **Mathieu Kury** to head of manufacturing operations.

Mek appointed **Maria Dzionk** operations manager.

Micro Precision Technologies named **David Prunier** general manager.

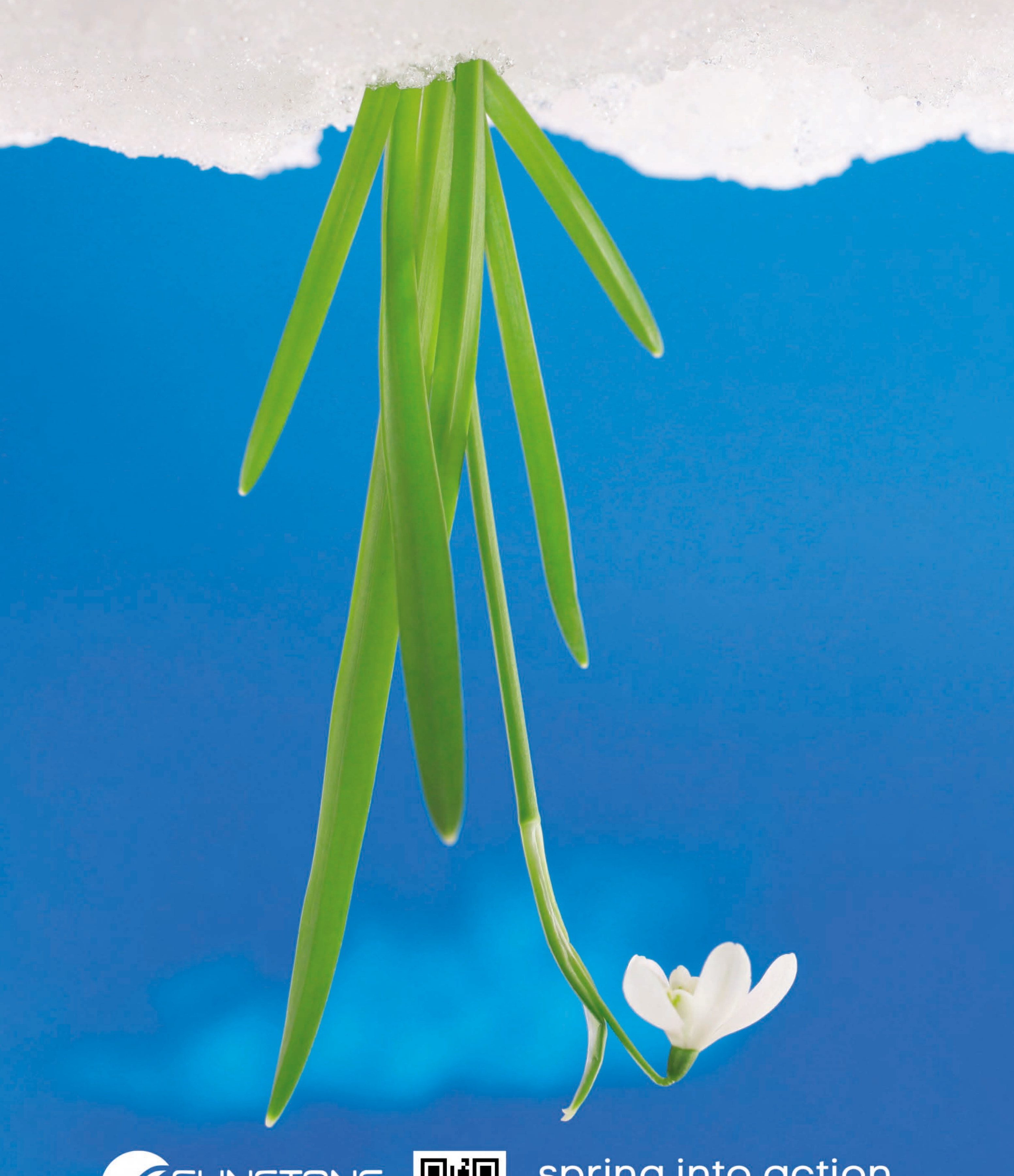
Nortech Systems announced the departure of **Christopher D. Jones** as CFO and senior vice president of finance effective June 8, and announced the death of board member **David Graff,** who passed away on May 28.

Pemtron Technology added **Fabio Pareira** to its engineering team.

STI Electronics hired **Norma Low** as quality manager.

Viscom promoted **Jacques L'Heureux** to vice president/key account management.

ZTEST appointed **Derrick Strickland** director.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PCB West Registration Now Open

PEACHTREE CITY, GA – The Printed Circuit Engineering Association has opened registration for the technical program for PCB West 2023, featuring nearly 50 presentations and more than 130 hours of in-depth electronics engineering training.

Among the industry experts on tap for this year's show are Lee Ritchey, Susy Webb, Tomas Chester and Zachariah Peterson.

The conference will be held Sept. 19 to 22 at the Santa Clara (CA) Convention Center and features classes for every level of experience, from novice to expert.

The scope of classes ranges from basics on design engineering and DfM, to designing and building RF and microwave products, board stackup, circuit grounding, PCB layout of DDR memory, thermal management, manufacturing PCBs, and more. New courses this year include the role of AI in PCB design, system level simulation, and signal integrity in thin PCB materials, among others.

Also new this year: Ask the Experts, a series of help sessions with experts in signal integrity, high-speed design, EMI, DfM, flex circuits and more.

Conference registrants who sign up by Aug. 18 can take advantage of the Early Bird Special discounts for the conference.

An exhibition featuring more than 100 leading suppliers to the electronics design and manufacturing industry will be held Sept. 20.

Chapter News

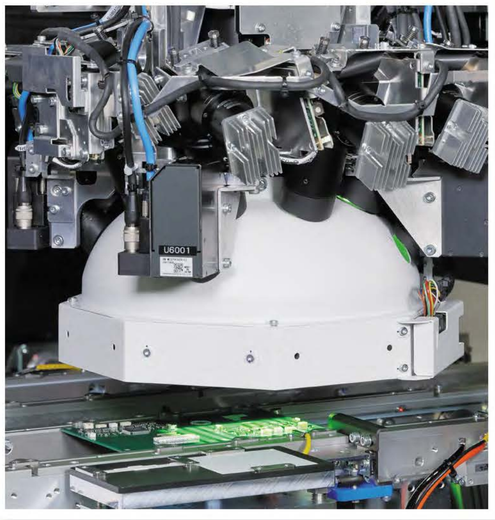
Education committee. The committee is reviewing the overview of free content that is available at pcea.net, with feedback due in June. This project is being managed by John Watson.

The committee is also updating the 2023 PCD&F Salary Survey prior to distribution to the membership.

Troy Hopkins, a senior hardware designer with Connect Tech, has been named chair of the Conferences task group.

Rio Grande Valley. The RGV Chapter had its first public meeting on June 1. We are planning our next meeting for September and will have more details as we get closer.

Eliminate defects with Yamaha's AI enhanced AOI



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Supply Chain Productivity Declines Cannot be Solved by Robots and AI Alone, Gartner Says

New technologies ranging from smart robotics to actionable AI have the potential to transform the supply chain function, but they will fail to lift historically low levels of labor productivity unless utilized as part of a broader strategy, according to research firm Gartner.

"There is legitimate excitement today around new technologies that hold out the promise of vastly enhanced organizational productivity," said Thomas Pocock, senior director, advisory, in Gartner's Supply Chain Practice. "Supply chain leaders must remember that these new technologies require the partnership of an engaged and productive workforce for these gains to be realized. Unfortunately, the data tell a discouraging story on this front."

Pocock highlighted data from a first quarter Gartner survey when 2,613 supply chain employees were surveyed to show the extent of supply chain's labor productivity challenges:

- Only 25% of the supply chain workforce is fully engaged.
- Turnover is 33% higher in the supply chain function than pre-pandemic.
- Only 16% of the supply chain workforce is willing to go "above and beyond" in their roles.

"Introducing new technologies, especially of the magnitude of AI or smart robots, would come with implementation challenges at any time," said Pocock. "Any new technology introduced in this environment is likely to be met with elevated levels of mistrust and change fatigue. It's clear there needs to be a new strategy to make such integrations work for all sides."

Pocock noted that technology is just one of a series of strategies that need to be reinvented to reverse supply chain's labor productivity slide. He recommended chief supply chain officers reexamine their approaches in three key areas:

Integrating technology and people strategies. New workplace technologies should be designed with the human-technology relationship front and center. Organizations must also create opportunities for reciprocal learning, or the opportunity for employees to safely make sense of new technology and see how technology is incorporating human input. Technology investments must be made side-by-side with equivalent investments in workforce training, skills development and knowledge curation.

Individual talent management. High-demand skills are often already available in supply-chain organizations but often trapped by the rigid nature of job descriptions. CSCOs can unlock more skills and flexibly deploy talent where it is needed by breaking down projects into component tasks and seeking skills needed for those tasks across the entire organization and even beyond it.

Organizational design. Organizations can leverage crisis situations and market opportunities as a reason to break down silos and find new, more efficient organizational structures. Spontaneous redesign of decision-making processes happened at many companies during the initial disruptions of the Covid era. They can be harnessed to build resiliency in the face of new challenges, such as persistent inflationary conditions or changing geopolitical considerations.

ALL STORED UP

Trends in the US electronics equipment market (shipments only)

	% CHANGE			
	FEB.	MAR.[r]	APR.[p]	YTD
Computers and electronics products	0.0	-0.6	-0.2	3.5
Computers	0.9	-1.6	1.6	9.0
Storage devices	-3.8	5.6	10.6	11.5
Other peripheral equipment	-1.3	8.1	1.5	51.5
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Nondefense communications equipment	0.7	-2.3	-0.9	1.4
Defense communications equipment	-1.4	-1.0	1.5	4.6
A/V equipment	-21.2	2.4	-0.8	-19.3
Components[1]	2.1	-3.3	-3.0	2.9
Nondefense search and navigation equipment	1.1	0.1	1.2	1.9
Defense search and navigation equipment	0.4	-0.3	1.2	2.4
Electromedical, measurement and control	0.3	1.4	0.6	1.8

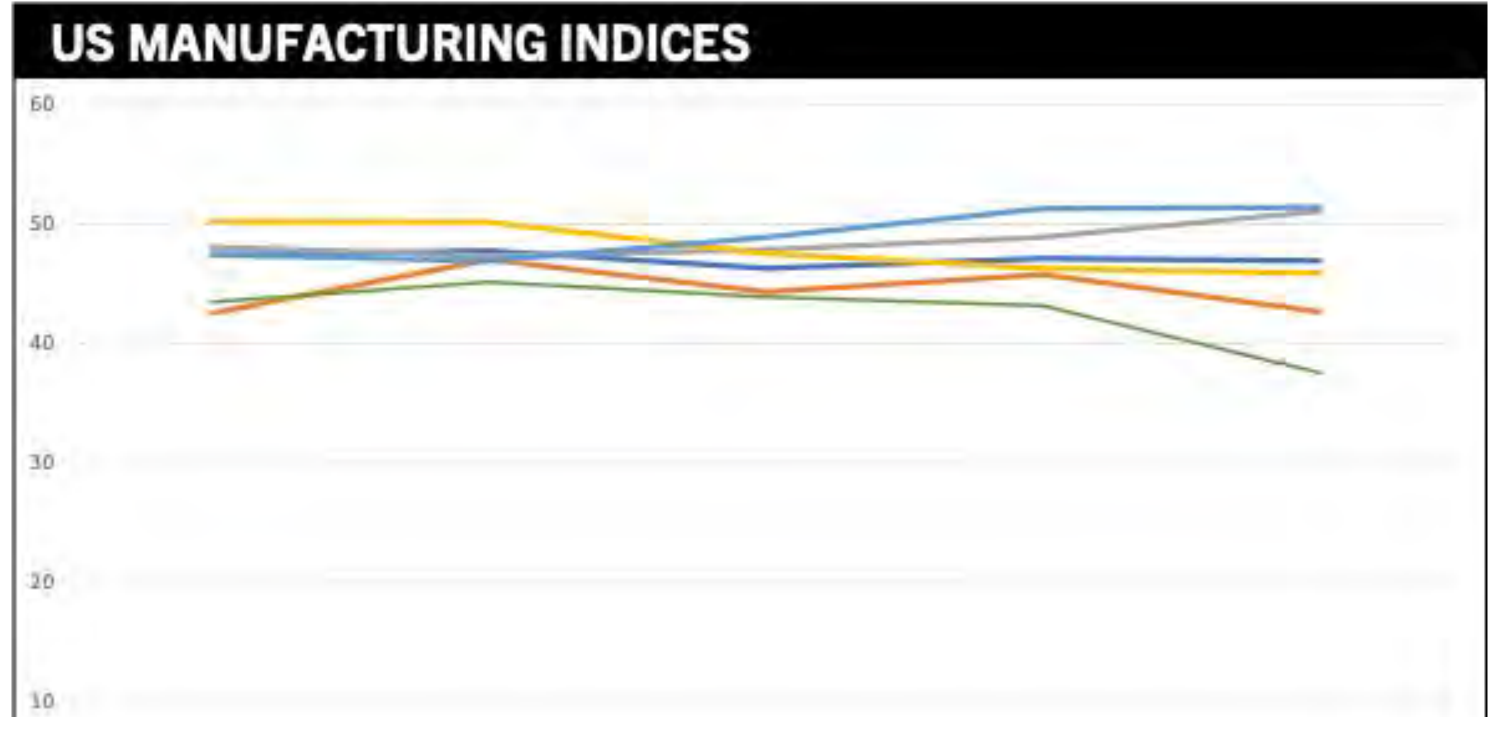
[r]Revised. [p]Preliminary. [1]Includes semiconductors. Seasonally adjusted.
Source: US Department of Commerce Census Bureau, June 5, 2023

KEY COMPONENTS

	JAN.	FEB.	MAR.	APR.	MAY
EMS book-to-bill[1,3]	1.36	1.30	1.28	1.21	1.24
Semiconductors[2,3]	-18.5%	-4.0%	0.3%	0.3%[p]	TBD
PCB book-to-bill[1,3]	0.94	0.99	0.91	0.89	0.89
Component sales sentiment[4]	65.8	82.2	90.6	88.7%	72.2%

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

US MANUFACTURING INDICES



Source: Institute for Supply Management, June 5, 2023

Hot Takes

Total North American **EMS shipments** in May were up 7.1% compared to last year. Shipments decreased 5.2% from April. Bookings increased 0.8% year-over-year and 4.4% sequentially. (IPC)

Global **PC and tablet shipments** will fall to 385 million units, down 15% compared to last year. (IDC)

Global tin prices have leveled as inventories build and demand slows. (Reuters)

Production volume of **smartphones** was 250 million units in Q1, a 19.5% year-over-year decrease and the lowest output since 2014. (TrendForce)

North American **PCB shipments** rose 6.7% year-over-year in May and fell 1.9% sequentially. Bookings were up 4.1% over last year and 6.7% versus April. (IPC)

Taiwan's exports of chips to the US rose for the 26th consecutive month in May, defying a downturn in the global semiconductor market. (Taiwan Ministry of Finance)

Global semiconductor materials revenue grew 8.9% to $72.7 billion in 2022, surpassing the previous market high of $66.8 billion set in 2021. (SEMI)

Global shipments of **LCD monitors** fell 7.4% sequentially and 21% year-over-year to 28.8 million units in the first quarter. (TrendForce)

Global **300mm fab equipment spending** for front-end facilities is expected to grow to a record high $119 billion in 2026 following a decline in 2023. (SEMI)

AR/VR headset shipments slowed 54% year-over-year in the first quarter. (IDC)

Semiconductor industry contraction likely moderated in the June quarter and a gradual recovery is starting in the current quarter. (SEMI)

Smartphone shipments will decline 3.2% in 2023, totaling 1.17 billion units for the year. (IDC)

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Will We Demand a New Supply Chain?

And will capital equipment makers stay put, relocate or – shudder! – exit the business?

IN MANY WAYS, the past three years have seemed very much like a dream, with life shifting from normal to masked panic and social distancing, to light at the end of the tunnel, to where we mostly appear to be now: back to normal! But while most faces are uncovered, businesses have taken down Plexiglas separating cashier from customer, and retail floors have only a few faded "stand here" decals visible on the floors, not all is truly back to normal.

Geopolitical strains have developed in Asia and an unprovoked war is taking place in Europe. Both series of events – combined with the pandemic – put unprecedented strains on a global supply chain that for decades relied upon political stability and free access to countries around the globe. While the pandemic focused most of us on the here and now, it also caused companies – and countries – to pivot on where and how they source product.

For North America, the lack of certain technologies, many central to our industry's ability to produce technology-rich products, became glaringly obvious and made many in industry and government even more concerned. That concern led directly to the CHIPS Act, which in time will certainly help alleviate some supply-chain issues in North America, although it is not a short-term panacea. For the rest of the world, however, strains will persist and possibly get far worse.

When a company establishes a global supply base or decides to open a facility in a different part of the world, it must make decisions such as where to invest and build new factories or R&D centers. These decisions are typically made with a long-term perspective, as once a beachhead is established,

additional investments in facilities and staffing are far more cost-effective. This is especially true when companies decide to establish facilities in a new country. Besides the typical growth pains of teaching new workers a company's technology and way of doing business, adapting to a new culture and language(s) complicates the initiative and can impact short-term profitability as company and employees come up to speed.

When events, be they geopolitical or natural disasters or emergencies, make it necessary for companies to pivot relatively quickly, the risk grows exponentially. Moving a base of manufacturing across town is daunting enough. Moving countries can make any other relocations look like a cake walk. Transitioning from an existing successful facility to a new and unknown environment because of events outside your scope of control is rarely the recipe for success.

And yet today, many companies are looking at the global political landscape and considering whether to pivot to another country because of the inherent risk of remaining in place or as a hedge if risk escalates. While the analysis of making substantial investments in new locations is taking place, capacity expansion in the existing location is most likely on hold, as is replacement of capacity as equipment comes to the end of its useful life.

Over the past couple years many aspects of the global supply chain have eased, from a little to significantly. With all the geopolitical uncertainty in the world, however, it may be impossible to return to the resilient, inventory-rich supply chain we enjoyed – and relied upon – pre-pandemic.

For those in electronics, and our industry in particular, the ability to maintain adequate inventories of raw materials from laminate to components is key to success. Possibly even more critical – although not often discussed – is where the capital equipment needed for production will be manufactured. Will OEMs producing the machinery most used in our industry – but only by our industry, which generally means relatively low annual unit sales – have the wherewithal to move their manufacturing if necessary, or will they instead pivot what they make to higher volume, more lucrative markets? And what about other specialty suppliers? Even with a strained supply chain showing demand, is the cost of moving a facility going to be worth it?

It took decades to develop and refine the global supply chain we have come to rely on. Over a few years the supply chain has become strained, and the availability of product is more bumpy road than seamless flow. While much of life appears back to pre-pandemic normal, our industry will feel the

strained supply chain for some time. Steady nerves and stout hearts are needed as companies navigate their way through what could be the beginning of a new supply paradigm – or a lengthy problematic period before the existing global supply chain settles back to normal.

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

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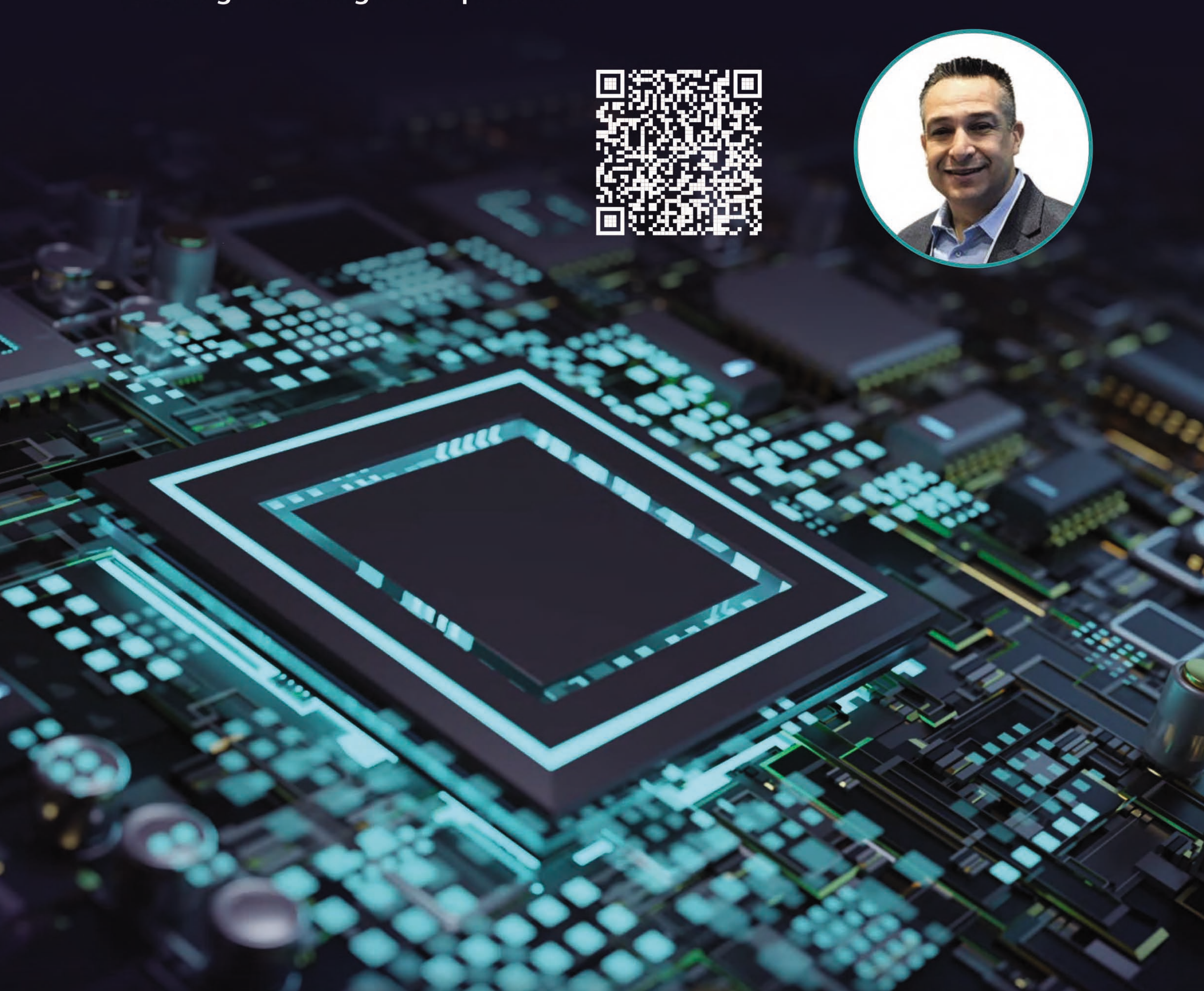

Advanced Packaging: The Hot Topic in the Florida Sun

ECTC revealed the latest developments in 3-D hybrid bonding.

