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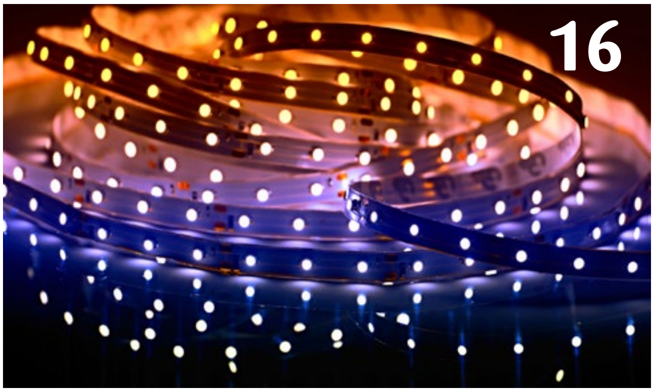
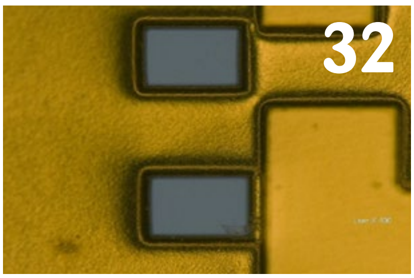
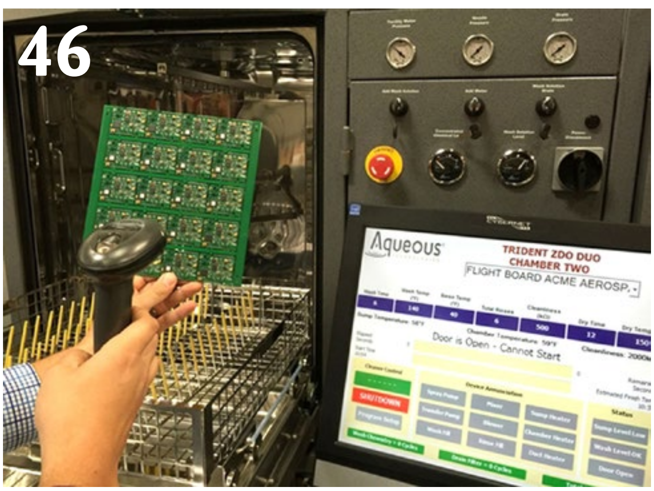
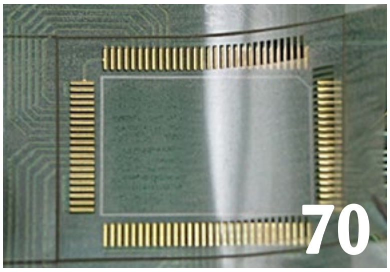


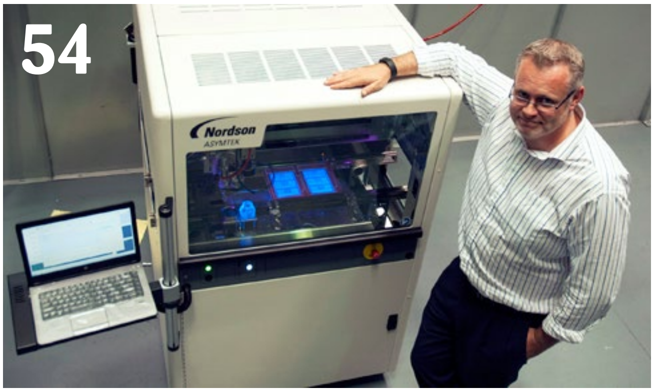


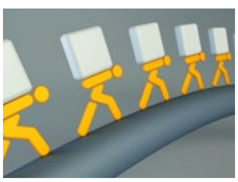


What's New?

This issue of *SMT Magazine* features the latest technology and process developments happening in the SMT, PCB assembly and EMS industries, and what to expect in the future.







DEPARTMENTS

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SHORTS

New Paradigms

by Stephen Las Marias
I-CONNECT007

The year 2015 saw many technology milestones reached and challenges overcome as R&D became more cutting edge. From high-performance sensors to 3D printing, automotive electronics, wearables, virtual reality and robotics, innovations abound in all technology sectors, helping improve almost every facet of our lives. Last month's CES 2016 exhibition showcased these latest and emerging technologies, and provided a glimpse of how the future will look.

In its recent whitepaper, market analyst IHS listed key technology segments to watch out for this year, which it expects will bring the global technology industry to even greater heights in 2016. Among these sectors are thinner, lighter and more flexible displays; ultrasonic sensors; data mining and predictive analytics; medical technology; connected home; automotive intelligence; and solar power.

While all of these developments bode well for the electronics manufacturing industry, they also offer many challenges in terms of the way they are being manufactured. The trend toward smaller, lighter, faster, lower-power and cheaper devices continues to put a strain on equipment and production processes, and remains top priority for electronics designers and manufacturers.

This leads me to this issue of *SMT Magazine,* which features "what's new" in the electronics manufacturing and assembly industry from a business and technology standpoint. For starters, Ravi M. Bhatkal, Ph.D., of Alpha Assembly Solutions writes about the growth of the LED lighting industry, driven by rapid technologi-

cal advances, simultaneous cost reductions and scale of manufacturing in LED packaging and systems integration technologies, as well as the key issues that need to be addressed by the LED lighting supply chain. He highlights the new developments in interconnects, in particular, high-reliability interconnects, to support the ever-growing application of LED lighting.

Frederick Blancas of Integrated Micro-Electronics Inc., meanwhile, writes about the technology market trends and developments that will help determine the direction for the EMS industry. He also discusses some of the technology innovations done by EMS firms themselves to help propel electronics assembly forward.

For this issue, we also asked our editorial advisory board, which is composed of experts from the different segments of the electronics manufacturing industry, what they think will be "new" in their respective industries for this year.

Dr. Jennie Hwang, one of our regular SMT Magazine columnists, writes about her outlook on the electronics hardware industry, and specifically, what will drive growth product development strategies. She also highlights the role of advanced materials and advanced manufacturing such as 3D printing, and how new developments in intelligent robot technology will help provide synergistic performance in the manufacturing industry.

The continuing development in wireless technologies such as mobile phones, wireless infrastructure and wireless LANs is driving the need for mixed technology packages in RF chips. William Coleman of Photo Stencil explains a two-print stencil printing procedure needed in mixed technology packages that have both flip chip and surface mount devices on the same substrate.

"Made in the U.S.A." is hot again in many industries. According to the Reshoring Initiative, 60,000 manufacturing jobs were added in the U.S. in 2014, up by 400% from just 12,000 in 2013. Meanwhile, 31% of respondents to the Boston Consulting Group's fourth annual survey of senior U.S.-based manufacturing executives at companies with at least $1 billion in annual revenues said that their companies are most likely to add production capacity in the U.S. within five years for goods sold in the U.S. The report added that the share of executives saying that their companies are actively reshoring production increased by 9% since 2014 and by about 250% since 2012.

Focusing on this increasing trend, industry veteran Gary Tanel, who recently joined McDonald Technologies, tackles the challenges and opportunities for smaller EMS when it comes to onshoring, as OEMs are increasingly looking for suppliers that are closer and smaller.

I also interviewed Craig Hunter of Vishay Intertechnology Inc. about the significant changes in the electronics manufacturing industry during the past decade, the persistent challenges, and new technologies that will provide opportunities and growth. He said that the growth of mobility, sustainability and connectivity will be major drivers for the future, while power efficiency, energy density and size/weight ratios will drive business and provide new solutions and markets.

For his part, Mike Konrad of Aqueous Technologies writes about the latest developments in the electronic assembly cleaning industry, and his company's efforts to reduce the footprint of cleaning through the design of equipment that uses less water, less electricity, less chemicals, less discharge, and less time than other processes.

Dr. S. Manian Ramkumar, professor and director of the Center for Electronics Manufacturing and Assembly, Manufacturing and Mechanical Engineering Technology and Packaging Science at the Rochester Institute of Technology, details new drop-in anisotropic conductive adhesive replacements for lead-based and lead-free solder assemblies.

Meanwhile, our technical editor Pete Starkey toured Electrolube's UK headquarters in the historic Leicestershire town of Ashby-de-la-Zouch. You can read his write-up about his visit, and what is driving product development at the company.

Also inside, the second part of *The PCB Magazine* Editor Patty Goldman's interview with Tom Borkes, founder of The Jefferson Project and the forthcoming Jefferson Institute of Technology. In the concluding part of their discussion, Tom describes another important tool in reducing labor cost through reducing labor content: designing for automation.

Another interview is that of I-Connect007 publisher Barry Matties, who spoke with Mentor Graphics Valor Division's Dan Hoz and Ofer Lavi Ben David to discuss where Industry 4.0 is taking the industry, and the changes it will bring to both large and small companies, customers, and the supply chain. They also discussed how Mentor connects different machines on the shop floor to provide universal Industry 4.0 visibility.

Finally, our columnist Bob Wettermann writes about paste printing solder paste in a select location in order to rework complex devices to duplicate the original manufacturing process as closely as possible. He also gives a preview of a soon-to-be-reported study, which compares the older miniature metal stencil printing process to the more modern plastic film with adhesive approach, and quantifies the differences in performance between the two for the first time.

I hope you enjoy this month's issue of *SMT Magazine*. We are always on the lookout for article contributions as well as columns—so if you're interested, feel free to drop me a note.

Next month, we'll discuss strategies that electronics assemblers are adopting to increase their profits and improve their yields. Stay tuned! **SMT**

Stephen Las Marias is managing editor of *SMT Magazine.* He has been a technology editor for more than 12 years covering electronics, components, and industrial automation systems.

Bridging the Bioelectronic Divide

A new DARPA program, the Neural Engineering System Design (NESD), aims to develop an implantable neural interface able to provide unprecedented signal resolution and data-transfer bandwidth between the human brain and the digital world. The interface would serve as a translator, converting between the electrochemical language used by neurons in the brain and the ones and zeros that constitute the language of information technology. The goal is to achieve this communications link in a biocompatible device no larger than one cubic centimeter in size.

NESD stands to dramatically enhance research capabilities in neurotechnology and provide a foundation for new therapies. Among its potential applications are devices that could compensate for deficits in sight or hearing by feeding digital auditory or visual information into the brain at a resolution and experiential quality far higher than is possible with current technology.

Achieving the program's ambitious goals will require integrated breakthroughs across numerous disciplines including neuroscience, synthetic biology, low-power electronics, photonics, medical device packaging and manufacturing, systems engineering, and clinical testing. In addition, NESD researchers will be required to develop advanced mathematical and neuro-computation techniques to first transcode high-definition sensory information between electronic and cortical neuron representations and then compress and represent those data with minimal loss of fidelity and functionality.

To accelerate that integrative process, the program aims to recruit a diverse roster of leading industry stakeholders willing to offer state-of-the-art prototyping and manufacturing services and intellectual property to NESD researchers on a precompetitive basis. In later phases of the program, these partners could help transition the resulting technologies into research and commercial application spaces.

New Year Outlook: Electronics Hardware

by Dr. Jennie S. Hwang
H-TECHNOLOGIES GROUP

Five words should capture the essence of electronics hardware going forward: smartness, mobility, connectivity, wearability and innovation.

Thanks to all the innovators! In 2016, electronics will move to a higher level of wearability, connectivity and mobility for IoT applications. This thrust will offer "cooler" products to consumers as well as high-efficiency to businesses, propelling "mobility" to "wearable mobility with connectivity and intelligence." The level of coolness has a lot to do with the ease and convenience of wearability (e.g., the wearable time before recharging the battery). The ability to synchronize the battery technology with the usefulness of electronics will "move and shake" the industry.

The growth and volume of electronics hardware will be driven by mobile devices. High-reliability and high-performance electronics demand new material innovation and better process deployment.

Advanced materials that offer unique properties, be it a polymer, metal or ceramic, to deliver revolutionary performance using layer-by-layer assembly as a versatile bottom-up nanofabrication technique will move forward. This advancement of tuning the materials at the atomic scale in conjunction with multi-scale modeling enables the design of the target material properties, opening breakthrough probability and rewarding application and business opportunities.

Manufacturing, aiming at productivity, will adopt higher levels of lean and modular design, agility, and intelligent automation. Advanced manufacturing including 3D printing will not go unnoticed. In this regard, further technology development will materialize. In addition, increasing number of products/components/parts manufactured by using 3D printing will be rolling out across the industry sectors. In

terms of country, China is becoming the largest user of 3D printers.

New development in intelligent robot technology and robot-human interaction to deliver synergistic performance will also make footprints on the advanced technology map.

Implementation of lead-free electronics is maturing, albeit with a few exemptions. The composition of lead-free alloys will not stay stagnant. Based on the fundamental metallurgy of solder materials, variations from the tin-copper-silver, tin-silver, tin-copper systems by minor tweakings will deliver different properties, thus target performance. Composition of lead-free alloys will proliferate.

Inventory and supply chain management will have heightened importance and priority to the manufacturing efficiency and cost.

On the SMT production floor, winners will go to the companies that adroitly command their operations to near perfection with manufacturing finesse coupled with robust knowledge, meaning close to defect-free operation. Commanding a defect-free production hinges on the sound basics: best practices in selecting materials, optimizing, and establishing the process with realistic process window.

Upcoming Appearance:

Dr. Hwang will present a lecture on "Preventing Manufacturing Defects and Product Failures" at IPC APEX EXPO, on March 17, 2016 in Las Vegas. **SMT**

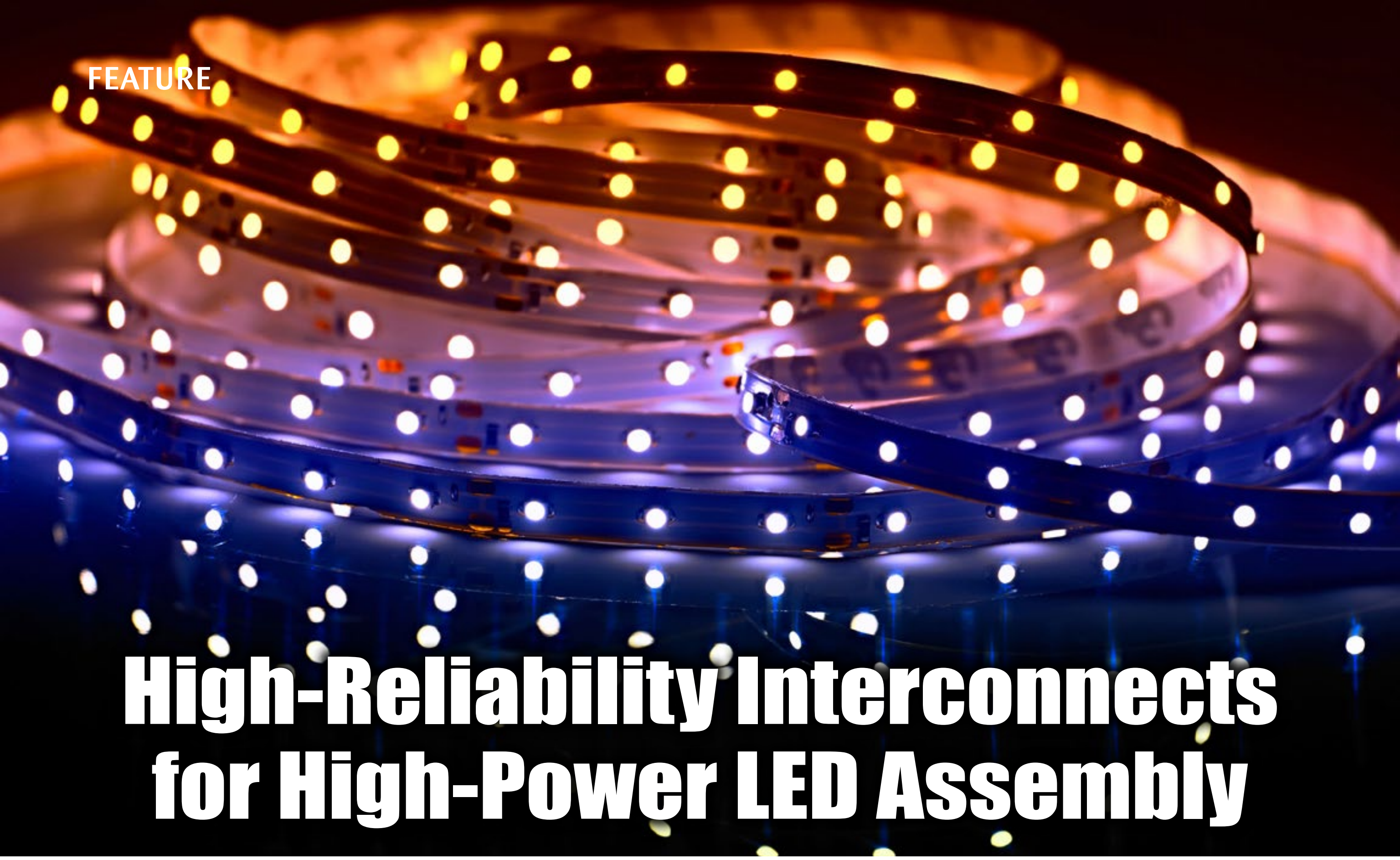
Dr. Hwang, an international businesswoman, international speaker, and business and technology advisor, is a pioneer and long-standing contributor to SMT manufacturing since its inception as well as to the lead-free electronics implementation. Among her many awards and honors, she is inducted to the WIT International Hall of Fame, elected to the National Academy of Engineering, and named an R&D-Stars-to-Watch. Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., SCM Corp, IEM Corp., she is currently CEO of H-Technologies Group providing business, technology and manufacturing solutions. She serves as Chairman of Assessment Board of DoD Army Research Laboratory, Commerce Department's Export Council, National Materials and Manufacturing Board, various national panels/committees, international leadership positions, and the board of Fortune-500 NYSE companies and civic and university boards. She is the author of 450+ publications and several textbooks, and an international speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees as well as Harvard Business School Executive Program and Columbia University Corporate Governance Program. Further info: www.JennieHwang.com.

Quantum Technology on a Chip

The lab of Prof. Hong Tang at the Department of Electrical Engineering in Yale University has devised a process of nanofabrication to create a silicon chip that contains all the components needed for a quantum information processor.

The two essential requirements for a scalable quantum information processor are quantum interference and single-photon detectors. The chip that the researchers designed contains a nanophotonic waveguide, which can guide light into small spaces and to wherever is needed on the chip. It also has a directional coupler that can split a light beam into two identical beams, or conversely, combine two beams into one output.

With this research, Carsten Schuck, post-doctoral researcher and lead author of the paper, which was published in Nature Communications, said the research team should eventually realize a programmable optical quantum processor that can run a quantum algorithm, allowing them to solve problems difficult for classical computers. He added that the same technology could also be useful for other applications, such as building extremely sensitive sensors or secure communication devices.



High-Reliability Interconnects for High-Power LED Assembly

by Ravi M. Bhatkal, Ph.D.
ALPHA ASSEMBLY SOLUTIONS

The LED revolution is on. Now more than 50 years in the making, LED technology enables the digitization of light. This analog-to-digital transformation of light sources, from traditional light sources such as incandescent, fluorescent and HID, to LED, enables a whole new range of applications and markets, from displays, to automotive and general lighting, and emerging markets such as indoor vertical farming and horticulture, Internet of Things (IoT) and visible light communications. Our ability to rapidly engineer applications-specific new product designs, coupled with appropriate LED light sources and driver and control electronics, is resulting in rapid adoption of this platform.

The LED general lighting segment, in particular, is growing at the fastest rate, with unit volumes of LED retrofit lamps, luminaires and tubes forecast to grow by 50% year-on-year 2016. This is driven by rapid technological advances, simultaneous cost reductions and scale of manufacturing in LED package technologies as well as systems integration technologies. The key issues that need to be addressed by the LED lighting supply chain include:

- Efficiency, brightness and light quality improvement (lumens per watt)
  - Higher efficiency of electrical power to light and lumen output per package for reduced energy consumption
  - High heat dissipation
  - Good light extraction and directionality

- Reliability and lifetime improvement (lumen maintenance over life)
  - Reliability of the package and the system determines their lifetime and lowers maintenance costs
  - Vibration and high-temperature thermal cycling performance

- Cost/lumen over the lifetime ($/lumen and lumens/$)
  - Increased efficiency and brightness, and increased reliability and lifetime reduce the cost per lumen over life

- New form factors
  - Greater integration and design freedom

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Role of interconnects in LED lighting and where high reliability interconnects fit

One important class of applications in the general lighting segment is high-power outdoor lighting such as street lighting. Customers (e.g., municipalities and building owners) expect very high reliability of such LED-based street lights, since major value propositions include energy savings as well as lumen maintenance over a long lifetime. For such applications, a B50, L70 lifetime of 35,000 hours is needed. For these high reliability and lifetime requirements, it is critical to have excellent assembly interconnect reliability (i.e., LED package to insulated metal substrate attach).

The role of interconnects in LED assembly is fundamentally to:

- Convey power and information efficiently and reliably over the rated life
- Get the heat out faster and reliably over the rated life
- Enable more light output, consistently, for longer time for the same package and system footprint

New super-high and ultra-high-power LED package designs provide high lumen density that can enable significant system cost reductions through fewer LEDs, smaller PCBs, and smaller heat sink size requirements. This, however, puts significant performance demands on interconnects (solder joints in particular) due to the nature of the materials stack in the assembly, and the high operating temperature inherent in such systems.