MORE THAN 50 presentations on hybrid bonding filled rooms to capacity at the IEEE Electronics Components and Technology Conference (ECTC) in Orlando, as did the Tuesday morning panel session. That panel discussion **(FIGURE 1)**, on “Copper Hybrid Bond Interconnections for Chip-to-Wafer Applications,” organized by Infinera and Qualcomm and moderated by TechSearch International, included perspectives from design and EDA (Synopsys) and research institute IMEC, users of hybrid bonding (AMD with production at TSMC and Intel with its internal development program), equipment makers Besi and EVG, and yield and reliability specialist PDF Solutions.

Figure 1. Sessions on hybrid bonding were plentiful – and popular.

Synopsys pointed out the importance of design tools and IMEC described key drivers for 2.5-D and 3-D integration technologies such as increasing system complexity, increasing need for heterogeneous integration, increasing die-to-die interconnect data bandwidth (more interconnect channels and higher interconnect speeds per interconnect), reducing die-to-die interconnect energy with shorter distance interconnect, scaled, lower capacitance interconnects, and lower voltage. IMEC noted the issue is not the number of interconnects but rather the available (local) interconnect density enabled by interconnect pitch scaling. Many of today's hybrid bonding applications using die-to-wafer structures are focused on the high-performance space where the cost can be justified, including stacking SRAM cache and logic-on-logic, as introduced by AMD's products in desktop, servers, and AI/machine learning.

Energy efficiency is driving development of new packaging solutions for the high-performance space. 3-D hybrid bonding offers more than three times the interconnect energy efficiency and more than 15 times the interconnect density compared to microbump solutions, according to AMD. 3-D hybrid bond interconnect is not without challenges, however, including external IP/die/package integration, new materials, power delivery, yield, test and cost, as described by Intel. While Besi and EVG presented options for the assembly, all agree that process yield depends on controlling particles and cleanliness. There was general agreement that die-to-wafer is more challenging than wafer-to-wafer. PDF reminded the audience that despite the presenter lineup, reliability should not be the last consideration! Responses to audience questions made it clear that test and known good die are essential to the success of the technology. The race to introduce hybrid bonding for high bandwidth memory (HBM) was apparent in dueling papers from Samsung and SK Hynix, as well as updates on Micron's activities. TSMC also presented the potential for the use of hybrid bonding in photonics applications where the EIC and PIC could be stacked. Wafer-to-wafer stacking has been in products for many years for image sensors and MEMS, and Sony continues to report progress in wafer-to-wafer bonding with larger chips. Volumes are expected to increase for 3-D NAND flash where wafer-to-wafer bonding is used to stack layers, as evidenced by recent announcements from Western Digital and Kioxia for licensing Adeia's direct bond interconnect technology.

More hot panel topics. Panels and professional development courses before the start of the full conference were well attended. A panel on "Advanced Integration Roadmap for Harsh Environment

– Current Status and Opportunities" led by Fraunhofer and Robert Bosch featured panelists from GM, Robert Bosch, ASE, Samsung, TSMC, Henkel, TU Delft, and Georgia Tech. TSMC suggested that with the large body sizes for ADAS, its CoWoS-R using an organic interposer instead of silicon interposer may be well suited to large-body-size packages. ASE explained that large packages often require board-level underfill, and corner balls are an issue for AEC-Q104. ASE reminded the audience that its FOCoS and FOCoS bridge packages reduce the pressure on substrates because routing in the RDL permits relaxed features and fewer build-up layers for the laminate substrate. Henkel noted requests for high-heat dissipation with underfill. Georgia Tech sees thermal (heat fluxes) as the biggest challenge.

A special session on "Photonic Integrated Circuit Packaging: Challenges, Pathfinding, and Technology Adoption," chaired by CEA-Leti and Cisco featured representatives from both organizations plus IBM, iNEMI, Teramount and Ficotec.

The Tuesday afternoon panel "Advanced Packaging Manufacturing in North America: Building the Ecosystem" was also a packed session. Organized by GE Research, ASE and TechSearch International, the panel featured representatives from government organizations (NIST and DARPA). DARPA's presentation explained the 3-D heterogeneous integration (3DHI) R&D focus areas such as multichip, multi-technology assembly and packaging (including die-to-die, wafer-to-wafer, die-to-wafer, and wafer-to-board processes, 3DHI interconnects (including fine-scale printing and additive manufacturing), thermal and power (including embedded thermal management with assembly and package, materials to extend temperature operation range, low-loss passive for power distribution, and efficient power conversion), tools for design, simulation and test, and prototyping services (including a 3-D assembly design kit).

The NIST presentation explained the purpose of the CHIPS for America bill is to strengthen and advance US leadership in R&D, developing an integrated ecosystem that drives innovation through a partnership with industry, academia, government and allies. A National Semiconductor Technology Center and a National Advanced Packaging Manufacturing Program will be created. The act is focused on significantly reducing the time and cost of moving from design to commercialization for member organizations and making semiconductor design capabilities accessible to a wide range of stakeholders. The program will establish and provide access to physical assets such as facilities, tools, and equipment with high capital costs. Access to in-house technical

staff to assist with overcoming technical and process challenges will also be provided. Creating an investment fund that is structured to attract significant private capital into semiconductor-focused emerging companies is also part of the plan. Building a sustainable workforce is also emphasized as key.

Industry was represented by Marvell Technology, Micron and Promex (a small North American OSAT). Promex explained the difficulties for small companies to raise funds to match government incentives and asked the important question: Who will be the customer for US-based packaging services? Barriers to onshoring include the current limited onshore capability and higher cost of US domestic production. Benefits to onshoring include turn time, ability to visit, communicate and learn, confidentiality, and the availability of alternate sources. Promex suggested focusing investment on emerging and next generations of packaging, developing improved technologies, construction of pilot lines, demonstration of capability and performance, then establishing relationships and price. Micron indicated labor cost was not the main problem for onshoring, but rather everything else. Efficiency is important. Collaboration on equipment and materials is essential. In response to a question about workforce development, Marvell indicated a need for technicians, adding that partnerships with community colleges are helpful. UCLA provided a university perspective, indicating the importance of working with industry and the role in education by providing a program that produces students with a multi-disciplinary background.

The Heterogeneous Integration Roadmap (HIR) Workshop, simultaneously held on Tuesday, included a perspective on Artificial Intelligence and Machine Learning in Package Co-Design for Chiplets, a discussion of challenges and opportunities for the heterogeneous integration of MEMs and sensors, an update on the US CHIPS and Science Act, and a presentation on additively manufactured electronics for heterogeneous integration.

Tuesday evening's panel discussion organized by IBM and Rapidus (Japan's new 2nm technology node silicon foundry) examined the Future of High-Density Substrates – Toward Submicron Technology. Presentations by Shinko Electric, Unimicron, Dai Nippon Printing (DNP), IBM and Penn State University highlighted the latest research on high-density substrate developments and glass packaging. Shinko Electric described its iTHOP high density organic interposer. Unimicron described challenges in producing large-area build-up substrates (>120mm x 120mm with more than 20 layers). New, semiconductor-like materials and equipment are required for future advanced

substrates. Warpage control is essential. DNP described its work with a glass core substrate. IBM described its dual chip module (split die) and mentioned the importance of good test coverage. Penn State is working on glass with a focus on RF applications. Standards for chiplet design were discussed including Bunch of Wires (BoW), and Universal Chiplet Interconnect Express (UCIe), with the latter having more momentum.

The conference opened Wednesday with a keynote by Professor Michael J. Manfra of Purdue University on “Unlocking the Potential of Quantum Computers: Challenges and Opportunities in Electronic Devices, Interconnects, and Packaging,” in which he explained that advances in quantum hardware on multiple scales are required to reach the promise of quantum computing.

Wednesday night the panel chaired by Brewer Science and GE Research from ECTC coordinated with University of Toronto from ITherm, the co-located conference, focused on diversifying the technical workforce to meet national needs including CHIPS Act initiatives. Panel members included representatives from University of Texas, Arlington, NextFlex, GE Foundation, and NIST.

On Thursday the conference opened with a panel chaired by Metawave Corporation and Fraunhofer with a discussion on “Millimeter-Wave Phased Array Front-End Integration and Packaging for Next-Generation Communication and Radar Systems,” including panel members from Teledyne Scientific, Northrop Grumman Space Systems, HRL Laboratories, Penn State University, Nokia Bell Labs, and IBM Research.

On Friday morning a panel session on “How Can Photonics Enable the Bandwidth Densities with Lower Energy per Bit in Emerging SiP,” was chaired by the EPS president and Lyte. The discussion focused on the tools to achieve the goal, with panel members from University of Toronto, Lightmatter, University of Southern California, and substrate and PCB maker AT&S providing the discussion.

Options and challenges with large packages. Advanced packages for high-performance applications discussed at the conference included silicon interposers and fan-out on substrate using RDL, some with the use of an embedded bridge. Many of the presentations address the challenges with the large body size packages that are being driven by AI/ML where an increasing number of HBMs are required. TSMC described its progress with silicon interposers using its CoWoS process and the shift to an organic interposer instead of silicon with CoWoS-R and CoWoS-L. MediaTek

reported on the challenges that it had to overcome with the solder mask cracking in large packages using fan-out RDLs. DNP described its 2µm line and space RDL structure and indicated that the use of the RDL instead of silicon interposer provides an improvement in resistance. ASE and Amkor presented papers describing their RDL structures with bridges. ASE explained co-design of a chiplet package with its FOCoS package versus a conventional FC-BGA. Amkor described its S-Connect bridge technology. IBM Systems described its AI hardware package using a high-density organic interposer.

Photonics/co-packaged optics. Co-packaged optics continues to be a hot topic with continued technical improvements. Rain Tree Photonics described its heterogeneously integrated wafer-level processed co-packaged optical engine for hyper-scale data centers. Broadcom discussed high-density integration technologies for silicon photonics-based optical I/Os. Fraunhofer discussed photonic system integration with glass substrates. AIM Photonics with Analog Photonics demonstrated a 300mm Si photonics interposer. Siliconware (SPIL) described co-packaged optics on glass substrates for 1.2.4 Tb/s data center switches and fan-out bridge structures for co-package optics. Cisco described its low-cost, high-volume singulation of silicon photonic ICs for low-loss waveguide-to-fiber array edge coupling.

Photonics developments for LiDAR in autonomous driving were also presented. CEA-Leti and Steerlight described an advanced 3-D integration TSV and flip chip technology for mobile LiDAR.

New materials and processes. New materials and process developments provided insight into future packaging possibilities. Ajinomoto described its work in build-up film. Toray Industries provided details of its photodefinable low-Dk and low-Df polyimide for high-frequency applications. Resonac discussed its low-Dk/Df photoimageable dielectric for RDL. Taiyo Ink discussed a low-Df thermosetting film. AGC presented its work on a low-Dk build-up material using micron-sized hollow silica. NAMICS discussed its liquid compression mold underfill with low warpage and narrow gap flow. Deca Technologies and Nepes described maskless laser direct imaging and adaptive patterning for ultra-high-density fan-out packaging.

Mobile device packaging. Packaging for mobile devices also featured new developments. Samsung discussed its panel FO process for high-end mobile applications. SPIL presented a comparable study of RDL first versus last in a fan-out package-on-package (PoP).

Presentations from IBM/Fujikura, ASE, Renesas, Corning, Amkor/Texas Instruments, and several universities provided the latest developments in RF including antenna-in-package (AiP).

Don't forget about wire bonding, but watch the emerging technologies! Wire bonding still represents a large percentage of all packages and presentations from Onsemi described developments on modeling and optimization for Cu wire bonding. A special section was devoted to sintering and soldering for high-power, high-reliability, and RF devices. New material developments were provided by Indium and Uyemura. Pac Tech described its laser solder-jetting process. Samsung examined the risks of hybrid low-temperature solder on SMT and board-level reliability for BGA packages. GE Research discussed planar SiC power module packaging and interconnections using direct ink writing. Presentations also covered emerging areas such as additive manufacturing and packaging for flexible electronics.

Next year, ECTC will be held in Denver, CO.

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Thermoelectric Cooling on Printed Circuit Boards

TECs can be a countermeasure to high current density.

THERMOELECTRIC COOLING, OR TEC, is seen as a breakthrough in small refrigerators that do not consume a lot of power. Sporting goods stores carry micro-fridges that plug into a car's weird circular power plug. Some of us – not me, of course – can remember when those plugs were used to create a glowing hot element to light cigarettes. Getting cold out of the same socket took a little more technology than creating a short circuit.

Where would you use a TEC device? Aside from keeping a six-pack (or a transplant organ) on ice, electronics can be kept at a reasonable operating temperature with the addition of a component or a cold plate like the one in **FIGURE 1**. It is 40mm square and 3.2mm thick. The basic function is that it gets cold on one side while getting warm on the other. Put it in the other way to warm up the contents. This can be placed below the board or above the high load component if it has a flat top. More remote placement is possible by incorporating a heat spreader. We'll circle back to that shortly.

Figure 1. A TEC device. (Amazon)

Thermal energy types. Thermal energy is transferred from one thing to another in one of three ways:

- Convection. Transfer by air or other fluids in motion.
- Conduction. Transfer by touch.
- Radiation. The scary stuff that we're not going to mention further.

Convection is the air conditioning, the open window, the little hand-held fan. Fully enclosed boxes would prevent this type of thermal transfer. Letting ambient air in and out with strategic ventilation ports is a normal part of industrial design. Pushing air into or out of the box is often done to keep high-performance chips at their maximum clock rate.

Compute-intensive activity will raise a device's internal junction temperatures, which will trigger the system to reduce the clock speed while turning on any active cooling systems. Who hasn't had enough browser tabs open to get the machine huffing and puffing trying to keep up? The effectiveness of the cooling systems is the ultimate throttle to mining bitcoins or slaying imaginary monsters.

Conduction is typically a passive operation where a material with the right properties and surface area will be attached directly to the hot spot. A gasket or special thermal grease increases the transfer area at the point of contact. Heat pipes move the energy to heat sinks. Heat sinks can be upgraded to active conduction/convection units with traditional computer fans. There are also low-profile fans for things like a laptop. When all of that still isn't enough, they can pack on a thermoelectric cooling device **(FIGURE 2)**.

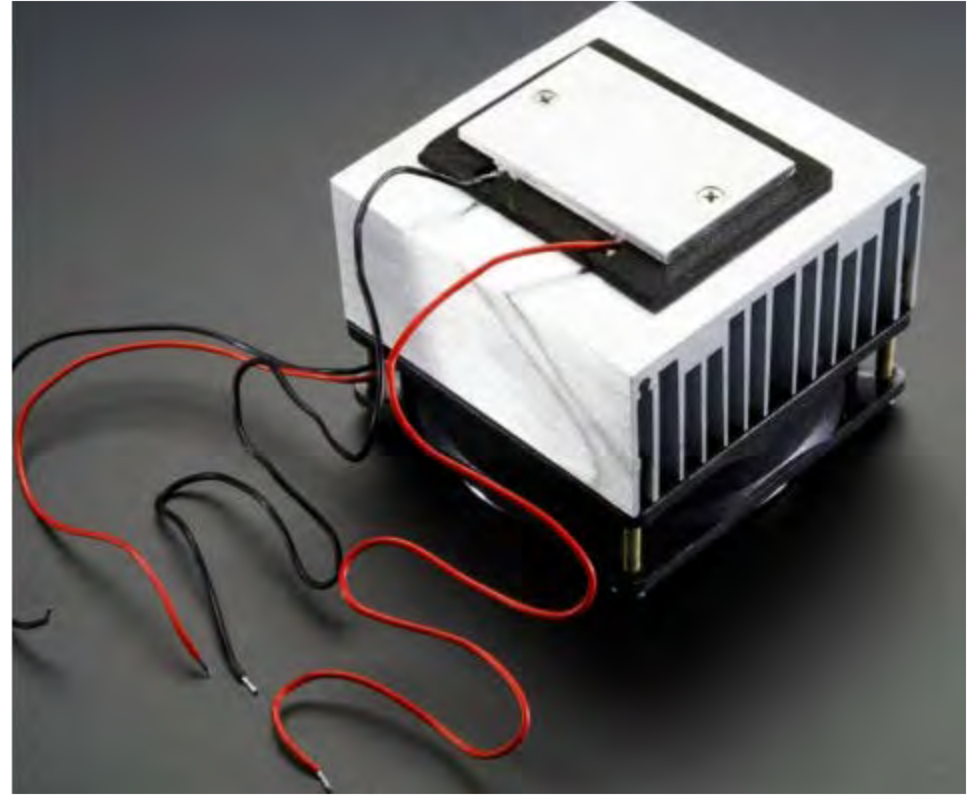

Figure 2. A complete TEC module using the same size element as above. (Adafruit)

PCB packages for thermoelectric devices. The more power you can feed to the TEC device, the more cooling it can do. At the PCB mounted level, there are a few popular packages. The TO-8 can and a so-called butterfly package are most familiar **(FIGURE 3)**. We had the larger type between a laser and a photodetector for an optical transponder. A lot of data was fed from a single optical fiber that had to be converted to many lanes of copper. That was our socket. Enterprise gear on the leading edge as well as science projects can take advantage of this technology.

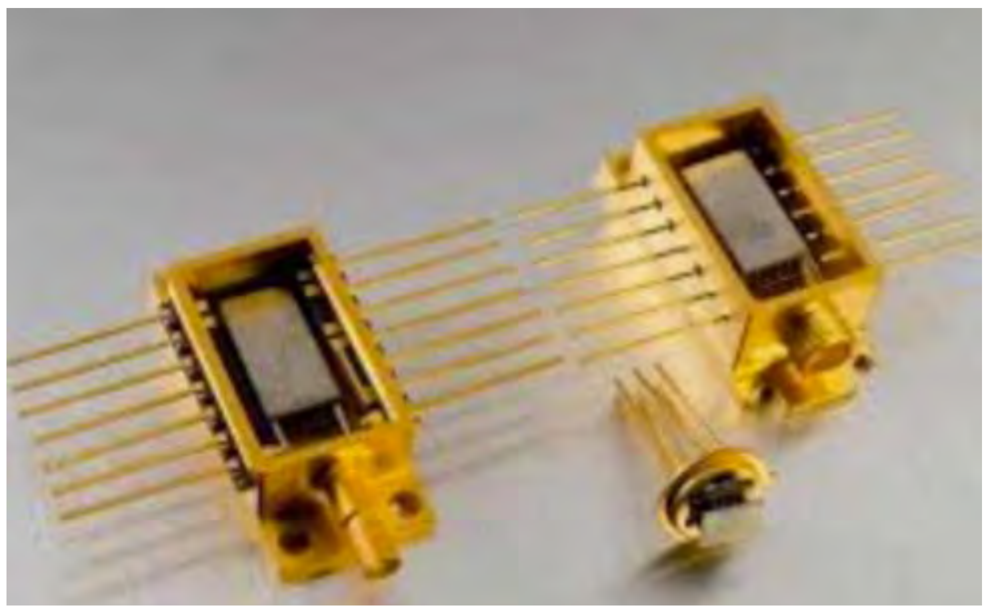

Figure 3. Typical TEC form factors. (AMS Technologies)

As far as components go, they are not small. The Chicago Bears had a player named William "The Refrigerator" Perry. In that context, these are very small refrigerators. The materials that go into a TEC need to have two properties that are not common in one material. One requirement is that they are electrically conductive. The other is that they are not thermally conductive. That leaves just a few materials, and they are not as common as copper or silicon. This requirement drives up the price of fabricating the devices.

The cross-purposes also make the Peltier effect rather inefficient compared to using a compressor and the mass of copper piping on the back of a traditional refrigerator. Being more expensive to make on a per-watt basis and costing more to run are the downsides. On the flip side, the advantage is that TEC cooling uses no moving parts unless the fan is considered. In either case, a compressor will fail and fail again before a solid-state refrigerator will. Reliability is rock solid for what you get.

Cooling the CPU and beyond. Lasers, as mentioned, along with LEDs, batteries and certain analog equipment, are all notorious for high-junction temperatures. TEC coolers are commonly packaged with a small device for monitoring and maintaining the optimum operating temperature. Turnkey thermal monitor modules come in a variety of wattages. Managing the thermal path from the die to the outside world can be the pivotal reliability challenge. Having a built-in cold plate is one more tool in the struggle to stay cool.

JOHN BURKHERT JR. is a career PCB designer experienced in military, telecom, consumer hardware and, lately, the automotive industry. Originally, he was an RF specialist but is compelled to flip the bit now and then to fill the need for high-speed digital design. He enjoys playing bass and racing bikes when he's not writing about or performing PCB layout. His column is produced by Cadence Design Systems and runs monthly.

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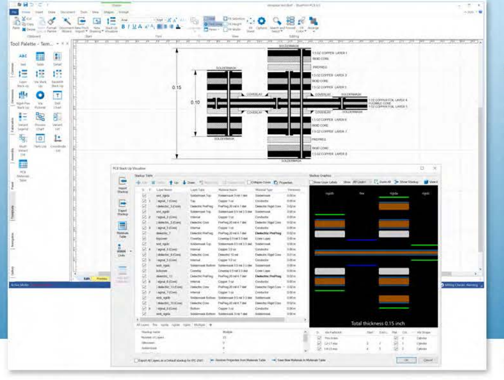

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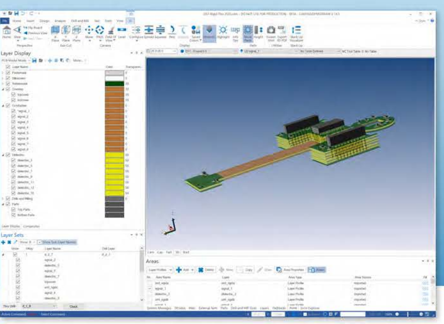
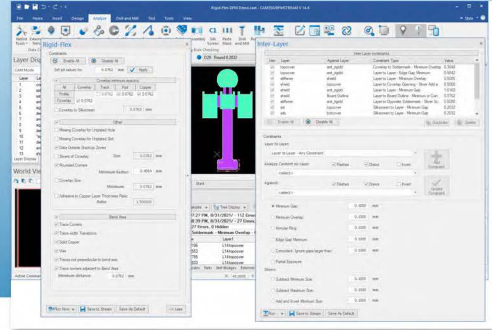


A rigid-flex design in 3D. Shown with layers spread to improve visualization of the layer stackup.



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Design and Manufacturing Collaboration

Clear communication with manufacturers can ease that queasy feeling.

YOU ARE FINALLY finished with that very complex monster of a printed circuit board (PCB) design while enduring a very tight project schedule. Now it's time to get the design data to manufacturing for fabrication and assembly, but there is a lingering doubt in the back of your mind, an uneasy feeling in the pit of your stomach as you hand off data to manufacturing. Why? I'll explain, based on my perspective gleaned from decades of designing PCBs.

Let me start with a question: Did you collaborate with your manufacturing suppliers up front? The answer for many is typically "No!" You may have simply designed a PCB without any manufacturer involvement whatsoever, generated output files and threw the data over the proverbial wall to the manufacturer in hopes that what you designed is buildable and will work as intended. Then, when a technical query (TQ) hits your inbox, you might get upset and wonder why you're being notified that the job is on hold because the design data contain issues or are missing information that needs to be addressed before fabrication can begin. In some cases, it's not just answering with a reply of "approved to modify as suggested," but rather it requires going back and redesigning! Sadly, this happens in our industry far too often, and in more instances than you would expect.

My topic this month is design and manufacturing collaboration. In my opinion, this topic consistently needs to be addressed. It's one of the three competing perspectives for success in PCB

design – which are layout solvability, performance, and manufacturability – with the goal of maximum placement and routing density, optimal electrical performance, and efficient, defect-free manufacturing. Anyone who designs PCBs needs to thoroughly understand how and why the decisions being made at the point of design will have an impact downstream, one way or another. The downstream ramifications due to poor upstream design decisions have the potential to be catastrophic in manufacturing.

At this year's PCB East, I collaborated with Summit Interconnect vice president of technology Gerry Partida on a technical session where we used comedy (or attempted, anyway) to shed light on the typical dialogue between a PCB designer and fabricator regarding design for manufacturing (DfM). We stressed to our audience the importance of having design and manufacturing collaboration throughout the entire design process. So far, this DfM comedy skit has received plenty of positive feedback, mainly because we discuss and show real-world examples.

As stated, collaboration between design and manufacturing is paramount. As a best practice, it should take place right out of the gate, starting at the project kickoff meeting. The fabrication and assembly suppliers should be included among the key stakeholders at the project table. Working with the fabricator to dial in the PCB stackup to ensure it meets PCB design requirements is key for success. From complex PCB stackups that include high-layer counts, HDI or micro HDI, multiple impedance requirements, PCB thickness requirements, current carrying capability in respective copper weights, to mitigating thermal requirements that may require exotic materials, today's complex PCBs leave no room for guessing! The potential for success significantly increases when this collaboration takes place.

Data exchange during this collaboration between design and manufacturing should be optimized. The best practice for this exchange is a format that is bidirectional, facilitating constant communication, and offers intelligence, such as ODB++ and IPC-2581. These types of data formats enable intelligent communication from engineering to manufacturing and vice versa. This includes having a manufacturing-to-engineering feedback loop. By having this in place, we enable lessons learned from manufacturing (fabrication and assembly) to be fed back to design/engineering. That bidirectional loop of communication and data exchange, especially utilizing intelligent data, has the highest potential to positively influence the design for downstream success. Don't get me wrong. The legacy methodology of supplying Gerber data and a netlist gets the job done. It has for decades

and continues to do so. Just know that intelligent data exchange is the most optimal way to exchange data from engineering to manufacturing.

Having optimized, integrated, bidirectional collaboration between engineering and manufacturing minimizes errors, especially during the data exchange. Having a continuous feedback loop of lessons learned being fed back to design/engineering enables PCB design success. By implementing these best practices, you're less likely to have that uneasy feeling in your stomach or receive TQs regarding the construction and buildability of the design.

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

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Data Overload

AI could be the key to understanding the data collected by the IoT.

BIG DATA IS useless and all the sensors in the world are not enough. Contentious? Maybe. I've talked in the past about the prospects for digitizing the world and it's true that we have many of the ingredients to make this happen: tiny, low-power sensors including optical and MEMS inertial sensors that provide contextual awareness; connectivity technologies for almost every practical and budgetary constraint; low-cost processing power and mass storage.

We're well on the way to seeing almost 30 billion devices connected to the IoT in the next couple of years, and there is no practical limit to this. We have enough IPv6 addresses to cover the earth's surface many times over with smart "things." We can easily collect the data we need to digitize the world.

The bigger challenge is to understand what that data are telling us and, from there, determine suitable responses. The sheer volume, velocity and variety of data we can now capture through IoT devices easily exceed the capacity of humans to analyze and extract meaningful insights manually. AI is the perfect companion to the IoT, capable of providing the assistance we need. Bringing them together as the AIoT is the key to tackling complex challenges such as sustainability. Studying the climate and humans' impact, the effects of using natural resources such as energy, and the prospects for controlling and managing these are subject to huge numbers of variables that are impossible for us to analyze effectively.

AI empowers us to deal with the masses of data that we can collect quickly and easily with our IoT applications. Moreover, given its ability to adapt and improve, AI can both automate responses and

generate insights and recommendations to optimize our systems for energy savings and carbon reduction. It's exciting to consider how AI can show us how we can achieve our goals by changing our behavior.

One example is reducing the pollution from urban traffic by improving traffic flow: something human planners have failed to accomplish satisfactorily for generations. There are simply too many variables to contemplate and the number of vehicles on the roads is increasing continually. Taipei has shown us a great example of how AI can help address this. Historically, the city's police officers have analyzed images from the network of traffic cameras to detect problems and restore flow. Their response rate was about 16%. Now, the Taipei Traffic Density Network (TTDN) is using AI to improve traffic-flow management by dynamically managing controls at intersections and leveraging current and predicted traffic density information. The AI also lets Taipei's systems adapt to changing patterns such as different daytimes, weekdays, and seasons including vacation periods. Keeping things moving ensures cleaner air and a lower carbon footprint; a goal shared with ultra-low-emission initiatives being promoted in other cities across the world. Equally important, it also helps shorten journey times and reduce accidents.

The infusion of AI is also changing the ways car vendors are managing customer relationships. With large datasets gathered from the field and augmented with data about product recalls and repairs – and even information from social media – carmakers can implement better predictive maintenance schedules. These can ensure better reliability, improve their brand image, and improve vehicle lifecycle management to minimize the burden placed on the environment.

The effects of AI on smart grids will be transformative as these acquire more data about generating capacity and consumer patterns. It will help improve planning and scaling, including sizing and positioning generating capacity and storage. Similarly, smart agriculture is leveraging AI applications fed by data from IoT sensors and drone cameras to direct farming activities and optimize crop yields.

Some changes may appear to be tiny, or even imperceptible. It's said that many people have been interacting with AI on a daily basis in their lives for some years already and are unaware of it. Some Taipei motorists may never know about TTDN and may perceive only a small reduction in journey time. On the other hand, the cumulative effect on lowering the city's carbon emission can be huge.

But small changes can be more acceptable, generally, to human beings who are typically comfortable with the present and fearful of the unknown. As technologists and engineers, our own passions are to create new solutions and we are excited to exercise our skills to deliver them. It is natural for us to have doubts about where all this may lead, however. Even some of today's most vocal futurists have expressed concerns about the power of AI, particularly if permitted to develop unchecked.

We can be confident that AI is not going to subjugate and supersede in the foreseeable future. This is not to deny that its effects are already transformative. Today's AI-powered generative tools like ChatGPT can significantly accelerate creative activities and can already offload routine processes such as writing letters and emails. Although it's clear that businesses will need to adopt them if they are to remain competitive, the standard of work produced is not high enough to take over more sophisticated tasks. Yet. There may be a warning in Amara's law, named for Roy Amara, scientist and former head of the Institute for the Future. "We tend to overestimate the effect of a technology in the short run and underestimate the effect in the long run."

But perhaps we can draw comfort from the fact that AI is the perfect learner. It improves every time without repeating mistakes. We can hope to see our cities and infrastructures get closer to our concepts of sustainability and become more supportive of cleaner living.

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The AI Revolution is Coming to PCB Design

System-driven part selection and routing are closer than ever.

IT'S RARE FOR a motivational keynote speaker to have a lasting impact on attendees. At Zuken Innovation World's US iteration in June, however, Dan Thurmon certainly set the pace for the conference. The author of *Off Balance on Purpose* and a popular Ted Talk on embracing uncertainty, Thurmon's address had attendees referencing and even reenacting portions of his opening presentation in their subsequent presentations. The motivational speaker helped set an energetic and educational tone for the conference that followed.

And thanks to the coming AI revolution, uncertainty is what's ahead.

Zuken Innovation World is a series of conferences around the world dedicated to bringing customers, partners and Zuken experts together. A good portion of the eight concurrent training tracks at the June event in Scottsdale, AZ, was dedicated to sessions led by customer-users sharing design best practices and success stories. Surprisingly for a conference dedicated to a specific supplier, there was never even a hint of sales; this was a full-on conference dedicated to networking and educating, where one could learn about upcoming technologies, best practices, and novel implementations of toolsets that only a user would discover. At times, it was overwhelming to decide which of the concurrent sessions to attend, as multiple competing interesting presentations were occurring!

An experience unique to ZIW is its "360" session, a town hall-style meeting in which anyone is free

to ask questions of upper management. With some well-publicized tech CEOs heading to prison for fraud, it is refreshing to experience a leadership team being so open and transparent with customers about opportunities and issues. A hot topic during the town hall was the announcement and release of the new artificial intelligence-enhanced PCB design software package and the laying out of a very aggressive roadmap for customer-trained AI "brains." Kent McLeroth, CEO and president of Zuken USA, reassured attendees who expressed concerns over the ethics of bringing such capabilities to life and the potential for displacing humans. And despite the stated focus on training the AI to design like a human, he didn't downplay the difficulty involved in capturing sufficient design data for proper training.

Asked during Zuken 360 how the project could be expedited to get into the hands of designers faster, McLeroth and the team were clear and forthright: cooperation and support from designers who provide good design will help with the training process. The AI brains are in place, they said, but more good design data are needed to train the AI. The promise of secure-site customer-trained AI was also in the aggressive near-term roadmap.

The timing couldn't be more perfect for Zuken's launch of its new AI-driven technology for PCB designs. Indeed, Zuken isn't just hopping on the AI bandwagon; rather, its UK-based R&D team has been pioneering and building this engine for years. The concept that a designer could design functional blocks and the system would make part selections and routing to complete the design is closer than ever. While Zuken's toolsets are used predominantly in Japan, it has made steady improvements and significant strides that should be of interest to the international community.

Multiple sessions presented by Zuken UK's Kyle Miller covered the capabilities and some of the details of the methodology used by the teams bringing this project to life. It should also be noted there was significant training for high-speed digital designers on DDR4 layout and design.

I interpreted this embrace of AI by Zuken to be an ongoing shift in PCB design technology, similar to the shift programming languages made to object-oriented languages and away from assembly languages. Assembly, like manual place-and-route, will still have a place in niche environments, but object-oriented languages dominate modern programming environments for their ease of use, handling, and capabilities in allowing a programmer to do more without diving into nitty-gritty details every use. And to address the ethics of such AI-assisted designs, I think we will see more designers, not fewer, as result of AI systems assisting the management of esoteric rules and

guidelines. While this might frighten some of the established design community, it should be reassuring to know new designers won't have to burn their fingers on bad designs, that AI would assist in making the designs a success and in turn, teach the designers good design practices.

Yes, there is uncertainty ahead. But given the aging design and layout population, the ability to pass design practices and training through AI is something to embrace and encourage. I look forward to how AI brains revolutionize the PCB design community, and at the very least, help push the ball forward making PCB design more accessible to new designers.

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GD&T and PCBs

Don't mix your units.

WHEN I FIRST started in the PCB fabrication industry, I was fresh from college and ready to jump in and make an impact. The first hurdle I hit was likely the same as many first-time designers: units of measure for PCB design. Remember back in school, your physics professors or science teachers likely pointed out missing units in tables, graphs or homework assignments? That problem.

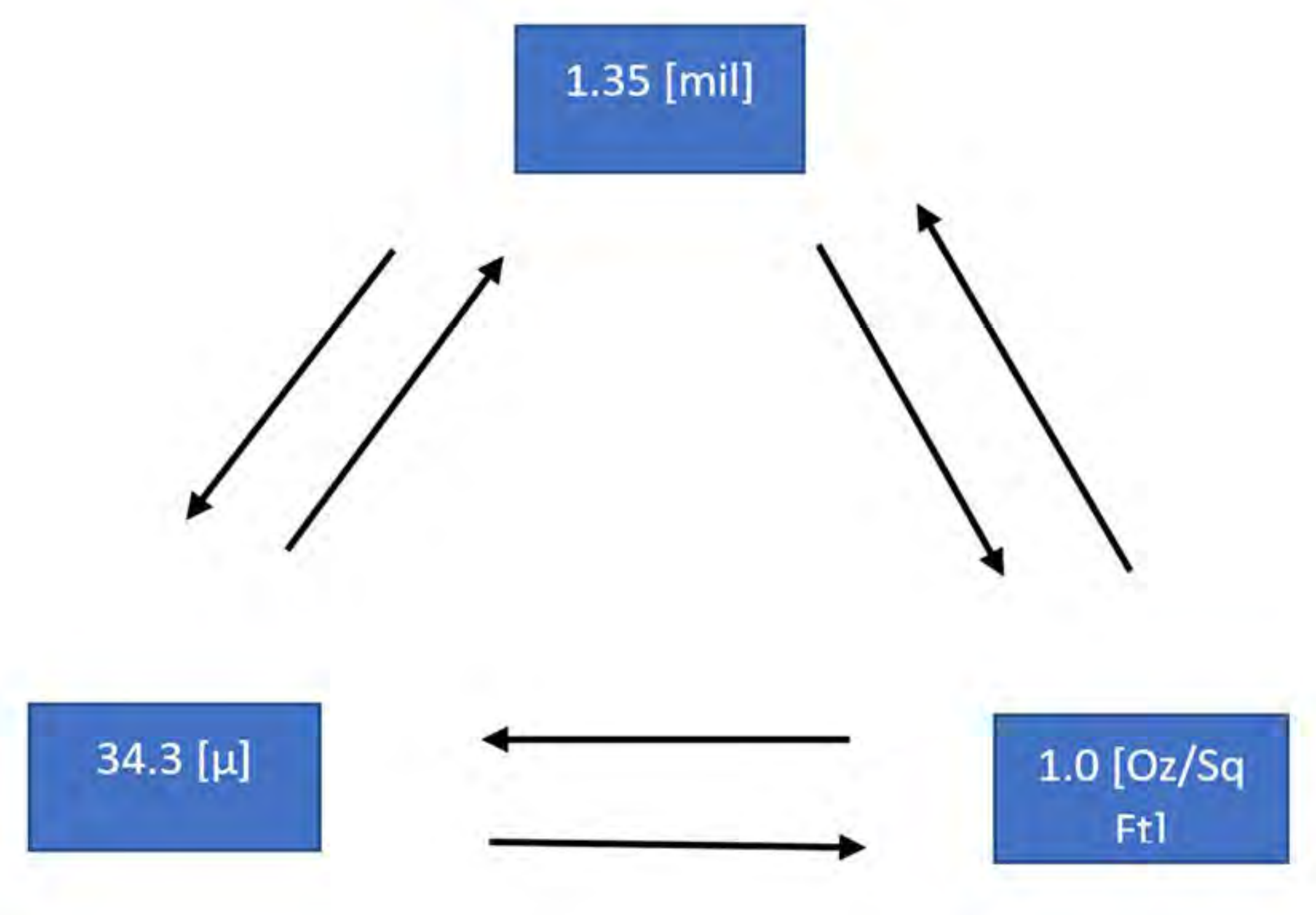

Figure 1. The three units of measure commonly used to describe the relative thickness of a PCB layer.

In PCB design and fabrication, at least in the US, three common ways are used to describe the relative thickness of a PCB layer. At this point in my career, I'm not going to fight about which should be the industry default (just kidding: it's microns. Get with the metric system America!). I am only going to take issue with consistency. If you mix units on a print or fail to tolerance them properly, you are going to have a *bad* time. By bad time, I mean waste time, money and make the print more confusing and difficult to manufacture. Let me explain.

What are the three main ways PCB thicknesses are called out or dimensioned? If you replied Metric and Standard, you are *partly* correct.

We have the metric unit of the micron [μm]. This is commonly used in HDI PCBs, interposers or very thin flexible circuits PCB drawings.

We have the mil, which is technically a shorthand way to express 1/1000 of an inch. Instead of saying, "thou," as in a mechanical workshop, we say, "mil." Many Department of Defense prints seem to prefer this nomenclature.

Then we have the interesting unit of measure, ounces per square foot [oz/sq ft]. This is weight over area. Typically, oz/sq ft is used to describe the thickness of a circuitry layer of copper, because 1oz. of copper is typically 34.3[μm], or 1.35 [mils] of thickness. This is often shortened in conversation to just "ounces." Weight being used to describe thickness; that's not confusing at all to newcomers!

I bring this up because I have had the pleasure of reviewing many drawings for all kinds of OEMs. While mainly DoD-centric, I see them from all types of industries – medical, aerospace, commercial, etc. What caught me off guard right away when I started doing this line of work was how inconsistent prints were. Even for major DoD primes, which make some of the most sophisticated electronics in the world, I could find it on most drawings I reviewed. The most memorable print I saw had dimensioned the copper layer thickness twice, in two different areas. It was called out in [oz/sq ft] and [μm]. The best part was that none of the dimensions also had a tolerance. But the Title Block, which was likely borrowed from the mechanical engineering department, listed tolerances greater than that of millimeters [mm]. Not mils, but good old

fashioned mm. And those tolerances were almost as thick as the final board thickness itself!

Programs like SolidWorks help mechanical engineers catch this problem, which is referred to as an overconstrained situation. All kinds of pop-up windows will hit your screen if you try to call out a dimension more than once. But PCB designers who haven't taken the basic GD&T course and are completely unfamiliar with the rules or general best practices will likely struggle. My advice is to – please – just pick a unit of measure and stick to it throughout the print. Also, don't dimension a feature twice.

A print inconsistent in usage and implementation will lead to confusion. In fabrication, those small submissions or improper callouts could cause significant problems with final fit, finish or performance. This will lead to delays and extra costs for your project. The last thing we want is to sit on another call asking if a part that is slightly oversized or improperly toleranced can be bought off. Pick your unit of measure and stay consistent! (And make it metric, please.)

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DESIGNER **TRAINING**

‘We Teach the Engineering of PCB Design’

For students at Palomar Community College, a finely-tuned design curriculum is just the beginning.

by **MIKE BUETOW**

It goes without saying that finding talent is a big deal in electronics hardware development. Outside of internal training programs, talent development falls to the handful of colleges, universities and third parties involved in teaching printed circuit design and manufacturing.

One of the original providers is Palomar College, located in San Marcos, CA, part of San Diego County. The community college has offered practical printed circuit design coursework since the mid-1990s.

John Watson is teaching a full-year PCB design class at Palomar

Community
College.

John Watson's day job is customer success manager at Altium. But twice a week during the school year, he teaches the course on printed circuit design at Palomar. He spoke with us in May for the PCB Chat podcast. This transcript of that interview is lightly edited for length and clarity.

Mike Buetow: As I understand it, there are two segments, printed circuit board design and advanced printed circuit board design. Give us a sense of what you cover in those courses.

John Watson: There's no background students are required to have, or any prerequisites. These are brand new designers. That's where I start things. With the basics class, my main objective is to walk them through the entire PCB design process. I have 16 weeks to do that. It's a really good chunk of time. I conduct class twice a week in the evenings. It is an online class, which makes it convenient for a lot of students.

In this class, we focus on the four stages of the PCB. We start with libraries, where we talk about the library structure, the component structure, things like that. The second stage is the schematic. From here, it's a linear process that we walk students through to create their own – and usually their first – PCB design. They go through the schematic, then we push that into the PCB, and then go into the documentation stage, where we output everything – Gerber packages, fab drawings, assembly drawing and so on. Our main focus on that class is to get them through that process from start to finish. Like I said, it's a very linear process, so we build on what we did the previous week, and say, "OK, now that you've done this, you now can do this next step."

In the advanced class, which is another 16 weeks, we pick up from where we created our document package and then we actually go into the fab and assembly processes. I think this is an area that a lot of times is missed by designers. I work with a lot of fabricators and assemblers in the area, and I've asked them, "How many PCB designers actually come and visit a fab house?" It's actually very, very low. I would encourage PCB designers to visit a fabricator, and understand how this all comes together. You'll have a much better understanding of printed circuit board design. It's really, really an interesting concept and process that they go through.