In the case of a super-high or ultra-high-power LED assembly on aluminum MCPCB, the ΔCTE between the LED and the MCPCB is 18–20, which is quite high, as shown schematically in Figure 1. During thermal cycling experienced by the LED assembly in applications such as outdoor lighting or automotive, the high ΔCTE causes significant strain energy build-up in the solder joint between the LED sub-mount and the MCPCB, during the thermal cycling experienced in use. This is shown schematically in Figure 2. This strain energy build-up causes micro-cracking, and eventually, failure of the joint.

Thus, for a given LED package structure and board material used, it is beneficial to use solder

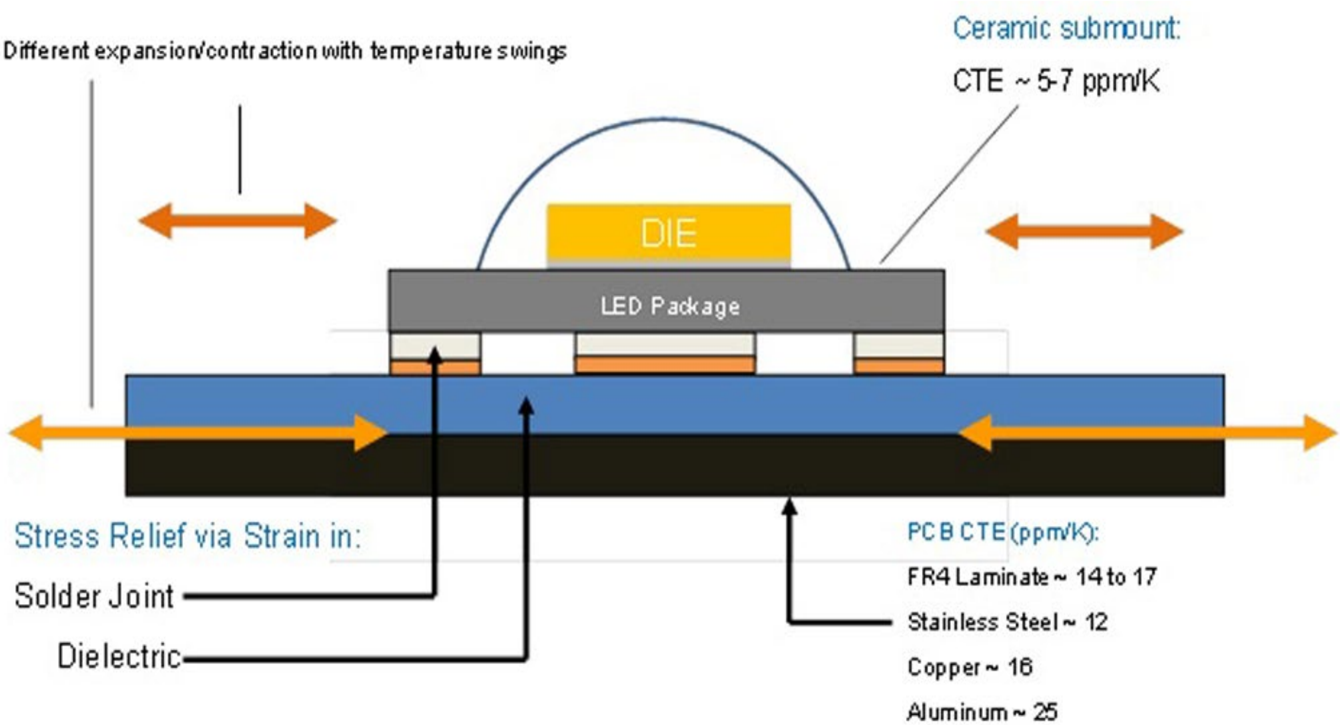

Figure 1: Schematic of chip-on-board stack with CTE mismatch.

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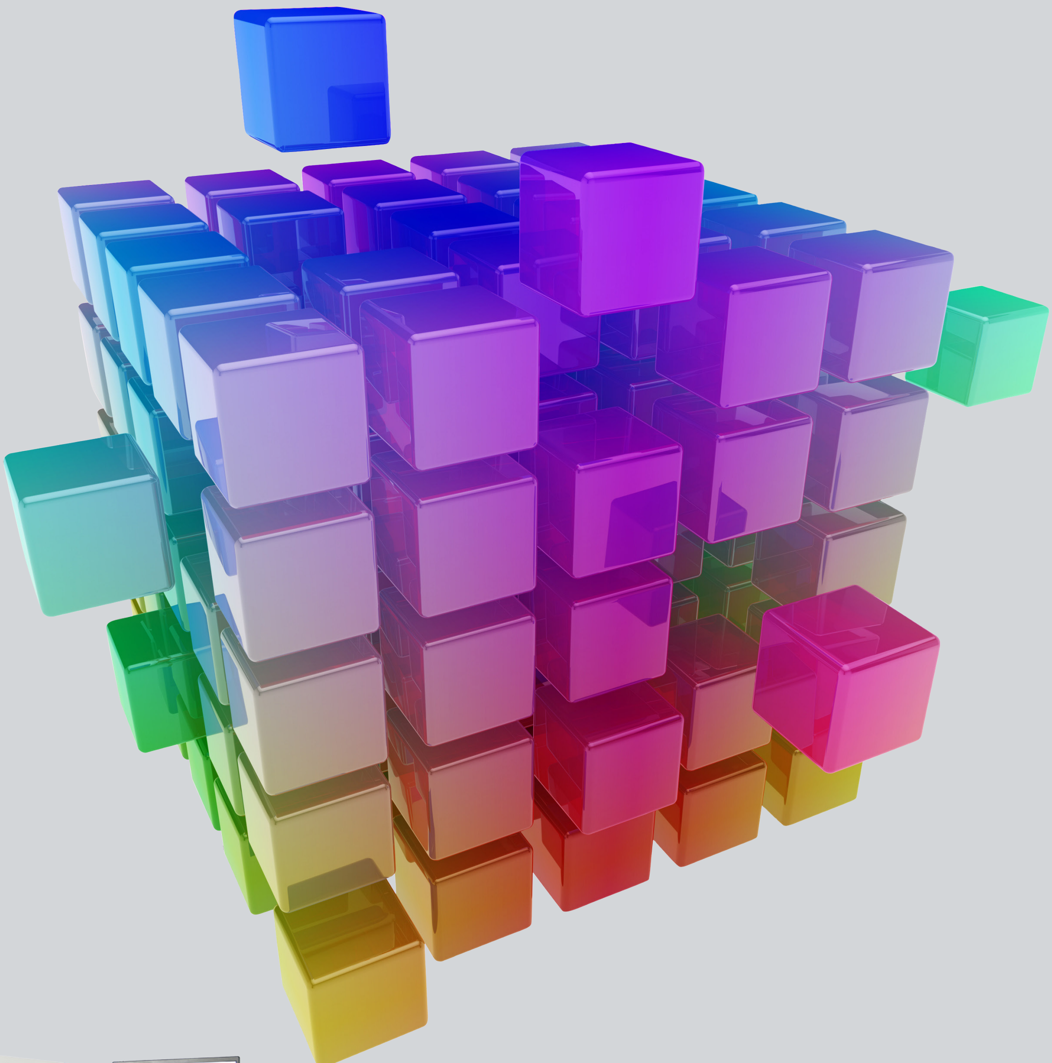

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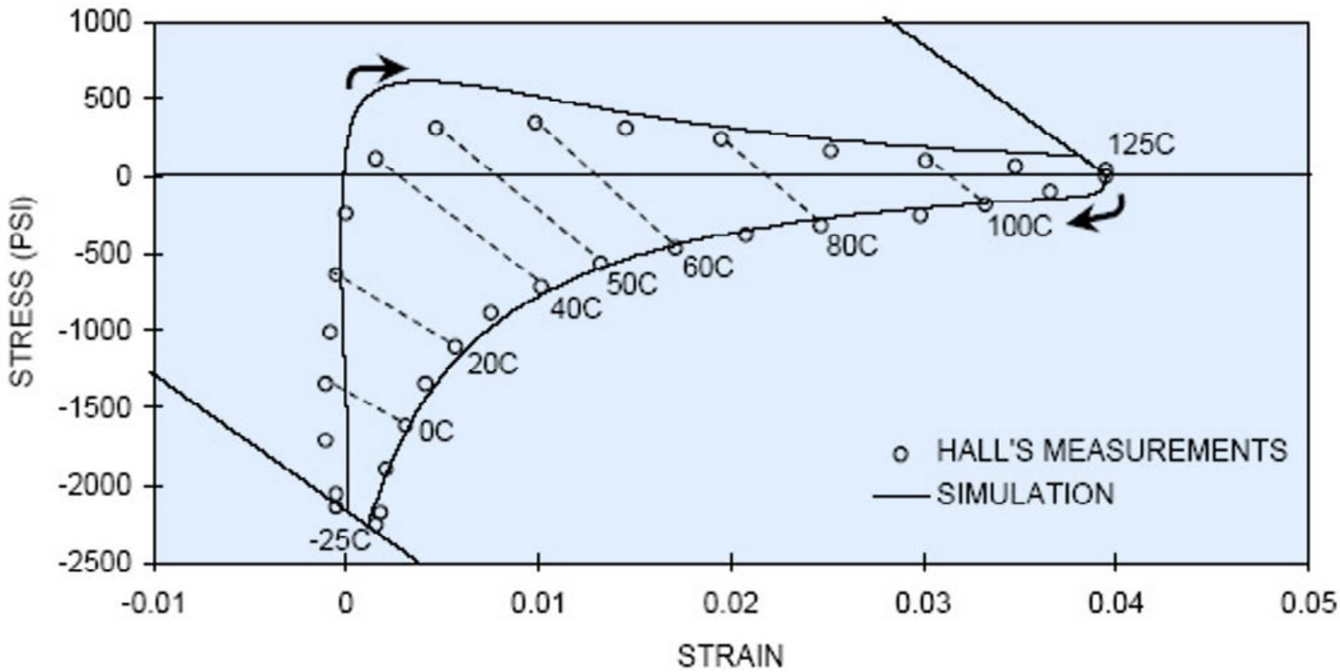


Figure 2: Schematic of stress-strain hysteresis showing strain energy build-up in solder joints, caused by thermal cycling and CTE mismatch. (Source: NIST)

joints with improved mechanical and thermal fatigue/creep and vibration resistance. A new class of creep-resistant and vibration resistant alloys has been developed, that can provide this capability, via a micro-structural control approach. These advanced alloys have been developed with special additives for improved thermal stability for high temperature operation and higher thermal fatigue and vibration resistance. These alloys have been commercially implemented for high power LED assembly.

Figure 3 shows and example of component shear data for a high power ceramic based LED assembled on a metal core PCB using such a creep resistant solder alloy-based solder (Maxrel), compared with SAC305 and a low silver alloy (SACX0807), over 1000 thermal cycles from -40°C to 125°C. It is clear that the creep resistant alloy maintains excellent shear strength even after 1000 thermal cycles under high CTE mismatch conditions.

Such creep resistant alloys can provide significant benefits, in addition to maintaining solder joint integrity over a long time. In particular, improved creep resistance limits the amount of strain energy build-up in the solder joints, and can thus reduce the resistance increase and forward voltage increase that could result from such a strain energy build-up. This can provide a direct benefit to limit power draw to maintain current input to the LED, and maintain lumen output over a longer period of time. For LED circuits connected in series, this becomes an especially important feature.

Parting Thoughts

LEDs are enabling the "digitization of light" and therefore, an "analog-to-digital transformation" in any application that uses light. Our ability to engineer the light wavelength spectrum gives us unprecedented control over light generation and allows us to tailor the light being produced, to the specific application at hand. Our ability to rapidly engineer applications-specific new product designs, coupled with appropriate LED light sources and driver and control electronics, is resulting in rapid adoption of this platform. This adoption is only accelerating, due to dramatic performance improvements, coupled with economies of scale and systems

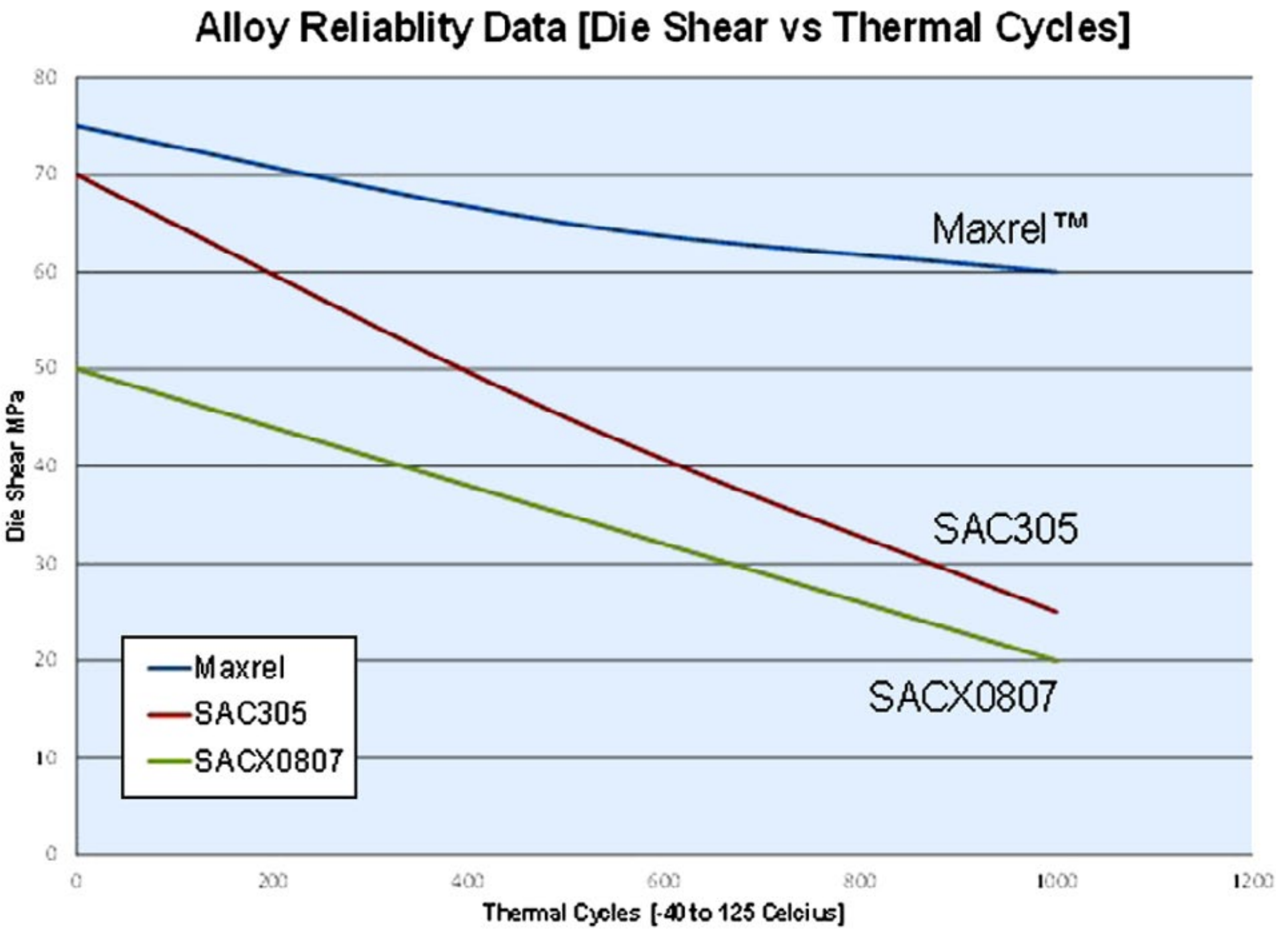


Figure 3: Component shear data for ceramic based LED on MCPCB using creep resistant alloy, over 1,000 thermal cycles.

cost declines. This combination of capabilities and favorable economics is enabling a whole new range of applications and markets, including obvious markets such as displays, automotive and general lighting, and emerging markets such as indoor vertical farming, IoT and visible light communications.

In the general lighting space in particular, which is the biggest emerging space using LEDs, significant LED systems cost reductions are being enabled through the availability of super and ultra-high power LED packages, for applications such as street lighting. Implementation of such packages in reliable, long lifetime systems calls for higher reliability, high operating temperature capable interconnects. Creep resistance of the solder alloys used is a significant determinant of solder joint reliability in high CTE mismatch assembly stacks under thermal cycling conditions. Solder joints with improved mechanical and thermal fatigue/creep and vibration resistance and bond line uniformity, are possible by using micro-structural control approach. Such alloys are being deployed now in commercial use. **SMT**

Ravi M. Bhatkal, Ph.D. is the vice president of energy technologies at Alpha Assembly Solutions, a MacDermid Performance Solutions company.

MilAero007 Highlights

[Libra Industries' Dallas Facility Completes Audits for ISO 9001:2008, AS9100 and ISO 13485-2012]

Libra Industries' facility in Dallas, Texas has successfully passed the audits for ISO 9001:2008, AS9100 and 13485-2012 certifications. With the certifications, Libra Industries is equipped to serve the aviation, space and defense, as well as medical device industries.

TT Electronics Acquires Aero Stanrew Group

The acquisition of Aero Stanrew Group Ltd will enable TT Electronics to provide a wider range of solutions to customers in the aerospace and defense sectors.

QCG Expands Production Facility

QCG has expanded its PCB assembly production facility with the addition of three brand new pick-and-place machines, an additional reflow oven, as well as additional skilled solder technicians and SMT operators.

Fabrinet Names Dr. Hong Hou as Chief Technical Officer

Dr. Hong Q. Hou recently joined Fabrinet as executive vice president and chief technical officer.

ECT Offers Quick Delivery Solution for Functional PCBA Testing

Everett Charles Technologies (ECT) introduces a new VG interconnect block to meet the requirements of high-speed applications featuring USB, HDMI, RJ45 connectors for use with off the shelf cabling.

Circuitronics Offers Wide Range of Action Services

Circuitronics, a supplier of customized manufacturing solutions for the energy, industrial, communications and mil-aero markets, has announced the offering of its Action Services.

STI Appoints Julio Estrada as Houston Training Center Manager

STI Electronics has appointed Julio Estrada as Training Center Manager for its Houston training center. Along with teaching classes, Estrada will ensure that daily operations of the company's training center run smoothly.

Computrol to Discuss High-Mix Manufacturing and Lot Traceability at ATX West

Computrol Inc. will discuss its complete line of electronics manufacturing services, including high-mix electronic manufacturing and lot traceability capabilities, at the upcoming Advanced Manufacturing Expo & Conference (ATX West) in Anaheim, California.

Variosystems China Now Certified to ISO/TS 16949

Variosystems Co. Ltd's facility in Suzhou recently completed its certification to ISO/TS 16949:2009 standards.

SMTC Receives Customer Value Leadership Award from Frost & Sullivan

SMTC Corp. has received the 2016 Global Frost & Sullivan Award for Customer Value Leadership for its true excellence in the EMS industry by employing best practices, providing end-to-end solutions, offering excellent and timely customer service, and clearly understanding unique customer needs.

FEATURE

EMS: Quo Vadis?

Where are you going?

(Copyright © 2016 Boeing)

by Frederick Blancas
INTEGRATED MICRO-ELECTRONICS INC.

"Come with me and you'll be in a world of pure imagination…We'll begin with a spin, traveling in the world of my creation. What we'll see will defy explanation."

If you have seen the 1971 film, "Willy Wonka and the Chocolate Factory" or its 2005 remake, the lyrics above, from the film's feature song, "Pure Imagination," will be familiar to you.

The song continues, *"If you want to view paradise, simply look around and view it. Anything you want to, do it. Want to change the world, there's nothing to it."*

Imagine yourself in a tour of a present day EMS factory. If you're a veteran in the industry, you'll probably be pleasantly amazed, but a bit bewildered by the changes. If you're a newbie, you might be excited by the many possibilities this factory could churn out.

As the song says, the EMS industry "began with a spin" and it now seems "to defy explanation."

In an industry that is constantly changing, EMS providers have reinvented themselves to stay relevant and fuel profitable growth. Let's take a look at five of these transformation trends in the EMS industry.

Come Fly with Me

"Come fly with me. Let's fly, let's fly away."
—Frank Sinatra, "Come Fly with Me" (1958)

Last year, Airbus predicted that the world would need 32,600 new commercial aircraft for the next two decades at a value of US$4.9 trillion. Boeing released its own forecast: 38,000 new planes worth US$5.6 trillion.

This contagious optimism about aircraft demand is driven by an increased air travel demand as well as technology advancements.

Electronic parts in aircraft are also on the rise to make air travel as safe and dependable as possible—and more convenient and entertaining.

Aircraft electronic parts include avionics—components that the pilot directly uses, such as navigation and radio communication equipment, as well as other electronic systems not directly used by the pilot that control and monitor flight and engine performance. Aside from aircraft entertainment and information systems, electronic parts found their way into the seat, kitchen, and plumbing systems.

> "Aside from aircraft entertainment and information systems, electronic parts found their way into the seat, kitchen, and plumbing systems."

EMS providers have diversified into serving the aerospace market along with other non-traditional markets as outsourcing in the traditional segments of computing, communications, and consumer electronics has become a low margin play. Avionics, infotainment systems, and even plastic and metal parts are being outsourced to EMS companies.