Let me go back one step here in our basics class. We actually design a controller board from the Mars Rover that we give to the students. That's their PCB project that they're working on throughout that semester. In the advanced class, we then look at three PCB designs, so we focus more on the PCB side of this and the layout side, because what we developed there is a much deeper dive into the PCB process. For the fab and the assembly process we visit a fabricator. We see the assembly process, we see the machines and the steps taken by the fabricator to take our data and create the board, and bring back to us a completed design.

The second stage of the advanced class is rigid-flex design. This is an amazing area. I think it's one of the faster-growing areas of PCB design, especially with all the wearable medical devices; products like this really have driven that entire industry. For four weeks I concentrate on rigid-flex design, and it's exciting to watch your students do that PCB. We then go into advanced PCB design, working on a BGA design; a rather big one. This now involves all those different important physics of electronics: EMC, EMI, link tuning, skin effect, and we talk about why things happen in the PCB in the way they do.

In the basics class I'm more concerned about students connecting the dots: "Let's solve the puzzle that you have in front of you." In the advanced class we look deeper into *why* a trace will be this length or *why* we need to have protection for EMC and EMI. I go a lot into the physics of a trace and the printed circuit board itself to understand why certain things are done, so they have a much broader picture of exactly why they should do things. For the last section of the advanced class we take the three PCBs we've done and put them together, and we actually build a system design. Now we're talking about system configuration, system design, harness design, things like that. We also get into more of the MCAD collaboration where we're looking at the role of the entire team and who is involved with what deliverables. Students now work together as a team on that final project.

Between the basic and the advanced classes, I have 32 weeks, which I will tell you is not enough. I was recently talking to a professor and department head at a major university about the program and they asked, "How long do you teach just PCB design?" I said, "Thirty-two weeks." And they go, "Wow, I do six weeks." What do you teach in six weeks? I barely scratch the surface. But this is a phenomenal program.

MB: Do you get into impedance control, transmission lines, things like that?

JW: Absolutely. And we tie this into the physics of it. We say, "If you have a trace of this length, what are we talking about here?" Because of the copper formation and the atoms and the free electron sitting out there that basically gets kicked around by everybody, we can now start developing from those basic physics principles some other things. I go, "So if this is true, then let's look at how this affects our layout. If we have a trace of this length, we can determine there's a set impedance." We talk a lot about single line impedance. We also talk about differentials, and why and where they're used. We get into length tuning. Then we get into the energy of the trace when we talk about EMC and EMI and how we control them. We look at the PCB in really, really deep detail in that advanced class, where we look at it and we say, "OK, there are some things here we like to control. We use these principles to benefit our design." Let me give you an example. When we're talking about differential pairs, we actually love crosstalk, right? We want crosstalk. But when we're talking about high-speed design, we don't want that. Having the students understand why certain things are used and how they are used, they begin to see a PCB in a different light. They don't see it as just solving the puzzle and making the connections. They look at it as an engineering, almost a mechanical, item. With the development of the PCB design, it's understanding the physics of it all. And that's exactly what I tried to bring to the students.

MB: You mentioned that the class is taught online. Is that a concession to Covid that's been carried over?

JW: Yes, and it's really been beneficial for us. I've enjoyed teaching it online rather than in the classroom because now what is happening is I can have a student who has a question share their screen, and we can walk through it as a class, watching the screen, which really makes it beneficial for everyone. Otherwise, if I was in a classroom setting, I'd have everyone gathered around the computer and peeking over each other's shoulders.

MB: You do a visit to a fab shop, but if this is online, how do you? How do you replicate that?

JW: The one time we come together as a class is that tour of the fab house.

MB: And if the students aren't located within a reasonable drive, do they sit that one out, or is there some other way that you try to convey that information?

JW: I can't record the tour, because it is an ITAR-compliant facility. But I have videos of the process from other tours. I have them look at those (videos) and, with my out-of-state students, I actually go visit them at some point. I've gotten into the habit to meet my students face-to-face. I want to find out why they are taking this course. That's usually a question I ask them the very first night: Take a piece of paper and write why you're doing this. I find that such a great motivator for them later, because I tell them, "This is not going to be an easy class. This is going to be very difficult if you've never done this before, and you're going to find this frustrating. Sometimes you're going to pull your hair out. I want you to write down why you're doing this, and then when you get into those situations where you are frustrated, pull that sheet of paper out, reread it and refocus yourself on why exactly you're doing this."

That's the principle we want to try even in the careers we have now. I do it in my career, to understand why I'm doing something.

MB: You're taking home-schooling really literally. Sounds almost like Mr. Hand showing up at Spicoli's house in *Fast Times at Ridgemont High.*

JW: I have come into this through the industry. I'm not a professor. I didn't go to school and say, "I'm going to be a teacher." As a person who's been in the industry for 43 years in electronics, and 23 of those in PCB design, it was something that I love doing. I don't just say, "Read this chapter and take a quiz." I bring real-world exercises and experience into this. I run my class the way I would run a company. As example, I will have students doing a PCB design or their lab working on their designs, and all of a sudden I'll say, "We just got a phone call from the sales department saying we have to cut $50 out of our bottom line. What do you do?" And you know, you hear the shrieks going up through the class. But this is real. I'd love to start a PCB design and everybody leaves me alone and nothing happens. There's no challenges and I just work through this whole process and it comes out the other side and goes to fab and it's all perfect.

MB: Good luck.

JW: Remember the old Atari video game called Pitfall? You're running through this jungle and the whole jungle would open up and you'd fall into this pit. And that's PCB design. That's how I described this to my students. It is like you're running a gauntlet of issues and problems and you try to keep control of it. But it's, how do you control that and what affects your design? This is how I

teach it: "You have this issue. Now where do we go? What's our first step? What's our next step?" and so on. One of the traits I give students is, "You will be successful in this course if you learn to eat the elephant. Take it one step at a time, one bite at a time. Don't get frustrated by it and you'll get through this." It's all done one step at a time. Understand what affects other things.

I really have a mixture of students. By the way, in my class I have EEs who are training for an EE degree. There's that level in the college system. There's also new PCB designers looking for career changes. That's probably one of the most interesting areas, because you would think that EE should have this all down. I actually find that the EEs have more of a problem with PCB design.

MB: Why is that?

JW: I think it's because they get too much into the details and lose their focus on the solution. The best way I can describe this is they will lay down the trace, for example, and they say, "Was that right?" The better question is: Is it a solution? I give each one the same schematic when they start, but I tell them every one of your PCBs is going to be different. What's unique about PCB design is the artistic side, where your individuality comes out in the design.

A lot of times I find that EEs have to look at it in a deeper sense. I've seen in my career that some of the best PCB designers are artists. People say you can't teach that side of it, it's something they have to see for themselves. It's where they see a solution. They see the PCB and visualize how this can come together.

MB: I do think that understanding or thinking in three dimensions helps a lot. Another colleague suggested that the future of PCB design is playing Minecraft right now, and I don't think she's wrong. It teaches you to think in three dimensions and not think of everything as a flat object, and particularly now the way that designs are going, there's so much connected. You have to think of the chip and board almost as a single object, to consider more than just this trace on this plane.

JW: Right. And we definitely get into that with the advanced classes when we start developing our layer stacks. The basics class (designs) a four-layer board. When we get into the advanced class, we're looking at eight and 10 layers because we're talking about a rather big BGA and they have to think, how do I formulate and put this puzzle together in much more of a broader sense?

When I take the students through the process, especially when we make the jump from the schematic to the PCB, I don't tell them what's going to happen. It's like, "OK folks, we're ready to jump from our schematic to our PCB. Go ahead and here's your process and we're going to push this." I take a step back and watch and they push their schematics in their PCB and all of a sudden it's like "holy smoke!" with all the connections and the components and the rats nest going everywhere. I love the fact that we can take these students and bring them through this process. I really think our industry needs this, and that's really what drives me. I've noticed for close to 10 years now, there is a downturn of available talent in our industry. I get calls every week from companies saying, "Are you available for work we have?" There is a real lack of talent in our industry and this has been a growing trend for at least 10 years. PCD&F does the yearly survey of PCB designers and they ask, "Do you intend to retire in the next 12 months?" Those percentages have been in the high 50s or low 60s for some time now. I did a presentation where I asked the audience, "Has anyone else heard the massive sucking sound coming from companies? It's the talent that's walking out the front door." Those designers that walk out with all their years of experience. It's something that I've seen for some time. When I had the opportunity to step in and reverse that trend, I grabbed it. Palomar College is one of the only colleges in the nation that offers PCB design at this level: 32 weeks. Most of the universities offer, at most, eight weeks of PCB design. It's one of those areas that we can take advantage of.

I have the college here working with companies saying, "If you need individuals for internships, we would love opportunities for our graduates." I have several students that have recently gone through my advanced class that were referred to me from their (employers). They go back to their company, and now they're in a better position.

MB: How many students take the basics class and then don't take the advanced class?

JW: About 70% from the basics go on to advanced. There is a drop. I'm working on opening the advanced class to those who are experienced designers. It's been requested a lot by individuals who know PCB design and would like to take the advanced class without the basics course as a prerequisite. Under the discretion of the professor, we can accept students into the advanced class. I'm going to be looking at it for spring semester 2024, which starts in January.

MB: Here's a key question. Do you teach hand routing or autorouting?

JW: I do not teach autorouting. First off, I don't see auto routing as a popular thing in PCB design. I would love to ask industry-wide how many designers autoroute PCBs. (I think) you'll find that the percentage is very, very low.

If someone is familiar with PCB design, they say, "Can I autoroute my board?" I would prefer not. The reason is, I want them to learn this process. My goal is to teach the students critical thinking. And when you just push the button and go get your coffee, there's a couple problems. One is, you're not involved in the PCB design process. You've stepped away. You've let it run its course through the AI of the program. From what I've seen, this is not popular in our industry because it pulls you out of the design process. I find that people do PCB design because it's the solving the puzzle, the creative process, that they want to do. Autorouting completely takes you out of that. So no, I don't teach autoroute. I teach them hand routing of boards. Now, I will bring in some of the active routing or the intermediate routing techniques that you're not just laying a trace down from point A to point B. There's some tricks on the tools themselves that are not autorouting but will help you to improve your routing techniques and still keep you in full control of the route process.

MB: That's fair. To what extent have you been able to modify or add to the curriculum? Have you been able to put your own personal stamp on it?

JW: Oh yeah, as a matter of fact, my curriculum is very fluid. I talk to companies about what they need, what technologies they're bringing in and developing, and from that I massage the curriculum each year, to focus on what companies are looking for in these special technologies. As we know, it's constantly changing in our industry. I think we're seeing some of the greatest innovations we've ever seen in our industry right now. Unbelievable innovations. I have to constantly keep looking at it and say: What do I change? What do I keep improving on? That's a major part of what I do, especially outside of class. An individual who came into my basics class was a janitor who wanted a career change. He went through the basics and the advanced class having never (previously) done a PCB design. Now he works for a company in Carlsbad as their junior PCB designer. I developed my curriculum from the companies. I then work with those companies, saying: "Here is an individual who has learned what you want him to learn, and give him an opportunity and open up an internship or a job."

MB: I love that about community colleges. With four-year institutions, one of the

metrics is "X percentage of our graduates have a job within six months." That's important. College is a huge investment of time and money. But community college is all about being employed, learning how to do something and put it into practice. And if I look at Zippia, the most common academic background for PCB designers in the US today is an associate's degree. Palomar is in the sweet spot in that.

Palomar is really punching above its weight when it comes to design, and there's also classes on geometric tolerancing and dimensioning. There's multiple classes on 3-D design using SolidWorks. Whether you're into electrical or mechanical, it seems like there's something for everyone.

JW: Oh absolutely. And that is something that we are known for at Palomar. Just looking at San Diego, for example, you will have specialty areas in each of the community colleges. Here, Palomar College is quickly becoming known for its engineering; if you want to learn engineering, our college is your place to go. And yes, we have programs that are not just for development but now also this manufacturing side; we're now looking at CNC milling and the mechanical and all these other disciplines in the design process, which is phenomenal. I'm looking forward to the time though, that we as a college could develop a kind of a system or a college project. We are all working in our own areas. We could come together and work as a college toward a single project of some kind that would involve all these different disciplines. That's what we're looking at doing in the future.

Table 1. PCB Designers Educational Background (Source: Zippia)

Education	
Advanced degrees	5%
Bachelor's	36%
Associate's	45%
High school	6%
Other	8%

MB: To that extent, Lorraine Community College in Ohio offers an SMT or an advanced assembly program for electronics, and they have built it to the point now where it's a bachelor's degree offered from a community college. The program is tied into local OEMs and assemblers who will effectively sponsor future employees. They're not their own employees, but they will say, "We have a need for five more people. So if you graduate five people in the next three years, we guarantee that we'll have a job for those folks." A very interesting model, but it does have a hard cap insofar as the number of students that are available to go through the program at any given time. With the Palomar design courses being online, the opportunities are much broader. And because you don't have the same kind of equipment constraints – you don't need an SMT line in your bedroom in order to learn this – there's a much broader potential reach. Do you have a cap on the number of students? There's a point where there's going to be diminishing returns. If there are 50 people in the class, you're not going to be able to do everything you can if there's 25.

JW: Exactly. We are capped for a class at 22. I usually shoot for 25. There will be a few dropouts at the very beginning, but each class can have 25. If, for example, my first class fills up and I have enough people on a waiting list, I could then approach the college and say we'd like to conduct a second class. These could be done on alternate nights of the week. That is an option.

Last year at this time, they were looking at canceling this class entirely. I spoke to the dean and told them that would be a very bad mistake because we are in an industry that needs these individuals. The need is there, and I took the challenge of filling this class. One of my major undertakings is not just to fill this class but also fill the waiting list.

This is the need is there, it's just a matter of getting the word out that this is available. You don't need a prerequisite. You don't have to have an EE. You don't have to have special training. I've seen individuals come from every area of life into this industry. I came up as an electronic technician. But you can do any path you wish. That's what's amazing about this.

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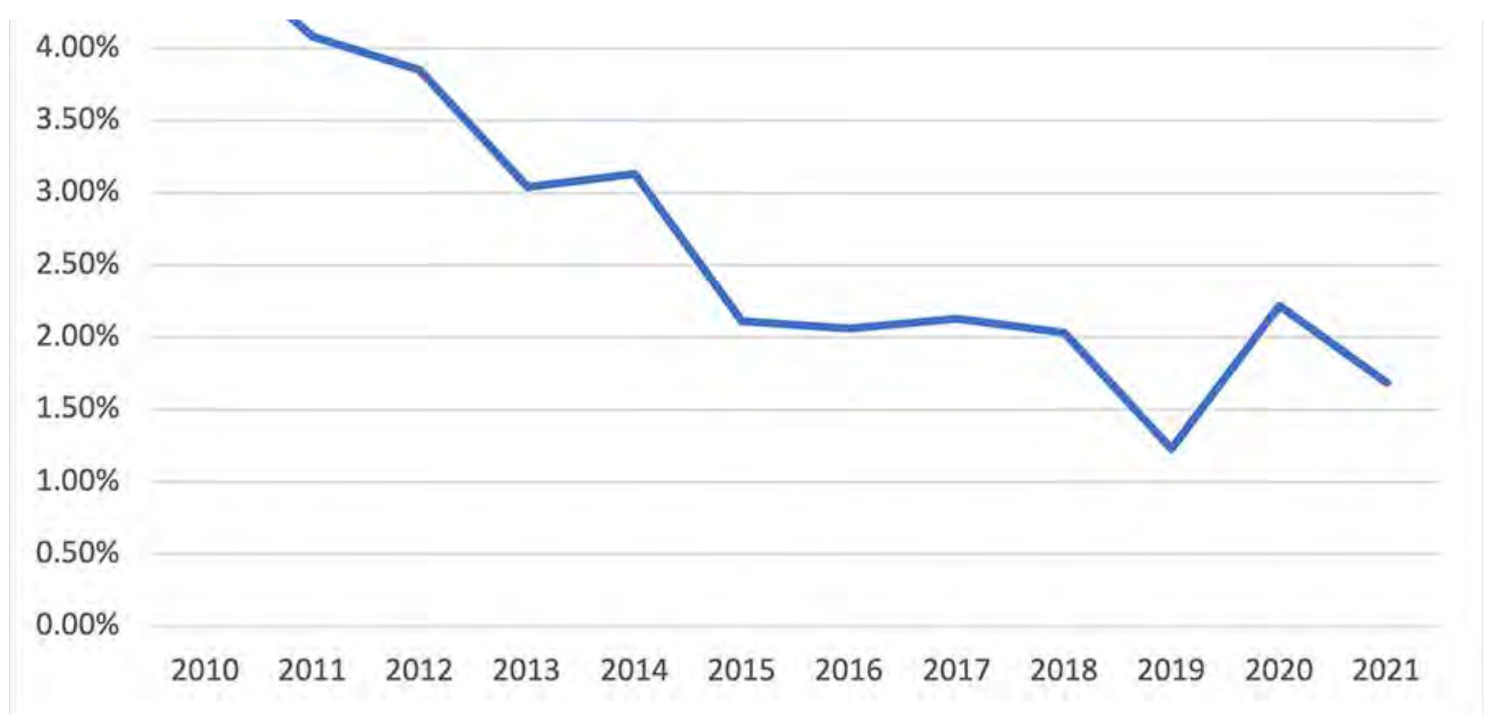

Figure 1. PCB designer unemployment rate by year.

MB: Yeah, the unemployment rate among PCB designers in the US is less than 2%. If you can do PCB design, you will be hired. I'll go back to Lorraine Community College for a moment. One of the things their director told me was that they've offered to license the program to other junior colleges around the country and have seen no interest. Has Palomar talked with other community colleges, or even for that matter, other four-year institutions about packaging this coursework and offering it in some shape or form?

JW: Yes, yes, we are looking at getting this course certified by the state right now and then any community college in California, at least to start, will be able to take this course and get credit for their own college. We are in that process right now. I get students from those colleges who are attending for the sake of learning but not getting college credit. We would like to be able to have them get college credit. The steps I need to go through with that is to get my course certified by the state community college system and then it will be accepted. Because it's online, it makes it convenient. Anybody, anywhere in California will be able to take this and get college credit.

Ed.: Palomar's DT-226 Basic PCB Class is scheduled to start Aug. 22 (https://palomar.programmapper.ws/academics/interest-clusters/dbe0f8d1-c2e1-450f-afa3-661d42bfc243/programs/536f5d77-4fde-47c1-6435-4d607d902c2f). The Palomar website is

palomar.edu. Prospective students may contact Watson at john.watson@altm.com or j.watson@palomar.edu.

Watson will also take part in a free panel on Next-Generation Engineers on Sept. 20 at PCB West (pcbwest.com) this year.

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

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QUALITY **ASSURANCE**

Rightsizing Continuous Improvement Focus

Match the resources that make sense in the scale of your operation.

by **MATT CLINE**

In the early 1990s, some observers were predicting that the EMS market would consolidate and shrink to a handful of large players building the bulk of the world's electronics products. But outsourced electronics manufacturing isn't a one-size-fits-all equation. Even large OEMs often have higher mix, lower volume or variable demand segments of business that fit best in a regional EMS provider. Consequently, regional EMS providers continue to thrive.

That said, just as different types of manufacturing projects are often best served by different tiers in the EMS industry, regional EMS companies often need to right-size internal processes to match the resources that make sense in that scale of business. One area that can benefit from this rightsizing approach is quality management and continuous improvement.

While similar ISO quality management system frameworks make sense regardless of company size, the types of metrics collected, the size of the dedicated quality staff and the methodologies in place to drive corrective action do benefit from a more tailored approach.

Key questions that can help right-size the approach include:

- What factors drive the bulk of defects found in our manufactured products?
- Based on project volumes, should defects be measured at the solder joint level, the part level or the product level?

- Does the cost of the defects likely to be caught offset the cost of inline automated inspection systems?
- Do metrics measure actionable improvement needs?
- Would process improvements outside of the production line do more to improve quality than more detailed inspections on the line?
- What range of tools is most effective for identifying issues, root causes and appropriate corrective action?

When the team at Electronics Design & Manufacturing (EDM) started asking those questions, not all answers tracked back to industry norms.

One key difference is that the company is employee owned. In an employee-owned stock plan (ESOP) arrangement, employees receive briefings on company financial results and distributions based on company profitability. The result is that employees see the financial connection between bad quality and quarterly operating results, which in our experience drives a higher level of attention to detail than may be found in companies where employees are compensated on hours worked alone.

The frequency of workmanship-related defects is low. Yields are typically over 99% and, on average, returned material authorizations (RMAs) number fewer than six per month. Typically, defects are caused by one-off mistakes, broker parts, customer test fixture issues and issues at the customer.

Quality assurance focus starts in new product introduction (NPI). The NPI coordinator works with the quality team to perform a risk analysis on process failure modes and then the team addresses the gaps.

While first-pass yield is measured for customer reporting purposes, in many cases it isn't the best tool to drive down to defect root causes. This is because most customers utilize custom functional tests and test fixture wear or narrow test parameters can cause a spike in defects that has nothing to do with workmanship. To drive corrective action, the quality team monitors defects per thousand parts, which are more applicable to a business its size. The team counts one defect per part regardless of the number of opportunities on that part. Yields are tracked using a real-time dashboard so no defect goes without visibility for more than a week. Typically, the root cause is

identified in hours or days depending on whether the issue is resident at the contract manufacturer or OEM.

Figure 1. A focus on actionable metrics and root-cause analysis followed by rapid corrective action works better at this facility.

The team's root cause analysis utilizes an 8-D methodology for failure analysis and corrective action, evaluating trends related to job number, part number and reference designator. In one recent issue that involved a wrong part, the part was used multiple times per board and not all placements were incorrect. The SMT machine was placing from two different reels. Root cause analysis identified a bad splice as the source of the issue, and the checks and balances on the process associated with splicing one reel to another to avoid downtime was strengthened with a barcode scanning step.

Use of third-party broker parts due to material constraints is one of the biggest drivers of quality issues. Often the brokers selling the parts have not had control over how the parts were handled or whether the parts have been tampered with. When broker parts must be ordered, the customer is

notified and a validation plan is developed. Validation steps can range from third-party testing to internal inspection and lot sampling. Incoming inspection looks for changes to part markings, such as ink that wipes off with a solvent. Electrical test or x-ray inspection may be performed on parts designated high risk for issues. Sampling takes parts from several areas of a reel because counterfeiters will normally place the counterfeits in the middle of the reel so that the ends will test good.

Another area of concern is handling of moisture-sensitive parts. Broker-sourced moisture-sensitive parts come in a sealed bag with new desiccant and a humidity indicator card. In those cases, the card is measuring the bag's humidity content, not the amount of moisture in an older, poorly stored part. To address that, parts with MSL3 or higher ratings are automatically baked to ensure appropriate moisture levels prior to soldering.

Quality metrics are tracked throughout the production process via automated inspection and test processes. Automated inspection includes 3-D solder paste inspection (SPI) and a 3-D AOI. Given the strength of process control, however, defect spikes in test or at the customer often require some detective work.

For example, use of broker parts can increase failure rates in tests with overly narrow parameters. In one case, changes in the weather changed failure rates. In those cases, the test engineering team works with the OEM to adjust test parameters to better align with the faults they are inspecting for.

In other cases, the issue is at the customer. The contract manufacturer's quality team works closely with customer quality managers to review customer internal processes and may even visit as part of root-cause analysis. In one project, a customer's facility was inserting USB cables at a bad angle due to housing design and in the process breaking the USB connectors on the PCBAs. The contract manufacturer's engineering team recommended an engineering change that added epoxy to give the connector additional mechanical strength and solved the issue. In another project, a customer's final assembly functional test had no ESD protection and PCBAs were getting damaged during test. The customer's manufacturing operations were predominantly focused on mechanical assembly where ESD protection wasn't a factor. The contract manufacturer's quality team worked with the customer to implement an ESD protection program.

As these examples illustrate, often the root cause of a defect spike at this contract manufacturer isn't

workmanship related. The challenge for regional contract manufacturers whose project volumes typically run in the tens of thousands rather than the millions is focusing attention on the right things: having procedures that prevent defect opportunities and rapidly responding to any spikes in defects. While automated inspection equipment and first-pass yield metrics play a role, these tools tend to be deployed to a lesser extent than found in facilities running project volumes in the millions. A focus on actionable metrics and root-cause analysis followed by rapid corrective action works better at this facility.

MATT CLINE is quality manager at Electronics Design & Manufacturing (EDM); mcline@edmva.com.

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CLEANING

Key Considerations When Selecting a Replacement Vapor Degreaser Cleaning Fluid

Can your preferred choice be dropped in?

by ELIZABETH NORWOOD

Let's set the scene. You have been using the same vapor degreasing fluid to successfully clean complex circuitry and printed circuit boards (PCBs) for years, only to learn that your trusted line of cleaning fluids will soon be discontinued. What do you do? How do you choose a replacement that meets the PCB cleaning challenges that you and many other fabricators face?

Factors to consider when choosing a replacement cleaning fluid include the equipment, the substrate being cleaned, the type of contamination being removed, the long-term availability and sustainability of the replacement fluid, and the level of support available from the supplier.

Taking these factors into consideration, PCB manufacturers can make an informed decision and select a replacement cleaning fluid that meets their specific needs while minimizing any negative impact on their cleaning processes.

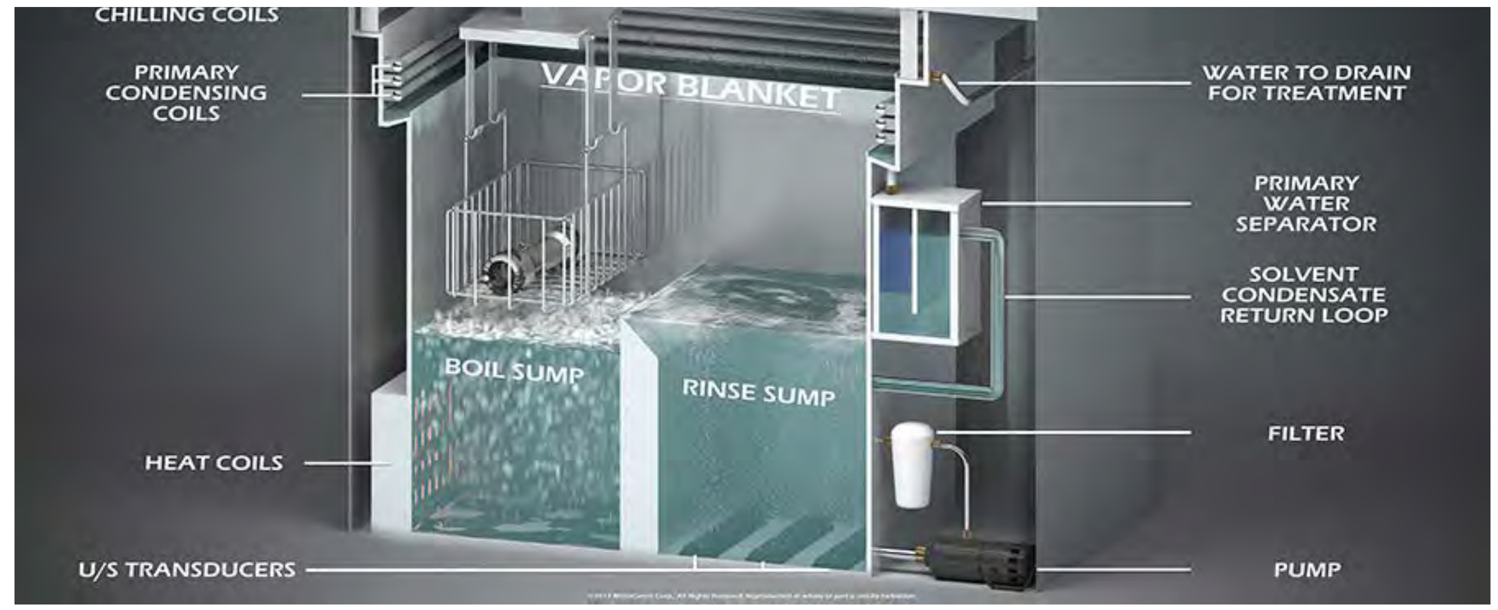

Figure 1. Manufacturers should ask if their vapor degreaser equipment will require upgrades or modifications to use the new fluid.

Consider Your Equipment

When looking for a replacement cleaning fluid, manufacturers should first consider the cleaning equipment they use. Manufacturers should ask potential suppliers questions about their cleaning fluid's compatibility with their equipment and if their equipment will require any upgrades or modifications to use the new fluid.

Many modern, nonflammable and environmentally progressive vapor degreasing fluids can be used in existing equipment, with the same operating methods. After emptying and cleaning the vapor degreaser of the previous fluid, the replacement cleaning fluid can be "dropped in" to the machinery without any significant change to the cleaning process. This means new or extra equipment is not required, with little disruption to production workflow.

It is important that manufacturers start to prepare for their cleaning fluid transition early. Transitioning from one solvent to another may involve testing new cleaning fluids on a small scale to ensure that they are effective and do not cause any damage to equipment or substrates. It may also involve training employees on how to use the new cleaning fluid and adjusting the cleaning process to ensure optimal performance.

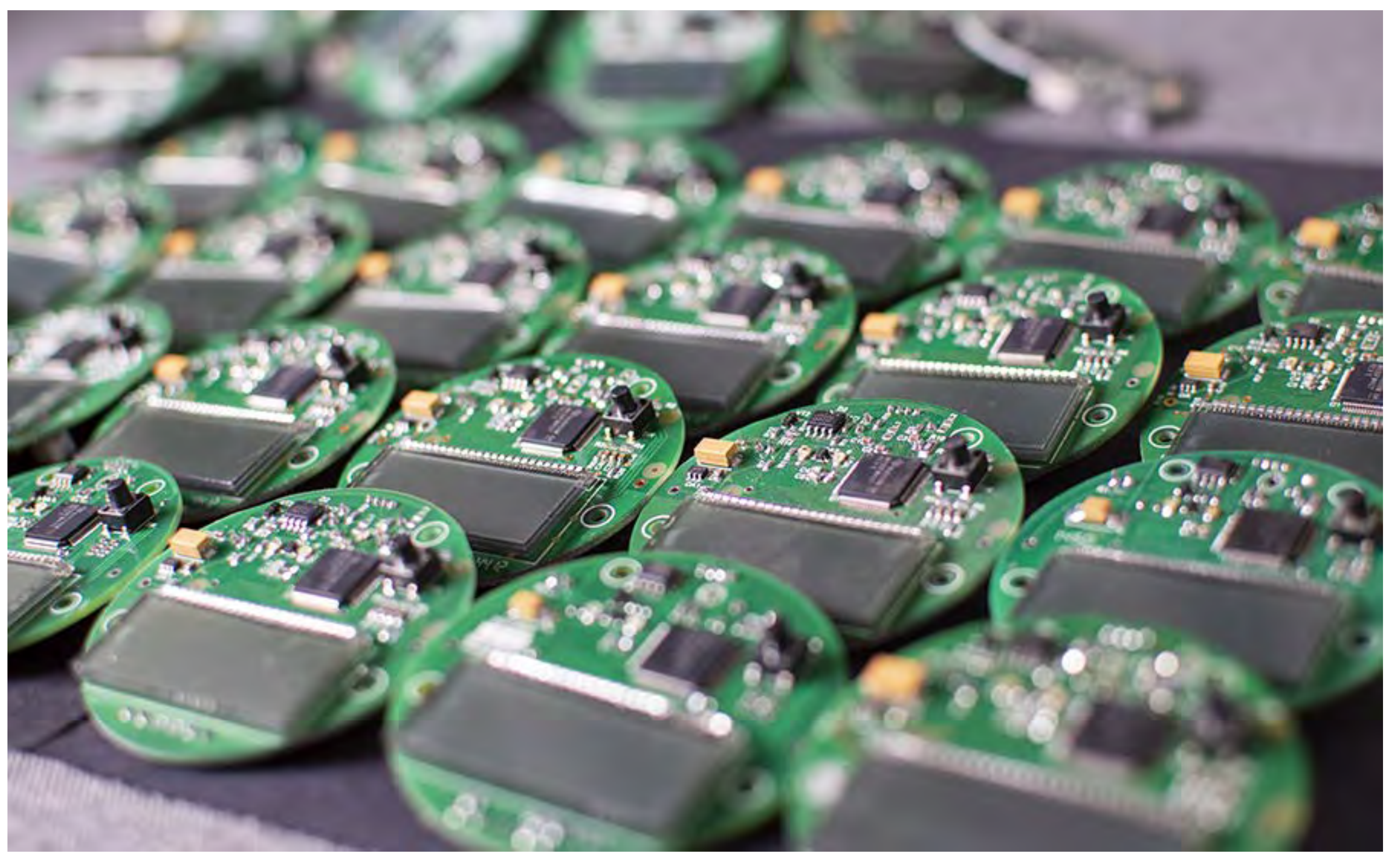

Figure 2. It is important to confirm PCB material and cleaning fluid compatibility.

Is it Compatible?

It is important to confirm material compatibility and to ensure the replacement vapor degreasing fluid under consideration will not negatively impact the substrate of the parts being cleaned.

Today's complex electronics are made from various materials, including metals, ceramics and plastics. A cleaning fluid must be strong enough to effectively remove any contamination, yet not cause damage to sensitive PCB materials such as polycarbonate and acrylic.

Modern vapor degreasing fluids offer high enough solvency (or Kb value) to selectively clean contamination, without damaging surfaces or delicate parts. Because modern vapor degreasing fluids are low boiling, they can effectively clean fragile electronics and minimize the risk of damage, especially to wafers and thin PCBs. They come in unique, customizable blends to accommodate many different types of applications. This permits removal of a particular soil from a specific substrate to help maximize cleaning effectiveness without material damage.

Figure 3. To ensure cleaning success, some cleaning fluid manufacturers can conduct onsite audits or in-lab tests with sample parts.

Type of Contamination

Cleaning is crucial to the success of most PCBs and must be completed correctly to guarantee the reliability and lifespan of the electronic component. To clean effectively, it is important to identify the contamination first to ensure the selected cleaning fluid will remove it.

Throughout the manufacturing process, PCBs contact all kinds of contaminants that must be removed. These include marking inks, uncured solder paste, adhesives, conformal coatings, and fingerprints. To ensure that PCBs operate without error, these contaminants must be removed.

PCB contamination is categorized into four main groups: insoluble particulate, organics, inorganics and water.

- Insoluble particulate is a polar contaminant that cannot be dissolved by water or a cleaning fluid, for example dust and metal chips. It electrostatically bonds to PCB surfaces and requires a dense electrostatic polar cleaning fluid that contains conductive molecules to break the static bond of the contaminant and displace the particulate.
- Organic or non-polar contaminants include rosin solder pastes and fluxes. Organic contaminants can also include non-polar oils and greases. These can be dissolved and removed with mild to medium strength organic flux removers.
- Inorganic, polar contaminants are the residue left by lead-free and no-clean fluxes and solder pastes and can be extremely difficult to remove. Inorganic contaminants usually require more aggressive flux removers to dissolve contaminants. However, it is important to perform a materials compatibility test before use.
- Water can become trapped in densely populated circuit boards when using an aqueous cleaning system. It is typically removed using air knives, but this may still leave moisture and allow water spots to form. Water contamination can be removed using batch drying inside a vapor degreaser outfitted with a water separator.

When replacing a cleaning fluid, testing is key to ensure the contaminant is successfully removed and the substrate is not affected. To ensure cleaning success, some cleaning fluid manufacturers can conduct on-site audits or in-lab tests with your sample parts. Based on the substrate and the contaminant, they can recommend or engineer the fluids and processes that work best.

Selecting a Cleaning Fluid for the Long-Term

When selecting a replacement cleaning fluid, PCB fabricators should choose one that has been on the market for some time and has a proven record of effectiveness and a long-term sustainability profile. Also, ensure the supplier has the knowledge and vapor degreaser cleaning expertise to support your choice.

Electronics manufacturers should also consider the long-term availability of the chosen fluid. If a fluid is available for a limited time only, it may be challenging to find a replacement when it is needed.

Check a fluid's sustainability credentials before making a decision. Many newer cleaning fluids are designed to be more environmentally friendly than older ones and benefit from meeting standards like those required by the US Environmental Protection Agency or the EU's rules of REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals). Some feature a zero ozone-depleting potential (ODP) and low volatile organic compound (VOC) content, as well as having low global-warming potential (GWP), which limit the negative impact on air quality.

Additionally, and importantly, most next-generation debinding fluids are human-safe with better toxicity profiles and higher TLVs (threshold limit values) than legacy fluids – making them less hazardous for exposed workers to use.

Look for a supplier with technical expertise in cleaning a variety of PCB substrates using different cleaning methods and who can perform on-site cleaning audits to identify materials used and the contamination to be removed.

Suppliers with laboratory support structure can aid a smooth transition. Those able to support PCB manufacturers throughout the process, from research and design, to testing and manufacturing, can identify and solve potential cleaning problems before the PCBs even go into production.

Additionally, ensure the company has a longstanding, sound reputation for customer service and can provide technical support, troubleshooting, and training on the new cleaning fluid.

Help is Out There

Knowing a tried and tested cleaning fluid is being discontinued can be concerning. Finding a replacement may seem like an impossible challenge, but effective alternatives exist.

Consider key features including equipment requirements, cleaning ability, substrate compatibility, and environmental sustainability. Work with a supplier that can provide a vapor degreasing fluid that addresses all these challenges with the added benefit of high levels of support and dependability. Once this is all in place, selecting a replacement cleaning fluid is not so daunting.

ELIZABETH NORWOOD is a senior chemist at MicroCare (microcare.com). She has been in the industry more than 25 years and holds a bachelor's in chemistry from the University of St. Joseph.

Norwood researches, develops and tests cleaning-related products. She currently has one patent issued and two pending for her work.

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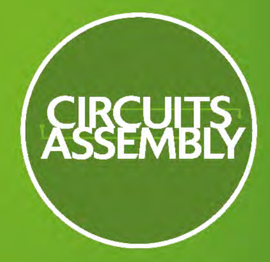

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THERMAL MANAGEMENT

Understanding Criticality of Thermal Performance in Thermal Interface Material Applications

Effects of types of TIM types, thicknesses and contact pressure in a real-world application.

by DR. RITA MOHANTY

Power electronics are integral parts of power components, power supplies, 5G networks, automotive and defense/space applications. All modern power electronics have two critical factors in common that drives the need for unprecedented thermal management: first, increased transistor density to meet the higher demand in increased computing power and second, component miniaturization leading to higher heat flux. It is well known in the electronics reliability field that 55% of the component failures in electronics devices are related to excess heat. The Arrhenius equation in Eq. 1[1] predicts that, for electronics, the lift of the device decreases by half[2] by increasing the device temperature by 10°C. Design engineers mitigate this issue by carefully selecting thermal interface materials (TIM) to keep the system/device temperature at the desired level.

$$AF = \frac{time_{use}}{time_{test}} = exp\left[\frac{E_A}{k}\left[\frac{1}{T_{use}} - \frac{1}{T_{test}}\right]\right]$$

EQ. 1

AF = Acceleration factor

T = Temperature

EA = Activation energy

K = Boltzmann constant

The primary function of a TIM is to replace the air between the heat-generating component and the heat spreader/heatsink to improve heat dissipation. **FIGURE 1** shows an illustration of a typical microelectronics packaging assembly with heatsink and TIM. Unevenness and roughness of the surface must be taken into consideration when implementing a thermal solution.

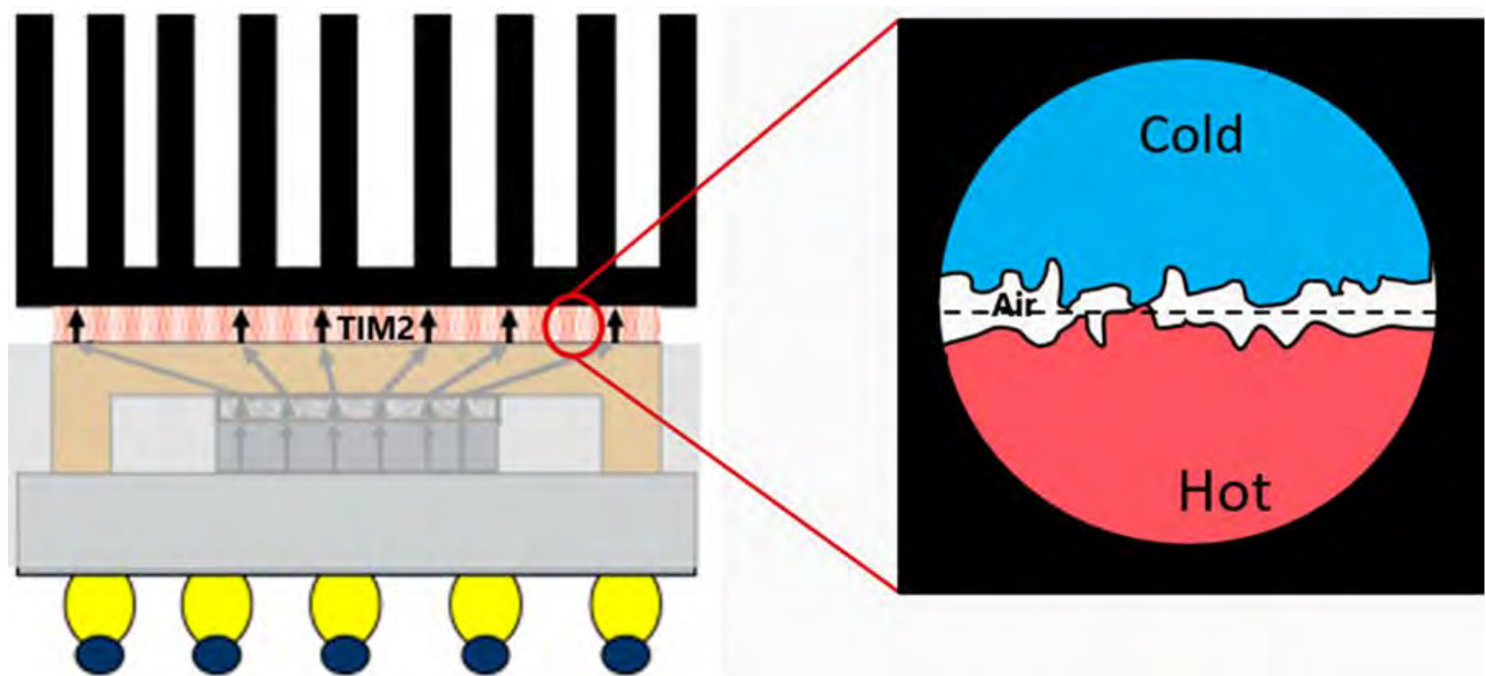


Figure 1. Illustration of rough interfaces.

For the heat to be adequately dissipated, it must reach the heatsink surface first. Efficiency of heat transfer from the hot device to the cold heatsink depends on effective thermal resistance of the bulk TIM and contact resistance at both surfaces.

Definitions

Thermal conductivity. Thermal conductivity (TC), designated as *k*, is the bulk property of a material that indicates its ability to conduct heat. It does not depend on the geometry or interfacial conditions of the test set up. Fourier's law of thermal conduction provides us a way to calculate *k*

using the equation in Eq. 2.

$$Q = -kA\frac{\Delta T}{d}$$

Eq. 2

Q = Heat flux (W)

k = Thermal conductivity (W/m-K)

A = Area (m^2)

d = Thickness (m)

FIGURE 2 is the graphical representation of Fourier's equation.