Valtronic, Sypris, and TT Electronics are some of the EMS providers engaged in aerospace programs. Valtronic, for example, engages in high-value aerospace projects, including airplane tire pressure sensors and aerospace electronic modules, from product conceptualization to integration and delivery.

Domo Arigato, Mr. Roboto

"Thank you very much, Mr. Roboto. For doing the jobs nobody wants to…"

—Styx, "Mr. Roboto" (1983)

With labor cost, supply, and quality issues in varied locations, EMS providers have turned to robotics to automate their production lines.

Automation, when implemented prudently, can increase throughput, improve quality, increase repeatability, and reduce labor-related costs. Further, the cost of non-quality decreases due to yield improvements, lower inspection costs, lower rework costs, and fewer field returns.

Demanding OEMs usually do a cost-benefit analysis of their outsourcing programs, comparing the analysis with automation with that of sans automation. Automotive and medical electronic products warrant a thorough joint assessment by the OEM and the EMS provider.

For complex products involving critical process steps such as precision press-fitting or selective soldering, OEMs are prone to choose automation.

In 2014, Integrated Micro-Electronics Inc. (IMI) partially automated a production line in its Jiaxing, China factory by way of a rotary assembly machine that performs eight different production steps from checking of the sub-assemblies after loading to identifying the bad outputs from the good ones.

This year, IMI will focus on developing a fully automated production line in its Jiaxing factory.

Don't You Worry 'Bout a Thing

"Everybody needs a change, a chance to check out the new…Don't you worry 'bout a thing."

—Stevie Wonder, "Don't You Worry 'Bout a Thing" (1973)

An electronic product is as good as how it functions. OEMs can't afford to worry about the functionality of their product—if they are able to meet the standards required.

To help the OEMs ensure that their products function as planned, EMS providers have been offering test process and test system design solutions.

The global automated test equipment (ATE) market is expected to be valued at US$4.48 billion by 2020, according to a report by Radiant Insights Inc. The demand drivers include increasing product design complexity and the need for effective product testing.

Throughout the new product introduction process, TT Electronics provides testing recommendations to accelerate the development and manufacturing process. For example, to accelerate the development cycle, they utilize flying

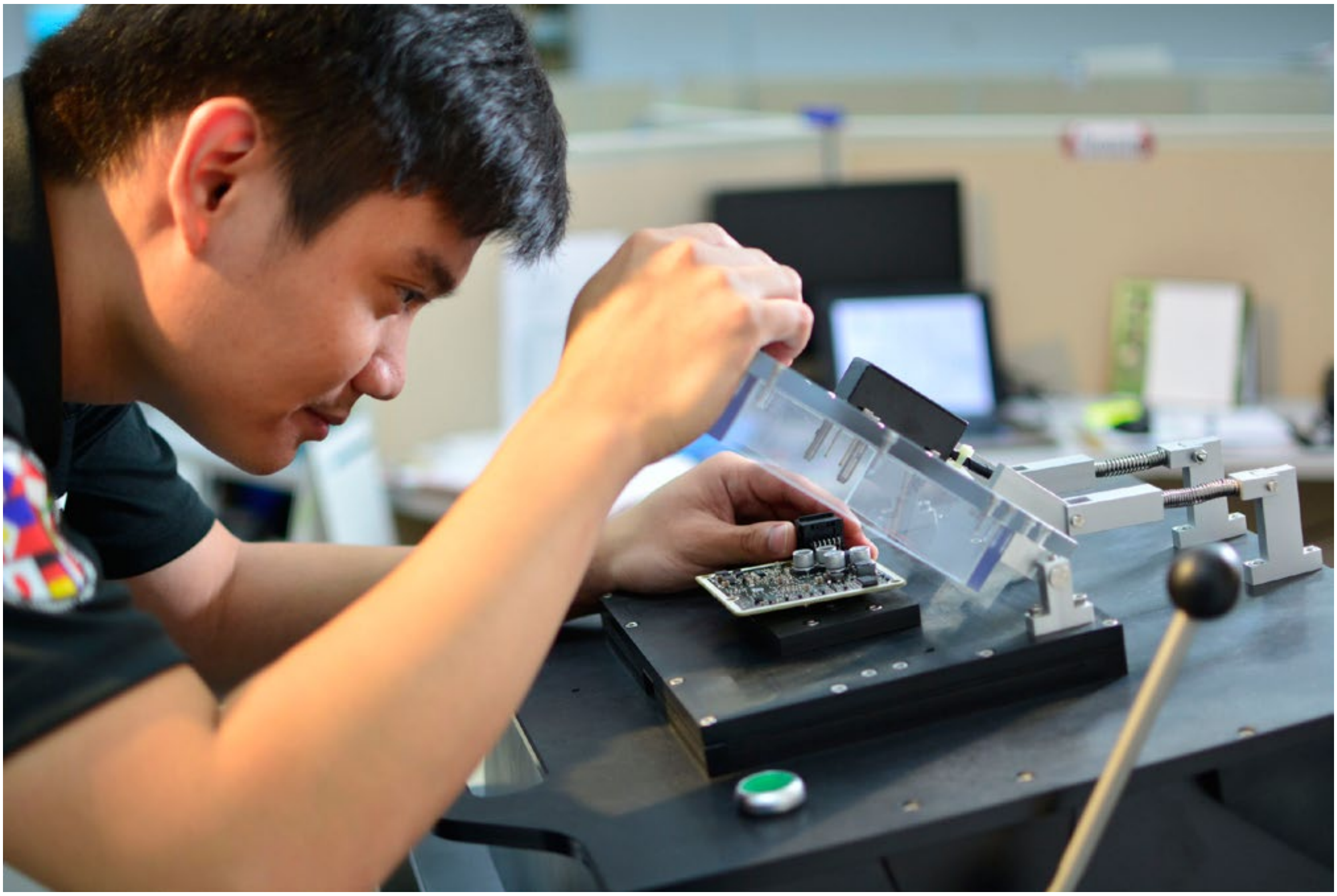


Figure 1: EMS providers have been offering test process and test system design solutions to help OEMs ensure that their products function as planned.

probe test systems as a faster alternative to traditional bed-of-nails testing in the production and prototype phases.

IMI designed last year two fully automated backend equipment for the function test, laser mark, barcode scan and unit sorting (using a six-axis robotic-arm manipulator) of automotive PCBAs and assemblies. Further, the company is currently working on its third generation six-axis camera focus and alignment system with built-in particle inspection for its latest camera platform.

I've Got the Power

"I've got the power, I've got the power."
—Snap!, "The Power" (1990)

As the demand for environment-friendly, energy-saving products and systems grows, a promising endeavor for EMS providers is power module assembly.

Power module, according to Wikipedia, "provides the physical containment for several power components, usually power semiconductor devices. These power semiconductors ('dies') are typically soldered or sintered on a power electronic substrate that carries the power semiconductors, provides electrical and thermal contact and electrical insulation where needed."

The demand for power module solutions drives the growth of the global power semiconductor market's growth. With an estimated 5% growth in 2015, the power semiconductor market is feeling the effects of increased demand for power modules in a variety of applications.

In an IHS Inc. report, the global power module market is expected to make up nearly a third of the power semiconductor market by 2019, growing at twice the rate of power dis-

cretes, the other key component of the power semiconductor market.

The growing demand for power modules is often attributed to their increased power density and greater reliability. IHS said that among the popular power module applications are those for inverters for wind converters, photovoltaic solar energy systems, industrial motor drives, and hybrid and electric vehicles.

In December 2015, IMI inaugurated its insulated gate bipolar transistor (IGBT) module or power module facility. This facility is into the process development and production of power modules involving highly flexible machines that can accommodate different application requirements of customers.

IMI president and CEO Arthur Tan said that the company "is one of the few companies in the world that is capable of handling not only the electronics manufacturing side of the power modules but also the power semiconductor side of it."

God Bless the Child

"God bless the child that's got his own, that's got his own."

—Billie Holiday, "God Bless the Child" (1941)

In their quest for improved competitiveness and sustainability, some EMS providers have given birth to spin-offs.

For these EMS companies, spin-offs are a less cumbersome way to venture into outside-the-core businesses because such businesses usually require a different skill set, mindset, or business model. But EMS providers can leverage existing experience, discipline, management style, or relationships, making the new endeavors less perilous.

Flextronics, for instance, has spun off a software startup, Elementum, to help companies track their supply chains in real time.

They began incubating Elementum in 2012 after building a software platform that would help Flextronics' customers—those running global operations with increasingly complex supply chains. In 2013, Flextronics decided that Elementum needed to be a separate company so that non-Flextronics customers could also avail themselves of the software.

As shown above, EMS providers have done reinventions and innovations. The probable answer to the question "Quo vadis?" is "everywhere." EMS providers ought to be everywhere as they continue to evolve, progress and advance.

It is no longer just a mere world of pure imagination, but the real world of EMS. The EMS industry will continue to change the world as if there's nothing to it. And all EMS players are all set. **SMT**

Frederick Blancas is a senior division manager at Integrated Micro-Electronics Inc. (IMI).

Electronics Industry News
Market Highlights

Security to Take a Major Role in Commercialization of Industry 4.0 Solutions
Revolutionary advances in information and communication technology have led to the explosive growth of mobile devices and brought about the age of the Internet of Things.

IHS Top 10 Economic Predictions for 2016
IHS expects a slightly better overall performance for the world economy in 2016, with an expected growth rate of around 2.9%, driven by solid growth in the United States and a slight pickup in the pace of Eurozone and Japanese economic activity, along with an expected easing of recessionary pressures in Brazil and Russia.

IoT Market to Nearly Double by 2019
Between 2015 and 2019, worldwide systems revenues for applications connecting to the Internet of Things (IoT) will nearly double, reaching $124.5 billion in the final year of this decade, according to a report from IC Insights.

Automotive LED Market to be Worth $2.29B in 2020
LED manufacturers are branching into the niche application markets as the competition in their industry expands. Currently, entering the automotive LED market is regarded as a blue ocean strategy because the market has relatively few contestants and allows for higher pricing.

Worldwide Robot Market to See Further Growth in 2016
Research firm TrendForce reveals that the global demand growth for industrial robots continues to accelerate on account of workforce shortages and loss of demographic dividends.

Automotive Display Systems to Grow to $18.6B by 2021
Driven by continued innovation in vehicle connectivity and safety technologies, global revenue from automotive display systems will grow at a compound annual growth rate of more than 11% to $18.6 billion by the end of 2021.

3D IC Market to Grow Above 79% CAGR to 2019
The continuous miniaturization of electronic devices and quick replacement cycle of mobile devices are expected to increase the demand for 3D ICs.

Growing Security Fears Boost Defence Budgets
Security fears and threats to stability have driven many Western governments to end cuts to defence spending, according to a new report by IHS Inc.

Global Electronics Industry Output Forecast to Reach $1.86T in 2015
Output for the global electronics industry is forecast to reach $1.861 trillion in 2015, compared to $1.04 trillion 30 years earlier.

Shipments of Connected Wearables will Reach 228 Million in 2020
According to a new report from analyst firm Berg Insight, shipments of connected wearables is forecast to reach forecasted to reach 228.3 million units in 2020, up from 72.5 million in 2015.

Two-Print Stencil Solutions for Flip Chip/SMT Assembly

by William Coleman
PHOTO STENCIL LLC

Mixed technology packages that have both flip chip (FC) and surface mount devices (SMD) on the same substrate are now being assembled in a normal SMT assembly process.

Instead of dipping the FC die in flux, both flux and paste are printed on the substrate. Then the FC and SMD are placed into the paste/flux with pick-and-place equipment and sent to a reflow oven where both are soldered to the substrate.

This assembly process requires a "two-print stencil" printing procedure and requires two in-line stencil printing machines. Normally, flux is printed first using a thin electroform stencil (40–50 µm thick) to print flux on the FC die pads. This is referred to as the "first print stencil." Immediately after the first print, the substrate is advanced to the second printer. The "second print stencil" is used to print solder

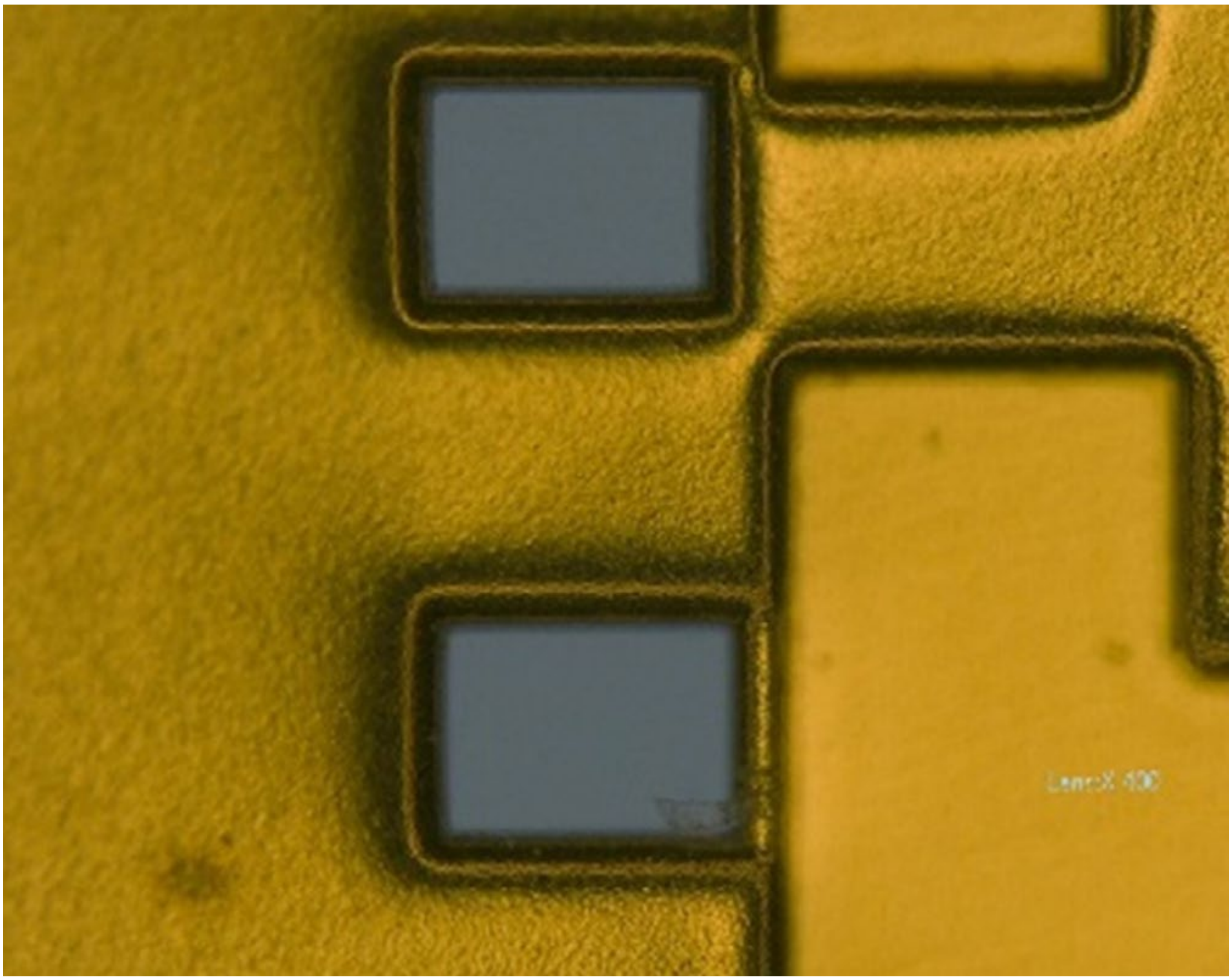


Figure 1: Solder paste aperture for 01005 and relief pocket for flux.

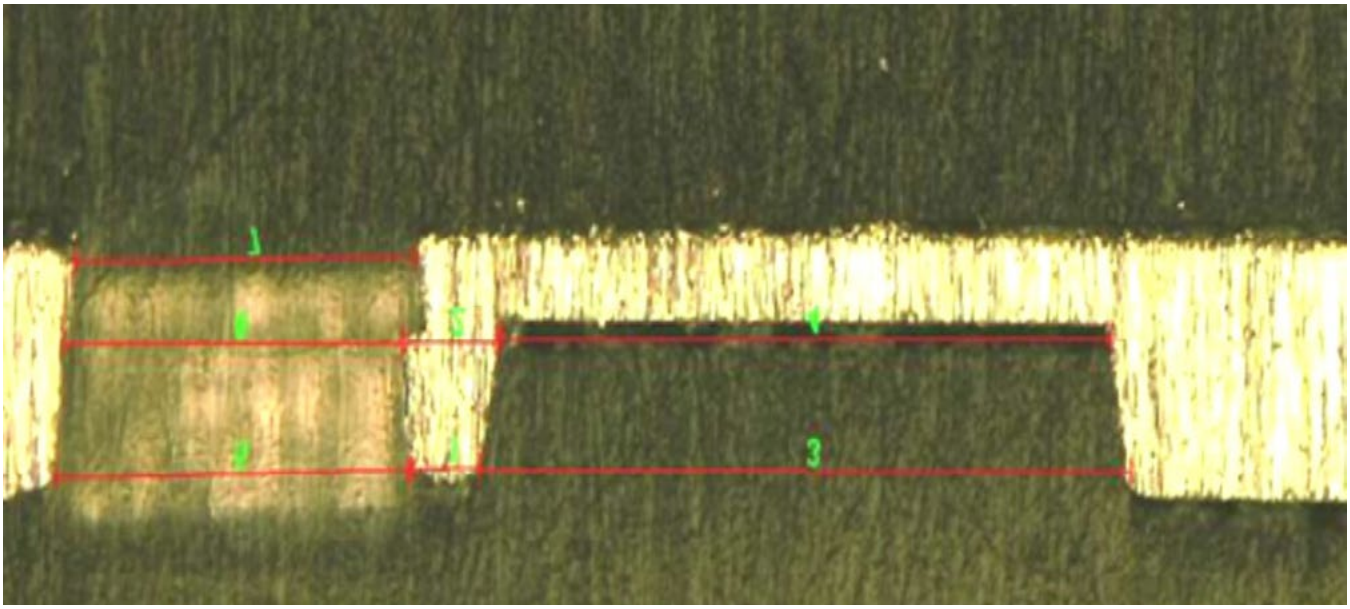


Figure 2: Cross section showing 40 µm spacing between solder paste aperture and the relief pocket.

paste for the SMDs. This stencil is normally an electroformed 75 µm thick stencil for the solder paste apertures but has a relief step pocket 50µm thick on the contact side of the stencil in the area where flux was printed with the first stencil. This relief pocket provides sufficient clearance to avoid contact with the previously printed flux.

> **"One of the primary applications driving mixed technology packages is RFICs for wireless applications such as mobile phones, wireless infrastructure and wireless LAN."**

It is also possible to print the solder paste first for the SMDs and the flux second. In this case, the first print stencil is typically a 50 µm thick electroform stencil for printing solder paste. The second print stencil is typically a 3D electroform stencil 150 µm thick with a 75 µm relief pocket to avoid contact with solder paste previously printed.

One of the primary applications driving mixed technology packages is RFICs for wireless applications such as mobile phones, wireless infrastructure and wireless LAN. Typically, these devices have multiple flip chips, 0201 as well as 01005 chip components mounted on a small substrate which are packaged as a MCM, QFN, or DFN. As these packages become smaller, the FC and SMD are packed closer together. This presents technical challenges to the second print stencil, reducing the distance of the relief pocket to the paste or flux aperture.

A new electroform process has been developed that allows the spacing between relief pocket and aperture to be reduced to 40 µm. Figure 1 shows solder paste aperture for 01005 and relief pocket for flux. Figure 2 is a cross section showing 40 µm spacing between solder paste aperture and the relief pocket. **SMT**

William Coleman is the vice president of technology at Photo Stencil LLC. He is also a member of the *SMT Magazine* Editorial Advisory Board.

Challenges and Opportunities for Smaller EMS for Onshoring

by Gary Tanel
MCDONALD TECHNOLOGIES

The onshoring trend has been speculated and talked about for a few years now, and is certainly a reality with greater opportunities and challenges. Responsivity, time to market, wage normalization, and intellectual property is driving OEMs to look for suppliers that are closer and smaller.

Pirating

If you attended this year's Consumer Electronics Show (CES) is Las Vegas, you might have seen that some foreign companies got in trouble for pirating new designs of U.S. companies that were manufacturing in Asia. This is a big concern for smaller companies that have new products but don't have the staff to combat this. As a result, they are sticking closer to home where they know the laws and have more control.

Automation: the Great Normalizer

As automation goes up, the impact of cheaper labor goes down. Automation also takes out the variability and human error. However, if you're not careful, you can create a lot of rework fast with high-speed equipment. A few highly skilled people running automated equipment is more efficient than lots of low pay manual assembly people making errors.

Multifunctional

In the past, the lead companies were vertically integrated, and then the trend for the smaller companies was to become more focused. Now, we are trending more multifunctional to eliminate the multiple mark-ups that drive up price.

Engineering, CCA, cables, and system integration is an attractive mix for the OEM in seeking a supply partner with deeper relationships. Partitioning sub-systems with multiple suppliers can lead to sub-optimization and system level inefficiencies.