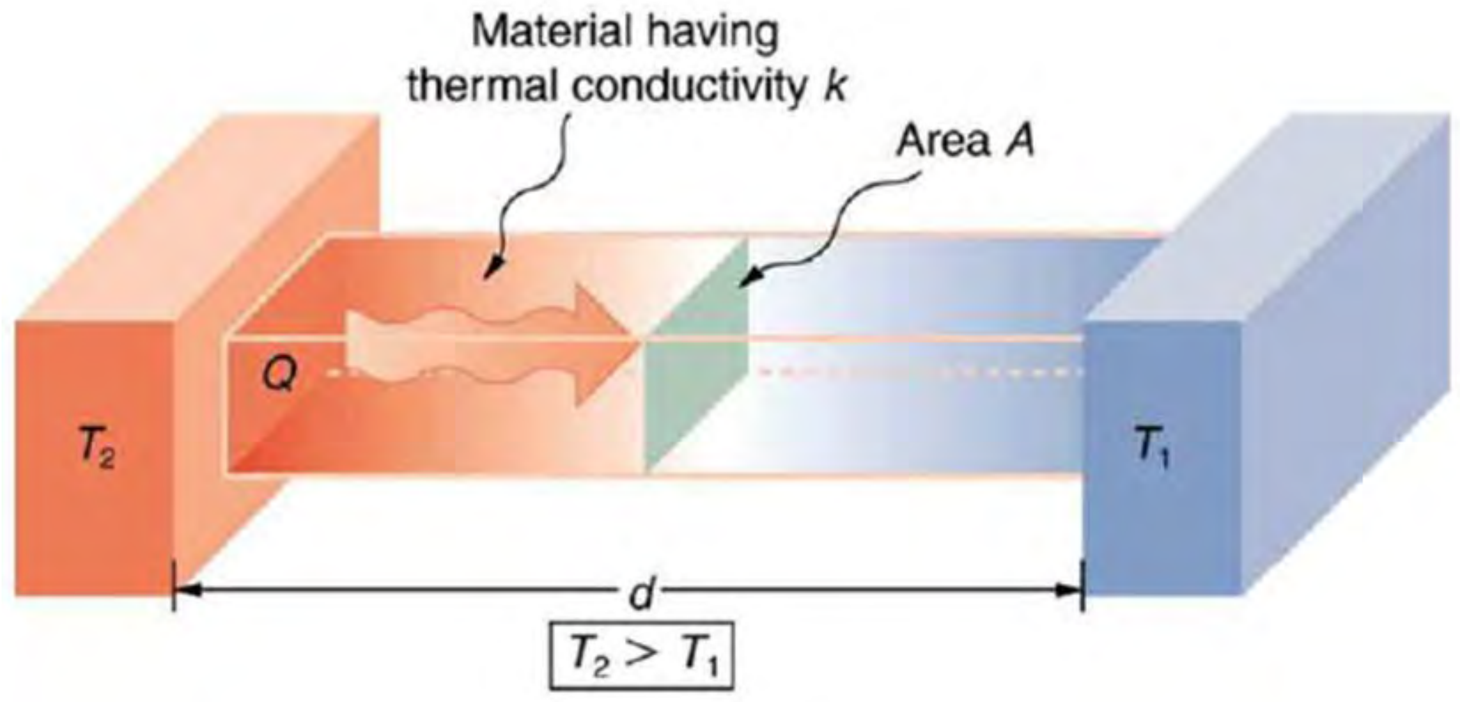


Figure 2. Fourier's law representation.

The term "thermal conductivity" applies to homogeneous materials only. Thermal interface materials, however, are not homogeneous. They are considered heterogeneous materials. Hence the proper terminology to describe the conductivity of TIM is "effective or apparent thermal conductivity." Effective thermal conductivity is calculated by Eq. 3.

$$k_{eff} = d/Z$$

Eq. 3

k_{eff} = Effective thermal conductivity, W/m-K

Z = Thermal impedance, °C-m^2/W

Thermal resistance. Thermal resistance (TR) can be thought of as the opposite of thermal conductance. For a steady state conduction as shown in Figure 2, the Fourier's equation for thermal resistance can be written as Eq. 4.

$$R = \frac{d}{kA}$$

Eq. 4

R = Thermal resistance, °C/W

Thermal impedance. Thermal impedance (TI) is similar to thermal resistance, and they are often used interchangeably. There is a distinct difference between thermal resistance and impedance, however. TI is defined as the temperature gradient per unit of heat flux, passing through the interface. As shown in Eq. 5, TI is obtained by simply multiplying the resistance, R, by the area over which the heat is dissipated.

$$Z = RA$$

Eq. 5

TI includes bulk thermal resistance of the TIM and contact resistance between the TIM and the two surfaces in contact with the TIM. As the thermal resistance is directly proportional (Eq. 3) to the TIM thickness, the thinner the TIM thickness, the lower the thermal resistance. Contact resistance on the other hand depends on the two contacting surface conditions and the ability of the TIM to fill in the surface roughness (Figure 1). Surface roughness and unevenness can trap air (air is a thermal insulator) reducing the effectiveness of TIM to transfer heat. **FIGURE 3** is a graphical

representation of the resistance in series across the component and heatsink assembly. Total resistance is the sum of all three resistances (impedance).

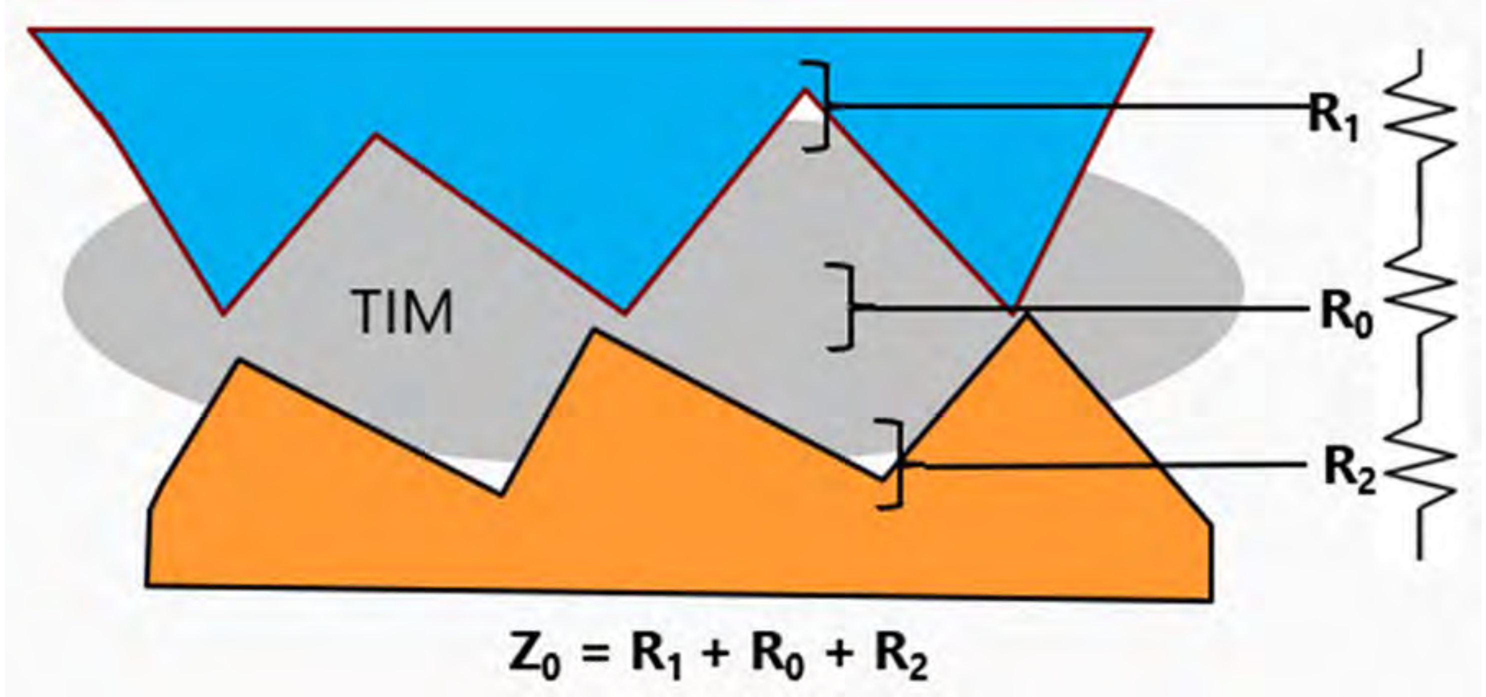


Figure 3. Thermal impedance explanation.

Thermal Performance Characterization

Thermal performance characterization of TIM is critical in selecting the right TIM for an application. Characterization can be challenging, however, as many industry standards are in use. Examples of such standards are ASTM D5470, JESD51:1-14, SEMI 750, and SEMI G68-96, to name just a few. In addition, these standards could have many test methods/variations. Using a standardized test method is imperative to enable the end-user to compare TIM products from different suppliers.

Two common types of testing are performed at the material level (TIM characterization). They are steady state and transient testing. The most common steady state testing equipment is based on the ASTM D5470 standard and transient testing is based on the ASTM E1461 Laser Flash method. This study used the ASTM D5470 test method (Steady State Thermal Testing-ASTM D5470-6[3]) to characterize all TIMs in testing.

A typical ASTM D5470 test setup to obtain effective thermal conductivity is shown in **FIGURE 4.**

Thermocouples (TC) are embedded on the surface of the hot and cold bar to measure the exact temperature of both surfaces. This setup assumes the following once steady state is reached:

- Temperature gradient is uniform across the column
- All power applied goes through the column only
- Heat flow is one-dimensional
- No interfacial resistance (negligible amount) between the cold and hot bars
- Both surfaces are flat and level.

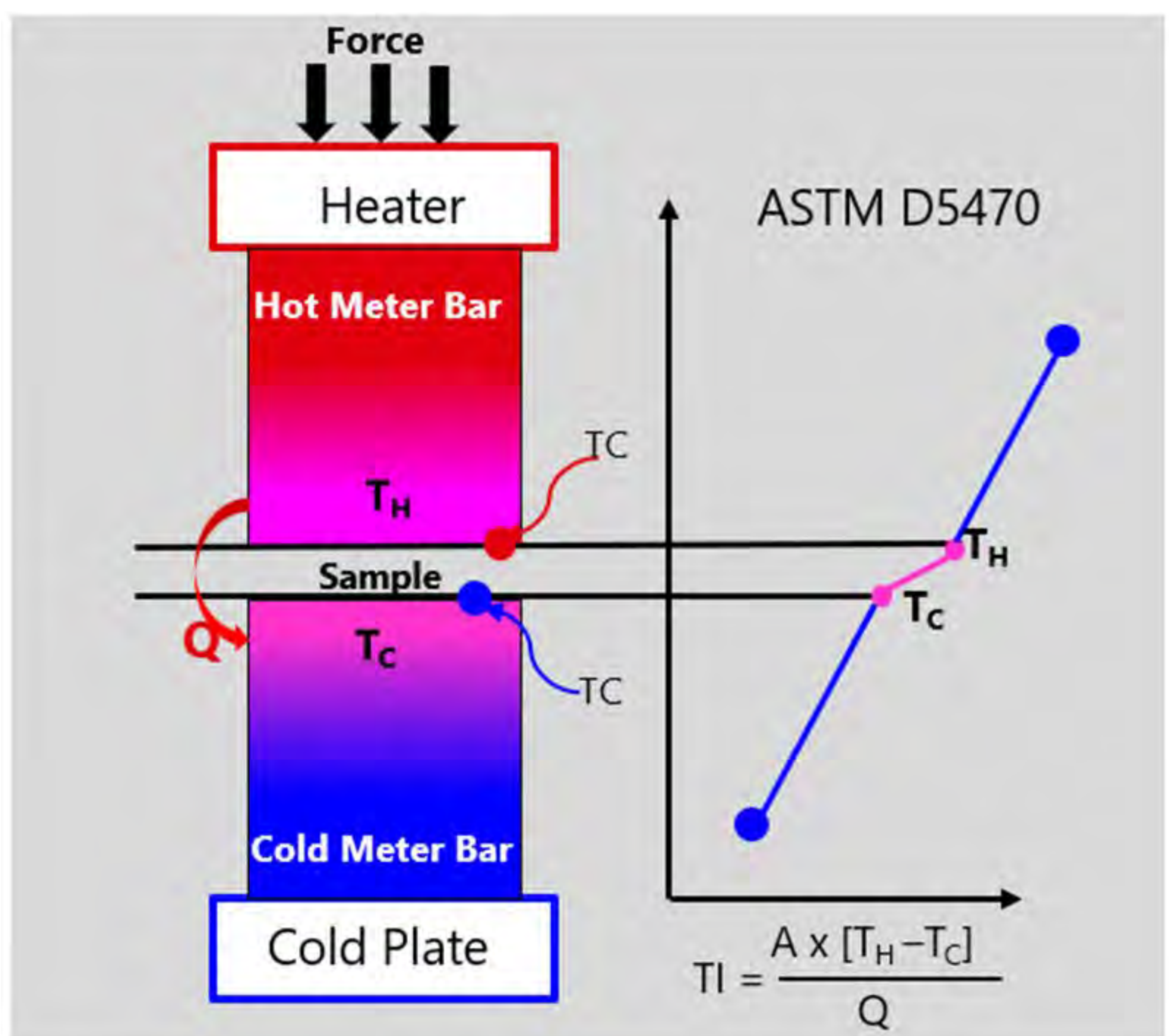


Figure 4. Schematic of steady state thermal test method.

When the sample is placed between the two bars, it poses some resistance to the flow of heat. Based

on the measured temperatures and known thickness, a TI can be calculated.
Effective thermal conductivity can be calculated from measured thermal impedance and measured sample thickness provided contact resistance << sample resistance (typically less than 1% of sample resistance).

Experimental Study

As described earlier, thermal performance of a TIM depends on the thermal conductivity, TIM thickness, area, and contact resistance at both interfaces. Contact resistance, on the other hand, depends on the TIM's ability to wet out (fill in the microscopic surface imperfection that could trap air) the mating surfaces. Better wet out can be achieved by various means. Examples are smoother surfaces, TIM's wetting ability (liquid versus pad), and increased pressure for better contact. This experimental study explored the effects of types of TIM (pad versus gel), TIM thickness and contact pressure as phase 1 of this study.

Experimental setup. The first part of the above hypothesis was tested by conducting a 2K design of experiment (DoE) as shown in **TABLE 1.** A gap pad and gel were selected for this study with listed thermal conductivity of ~5W/m-K. The second part of the study (Ladder Study) used various pad thicknesses and assembly (test) pressure to observe its effect on thermal impedance. The sample used for this study was an ultra-low modulus gap pad with TC of ~6W/m-K. **TABLE 2** shows the experimental matrix.

Table 1. 2K DOE Table

TIM Type	TIM Thickness (mm)	Replicates
Gel	0.5	3.0
	3.0	3.0
Gel pad	0.5	3.0
	3.0	3.0

Table 2. Ladder Study for Effect of Contact Pressure

Ultra Low Modulus Gap Pad with 6W/M-K TC									
Thickness	Contact Pressure (psi)								Replicates
40	10	20	40	60	80	95	80	95	3
60	10	20	40	60	80	95	80	95	3
80	10	20	40	60	80	95	80	95	3
100	10	20	40	60	80	95	80	95	3
125	10	20	40	60	80	95	80	95	3

FIGURE 5 shows the equipment used in this study. Gap pad samples were cut to a diameter of 33mm (1.3″). Liquid samples are applied to the tester with a measured volume to achieve desired thickness with a diameter of 33mm **(FIGURE 6)**. The TIM tester has a built-in thickness measurement system that accurately measures and records the thickness of each sample.

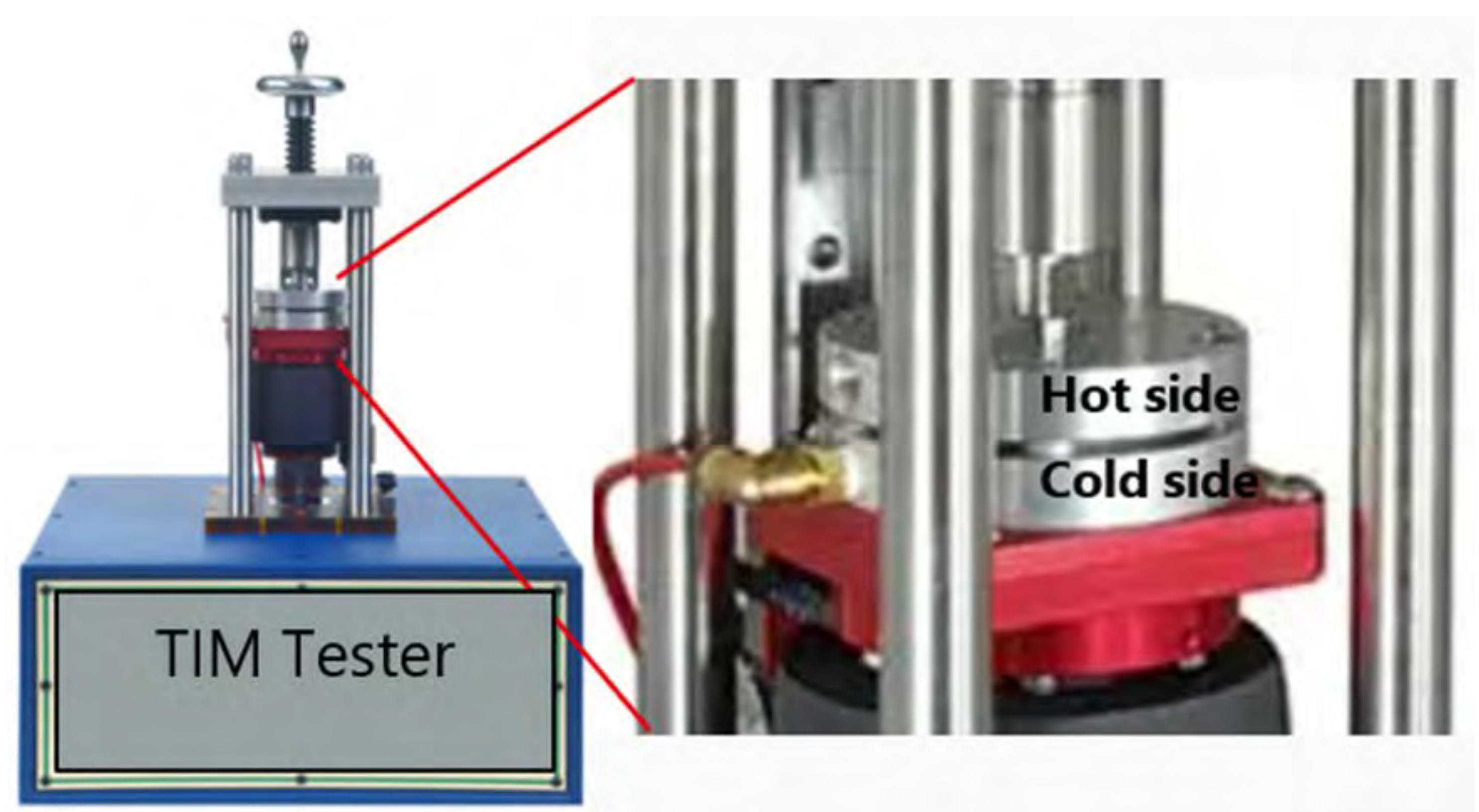


Figure 5. Test equipment.

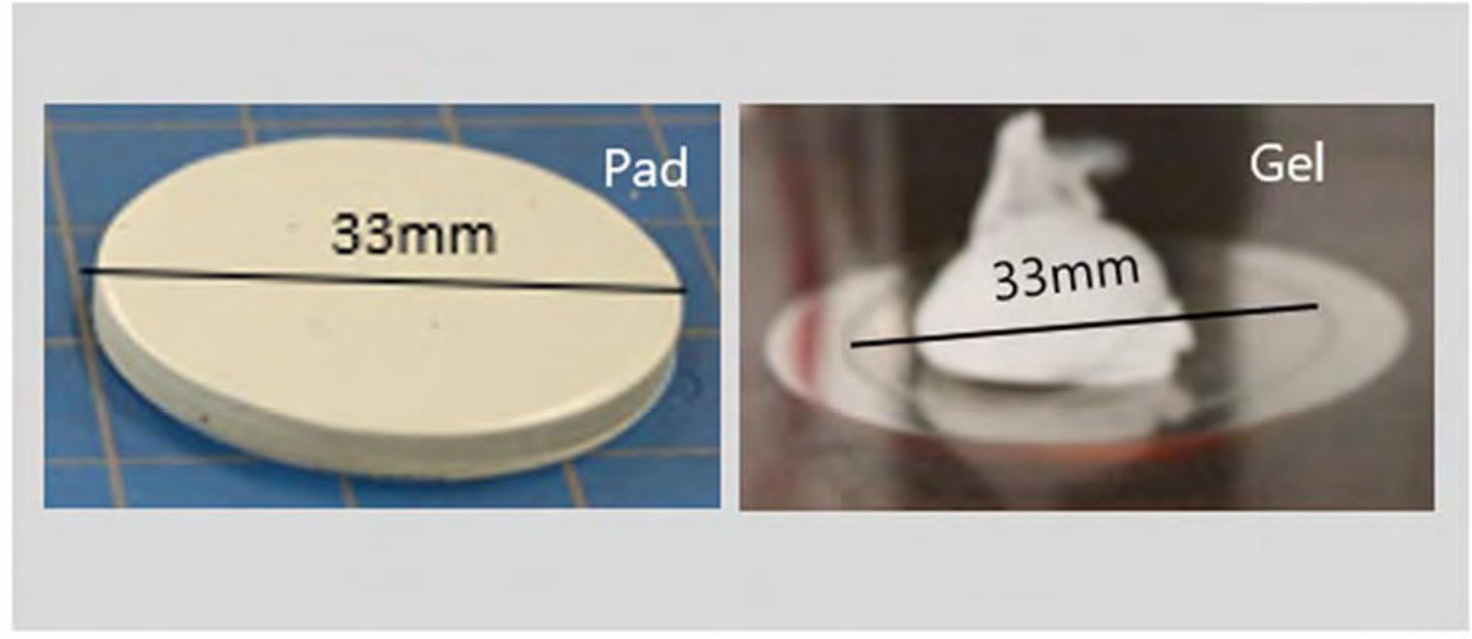


Figure 6. Test specimen examples.

Predictions. As a gel is a liquid TIM, it should provide better wet out of the surfaces leading to lower thermal resistance as compared to a pad. The same theory should be applicable to thinner TIM thickness as described in section II. By increasing the assembly pressure for a pad, we should also observe better wet out.

Results and Analysis

Thermal impedance analysis. As predicted, DoE analysis for TI shows that regardless of product type, TIM thickness has the largest impact on the TI: The thinner the TIM thickness, the lower (better) the TI. Product type analysis also agrees with the prediction that gel (which is a liquid) wets out the interface better, leading to lower TI.

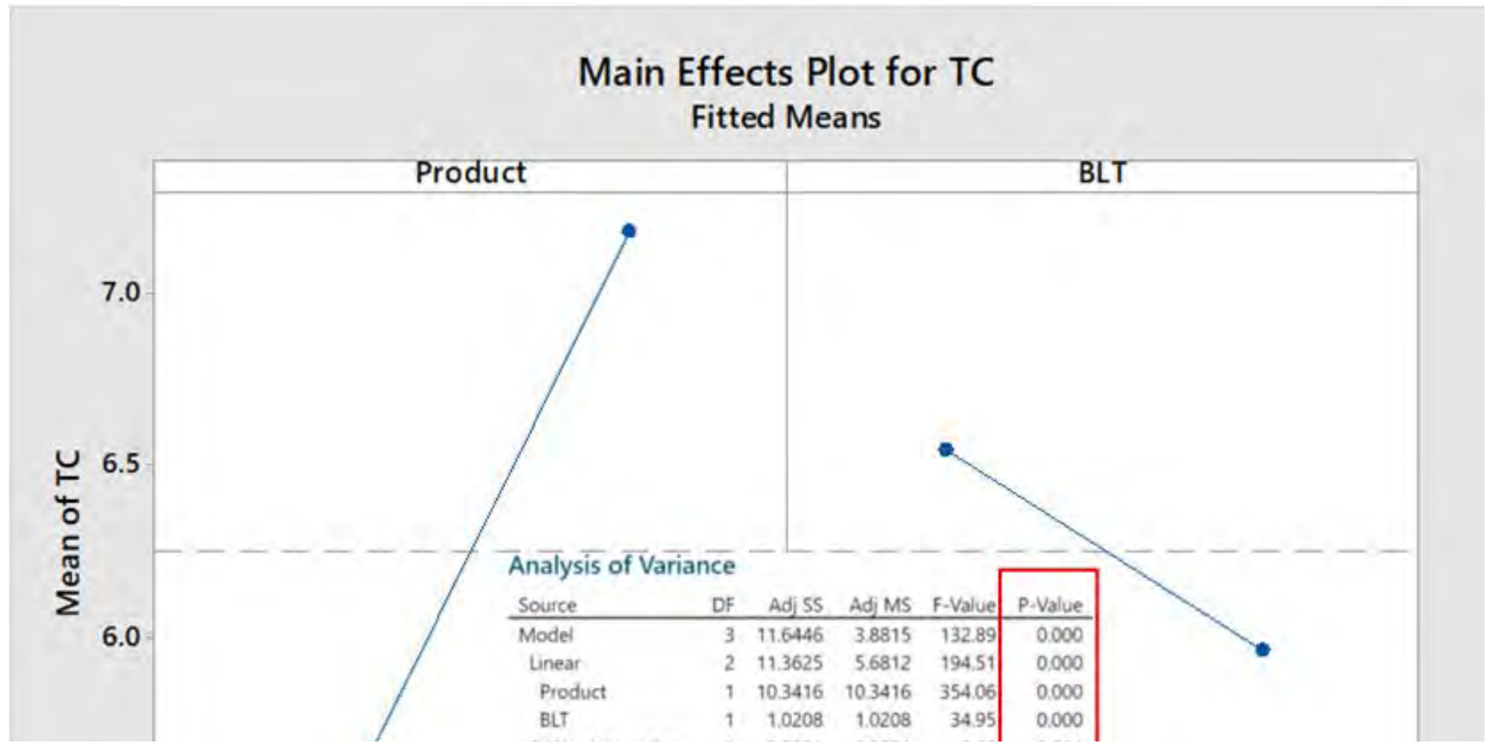
FIGURE 7 shows the main effect plot and ANOVA analysis as obtained from MiniTab analysis. A P-Value of 0.0 for all main effects and interaction indicates statistical significance of product type and TIM thickness.

Analysis of Variance

Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	1.17066	0.39022	596.97	0.000
Linear	2	1.15423	0.57711	882.89	0.000
Product	1	0.04037	0.04037	61.76	0.000
BLT	1	1.11386	1.11386	1704.02	0.000
2-Way Interactions	1	0.01643	0.01643	25.13	0.001
Product*BLT	1	0.01643	0.01643	25.13	0.001
Error	8	0.00523	0.00065		
Total	11	1.17589			

Figure 7. DoE analysis for thermal impedance.

Effective thermal conductivity analysis. Effective TC was calculated using Eq. 3 with the measured TIM thickness as described earlier. Effective TC depends not only on the bulk TC of the sample but also on the contact resistance. The trends observed in effective TC are similar to TI, as predicted by the hypothesis. The result from the MiniTab analysis is presented in **FIGURE 8.**



Source	DF	Adj SS	Adj MS	F-Value	P-Value
Model	3	11.6446	3.8815	132.89	0.000
Linear	2	11.3625	5.6812	194.51	0.000
Product	1	10.3416	10.3416	354.06	0.000
BLT	1	1.0208	1.0208	34.95	0.000

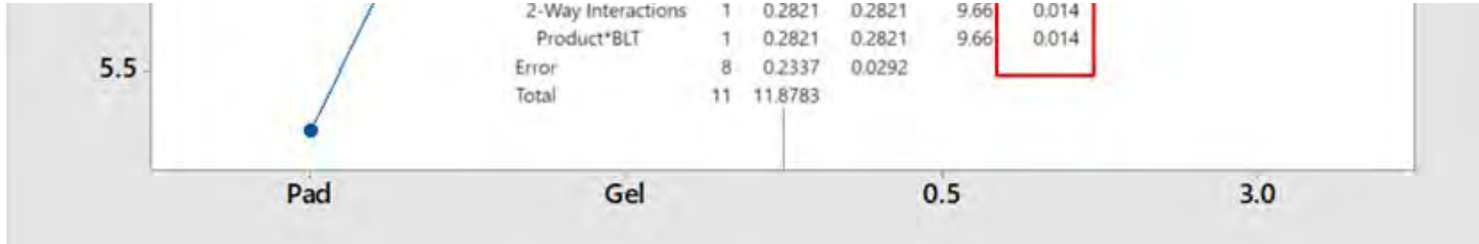


Figure 8. DoE analysis for effective TC.

Assembly (test) pressure effect. Assembly pressure effect test was conducted using the same test setup as shown in Figure 4. A typical sample condition before and after testing is shown in **FIGURE 9** for a 125-mils thick sample. As expected, at higher pressure, the sample becomes much thinner and squeezes out to the outside perimeter of the test fixture.

Figure 9. Effect of pressure on sample condition: a) image of test setup, b) sample prior to testing, c) sample after 40psi testing, (d) sample after 95psi testing.

FIGURE 10 shows the results from the ladder study as described in Table 2. As predicted, there is a clear trend in improved thermal performance (lower TI) with increased pressure regardless of initial sample thickness. This is the result of better wet out and thinner bond line with increased test pressure.

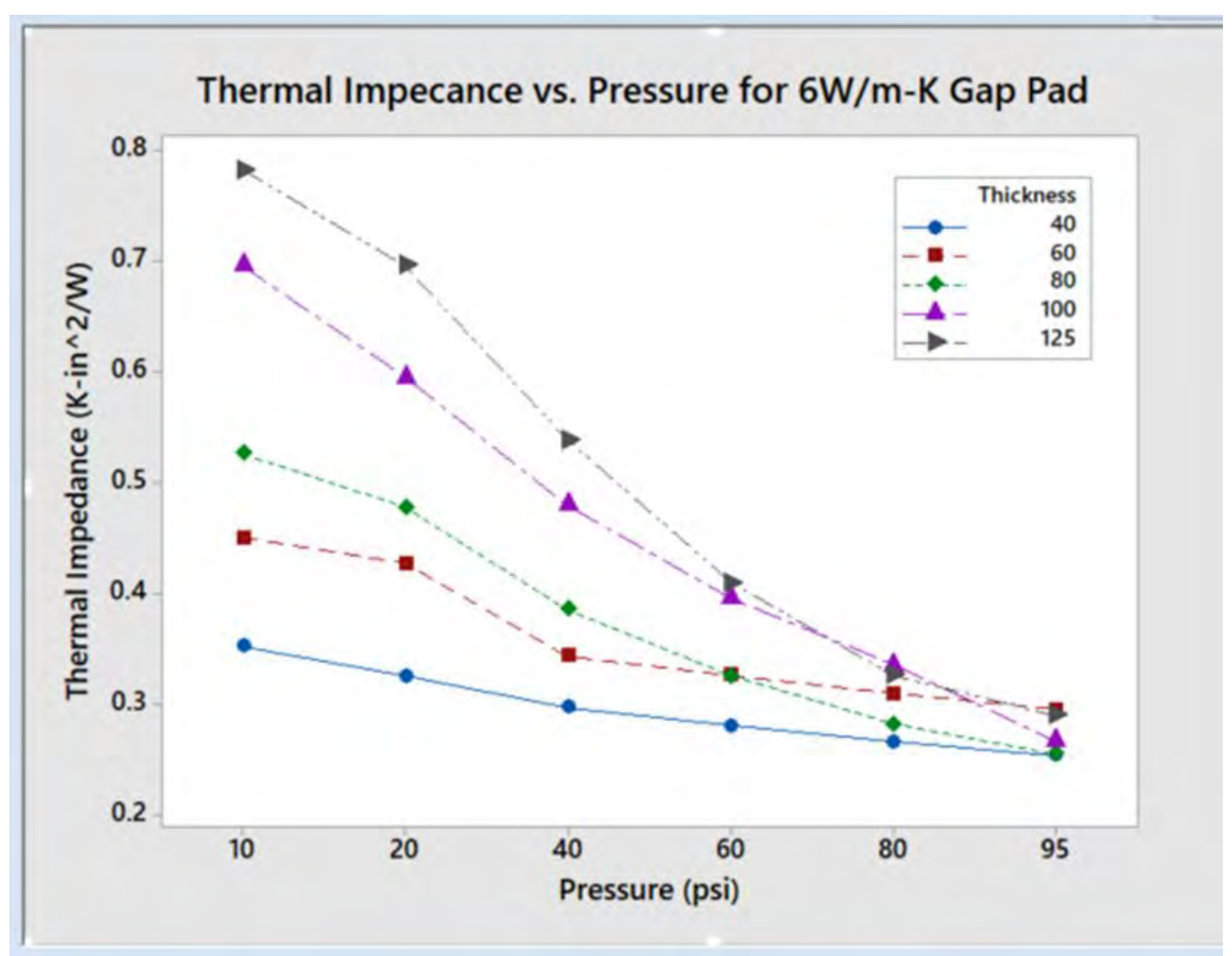


Figure 10. Effect of pressure on thermal impedance.

Summary and Conclusion

The primary objective of this study was to provide the end-user of thermal interface materials a

means to select, evaluate and implement a thermal solution for their applications above and beyond the review of a published technical data sheet (TDS). The traditional approach of focusing on the TC of a TIM is no longer sufficient to meet today's stringent requirements of high-performing electronics. A better approach is to evaluate the thermal performance of a TIM – taking into account bulk thermal conductivity, the TIM's ability to wet out the contact surfaces and bond line thickness.

Results from this study clearly demonstrate the bond line thickness effect on the overall thermal performance. Figures 6 and 7 show that regardless of the TIM type, pad or gel, thinner bond line provides lower impedance and higher effective thermal conductivity.

This study further demonstrates that by mechanically pushing the air out of the interface, thermal performance can be improved. The practical aspect of this strategy must be considered, however. Most gap pads cannot be compressed more than 40-50% of the original thickness. This is demonstrated in Figure 8 where excess force destroys the sample. This will create high risk in real applications.

Acknowledgments

I would like to express my sincere gratitude to David Franco, Peter Jones and John Prindl from Henkel for conducting all laboratory tests and providing insight to the test equipment and methods. Without their support, this work would not have been possible.

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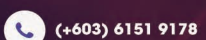
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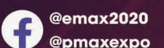
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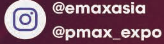
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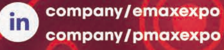
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The Visual Factory and Legacy Equipment and Processes

MES upgrades capture kanban inventory levels, allowing electronic replenishment pulls.

THE VISUAL FACTORY has come a long way since the concept was introduced, moving from production status viewable by walking the factory floor to a comprehensive collection of real-time data viewable from any interconnected computer. That evolution isn't seamless for many electronics manufacturing services (EMS) providers, however. While newer equipment platforms are designed to integrate with manufacturing execution systems (MES) easily, legacy equipment platforms may require specialized programming or other workarounds to achieve desired interoperability. Equipment communication incompatibilities often lead to multiple shop floor control systems being utilized among work areas, which is inherently inefficient.

SigmaTron International's Chihuahua, Mexico, facility recently dealt with these issues when the facility began transitioning to the company's proprietary Tango MES. The company's corporate IT and operations teams have worked together to define enhanced shop floor capabilities in production and are upgrading system capabilities across facilities. The challenge for facilities implementing the latest enhancements is creating efficient equipment interfaces and integrating or replacing legacy processes.

The team started planning the transition in October 2022. One of the first issues identified involved bar code scans. The equipment and the MES each required a scan and that was slowing changeover time. The team was able to resolve the issue and create a single-scan process for its newest SMT

equipment platform after discussing the issue with the equipment manufacturer. The company is standardizing on an SMT platform that integrates with the MES easily via an API and a software tool development kit. The facility also has legacy equipment that doesn't integrate well, however, and that requires a platform-by-platform reverse engineering effort. In the case of older equipment with no software interfaces for interoperability, local programmers may be hired to create the interface.

The goal once the MES is fully integrated with all equipment platforms is to have one system capable of providing traceability at the lot, unit and component level accessible from any computer that integrates shop floor control and includes enforced routing. The MES will also enable the team to view what is being produced and what inventory is in place in every step of the process from their desktop computer or a tablet.

Incoming quality control (IQC) labels materials as they are received and then associates that bar code with each printed circuit board assembly (PCBA). SMT machines verify correct feeder/table loading based on material bar code information compared to programming data, and the enhancements integrate this activity with the MES.

Following full implementation, production lines will transition from use of physical kanban cards to electronic kanban cards based on shop orders. Monitors mounted in each production area will show what is planned for production that day. Finished unit count versus daily goals are also visible on monitors on the production floor.

The facility does both PCBA and higher-level assembly (HLA) work. There are no dedicated PCBA production lines so work can be moved among lines based on available capacity. PCBA production goes into a supermarket kanban. As PCBAs are pulled from the supermarket to support HLA demand, replenishment orders go back to SMT or through-hole lines to restock the supermarket. Currently, the supermarket uses a manual visual system of physical kanban cards and works on a first in, first out (FIFO) inventory management philosophy. Personnel need to visit the area to see what is in it. Once the MES is fully implemented, kanban inventory levels will be visible in the system and replenishment pulls will be done electronically. Since the information associated with each assembly includes date manufactured, FIFO discipline will be easier to maintain.

The system will also be used in continuous improvement efforts. The facility tracks the cycle time of

each product and sets targets for improvement every five to seven months.

The ME implementation in the SMT area is scheduled to be completed in the third quarter this year.

The primary benefit of a holistic approach to automating the visible factory is the ability to have critical data where it is needed, when it is needed for appropriate management decision making at all levels of the organization. A secondary benefit is that it forces operations personnel to look at the current state of the factory floor and streamline the system and process workarounds that pop up over time due to equipment and system interoperability incompatibilities. While this automation process takes time to implement, the result is greater efficiency and better ability to address variations in demand or component availability. On a positive note, newer manufacturing equipment platforms take this need for interoperability into account, so achieving this goal will become easier over time.

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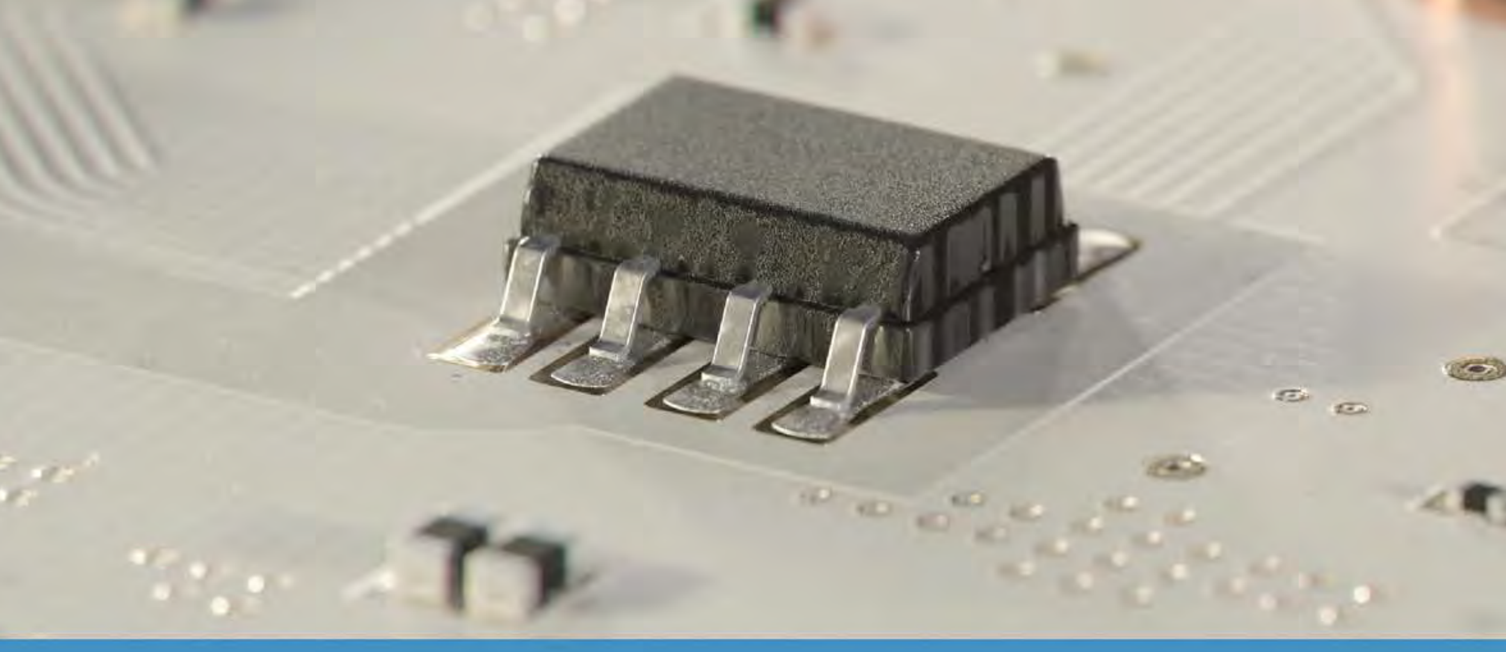

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SEEING **IS BELIEVING**

Courtship of a Tech Bro

Bluster, manipulation and gaslighting – all in a week's work.

"… 90 PERCENT OF the startups founded by dweeby young men in San Francisco are simply trying to answer the question: 'What things isn't my mom doing for me any more?' Creating a frictionless future seems to mean launching speedy meal delivery, dog walking, and laundry apps. 'There is a tendency in Silicon Valley to want to be revolutionary without, you know, revolutionizing everything …' Too many moonshots are still sputtering on the launch pad. It is not yet clear that innovations such as social media, cryptocurrencies, or the metaverse yet represent any net positive for humanity. As skeptical economists never tire of pointing out, the digital revolution has so far had little quantifiable effect in lifting productivity."

– John Thornhill, *Financial Times*

"Money talks, but it doesn't tell the truth."

"Time heals all wounds, right up to the moment that it kills you."

– Herbie Cohen

And still they come.

"I'm sending you a sample of our high-resolution webcam for scanning. An MOV file, showing a previous scan of a down-rev unit, is attached for reference."

OK. Got it. Reviewed your MOV. We can do that.

The courtship started with such promise. Those were idyllic days, one week ago.

So, you would like us to do a complete scan of this camera, correct? Just scan and provide images for your use/analysis?

"Exactly. Having a scale reference in the video sweep will be helpful. I am actually mainly trying to gauge pricing for future needs. Trying to find a local partner. If we sweep in X, Y and Z for the video outputs – that would be most ideal."

And actually mainly not relying on proper spelling and grammar to convey your message. Genius feels no need to apologize.

How did you find us?

"(———-) from (———) recommended you – the consumer electronics/product design community is pretty small 🙂Random question – do you have expertise in testing USB 3.1 cables for signal integrity?"

Your camera arrived yesterday. Cost to scan it and provide an MOV file: $1500 lot charge. Give us a PO and we'll get started.

"Cost is okay. Is this what we would expect in the future per item scanned? Full transparency, I am trying to decide if to rent [sic] an on-site CT from (———) or go with outsourcing for this year's development. What would be the typical turnaround time for future scans? Is one day turn from receipt reasonable? Last, is it possible to work through credit card payments? Makes it much easier than sending over a PO."

Cost is dependent upon many factors: part size, quantity, resolution, magnification, area/region of interest, deliverables needed, etc. Our typical quoted turnaround time is five to 10 working days. Faster turnarounds are often possible, with prior scheduling. In your case, we should be able to scan the camera this week.

We will accept credit card payment for this first project. Please call us on Monday to give us your credit card information, which we will destroy (shred) at the conclusion of the project. Longer term, our preference would be to set you up on account and operate using purchase orders.

Do we have your corporate address? If not, can you please send it, so we can set you up this week in our ERP system?

“Completely understand about the cost dependency. However, our scan requests will always be the size and complexity of this job – we should be predictable. To be honest, five days is steep for us, typically the scans will be the gating element during time-critical manufacturing situations. I imagine it is hard to make guarantees and it depends on work loading. However, I would love to get an understanding of faster turnaround and if expedited pricing applies. Corporate address is: (———). Let’s get an account set up – please let me know what other information you will need.”