Labor Wages

We have seen the average wage for Asian workers trending up as money has been pouring into the system, particularly in the larger manufacturing centers. This is taking some of the edge off their competitiveness and opening up opportunities for regional markets around the world. Logistics, travel, politics, shipping inventory, taxation, and the value of the U.S. dollar around the world have a larger impact than lower labor rates.

The shops that are agile and efficient are busy. The others are waiting for a time gone by. **SMT**

Gary Tanel is the vice president for business development at McDonald Technologies and a member of the *SMT Magazine* Editorial Advisory Board.

Flexible and Transparent Pressure Sensor

Healthcare practitioners may one day be able to physically screen for breast cancer using pressure-sensitive rubber gloves to detect tumors, owing to a transparent, bendable and sensitive pressure sensor newly developed by Japanese and American teams.

Conventional pressure sensors are flexible enough to fit to soft surfaces such as human skin, but they cannot measure pressure changes accurately once they are twisted or wrinkled, making them unsuitable for use on complex and moving surfaces. Additionally, it is difficult to reduce them below 100 micrometers thickness because of limitations in current production methods.

To address these issues, an international team of researchers led by Dr. Sungwon Lee and Professor Takao Someya of the University of Tokyo's Graduate School of Engineering has developed a nanofiber-type pressure sensor that can measure pressure distribution of rounded surfaces such as an inflated balloon and maintain its sensing accuracy even when bent over a radius of 80 micrometers, equivalent to just twice the width of a human hair. The sensor is roughly 8 micrometers thick and can measure the pressure in 144 locations at once.

The device demonstrated in this study consists of organic transistors, electronic switches made from carbon and oxygen based organic materials, and a pressure sensitive nanofiber structure. Carbon nanotubes and graphene were added to an elastic polymer to create nanofibers with a diameter of 300 to 700 nanometers, which were then entangled with each other to form a transparent, thin and light porous structure.

"We've also tested the performance of our pressure sensor with an artificial blood vessel and found that it could detect small pressure changes and speed of pressure propagation," says Lee. He continues, "Flexible electronics have great potential for implantable and wearable devices. I realized that many groups are developing flexible sensors that can measure pressure but none of them are suitable for measuring real objects since they are sensitive to distortion. That was my main motivation and I think we have proposed an effective solution to this problem."

Supply Lines
Highlights

[The Key to Understanding Industry 4.0: Show, Don't Tell!]

At the recent productronica event in Germany, Mentor Graphics set up a racecar track in their booth. Michael Ford, senior marketing development manager at Mentor's Valor Division, explains why it's a perfect analogy for understanding Industry 4.0.

Innovative New Uses for Ceramic Column Grid Arrays from TopLine

TopLine president and CEO Martin Hart discusses his paper on ceramic column grid arrays (CCGA) at the recent SMTA International show in Chicago, and TopLine's drive to find new uses for CCGA.

Mentor Graphics: The Past, Present and Future of Analytics

Farid Anani, consulting manager with Mentor Graphics' Valor Division, discusses with I-Connect007's Andy Shaughnessy a paper he presented at SMTAI that focused on analytics and how it can be used to increase business revenue.

Kester Highlights Strategies to Address High-Reliability Issues

Lynnette Colby, global product manager at Kester, discusses the biggest challenge their customers are facing—reliability—and how using materials other than halogen can help address this issue.

Alpha Talks Challenges of Solder Recycling

Alpha's Jason Fullerton talked with I-Connect007's Patty Goldman about his presentation on recycling solder and why doing this in-house is not a good idea.

Mycronic Lands Order for a Prexision-80 Mask Writer

Mycronic has received an order for a Prexision-80 mask writer for advanced display applications from a customer in Asia.

Multitest Launches New Contactors for WLP/WLCSP Testing

Multitest has expanded its contactor portfolio with the release of the Mercury 030 probe, which meets the increasing demand for cost-efficient high-performance WLP/WLCSP contacting solutions.

Mirtec Reports 52% Growth in Q4 2015

MIRTEC Co. Ltd has reported continued growth in sales revenue for its North American Sales and Service Division for 2015. According to Mirtec president Brian D'Amico, the North American Division has grown by more than 52% in the fourth quarter of 2015 compared to the previous year.

Alpha Selects YAMAHA YCP10 High-Performance Compact Printer for Key Laboratory Facility

Alpha has chosen Yamaha Motor IM's YAMAHA YCP10 High-Performance Compact Printer has for purchase and installation at a key laboratory facility in New Jersey.

Europlacer Heads into 2016 with a Major Milestone

Europlacer, a manufacturer of flexible SMT pick-and-place systems, is celebrating Europlacer Americas' 10-year anniversary.

EFFICIENCY, ENERGY AND CONVENIENCE: Driving New Solutions and Markets

by Stephen Las Marias
I-CONNECT007

In an interview with I-Connect007, Craig Hunter, senior director for global marketing communications at Vishay Intertechnology Inc. and a member of the *SMT Magazine* Editorial Advisory Board, discusses significant changes in the electronics manufacturing industry during the past decade, persistent challenges, and new technologies that will provide opportunities and growth.

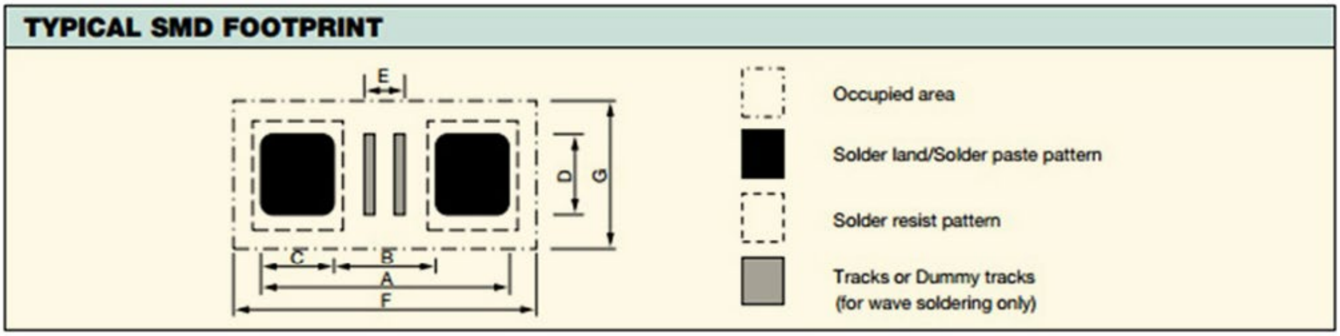
***Stephen Las Marias:** From your perspective, what would you consider the three most significant technology developments in the electronics manufacturing industry during the past five to ten years?*

Craig Hunter: Component miniaturization, the increase of battery-backed equipment, and the role of the Internet in helping engineers design and build end products.

***Las Marias:** What about challenges?*

Hunter: In terms of miniaturization, electrical challenges and mechanical challenges when making things smaller have an almost inverse relationship with the size reduction. Simply adding terminations to 0201 products would have been extremely costly 20 years ago. Another good example is that when placing 0201 components on a PCB, the margin for error represents a much larger area than previous larger case size versions. A 0201 chip capacitor physically occupies an area of 0.65 x 0.3 mm, yet the recommended pad layout is typically 0.9 x 0.6 mm. So, the total area the designer needs to specify is roughly 175% bigger than the specific part. The same calculation for a 0805 chip is just 55% bigger than the part.


Craig Hunter



REFLOW SOLDERING

SIZE	FOOTPRINT DIMENSIONS IN mm							PROCESSING REMARKS	PLACEMENT ACCURACY
	A	B	C	D	E	F	G		
0201	0.65	0.23	0.21	0.30	n/a	0.90	0.60	Reflow or hot plate soldering	± 0.05
0402	1.50	0.40	0.50	0.50	0.10	1.75	0.95		± 0.15
0603	2.30	0.70	0.80	0.80	0.20	2.55	1.40		± 0.25
0805	2.80	1.00	0.90	1.30	0.40	3.05	1.85		± 0.25
1206	4.00	2.20	0.90	1.60	1.60	4.25	2.25		± 0.25
1210	4.00	2.20	0.90	2.50	1.60	4.25	3.15		± 0.25

Figure 1: Placement accuracy for different surface-mount device (SMD) sizes.

So bearing in mind the lost capacitance of an MLCC when reducing size, you can see how device performance has had to increase significantly when reducing case size.

With regard to the Internet, the fast development of consumer behavior has dramatically affected customer behavior on industrial websites. While Internet giants like Google, Amazon, etc., have invested billions in solving customer frustration issues to stop customers from going to other sites, industrial manufacturers and distributors are trying hard to play catch-up and provide the required content. A recent study stated that engineers make over 55% of their decisions without talking to anyone. So the critical need to meet their needs is obvious.

Battery-backed equipment: The need to improve efficiency, reduce losses, and lower power consumption requirements has moved to the forefront of component technology. It's not funny math to point out that if a MOSFET operates at 94% efficiency and is improved to 97%, then you reduce losses by 50%.

Las Marias:* *What continues to be the greatest technology challenge in the electronics manufacturing industry nowadays?

Hunter: R&D has a cost, reliability has a cost, and quality has a cost, and there's been a lot of industry ink used to explain the problems associated with counterfeit parts. At the front-end of a design, component price can be overstressed. When true installed cost due to part failure is reviewed, the value of working with a reputable manufacturer/distributor can often result in a much lower cost.

Las Marias:* *What new technology or technologies would you say will have a big impact on the electronics manufacturing industry in the next 12 to 18 months?

Hunter: The growth of mobility (electric vehicles), sustainability (alternative energy solutions) and connectivity (wearable technologies) will be major drivers for the future. Here, power efficiency, energy density and size/weight ratios will drive business and provide new solutions and markets. As products are made smaller, yet maintain important performance capabilities, the opportunity to develop new products emerges. An example is the movement from a mainframe to a desktop PC to a notebook to a tablet, to a smartphone, and now to a watch.

Due to cost, production numbers are usually much larger as the size of the specific equipment is reduced. But it takes tremendous efforts, and of course, time to create a smaller component with a similar performance at a lower cost.

In alternative energy, the need for higher energy density without trading reliability is a battle which is continually being fought. Remote failures at an offshore windfarm, for example, are extremely costly.

What we don't know and unforeseen circumstances are another problem. Electric vehicles when involved in accidents might become "hot" and cause rescue service personnel or good samaritans from the general public to arrive on the scene and prevent serious injury. On a lighter side, recently in the UK companies have been testing driverless cars in city centers. For obvious safety reasons, the cars include systems to avoid collisions with pedestrians. But it has apparently become something of a game on Friday and Saturday nights to corner the vehicle with one person on each side forcing the car to stop moving.

So, improvements in convenience, energy usage, and efficiency might have unintended or unexpected consequences which need to be addressed for safe introduction into the marketplace.

Las Marias:* *What can you say about the Internet of Things (IoT) and Industry 4.0? How do you think they will impact electronics manufacturing?

Hunter: It has only been recently that the IoT and Industry 4.0 have been more accurately defined and understood. It's clear that the potential to remotely and smartly monitor performance and resource usage can dramatically improve efficiency in terms of things like production and energy utilization. Being able to do accomplish improved decision-making over a greater percentage of the day can really have a positive impact on a global basis and reduce costs across the board.

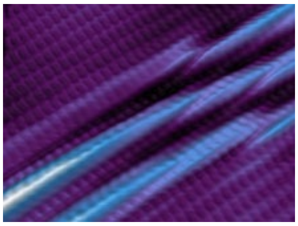
Las Marias:* *What is your outlook for the electronics manufacturing industry in terms of development over the next three to five years?

Hunter: Every week it seems like something new is released that makes things safer, more convenient, or faster to achieve, based on electronics. In addition, bandwidth and accessibility of networks means we're also more connected. These two factors mean that electronics will play an ever-increasing part in our lives. With the workplace starting to become connected, there will be very significant opportunities for growth.

Las Marias:* *Thank you, Craig.

Hunter: Thank you. **SMT**

Scientists Create Atomically Thin Metallic Boron



A team of scientists at the U.S. Department of Energy's (DOE) Argonne National Laboratory, Northwestern University and Stony Brook University has, for the first time, created a two-dimensional sheet of boron – a material known as borophene.

Borophene is an unusual material because it shows many metallic properties at the nanoscale even though three-dimensional, or bulk, boron is nonmetallic and semiconducting.

Because borophene is both metallic and atomically thin, it holds promise for possible applications ranging from electronics to photovoltaics, according to Argonne nanoscientist Nathan Guisinger, who led the experiment.

The discovery and synthesis of borophene was aided by computer simulation work led by Stony Brook researchers Xiang-Feng Zhou and Artem Oganov, who is currently affiliated with the Moscow Institute of Physics and Technology and the Skolkovo Institute of Science and Technology.

The experimental work was funded by the DOE's Office of Science and was performed at Argonne's Center for Nanoscale Materials, a DOE Office of Science User Facility, and at the Northwestern University Materials Research Center.

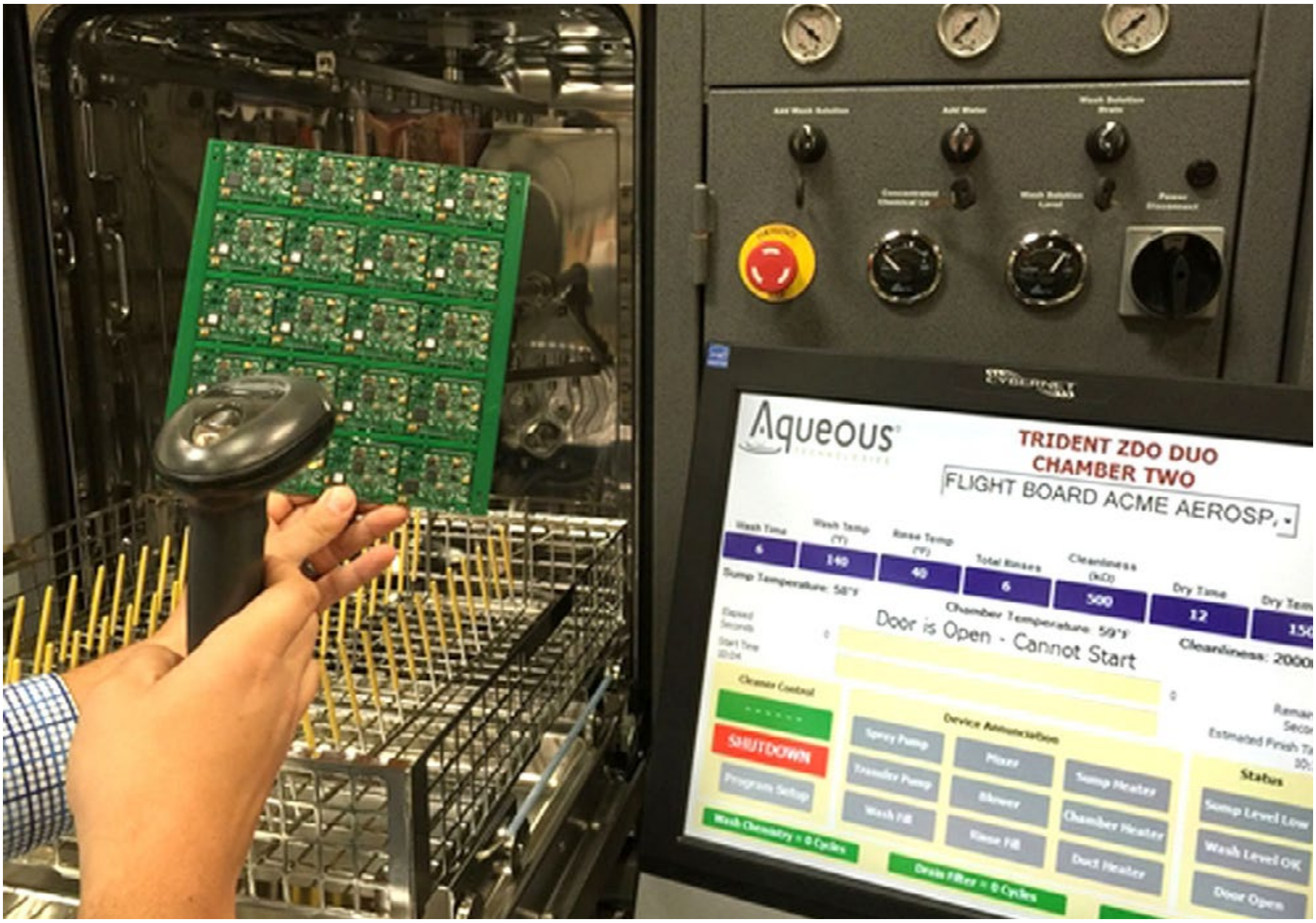
Greener Cleaning

by Mike Konrad
AQUEOUS TECHNOLOGIES

The electronic assembly cleaning industry is unique among other assembly equipment segments. Very few, if any, other assembly processes are considered unnecessary by some while being absolutely required by others. The fact is, assembly contamination may or may not cause a reduction in product reliability. Each assembly has a "contamination tolerance signature." While some assemblies are impervious to contamination residues, others are not.

The amount of electronic assemblies with a high tolerance for contamination is shrinking. Assembly design including size, component type and density, stand-off heights, electrical voltage and current factors, as well as end-product in-use environmental/climatic conditions all play a role in determining the contamination tolerance signature of an electronic assembly. Add to that a cost of failure analysis and the decision to remove process residues/contamination or leave them on the assembly is an easy one. While other electronic assembly processes measure performance in "more" (more feeders, more zones, more magnification, more capacity), cleaning equipment and chemicals measure progress in "less" (less water, less chemicals, less VOCs, less discharge, less contamination, etc.). In the cleaning world, less is more.

In 1992, Aqueous Technologies made a commitment to reduce the footprint of cleaning. We designed equipment that cleaned electronic assemblies using less water, less electricity, less chemicals, less discharge, and less time than oth-



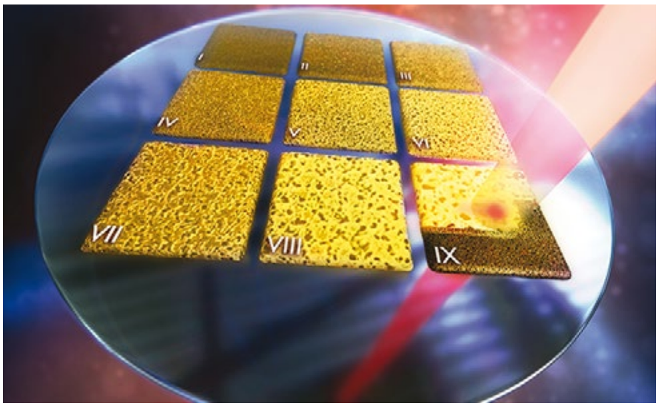
er processes common in that era. While less was more 23 years ago, even less is even more today.

During 2015, Aqueous Technologies' products saved millions of gallons of water (a fact not lost on our West Coast customers). More of our zero discharge cleaning systems were sold than any other year resulting in the savings of millions of gallons of water consumed and the complete elimination of a need for a drain. Our goal in 2016 is to continue our environmental stewardship by providing more zero discharge models to companies who clean their assemblies, resulting in improved product reliability and a cleaner, greener planet. **SMT**

Mike Konrad is the president of Aqueous Technologies. He is also a member of the *SMT Magazine* Editorial Advisory Board.

Researchers Go for the Gold on a Single Chip

Lawrence Livermore National Laboratory researchers have created a library of nanoporous gold (np-Au) structures on a single chip that has direct applications for high-capacity lithium ion batteries as well as neural interfaces.



np-Au is produced through an alloy corrosion process known as dealloying that generates a characteristic three-dimensional nanoscale network of pores and ligaments.

LLNL researchers and their University of California, Davis collaborators describe a method for creating a library of varying np-Au morphologies on a single chip via precise delivery of tunable laser energy. UC Davis professor Erkin Seker served as the principal investigator of the UC Fees project that primarily funded the work, along with co-PI Monika Biener of LLNL's Materials Science Division.

"Traditional heat application techniques for the modification of np-Au are bulk processes that cannot be used to generate a library of different pore sizes on a single chip," said LLNL staff scientist Ibo Matthews, co-author of the paper. "Laser microprocessing offers an attractive solution to this problem by providing a means to apply energy with high spatial and temporal resolution."

The researchers used multiphysics simulations to predict the effects of continuous wave vs. pulsed laser mode and varying thermal conductivity of the supporting substrate on the local np-Au film temperatures during photothermal annealing.

They were then able to fabricate an on-chip material library consisting of 81 np-Au samples of nine different morphologies for use in the parallel study of structure–property relationships.

"These libraries have the potential to drastically increase the throughput of morphology interaction studies for np-Au, specifically in applications such as high capacity lithium ion batteries, cell-material interaction studies for neural interfaces, analytical biosensors, as well as nanoscale material science studies," said Biener, co-author of the paper.

This work sets the foundation for understanding laser-based annealing of porous thin film materials. The fabrication of single chip material libraries has the potential to increase the throughput of material interaction testing in many disciplines through easy single-chip material screening libraries.

LLNL's Juergen Biener of the Material Sciences Division collaborated on the work along with UC Davis researchers Christopher Chapman (lead author) and Ling Wang.


Factory Intelligence
TAKE THE LEAD
It takes more than hard work and willpower to win the race. Smart use of technology makes the difference between first and second place.
Factory Intelligence.
MEASURE.
REACT.
TAKE THE LEAD.

Magnetically Aligned Novel ACA Revolutionizes 3D Chip Stacking

by Dr. S. Manian Ramkumar
ROCHESTER INSTITUTE OF TECHNOLOGY

The use of anisotropic conductive adhesive (ACA) is not new within the electronics industry; however, drop-in replacements don't exist for lead-based and lead-free solder assemblies. Current ACAs require pressure and sequential assembly of components. Sunray Scientific's Novel ACA (ZTACH) is an excellent drop-in ACA replacement that will revolutionize the packaging industry and make electronic products more sustainable and green. ZTACH has been proven to enable the use of existing SMT equipment, lower the processing temperatures (75–150°C), and also eliminate the need to apply pressure, thereby eliminating the need to invest in new equipment and processes and reducing energy consumption.

ZTACH is composed of conductive, ferromagnetic particles in an epoxy matrix, which is printed or dispensed on the individual pads or the entire footprint of the components. The material is cured in a reflow oven, after all components are in place, in the presence of a magnetic field. The magnetic field aligns the conductive particles in the Z-axis direction, during curing, thereby eliminating the need for pressure. The formation of conductive columns within the adhesive matrix during cure provides a very high insulation resistance between adjacent conductors and also eliminates the need for precise printing or dispensing of adhesives onto individual fine pitch pads (Figure 1). Modification

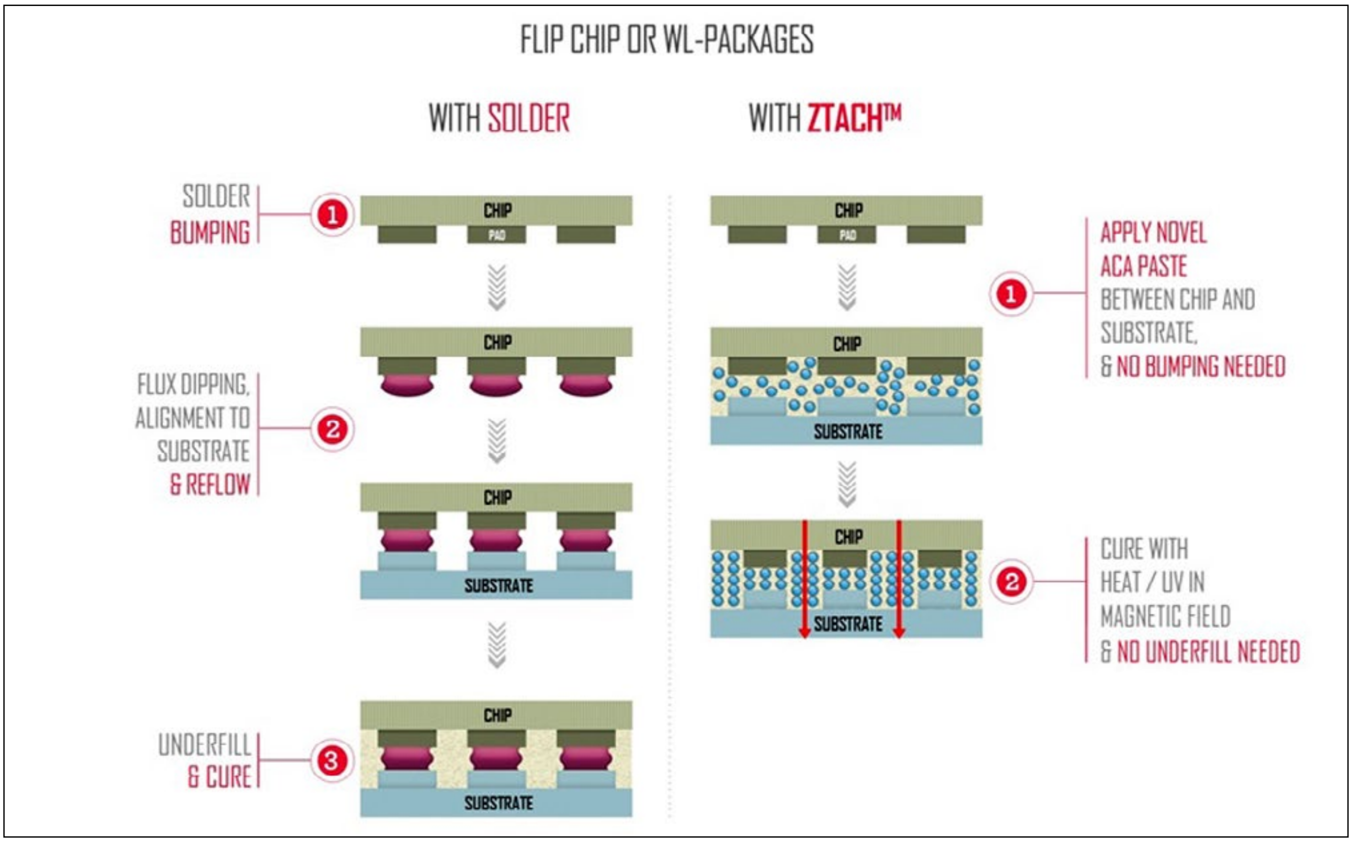


Figure 1: The formation of conductive columns within the adhesive matrix during cure eliminates the need for precise printing or dispensing of adhesives onto individual fine pitch pads.

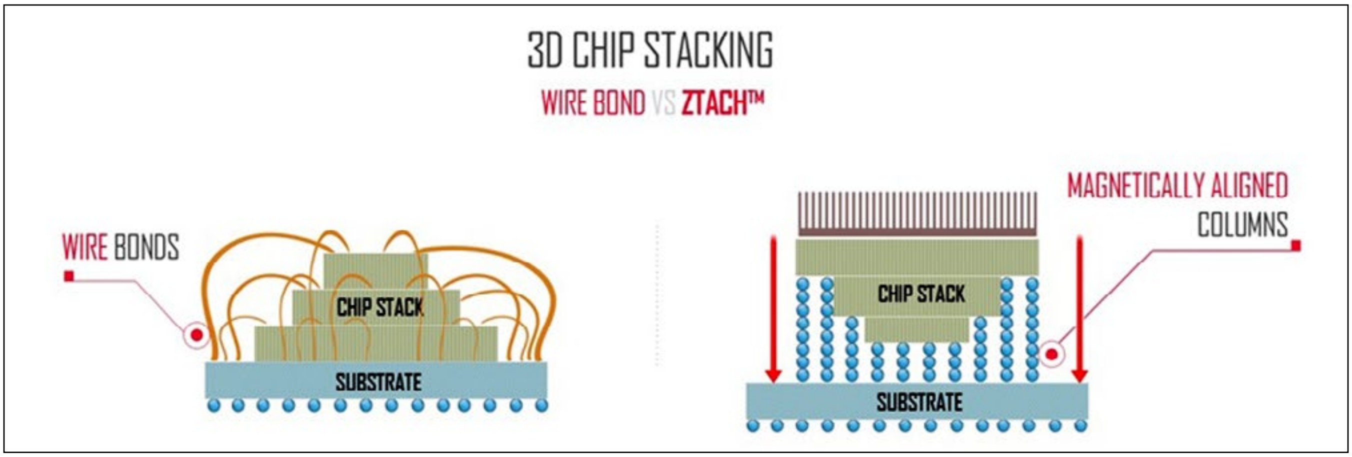


Figure 2: Immediate benefits in 3D chip stacking include the elimination of wire bonding.

of the filler size and filler proportion enables control of the column density, column spacing and the required contact pad area for minimum resistance. ZTACH can be mass cured, eliminating the need for sequential component assembly. The formation of many parallel columns especially with micron and sub-micron sized particles between mating pads reduces the resistance considerably.

Immediate benefits in 3D chip stacking include the elimination of wire bonding through the reverse pyramidal stacking of chips using ZTACH (Figure 2). Benefits related to substrate level packaging include the use of existing SMT equipment, lower processing temperatures, no co-planarity concerns, reduced stencil complexity, no need to apply pressure, in-line curing without exceeding reflow time, and no separate underfill process needed.

Dr. S. Manian Ramkumar is professor and director of the Center for Electronics Manufacturing and Assembly, Manufacturing and Mechanical Engineering Technology and Packaging Science at the Rochester Institute of Technology in Rochester, New York. He is also a member of the *SMT Magazine* Editorial Advisory Board.

Revolutionary Eye-Tracking Technology for Smart Watches

Whether choosing music tracks, responding to missed calls or checking social media notifications, the eye-tracking technology called Orbits allows smart watch wearers to select a function at a glance. Users can effectively press buttons and turn dials displayed on the watch simply by having their eyes briefly follow a small token orbiting the dial.

In a paper – Orbits: Gaze Interaction for Smart Watches using Smooth Pursuit Eye Movements – researchers from Lancaster University's School of Computing and Communications were able to demonstrate that users robustly select from up to eight moving input targets while avoiding any unintended activation when they just look up the time or other information displayed. The researchers have taken advantage of 'smooth pursuits' – a distinctive form of eye-movement that only occurs when we fixate on a moving target.

Because this trait only happens when following a stimulus, it ensures a high degree of accuracy. After a short initial acceleration, the eye converges with the target within 300 milliseconds, so functions can be selected very quickly. In addition, the smooth pursuits trait also means no irritating calibration between the eye-tracker and display is required.

The technology works independently of the target's size, so it is better suited to the small screen sizes of devices like smart watches than other existing forms of interaction, such as touchscreens.

SMTA
Surface Mount Technology Association

2016 EDUCATIONAL PROGRAMMING

CONFERENCES

South East Asia Technical Conference on Electronics Assembly Technologies
April 12-14
Penang, Malaysia

International Conference on Soldering and Reliability
May 9-11
Toronto, Ontario

Symposium on Counterfeit Parts & Materials
June 28-30
College Park, MD

SMTA International
September 25-29
Rosemont, IL

Medical Electronics Symposium
TBA

International Wafer-Level Packaging Conference
October 18-20
San Jose, CA

Guadalajara Technical Forum & Expo
October 5-6
Guadalajara, Mexico

High Reliability Cleaning & Conformal Coating Conference
October 25-27
Rosemont, IL

LED A.R.T. Symposium
November 29-December 1

WEBTORIALS

January 27 & 28 | 1:00pm EST
Solder Joint Voids- All You Should Know
Jennie S. Hwang, Ph.D., H-Technologies Group

February 9 & 16 | 12:00pm EST
Printed Circuit Board Failures - Causes and Cures
Bob Willis, Bobwillisonline.com

March 29 & 31 | 1:00pm EST
Solder Paste Printing for Beginners
Chrys Shea, Shea Engineering Services

April 26 & 28 | 1:00pm EST
Solder Reflow Fundamentals - Thermal Profiles & Defect Mitigation
Fred Dimock, BTU International and Karl F. Seelig, AIM

May 17 & 19 | 1:00pm EST
It Is Time For Low Temperature - Low Temperature Solders, New Development, & Their Applications
Ning-Cheng Lee, Ph.D., Indium Corporation

...More topics to be announced.

CERTIFICATION

SMT Processes
May 9-11
Toronto, Ontario

SMT Processes
May 24-26
Querétaro, Mexico

SMT Processes
September 27-29
Rosemont, IL

...More locations to be announced.

MORE INFORMATION:

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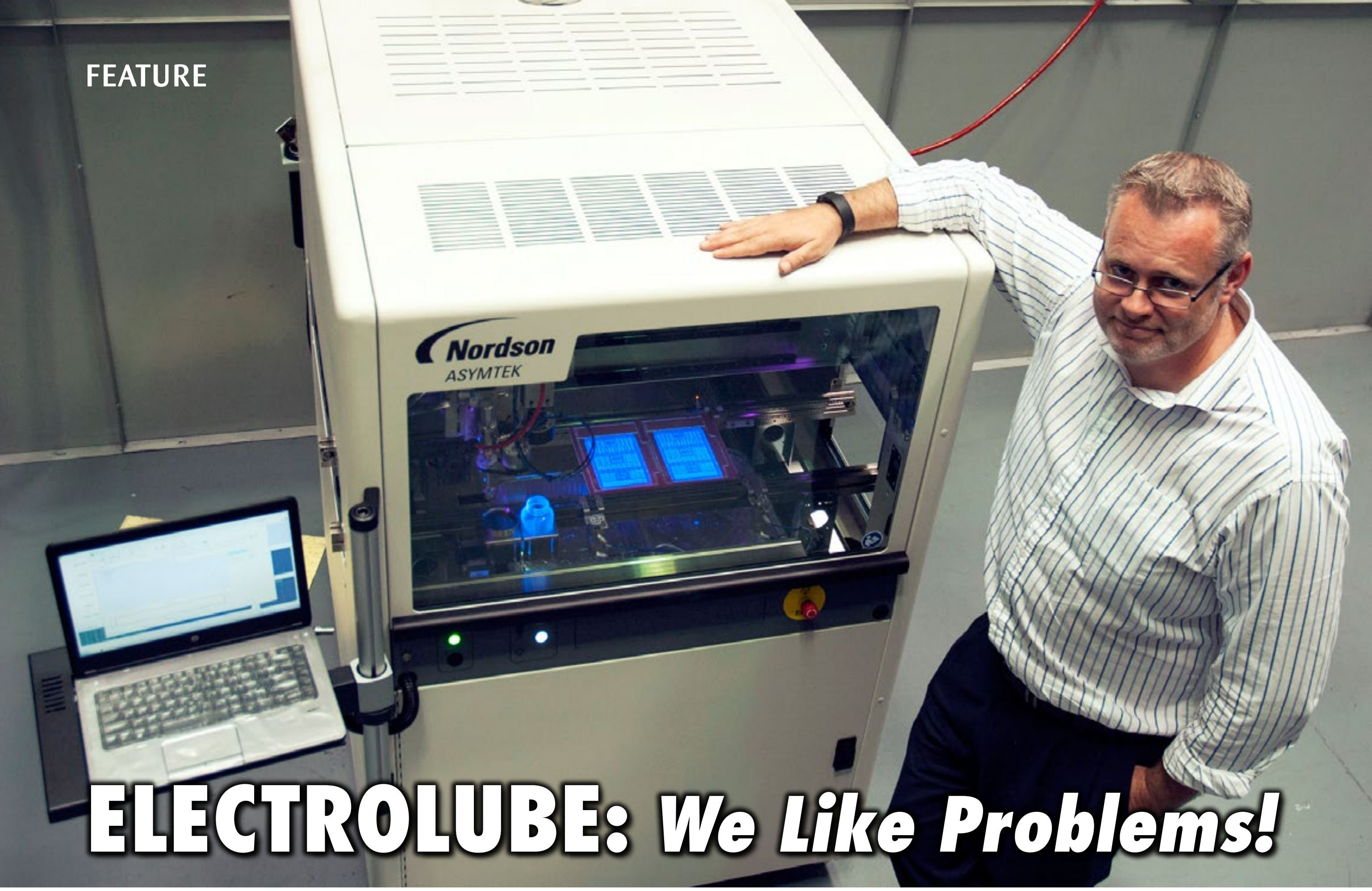


ELECTROLUBE: *We Like Problems!*

by Pete Starkey
I-CONNECT007

Introduced to Electrolube's President, Gerald Kingsbury, and Group Managing Director Ron Jakeman at productronica, I was delighted to accept their invitation to visit their UK headquarters in the historic Leicestershire town of Ashby-de-la-Zouch, whose name dates back to the Norman conquest of England in the 11th century.

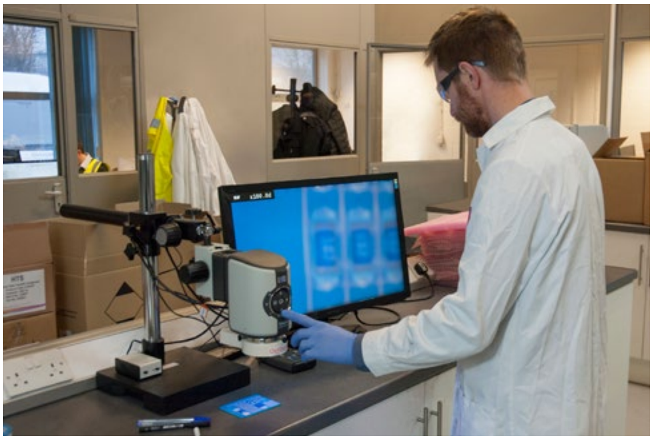
And Electrolube itself has historic links too. Founder Henry Kingsbury's wife, Gerald Kingsbury's mother, was a direct descendant of Boer War hero Field Marshal Sir John French, 1st Earl of Ypres, whose portrait takes pride of place in the company's boardroom.

From a background in the electronics industry, Henry Kingsbury began manufacture of volume controls in the early 1940s, trading as Kingsbury Components, and overcame the tendency of volume controls of that era to fail open-circuit by developing an oil that improved electrical performance, reduced operating friction and extended the life of contact surfaces. This evolved into a range of contact lubricants which became the basis of the Electrolube brand and a company now recognised as a global specialist and brand leader in formulated chemical products for the electronics industry.

With a presence in 55 countries, Electrolube's extensive portfolio now includes thermal management materials, conformal coatings, encapsulation resins, electronic cleaning solutions and general maintenance products. Electrolube remains a private company owned by the Kingsbury family and continues to expand, with R&D, manufacture and distribution long established in China to complement the UK operation, and a new manufacturing plant being commissioned in India.

In my conversation with Ron Jakeman and group technical director Dr. John Humphries, it became clear to me that Electrolube's strength has been built upon the combination of the technical skills of its people and their ability to work closely with customers, with the company's culture of collaboration, innovation, thought-leadership and customer service. Not a complicated formula, but the results speak for themselves and justify the mission statement, "To strive to exceed our customers' expectations

A look inside Electrolube's huge raw materials warehouse.



with innovative new products and the highest possible levels of customer service" and the Electrolube tagline, "The Solutions People."

"We like problems!" was the preface to an explanation of the company's focus on research and development, whether by adapting existing products to meet specific needs, or by embarking on long-term projects to develop entirely new solutions to existing or anticipated performance and reliability challenges, guided by a specialist technical support group and funded by a substantial R&D budget. Having R&D in China as well as in the UK enabled rapid response to local market demands, and closely coordinated collaboration between the individual teams gave two-way synergistic benefits. In addition to technical performance considerations for new products, there was increasing emphasis on finding environmentally friendly solutions. Electrolube was recently challenged to resolve long-term problems experienced by a customer utilising surface modifier materials; the technical team wholeheartedly embraced the challenge and developed a brand new product that not only met the specifications but exceeded them.

The automotive industry is currently a major driver of product development, particularly in conformal coatings and encapsulants for electronics in hostile under-hood environments, and there were numerous new applications associated with power management in hybrid and electric drive systems. The rapid growth of LED technology in automotive, domestic and municipal lighting applications has accelerated the development of new thermal transfer materials and UV-stable coatings.

All of the product groups were elegantly described and illustrated in individual technical brochures which gave expert guidance on product selection for typical applications, as well as performance and reliability test results, in several languages. Additionally, full technical data sheets and material safety data sheets were available for each individual product.

Time for a plant tour—and not feeling at all conspicuous in my bright yellow high-vis jacket!—I enjoyed a comprehensive walkabout with manufacturing manager Nigel Miller. Starting with an enormous raw materials warehouse, with hundreds of different items—every package individually bar-coded at goods inwards, and its identity maintained throughout the process—we proceeded through a series of pro-

Electrolube's headquarters is in Ashby-de-la-Zouch, Leicestershire in England.

State-of-the-art equipment for dispensing and coating, environmental testing and thermal cycling help maintain the high quality of Electrolube's products.

duction departments equipped with seemingly every conceivable variation of built-for-purpose mixing and blending plant, and its associated packaging equipment. There was evidence of meticulous materials and process control and documentation, retained batch and quality assurance sampling, both in the manufacturing areas and in the adjacent quality assurance laboratory. New product development and evaluation continued in an adjoining laboratory, which had the benefit of state-of-the art dispensing and coating equipment together with facilities for environmental testing and thermal cycling.

A logical extension of the philosophy of customised product development was customised packaging, and I was fascinated to observe the diversity of options offered. It seemed that Electrolube really concentrated on individual customer requirements across a wide range of packaging solutions including bulk containers, gallon cans, litre bottles, small tins, tubes, sachets, syringes and aerosols. The skills and facilities were present to accommodate varying sizes of production batches or even bespoke small batches as required. And Electrolube even prints their own labels.

Across the yard to a remote building where flammable materials were processed. Scrupulous attention to health and safety was evident throughout the whole of the operation, and especially here—leave your cellphone at the door! I had never seen an automated aerosol-charging line before, and this was a memorable experience.

Finally to a busy order-picking and despatch department, the barcode system keeping all of the myriad product lines clearly identified, and dozens of palletised loads awaiting shipment to distributors and customers world-wide.

Everywhere I went, there was a buzz of cheerful industriousness—a team of people working skilfully and purposefully with a nice community spirit.

Wrapping up, I asked Jakeman what he believed primarily differentiated Electrolube from its competitors. He replied that, apart from the expertise of his people and their commitment to innovation and personal customer service, it was the extent of Electrolube's range of product groups and their brand leadership in many different fields, whereas typical competitors tended to be identified with a single product line.

I thanked him and his colleagues for a most enjoyable and informative experience, and wished them ongoing success in 2016. **SMT**

Based in the U.K., I-Connect007 Technical Editor **Pete Starkey** has more than 30 years' experience in the PCB industry and a background in process development, technical service and technical sales. Starkey is a fellow of the Institute of Technology, a member of the SMART Group Technical Committee, and an active supporter of the European Institute of Printed Circuits.