Call me jaded, but when someone asks me to “get an understanding” of something we’ve clearly explained, my thoughts are that they are really trying persuasion: leveraging the promise of future business so that we do things their way. This is akin to someone saying, “I’m confused,” as a rhetorical trick, when in fact they aren’t confused at all, only manipulative. We know their kind.

Next business day, apparent triumph:

You can download the videos using the link below. Will send password separately. The link will expire after five clicks or seven days. Scan data, free viewer, and images are provided on a USB drive shipping with the unit.

See previous email. Job was done Tuesday and is now ready to pick up, call me or let me know the best (time) I can call you for credit card information.

Guy is anxious. Doing our utmost to quell his anxiety. Results usually do that. One-day turnaround, on our own initiative. Sometimes we do this for promising customers, to show we’re listening, and we’re flexible. You’d think he’d be happy. You’d be wrong.

“What happened after our phone conversation last week where I asked you to hold the job? Mainly because the quoted lead time was not competitive.”

Hold the job? Lead time not competitive? Then why did you ship your part to us for inspection? We obliterated the quoted lead time, yet we’re the Bad Guys? Methinks the young man doth want his cake and eat it too. One begins to suspect the existence of parallel projects going on behind the

dialogue, except that someone lost track of the timing. Not unlike dating two people in separate booths at opposite ends of the same five-course restaurant, with reservation times slightly out of sync (main course at one, dessert at the other). A stealthy Darwinian approach to business (survival of the fastest). What to do when the script is abandoned, he gets caught, and his bluff is called? Regroup and fall back on the tried-and-tested method of scoundrels everywhere: double down and bluster your way through, in the hope that intimidation changes the subject. Imaging for failure analysis and inspection is a pattern recognition business, and this familiar pattern is becoming depressingly recognizable.

The job is done. We did it in two days. We discussed early on that expedites were possible, long before you had any conversation with our Customer Service Manager. So we helped you out and took the liberty of getting you the images you requested. Please send credit card information.

"Sorry Robert that is wrong. I spoke to him last week (before you ever got to process this project) over the phone when he called to collect credit card payment. Please discuss internally."

We know gaslighting when we see it.

Sorry, that is wrong. Our Customer Service Manager has no recollection of any request from you to put anything on hold. Our people proceeded with your scanning project in good faith, to help you, with my approval. You made your urgency clear, and we did our best to respond and support. As a new customer, it was in our interest, and yours, to assume some risk and get this done. So, we did. I have no need to discuss internally. The time for discussion is over. Please provide credit card information.

"Can you explain why I did not give him the credit card information last week over the phone? We are not paying for a miscommunication."

I don't know, there are lots of reasons to withhold credit card information. General busyness. One's secretive nature. Nuclear annihilation distracted you. A lot can happen in a day. Life calls, and time is limited. You're a busy guy doing important work. Like running parallel jobs with two competitors, in the hope one will finish first, and the aftermath can be sorted out or dismissed as insignificant or attributed to simple confusion. We tried to help (ungrateful wretch). Do we deserve this?

Come to think of it, maybe you should pay for miscommunication. You are wasting our time, using fraudulent means, and time is money. Time to be an adult (if you can).

You tell me. Apparently, you believe you have a divine right to free services as well. Please return the images we sent you, since you refuse to pay for them. Nice try.

From speed dating to fully detonated bridge in days, start to finish, including a weekend. Hearts aflutter to acrimony in little more than a week. Thanks for nothing.

He never returned the images. But we have his camera.

An efficiency-minded business school professor examining this dialogue as a case study for MBA students might conclude that the whole affair was enacted, and dispatched (in its way), in timely fashion. The client revealed himself and, following short bursts of vituperation, both parties sullenly moved on, resolved to do business elsewhere, with minimal collateral damage done. One more ring added to the Tree of Experience.

Good call, Professor.

Woe betides the next customer fitting the same description, with similar requirements, and similar urgency, as this story documents. Technological innovation is an iterative process. So is sales and service.

What is the sound of mental notes being filed away in an accessible spot?

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

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ALTAIR SIMULATION 2022.3 SOFTWARE

Simulation 2022.3 brings updates that focus on cloud collaboration and computing, end-to-end simulation workflows, and design creation with AI-powered simulation. New features include updates to Altair One that eliminate data silos, IT constraints and access barriers, as well as new seamless digital thread workflows that connect Altair One and Altair HyperWorks for previewing and modifying models, tracking data, accessing online libraries, and more. New features also include efficient end-to-end simulation workflows to Altair HyperMesh, Altair Inspire and Altair SimLab. Enables users to utilize Inspire Fluids to create, modify, and change part and assembly shapes that meet hydraulic design objectives, and Inspire now supports the Linux user interface and offers a new set of geometry creation tools. Also includes electronic system design improvements that give users the power to perform battery module modeling and thermal analysis of complex electronic systems with greater efficiency. AI-powered simulation also enables users to better capture expert decision-making for improved design-of-experiments outcomes, and expanded integration for creating general links among variables of any type and create responses from external file types.

Altair

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ALTIUM 365 GOVCLOUD STORAGE

Altium 365 GovCloud offers organizations the features and advantages of the Altium 365 cloud platform, along with additional security measures customized for highly regulated industries. Can

help organizations manage regulated product development, meet flow-down requirements as contractors and suppliers, maintain strict control over access to their IP, and reduce IT overhead while meeting regulatory requirements such as ITAR and EAR. Features the ability to prevent unauthorized outbound traffic from leaving the environment using an outbound proxy, disables sharing outside of the workspace, prevents users from storing any data in their Altium 365 Personal spaces, and blocks connections to third-party PLM systems. Also features the ability to allow inbound access to the workspace only for authorized IP addresses, plus blocks access to the workspace from outside the US.

Altium

altium.com

ELSYCA PCBBALANCE V2.1 DFM TOOL

PCBBalance v2.1 DfM software now features additional color plot visualization options for Plot Key Performance Indicator values per PCB product on the panel, including standard deviation, CPK, and fraction of surface within specifications. Allows adjustment of copper balancing position by defining small shifts in (X,Y) directions upon export; plus the ability to define zones that are to be excluded from copper balancing, using either a Gerber input file containing the outline of the no-go zones or using a Gerber input file containing a full image of these zones. Other new features include the import of predefined plating process and balancing parameter sets (recipes) from a custom directory and the ability to save new recipes to a custom directory, the ability to manually select plate boxes from library or automatically select them based on panel size, and the ability to decouple front and back side image balancing parameters to permit optimal copper balancing pattern on both sides. Also features an upgraded simulation algorithm that provides a more accurate prediction of the copper deposit thickness in and around HDI areas to account for high local copper density fractions during the copper plating processes.

Elsyca

elsyca.com

INSTADEEP DEEPPCB AI

DeepPCB AI performs fully automated routing for printed circuit boards of up to 150 pairs and two layers. All solved boards under design rule checks and are fully compatible with KiCad. Users upload .dsn files to cloud platform, and results are provided in 24 hr. Leverages novel AI technology combined with powerful GPUs and cloud infrastructure to offer the first pure AI PCB routing engine. Automation relies on reinforcement learning (RL), an AI technology particularly suited for decision-making problems. Users can see how the AI system progressively increases the quality of its routing as it learns to solve the user's board.

InstaDeep

deeppcb.ai

OKI ELECTRIC CABLE ENVIRONMENT-PROOF FPCS

Environment-proof FPC (flexible printed circuit) products are designed for use under harsh conditions, including conditions found in high-temperature and high-pressure steam environments. Heat-proof FPC features proprietary surface treatment on copper foil to improve adhesion to the insulating layer. High-pressure steam-proof FPC incorporates silicone resin into the insulating layer to improve resistance to high-pressure steam. Is said to maintain insulation layer adhesion after exposure to high-temperature heat treatment at 200°C for 1,000 hr. (for heat-proof FPC) and after high-pressure steam treatment at 132°C and 0.2MPa for 15 min. through 250 cycles (for high-pressure steam-proof FPC). Both meet all JPCA-UB01 requirements for insulation resistance and other electrical characteristics.

OKI Electric Cable

oki.com

ROHM N-CHANNEL MOSFETS

RS6xxxxBx and RH6xxxxBx series of N-channel Mosfets are suitable for applications operating on

24V/36V/48V power supplies, such as base stations, servers, and motors for industrial and consumer equipment. Achieve $R_{DS(on)}$ of 2.1mΩ – approximately 50% lower than conventional Mosfets – by increasing device performance and adopting the HSOP8/HSMT8 package featuring low-resistance copper clip connections. Also features improved element gate structure that reduces Q_{gd} approximately 40% versus conventional products. Achieve efficiency of approximately 95% (peak) in the output current range during steady-state operation.

Rohm Semiconductor

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STACKPOLE RNCL RESISTORS

RNCL thin-film high power anti-surge chip resistors provide high power ratings per chip size with resistance values down to 50mΩ. Provide high precision and stability with tolerances down to 0.5% and TCR of 50 and 100ppm. Show very low resistance shift of less than 1% under IEC industry standard tests for short time overload, load life and biased humidity. Also has significantly higher pulse handling than typical thin-film chip resistors due to proprietary materials and design.

Stackpole Electronics

seielect.com

TOYOCHEM LIOTELAN SHIELDING FILMS

Liotelan line of highly flexible conductive and insulating sheet films are designed for protecting electrical and electronic equipment. Exhibit high water-resistance and are highly flexible with a high elongation of 500%. Can be hot-press molded on to the EMI noise source on the printed circuit board to form a lightweight multilayer shield with a more compact format than a metal shielding – for creating electronics devices of lower profiles and lighter weights without compromising shielding effectiveness. Potential applications are wearable devices, wireless communications and other smart devices.

Toyochem

toyo-chem.com

VISHAY VOMDA1271 MOSFET DRIVER

VOMDA1271 automotive grade photovoltaic Mosfet driver is designed to deliver high performance for automotive applications. Features integrated turn-off circuit that enables a turn-off time of 0.7ms typical, the fastest for a Mosfet driver in the compact SOP-4 footprint. Also provides a turn-on time of 0.05ms, and is said to be the only driver in this package size to offer an isolation voltage of 3750V and a typical open circuit output voltage of 8.5V. Is intended for use in pre-charge circuits,

wall chargers, and battery management systems for electric and hybrid electric vehicles. Features an AlGaAs infrared LED (IRLED), which emits light that is absorbed by a photovoltaic gate array to turn on a Mosfet and simplifies designs and lowers costs by eliminating the need for an external power supply. Can be driven by a microcontroller's GPIO pin, and is RoHS-compliant, halogen-free, and Vishay Green.

Vishay Intertechnology

vishay.com

CA

CIRCUITMEDIC 201-7100 REWORK TOOL SET

201-7100 Precision Surface Mount Rework Tool Set includes nine finely crafted tools for precision repairs on circuit board assemblies. Crafted to meet the demands of modern electronics, this toolset is designed to help perform intricate repairs, ensuring the longevity and optimal performance of electronic devices. Caters to every aspect of circuit board repair, rework, and assembly. Are built to withstand rigorous use in demanding environments. Comes with a specially designed metal mesh storage tray for easy access, organization and portability.

CircuitMedic

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HENKEL BERGQUIST HI FLOW THF 5000UT TIM

Bergquist Hi Flow THF 5000UT phase change film TIM permits low mechanical pressure to achieve thorough wet out and an ultra-thin bond line at the interface. Is for challenging package designs with complex architectures, such as lidless multi-chip devices used in high-performance compute and industrial applications. Demonstrates low thermal impedance across various bond line

thicknesses at both ultra-low and higher pressure (0.04°C-cm^2/W at 35psi, 0.06°C-cm^2/W at <10psi), delivers excellent reliability as evaluated up to 150°C, and achieves thermal conductivity up to8.5W/m-K. Provides heat sink suppliers with no-mess, easy application and integrators with simple final assembly, and film medium – as opposed to liquid materials – permits application before shipment. Does not require pre-burn before use.

Henkel

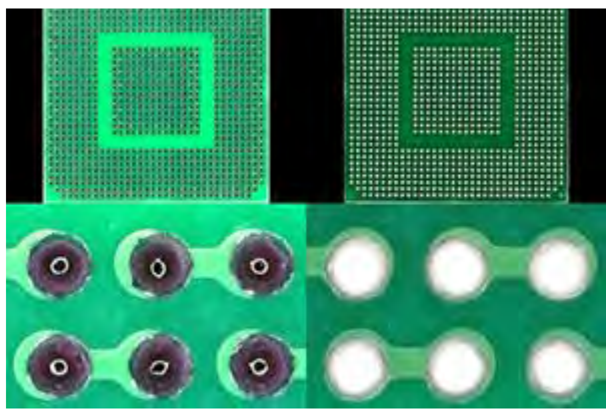
henkel.com

METCAL CV-IOT GATEWAY MODULE

CV-IOT Gateway Module and desktop application enables operations management to collect advanced soldering data from every benchtop station on their network. Allows utilization of information on every joint to improve process control and efficiency in the soldering process, and a standard handheld barcode scanner can be added to the setup for board-level traceability. Desktop application can be used to analyze data collected by the system to evaluate operator efficiency, quality of solder joints, temperature and power profiles, and the cartridges used (including geometries, part numbers, serial numbers, and lot codes) for each soldering process. Can set up alerts to notify managers in real time when processes are not being followed or when there is a concern with a soldering station. Stores information in standard database structure, and plugs directly into the CV unit and the computer or network only through a wired connection to ensure data security. Compatible with all Metcal Connection Validation soldering systems.

Metcal

metcal.com

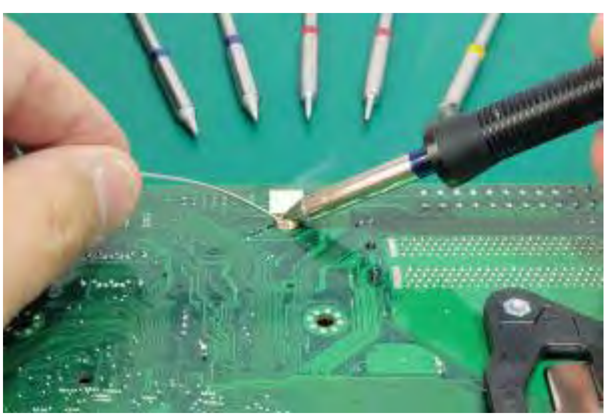


SHENMAO SMBF-08 BGA FLUX

SMBF-08 visible no-clean BGA flux is for SMT assembly and BGA ball mount processes. Visible black coloration allows easy identification and evaluation during AOI, and is halogen-free (ROL0) and fully compliant with RoHS, RoHS 2.0, and REACH regulations. Is said to be suitable for various processes, including stencil printing, dipping and pin-transfer methods. Its printability, wettability and solderability make it highly effective for a wide range of IC packages, including system-in-package (SiP), wafer-level- package (WLP), and flip chip technologies.

Shenmao

shenmao.com



THERMALTRONICS M SERIES – POWER PLUS SOLDERING CARTRIDGES

M Series – Power Plus soldering cartridges are designed to address demanding soldering applications without upgrading to other premium handles. Developed specifically for heavy-duty soldering jobs, offering exceptional performance and extended tip life. Is said to incorporate a larger copper mass and additional plating to deliver superior soldering performance and durability. Allows TMT-9000S soldering system users to achieve results without increasing tip temperature. Have a range of options, boasting more than 30 different styles so users can find the cartridge to suit specific application requirements.

Thermaltronics USA

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VISION ENGINEERING MANTIS MICROSCOPE

Mantis Stereo Microscope features the latest developments in optics, digital cameras, and fully adjustable LED lighting. Includes improved optics for both hand-to-eye coordination and depth perception, a three-position turret to house up to three objectives ranging from 3x to 15x, the introduction of an 8x super long working distance lens, five different illumination options providing flexibility to optimize the lighting to view the perfect image, and an improved, higher resolution camera for image and video capture. Also features an option to switch between white light and UV light using a toggle switch. Designed with eyepiece-less technology that delivers a large, high-quality optical stereo image, making it more comfortable and easier to view than traditional microscopes, and comes with a range of new stand options and accessories for flexibility, stability and a reduced footprint on the workstation.

Vision Engineering

visioneng.us

YAMAHA MOTOR YRP10 PRINTER

YRP10 stencil printer achieves high-speed, high-precision solder printing, fully automated setup changeovers, and supports dual-lane production. Features excellent rigidity, a 3S head with new squeegee, and a stencil vacuum mechanism. Automates setup changeovers, such as automatic push-up pins and stencil replacement, which greatly reduces labor and human error when changing out products. Dual-lane specification that enables completely independent operation for each lane can also be selected to flexibly support a wide variety of types of production.

Yamaha Motor

yamaha-motor-robotics.eu

In Case You Missed It

Nanoprinting

"An All-in-One Nanoprinting Approach for the Synthesis of a Nanofilm Library for Unclonable Anti-Counterfeiting Applications"

Authors: Junfang Zhang, *et. al.*

Abstract: Current materials for anti-counterfeiting labeling typically contain toxic inorganic quantum dots and the techniques to produce unclonable patterns require tedious fabrication or complex readout methods. Here the authors present a nanoprinting-assisted flash synthesis approach that generates fluorescent nanofilms with physical unclonable function micropatterns in milliseconds. This all-in-one approach yields quenching-resistant carbon dots in solid films, directly from simple monosaccharides. Moreover, the authors establish a nanofilm library comprising 1,920 experiments, offering conditions for various optical properties and microstructures. The authors produce 100 individual physical unclonable function patterns exhibiting near-ideal bit uniformity (0.492±0.018), high uniqueness (0.498±0.021) and excellent reliability (>93%). These unclonable patterns can be quickly and independently read out by fluorescence and topography scanning, greatly improving their security. An open-source deep-learning model guarantees precise authentication, even if patterns are challenged with different resolutions or devices. (*Nature Nanotechnology,* June 2023, https://doi.org/10.1038/s41565-023-01405-3)

Solder Joint Reliability

"Mechanical Characterization of SAC305 and SnPb36Ag2 BGA Assemblies Under Static Flexural

Loading"

Authors: Jean Baptiste Libot, Olivier Dalverny, Joël Alexis and Jeremy Bosq

Abstract: Static bending-induced solder joints damage is a main reliability concern for aerospace and military industries whose printed circuit board assemblies (PCBAs) are required to remain functional under flexural loading. To dissipate heat in equipment, it is common to install thermal gap pads on electronic packages. When compressing thermal gap pads during the fixture process, the PCBA can bend and solder joints can therefore crack if the deflection is too much. This paper reports the durability of 96.5Sn-3.0Ag-0.5Cu (SAC 305) and 62Sn-36Pb-2Ag (SnPb36Ag2) ball grid array (BGA) assemblies under static flexural loading at -55°C, 20°C and 125°C. As electronics equipment can be stored at high temperature for prolonged durations, some SAC 305 test vehicles were also aged at 125°C for 192hr. For each test configuration, the bending tests were conducted at a ramp-rate of 2mm/min and the central displacement-to-failure was measured. Finite element modeling (FEM) analysis was conducted considering a global-local approach, and the transfer function between the central displacement-to-failure and the local PCB strain near the critical solder joints were determined for each test configuration. The results give the necessary data for designers to assess whether a specific PCBA design subjected to static bending is at risk. (*Journal of Surface Mount Technology,* vol. 36, no. 1, March 2023; https://journal.smta.org/index.php/smt/article/view/34)

Thermal Management

"Enhanced Thermal Conductivity of Nanodiamond Nanosheets/Polymer Nanofiber Composite Films by Uniaxial and Coaxial Electrospinning: Implications for Thermal Management of Nanodevices"

Authors: Zhouqiao Wei, *et al.*

Abstract: Smaller and smarter electronics have revolutionized many aspects of life, from communication to medicine. But shrinking sizes mean these devices concentrate heat in smaller areas, which can cause lagging computing speeds and even force devices to completely shut down unexpectedly to prevent damage. To dissipate this heat, researchers are turning to nanocomposite materials that contain a flexible polymer and thermally conductive filler. A simple way to make

nanocomposites is by electrospinning, in which a solution of polymer and filler is jetted out of a syringe through an electrically charged nozzle, forming fibers that build up into a thin film. While simple, electrospinning from a single solution, or uniaxial electrospinning, makes it difficult to control the material's properties. The authors used a two-solution technique, called coaxial electrospinning, to better control the fiber design and improve heat dissipation of a new nanocomposite. The researchers chose polyvinyl alcohol and a separate solution with the thermally conductive filler, a nanodiamond material, to produce the new nanocomposite. By fitting a syringe of each solution onto a nozzle that combined the two, the researchers made fibers with a polyvinyl alcohol core and nanodiamond coating, rather than a random distribution of the two components. The researchers say the coated fibers act as a "highway" to direct heat, like traffic, along and across the fibers throughout the film. In tests, the new materials dissipated heat better than those made with the traditional nozzle and were four times as thermally conductive as previously reported nanocomposites. (*ACS Applied Nano Materials,* May 17, 2023; https://pubs.acs.org/doi/10.1021/acsanm.3c00591)

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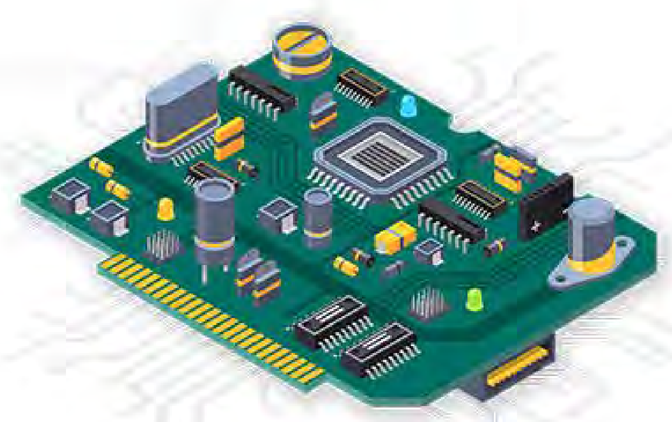

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