SIDEBAR

The Automotive Industry: Electrolube Meets the Highest Demands

The global automotive industry is one of the key sectors within the electronics market. Due to the increasing demands of consumers and the high level of competition within the industry, its rapid development and expansion has positioned it at the forefront of electronics applications. Specifications are frequently reviewed in order to establish the best possible performance from any electronic device in the vehicle. Such specifications are amongst the most difficult for electronics devices to achieve, once again confirming the expectations and desire of this industry to achieve the optimum performance for its customers.

In a typical car today, electronic systems are critical to the smooth and safe operation of the vehicle. Even before the engine starts, electronics have already unlocked the car. Once you start the engine and step on the accelerator, sensors assist in moving out of your parking space, engine control units (ECUs) tune the engine performance, monitor the pressure of the tyres and safety systems are powered up in standby mode. As you prepare for your journey, adjust the air conditioning, ensure your phone is connected to the entertainment system, set your destination on the satellite navigation system and initiate your favourite music, yet more electronic systems are brought to life.

The electronics continue to manage your interior temperature through the HVAC system. Sensors and control systems detect crash situations, deploy airbags and side impact protection and can automatically notify the emergency authorities of the location of an accident, should the driver be incapacitated. Braking is controlled to prevent dangerous situations such as locked brakes; automatic transmission and management systems are used to change gears, maximise fuel efficiency, monitor and minimise emissions. Active collision detection systems use cameras and radar systems to alert drivers of impending situations and prevent lane drift.

The usage of automotive electronics appears set for continuous development as consumers demand ever more performance, safety, comfort, convenience and entertainment from their vehicles. Systems are being developed that will do more to avoid accidents, protect and entertain occupants and reduce the environmental impact of the journey. With electronic systems often exceeding 20% of the total vehicle value and vehicle warranties typically offered for 5–7 year durations, reliability of these electronic systems is vital. Combined with the requirement for 'greener,' more efficient vehicles, innovation and cooperation are key to achieving the highest targets in this field.

With our expansive product range of formulated chemical products, we supply leading manufacturers of electronic devices for the automotive industry, amongst others, thus offering the 'complete solution' at all levels of protection. With a strong emphasis on both research and collaboration, we are constantly developing new and environmentally friendly solutions for our customers. Our unrivalled, very personal customer service also extends to every corner of the world. You can rely on our experienced staff to be knowledgeable and up to speed with the latest technological developments. Having a named single point of contact helps ensure we work closely with our customers, solving problems clearly and efficiently. **SMT**

FEATURE

THE JEFFERSON PROJECT, Part 2:

Automation as a Counterweight to Low Labor-Rate Assembly

by Patty Goldman
I-CONNECT007

This is Part 2 of an interview I conducted at SMTAI with the founder of The Jefferson Project and the forthcoming Jefferson Institute of Technology, Tom Borkes. In Part 1, which ran in the January 2016 issue of SMT Magazine, Tom provided his well-researched plan to introduce students to tech manufacturing through a four-year, hands-on, real-world college learning experience that brings tech manufacturing to them. We also discussed the paper he presented at SMTAI, which focused on the concept of building meta-process control into an assembly operation's infrastructure.

In Part 2, taken from the original interview, Tom expands on the example set forth in his SMTAI paper, and describes another important tool in reducing labor cost through the reduction of labor content: designing for automation.

***Goldman:** You spoke about meta-process control as a tool to help reduce the labor associated with dealing with assembly yield loss. Please tell me about the other subject the paper addresses—design for automation.*

Borkes: A good example is the one we introduced in the paper. We looked at a product for opportunities to reduce labor cost by reducing labor content through automation. From a design point of view, components that require hand soldering, relatively speaking, are usually labor intensive. The components chosen in this case were standard right-angle pins (Figure 1).

In this application, they are usually found in groups of five per board and are soldered to small daughter circuit cards. The pins permit the small PCBs to be plugged-in to a motherboard, vertically, to save board real estate. The bare small circuit boards are fabricated in 200-up panels (i.e., using 1000 pins per panel. Normally what you do is singulate the panel and take five standard right-angle pins, put them in the board, and hand solder them. An assembly constraint is that when you're done the five pins must parallel to each other.

We created a new pin. This pin was designed for total automation so you can print paste over the through-holes on the board, insert this pin,

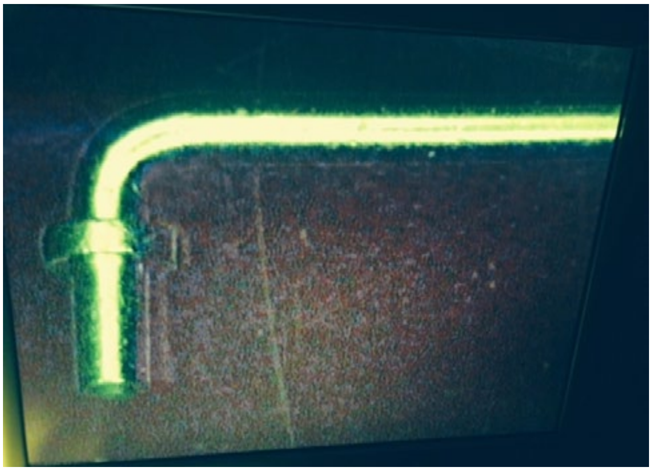


Figure 1: Traditional standard right-angle pin.

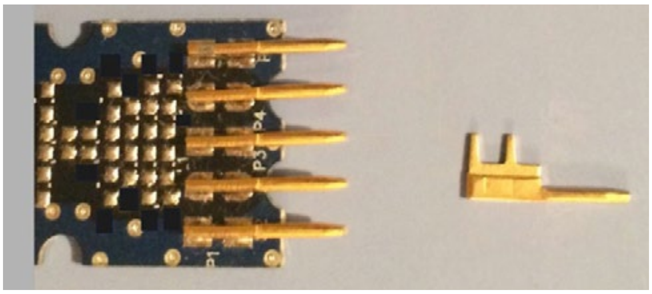


Figure 2: Daughter board assembly with pin designed for total automation.

which has two legs on it, right into the paste; then, it can be sent through a reflow oven.

Now, you could ask, "Well, why don't you just use the standard pin: print paste (paste-in-hole), insert the pins and send it through the oven?" The problem is with a standard right-angle pin, the pins will rotate while going through the oven.

But these have to stay parallel to each other to permit them to be plugged into the sockets on the motherboard. This is a case study we use in the paper as an example of design for automation. You can redesign the boards to use the new, automatable pins as was done in the application; however, what's better is if you design this kind of pin into the board to begin with. This allows the process to be automated without the cost and time involved in a board redesign. If you try and automate using a standard right-angle pin, you end up having to rework

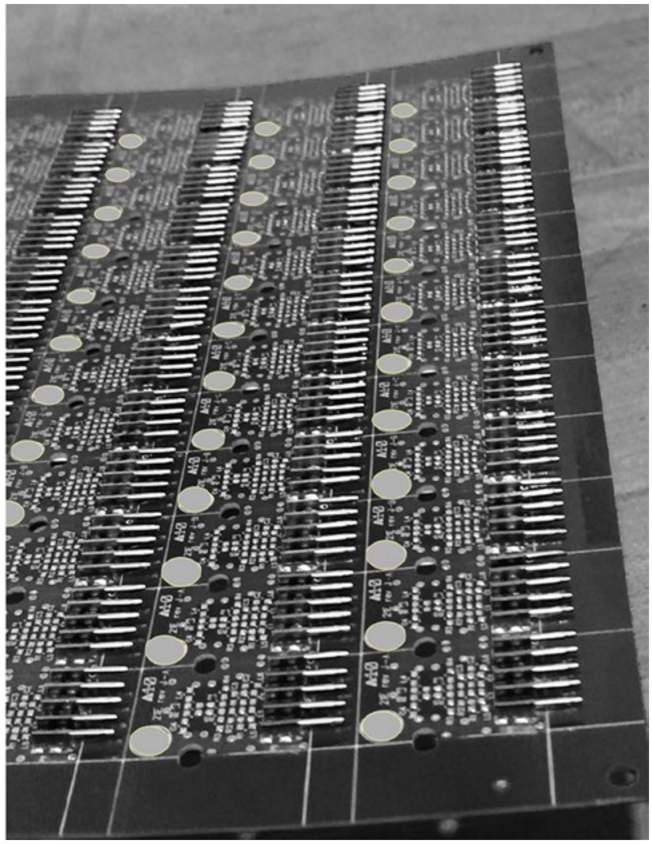


Figure 3: Portion of 200-up daughter circuit board panel after reflow with pin designed for automation.

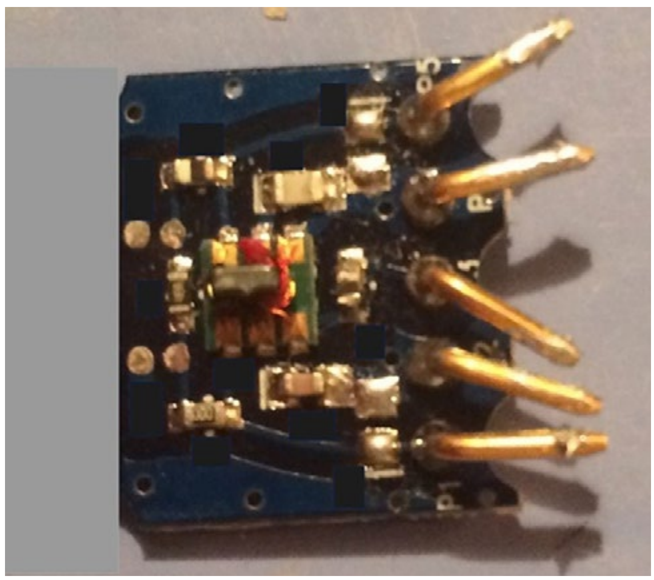


Figure 4: Standard pin post-reflow daughter board assembly using a standard paste-in-hole process.

every board by hand soldering touch-up—it doesn't make any sense. Even though you may have very good people doing the soldering, you occupy and pay them for the rework. This, of course, adds to the total labor cost of the product, making it harder to compete with low labor rate markets. That's one example of the many we have done. But, you may ask, what about material cost of the new pin?

Here's the punch line: This new pin costs the same, because it's a stamping/coining process that we use to manufacture it. In other words, you are not paying any premium on the price of the material, which is important. One must always compare total costs, including material differences and non-recurring costs to see if there is a reasonable return—or, worse, any return—on the investment.

***Goldman:* But it's a much better design.**

Borkes: Yes, and for a number of other reasons besides labor content reduction, it's a good solution—but, I won't go into them here.

***Goldman:* What about pin insertion in the daughter board. I thought you said the entire process was automatable with the new pin?**

Borkes: Total automation of the pin assembly process was the project goal—the production quantities involved permitted investing in tooling. The thing is, how do you automate the pin insertion? Putting the pins in tape and reel was one possibility. However, this adds an additional material cost of 3.5 – 4 cents per pin, plus NRE and tooling costs. We chose to use a

Figure 5: Top view of bowl for automatable pin.

vibratory bowl feeder to present the pin to the pick-and-place machine.

You see all those little pins in the video? You can see how they work their way up the bowl automatically, and then they work their way into this linear track. As you can see, the bowl feeder is designed to be mounted as any other component feeder on the pick-and-place machine—the same machine that's placing any other surface mount parts on the panel. During operation it appears that the bowl is rotating, but it's not; it's an optical illusion. Those pins are actually vibrating, up the ascending bowl track. The bowl isn't rotating at all.

Goldman:* *Oh, perfect. Then they get placed.

Borkes: You can see at the end they are automatically inserted into the solder paste. Then it will go through the oven and come out finished. You've automated the insertion process. You've automated the soldering process. Everything is automated.

Goldman:* *Who makes that equipment to line up those pins?

Borkes: Many companies make the bowl feeders.

Goldman:* *What is the process variation like?

Borkes: With the pins lined up like soldiers in the bowl, you can achieve those 99.5%-plus yields. Once the process is developed and statistically capable, there is very little process variation—i.e., a high Cpk index—so a small variation in a relatively wide process window.

Goldman:* *Without that manual hand soldering operation, which is huge cost reduction.

Borkes: In fact, when you print the paste-in-hole during the same pass as the SMT components and use a bowl feeder to present the pins to a pick-and-place machine to permit automatic insertion, you cut the assembly labor content down by about 87% because it's all automated. You don't have the variability of a person with a soldering iron, soldering all these pins.

Goldman:* *First of all, the operators doing the soldering want to try to be as fast as they can.

Borkes: Exactly, then they've got to worry about the lining up of the pins, and they're holding them with tweezers. It's a lot less variation, and it's a lot more robust to work with an automation process.

However, again, this leads us back to the need for the school, to produce well trained, multi-functional engineers to develop and manage this level of automation and the rest of the operation including procurement, scheduling, set-up, equipment maintenance, change-over, etc., in a product team arrangement. The traditional organizational structure we have right now, what I call the Henry Ford division of labor model, in most cases uses very minimally skilled, very low-wage direct labor. Then, these people have to be supported by a hierarchal arrangement of departments whose indirect cost and overhead burden needs to be absorbed in the labor sell rate. This is what takes a $13.98 direct operator average wage on the floor and makes it a $32 labor sell rate.

But there is an ironic thing that happens here: If your strategy to compete with low labor rate markets is to reduce labor content through exploiting automation, you're not going to have a lot of direct labor to absorb all that overhead. You're going to be forced to find a way

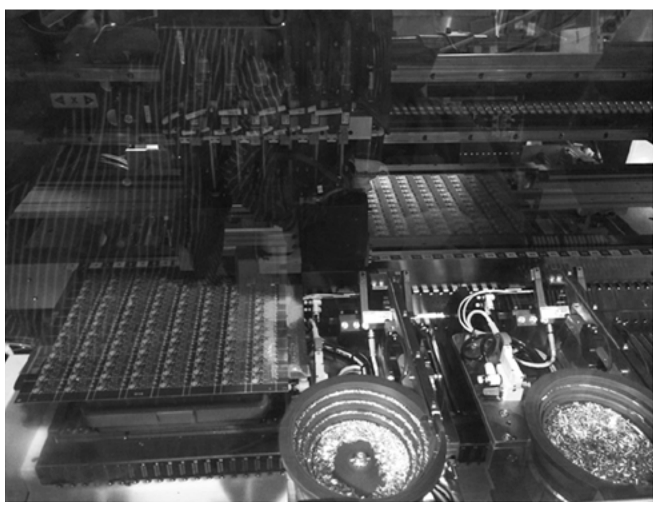


Figure 6: Typical vibratory bowl feeders mounted on standard SMT placement machine.

to take a lot of this non-value-added stuff and take some of these things that are done now in an indirect way and have the people that are direct labor do them. Your direct labor is going to be more in terms of hourly rate, but there's going to be so much less of it. The people on the floor are going to be multi-functional engineers.

"The people on the floor are going to be multi-functional engineers."

Goldman: ***As opposed to operators, which has advantages.***

Borkes: The advantage is that you're not going to have all this other stuff that needs to be absorbed into that direct labor. It's basically the restructuring of the organization, from many departments, where people are grouped with common skills, to small, self-managed, multi-skilled project teams.

Goldman: ***Where are you in the process of getting students into your program?***

Borkes: That's a good question. When the time is right, the students will be judiciously selected from high school graduates. The first class will be 40 students. After four years we estimate the student body size will be consistently about 120 students. As I said in the beginning, this is a very ambitious project. We're talking with an organization that accredits engineering colleges on the East Coast. The program will result in a four-year Bachelor of Science program in Design and Manufacturing Sciences.

I tell you the biggest problem is finding professors and staff. One of the things that's key to the success of students using a business as their classroom is having professors at the school leading the projects on the EMS floor. We're looking for staff that has the real world experience, but also the teaching abilities. We're looking for six people that will be part of the leadership group on the manufacturing floor, but who can teach in the classroom, as well.

Goldman: ***You first need people to teach basic things like engineering for accreditation.***

Borkes: That's correct. Right now we're writing three supplemental text books which takes, for example, the traditional calculus curriculum that's typically taught in that ivory tower and applies it to the high-tech product assembly done at the Jefferson Electronic Manufacturing (JEM) Center—applying the theory to motion control of a pick-and-place machine, for example.

Goldman: ***Yes, which is normally taught in university as all theory.***

Borkes: And they never use it again in their lives, but I'm taking aspects of that and applying it to the manufacturing floor, as I am also doing with chemistry. An awful lot of chemistry goes on in what we do in the real world. What I want to do is relate the chemistry, the theory that they're typically taught, to the chemistry that's used on the manufacturing floor—as well as physics, economics, etc. It's non-traditional, that's for sure.

Goldman: ***But you can't start until you're accredited.***

Borkes: I don't know when we're going to start. That whole accreditation thing is a massive subproject on its own, especially considering this isn't a traditional college. We're looking for the first freshman class to start as soon as possible. We want to do it right, but it is hiring staff, putting the manufacturing and school facility together, working with industry, etc., which are presenting challenges. All those things make it a very multi-faceted, non-traditional project with lots of variables. One possibility is linking up with an existing school with accreditation.

Normally, before independent accreditation is granted for a new school, you need a number of graduating classes.

We do a one-page quarterly newsletter where I present a summary of the status of the school's development. It shares much of the same things we've talked about today. Also, if you go to our website, all the papers that we've written on this and technical subjects can be found under the "Resources" column.

***Goldman:** You must be doing a lot of outreach?*

Borkes: In fact, we're going all over the country talking to high schools. It's fascinating to me, because if you think of education as a pipeline, these young kids at five years old enter the pipeline. Our project addresses a specific part of the pipeline—the college undergraduate level. Our success is going to be largely a function of the quality of the people coming out of high school. One of the things that I have found in my travels, through being invited to speak at different high schools, is that there are high schools that offer robotics clubs, and they are getting students excited about automated, high-tech product assembly.

"Our success is going to be largely a function of the quality of the people coming out of high school."

Just to show them this stuff, and to let them know they could earn a high salary doing this someday, is exciting and eye-opening to them. That's the irony, right? We talk about competing with low labor-rate environments, but in this high-tech automation approach we need a small number of very highly skilled, cross-trained people to work on the manufacturing floor.

This is another facet of the strategy that is interesting. In the United States, the academic year is 180 days. In South Korea the academic year is 250 days—that's 80 more days the students are going to school in South Korea. I've worked with Samsung, and I've worked with several other South Korean companies. If you look at Hyundai, Kia, and all these great South Korean companies, what you'll find is that the skill sets that their engineers have are really geared towards manufacturing as an upper echelon engineering profession, whereas in this country, if you can't qualify to be a mechanical or electrical engineer, or computer scientist, you can always be a manufacturing engineer. One of our goals is to change that mentality. One way to change that is through automation and making sure the students understand the importance of the physics and science that goes into all of this. Our academic year will be on a trimester basis, 16 weeks each, so it's 48 weeks of intensive study. This comes very close to the 250 days in South Korea's school year.

***Goldman:** It's also more like a real manufacturing environment—you don't get summers off.*

Borkes: That's a very astute observation. Since the for-profit business has to be taken care of to be successful, that's the calendar that the students' education is on as well. They'll play an integral part in the success of that classroom in which they're learning. They're able to not only apply part of their day to building products, but also to their class work. For instance, I'm designing two classes that have never been heard of: The Anatomy of an Electronic Product, and the Formation of Technological Thought in the Western World.

These are important, basic classes that the students will take early on, in their first trimester. That will set the scene for a lot of what we're going to build. We've turned things upside down: where traditionally, you've had very smart professors, who are very good in their niche areas of science, math, economics, the humanities, or history, teach students the theory. Then, the students take that theory and go into the real world, and try to apply it somehow. How much they can apply is uncertain. There's not a good correspondence between the two.

***Goldman:** No, there sure isn't. I remember taking*

some engineering courses and thinking, "But how does this connect?" It needs to make a connection.

Borkes: That's the advantage we have. We'll actually be able to talk in real time about solder paste or about flux chemistries in the chemistry class, yet teach the traditional classwork that's needed for accreditation, as well. Mortimer Adler, who is one of my heroes, was an American philosopher. He died in 2001. He led a group responsible for an educational strategy called The Paideia Proposal, and he was fond of saying "You know, there's learning for learning and there's learning for earning."

Many students have no clue as to the value of what they're being taught. They're relying on schools to provide them with educational content that's going to be valuable to them going into the real world, as well as develop a love of learning and general knowledge that will enhance their lives. Adler said, the most successful schools are the ones that instill a combination of both. They provide their students with learning for learning and earning. Certainly in manufacturing what we've done falls far short of the mark on learning for earning. The skills that are learned have very little relevance in manufacturing. That's why we don't get people who are attracted to manufacturing—they don't really even know that it exists; the professors in most cases have no real-world experience, either.

It's a dilemma. It's a big ship to turn. I'm convinced that we can change this using the theory of concurrent education. Some people tend to think we do this already with these apprenticeship and co-op programs. I call those weakly concurrent. There is no real correspondence between what the student is doing in school and their apprenticeship program at a company. Concurrent education is the educational theory that all of what we've discussed is based upon.

We really want to merge the two worlds, academia and the real world, for the benefit of the student, and our manufacturing industry. A successful student, in many cases, is being guaranteed a good job upon graduation.

Goldman: Well, Tom, we've been talking for quite a while here!

Borkes: Yes. As you can see with me it's a passion at best, an obsession at worst, but it's something that needs to be addressed. In a sense, it's like peeling back an onion. Instead of more and more onion, you find more synergy with stakeholders who have much to gain with the concept of concurrent education in the context of high-tech electronic product assembly, in general, and trying to compete in high labor-rate markets, specifically. Many have learned the hard way that you just can't buy the automation and hope to be successful; you need to pair the equipment with a world class workforce—a workforce that has been trained differently, structured differently, and focused on product teams and not departments. Nibbling around the edges with short, disjointed apprenticeship and co-op programs and politicians waving the STEM acronym around will not get it done.

"It's a big ship to turn. I'm convinced that we can change this using Concurrent Education."

Goldman: Thank you very much for your time.

Borkes: My pleasure. SMT

References

1. The Jefferson Project.

Patty Goldman is the managing editor of *The PCB Magazine* and a 30+ year veteran of the PCB industry, with experience in R&D of imaging technologies, wet process engineering, and sales and marketing. To reach Goldman, click here.

Rework Site Printing using Mini Stencils—Plastic Adhesive vs. Metal

by Bob Wettermann
BEST INC.

In order to duplicate the original manufacturing process as closely as possible, the rework of complex devices can be accomplished by paste printing solder paste in a select location. Ever since the advent of widespread usage of surface mount devices such as fine pitch QFNs or BGAs, this practice has continued to grow. Today's pitches are commonly 0.5–0.4 mm with packages of tiny outline sizes 510 mm square, making the rework of such devices a challenge. Spacing to neighboring components continues to be compressed so the rework techniques are getting more challenging from a practical point of view.

The process of printing consistently has given rise to a more modern technique for printing solder paste in a given location for fine pitch devices without there having to be poor yields or highly skilled technicians to perform the work. A soon-to-be-reported study compares the older miniature metal stencil printing process to the more modern plastic film with adhesive approach. This report quantifies the differences in performance for the first time.

The miniature metal stencil (Figure 1), while matching the original SMT printing stencil, has several shortcomings with respect to the rework printing process. This technique, while perfectly capable for most SMT boards, has fallen out as preferred and capable method for several reasons. With the tighter spacing between components these "mini" metal stencils are too large for modern board layouts as there needs to be an oversized area compared to the print area for the holding and supporting of the stencil. In addition, the finer pitches and pad sizes makes it difficult, even for the most skilled rework technicians, to perfectly print in a single pass the correct volume of solder paste onto the PCB. With ever-thinning stencils due to lower paste volume requirements, these metal stencils are easily bent or damaged during cleaning

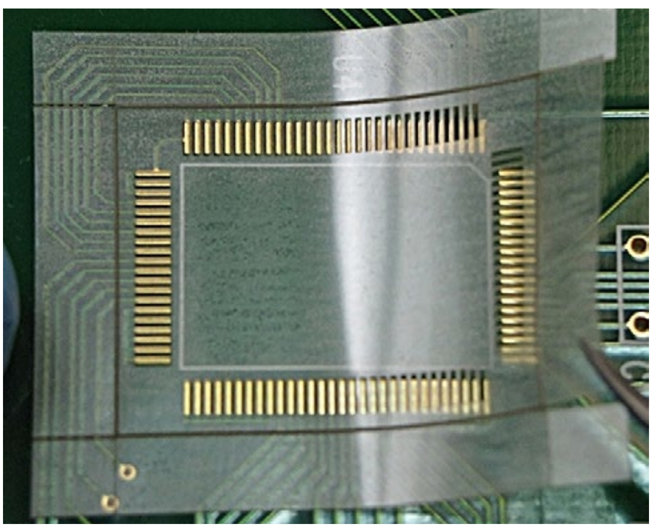


Figure 1: Adhesive-backed plastic film stencil used for rework.

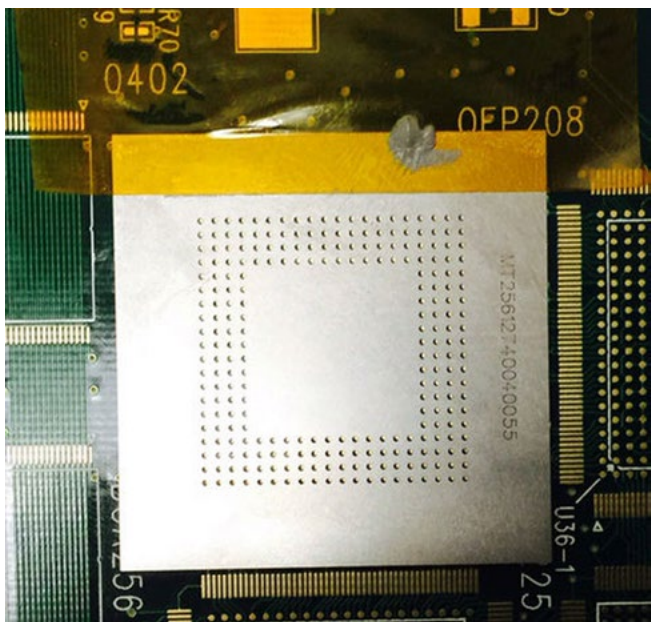


Figure 2: Mini metal used for rework.

or squeegeeing, meaning that it is difficult to retain a co-planarity with the PCB. The lack of co-planarity causes solder paste to squirt out from underneath the stencil. These problems make the miniature metal stencils less suitable today for the deposition of solder paste during rework.

Plastic film stencils (Figure 2) have taken over where the mini metal stencils have left off. They offer up some distinct advantages based on the user complaints over their mini metal stencil counterparts. Their repositionable adhesive backing allows the user to move the stencil around creating micro-fine alignments on the PCB after the macro adjustments have been made. In addition, the adhesive helps ensure co-planarity with the PCB even if the board is slightly warped. The sticky backing also allows the user to use multiple swipes with the squeegee, thus ensuring the apertures are "filled" completely. The flexible nature of the stencil allows for the stencil to be used in very tight areas, which need to be printed prior to rework. These stencil designs even allow for "flaps" to be built into the stencil design and prevent solder paste from being pushed outside of the rework area requiring further clean-up. For these and other reasons the adhesive-backed plastic film stencil is now the preferred rework stencil.

In a recent study, the results of which will be published at the APEX conference in March of 2016, the printing consistency between these two types of rework paste printing stencils will be revealed. In the meantime, select data from the study as well as the results of that study are included in this discussion.

In this study, a solder paste inspection measuring system measured the solder paste volume and solder paste "brick" height at each of the pad

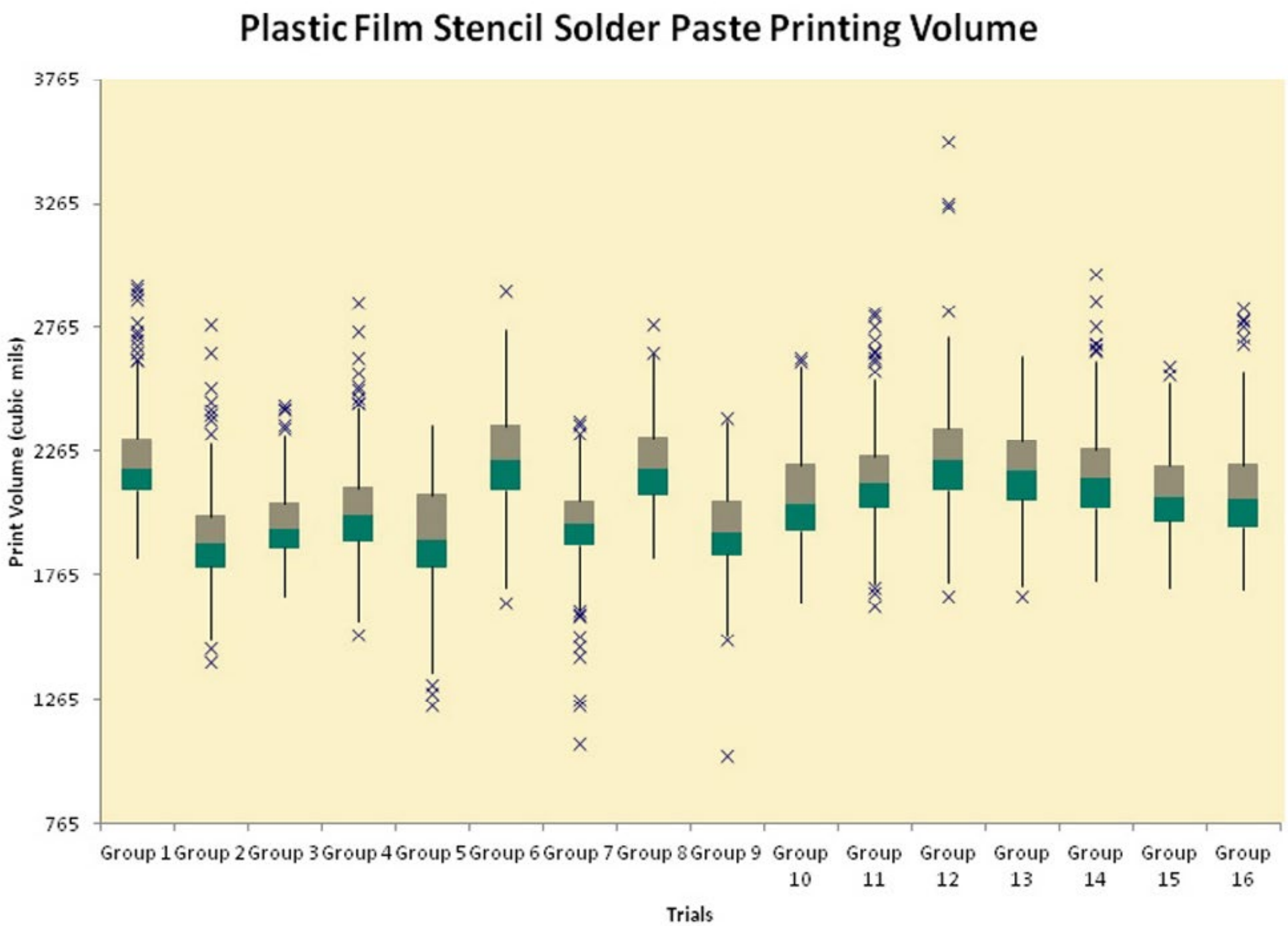


Figure 3: Box and whisker plot for plastic film adhesive-backed rework stencil for solder paste height trials.

locations. After initial calibration, an ASC AV862 offline semi-automated measuring system was utilized to take the measurements. This system used Gerber data as input information in order to find the location of each of the solder pads. After this set up the camera scans each of the locations that it recognizes as having solder paste and measures the height and volume amongst seven parameters per pad location. These results were then tabulated, graphed and analyzed.

Results

Figures 3 and 4 are the box and whisker plots for the solder paste where for the plastic adhesive-backed film and miniature metal stencils. Other charts and data including solder height, release efficiency and a comparison between theoretical versus actual print volumes was part of the complete study.

Sneak Peak at the Conclusion

The print height using the plastic film adhesive-backed stencil is more consistent and repeatable compared with the more traditional miniature metal rework stencil. This can be linked to the process of printing using the adhesive backing of the plastic film stencil as it keeps the solder paste from squirting out from underneath the stencil while also preventing it from shifting around during the manual printing cycle. Due to the adhesive holding the stencil to the board, the plastic film stencil also allows for multiple print passes to ensure the apertures are filled up. Subsequent prints of the mini metal stencil allows for the build-up of solder paste on the aperture walls and hence smaller volumes of paste being deposited on the board. The print volume averages were nearly identical for both of the populations, but the consistency of the solder paste

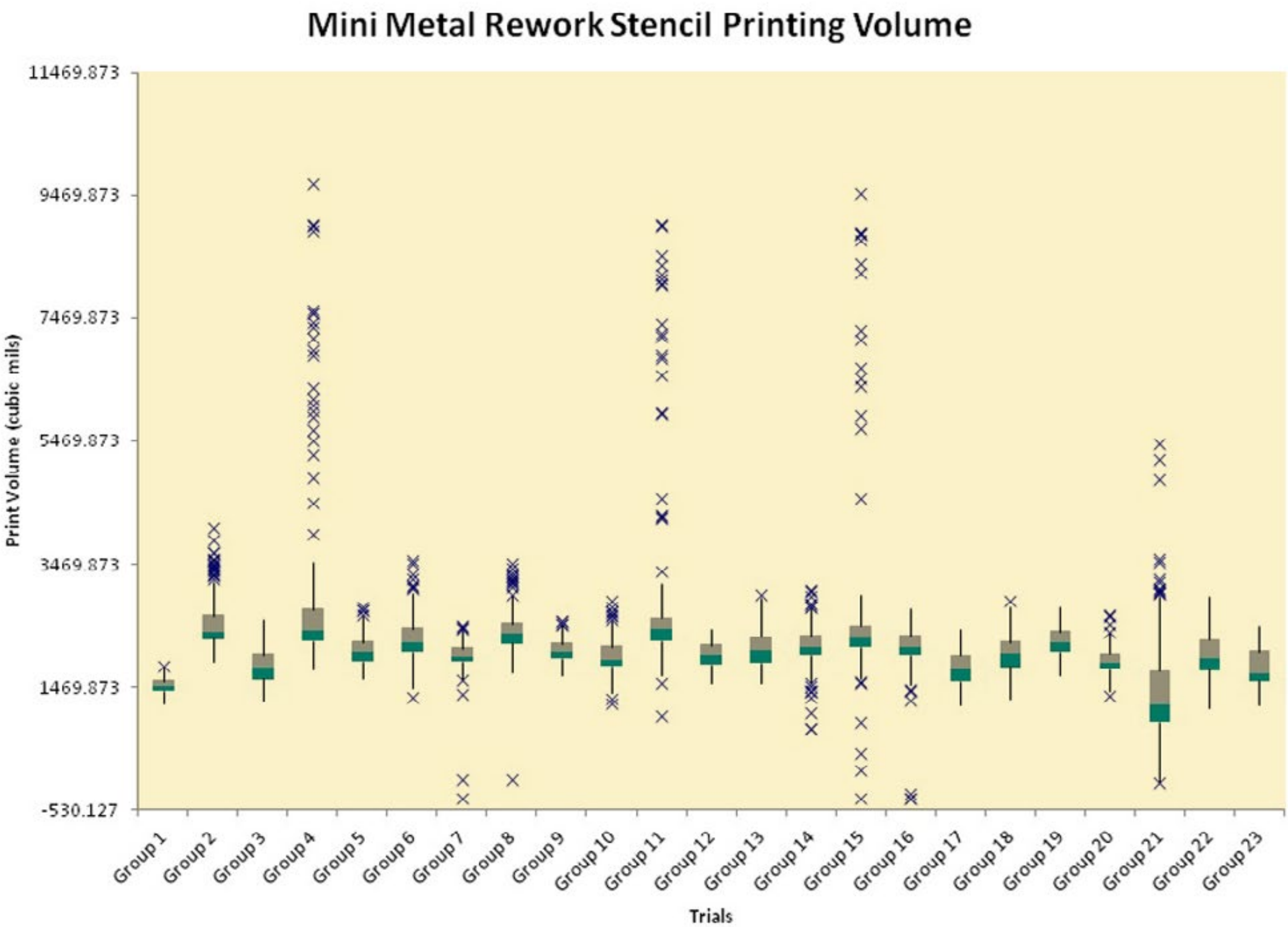


Figure 4: Box and whisker plot for mini metal rework stencil for solder paste height trials.

print volume was much better with the plastic film adhesive-backed stencil. Also, because the plastic film stencil is single use that is not subject to the "plugging" of the metal stencil apertures, its print consistency was found to be more stable than its metal counterpart. **SMT**

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Bob Wettermann is the principal of BEST Inc., a contract rework and repair facility in Chicago.

Bioinspired Technology

The next great technological advance in smartphone screens and solar cells could come from an unexpected source—giant clams. New research from UC Santa Barbara shows some species of these large bivalves produce their white coloration via color-mixing techniques akin to those used in reflective displays.

Appearing in the journal Optica, the study focuses on two species of giant clam and the symbiotic photosynthetic algae with which they cohabitate. Iridescent cells on the inside edge of the clams' shells where the algae live produce a dazzling array of colors, including blues, greens, golds and—more rarely—white, which the animals mix in different ways.

Both clam species create white by mixing clusters of colors in much the same way that the electronic displays found in televisions, smartphones and electronic billboards combine red, blue and green pixels to make white. However, most of today's displays generate light using LEDs or another light source, while the clams require only sunlight.

"If we could create and control structures similar to those that generate color in the clams, it might be possible to build color-reflective displays that work with ambient light sources such as sunlight or normal indoor lighting. Producing color the way giant clams do could lead to smartphone, tablet and TV screens that use less power and are easier on the eyes," said lead author Amitabh Ghoshal, a postdoctoral fellow at UCSB's Institute for Collaborative Biotechnologies (ICB).

Ghoshal worked with Daniel Morse, a professor emeritus in the campus's Department of Molecular, Cellular, and Developmental Biology and director of this research, and UCSB alumna Elizabeth Eck, now a graduate student at UC Berkeley.

INDUSTRY 4.0: Creating a Standard

By Barry Matties
I-CONNECT007

In this interview, I sit down with Mentor Graphics Valor Division's Dan Hoz, general manager, and Ofer Lavi Ben David, product line director, to discuss where Industry 4.0 is taking the industry, and the changes it will bring to both large and small companies, customers, and the supply chain, including how Mentor connects different machines on the shop floor to provide universal Industry 4.0 visibility.

***Barry Matties:** Please start by telling me about your positions at Mentor Graphics and what you're responsible for.*

Ofer Lavi Ben David: I'm responsible for the shop floor products from the Valor division of Mentor Graphics.

Dan Hoz: I'm the general manager of the Valor division.

***Matties:** Good, so what does that mean? I will start with you Ofer.*

Lavi Ben David: I look after everything from product development and marketing activities, to sales and business responsibilities for the products within the division. I work with our sales department, our marketing department, and of course our factory R&D resources.

Hoz: Mentor Graphics acquired us six years ago. I was the CEO and the President of Valor Computerized systems. It was a listed company. The goal or the strategy for Mentor was to get into an adjacent market and expand their solutions—not just within the design market and the design space, but also into other spaces and markets. They found the design for manufacturing flow to be a very interesting one, and so far it has proven to be a successful one.

That was Valor's strength. Today, we are still a division within Mentor. I'm responsible for both R&D and marketing. We have a direct sales channel, which is the FPO. We also sell through our World Trade Sales Organization, which is the largest sales department within Mentor. We also have customer support and a legal depart-

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ment and all the other things we get from the corporate side.

***Matties:** From the Valor side, obviously you've been affiliated with Mentor for many years. What sort of changes have you seen recently, from your perspective, and what are the real shifts going on there?*

Hoz: One of the most recent changes is Industry 4.0. Its six design principles are perfectly aligned with the way we developed our solutions quite a while ago because of business needs that came from our customers. As such, we are a company that can really deliver solutions for Industry 4.0. I'm not just talking about technical solutions, but also at the business level starting from design all the way down to manufacturing. If it's okay with you, I want to show you and walk you through a short presentation.

"This is about designing in one place and manufacturing in the same place versus designing everywhere and building anywhere."

We are talking about the design for smart factories of the future, and basically the need or the driver in the market is of course to address increased level of complexity and customization, shorten product lifecycle and increase process globalization. This is about designing in one place and manufacturing in the same place versus designing everywhere and building anywhere. The six principles I mentioned are connectivity, decentralization, human-machine interactions, virtualization, modularity and real-time capability. If we talk about connectivity, this is the ability of all the players to connect via the internet of things—I'm talking about humans, machines and factories. Decentralization is also important.

***Matties:** That's probably the largest area.*

Hoz: You're right. This is the ability of systems to make decisions on their own and this is what we call a "single machine factory." Now, we look at the solutions to support the needs of the six principles. We start with the NPI—a very early stage in the design flow. Taking the design, going down through the machine programming to understand which machines you want to use. You schedule it and then you start manufacturing it. There's process preparation where you do the machine programming, the documentation, and production portability, which is extremely important for this industry 4.0., which is just about software. Industry 3.0 was about hardware.

***Matties:** It's about software and data.*

Hoz: It's about the data—where you can collect the data and then how you normalize the data, so everyone can speak the same language.

Lavi Ben David: In that aspect, I think we are also in a very good position because over the years we have had machine vendors where everyone comes in with their own proprietary interface. What we were doing on the shop floor was connecting and cooperating with those big providers to connect and communicate with their machines and overcome this challenge of a big environment with many protocols, many languages and different capabilities from the machines that are a separate ecosystem in the factory. We are coming to them with our ability to connect those machines and then provide a single, universal communication protocol for these interfaces. I think although we are not an equipment or hardware provider, with our capabilities to connect to the different machines on the shop floor we are in a position to provide this universal Industry 4.0 visibility.

***Matties:** It sounds like you're coming in as a package or a total solution, from design to completed product.*

Hoz: If you look around through software providers that might have an Industry 4.0 solution, most will only talk to you about the manufacturing, per se. We are taking it a few stages earlier, from design. That's the advantage and this is what we call the left shift concept—every time you can identify something at an earlier stage, it will probably save you 10 times the amount it would cost to repair an error detected at later stage.

Yesterday, there was a very nice NES panel discussion here. There were six people talking from different companies and the last question was, "I work through so many processes and so many machine vendors in so many spaces. Everyone speaks different language. Can we have a standard language for everything like in other spaces, like the semiconductor spaces?" In the past, we used a format called ODB ++. That's a very elegant way of saying "getting the data." We came up with that. Now we are going to do the same for manufacturing. It's going to be a standard language for everyone that will enable them to get the data, collect the data, normalize it and share it between the different machines.

***Matties:** And the machines can be connected universally? And when I say universally, I don't mean from machine to machine in one factory, but across the globe—like being able to have my machine in Brazil talk to my machine in London.*

Hoz: Without naming names, a customer of ours in Brazil that runs some programming for his product said, 'Okay, I want to use this programming now in China, how do I do that?' We sent his manufacturing data package over to China and they got the programming, the set of instructions, and everything was documented. They went to the lines and programmed it and then started to manufacture the product.

***Matties:** This is part of the human machine interaction, and the idea is that we're really limiting that with 4.0, right? There's still an interaction, but it's reduced.*

Hoz: Yes. We do see it happening and everything will be automated. I think that we'll get more people or customers that say, "Okay, what about my job?"

***Matties:** What do you say to that?*

Hoz: Everything is going to be automated, that's why we come in. We will be able to take you to the next level, to do something smarter that will challenge you but give you the opportunity to contribute more.

***Matties:** In some cases, the reality is those jobs might go away. That's just the reality, because we're reducing our labor by bringing in smarter systems.*

Hoz: It's about lifestyle. We want to have a better lifestyle. We want to do things much easier than what we do today. We want to use a system to connect everything to each other. We will enable that. This will become much cheaper to buy, so maybe even the blue collar guy that works in the factory level, in order to buy this device, he has to work something like a month. Now, he will be able to work only two weeks, in order to get this device.

***Matties:** There's a benefit. I'm not arguing with that. The Whelen factory that just came in America, in New Hampshire, was spending $7 million a year on circuit boards in China, and for $12 million they set up a facility that is completely automated. That factory normally, without that automation and 4.0, would have been maybe 80–100 people, and they're doing it with 17.*

Hoz: Two weeks ago I was in China and I visited different customers there. They're all talking about Industry 4.0, or as they call it IT2. They were talking about automating everything, computerizing everything and they were saying that in 10 years, instead of people going on the lines there, it will be robots that make it faster.

***Matties:** Because they realized that labor rates were their competitive advantage, but that's gone. Down in Dongguan, and those areas, in some cases the government is coming in and saying, "You can't hire people. You have to automate." They say it's because they don't want more traffic on the roads, but what they don't want to do is lose the industry to India or Vietnam or somewhere else.*

Hoz: They've gone through this transformation faster than anyone else, although they're carrying like 1.4 billion people behind them. So many people but they still want to put robots there. If you look at our results, you will see that the majority of our business today is generated through the Pacific Rim and the Japan area, not in the U.S. This is where the business is, with big volumes and many manufacturing sites. It might be an American logo and an American company, but the manufacturing won't be done there. They want to have the design in one place. Send it over here to Europe and then ship it then to South America or wherever.

Lavi Ben David: A few years ago investing in software in China was never even considered. The answer was to put in another line and put more people there. Today, they invest in software to increase their performance, utilization and efficiencies and this is seen clearly with our results.

Hoz: Another aspect of Industry 4.0 is from the design stage and this is the digital product model. Everything is digitalized. You get the design, the schematic and the layout. You get the X-ray shapes from our library and then compare the CAD and the BOM. You compare, and you see that there is a match there and you send it to the panel design. Everything is automated. You do the product summary and start giving work instructions to all of the machines, like line programming, documentation, and stencil design. You then start programming the SMT line and the other machines in the process. Everything is digitalized and sent to the assembly.

What's good about this is that when we are finished doing that is there is feedback. In Industry 4.0, you have to connect with everything. What do you do with that information and data? You have to have a system that can really take the feedback and bring it all the way back to the designers, so next time they designs there's improvement and you will find the manufacturing constraints in zero time. The feedback loop that we do is another angle for Industry 4.0.

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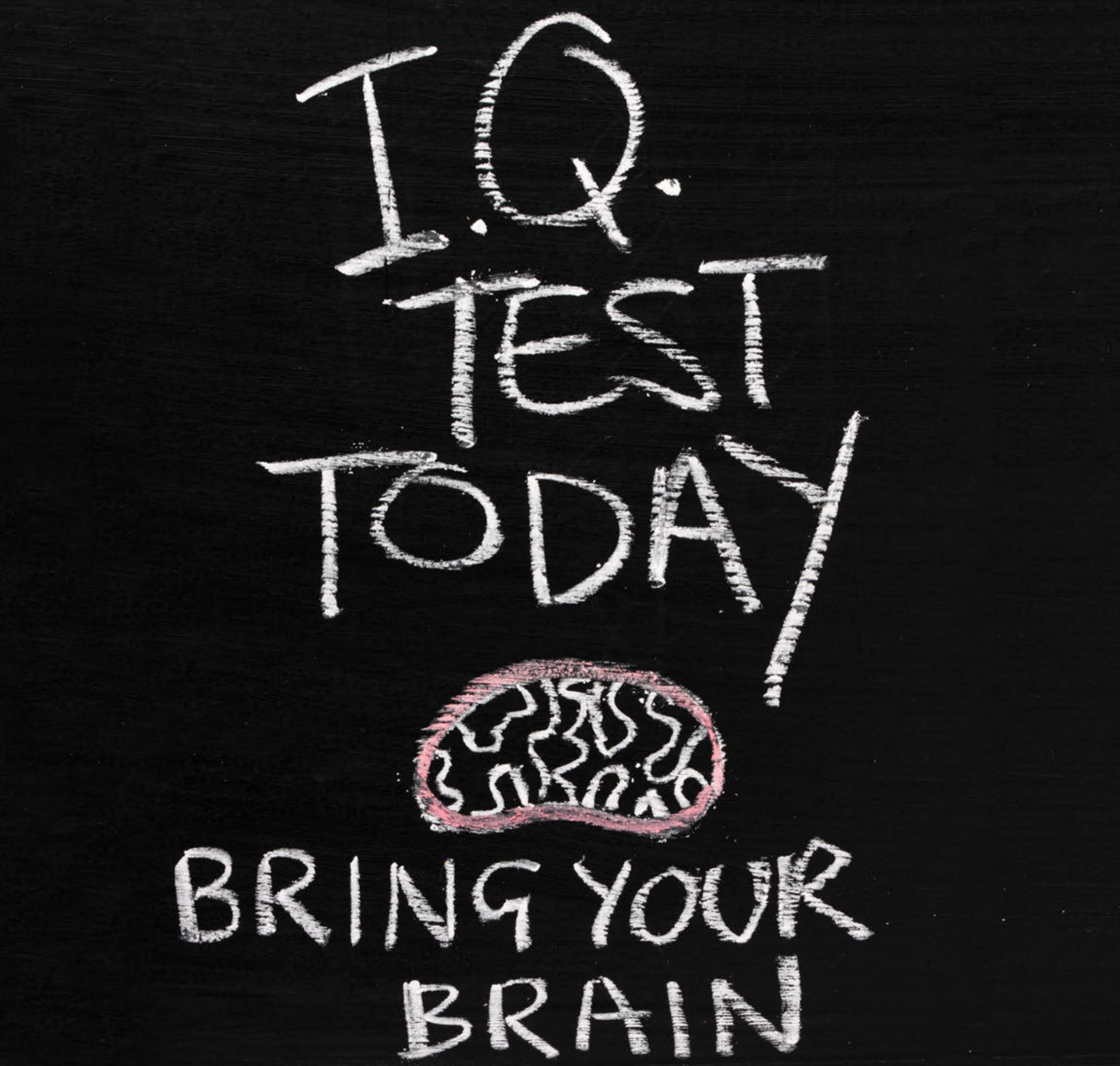

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Our vision and strategy is to try to get into this design to manufacturing flow everywhere and start connecting everything together. This is about connectivity and modularity that will enable manufacturers to decide what goes on each machine line of each factory. They don't need to go back to the ERP system. They can make their own decisions and say, "Okay, I'm in China, and I'm going to send this one to Brazil. They can do it there." This is about globalization, in a nutshell.

Lavi Ben David: The discussion around design in Industry 4.0 is how to make the manufacturing better, but once you get the design into manufacturing, eventually the manufacturer doesn't have a lot of space left. We want to make the design more intelligent and want to find more of the problems so when it goes to the manufacturers there are less mistakes and less chance that it will fail. In order to do that, you want to give feedback for the designer about the manufacturability of the processes—feedback on connecting the machines, collecting all the manufacturing data, and the result of the manufacturing process. By sending this back to the designer the design will be more intelligent. This is where we think Industry 4.0 will also benefit the design process itself.

"It's called material management, and basically this is something that we've done before Industry 4.0. This is where we have complete visibility of material across all manufacturing sites."

Matties: Now when we look at materials though, the other huge benefit is reduction of cost, reduction of inventory and less materials sitting because instead of having material there 48 hours in advance, it's there 20 minutes in advance.

Lavi Ben David: Yeah, and this is something that we've been doing for many years now. It's called material management, and basically this is something that we've done before Industry 4.0. This is where we have complete visibility of material across all manufacturing sites. We are also in a position where we can provide solutions for all generic equipment, regardless of which machines and tools you are using.

With the visibility of the right materials and the scheduled work orders, we make sure that materials are kept in the warehouse and are delivered just in time to the shop floor, just before they need them. We have a customer site where all the materials are being delivered by robots, as they need it, to go into the manufacturing line. The operator stays by the lines and they keep minimal manufacturing materials on the shop floor. When it is in inventory, we also form a transactional point of view and keep the material stock accurate in the supply chain management solution. The reordering mechanism is more efficient and provides huge savings on the materials.

Hoz: Some expensive components have a very short life and expiration. If you don't mix work orders and use it properly and program it in advance, so that you know exactly how to make the right order, you will lose money. It's not just talking about meeting some standards or that this is a nice trend that you need to adhere to, just look at the ROI. And of course, we also provide you with all the compliance requirements coming from the guys that sit at the top of the food chain or their customers.

Matties: When you order the material and manage it the way that you do, on a percentage basis, what sort of advantage have you brought for a customer?

Lavi Ben David: Close to 70% of the manufacturing costs is the labor to materials. It's a big money saver. With production, we can reduce the materials spending by around 70–80%. This is a very significant level. Now you can argue, 'Okay, what's the ROI for that?' Usually, with our product there, the ROI is less than six months. They already advance all of their investment based on their saving of materials alone.

It's not only just on the arrivals of materials, but it's also on making sure the right materials go to the right place, because sometimes there could be leftover materials—materials not used on the next line but can be used in manufacturing. We're really optimizing the materials and material ordering all the way through the manufacturing site. It was huge savings for our customer that was using robots to collect leftover materials and put huge piles of materials on the shop floor. Now it's all clean and he just sends the robots to resupply to the machine.

Mentor Graphics Valor Division's Ofer Lavi Ben David and Dan Hoz.

Hoz: Just to give you an example, if you have a reel with 1,000 components and you want them on one work order. Let's say you consume 700, what do you do with the rest? Do you put it back in the warehouse? First of all, once it has left the warehouse, the ERP system has an open balance. Now it turns into a work in progress and you cannot go back. You can go down to the finished goods, but you can't go back. The 300 will probably stay there on the line. If they are lucky and there's another order they'll find something to do with it. If not, it will just be next to the machine in the trolley and then you will see it will add up. We eliminate this problem.

Matties: If you need 700, then 700 will show up and not 1,000.

Hoz: Exactly, and if you do have 1,000, we'll take care of the 300. We know in the production plan to use the next work order that will consume these 300 components and not others.

Matties: With the Industry 4.0 smart factory, there's a new kind of workforce that needs to emerge. It's not going to be the same kind of employee we've hired in the past. It's going to be somebody that might be more computer oriented, etc. How do you see it?

Hoz: To some extent they will be more computer oriented, but on the other hand we're going to make it very simple. You just connect it and it will work. Maybe at the engineering level there will be some people that will be more responsible. But it's not just about needing smarter people. We need people that will be more responsible because now they can extend the responsibility not just over one line, but it could be over a factory or even multiple factories. We can virtualize the manufacturing in Brazil from where I'm sitting now in China. It's giving them more responsibility, but they don't necessarily need a higher IQ.

Lavi Ben David: We see also in China a lot of manufacturers, whether they are local or whether they are international, adapting those technologies and adapting to our software and using it for Industry 4.0 implementation.

Hoz: The nice thing about our solution is that we don't need to change everything that's already in place. It shouldn't be an ERP system, in terms of the amount of implementation time that you have to put in or that you have to invest in order to implement that. We come in, connect the systems, get the data, collect the data, normalize it, and send it up.

***Matties:** You're standardizing the language, so that solves the problem and that's your advantage. Is there anything else that we should talk about that we haven't already covered?*

Hoz: Maybe we can talk about decentralization, in terms of big data. Not to keep everything in one place, so you can put it at risk but decentralize it, or distribute it even.

Lavi Ben David: From a data collection perspective, instead of housing it in a centralized place that is in danger of failure when you have a complete shutdown, we decentralize it to a lot of small computers that can share and also store all the information, so it's decentralized at the collection level.

The last is big data, which suddenly everyone is collecting and there is a standard way to collect the data and everything is visible. We want to take this information in the big data capabilities and perform a sophisticated analysis and provide feedback to the designer and to the OEMs. We'll provide them the visibility of how they can improve their products on the next cycle so it will be faster and have better quality with their design. This is really where the next step is from our perspective.

Hoz: In my view, the world of manufacturing starts at the design level. It's very important to capture everything into one picture and really control, communicate, and exchange data between the different entities here and run it back and forth. Our goal is to connect everything together. Industry 4.0 is an important milestone for these businesses and for these manufacturing houses but for us, it has been for years in the making. We would like to create an ecosystem for every company that manufactures anything to be able to virtualize everything and feel like all their global manufacturing can be controlled over one basic machine.

***Matties:** Now what you guys are describing is tier-one level. What about the smaller guys that have one facility? Do your solutions fit for them as well?*

Hoz: It's the same, but scaled. These types of factories are characterized with, in most cases, low volume and high mix because the mass production is done, in most cases, in cheaper places. These shops are expertizing in different types of manufacturing. They do lots of prototypes in very high mix but the volume is low. How do you change the programs like that? How do you move from one prototype to another?

***Matties:** Quickly.*

Hoz: Yes, exactly. We take the program into account, computerize it and generate one program that can run all the different work orders at the same time. The changeover time is quick and there's also the material savings and production planning in that respect.

***Matties:** The small guys have to feel like there's a solution that's affordable and achievable because they don't always have the infrastructure and resource to implement such systems.*

Hoz: These board shops also need to have some kind of competitive edge from others. Everything is automated, everything is computerized and there is no room for mistakes for them. They cannot just afford buying another machine. Everything has to be optimized and everything has to be manufactured right the first time.

The connection with the designers is extremely important with the checks that they have to run and the programs that they have to do for the machines. The documentation that they have to provide to the customers is also extremely important. If you look at our customer portfolio, you'll see tier ones, tier twos, but also many others. We have more than 1,000 customers worldwide; not all of them can be tier one, but this is their aspiration.

***Matties:** Gentlemen, thank you so much for your time. I really appreciate it.* SMT

TOP TEN

Recent Highlights from SMT007

1 ECHA Publishes Updated REACH Guidance

The updated guidance is a “fast-track update” to make “quick” corrections to the guidance so that it conforms to the September 10, 2015 EU Court of Justice ruling on the calculation of levels of substances of very high concern in articles under the REACH regulation.

2 IPC Commends U.S. Senate on Passage of Frank R. Lautenberg Chemical Safety for the 21st Century Act

The IPC – Association Connecting Electronics Industries commends the U.S. Senate for passing the Frank R. Lautenberg Chemical Safety for the 21st Century Act (S. 697), which aims to reform the Toxic Substances Control Act (TSCA) of 1976 to reflect 21st century realities.

3 SMTA Appoints Tanya Martin New Executive Administrator

The SMTA has appointed Tanya Martin, SMTA director of operations, to the role of executive administrator effective January 1, 2016. She takes over from JoAnn Stromberg, who retired on December 31, 2015 after 29 years with the association.

4 Jabil Posts Outstanding First Quarter

Jabil Circuit Inc. has reported unaudited net revenue of $5.2 billion for the first quarter of fiscal year 2016, a 14% increase year-on-year.

5 Inovar Adds Industry Expert Charlie Barnhart to Its Board of Directors

Charlie Barnhart, a well known EMS industry insider, has joined Inovar Inc.'s board of directors. As a board member, Barnhart's primary objective will be to help Inovar grow in footprint, capabilities and service innovation.

6 CE3 Electronics Builds State of the Art Facility

CE3 Electronics, Atlantic Canada's largest contract manufacturer that specializes in high-technology electronic and electrical assemblies, recently completed a new 45,000 sq. ft. facility that is fully facilitated for CGP (controlled goods).

7 Firstronic Expands Conformal Coating Capability

Firstronic is expanding its conformal coating capability, adding a new line in both its Grand Rapids, Michigan and Juarez, Mexico facilities.

8 IPC Applauds President Obama for Recognizing Manufacturing's Key Role in U.S. Job Creation

The IPC – Association Connecting Electronics Industries commends President Barack Obama for highlighting the critical and continuing contribution of the manufacturing sector to the U.S. economy, in his final state of the union address.

9 Stefan Hedelius Appointed New President and CEO of NOTE

Stefan Hedelius has been appointed as the new president and CEO of NOTE. He will take up his position on 7 March 2016.

10 Flex to Manufacture HiQ Solar's TrueString Inverters and Accessories

PV inverter innovator HiQ Solar has selected Flex to manufacture its TrueString inverter family, which is increasingly popular in commercial 3-phase PV installations and was recognized last year with an Intersolar PV award for innovation.

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Stafford, Texas, USA

Dallas Expo & Tech Forum
March 3, 2016
Plano, Texas, USA

IPC APEX EXPO Conference & Exhibition 2016
March 15–17, 2016
Las Vegas, Nevada, USA

CPCA Show (China International PCB & Assembly Show)
March 15–17, 2016
Shanghai, China

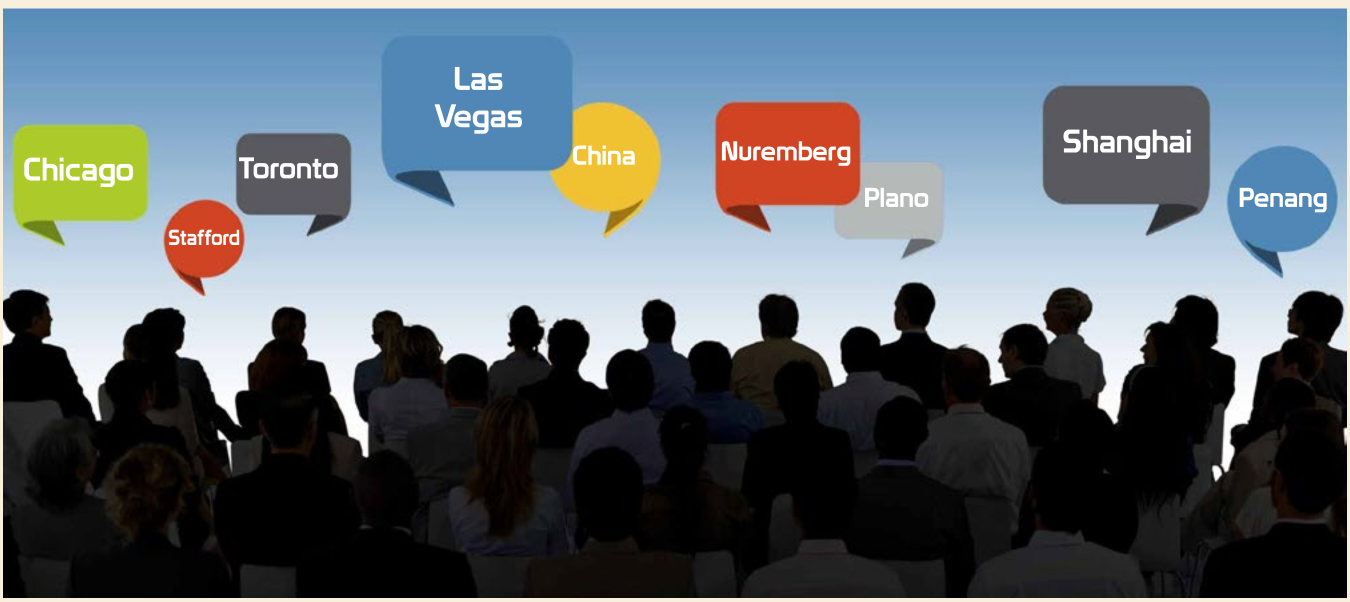
South East Asia Technical Training Conference on Electronics Assembly Technologies 2016
April 12–14, 2016
Penang, Malaysia

NEPCON China
April 26–28, 2016
Shanghai, China

SMT Hybrid Packaging
April 26–28, 2016
Nuremberg, Germany

International Conference on Soldering and Reliability
May 9–11, 2016
Toronto, Ontario, Canada

IPC-SMTA Cleaning and Conformal Coating Conference
Oct 25–27, 2016
Chicago, Illinois, USA



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